Thurrock Flexible Generation Plant

Environmental Statement Volume 3
Chapter 17: Marine Environment

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Environmental Impact Assessment

Environmental Statement

Volume 3

Chapter 17

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Summary

This document provides the Environmental Impact Assessment of the effects of the Thurrock Flexible Generation Plant on the marine environment of the Thames Estuary. This is primarily for the construction and operation of a causeway in the intertidal adjacent to the Thurrock Flexible Generation Plant. The chapter provides both the assessment of the physical and biological effects.

Qualifications

The coastal processes sections of this document have been prepared by Heidi Roberts, (MSc Applied Marine Science), Head of Physical Processes at ABPmer who has 20 years’ experience of Environmental Impact Assessment (EIA) in marine and estuarine environments. The marine ecology sections of this document have been prepared by Shona Guinan (MSc, BSc), a Marine Consultant with two years of experience in marine consultancy and Dr Kevin Linnane, a Principal Marine Ecologist at RPS, with a doctorate in intertidal ecology and over 10 years' experience in marine consultancy, working in a range of coastal and offshore sectors.

It has been checked by Peter Whitehead an Applied Marine Scientist at ABPmer with over 40 years' experience in estuary processes, sediment dynamics and EIA, and Nicola Simpson MSc, Associate Director at RPS, who has 20 years' experience in marine ecology, specialising in EIA for coastal and offshore developments.

1. Introduction

1.1 Purpose of this chapter

1.1.1 This chapter presents the findings of Environmental Impact Assessment (EIA) undertaken to assess the potential impacts of Thurrock Flexible Generation Plant on the marine environment. The primary purpose of the Environmental Statement is to support the Development Consent Order (DCO) application, and associated deemed marine licence (DML), for Thurrock Flexible Generation Plant under the Planning Act 2008 (the 2008 Act).

1.1.2 Specifically, this chapter considers the potential impact of Thurrock Flexible Generation Plant seaward of Mean High-Water Springs (MHWS) during its construction, operation and maintenance, and decommissioning phases. The Thurrock Flexible Generation Plant includes the construction and operation of a causeway and associated works within the tidal Thames Estuary, therefore there is potential for effects on the marine environment, particularly on the physical estuary processes and their effects on estuary water quality and marine ecological receptors. Estuary processes is the term used to incorporate the physical hydrodynamic processes (flow, water level and waves) and the resulting patterns of sediment mobilisation and transport. This chapter summarises the detailed technical information on these processes set out within Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment. Detailed baseline information which underpins the impact assessments is presented in Section 3 of this chapter, with a further detailed description of the benthic intertidal and subtidal ecology within the footprint of the project presented within Volume 6, Appendix 17.1: Phase 1 Intertidal Ecology Survey Report and Benthic Ecology Desktop Review. Effects of the project on intertidal birds are considered within Volume 3, Chapter 9: Onshore Ecology of the Environmental Statement.

1.1.3 This chapter considers impacts on marine environmental receptors of designated sites within the zone of influence of the project, including interest features of internationally designated sites (Natura 2000 sites) and nationally designated sites (i.e. Marine Conservation Zones; MCZs). A detailed assessment of the potential effects on the integrity of Natura 2000 sites is presented within the Habitats Regulation Assessment Report (HRAR, application document A5.2) for Thurrock Flexible Generation Plant which accompanies the ES.

1.1.4 In particular, this Environmental Statement chapter:

- Presents the existing environmental baseline established from desk studies, surveys and consultation to date;
- Presents the potential environmental effects on marine environments arising from the proposed Thurrock Flexible Generation Plant, based on the information gathered and the analysis and assessments undertaken;
- Identifies any assumptions and limitations encountered in compiling the environmental information; and
- Highlights any necessary monitoring and/or mitigation measures that could prevent, minimise, reduce or offset the possible environmental effects identified in the EIA process.

1.2 Planning policy context

1.2.1 Planning policy for energy generation Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to the marine environment, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; Department of Energy and Climate Change (DECC), 2011a) and the NPS for Fossil Fuel Electricity Generating Infrastructure (EN-2, DECC, 2011b).

1.2.2 NPS EN-1 includes guidance on what matters are to be considered in the assessment. These are summarised in Table 1.1 below.

Table 1.1: Summary of NPS EN-1 and EN-2 provisions relevant to this chapter.

Summary of NPS EN-1 and EN-2 provision	How and where considered in this chapter
Coastal Change (Section 5.5 of NPS EN-1)	
Where relevant, applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures.	Hydrodynamic and sediment transport assessments have been undertaken for the construction and operation of the causeway. These are supported by numerical hydrodynamic modelling which is presented at Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment.
For any projects involving dredging or disposal into the sea, the applicant should consult the Marine Management Organisation (MMO) at an early stage.	The effects of dredging and disposal at sea relating to Thurrock Flexible Generation Plant are discussed in Section 4.1. Consultation was undertaken with the MMO during the scoping and throughout the pre-application phase (see Section 1.4).

Summary of NPS EN-1 and EN-2 provision	How and where considered in this chapter
Biodiversity (Section 5.3 of NPS EN-1)	
Where the development is subject to EIA the applicant should ensure that the Environmental Statement clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity.	Effects on internationally, nationally and locally designated sites and protected species have been discussed within this assessment (Sections 3.1 and 4). See also the Habitats Regulation Assessment for Thurrock Flexible Generation Plant (application document A5.2). Baseline information on these receptors is presented in Section 3.1.
The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests.	Measures taken to conserve biodiversity are discussed in Section 2.9.
In having regard to the aim of the Government's biodiversity strategy the Infrastructure Planning Commission (IPC) [now Planning Inspectorate (PINS)] should take account of the context of the challenge of climate change: failure to address this challenge will result in significant adverse impacts to biodiversity. The policy set out in the following sections [of NPS EN-1] recognises the need to protect the most important biodiversity and geological conservation interests. The IPC [PINS] may take account of any such net benefit in cases where it can be demonstrated.	The future baseline scenario, including the requirement to take account of potential effects of climate change, are considered in Section 3.2. Assessments have considered the potential for both adverse and beneficial effects, for example potential beneficial effects on biodiversity associated with the introduction of hard substrates.
As a general principle, and subject to the specific policies below, development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable alternatives; where significant harm cannot be avoided, then appropriate compensation measures should be sought.	Measures taken to conserve biodiversity are set out in Table 2.10.
In taking decisions, the IPC [now PINS] should ensure that appropriate weight is attached to designated sites of international, national and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment.	Effects on internationally, nationally and locally designated sites and protected species have been discussed within this assessment (Sections 3.1 and 4). See also the Habitats Regulation Assessment for Thurrock Flexible Generation Plant (application document A5.2).
MCZs introduced under the Marine and Coastal Access Act (MCAA) 2009 are areas that have been designated to conserve marine flora and fauna, marine habitat, or features of geological or geomorphological interest. The Secretary of State is bound by the duties in relation to MCZs imposed by sections 125 and 126 of the MCAA 2009 (paragraph 5.3.12 in NPS EN-1).	MCZs have been considered within this assessment (Upper Thames rMCZ and Swanscombe MCZ; Sections 3.1 and 4).
Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the IPC [now PINS] should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate.	Measures taken to conserve biodiversity are set out in Table 2.10.
Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The IPC [now PINS] should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations.	All species and habitat receptors, including those of principal importance for the conservation of biodiversity in England are considered in Section 3, with valuation of these receptors in the context of their conservation importance considered throughout Section 4.
The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: • during construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; • during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements; • habitats will, where practicable, be restored after construction works have finished; and • opportunities will be taken to enhance existing habitats and, where practicable, to create new habitats of value within the site landscaping proposals.	Mitigation measures are set out in Section 2.9.

1.2.3 NPS EN-1 also highlights a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 1.2 below.

Table 1.2: Summary of NPS EN-1 policy on decision making relevant to this chapter.

Summary of NPS EN-1 policy on decision making (and mitigation)	How and where considered in this chapter
Coastal Change	
The Environmental Statement should include an assessment of the effects on the coast. In particular, applicants should assess: • The impact of the proposed project on coastal processes and geomorphology, including by taking account of potential impacts from climate change. If the development will have an impact on coastal processes the applicant must demonstrate how the impacts will be managed to minimise adverse impacts on other parts of the coast; • The implications of the proposed project on strategies for managing the coast as set out in Shoreline Management Plans (SMPs)…any relevant Marine Plans…and capital programmes for maintaining flood and coastal defences; • The effects of the proposed project on marine ecology, biodiversity and protected sites; • The effects of the proposed project on maintaining coastal recreation sites and features; and The vulnerability of the proposed development to coastal change, taking account of climate change, during the project's operational life and any decommissioning period (paragraph 5.5.7 of NPS EN-1).	The causeway and berth for the causeway is designed to remain operational over the life-time of the facility accounting for the effects on the tidal water levels from climate change. The facility has been modelled to establish the scale of impact on the physical processes and the resultant likely impact on the local geomorphology and the wider estuary, including the potential for interaction with other uses and users of the estuary (i.e. cumulative effects). The modelling has been used to assess the potential for effects on water levels and sediment regime that may affect the coastal and flood defences and /or the existing Shoreline Management Planning. The data from the modelling also provides input to allow assessment of effects on marine ecological and nature conservation receptors. The modelling is presented in Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment.
The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of MCZs, candidate marine Special Areas of Conservation (cSACs), coastal SACs and candidate coastal SACs, coastal Special Protection Areas (SPAs) and potential Sites of Community Importance (SCIs) and Sites of Special Scientific Interest (SSSI) (paragraph 5.5.9 of NPS EN-1).	The effects of construction and operation of the marine elements of the Thurrock Flexible Generation Plant on identified designated features, including indirect effects of estuary processes, have been considered within Section 4.
The Secretary of State should not normally consent new development in areas of dynamic shorelines where the proposal could inhibit sediment flow or have an adverse impact on coastal processes at other locations. Impacts on coastal processes must be managed to minimise adverse impacts on other parts of the coast. Where such proposals are brought forward consent should only be granted where the Secretary of State is satisfied that the benefits (including need) of the development outweigh the adverse impacts (paragraph 5.5.11 of NPS EN-1).	Potential impacts on sediment transport are assessed in Sections 4.1 and 4.2 of this chapter of the Environmental Statement using the results of the modelling exercise (see also Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment).
The resilience of the project to climate change (such as increased storminess) should be assessed in the Environmental Statement accompanying an application (section 4.8 of NPS EN-1).	The resilience of the causeway to climate change has been accounted for in its design (Volume 2, Chapter 2: Project Description).

Summary of NPS EN-1 policy on decision making (and mitigation)	How and where considered in this chapter
Biodiversity	
The Secretary of State should have regard to the Government's biodiversity strategy, which includes aims to ensure a halting, and if possible a reversal, of declines in Priority Habitats and Species, with wild species and habitats as part of healthy, functioning ecosystems; and the general acceptance of biodiversity's essential role in enhancing the quality of life, with its conservation becoming a natural consideration in all relevant public, private and non-governmental decisions and policies. The Secretary of State should also take account of the challenge of climate change (paragraphs 5.3.5, 5.3.6).	Relevant baseline data have been collated (Section 3) in order to determine the marine environment baseline and inform the mitigation strategies to help protect Priority Habitats and Species (e.g. saltmarsh habitats) and for the conservation of biodiversity. The role of habitats and species in the ecosystem has been considered in the assessment of their value, where applicable (Section 3). Reference is made to the potential effects of climate change on biodiversity in Section 3.2.
The development should aim to avoid significant harm to biodiversity, including through mitigation and consideration of reasonable alternatives (paragraph 5.3.7).	The design of the Thurrock Flexible Generation Plant has taken into account the need to protect biodiversity and prevent significant harm. Mitigation measures described in this chapter include measures to protect and minimise the potential for adverse effects on biodiversity (Section 2.9).
Appropriate weight should be given to designated sites, protected species, habitats and other species of principal biodiversity conservation value (paragraph 5.3.8).	The ecology and nature conservation values of sites, species and habitats identified within the study area, have been assessed and are explained in this chapter. The value of each feature has informed the assessment of effects (Section 4).
Many individual wildlife species receive statutory protection under a range of legislative provisions. Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations. The Secretary of State should refuse consent where harm to the habitats or species and their habitats would result, unless the benefits (including need) of the development outweigh that harm. In this context, the Secretary of State should give substantial weight to any such harm to the detriment of biodiversity features of national or regional importance which may result from a proposed development (paragraphs 5.3.16-5.3.17)	Records of consultation are presented in Table 1.3. A detailed baseline characterisation is presented in Section 3, with Section 4 presenting a robust impact assessment which considers the effects of the development on these environmental receptors, including marine ecology.

Summary of NPS EN-1 policy on decision making (and mitigation)	How and where considered in this chapter
Appropriate mitigation measures should be included as an integral part of the development. Where appropriate mitigation will be put in place the Secretary of State should consider what appropriate requirements should be attached to any consent and/or planning obligations (paragraphs 5.3.18-5.3.19). Mitigation measures agreed with Natural England and confirmation as to whether or not Natural England intends to grant or refuse any necessary licence applications will be taken into account during the processing of an application (paragraph 5.3.20).	Mitigation measures are outlined in Section 2.9, including reference to where these are secured within the DCO.

1.2.4 With respect to the marine environment, other relevant policies and plans are:

- the National Policy Statement for Ports (NPSfP) (Department for Transport, 2012);
- the UK Marine Policy Statement (MPS) (HM Government, 2011), which provides a framework for marine plans and decision making in the marine environment as required by Section 44 of the Marine and Coastal Consent Act 2009; and
- The Thames Estuary 2100 Plan (Environment Agency, 2012).

1.2.5 The NPSfP requires the generic impacts of any port development on biodiversity and geological conservation to be assessed. This includes both direct and indirect effects of infrastructure and operations along with capital and maintenance dredging in accordance with relevant legislation. In addition, effects of climate change, on-going coastal evolution and flood risk issues need consideration to ensure future sustainability.

1.2.6 The MPS sets out High Level Marine Objectives (HLMOs) to provide an appropriate, consistent approach to marine planning in UK waters to ensure sustainable use of marine resources and strategic management of all marine activities. The aim is to achieve clean, healthy, safe, productive and biologically diverse oceans and seas. The relevant marine planning area is the South East; the plan for this area is yet to be developed.

1.2.7 Section 2.6.7 of the MPS relates to climate change and indicates that an assessment of potential impacts of climate change should be undertaken when developing Marine Plans.

1.2.8 The Thames Estuary 2100 Plan (Environment Agency, 2012) sets out recommendations for flood risk management for London and the Thames Estuary through to the end of the century. The assessments underpinning the plan considered tidal flooding, high river flows as a result of rainfall and surface water flooding. In addition, the condition of existing flood walls, embankments and barriers was analysed, and a raising/replacing programme recommended.

1.3 Legislation

EU Marine Strategy Framework Directive (2008/56/EC)

1.3.1 Guidance provided within the Marine Strategy Framework Directive (MSFD), adopted in July 2008, has also been considered in this assessment. The overarching goal of the Directive is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment. To this end, Annex I of the Directive identifies 11 high level qualitative descriptors for determining GES. These include: biological diversity, non-indigenous species, elements of marine food webs, sea floor integrity, alteration of hydrographical conditions, contaminants and marine litter.

Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora

1.3.2 The Council Directive 92/43/EEC (the Habitats Directive) was adopted in 1992, providing a means for the European Union (EU) to meet its obligations under the Bern Convention. The aim of the Directive is to maintain or restore natural habitats and wild species listed on the Directives Annexes at a favourable conservation status.

1.3.3 This protection is granted through the designation of European Sites and European Protected Species. The Habitats Directive first transposed into UK law through the Conservation (Natural Habitats, &c.) Regulations 1994 and has been superseded in England and Wales by the Conservation of Habitats and Species Regulations 2017.

Wildlife and Countryside Act 1981 (as amended)

1.3.4 The Wildlife and Countryside Act (WCA) 1981 (as amended) consolidated and amended earlier national legislation and implemented the European Directive 2009/147/EC on the conservation of wild birds (The Birds Directive) in the UK. The act gives protection to native species which are under threat, controls the release of non-native species and enhances protection of SSSIs, including habitats within these (e.g. saltmarshes and mudflats) and the species on which they rely (e.g. bird species).

Conservation of Habitats and Species Regulations (2017)

1.3.5 The WCA 1981 is complemented by the Conservation of Habitats and Species Regulations 2017 (hereafter referred to as The Habitat Regulations). This is the most recent legislation to implement in law the European Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive) adopted in 1992.

1.3.6 The regulations require the potential effects on European Protected Habitats to be a key consideration in planning decisions. If it is likely that the designated features have the potential to be impacted, then an appropriate assessment is required under Article 6(3) of the Habitats Directive with consideration of mitigation options to avoid adverse effects. If uncertainty remains over a potentially significant effect, then alternative solutions need to be considered.

Port of London Act 1968 (as amended)

1.3.7 The Port of London Authority (PLA) is a harbour authority, licensing authority and landowner with the duty to administer, preserve and improve the port of London. The Port of London Act (1968) was established for the purpose of preserving and improving the conservancy of the river and estuary.

1.3.8 Section 66 of the Port of London Act describes the requirement for a River Works Licence for any works within the River Thames. This applies to all works below the mean high-water mark, inclusive of work which may be carried over under the river or involve overhanging the river.

1.3.9 Dredging activities on the Tidal Thames require a licence under Section 73 of the Port of London Act (1968, as amended). Dredging works are defined as including any operation to cleanse, scour, cut, deepen, widen, dredge or take up or remove material from the bed and banks of the Thames. Section 73 licence requirements ensures assessments are conducted on the potential effect works may have on navigation and the environment.

Marine and Coastal Access Act (MCAA) 2009

1.3.10 As well as replacing consents under the Food and Environment Protection Agency (FEPA) 1985 and the Coast Protection Act (CPA) 1949, the MCAA 2009 also introduced a new planning system for marine environmental management and a requirement to obtain Marine Licences for works at sea.

1.3.11 The MCAA inserted a new section (Section 149A) into the Planning Act 2008 which enables an applicant for a DCO to apply for 'deemed Marine Licences' as part of the DCO process. The MMO is the responsible authority in England and works with PINS to ensure that the deemed Marine Licences are transposed into the DCO. The MMO remains the monitoring and enforcement body in respect of the conditions and restrictions set out in the deemed Marine Licences.

1.3.12 The MCAA also enabled the designation of MCZs in the territorial waters adjacent to England and Wales and UK offshore waters. The purpose of these conservation measures is to halt the deterioration of the state of the UK's marine biodiversity and promote recovery where appropriate, support healthy ecosystem functioning and provide the legal mechanism to deliver our current European and international marine conservation commitments, such as those laid out under the Marine Strategy Framework Directive (MSFD), OSPAR Convention and Convention on Biological Diversity.

Other

1.3.13 A list of other relevant legislation and policies are presented below:

- The Convention on Biological Diversity 1992 (Biodiversity Convention or CBD);
- UK Biodiversity Action Plan;
- London Biodiversity Action Plan;
- Conservation of Seals Act 1970;
- OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic 1992;
- IUCN Red List of Threatened Species;
- The Natural Environment and Rural Communities Act (NERC Act) 2006;
- The Water Resources Act 1991; and
- Water Framework Directive (2000/60EC; see Volume 6, Appendix 17.3: Water Framework Directive Assessment).

1.4 Consultation

1.4.1 Key issues raised during scoping and other pre-application consultation specific to the marine environment are listed in Table 1.3, together with details of how these issues have been considered in the production of this chapter and cross-references to where this information may be found.

1.4.2 It should be noted that the Thurrock Flexible Generation Plant Scoping Report included an option for a cooling water intake and outfall into the Thames Estuary. This is no longer included in the DCO Application and therefore stakeholder comments in relation to the impacts of such infrastructure (e.g. entrainment and impingement of marine ecology receptors, discharge of biocides to the Thames Estuary etc.) have not been included in Table 1.3. However, those scoping responses in relation to construction operations within the Thames Estuary that are applicable to the now proposed marine works are summarised below.

Table 1.3: Key points raised during scoping and pre-application consultation.

Date	Consultee and type of response	Points raised	How and where addressed
September 2018	PINS Scoping Opinion	The Applicant considers that there is no potential for impacts to saltmarsh, however no specific justification is provided in this regard. The Inspectorate does not agree that sufficient information has been provided to scope this matter out. In particular, the Inspectorate notes the potential for construction and operation of the cooling water pipeline to result in changes to coastal processes and sedimentation patterns, which could impact on the saltmarsh habitats. The ES should describe the potential impacts to saltmarsh and any likely significant effects on this habitat should be assessed. This should include consideration of any cumulative effects, including with the consented new jetty 13, Tilbury2 and Tilbury Energy Centre.	A Phase 1 habitat survey was conducted to map the extent of saltmarsh habitats in the immediate vicinity of the causeway, and various other surveys have been reviewed to support the development of the baseline (Section 3). The impacts of the construction and operation of Thurrock Flexible Generation Plant are presented within Section 4, including impacts on saltmarsh habitats. Cumulative effects on marine environmental receptors are considered in Volume 4, Chapter 30. This considers the effect of Tilbury2, however the Tilbury Energy Centre is no longer being taken forward and has therefore been screened out of the cumulative impact assessment (see Volume 5, Chapter 18: Cumulative Effects Assessment Introduction and Screening).
September 2018	PINS Scoping Opinion	The Scoping Report explains that the existing jetty or consented new jetty for the Goshems Farm land raising operation will be used, if construction materials are to be delivered by barge. No dredging of the seabed or refurbishment of the jetty would be required. The Applicant considers that the 'limited and temporary intensification of jetty use' (relative to the existing use) would not result in any significant effects on the aquatic environment. The Inspectorate considers that additional justification should be provided to support this statement, particularly in terms of the anticipated number and frequency of deliveries and the cumulative impact with other proposed developments. In addition to aquatic receptors, the Inspectorate considers that there may be impacts from use of the jetty in terms of increased disturbance to birds (as referenced in Table 4.6, ID 4.6.1 [i.e. of the PINS Scoping Opinion]). The Inspectorate does not agree to scope out this matter out of the ES.	The effects of construction and operation of a causeway on marine environmental receptors have been assessed in Section 4. Effects of the causeway during construction and operation on intertidal ornithology receptors are assessed in Volume 2, Chapter 9: Onshore Ecology. The Goshems Farm jetty will not be used during construction, with the causeway to be used for abnormal indivisible loads (see Volume 2, Chapter 2: Project Description).
September 2018	PINS Scoping Opinion	Table 8.6 of the Scoping Report summarises the proposed approach to aquatic surveys that will inform the assessment. Details including sampling locations, equipment, methodology and the level of sample replication should be provided in the ES. Table 8.6 shows that several surveys are not programmed in until Winter 2018; Spring/ Summer 2019. The Applicant should ensure that the ES is informed by relevant and up to date survey information; the Applicant should also make effort to agree the sufficiency of surveys with relevant consultation bodies.	Surveys have been conducted following consultation with relevant consultation bodies, including a Phase 1 habitat assessment and a Phase 2 sediment sample survey (see Section 3).
September 2018	PINS Scoping Opinion	The potential impacts from underwater noise to sensitive aquatic receptors should be assessed using species-specific methodologies, supported by recent scientific literature. For example, Popper *et al* (2014) in relation to fish and National Marine Fisheries Service (NMFS) (2016) in relation to marine mammals. Any measures to mitigate impacts from underwater noise should be described in the ES.	The impacts of underwater noise on marine ecology receptors has been assessed within paragraph 4.1.73 *et seq.*
September 2018	PINS Scoping Opinion	The assessment of potential impacts from the operational water-cooling pipeline should include impacts resulting from scour (and any associated habitat loss), as well as from access and maintenance of the pipeline. The likely timings of maintenance works should be explained, with a focus on avoidance of sensitive periods for birds. Any proposals for mitigating and/ or monitoring the impacts from the cooling water system should be described in the ES.	While a cooling water pipeline is not included in the Project Description, Section 4 provides an assessment of the effect of construction and operation of the causeway on local estuarine processes, including scour effects. Effects of the causeway during construction and operation on intertidal ornithology receptors are assessed in Volume 2, Chapter 9: Onshore Ecology.

Date	Consultee and type of response	Points raised	How and where addressed
September 2018	PINS Scoping Opinion	Paragraph 8.110 of the Scoping Report explains that construction of the cooling water pipeline may result in disturbance/ suspension of sediments. The Inspectorate advises that these impacts should also be considered in relation to operation of the water-cooling pipeline. The ES should explain how much sediment could be re-suspended, over what timeframe, and whether contaminants are likely to be present. The Applicant should discuss and agree the assessment approach (including the need for chemical analysis) with relevant consultation bodies including the Environment Agency. Any other impacts to coastal processes should be described in the ES and assessed where significant effects are likely.	The effect of disturbance to sediments during construction on water quality and marine ecology receptors have been assessed in Section 4.1. The presence of sediment bound contaminants within the footprint of the proposed marine infrastructure have been fully characterised, as detailed in Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review.
September 2018	PINS Scoping Opinion	Paragraph 8.136 of the Scoping Report explains that construction noise from piling has the potential to adversely affect wildlife and bird species, but it is not clear whether any of the proposed structures in the marine environment would require piling. If piling is required within the marine area, the Applicant should model the predicted noise levels and assess any likely significant effects to aquatic receptors.	The impacts of underwater noise have been assessed for the marine environment and the various receptors identified in the marine environment in paragraph 4.1.73 *et seq*. There will be no piling activities associated with construction of the causeway.
September 2018	PINS Scoping Opinion	If the cooling water pipeline option is pursued, the Inspectorate assumes that construction and maintenance dredging may be required. The assessment in the ES should take into account the areas to be dredged and the dredging techniques to be employed; the anticipated quantity of material to be removed and the maximum dredging depth; the frequency of maintenance dredging; and the final disposal location of dredged material. The ES should assess the impacts associated with any dredging of the River Thames, taking into account its status as a Water Framework Directive (WFD) water body (see also the Inspectorate's comments regarding the WFD in Table 4.9, ID 4.9.7 of this Opinion). Any cumulative impacts from dredging (e.g. with Tilbury2 and Tilbury Energy Centre) which are likely to result in significant effects should also be assessed.	The impacts of dredging have been assessed for the marine environment and the various receptors identified in the marine environment in Section 4.1 and cumulative effects with other projects have been assessed in Volume 4, Chapter 30. A WFD Assessment has been presented in Volume 6, Appendix 17.3: Water Framework Directive Assessment of the Environmental Statement.
September 2018	PINS Scoping Opinion	The Inspectorate is aware that the consultation for the MCZ has now closed and this affects its status. The ES should appropriately assess impacts to the MCZ.	This chapter has considered the potential impacts which may occur to MCZs and rMCZs within the vicinity of the area, as discussed in Section 3.1.
September 2018	PINS Scoping Opinion	The Applicant should identify other developments with the potential to impact on the marine environment in the Thames Estuary and assess the potential for cumulative impacts together with the proposed development.	The effect of the development cumulatively with other projects in the Thames Estuary has been considered in Volume 4, Chapter 30.
September 2018	Environment Agency – Scoping Opinion	Saltmarsh can only be scoped out on the understanding that no saltmarsh (including upper saltmarsh species) are present in the River Thames corridor. Rather than scoping out a particular habitat type, the assessment should just state that it will scope in all habitats within the zone of influence of the development.	Effects on saltmarsh from the construction and operation of the causeway are assessed in Section 4.
September 2018	Gravesham Borough Council – Scoping Opinion	It is suggested that consideration be given as to whether the NSIP proposals for the London Resort at Swanscombe Peninsula could result in cumulative impacts that need to be taken into consideration; particularly if water cooling is used or water transport is used during the construction phase, given the proposed MCZs detailed in the Scoping Report.	Effects on MCZs are considered in Section 3.1. The effect of the development cumulatively with other projects in the Thames Estuary has been considered in Volume 4, Chapter 30.
September 2018	Natural England – Scoping Opinion	The summary statement in Table 8.7 of the Scoping Report is not sufficiently detailed to allow Natural England to agree that the impacts to saltmarsh habitat may be scoped out. There is potential that works to install a water cooling pipe would release sediments which could smother saltmarsh habitats, and therefore saltmarsh should be scoped in.	Effects on saltmarsh from the construction and operation of the proposed causeway are assessed in Section 4.

Date	Consultee and type of response	Points raised	How and where addressed
September 2018	Essex County Council – Scoping Opinion	It is recommended that the HRA screening needs to identify which Impact Risk Zones (IRZs) the site falls within for Natura 2000 sites identified by Natural England on the MAGIC website for this type of development which may or may not be 10 km. An assessment should also be made of SSSIs, local wildlife sites (LWS) (within 2 km) and recommended rMCZs.	The latest rMCZ site boundary revisions have resulted in the Thames Estuary rMCZ being split into smaller components and reduced in extent, with the result that there are now no rMCZs within 2 km of the Thurrock Flexible Generation Plant (see Section 3). The potential impacts on marine ecology receptors, including fish features of the (r)MCZs, are considered in Section 4.
August 2019	Environment Agency - Meeting	Meeting to discuss potential ecological enhancement opportunities associated with marine works.	
August 2019	PLA and MMO – email correspondence	Consultation on intertidal sampling plan. PLA responded clarifying determinants required for laboratory analysis.	Intertidal survey was undertaken according to the agreed methods with PLA, including testing of agreed determinants (see Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review).
August 2019	MMO – Meeting	Update on marine elements of the project, including construction and use of causeway and dredging activities.	N//A
October 2019	Environment Agency – Response to consultation on project changes	Water Framework Directive compliance assessment will need to be produced for marine works including dredging and construction works.	A WFD Assessment has been presented in Volume 6, Appendix 17.3: Water Framework Directive Assessment of the Environmental Statement.
		Comments on the choice of dredge method and considerations for water quality.	Effects of dredging on marine environmental receptors, including water quality, have been considered in Section 4.
		Requirement to undertake site specific sediment chemistry sampling to inform licensing process.	Site specific sediment chemistry sampling was undertaken as part of the intertidal survey, following the agreed methods with PLA, including testing of agreed determinants (see Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review).
		Disposal methodology – comments in relation to licensing requirements for disposal, depending on whether this will be on land, or at sea (and therefore require a marine licence).	It is intended that sediment dredged during construction of the causeway will be used on site as part of the Saltmarsh Enhancement and Maintenance Plan (application document A8.10) to increase mudflat levels which will encourage colonisation by saltmarsh communities.
October 2019	Kent and Essex Inshore Fisheries and Conservation Authority– Response to consultation on project changes	Comments relating to the construction of the intertidal causeway and effects on the existing environment and particularly soft sediments of the Thames shoreline.	The impacts of construction and operation of the Thurrock Flexible Generation Plant causeway on marine receptors are presented within Section 4, including impacts on soft sediment habitats.
		Comments on decommissioning of the causeway following use during the construction phase.	As set out in Volume 2, Chapter 2: Project Description it is assumed that the causeway would be left *in situ* and not removed after the projected 35 year life-time of the proposed development. As such, decommissioning impacts are scoped out of the assessment (see Section 2.8).
November 2019	Marine Management Organisation – Response to consultation on project changes	Recommended that further detail should be provided (in the ES) including design details (including structure dimensions, exact location, piled or solid foundation); dredging details (including coordinates, expected side slope angles, depth of dredging, maintenance dredging); construction methodology; preparation for barge grounding including dredging methods and operations; size of barges and description of berthing operations	See Volume 2, Chapter 2: Project Description

Date	Consultee and type of response	Points raised	How and where addressed
		Impact assessment should include scour and/or accretion potential as well as morphological effects due to dredging activities and vessel movements Generation of sediment plumes and sedimentation Loss of habitat	Scour/accretion effects, sediment plumes and sedimentation set out in Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment, sections 4 & 5. Effect on habitats in described in Appendix 17.1 Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review and section 4 of this chapter
		Cumulative and inter-related impacts in respect of hydrodynamics and geomorphology as a result of dredging, construction and operation activities	See Volume 4, Chapter 30: CEA Marine Environment and Section 4.4 & 4.6 of this chapter.
		Provide a full description of expected sour, accretion and morphological effects	See Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment
		Subsequent effects of erosion and accretion should be appropriately assessed through prediction on impacts of hydrodynamics	See Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment
		Further details of dredge operations, including of sediment sample analysis, the results of which are required on an MMO results template.	See Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review
		Further information of dredge methodology (location, depth, volume); type of material (sample analysis/capital or maintenance); dredge history of the area; disposal methodology/site assessment; KLM file or Shapefile.	See Volume 2, Chapter 2: Project Description
		Effect on saltmarsh habitat	See application document A8.10: Saltmarsh Enhancement and Maintenance Plan
		Need for up to date bathymetric and intertidal topographic information. Discussion of implications of uncertainties relating to (lack of) geotechnical information on underlying sediments.	See Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment
November 2019	Environment Agency – meeting and follow up.	Review of draft Chapter 17: Marine Environment and Appendices 17.1 and 17.2. Minor comments on hydraulic modelling (Appendix 17.2) addressed in follow up correspondence.	N/A. Addressed via correspondence following meeting.

2. Assessment Approach

2.1 Guidance / standards

2.1.1 The assessment has followed the standard source-pathway-receptor approach, with the assessments and determination of significance presented within this chapter undertaken in accordance with the methodology set out in Volume 2, Chapter 4: Environmental Impact Assessment Methodology. These follow best practice guidelines for EIA, with consideration of the Design Manual for Roads and Bridges (DMRB), particularly with reference to definitions of magnitude and sensitivity (see Section 2.6 for further detail). The assessment methodology used within this marine environmental impact assessment has been developed from a range of sources including statutory guidance, RPS and ABPmer's EIA project experience and consultation undertaken as part of these projects, and uses current best practice including guidance from the Government, Government Agencies, Institute of Environmental Management and Assessment (IEMA) and Chartered Institute of Ecology and Environmental Management (CIEEM). With respect to marine ecological receptors, the impact assessment has had specific consideration to the CIEEM Guidelines for Ecological Impact Assessment (EcIA; 2018).

2.2 Assessment methodology (estuary processes)

2.2.1 The method of assessment has incorporated a desk-based study compiling data and information from public domain sources to provide a baseline description of the study area. Expert geomorphological analysis has been used to develop an understanding of the physical processes at work.

Numerical modelling study

2.2.2 To provide a quantification of the likely changes resulting from the causeway and its operation, hydrodynamic modelling has been completed using the Danish Hydraulic Institute (DHI) software package MIKE21FM (Flexible Mesh). The model allows assessment of temporal and spatial variations in water levels and depth-averaged currents. The model has been used to quantify the extent of hydrodynamic changes as a result of the following scenarios:

- The causeway;
- The causeway plus Roll on Roll off (RoRo) vessel; and
- Cumulative scenario incorporating Tilbury2.

2.2.3 As part of the numerical modelling, several sediment scenarios were assessed and are reported in Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment. Using bed shear stress analysis and conceptual understanding of the baseline environment, the hydrodynamic model results have been used to determine the potential for changes in sediment mobilisation as a result of the causeway. The potential for erosion and deposition around the causeway has been assessed using measured suspended sediment data from Tilbury2 in combination with modelled results of flow speed and associated bed shear stresses. The assessment of the potential extent of the dredge plume has been undertaken using the sediment plume modelling completed for Tilbury2 as an analogue.

2.2.4 Details of the study including model build, calibration, sediment analysis and results are presented as Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment.

2.2.5 Using expert geomorphological analysis, the modelling results have been interpreted to determine the scale of effects from the causeway during construction and operation.

2.3 Baseline studies

2.3.1 To support the development of this assessment, data from both desktop study and site-specific survey have been collated. Data collected from this desktop study and site-specific survey have been used to establish a robust and up-to-date characterisation of the baseline environment for the study area.

Desktop study

2.3.2 Information on the marine environment (i.e. estuary processes, water quality and marine ecology receptors) within the study area were collected through a detailed desktop review of existing studies and datasets (see Table 2.1 for key data sources). Due to the close proximity of the proposed development to the existing Tilbury2 project and the formerly proposed Tilbury Energy Centre, data and reports from these two developments have been reviewed and used, as relevant, to support the development of the baseline section.

2.3.3 Further, a review of existing statutory sites of nature conservation interest, such as SSSIs, SPAs, Special SACs, MCZs and National Nature Reserves (NNRs), and non-statutory sites, such as Sites of Nature Conservation Interest (SNCIs) was conducted to identify areas of nature conservation interest within the vicinity of the proposed development.

2.3.4 To allow for the identification of these designated sites and protected species, a search area of 5 km was used from the Thurrock Flexible Generation Plant causeway in the intertidal, although for more mobile marine ecology receptors (e.g. migratory fish species), designated sites further upstream were also considered within the marine ecology study area (see Section 2.4).

Table 2.1: Summary of key desktop reports.

Title	Year	Reference
Tilbury2 Proposed Port Terminal Environmental Statement	2017	Port of Tilbury (2017) Tilbury2 Environment Statement. Volume 6 Part A. TR030003. Document Ref: 6.1.
		HR Wallingford (2017) Appendix 16.D: Hydrodynamic Sediment Modelling. Port of Tilbury London Limited. Tr030003. Volume 6 Part B. Document REF: 6.2 16.D
Port of London Authority: Dredge Protocol and Water Framework Directive Compliance Baseline Document	2014	PLA (2014) Maintenance Dredge Protocol and Water Framework Directive Compliance Baseline Document
Thames Tideway (FLO JV) – Jetty Design Licence Application Report	2017	Atkins (2017) Thames Tideway – Jetty Design Licence Application Report, MMO marine consent applications
Environment Agency LiDAR data		Environment Agency LiDAR
PLA Bathymetric Survey	2016	PLA (2016) Bathymetric Survey
Tilbury Energy Centre Subtidal and Intertidal Fish Survey Report	2018	APEM (2018) Tilbury Energy Centre Subtidal and Intertidal Fish Survey Report. Preliminary Environmental Information Report: Appendix 10.7. APEM Scientific Report P00001435 WP4-5 prepared for RWE Generation UK. See Appendix 17.4: Third Party Survey Reports.
Tilbury Energy Centre Saltmarsh Survey Report	2019	APEM (2019) Tilbury Energy Centre Saltmarsh Survey Report. Preliminary Environmental Information Report: Appendix 10.6. APEM Scientific Report P00001435 WP6 prepared for RWE Generation UK. See Appendix 17.4: Third Party Survey Reports.
Tilbury Biomass Power Station Fisheries data	2012	Jacobs (2012) Tilbury Biomass Phase 2 Technical Appendix. Fisheries Baseline Data
Cefas fish spawning and nursery habitats in UK waters	2012	Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012) Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56pp
Thames Marine Mammal Sighting Survey	2019	Zoological Society of London (2019) Thames Marine Mammal Sighting Survey. [Online] Available at: https://www.zsl.org/conservation/regions/uk-europe/thames-marine-mammal-conservation [Accessed 29 August 2019].
Thames Marine Mammal Sightings Survey Ten Year Report	2015	Tickell, S. and Barker, J. (2015) Thames Marine Mammal Sightings Survey Ten Year Report (2004-2014), UK & Europe Conservation Programme Zoological Society of London.

Site specific surveys

2.3.5 To gain a full understanding of the intertidal physical, chemical and ecological baseline within the immediate vicinity of the site a site-specific intertidal survey was undertaken (Table 2.2). A Phase 1 intertidal survey was conducted in August 2019 at the proposed causeway location (see Figure 2.2). Observations were recorded on the shore type, wave exposure, sediments/substrates present and descriptions of species/biotopes present. The spatial relationships between these features were recorded via GPS, supporting the development of a habitat map.

2.3.6 Phase 2 sediment core sampling was also undertaken to characterise the sediment type and contaminant loads in vicinity of the proposed causeway. All sampling methods and determinants were agreed with PLA prior to undertaking the survey (see Table 1.3). Three sediment cores were collected and analysed in the vicinity of the proposed causeway, i.e. within a 100 m corridor centred on two potential alignments of the causeway footprint. The results of the particle size analysis (PSA) have been used to define bed shear stress and hence potential changes in patterns of erosion and deposition.

2.3.7 A summary of the findings of this survey, along with consideration of the survey results in the context of historic datasets from the area, is presented in Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review and summarised in Section 3.

Table 2.2: Summary of site-specific surveys undertaken.

Title	Extent of survey	Overview of survey	Survey provider	Year	Reference to further information
Site specific surveys within the study area					
Phase 1 and Phase 2 Intertidal Survey Report and Benthic Ecology Desktop Review	Thurrock Flexible Generation Plant causeway location and vessel grounding pocket	Phase 1 intertidal walkover and Phase 2 sediment sample analysis. The report also includes consideration of the site specific survey data in the context of historic datasets from the area.	RPS Energy Ltd	2019	Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review

2.4 Study area

Estuarine processes

2.4.1 The study area for the estuarine processes' assessment is illustrated in Figure 2.1. It is located within the Thames Estuary and approximately extends between Grays and Mucking Flats, from west to east respectively. This stretch of the Thames Estuary in which the causeway for the Thurrock Flexible Generation Plant would be situated is locally referred to as Gravesend Reach and this name is used in this study.

2.4.2 The study area extents are required to capture the process effects associated with the meander bends at Tilbury Docks to the west and East Tilbury Marshes to the east. This allows any variations of tidal flows and the influence on the sediment transport to be accounted for in the assessment process. The landward boundary is highest astronomical tide (HAT) at the coastal defence.

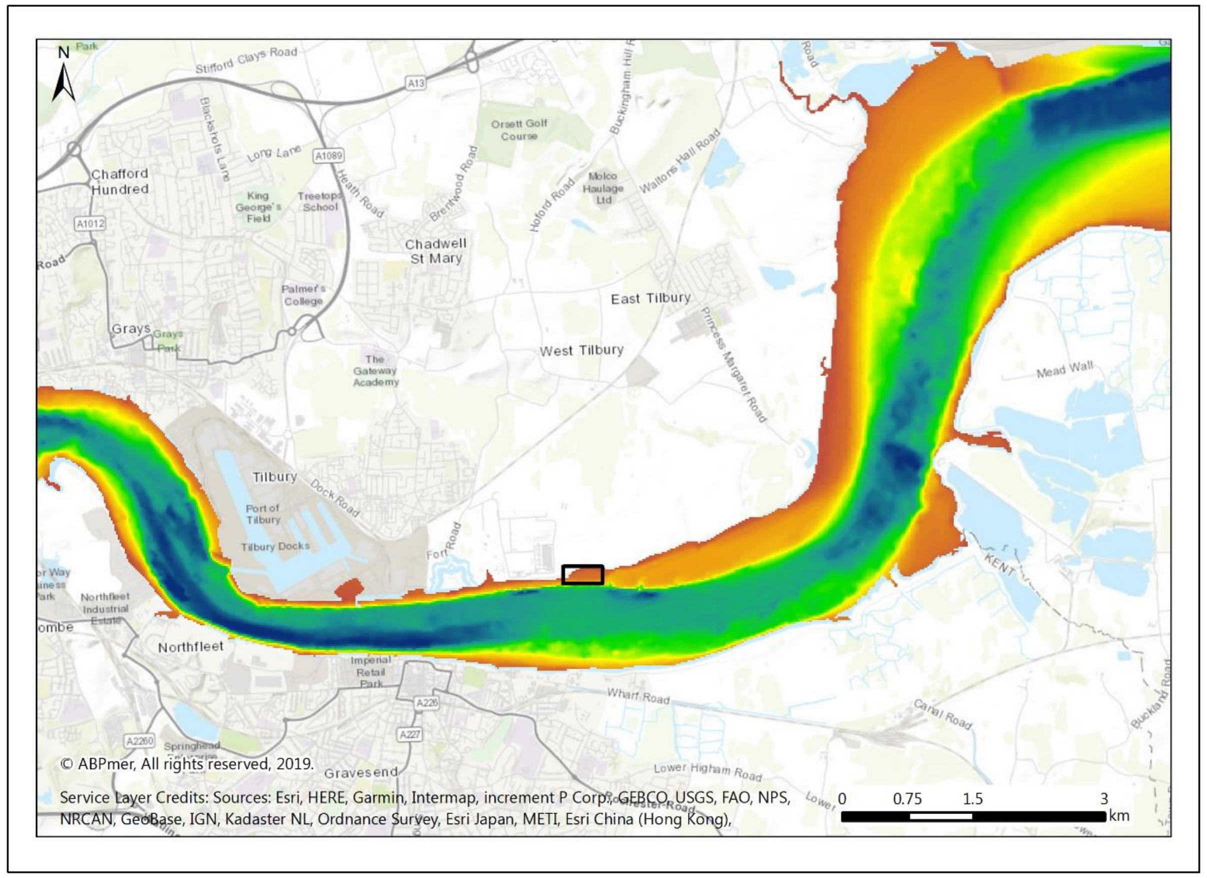

Figure 2.1: Study area applied in assessing the estuarine processes.

2.4.3 The study area, Gravesend Reach, is appropriate because the causeway is unlikely to have significant hydrodynamic (and hence geomorphological) effect other than very local to the structure. This is based upon a review of local estuary conditions and the structure's position in the tidal frame, on the intertidal mudflat. Furthermore, the hydrodynamic and sediment modelling in support of the adjacent, much larger, Tilbury2 development concluded that the extension of its jetty infrastructure, dredging of a new RoRo berth and its approaches on the tidal regime are:

"expected to be localised to the close vicinity of the dredge pocket and the pontoon. Generally, speeds are anticipated to decrease by 0.2 m/s as a result of the increased depths at the dredged pocket, apart from in the vicinity of the pontoon where speeds are likely to increase by between 0.1 - 0.2 m/s. Although this represents an approximate 50% local change in rates, the overall difference to the wider system is negligible." (Port of Tilbury, 2017)

2.4.4 The study area is therefore considered appropriate to fully capture any potential physical changes arising from the development.

Marine ecology

2.4.5 For marine ecological receptors and water quality, a slightly larger study area has been considered, extending from the immediate project footprint associated with the causeway and incorporating the Thames Middle WFD transitional waterbody (see Figure 2.2). Although the majority of impacts will be limited to the immediate vicinity of the marine elements of the project, this wider study area considers the potential effects of the project on mobile receptors, including fish species with spawning/nursery habitats further upstream in the Thames Estuary and also assesses the areas of habitat affected in the context of an ecologically relevant baseline.

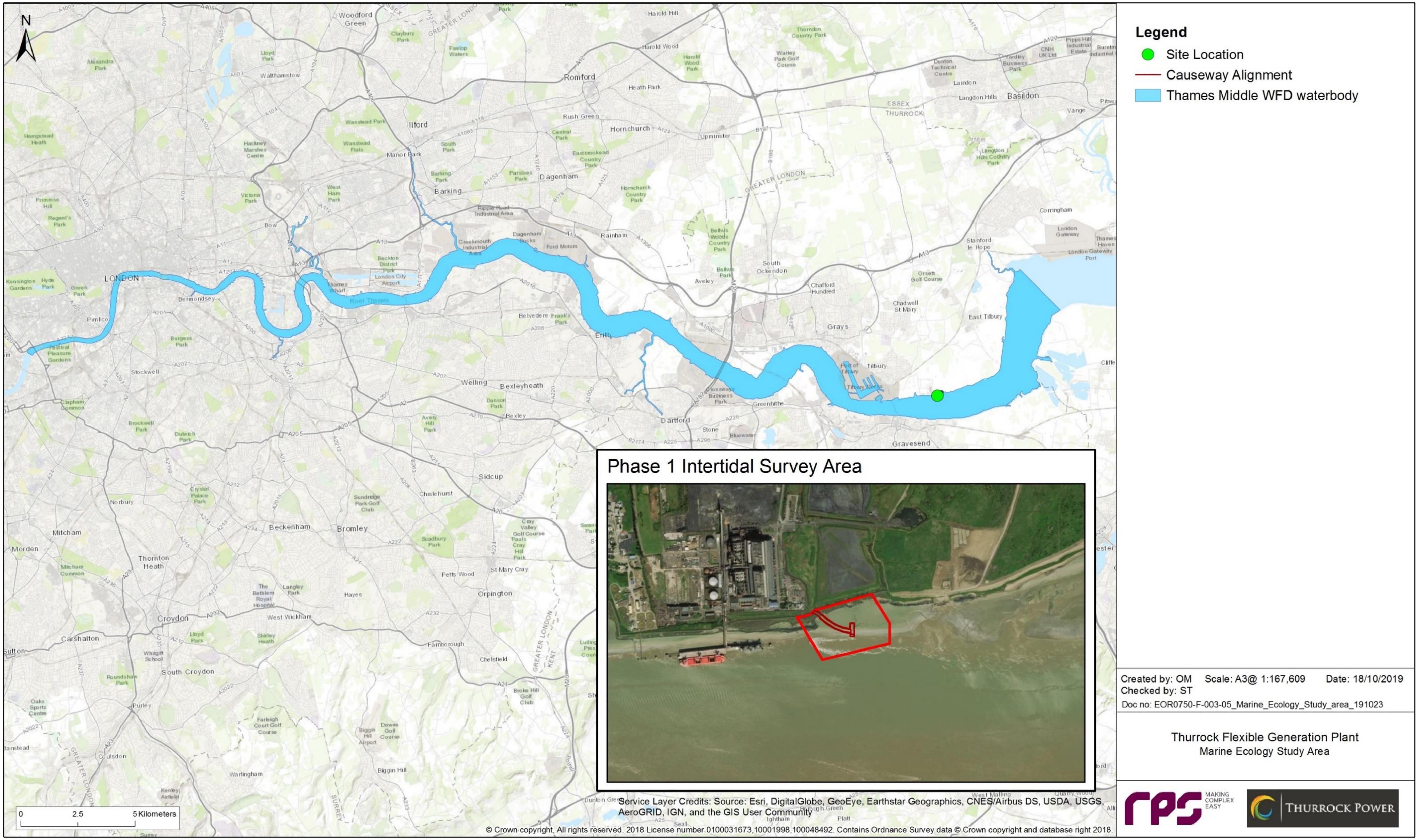

Figure 2.2: Marine ecology and water quality study area (including Phase 1 intertidal survey area).

2.5 Uncertainties and/or data limitations

2.5.1 No specific surveys of the local hydrodynamics have been undertaken to determine the baseline flow regime and provide calibration data for the modelling. The hydrodynamic model built for this assessment has therefore been validated against predicted data along the Thames, historical flow measurements and previous modelling data used for the Environmental Statement for the Tilbury2 Development (HR Wallingford, 2017).

2.5.2 The model (used in this assessment) is based uses the 2016 bathymetry data (UKHO, 2017) whilst the Tilbury2 modelling uses the 'Thames Base' model which had a bathymetric update in 2009 (HR Wallingford, 2017). The different bathymetries are likely to result in some differences in representation of the estuary bed, but these are not considered to be significant.

2.5.3 The models were calibrated mainly for the subtidal flows, therefore flow speeds and directions over the mudflats (i.e. in the vicinity of the proposed causeway) may not be as accurately replicated. The modelling, however, provides comparative quantification, although absolute values may not be the same. These limitations are accounted for within the expert interpretation of the modelling results.

2.5.4 All sedimentary effects are based on the difference in the flow regime and bed shear stresses, relative to derived thresholds for accretion and erosion, based on the bed material characteristics, which have been sampled and analysed. The sedimentary effects are therefore established through informed geomorphological interpretation rather than direct modelling.

2.5.5 The proposed Thurrock Flexible Generation Plant, located in the Thames, is within the vicinity of various large development projects with marine components (e.g. Tilbury Energy Centre and Tilbury2), for which there have been various baseline marine ecological surveys conducted within recent years. Within context of these existing studies, the site specific baseline ecological surveys conducted to support this assessment are therefore considered appropriate to inform a robust impact assessment of the Thurrock Flexible Generation Plant.

2.6 Impact assessment criteria

Estuarine processes

2.6.1 The estuary flow regime may be altered by the presence of the causeway and the presence of the RoRo vessels. However, this change should be considered a 'pathway' rather than a receptor as it is the mechanism that controls local and regional patterns of sediment transport, erosion and deposition. These in turn may directly influence short- and long-term net morphological change on the intertidal and subtidal environment. Hence it is the physical characteristics of the intertidal and subtidal environments that are defined as the receptors in the physical process domain.

2.6.2 Similarly, maritime infrastructure (discussed further in paragraph 3.1.10) is also included as a receptor. These are the jetties and estuary infrastructure to which the potential significant modification of the hydrodynamics and sediment processes occurring around them that could indirectly affect their operability (for example, scour and maintenance dredge requirements).

2.6.3 The assessments of effects on marine ecology receptors and water quality are informed by these results (assessment methodology for these is presented in paragraph 2.6.8 *et seq*. below).

2.6.4 Whether a receiving environment is exposed to an impact or change depends on there being a route or pathway. The magnitude of the impact and its ability to affect a receptor also depends on a range of other factors, primarily:

- Scale of change – the scale of change above and beyond the baseline conditions and natural variability;
- Spatial extent - the spatial extent of any change; and
- Frequency and duration - The ability for a change to be repeated along with the length of time a change can be considered to operate over. This is described as being either a short or long-term period. 'Short-term' changes are more likely to occur as a result of activities during the construction phase (which are temporary in nature), whilst 'long-term' is more likely to be relevant to the operational period.

2.6.5 An impact can only occur if the receptor is exposed to a change to which it is sensitive, and the definitions of magnitude and sensitivity are provided in Table 2.6 and Table 2.7 respectively.

2.6.6 The significance of the effect upon marine receptors is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 2.5. Where a range of significance of effect is presented in Table 2.5, the final assessment for each effect is based upon expert judgement.

2.6.7 For the purpose of this assessment, any effects with a significance level of minor or less are considered to be **not significant** in EIA terms.

Table 2.3: Criteria for magnitude of impact (estuarine processes and marine infrastructure).

Magnitude of impact	Definition used in this chapter
Major	Continuous (positive or negative) change, over the whole development area and beyond (i.e. offsite extending into the far-field), of a scale that will change key characteristics or features of the particular environmental aspect's character or distinctiveness.
Moderate	Noticeable (positive or negative), temporary (during the project duration) or infrequent change, over the far-field, of a scale that will partially change key characteristics or features of the particular environmental aspect's character or distinctiveness; or continuous change to the near-field environment of a scale that will change key characteristics
Minor	Noticeable (positive or negative), temporary (for part of the project duration) change, or barely discernible change for any length of time, over a small area, to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Negligible	Positive and negative changes which are not discernible from background conditions.
No change	No detectable change.

Table 2.4: Criteria for receptor sensitivity (estuarine processes and marine infrastructure).

Sensitivity	Definition used in this chapter
Very High	Very high importance and rarity, international scale and very limited potential for substitution. No capacity to accommodate the change.
High	High importance and rarity, national scale and limited potential for substitution. Low capacity to accommodate the change.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution. Moderate capacity to accommodate the change.
Low	Low or medium importance and rarity, local scale. Moderate to High capacity to accommodate the change.
Negligible	Very low importance and rarity, local scale. High capacity to accommodate change.

Table 2.5: Matrix used for the assessment of the significance of an effect.

		Magnitude of impact				
		No change	***Negligible***	***Minor***	***Moderate***	***Major***
Sensitivity of receptor	***Negligible***	No change	Negligible	Negligible or minor	Negligible or minor	Minor
	Low	No change	Negligible or minor	Negligible or minor	Minor	Minor or moderate
	Medium	No change	Negligible or minor	Minor	Moderate	Moderate or major
	High	No change	Minor	Minor or moderate	Moderate or major	Major or substantial
	Very high	No change	Minor	Moderate or major	Major or substantial	Substantial

Marine ecology and water quality

2.6.8 As outlined above, the significance of an effect is determined based on the magnitude of an impact and the sensitivity of the receptor affected by the impact of that magnitude. This section describes the criteria applied for marine ecological receptors and water quality in this chapter to characterise the magnitude of potential impacts and sensitivity of these receptors. The terms used to define magnitude and sensitivity are based on those used in the DMRB methodology, which is described in further detail in Volume 2, Chapter 4: Environmental Impact Assessment Methodology and is consistent with those used for terrestrial ecology receptors (see Volume 2, Chapter 9: Onshore Ecology).

2.6.9 Potential impacts of the Thurrock Flexible Generation Plant have been assessed through considering how each Important Ecological Feature (IEF) would be affected by the temporary and permanent elements of the projects design. In the impact assessment, the following have been taken into account:

- Type of impact - positive or negative;
- Extent or spatial scope of the impact;
- Reversibility of impact - whether the impact is naturally reversible or reversible through mitigation measures;
- Timing and frequency of the impact, in relation to ecological changes; and
- Likely duration of the impact - short-term (< 1 year), medium-term (< 5 years) or long-term (5 or more years).

2.6.10 The criteria for defining magnitude in this chapter are outlined in Table 2.6. In this table, 'integrity' for sites is defined as the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it is classified.

Table 2.6: Criteria for magnitude of impact (marine ecology and water quality).

Magnitude of impact	Definition used in this chapter
Major	The impact is likely to have an adverse effect on the integrity of a site IEF or the conservation status of a species or species assemblage IEF (adverse).
	The impact is likely to cause a large scale or major improvement, extensive restoration or enhancement, or a major improvement of the conservation status of an IEF (beneficial).
Moderate	The impact adversely affects an IEF but is unlikely to adversely affect its integrity or conservation status (adverse).
	The impact is likely to be of benefit to an IEF or improve its conservation status (beneficial).
Minor	The impact adversely affects an IEF but would not adversely affect its integrity or conservation status (adverse).
	The impact is likely to be of minor benefit to an IEF (beneficial).
Negligible	There would be minimal effect on the IEF (adverse).
	There would be minimal benefit to the IEF (beneficial).
No change	There would be no detectable change from the baseline condition of the IEF.

2.6.11 The criteria for defining sensitivity of marine ecological receptors are outlined in Table 2.7. Sensitivity takes into account the value of an IEF as well as vulnerability and recoverability. Therefore, while value is usually the primary consideration when determining sensitivity, professional judgment, alongside empirical evidence, is also used to determine how sensitive an IEF may be to impacts when these other factors are considered.

2.6.12 Information on the sensitivities of marine ecological receptors (particularly benthic habitats) to specific activities/impacts associated with construction and operation and maintenance of the causeway for the Thurrock Flexible Generation Plan is also drawn from the Marine Evidence based Sensitivity Assessment (MarESA; Tyler-Walters *et al*., 2018). The MarESA is a database which has been developed through the Marine Life Information Network (MarLIN) of Britain and Ireland and is maintained by the Marine Biological Association (MBA), supported by statutory organisations in the UK (e.g. Joint Nature Conservation Committee (JNCC) and Natural England). This database comprises a detailed review of available evidence on the effects of pressures on marine species or habitats, and a subsequent scoring of sensitivity against a standard list of pressures, and their benchmark levels of effect. The evidence base presented in the MarESA is peer reviewed and represents the largest review undertaken to date on the effects of human activities and natural events on marine species and habitats. It is considered to be one of the best available sources of evidence relating to recovery of seabed species and habitats.

2.6.13 The sensitivity of the benthic ecology habitats has been defined as the likelihood of change when a pressure is applied to a feature and is a function of the ability of the feature to tolerate or resist change (resistance) and its ability to recover following any change (resilience). Resistance characteristics indicate whether a receptor can absorb disturbance or stress without changing character. Resilience or recoverability is the ability of a habitat to return to the state of the habitat that existed before the activity or event which caused change. Full recovery does not necessarily mean that every component species has returned to its prior condition, abundance or extent, but that the relevant functional components are present, and the habitat is structurally and functionally recognisable as the initial habitat of interest.

2.6.14 Sensitivities of identified marine ecological receptors to the key activities across the project lifetimes (i.e. construction and operation and maintenance phases) are summarised according to the MarESA, where such information exists. Where sensitivity information on receptors were not available through the MarESA, suitable proxies have been used alongside other sources of empirical evidence. This includes fish and marine mammal receptors, where information on sensitivity is not usually provided by the MarESA and therefore other published data sources have been used.

Table 2.7: Criteria for receptor sensitivity (marine ecology and water quality).

Sensitivity	Definition used in this chapter
Very High	Habitats or species that form part of the cited interest within an internationally protected site, such as those designated under the Habitats Directive (e.g. SACs) or other international convention (e.g. Ramsar site). A feature (e.g. habitat or population) which is either unique or sufficiently unusual to be considered as being one of the highest quality examples in an international/national context, such that the site is likely to be designated as a site of European importance (e.g. SAC).

Sensitivity	Definition used in this chapter
High	Habitats or species that form part of the cited interest within a nationally designated site, such as an SSSI or a (r)MCZ. A feature (e.g. habitat or population) which is either unique or sufficiently unusual to be considered as being one of the highest quality examples in a national context for which the site could potentially be designated as a SSSI or (r)MCZ. Presence of UK Biodiversity Action Plan (BAP) habitats or species, where the action plan states that all areas of representative habitat or individuals of the species should be protected.
Medium	A feature (e.g. habitat or population), which is either unique or sufficiently unusual to be considered as being of nature conservation value from a regional level. Habitats or species that form part of the cited interest of an Local Nature Reserve (LNR), or some local level designated sites, such as a LWS, also referred to as a non-statutory SINC or the equivalent, e.g. Ancient Woodland designation. Presence of Local BAP habitats or species, where the local action plan states that all areas of representative habitat or individuals of the species should be protected.
Low	A feature (e.g. habitat or population) that is of nature conservation value in a local context only, with insufficient value to merit a formal nature conservation designation.
Negligible	Common place feature of little or no significance. Loss of such a feature would not be seen as detrimental to the ecology of the area.

2.6.15 As outlined above for estuarine processes, the significance of the effect upon the marine environment is determined by correlating the magnitude of the impact and the sensitivity of the receptor, with the framework for this assessment presented in Table 2.5. Where a range of significance of effect is presented in Table 2.5, the final assessment for each effect is based upon expert judgement. As for estuarine processes, any effects on marine ecological receptors and water quality with a significance level of minor or less are considered to be **not significant** in EIA terms.

2.7 Maximum design envelope parameters for assessment

2.7.1 The maximum design envelope has been selected based on the elements of the project which have the potential to result in the greatest effect on marine environmental receptors, specifically the construction and operation of the causeway in the intertidal. These parameters have been identified based on the overview description of the development provided in Volume 2, Chapter 2: Project Description, including all potential development options where these are under consideration by the Applicant.

2.7.2 The maximum design envelope parameters are to be considered worst case and effects of greater adverse significance are not predicted to arise should any other development scenario within the project design envelope be taken forward in the final design of the Thurrock Flexible Generation Plant. The maximum design envelope parameters for this chapter are described in Table 2.8.

2.8 Impacts scoped out of the assessment

2.8.1 On the basis of the baseline environment and the project description outlined in Volume 2, Chapter 2: Project Description, a number of impacts are scoped out of the assessment for estuarine processes. These impacts are outlined, together with a justification for scoping them out, in Table 2.9.

2.8.2 As set out in Chapter 2 it is assumed that the causeway would be left in situ and not removed after the projected 35 year life-time of the proposed development. As such, the effects on marine environmental receptors during the operation and maintenance phase would continue beyond the decommissioning phase of the remainder of the proposed development, albeit with no maintenance input.

Table 2.8: Maximum design envelope parameters assessed.

Potential impact	Maximum design scenario	Justification
Construction		
Changes in flow conditions through the construction, presence and operation of the causeway and effects on seabed sediments and maritime infrastructure; and Changes in sediment transport processes through the construction, presence and operation of the causeway and effects on seabed sediments and maritime infrastructure.	Causeway and vessel grounding pocket as low down in the intertidal zone as potentially required, within the Order Limits.	This will create the maximum blockage effect to flows and the maximum direct footprint of effect on the intertidal zone (and likely indirect effect from the change in flows).
	Causeway at most westerly location within Order Limits, taking causeway and access maximum radius into account.	Westernmost location would be the most likely to have the greatest potential for cumulative effect with the consented Tilbury2 (and vice versa).
	Causeway design has the most perpendicular design (relative to the existing tidal defences), with the sharpest radius to its curve after a perpendicular section, that is reasonably likely.	The least hydrodynamically streamlined design with greatest potential for impacts on the flow regime.
	Maximum height of causeway (2.7m) along its length defining the slope relative to Ordnance Datum Newlyn (ODN) or Chart Datum.	Creates the maximum blockage to flow vertically in the tide and the time in the tide when it occurs.
	RoRo vessel dimensions up to 100 m length, 20 m beam and 3.5 m draught (loaded) with 0.5 m under keel clearance.	Reasonable maximum for RoRo vessels that may be used. Largest dimensions have greatest potential effect on river flow while berthed, the maximum footprint of intertidal habitat affected, and greatest dredging requirement to accommodate vessel draught.
	Up to 60 RoRo vessels deliveries, with maximum frequency one delivery per three days, over the 6 year construction phase. Either all deliveries occurring during a single construction phase or divided approximately equally over construction Phase 1 and 2.	Maximum frequency of deliveries (single phase construction) or maximum duration of use (multi-phase construction) with greatest potential impact due to disturbance from vessels and unloading activities.
	16,100m^3 material in total with 13,000 m^3 assumed to be removed by water injection dredging (WID) as a worst case scenario; the rest removed by land- based plant and therefore not subject to dispersal in the water column.	The WID method of dredging has been assessed as this method will create the greatest change to the sediment in the water column from the dredge location.
Temporary habitat loss/disturbance during construction activities and effects on marine ecology receptors.	Capital dredging of vessel grounding pocket over a footprint of approximately 14,200 m^2 in the intertidal.	This represents the maximum design scenario for the footprint of dredging at the vessel grounding pocket adjacent to the causeway. All dredging to prepare the seabed for causeway construction are considered under the long term habitat loss impact below.
Increases in suspended sediment concentrations (SSC) and associated deposition during construction activities (including dredging) and effects on water quality and marine ecology receptors.	16,100m^3 material in total with 13,000 m^3 assumed to be removed by WID as a worst case scenario; the rest removed by land- based plant and therefore not subject to dispersal in the water column.	The WID method of dredging has been assessed as this method will create the greatest change to the sediment in the water column from the dredge location.
Release of sediment bound contaminants during dredging operations and effects on water quality and marine ecology receptors.		
Underwater noise during construction (e.g. dredging activities) and effects on marine ecology receptors.	Up to 60 barge deliveries over the 6 year construction phase. Maximum frequency of one delivery per three days. Dredging via backhoe dredging, trailing suction hopper dredger, cutter suction dredging or water injection.	Key sources of underwater noise during the construction phase.
Accidental release of pollution (e.g. due to spillage) and effects on water quality and marine ecology receptors.	Storage of fuel and refuelling or minor maintenance of construction plant within main development site. Up to 60 barge deliveries over the 6 year construction phase. Maximum frequency of one delivery per three days.	These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction and source of contaminants (e.g. fuel) on the development site.

Potential impact	Maximum design scenario	Justification
Operation and maintenance		
Long term/permanent habitat loss due to presence of the causeway.	Loss of approximately 5,380 m^2 of intertidal habitat beneath the footprint of the causeway and habitat changes due to presence of the causeway structure (i.e. effects of changes to sediment transport processes). Causeway to be retained throughout operation and maintenance phase and left in situ post decommissioning.	Maximum footprint of causeway in the intertidal.
Changes in flow conditions through the presence of the causeway; and Changes in sediment transport processes through the presence of the causeway	Causeway and vessel grounding pocket as low down in the intertidal zone as potentially required, within the Order Limits.	This will create the maximum blockage effect to flows and the maximum direct footprint of effect on the intertidal zone (and likely indirect effect from the change in flows).
	Causeway at most westerly location within Order Limits, taking causeway and access maximum radius into account.	Westernmost location would be the most likely to have the greatest potential for cumulative effect with the consented Tilbury2 (and vice versa).
	Causeway design has the most perpendicular design (relative to the existing tidal defences), with the sharpest radius to its curve after a perpendicular section, that is reasonably likely.	The least hydrodynamically streamlined design with greatest potential for impacts on the flow regime.
	Maximum height of causeway (2.7m) along its length defining the slope relative to Ordnance Datum Newlyn (ODN) or Chart Datum.	Creates the maximum blockage to flow vertically in the tide and the time in the tide when it occurs.

Table 2.9: Impacts scoped out of the assessment.

Potential impact	Justification
Construction	
Wave effects	Construction vessels/ plant will predominantly work at low tidal states (in the dry) therefore will have no effects on waves. Due to the location of the causeway, wave activity is low and there will be no changes on the propagation of the waves to affect other locations. Local changes to wave climate from the causeway and vessels would be negligible.
Operation	
Wave effects	Due to the location of the causeway, wave activity is low and there will be no effects on the propagation of the waves to affect other locations. Local effects from the causeway will be negligible.

2.9 Measures adopted as part of Thurrock Flexible Generation Plant

2.9.1 A number of measures have been designed in to the Flexible Generation Plant to reduce the potential for impacts on marine environments in the project area. These are listed in Table 2.10.

Table 2.10: Designed-in measures

Measures adopted as part of Thurrock Flexible Generation Plant	Justification
Design Measures	
The Thurrock Flexible Generation Plant has been developed to avoid designated sites and other ecologically sensitive habitats wherever practicable.	To minimise loss of habitats of conservation interest.
A Saltmarsh Enhancement and Maintenance Plan (application document A8.10) has been developed to encourage the development of saltmarsh habitats in the vicinity of the proposed causeway structure. The aim of these proposals is to deliver Biodiversity Net Gain, by offsetting the loss of mudflat and saltmarsh habitats due to the presence of the causeway structure.	To compensate for loss of habitats of conservation interest and provide for enhancement.
Construction measures	
All relevant mitigation measures will be implemented through the Code of Construction Practice (Document A8.6 accompanying the DCO application)	To minimise the likely impacts on marine ecological receptors, including biosecurity measures to prevent spread of invasive species.
Site induction and toolbox talks will include mitigation requirements included in this chapter and in Volume 6, Appendix 9.3: OEMP.	To help ensure adherence to the ecology mitigation strategy and protection of habitats and species of nature conservation interest.
All works will be carried out taking full account of legislative requirements and EA guidance.	To minimise the likely impacts on marine ecological receptors.
Further details of measures relating to pollution prevention are set out in Volume 3, Chapter 15: Hydrology and Flood Risk and are described in the CoCP (Document A8.6 accompanying the DCO application). Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.	To minimise the potential for pollution incidents to affect habitats.
Biosecurity measures will be implemented to minimise risk of spread of marine invasive and non-native species. This may include measures to for rock materials for causeway construction, in the unlikely event that this material is sourced from the marine environment (it is anticipated that this material will originate from non-marine sources). The plan will outline measures to ensure vessels comply with the International Maritime Organization (IMO) ballast water management guidelines, it will consider the origin of vessels and contain standard housekeeping measures for such vessels as well as measures to be adopted in the event that a high alert species is recorded.	To minimise the potential risk of spreading disease and invasive species.
Post-construction measures	
Monitoring of saltmarsh habitats has been proposed as part of the Saltmarsh Enhancement and Maintenance Plan (application document A8.10). This will include annual post construction monitoring to assess the extent to which saltmarsh communities are colonising the relevant area where enhancement measures are being put in place.	To ensure the establishment of saltmarsh habitat.
Operation and maintenance measures	
The measures to be adopted for the avoidance of pollution of the environment during the operation of the Thurrock Flexible Generation Plant infrastructure are set out in Volume 3, Chapter 15: Hydrology and Flood Risk.	To protect retained habitats and species.

3. Baseline Environment

3.1 Current baseline

3.1.1 The Thames Estuary is an important UK waterway, supporting a busy international port, providing water resource for both industrial and domestic use, and a key recreational area for the south of England.

3.1.2 The Thames is comprised of typical UK estuarine habitats such as mudflats, sandflats, boulders and rocky habitats, saltmarsh, saline lagoons and intertidal creeks. These habitats, along with a strong tidal influence and large freshwater input, supports a variety of flora and fauna at various life cycle stages.

Designated sites

3.1.3 To allow for identification of designated sites around the vicinity of the project, a buffer of 5 km study area was applied. Within this area, there are four designated sites (Figure 3.1), including one European Designated Site (Natura 2000 site) and a Ramsar site, which are designated for seabed and ornithological features (note: effects of the project on intertidal birds are considered within Volume 3, Chapter 9: Onshore Ecology of the Environmental Statement). Beyond the 5 km buffer, there are two MCZs (one designated and one recommended) upstream of the project boundary, identified in Scoping and are therefore also discussed below:

- Thames Estuary and Marshes Special Protection Area (SPA) (1.4 km);
- Thames Estuary and Marshes Ramsar Site (1.4 km);
- South Thames Estuary and Marshes Site of Special Scientific Interest (SSSI) (1.3 km); and
- Mucking Flats and Marshes Site of Special Scientific (SSSI) (2.3 km); and
- Swanscombe MCZ (6 km upstream) and Upper Thames recommended MCZ (rMCZ; approximately 35 km upstream).

Thames Estuary and Marshes Special Protection Area (SPA)

3.1.4 Thames Estuary and Marshes SPA is located in the outer Thames Estuary, stretching from the western side of Cliffe Pools to Gain Tower. Predominantly comprised of extensive intertidal mudflats which are visible at low tides, with areas of saltmarsh around the Isle of Grain and a complex channel system in Yantlet Inlet. Further, disused quarry pits provide an extensive series of waterbodies at Cliffe Pools (Natural England, 2018).

3.1.5 This variety of habitat types provide important feeding and roosting areas for qualifying species: avocet (*Recurvirostra avosetta*), black-tailed godwit (*Limosa limosa islandica*), dunlin (*Calidris alpina alpina*), grey plover (*Pluvialis squatarola*), hen harrier (*Circus cyaneus*), knot (*Calidris canutus*), redshank (*Tringa totanus*) and ringed plover (*Charadrius hiaticula*). The site regularly supports large numbers of birds, supporting over 33,000 individual waterfowl over winter (JNCC, 2005).

Thames Estuary and Marshes Ramsar

3.1.6 Thames Estuary and Marshes Ramsar is a complex rain-fed, brackish, floodplain grazing marsh comprised of intertidal mudflats and saltmarsh (JNCC, 2008). The site supports internationally important populations of grey plover, common redshank, dark-bellied brent goose (*Branta bernicla bernicla*), common shelduck (*Tadorna tadorna*), northern pintail (*Anas acuta*), ringer plover, red knot and dunlin. Further, the site also supports a number of rare plants and animals, and twelve British Red Data Book species of wetland invertebrates such as ground beetle (*Polistichus connexus*) (JNCC, 2008).

South Thames Estuary and Marshes Site of Special Scientific Interest (SSSI)

3.1.7 Thames Estuary and Marshes SSSI covers a total area of over 52 km^2 from Gravesend to the eastern end of Isle of Grain, forming a major component of the Greater Thames Estuary (Natural England, 1991a). This SSSI consists of an extensive mosaic of grazing marsh, saltmarsh, mudflat and shingle habitats, 95% of which are classified as 'favourable' condition. These habitats provide feeding and breeding grounds for regularly over 20,000 waterfowl, including rare species such as garganey (*Anas querquedula*), pintail, avocet and bearded tit (*Panurus biarmicus*) (Natural England, 1991).

Mucking Flats and Marshes Site of Special Scientific Interest (SSSI)

3.1.8 Mucking Flats and Marshes SSSI covers a total area of 3 km^2 of mudflats and saltmarsh, which provide the largest intertidal feeding area west of Canvey Island on the north bank of the Thames. These habitats have been classified as favourable condition for 94% of the site. Ringer plover occurs in internationally important numbers, while shelduck, grey plover, dunlin, redshank and black-tailed godwit are present in nationally important numbers. This site has a high value due to its proximity to Cliffs and Cooling Marshes SSSI and Higham Marshes SSSI which provides an interchange for roosting and feeding birds. The site also supports uncommon saltmarsh which has a high invertebrate interest (Natural England, 1991b).

Swanscombe Marine Conservation Zone (MCZ) and Upper Thames rMCZ

3.1.9 In 2011, the Thames Estuary was put forward as a rMCZ to protect two features in particular: the fish species European smelt (*Osmerus eperlanus*) and tentacled lagoon worm (*Alkmaria romijni*). However, this larger rMCZ was subsequently divided into two sites (Natural England, 2018), the Upper Thames rMCZ and the now designated Swanscombe MCZ. Both designations are upstream of the project boundary, with Swanscombe MCZ located approximately 6 km upstream (see Figure 3.1) and the Upper Thames rMCZ located approximately 35 km upstream (i.e. upstream of Battersea Bridge). Swanscombe is designated for the intertidal mud and tentacled lagoon worm features, while the Upper Thames rMCZ is recommended for designation for European smelt.

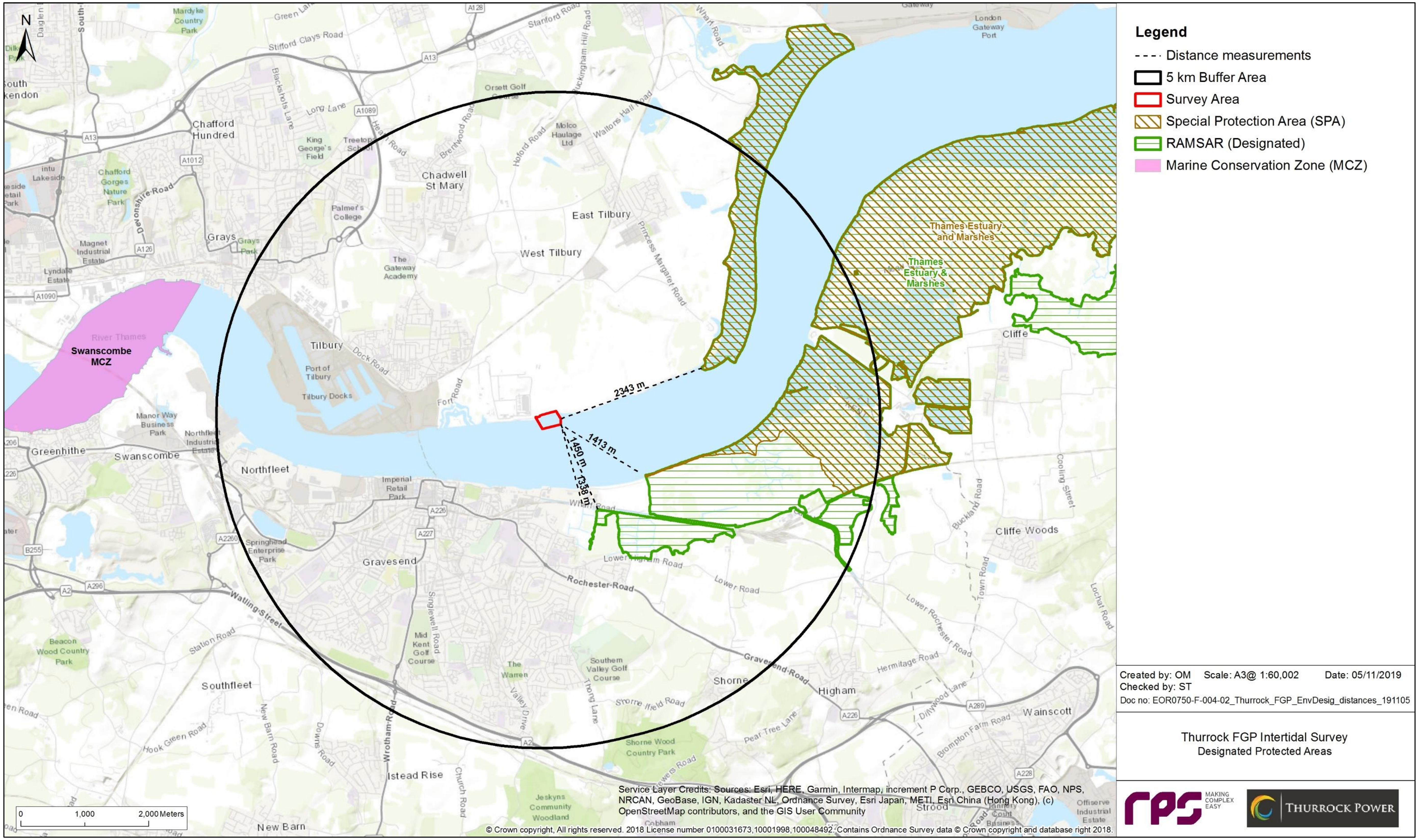

Figure 3.1: Designated sites with marine features within a 5 km buffer from the project site

Estuarine processes

3.1.10 Estuaries in the UK are transitional habitats (Elliott and Whitfield, 2011) that are typified by diverse hydrodynamic flows, semi-diurnal tidal cycles and freshwater, marine and intermediate salinity regimes (Attrill, 2002). The Thames Estuary, within which the study area is located is a classic macrotidal funnel-shaped estuary. The estuary is approximately 82.5 km in length to the normal tidal limit (NTL) at Teddington Weir, narrowing in width from around 2.1 km at the mouth to circa 85 m (PLA, 2014). The estuary has been heavily modified over time by anthropogenic influences including the reduction in flood storage capacity due to the tidal defences, reclamations and the construction of numerous jetty structures along its length. These modifications have had significant impacts on the estuarine processes and morphodynamics. The most significant anthropogenic changes that have occurred along Gravesend Reach, within which the proposed works are located, include the construction of port facilities at Tilbury and additional oil and gas terminals, wharfs, jetties, and piers along with the tidal constriction associated with the flood defences.

3.1.11 Immediately to the west of the proposed *causeway* location is the existing Thurrock Power Station pontoon/jetty infrastructure which is being retained as part of the Tilbury2 development. To the east is the recently constructed jetty at Goshems Farm. The jetty has been constructed to allow the material generated from the Crossrail and Thames Tideway projects to be transported to the Goshems Farm site used beneficially for land raising.

3.1.12 The locations of the nearby infrastructure are illustrated Figure 3.2.

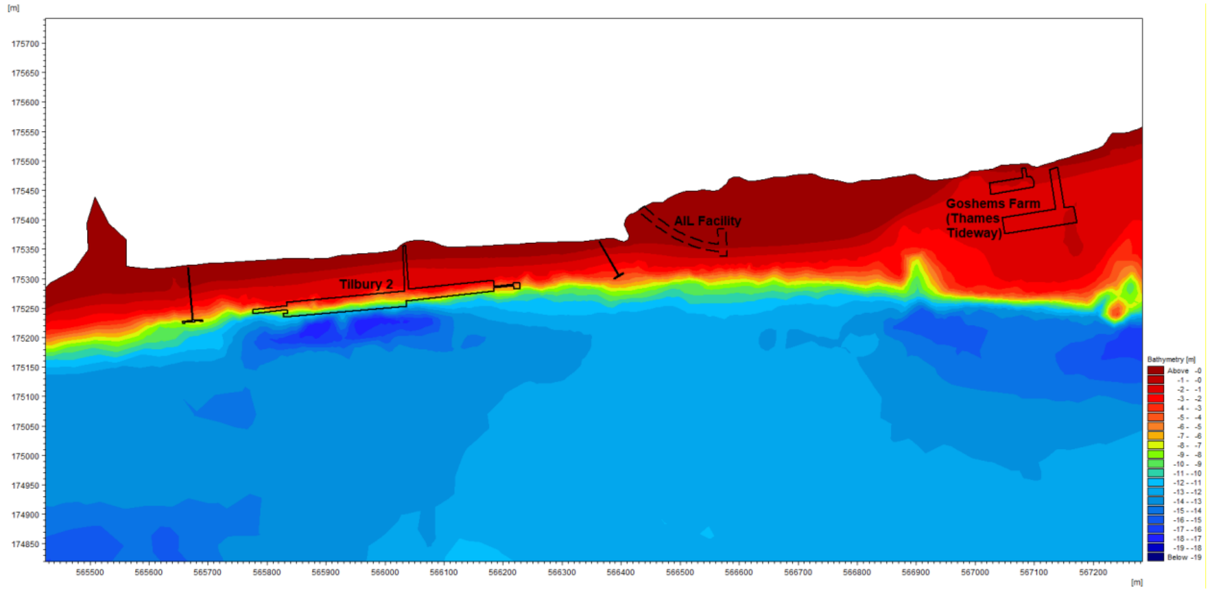

Figure 3.2: Locations of marine infrastructure.

Figure 3.3: Tilbury2 RoRo pontoon under construction at the time of writing.

Data sources

3.1.13 Bathymetric characteristics have been derived from UKHO Admiralty Chart 2484 and the 2016 PLA bathymetric survey (PLA, 2016).

3.1.14 Hydrodynamic properties along this stretch of the Thames Estuary are obtained from the hydrodynamic modelling completed for the study (Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment), Tilbury2 Power station study (HR Wallingford, 2017), Admiralty Total Tide (UKHO, 2019) water levels and tidal stream data along with previous historic flow measurements in the wider Thames.

3.1.15 Sediment samples and photographs from the site at low tidal states have been used to assist interpretation of the sedimentary baseline character.

Geology and surface sediment

3.1.16 The bedrock geology across the study area comprises chalk from the Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated), laid down in the Cretaceous period. Overlying the solid geology is a thick band of fluvial alluvium (comprising of clay, silt, peat and sand) and gravel deposits associated with deposition from the River Thames.

3.1.17 The surface sediment across the intertidal and towards the subtidal bed comprises sand and mud of varying stiffness and compaction (Figure 3.4). Sediment sampling near the proposed causeway undertaken for the project show that the sediment fines from the lower intertidal towards the upper elevations. The median diameter (d50) reduces from about 50 microns to 15 microns up the intertidal with the clay content increasing from about 9% to 14%, hence increasing the cohesivity. The coarsest material is fine sand up to circa 250 microns with the proportion of the Particle size distribution reducing from 13% to 5%. Full results of the PSA undertaken on site specific sediment samples are presented in Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review.

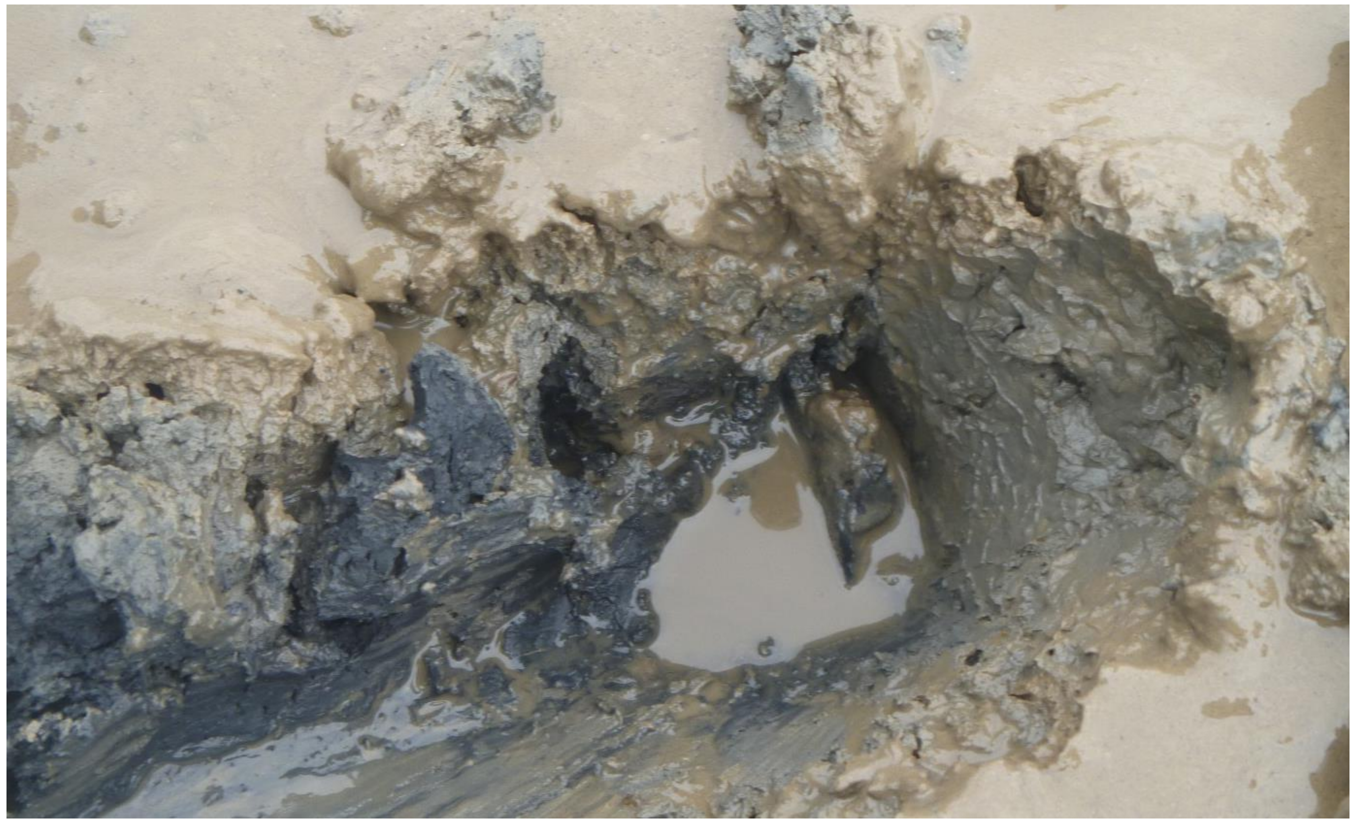

Figure 3.4: Interpreted 'ledge' feature identified across the intertidal mudflat.

3.1.18 Towards the subtidal bed and in proximity to the Power Station Jetty, the sediment is mainly sandy mud coarsening into the subtidal main channel. Overlying the mud around the causeway and fronting the defence structures are pockets of intertidal upper marsh, grading into saltmarsh.

3.1.19 Intermittently present are seaweed covered large cobbles and boulders overlying mud, which are more likely to relate to the characteristics of the made ground landward of the defence structures (Figure 3.3).

Morphology

3.1.20 The morphology of Gravesend Reach is characterised by the presence of intertidal mudflats backed by saltmarsh along the estuary banks, behind which are tidal defence structures. At the development site the upper intertidal (above the level of Ordnance Datum Newlyn (ODN), [+3.12 m Chart Datum (CD)]) slopes at a gradient of *circa* 1:70 for 100-160 m, before steepening to an average of about 1:65 down to the main channel depth of *circa* 10 m below CD (13 m below ODN). The main channel is approximately uniform in level, for about 480 m width before sloping up an average gradient of 1:20 on the south side. This slope is interrupted by a subtidal ledge circa 60-90m wide at an elevation 2-3 m below CD. Of note, Figure 3.5 shows that within the location of the development site there is a small unconformity in the intertidal mudflat profile created by an 'outcrop' of unconsolidated mud. This creates a minor 'ledge' feature, up to *circa* 0.2 m high. The proposed development will cross this feature. The mud below the 'ledge' is more consolidated and generally finer than above, where more sand is evident.

Figure 3.5: Interpreted 'ledge' feature identified across the intertidal mudflat

Hydrodynamics

3.1.21 The Thames Estuary is a well-mixed, highly dynamic, macrotidal estuary with a tidal range in excess of 4 m, which is also the same for Gravesend Reach. Tidal levels generally increase from east to west through the estuary. Levels at the closest tidal point at Tilbury are summarised in Table 3.1 below.

Table 3.1: Tidal levels at Tilbury.

Tidal Level		Tilbury	
		m(CD)	m(ODN)
Highest Astronomical Tide	HAT	7.1	4.0
Mean High Water Springs	MHWS	6.4	3.3
Mean High Water Neaps	MHWN	5.4	2.3
Mean Sea Level	MSL	3.4	0.2
Mean Low Water Springs	MLWN	1.4	-1.7
Mean Low Water Neaps	MLWS	0.5	-2.6
Lowest Astronomical Tide	LAT	-0.1	-3.2
Spring Tidal Range	MHWS – MLWS	5.9	
Neap Tidal Range	MHWN – MLWN	4	
Ordnance Datum Newlyn (ODN) is 3.12 m below Chart Datum (CD)			

3.1.22 Within the Thames Estuary, ebb flow is to the east, while flood is to the west. The fastest tidal flow speeds occur on the ebb tide. Near-bed peak ebb flow speeds along Gravesend Reach have a maximum of about 1.6 m/s in the middle of the channel on spring tides. Speeds over the intertidal areas (where the proposed causeway is located) are generally less than 0.2 m/s on either side of the estuary. Peak flow speeds in the middle of the channel on the flood tide were marginally slower, with a maximum speed of about 1.2 m/s (Figure 3.6).

3.1.23 Notably, in the vicinity of the proposed causeway site flow speeds are symmetrical across the channel, with the fastest speeds occurring in the middle of the channel, reducing towards the edges as the water shallows. For the most part flows are approximately coincident with the orientation of the main channel. Although small scale localised circulations are evident around jetty structures.

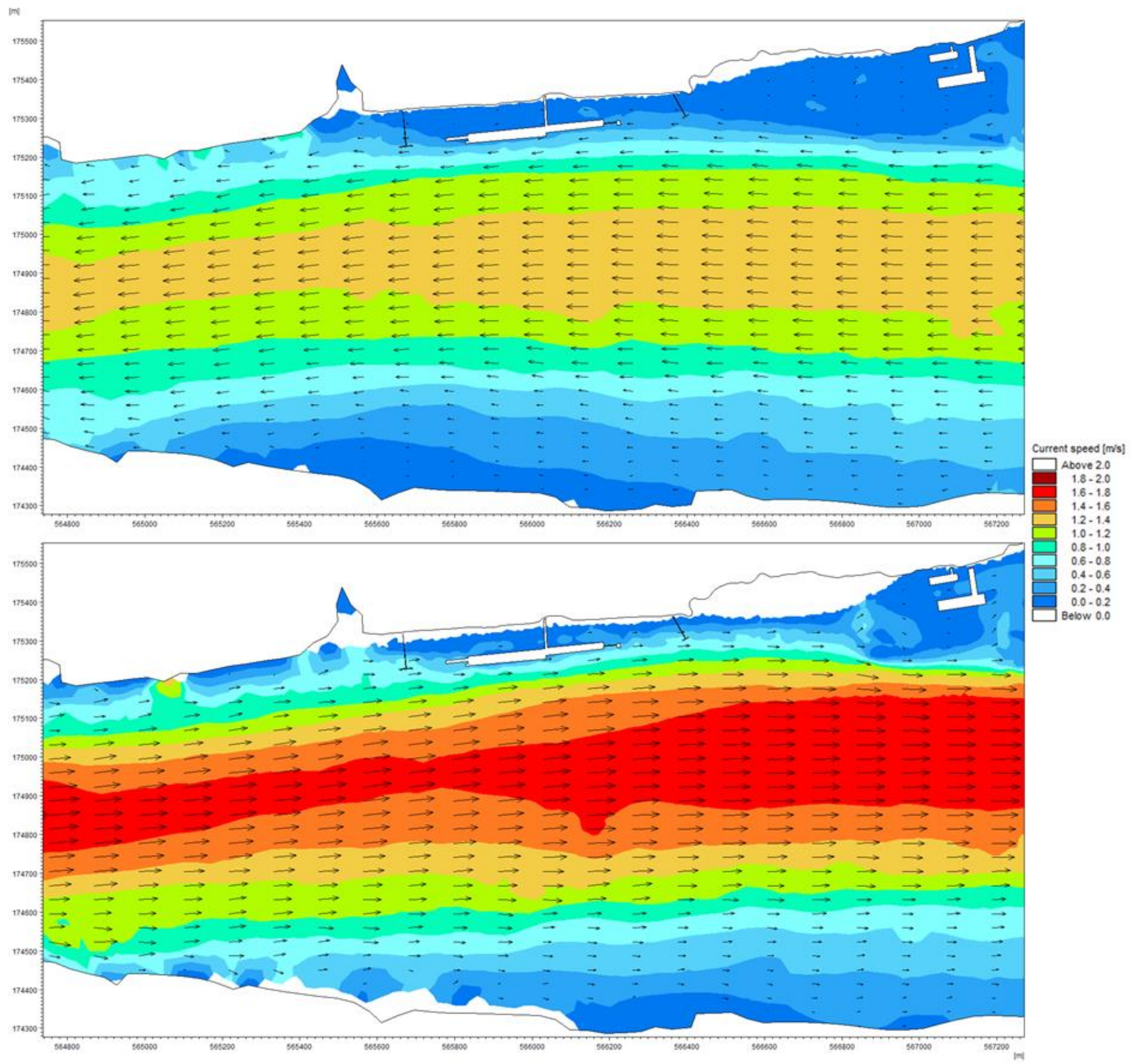

Figure 3.6: Flow speeds around the site of interest during peak flood (top) and peak ebb (bottom).

3.1.24 In this part of the Thames Estuary, there is little influence from waves. The waves present within Gravesend Reach are mainly the result of locally generated wind waves, as the longer period swell waves, generally dissipate over the Outer Estuary sandbanks and wide intertidal mudflats (PLA, 2014). Due to the relatively short fetch and small generation area, the wave climate is characterised by small short period waves.

3.1.25 In line with the prevailing winds, the most common wave direction in proximity to the proposed site is from the west and southwest, but the largest waves come from the east due to the longer fetch and the gradual widening of the estuary towards the east (HR Wallingford, 2017). Typical significant wave heights are about 0.6 m for a 100 year return period, while wave heights of less than 0.2 m occur approximately 92% of the time (HR Wallingford, 2017). Due to the short fetch associated with the prevailing wind direction, the mean wave periods is typically less than 2.5 s.

Sediment transport

3.1.26 Since 1900, the upper Thames Estuary subtidal channel has deepened and widened, reducing intertidal area. In the lower Thames Estuary however, the subtidal channel has deepened and narrowed, increasing the intertidal area. These changes broadly balance the sediment budget of the Thames Estuary (Baugh *et al*., 2013).

3.1.27 Sediment transport within the Thames Estuary principally occurs in relation to the tidal characteristics with negligible influence from waves (PLA, 2014). Within the Gravesend Reach, the historic bank encroachment has resulted in an increase in the speed of tidal currents which have the capability to mobilise large volumes of sediment. Measurement of the total sediment flux measured up to 65,000 tonnes of sediment passing through the Reach on spring tides, reducing to 20,000 tonnes on neap tides. A maximum flux of 6,000 kg/s was observed on both the flood and ebb (HR Wallingford, 2017).

3.1.28 The dominant mode of transport within Gravesend Reach is through suspended sediment and is indicative of a highly dynamic environment. Observed near bed SSC in proximity to the power station jetty recorded fine (silt and clay) concentrations of up to 1,600 mg/l, which reduced to about 1,300 mg/l (HR Wallingford, 2017). Average sand concentrations of 80 mg/l (near bed) and 30 mg/l (mid depth) indicated a dynamic system. A programme of borehole investigation in 2002 identified a dominance of fine silt and clay in the bed composition (HR Wallingford, 2017).

3.1.29 The Thames Estuary sediment budget calculates that *circa* 2 tonnes of sediment is transported across a given estuary cross section every second (approximately 46,000 tonnes on the flood tide), 93% of which is returned to sea. The budget concludes the estuary to be in a state of dynamic equilibrium which includes an average subtidal dredging of *circa* 225,000 m³ per annum since 1961 (PLA, 2019).

3.1.30 Studies within the Thames Estuary indicate that sediment movement as bedload is very small in comparison to the suspended sediment transport.

3.1.31 In terms of the depositional environment, Gravesend Reach is subject to deposition of suspended sediment moving along the river from west to east, with deposition occurring at low water.

Benthic intertidal and subtidal ecology

3.1.32 The benthic ecology and sediment quality baseline described within this section is a summary of that presented within the Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review, which presents the findings of the site specific intertidal survey (including site specific Phase 2 sediment chemistry sampling) alongside key desktop data sources. As outlined in Section 2.3, the key desktop information sources for the local area include Tilbury2 and the Tilbury Energy Centre developments.

3.1.33 In 2019, the Phase 1 habitat survey was conducted in intertidal area, located in a very sheltered area on the north bank of the Thames Estuary to the east of Tilbury Docks. The intertidal zone was characterised by extensive mud flats with discrete areas of mixed and hard substrates. Saltmarsh habitats were present at the upper shore with mixed sediments, man-made boulders and fucoid seaweed habitats characterising a narrow strip in the mid shore and mud flats dominating in the mid to lower shore. Zonation was evident along the shore, with distinct boundaries of the saltmarsh and mudflats. The habitats observed within this survey were reflective of these observed in recent surveys for Tilbury Energy Centre and Tilbury2 (APEM, 2019 (Appendix 17.4); Port of Tilbury, 2017).

3.1.34 The intertidal biotopes recorded during the Phase 1 habitat survey are summarised in Table 3.2 and mapped in Figure 3.7; these are typical for a mid estuary setting in the UK. Broadly, the upper shore was characterised by established saltmarsh (LS.LMp.Sm) and the majority of the mid to lower shore was characterised by intertidal muddy sediments with two biotopes present *Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud (LS.LMu.MEst.HedMacScr) and littoral mud (LS.LMu). Separating the saltmarsh and intertidal mud were areas of rocky habitat colonised in places by seaweeds (LR.LLR.F.Fves and LR.LLR), with some small patches of impoverished mixed sediment.

Table 3.2: Littoral biotopes observed in 2019 Phase 1 habitat survey (JNCC, 2019)

Shore position	Biotope/NVC Code	Biotope Name
Upper shore	Ls.LMp.Sm	Saltmarsh
Upper to mid shore	LR.LLR.F.Fves	*Fucus vesiculosus* on moderately exposed to sheltered mid eulittoral rock
	LS.LMx.GvMu.HedMx	*Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud
	LR.LLR	Low energy littoral rock
	LS.LSa.St	Strandline
Mid to lower shore	LS.LMu.MEst.HedMacScr	*Hediste diversicolor, Macoma balthica* and *Scrobicularia plana* in littoral sandy mud
	LS.LMu	Littoral mud

3.1.35 The results of the site specific survey were similar to, and had similar conclusions to that of the Tilbury Energy Centre and Tilbury2 surveys, with slight differences in the biotope classifications, although generally the intertidal habitats/communities were typical of the middle Thames Estuary. With respect to subtidal habitats, the Tilbury Energy Centre and Tilbury 2 surveys indicated that these were characterised by sandy muddy sediments with species such as the polychaete *Polydora*, the oligochaete *Tubificoides* and the amphipod *Corophium volutator* dominating. Both the Tilbury Energy Centre and Tilbury2 surveys classified the subtidal habitats in the vicinity of the Thurrock Flexible Generation Plant as the *Polydora ciliata* and *Corophium volutator* in variable salinity infralittoral firm mud or clay (SS.SMu.SMuVS.PolCvol) biotope, with the Aphelochaeta marioni and Tubificoides spp. in variable salinity infralittoral mud (SS.SMu.SMuVS.AphTubi) biotope present further east and west. Overall both intertidal and subtidal assemblages were typical of those found throughout the Thames Estuary, with consistency across the site specific survey data and historic datasets from the area.

3.1.36 The water and sediment quality baseline described within this section has been developed based on a review of available data from recent surveys conducted during the ES development of Tilbury Energy Centre Environmental Statement, Tilbury2 Environmental Statement (Port of Tilbury, 2017) and through site specific surveys for Thurrock Flexible Generation Plant.

Figure 3.7: Intertidal biotopes recorded during Thurrock Flexible Generation Plan Phase 1 survey.

Sediment quality

3.1.37 As outlined above, site specific sediment sampling was undertaken during the Phase 1 intertidal walkover survey, which comprised sediment core sampling at three locations coinciding with the causeway footprint (see Figure 3.7). All methods and results are fully discussed in Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review. The sediment chemistry analysis were compared with Cefas action levels 1 and 2 (AL1 and AL2), which give an indication of how suitable the sediments are for disposal at sea. Contaminant levels which are below AL1 are of no concern and are unlikely to influence the marine licensing decision while those above AL2 are considered unsuitable for disposal at sea. Those between AL1 and AL2 would require further consideration before a licensing decision can be made. These were also compared to the Canadian Sediment quality guidelines (CCME, 2001), which give an indication on the degree of contamination and the likely impact on marine ecology. For each contaminant, the guidelines provide threshold effects levels (TEL), which is the minimal effect range at which adverse effects rarely occur and a probable effect levels (PEL), which is the probable effect range within which adverse effects frequently occur.

3.1.38 Sediment chemistry analysis indicated that most metals were below the Cefas AL1, with the exception of chromium and mercury, both of which exceeded AL1 at all three sampling locations (although chromium was below the Canadian TEL for two of these). Zinc and nickel also exceeded the Cefas AL1, although at one location only. In all cases, although the Cefas AL1 was exceeded, these were small exceedances and still well below the Cefas AL2 (and the Canadian PEL). The results for Polycyclic Aromatic Hydrocarbons (PAHs) were also found to be elevated above the Cefas AL1 for 11 of the 17 determinants tested. There is no Cefas AL2 for PAHs, although the concentrations of all PAHs were well below the Canadian PEL thresholds.

3.1.39 Samples taken in 2007/2008 to support the Tilbury2 Environmental Statement indicated all determinants were below Cefas AL1, except copper, zinc, lead, chromium, nickel and mercury concentrations. In 2017, only arsenic, chromium and nickel exceeded AL1. Generally, contaminants exceeding AL1 were noted in surface samples, and no AL1 exceedances were observed below 3 m depth. Mercury was recorded above AL2. Hydrocarbon levels were elevated above AL1 for individual PAHs at most stations in the 2007/2008 surveys. In 2017, very few AL1 exceedances for PAHs were observed throughout all samples. However, one station exceeded all AL1 thresholds for PAHs, and Perylene was above AL1 at 14 of the 23 samples analysed (Port of Tilbury, 2017). These indicate that the results of site specific sediment chemistry sampling undertaken for the Thurrock Flexible Generation Plant were typical for this part of the Thames Estuary.

Water quality

3.1.40 The WFD (200/60/EC) requires natural water bodies (including marine waters at up to 1nm) to achieve GES and Good Chemical Status (GCS), and all Artificial and Heavily Modified Water Bodies (A/HMWB) to achieve Good Ecological Potential. This directive requires EU Member States to implement River Basin Management Plans (RBMPs), which sets environmental objectives for groundwater and surface water (including estuaries and coastal waters).

3.1.41 Between 2009 – 2014, and in 2016, the Environment Agency classified the Thames Middle water body with an overall classification of 'moderate', based on a 'moderate' Ecological Status and a 'failed' Chemical Status. The reasons behind not achieving Good Chemical Status or GES include:

- Physical modifications (coastal protection and flood protection);
- Point source contamination (Tributyltin compounds related to landfill leaching, sewage discharge and use of restricted substances); and
- Diffuse source contamination (Tributyltin compounds related to contaminated water bed and urbanisation).

3.1.42 In 2015, the Thames Middle waterbody was classified as 'moderate' ecological status and 'good' chemical status. This classification as an overall 'good' chemical status in 2015 was due to an improvement in priority substances and priority hazardous substances. In 2016, GCS was assessed as a 'fail' due to a 'fail' assessment for priority hazardous substances (i.e. Tributyltin compounds).

Fish and shellfish

3.1.43 The Thames estuary has a strong tidal influence, with a relatively large freshwater input. Fish species present range from freshwater species, estuarine residents (i.e. entire lifecycle within estuary) to marine species.

3.1.44 To support the development of the Tilbury Energy Centre Environmental Statement, subtidal and intertidal fish surveys were conducted during May, August and October 2017 and February 2018 to provide a characterisation of the fish assemblages present. Subtidal sampling was conducted via beam trawl, otter trawl and pelagic trawling (APEM, 2018; Appendix 17.4). Intertidal sampling was undertaken using fyke, seine and push nets.

3.1.45 A total of 34 species (18,036 fish) were recorded across all gears during subtidal trawls, and 16 species (1,364 fish) across all intertidal surveys. These species were typical of those previously observed within the Thames Estuary by the Environment Agency, and during monitoring for Tilbury B Power Station (Jacobs, 2012). Species recorded included a range of both commercially important and protected species, such as including European eel *Anguilla anguilla*, European smelt *Osmerus eperlanus*, river lamprey *Lampetra fluviatilis*, European seabass *Dicentrarchus labrax*, common sole *Solea solea* and Atlantic herring *Clupea harengus* (APEM, 2018; Appendix 17.4). These surveys are discussed further below.

Subtidal fish ecology

3.1.46 A total of 18,036 fish and 34 species were recorded from the subtidal surveys. The sand goby complex (individuals of both *Pomatoschistus minutus* and *Pomatoschistus lozanoi*) was the most abundant species representing 73% of total fish counts, 12% of beam trawl catch, 37% of otter trawl catch and 51% of pelagic trawl catch; APEM Ltd., 2018; Appendix 17.4). The second most abundant species was European smelt with 1,465 individuals recorded across all gear types (3% beam trawls, 43% otter trawls and 54% pelagic trawls). Common sole was the third most abundant species, observed 791 times across all gear types (36% beam trawls, 62% otter trawls and 2% pelagic trawls). Atlantic herring, whiting, European sprat, European flounder were observed in abundances of over 300 individuals (APEM Ltd., 2018; Appendix 17.4).

3.1.47 Highest diversity of species was observed during surveys conducted in October (26 species), followed by May (21 species), and August/February (18 species). Highest catches of the sand goby complex were observed in August and October surveys (5,874 and 6,003 individuals, respectively). European smelt and common sole catches were greatest during the May survey (987 and 567 individuals, respectively) (APEM Ltd., 2018; Appendix 17.4).

Intertidal fish ecology

3.1.48 A total of 1,364 individuals and 16 species were recorded from the intertidal surveys. The most abundant species were the common goby *Pomatoschistus microps* (572 individuals, 42% of total catch), and European seabass (479 individuals, 35% of total catch). Common goby was predominantly recorded within push nets (88% of total common goby catch), with highest catches observed in August and October surveys. European seabass was recorded in highest abundances within fyke nets (69% total seabass catches) during October and February surveys.

3.1.49 European seabass dominated seine net catches in May and February surveys, and common goby was most abundant in seine nets during August and October surveys. European smelt, European flounder (*Platichthys flesus*) and sand goby were all observed in abundances greater than 50 individuals (APEM Ltd., 2018; Appendix 17.4).

3.1.50 Across all intertidal surveys, a total of ten invertebrate taxa were recorded in low catches. The most abundant of these was the shore crab *Carcinus maenas* and brown shrimp *Crangon crangon.* Invasive non-native species were also recorded during the surveys, such as oriental shrimp *Palaemon macrodactylus* and Chinese mitten crab *Eriocheir sinensis* (APEM, 2018; Appendix 17.4).

Spawning and nursery grounds

3.1.51 The lower Thames Estuary is considered to be an important spawning and nursery ground for common sole (Ellis *et al*., 2012), corresponding with site survey data which indicates highest catches of common sole in subtidal trawling in May (APEM Ltd, 2018; Appendix 17.4). As this species spawns, individuals migrate from deeper water to shallower waters for summer, before returning to deeper waters during the winter (Walker and Emerson, 1990).

3.1.52 Within Tilbury Energy Centre fish surveys (APEM, 2018; Appendix 17.4), elevated abundances of clupeids (European sprat and Atlantic herring) were observed during winter month surveys, corresponding with utilisation of nursey, spawning and winter grounds nearer to the coast. These species migrate back into deeper waters for the summer season to facilitate greater feeding opportunities (Ellis *et al*., 2012). Likewise, European smelt were predominately observed as juvenile individuals during subtidal surveys. This species inhabits the Thames from juvenile stages to mature stages, seeking deeper and cooler waters in the summer (Power and Attrill, 2007). As outlined in paragraph 3.1.9, the Thames estuary is known to host important spawning habitat for smelt, with an important UK population known to occur in the region.

Marine mammals

3.1.53 Marine mammals are protected within UK waters through various legislation, which varies for pinnipeds (seals), and cetaceans (whales, dolphins and porpoise). Cetacean species are protected by The Wildlife and Countryside Act 1981, and harbour porpoise and bottlenose dolphin are listed as EC Habitats Directive (92/43/EEC) Annex II species. Further, grey and harbour seal are listed as protected species under Annex II and Annex V of the EC Habitats Directive (92/43/EEC) and are protected by the Conservation for Seals Act 1970. The Conservation of Seals (England) Order 1999 and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) also protects marine mammals within UK waters.

3.1.54 Several marine mammal species frequent the Thames Estuary area, including pinnipeds, and cetaceans. Due to the large ranges marine mammals can cover, the study area for marine mammals within this chapter covers the entirety of the tidal Thames.

3.1.55 The Zoological Society for London Thames Marine Mammal Sighting Survey (TMMSS) (ZSL, 2019) reports the presence and distributions of marine mammals in the Thames.

The TMMSS records sightings across the entire Greater Thames Estuary, from Teddington Lock in the West, Felixstowe in the North East and Deal in the South East. These recordings are reported through opportunistic sightings from members of the general public, and through observations recorded by anglers, bird watchers, tour boats and other groups such as Port of London Authority, Environment Agency, Thames River Police, Port of London Health Authority and the Kent Mammal Group. Records of these observations have supported the development of a long-term dataset for the Thames which spans back to 2004.

3.1.56 Between 2004-2014, a total of 2,732 animal sightings were submitted to TMMSS, which was filtered to 1,317 valid sightings, with pinniped sightings the most common (~82%), followed by cetaceans (~18%) with several other sightings of otters (Tickell and Barker, 2015). Based on the TMMSS data, the most frequently observed species were grey seal, harbour seal, harbour porpoise and bottlenose dolphin. Greatest densities of sightings were focused around Canary Wharf in Central London, at a density of 138 sightings per km^2, however this was described as likely due to high numbers of potential observers in this area. Pinnipeds and cetaceans were observed throughout the Greater Thames Estuary, with Teddington Lock the most westerly record of cetaceans and Hampton Court Palace the most westerly point of observed pinnipeds (Tickell and Barker, 2015).

3.1.57 Harbour seals are frequently observed and most abundant marine mammal species in the Thames Estuary, with 482 individuals observed during a harbour seal population count in 2013 (Barker *et al*., 2014). A baseline population of 670 within the estuary is estimated, and tagging data suggests there are two sub-populations of harbour seal within the Thames Estuary (Barker *et al*., 2014). These individuals are often sighted hauled out on the sand banks in the outer Thames Estuary, and are understood to utilities five major foraging areas in the estuary.

3.1.58 Although grey seals are observed within the Thames, they do not breed within the estuary and are frequently observed as solitary animals. Harbour porpoise are regularly sighted in the Thames, with sightings peaking between April and August. Bottlenose dolphin is also observed within the Thames, however greater abundances of this species occur along the European shelf. White-beaked dolphin and minke whale have also previously been observed within the estuary, however it is understood that where these are observed, this is usually in the Outer Thames Estuary, as these species generally make use of offshore waters.

3.1.59 Overall, although the Thames Estuary supports marine mammal species including grey seals, harbour seals, harbour porpoise and minke whale, the presence of the marine mammals is lower than elsewhere in the UK. In the waters surrounding the proposed development area, the waters are not known to support breeding marine mammals.

3.2 Future baseline

3.2.1 At the time of writing, the RoRo pontoon and piles construction associated with the Tilbury2 development was underway but had not been completed. Therefore, the current baseline description does not account for any differences in the physical environment as a result of that development. At the point when the causeway is constructed at the Thurrock Flexible Generation Plant, it is likely that Tilbury2 would be completed. This section therefore summarises any expected differences in the physical environment from those already documented in the current baseline.

Tilbury2

3.2.2 Modelling results presented in HR Wallingford (2017), indicate that with the operation and berthing of vessels along the Tilbury2 RoRo pontoon, there is up to a 0.4 m/s reduction in the easterly peak ebb flow speed in the deep main navigation channel off the proposed causeway, associated with a blockage effect from moored vessels. In the absence of moored vessels (i.e. pontoon, mooring structure and dredging) there is an approximate 0.1 m/s reduction in the flow speed. At the same location, in between the Tilbury2 RoRo pontoon and the proposed site, there is predicted to be negligible effect on the flood tide.

3.2.3 The modelled reductions in flow speed are localised and remain in line with the Tilbury2 RoRo pontoon. The modelled changes in the flow speed (HR Wallingford, 2017) do not extend to the river bank or the proposed causeway.

3.2.4 The modelled results indicate that there are marginal changes to the tidal direction at lower tidal states, i.e. from about an hour before low water. However, as is described for the changes in flow speeds, this only occurs in the presence of moored vessels and are localised to the Tilbury2 RoRo pontoon and do not impact on the hydrodynamics at the proposed causeway. As a result, it is considered that for the currently proposed development there will be negligible difference between the current and future baseline physical environment.

3.2.5 There is no perceived change to the sediment transport for both fine (silt and clay) and coarse (sand) sediment within and in proximity to the proposed site with the Tilbury2 RoRo pontoon. This is based on the annualised post-development modelled outputs of sediment transport as presented in HR Wallingford (2017). The modelled changes are only in proximity to the RoRo pontoon, with up to 0.7 m cumulative (silt and sand) sediment infill per year, due to the shielding effect of the pontoon piles.

Climate change

3.2.6 The baseline environment is not static and will exhibit some degree of natural change over time, with or without Thurrock Flexible Generation Plant in place, due to naturally occurring cycles and processes. Therefore, when undertaking impact assessments, it is necessary to place any potential impacts in the context of the envelope of change that might occur naturally over the timescale of the project.

3.2.7 Further to potential change associated with existing cycles and processes, it is necessary to take account of potential effects of climate change on the marine environment. Variability and long-term changes on physical influences may bring direct and indirect changes to marine habitats and communities in the mid to long term future (UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3), DECC, 2016).

3.2.8 Climate change is predicted to affect the estuary hydrodynamics with water levels anticipated to rise by between 0.4 m and 0.5 m by 2070 (derived using the 95%ile UKCP18 Representative Concentration Pathways 4.5 and 8.5 for the inner estuary grid square at Canvey Island). Rainfall and associated river flow is also predicted to increase. The sediment transport regime of the Thames Estuary is considered to be broadly in equilibrium and the influence of climate change is not expected to change this.

3.2.9 A rise in sea level may allow larger waves, and therefore more wave energy, to reach the coast in certain conditions and consequently result in an increase in local rates or patterns of erosion and the equilibrium position of coastal features. Key features of the Thames Estuary intertidal area such as mudflats and saltmarshes may be reduced in size or lost due to this rise in sea levels and associated reduction in area of the coastal zone. These saltmarshes are a key system of the ecosystem, providing habitat to birds, fish and invertebrates while filtering pollutants, reducing flood risk, and sequestering carbon.

3.2.10 Climate change is likely to affect biodiversity in other ways beyond effects of coastal squeeze outlined above. Impacts on species include changes in distribution and abundance, the timing of seasonal events and habitat use and, as a consequence, there are likely to be changes in the composition of plant and animal communities. Habitats and ecosystems are also likely to change in character. There is the potential for the habitats and species within the Thurrock Flexible Generation Plant project area to be impact by climate change due to changes in available habitat, and due to coastal squeeze.

3.2.11 Recent research has suggested that there have been substantial changes in the fish communities in the northeast Atlantic over several decades as a result of a number of factors including climate change and fishing activities (DECC, 2016). Climate change may influence fish distribution and abundance, affecting growth rates, recruitment, behaviour, survival and response to changes of other trophic levels. One potential effect of increased sea surface temperatures is that some fish species will extend their distribution into deeper, colder waters.

3.2.12 In these cases, habitat requirements are likely to become important, with some shallow water species having specific habitat requirements in shallow water areas which are not available in these deeper areas. Therefore, estuary habitats may become vital habitat areas for fish species due to their shallow waters. Climate change may also affect key life history stages of fish and shellfish species, including the timing of spawning migrations (BEIS, 2016). However, climate change effects on marine fish populations are difficult to predict and the evidence is not easy to interpret and therefore it is difficult to make accurate estimations of the future baseline scenario for the entire lifetime of the Thurrock Flexible Generation Plant project.

4. Assessment of Effects

4.1 Construction phase

Changes in flow conditions through the construction, presence and operation of the causeway and effects on seabed sediments and maritime infrastructure

4.1.1 This impact assessment considers effects on the physical seabed sediment receptors and local marine infrastructure. Direct effects (i.e. habitat loss and disturbance) of construction and operation of the causeway on marine ecological receptors (including intertidal habitats) are considered in paragraph 4.1.28 *et seq*. and paragraph 4.2.1 *et seq.*, respectively.

Magnitude of impact

4.1.2 The assessment of change in flow conditions has considered the presence of both the causeway and the RoRo vessel for the duration of the construction period. This has been undertaken using a representation of the causeway and vessel grounding pocket; with and without the vessel and modelling the changes in flow regime over spring tides. This represents a worst case scenario with respect to effects on flows and models the effect at the times of the *circa* 60 vessel movements over the construction period, and the effects during the long periods when the causeway is empty.

4.1.3 Hydrodynamic numerical modelling has been completed in support of the EIA. Separate numerical model runs have been undertaken for the causeway and the causeway with a RoRo vessel (barge). Modelling results are provided and described in Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment.

4.1.4 The modelling shows that the greatest change to the local flow patterns is as a result of both the causeway and the moored vessel. Effects on the flow regime are confined to within:

- 215 m up estuary;
- 250 m down estuary;
- 50 m offshore; and
- Across the intertidal mudflat to the shore.

4.1.5 There is no effect on the main estuary flows or flood flows towards Tilbury2 or Goshems Farm.

4.1.6 The greatest changes are reductions in the peak flow speeds of up to 0.12 m/s (30%) on the ebb tide. Detailed difference plots (Volume 6, Appendix 17.2) show further small changes are caused by the introduction of the vessel, however these are predominantly within the berth under the vessel and immediately shoreward.

4.1.7 Flow directions are relatively unaffected by the development except in the immediate vicinity of the causeway.

4.1.8 The magnitude of change in the estuary flow regime is predicted to be **minor** with a noticeable change limited to within proximity of the causeway.

4.1.9 The change in flow patterns does not extend to the adjacent maritime infrastructure and therefore there is no pathway to the receptor.

Sensitivity of the receptor

4.1.10 The intertidal and subtidal substrates are not subject to nature conservation designations (discussed further in paragraph 4.1.28 *et seq*. and paragraph 4.2.1 *et seq*.). The features are subject to significant variation in flow regime over a range of temporal scales (storms, tides, seasons etc) and, therefore, have a high capacity to accommodate change in the flow regime. The sensitivity of the intertidal and subtidal substrate to changes in the local flow conditions is considered **negligible.**

4.1.11 The sensitivity of maritime infrastructure to changes in hydrodynamics is considered medium or low depending upon the infrastructure affected. The Tilbury2 jetty is considered of medium sensitivity due to it importance at a regional scale (and moderate capacity to accommodate the change) with Goshems Farm considered to be locally important.

Significance of effect

4.1.12 Overall, it is predicted that the **minor** magnitude of impact on the **negligible** sensitivity intertidal and subtidal receptor will result in a **negligible** significance of effect. This effect is not considered either beneficial or adverse. This is **not significant** in EIA terms.

Further mitigation or enhancement

4.1.13 No significant adverse effects have been predicted and therefore no further mitigation is considered to be required.

Changes in sediment transport processes through the construction, presence and operation of the causeway and effects on seabed sediments and maritime infrastructure

4.1.14 This impact assessment considers effects on the physical seabed sediment receptors and local marine infrastructure. Direct effects (i.e. habitat loss and disturbance) of construction and operation of the causeway on marine ecological receptors (including intertidal habitats) are considered in paragraph 4.1.28 *et seq*. and paragraph 4.2.1 *et seq.*, respectively.

Magnitude of impact

4.1.15 The small changes in hydrodynamics from the causeway and presence of the RoRo vessel will have negligible morphological effect other than shoreward of the structure (see Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment for details). Bed shear stresses (BSS) in the 'shelter' of the causeway are generally reduced over the mudflat to the approximate threshold for deposition for the sediment throughout the period of tidal emersion, creating an accretional tendency with little or no scope for re-erosion.

4.1.16 An assessment of the likely sedimentation rates indicates that depths of accumulation of 1 – 1.5 m can be expected over the intertidal behind the causeway, before a new equilibrium is established *circa* 3 – 5 years following construction. This sedimentation has the potential to result in saltmarsh developing behind the causeway from about 18 months after construction, however, mudflat is likely to be maintained behind the berth, albeit at a higher elevation.

4.1.17 At the berth, a slight scour effect is indicated on the flood tide, but the accretional tendency is marginally enhanced on the ebb, due to the 'shelter' effect of the vessel. These differences resulting from the vessel are unlikely to be noticeable from those for the causeway alone.

4.1.18 The rates of accumulation indicate that maintenance dredging of the vessel grounding pocket is likely to be 2,000 – 6,000 m^3/yr.

4.1.19 The magnitude of change in the sediment transport processes at the scale of the Thames Estuary and Gravesend Reach is predicted to be **negligible**, however a noticeable change in intertidal elevation will occur within proximity of the causeway.

4.1.20 The increase in the potential for deposition behind the causeway will result in the potential for the existing mudflat to accrete such that its position in the tidal frame changes with the potential for saltmarsh colonisation directly behind the causeway. The implications of the presence of the causeway on saltmarsh habitats are considered further in paragraph 4.2.1 *et seq*.

4.1.21 The overall extent of intertidal feature is not changed, albeit it will be at a higher elevation and therefore the magnitude of change on the intertidal area is **moderate** but only in the very local area. It should also be noted that the vessels will only be berthed intermittently during the construction phase. This assessment assumes the vessel is permanently berthed and therefore considers the worst case.

4.1.22 The change in sediment transport does not extend to the Tilbury2 jetty or Goshems Farm and therefore there is no pathway to the marine infrastructure receptor.

Sensitivity of the receptor

4.1.23 The intertidal and subtidal features are not subject to nature conservation designations (discussed further in paragraph 4.1.28 *et seq*. and paragraph 4.2.1 *et seq*.) but changes in the erosion and accretional patterns can change the position of the intertidal substrate in the tidal frame. The sensitivity considered within the context of the wider hydrodynamic and sediment transport regime is **low**.

4.1.24 The effects of the presence of the causeway structure on intertidal habitats, including effects of long term habitat loss beneath the causeway footprint and changes in habitat types due to increased sedimentation are discussed in paragraph 4.2.1 *et seq*.

4.1.25 The sensitivity of the maritime infrastructure is again medium or low depending upon the local or regional importance of the infrastructure affected.

Significance of effect

4.1.26 At the scale of Gravesend Reach, the impact on the sedimentary processes affecting the intertidal and subtidal areas is predicted to be of **negligible** magnitude for the **low** sensitivity intertidal and subtidal habitat, resulting in a **negligible** significance of effect. Over the small area of intertidal mudflat shoreward of the extent of causeway, the predicted accretion has a **moderate** magnitude. Combined with **low** sensitivity, the local area effect is increased to one of **minor** significance. These effects are not considered either beneficial or adverse. Both the estuary wide and local significance of effect are **not significant** in EIA terms.

Further mitigation or enhancement

4.1.27 No significant adverse effects have been predicted and no further mitigation is required.

Temporary habitat loss/disturbance during construction activities and effects on marine ecology receptors

4.1.28 This impact assessment considers effects on marine ecological receptors including intertidal habitats, fish and marine mammals receptors.

4.1.29 Temporary habitat loss/disturbance may occur as a result of navigational dredging (i.e. backhoe or WID) in the vicinity of the proposed causeway, i.e. the vessel grounding pocket at the end of the causeway. Any removal of sediment for the purposes of preparation of the seabed for causeway construction are considered in paragraph 4.2.1 *et seq.*, as long term habitat loss (i.e. beneath the foundation of the causeway structure). The relevant MarESA pressure which best matches this impact on benthic ecology receptors is:

- Habitat structure changes – removal of substratum.

Magnitude of impact

4.1.30 During the construction phase, dredging of the vessel grounding pocket at the seaward end of the causeway will result in the removal of approximately 13,200 m^3 of sediment over a footprint of 6,470 m^2. This will be limited to above Mean Low Water Springs (MLWS) and therefore will affect intertidal habitat habitats only (see Figure 3.7), with no effect on subtidal habitats. Other mobile marine ecological receptors may also be affected (e.g. fish and marine mammals). This area is small in the context of the intertidal mudflat habitats present across the marine ecology study area (i.e. Thames Middle WFD waterbody), representing 0.07% of intertidal soft sediments within the WFD waterbody.

4.1.31 The habitat loss/disturbance related to dredging activities and impact on marine ecology receptors is temporary and reversible, being limited to the construction phase only, with sediments expected to infill the vessel grounding pocket within months to a few years following the construction phase (see paragraph 4.1.18).

4.1.32 The temporary habitat loss impact is predicted to be of local spatial extent, medium term duration, intermittent and reversible following the construction phase. It is predicted that the impact will affect marine ecology receptors directly and indirectly. The magnitude is therefore considered to be **minor**.

Sensitivity of the receptor

4.1.33 The key receptors which are expected to be affected by temporary habitat loss/disturbance during construction activities are, intertidal mudflats, the estuarine fish assemblage and marine mammals.

4.1.34 According to the MarESA, the sensitivity of the LS.LMu.MEst.HedLimScr biotope is medium, based on a low resistance (i.e. dredging will lead to the mortality of characterising species within the dredge footprint) but a high recovery (i.e. full recovery within 2 years; Tillin and Ashley, 2016).

4.1.35 Fish and marine mammal species occurring within the Thames Estuary are likely to avoid construction operations and will therefore not be directly affected by temporary habitat loss effects. However, navigational dredging at the causeway and use of the vessel grounding pocket during construction will result in loss of access to this area to these mobile receptors. However, as outlined in paragraph 4.1.30, the area affected is extremely small in the context of the marine ecology study area (i.e. Middle Thames Estuary WFD waterbody) and there is nothing to indicate that this part of the Thames Estuary is particularly important for fish and marine mammal receptors. Furthermore, following the completion of the construction phase, estuarine fish populations and marine mammals will be able to redistribute into the affected area, with sediments and benthic communities expected to fully recover within a period of 1-2 years.

4.1.36 The intertidal habitats which will be affected by temporary habitat loss effects are considered to be of medium vulnerability, high recoverability and national value. The sensitivity of the receptor is therefore, considered to be **medium**.

4.1.37 Estuarine fish and marine mammal populations within the Thames Estuary are considered to be of low vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

4.1.38 Overall, it is predicted that the **minor** magnitude impact on the **low** to **medium** sensitivity receptors would result in a **minor adverse** effect, which is **not significant** in EIA terms.

Further mitigation or enhancement

4.1.39 No significant adverse effects have been predicted and no further mitigation is considered to be required.

Increases in suspended sediment concentrations and associated deposition during construction activities (including dredging) and effects on water quality and marine ecology receptors

4.1.40 This impact assessment (Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment) considers effects on maritime infrastructure, water quality and marine ecological receptors including intertidal and subtidal habitats, fish and marine mammal receptors.

4.1.41 Dredging operations will result in increases in SSC and associated sediment deposition, which will affect marine ecological receptors and water quality of the Thames Estuary. The relevant MarESA pressures which best match this impact temporary habitat loss and disturbance interactions on benthic ecology receptors are:

- Changes in suspended solids (water clarity); and
- Smothering and siltation rate changes (light).

Magnitude of impact

4.1.42 Capital dredging will be required at the seaward section of the causeway within the vessel grounding pocket. The total dredging and excavation quantities are estimated to be *circa* 16,000 m^3, of which about 3,000 m^3 will be excavated beneath the foundation of the causeway by land-based plant at low states of tide. The method of dredging the berth is yet to be determined, however, the current assessment has assumed WID which is considered a worst case for sediment disturbance. WID seeks to move the sediment from an area through the injection of water and will release material into suspension in the form of a plume.

4.1.43 Realistic dredge rates mean that the 13,000 m^3 of dredging is likely to take around 17 days. Sediment is likely to be dispersed up to 20 km up and down river and over its full width.

4.1.44 The assessment considers that increases in average SSC are unlikely to exceed 10 mg/l greater than 1 km either side of the dredge (against natural background SSC of over 1,000 mg/l; see Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment and paragraph 3.1.28). Isolated 'spikes' in SSC of the order of 100 mg/l above background are likely close to the dredge location during the dredge.

4.1.45 The local plume effects will be transient and considerably less than those for Tilbury2 which were concluded to be a minor adverse effect on the Thames Estuary as presented in Volume 6 Part A of the Tilbury2 ES (Port of Tilbury, 2017).

4.1.46 Any permanent accretion arising from the dredge is likely to occur on the lower intertidal within the 1 km extent, however depths of accumulation will be low (of the order of 1 mm) and therefore unmeasurable against the background sediment transport regime within the estuary.

4.1.47 It is therefore considered that the effects of sediment dispersion from the dredge would not extend to the adjacent maritime infrastructure and therefore there is no pathway to the receptor.

4.1.48 Increases in SSC and sediment deposition during the construction phase is predicted to be of local spatial extent, short term duration, intermittent and reversible, with suspended sediments returning to baseline levels soon after cessation of dredging activity. It is predicted that the impact will affect the water quality directly and marine ecological receptors indirectly. The magnitude is therefore considered to be **negligible**.

Sensitivity of the receptor

4.1.49 The key receptors which are expected to be affected by this impact are, intertidal and subtidal habitats, the estuarine fish assemblage, marine mammals and water quality of the Thames Estuary.

4.1.50 The sensitivities of the relevant intertidal and subtidal habitats (i.e. biotopes) to the pressures outlined in paragraph 4.1.40, according to the MarESA, are presented in Table 4.1. This shows that sensitivity of these habitats to increases in SSC and sediment deposition is low or not sensitive, which reflects that the communities associated with these habitats are typical of an estuarine setting, with naturally high suspended sediments.

Table 4.1: Sensitivity of biotopes to increases in SSC and sedimentation, according to MarESA pressures (De-Bastos and Hiscock, 2016; Tillin and Ashley, 2016; De-Bastos and Hill, 2016)

Biotope	Sensitivity to defined MarESA pressure	
	Changes in suspended solids (water clarity	Smothering and siltation rate changes (light)
LS.LMu.MEst.HedLimScr	Not sensitive	Low
SS.SMu.SMuVS.PolCvol	Low	Low
SS.SMu.SMuVS.AphTubi	Not sensitive	Not sensitive

4.1.51 Estuarine fish and marine mammal receptors are also expected to have limited sensitivity to increases in SSC and associated deposition. In the immediate vicinity of dredging operations, SSC are expected to be high and these receptors would be expected to avoid the immediate vicinity of dredging operations. However, as set out in paragraphs 4.1.43, with increasing distance from the dredging footprint, it would be expected that SSC would be reduced to a level that would not represent a significant shift from the baseline situation.

4.1.52 As outlined in paragraph 3.1.42, prior to 2016, the Middle Thames Estuary was considered to be of good chemical status, although in 2016 this was assessed as a ‘fail’ for priority hazardous substances (i.e. Tributyltin compounds). Increases in SSC will not lead to a deterioration of the water quality of the Thames Estuary, as any increases in SSC will be largely localised to the immediate vicinity of the vessel grounding berth and are expected to reduce to levels reflective of the baseline situation within 1 km from the project footprint. In addition, any increase in SSC will be temporally limited, with any increase expected to return to background levels soon after following cessation of dredging operations.

4.1.53 The intertidal and subtidal habitats which will be affected by increases in SSC and sediment deposition are considered to be of low vulnerability, high recoverability and national value. The sensitivity of the receptor is therefore, considered to be **low**.

4.1.54 Estuarine fish and marine mammal populations within the Thames Estuary are considered to be of low vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be **low**.

4.1.55 The water quality of the Thames Estuary is considered to be of low vulnerability, high recoverability and high value. The sensitivity of this receptor to this impact is therefore considered to be **low**.

Significance of effect

4.1.56 Overall, it is predicted that the **negligible** magnitude impact on the **low** sensitivity receptors would result in a **negligible** effect, which is **not significant** in EIA terms.

Further mitigation or enhancement

4.1.57 No significant adverse effects have been predicted and no further mitigation is considered to be required.

Release of sediment bound contaminants during dredging operations and effects on water quality and marine ecology receptors.

4.1.58 This impact assessment considers effects on water quality and marine ecological receptors including intertidal and subtidal habitats, fish and marine mammal receptors.

4.1.59 Disturbance of sediments during the construction phase may result in the release of sediment bound contaminants, with consequent effects on marine ecology receptors and water quality. MarESA sensitivity assessments for chemical pressures (e.g. metal and hydrocarbon contamination) are not available for the relevant subtidal and intertidal habitats present in the vicinity of the Thurrock Flexible Generation Plant project boundary, however these are available for some of the characterising species. The relevant MarESA pressures which best match the impact temporary habitat loss and disturbance interactions on benthic ecology receptors are:

- Heavy metal contamination; and
- Hydrocarbon contamination.

Magnitude of impact

4.1.60 As outlined in paragraph 3.1.37 *et seq*. and Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review, contaminant levels recorded within the footprint of the causeway were found to be typical for an estuarine environment with low levels of contaminants, particularly for all organotins and polychlorinated biphenyls (PCBs) which were found to be well below Cefas AL1. For metals, only mercury, chromium (both at three locations), and nickel and zinc (both one location only) were found to be above Cefas AL1, with all other metals below the Cefas AL1. For those metals where the Cefas AL1 was exceeded, these were slight exceedances and were well below the Cefas AL2 and the Canadian Probable Effects Level (PEL), the level at which adverse effects frequently occur. In addition, for chromium, two of the three locations had levels which were below the Canadian Threshold Effects Level (TEL), the minimal effect range within which adverse effects rarely occur. For PAHs, most of these were above the Cefas AL1 and/or the Canadian TEL values (where these were available for the individual determinants), however, all were well below Canadian PEL thresholds.

4.1.61 As outlined in paragraph 4.1.42 *et seq*., the volumes of sediment disturbed during the construction phase will be low (i.e. up to a maximum of 16,100 m^3). Plume modelling has shown that SSC will be quickly diluted and dispersed within the Thames Estuary and therefore any contaminants brought into suspension will also be dispersed to levels which are not harmful to marine ecology receptors and water quality.

4.1.62 Where sediments are excavated during low tide periods, the amount of SSC into the water column will be reduced, although as a maximum design scenario, dredging has been assumed to be undertaken using WID. Deposition of intertidal sediment in the lee of the causeway to raise the level of the mudflat will also limit the amount of sediment bound contaminants brought into suspension.

4.1.63 As such, due to the small volume of sediment to be mobilised, the generally low levels of contaminants present in sediments and the high dilution potential of the Thames Estuary (where contaminants are brought into suspension), the impact is expected to be limited in extent and in contaminant levels.

4.1.64 The release of sediment bound contaminants during construction is predicted to be of local spatial extent, short term duration, intermittent and reversible. It is predicted that the impact will affect the receptors directly (water quality) and indirectly (marine ecology receptors). The magnitude is therefore considered to be **minor**.

Sensitivity of the receptor

4.1.65 The sensitivities of some of the characterising species of the intertidal and subtidal biotopes to the pressures heavy metal and hydrocarbon contamination, according to the MarESA, are presented in Table 4.2. This shows that sensitivities to metal contamination range from very low to moderate and sensitivity to hydrocarbon contamination ranges from not sensitive to moderate. As outlined above, the levels of intertidal sediment bound contaminants present in the Thurrock Flexible Generation Plant project area are relatively low and at a level which is tolerable to the species presented in Table 4.2. Any increase in metals or PAH concentrations in the water column due to dredging would be limited and would be quickly diluted and dispersed (see paragraph 4.1.63) to levels which would not have an adverse effect on benthic subtidal and intertidal communities. However, should any adverse effects occur as a result of resuspension of heavy metals or PAHs, the recoverability of these characterising species is medium to high following exposure to these contaminants.

Table 4.2: Sensitivity of biotopes to increases in contaminant concentrations, according to MarESA pressures (Budd, 2008; Budd and Rayment, 2001; Rayment, 2007)

Species	Sensitivity to defined MarESA pressure	
	Heavy metal contamination	***Hydrocarbon contamination***
Ragworm *(Hediste diversicolor)*	Moderate	Low
Baltic tellin *(Limecola balthica)*	Moderate	Moderate
Bristleworm *(Aphelochaeta marioni)*	Very low	Not sensitive

4.1.66 For the estuarine fish assemblage, the sensitivity of the individual species will vary depending on a range of factors including species and life stage. Due to their increased mobility, adult fish (including migratory fish species) are less likely to be affected by marine pollution. Fish eggs and larvae are likely to be particularly sensitive, with potentially toxic effects of pollutants on fish eggs and larvae (Westerhagen, 1988). Effects of heavy metals and PAHs contamination on fish eggs and larvae may lead to effects such as abnormal development, delayed hatching and reduced hatching success (Bunn *et al*., 2000). Any such events will therefore have varying levels of effect dependent on the species present and pollutants involved. However, as outlined above, any sediment bound contaminants would be expected to be dispersed quickly and the proportion of fish habitats affected (e.g. common sole spawning grounds) will be small in the context of these widespread habitats and therefore the level of effect is predicted to be small. Similarly, effects of resuspension of contaminated sediments would be expected to be limited for marine mammals, as their prey species (i.e. adult fish) would be unlikely to be affected.

4.1.67 As outlined in paragraph 3.1.42, prior to 2016, the Middle Thames Estuary was considered to be of good chemical status, although in 2016 this was assessed as a 'fail' for priority hazardous substances (i.e. Tributyltin compounds). For all other priority substances (including heavy metals and PAHs) the chemical status was considered to be good in 2016. As outlined above, the concentrations of some heavy metals and PAHs are elevated above Cefas AL1, although given the small volumes of sediment disturbed during dredging operations for the proposed development and the high potential for dilution (see paragraph 4.1.63), these would not be expected to result in a deterioration of the water quality of the Thames Estuary, particularly given the short term duration of the dredging operations during the construction phase.

4.1.68 The intertidal and subtidal communities which may be affected by resuspension of contaminated sediments are considered to be of low to medium vulnerability, medium to high recoverability and national value. The sensitivity of the receptor is therefore, considered to be **low**.

4.1.69 Estuarine fish and marine mammal populations within the Thames Estuary are considered to be of low vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be **low**.

4.1.70 The water quality of the Thames Estuary is considered to be of low vulnerability, high recoverability and high value. The sensitivity of this receptor to this impact is therefore considered to be low.

Significance of effect

4.1.71 Overall, it is predicted that a **minor magnitude** impact on the **low sensitivity** receptors would result in a **minor adverse** effect, which is **not significant** in EIA terms.

Further mitigation or enhancement

4.1.72 No significant adverse effects have been predicted and no further mitigation is considered to be required.

Underwater noise during construction (e.g. dredging activities) and effects on marine ecology receptors

4.1.73 This impact assessment considers effects on marine ecological receptors with known sensitive to underwater noise, specifically fish and marine mammals receptors.

4.1.74 The potential for noise generated during the construction activities for the proposed development that may affect the marine environment are expected to be limited. The main activities which will introduce noise into the marine environment will be dredging and vessel noise, with potential for effects on the estuarine fish assemblage and marine mammals receptors.

Magnitude of impact

4.1.75 The Thames Estuary is a busy working river, with a number of operational ports throughout the estuary, including Tilbury Docks located immediately adjacent to the marine elements of the Thurrock Flexible Generation Plant. The Tilbury2 Environmental Statement presented measurements of background underwater noise in the vicinity of the proposed development, and showed root mean square (RMS) sound pressure levels of approximately 124 dB re 1 μPa over a 24 hour period, with peaks of over 161 dB re 1 μPa ($SPL_{RMS,\ 10s}$) showing that baseline noise levels vary considerably in this part of the Thames Estuary (Port of Tilbury, 2017).

4.1.76 During the Thurrock Flexible Generation Plant construction phase, the main sources of underwater noise will be dredging for the construction of the causeway and for the vessel grounding pocket at the end of the causeway and vessel movements. These noise sources are received as a low-level chronic exposure (as opposed to acute impulse and intense noises from e.g., piling operations) and can affect marine mammals, fish and shellfish receptors by masking sounds in the sea soundscape (Popper and Hastings, 2009; Richardson *et al.,* 1995). Noise levels associated with dredging are characterised as relatively low frequency broadband noise (i.e. main energy below 1 kHz) and are similar to those associated with a typical merchant vessel (Robinson *et al.,* 2011).

4.1.77 A study which measured noise levels associated with aggregate dredging (Robinson *et al.*, 2011) indicated that one of the major sources of noise from dredging was related to the aggregate material passing through the draghead, pipe and pump, with coarse, gravelly material generating more high frequency noise compared to sand. As such, noise levels associated with dredging are not expected to increase noise levels much beyond the background noise levels (i.e. typical noise levels associated with the neighbouring port area). Furthermore, if dredging is undertaken at periods of low water, this will further limit the potential for increases in underwater noise during dredging operations. Dredging activities associated with construction of the marine elements of the Thurrock Flexible Generation Plant will be short term activities (i.e. over a period of days to weeks; see paragraph 4.1.43) in the context of the overall construction programme of up to six years.

4.1.78 Some increase in underwater noise may also result from the movement of vessels both during dredging operations, but also during the construction phase when barges will be used to deliver abnormal indivisible loads to the causeway, resulting in potential disturbance to marine ecological receptors. There will be up to 60 barge deliveries over the up to six year construction phase and therefore these will represent temporary and short term events during the construction phase. Radiated vessel source sound pressure levels relate to factors including ship size, speed, load, condition, age, and engine type and can range from <150 dB re 1μPa to over 190 dB re 1μPa dB re 1 μPa re 1 m (rms) (McKenna *et al.*, 2012). Underwater noise from barges and dredging vessels will most likely fall within a low frequency spectrum and therefore impact magnitude will be lower than for high speed vessels in terms of masking communications of species which hear within a higher frequency spectrum (Pirotta *et al.,* 2013). This is particularly the case in the context of the baseline underwater noise levels within this part of the Thames Estuary, as set out in paragraph 4.1.75.

4.1.79 The underwater noise impact is predicted to be of local spatial extent, short term duration, intermittent and reversible. It is predicted that the impact will affect marine ecology receptors directly. The magnitude is therefore considered to be **negligible**.

Sensitivity of the receptor

4.1.80 Sound plays an important role for fish and marine mammal species, allowing them to communicate with one another, detect predators and prey, navigate their environment, and avoid hazards. As outlined above, the noise levels associated with dredging and vessel movements during the construction phase are considered to be low in the context of baseline underwater noise levels in the vicinity of the project (e.g. measurements from Tilbury2; Port of Tilbury, 2017). Noise associated with dredging and vessel movements are not expected to lead to injury effects on marine mammals and fish, except where these occur in very close proximity to the noise source for long periods of time (which is unlikely as receptors would be expected to move away from the noise source before injury would occur). As such, effects on marine ecological receptors are expected to be limited to behavioural effects, such as avoidance reactions, masking and changes in behaviour (e.g. swimming or schooling behaviour in fish), particularly for fish, as the frequency range of the expected noise levels are in the most sensitive hearing range for most fish species (i.e. <1 kHz).

4.1.81 Recent peer reviewed guidelines have been published by the Acoustical Society of America (ASA) which provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. For the purposes of this assessment, these Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.,* 2014) were considered to be most relevant for impacts of underwater noise on fish species. For non-impulsive noise (including vessel movement and dredging), Popper *et al.* (2014) considered that there was a moderate to high risk of behavioural effects on fish in the near field (i.e. tens of metres), an intermediate risk of behavioural effects in the intermediate field (i.e. hundreds of metres) and a low risk in the far field (i.e. kms from the source). It should be noted, however, that the response of the fish will depend on the reasons and drivers for the fish being in the area. Foraging or spawning, for example, may increase the desire for the fish to remain in the area despite the elevated noise level. Furthermore, as outlined in paragraph 4.1.76, the noise sources from dredging are expected to be within the range of baseline noise levels for this part of the Thames Estuary and therefore it would be expected that the fish assemblage within the area would have some tolerance to the underwater noise levels predicted from the Thurrock Flexible Generation Plant construction.

4.1.82 With respect to marine mammals, a recent review of evidence of the effect of dredging on marine mammals has indicated that there is limited effect of dredging noise on marine mammals, given many industrial activities occur concurrently. Where behavioural effects may occur, these will be short term behavioural reactions in baleen whales and seals, although these would be temporary and reversible in nature (Todd *et al.,* 2015).

4.1.83 The estuarine fish assemblage and marine mammal receptors are considered to be of low vulnerability, high recoverability and regional value. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

4.1.84 Overall, it is predicted that **negligible magnitude** impact on the **low sensitivity** receptors would result in a **negligible effect**, which is **not significant** in EIA terms.

Further mitigation or enhancement

4.1.85 No significant adverse effects have been predicted and no further mitigation is considered to be required.

Accidental release of pollution (e.g. due to spillage) and effects on water quality and marine ecology receptors

4.1.86 This impact assessment considers effects on water quality and marine ecological receptors including intertidal and subtidal habitats, fish and marine mammals receptors. There is potential for accidental release of pollution during the construction phase of the project, e.g. due to leaks and spills to watercourses and the Thames Estuary with potential effects on these receptors.

Magnitude of impact

4.1.87 The level and severity of any potential pollution effect is entirely dependent on the nature of the pollution incident. As outlined in Volume 2, Chapter 9: Onshore Ecology, there is potential for pollutants to enter the marine environment via watercourses in the vicinity of the main construction site (i.e. Zone A). In addition, there is the potential for accidental release of pollutants directly to the Thames Estuary during construction of the causeway and during the construction phase when barges will be used to deliver abnormal indivisible loads to the causeway. As set out in Table 2.10, measures will be adopted to minimise the risk of pollutants entering watercourses, including the Thames Estuary, and should they occur, to minimise the magnitude of such pollution events. Further details of the pollution control measures are presented in the CoCP (Document A8.6 accompanying the DCO application).

4.1.88 With the implementation of the appropriate control measures, the accidental release of pollution impact is predicted to be of local spatial extent, short term duration, intermittent and reversible. It is predicted that the impact will affect marine ecology receptors directly. The magnitude is therefore considered to be **negligible**.

Sensitivity of the receptor

4.1.89 The sensitivity of water quality and marine ecological receptors to contaminants, including hydrocarbons and heavy metals, is summarised in paragraph 4.1.65 *et seq*. However, due to the implementation of appropriate control measures, the risk of any such pollution events will be minimal.

4.1.90 Marine ecological receptors (including intertidal and subtidal communities, fish and marine mammals) are considered to be of low to medium vulnerability, medium to high recoverability and regional to national value. The sensitivity of the receptor is therefore, considered to be **low**.

4.1.91 The water quality of the Thames Estuary is considered to be of low vulnerability, high recoverability and high value. The sensitivity of this receptor to this impact is therefore considered to be **low**.

Significance of effect

4.1.92 Overall, it is predicted that a **minor magnitude** impact on the **low sensitivity** receptors would result in a **minor adverse** effect, which is **not significant** in EIA terms.

Further mitigation or enhancement

4.1.93 No significant adverse effects have been predicted and no further mitigation is considered to be required.

4.2 Operational and maintenance phase

Long term/permanent habitat loss due to presence of the causeway

4.2.1 This impact assessment considers effects on marine ecological receptors, particularly intertidal habitats, as construction of the causeway across the intertidal will result in the direct loss of saltmarsh and intertidal mudflat habitats. This is considered to be a permanent impact, with the causeway left in place following the construction phase, through the operation and maintenance phase and post decommissioning. The relevant MarESA pressure which best matches this impact on benthic ecology receptors is:

- Physical change (to another seabed type).

Magnitude of impact

4.2.2 The maximum footprint of the causeway in the intertidal zone is predicted to be 5,380 m^2, with approximately 610 m^2 of habitat loss affecting saltmarsh habitats and approximately 4,700 m^2 of habitat loss within the intertidal mudflat habitats. A small amount of intertidal rock (i.e. approximately 70 m^2) will also be lost, although the rock habitat recorded during the Phase 1 intertidal survey (Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review) was anthropogenic in origin and therefore loss of this habitat would not represent a significant change to the baseline situation. The proportions of intertidal mudflat and saltmarsh habitat affected by habitat loss due to the presence of the causeway is small in the context of the available habitat in the Middle Thames Estuary (i.e. 0.06% and 0.05%, respectively, of these habitats in the Middle Thames WFD waterbody).

4.2.3 The long term habitat loss impact is therefore predicted to be of local spatial extent, long term duration, continuous and not reversible. It is predicted that the impact will affect marine ecology receptors directly. The magnitude is therefore considered to be **minor**.

Sensitivity of the receptor

4.2.4 Construction of the causeway across the saltmarsh and intertidal mudflat habitats will lead to a change to the physical structure of these habitats, from soft sediment and vegetated habitats to a rock substrate. The communities within these habitats will be directly affected, with no potential for recovery while the causeway is in place. The causeway will be installed during the construction phase, although will remain throughout the operation and maintenance phase and left in place post decommissioning. As such this will result in a permanent loss of these habitats within the area affected. While the proportion of the habitat affected is small and the habitats affected are not listed as a feature of a designated site (e.g. SSSI, SAC/SPA or MCZ) saltmarsh and intertidal mudflat habitats are important within the Thames Estuary, providing habitat for a range of floral and faunal species, including foraging habitat for intertidal bird species.

4.2.5 The intertidal habitats (i.e. intertidal mudflat and saltmarsh) which will be affected by long term habitat loss effects are considered to be of high vulnerability, with no recovery potential and of high/national value. The sensitivity of the receptor is therefore, considered to be **high**.

Significance of effect

4.2.6 Overall, it is predicted that **minor magnitude** impact on the **high sensitivity** receptors would result in a **minor to moderate adverse** effect. While the extent of the impact is highly localised and would represent only a small proportion of the habitats within the wider area, the habitats affected are high value receptors and therefore the loss of these would represent a significant effect in EIA terms, although only at a local level.

Further mitigation or enhancement

4.2.7 As outlined in paragraph 4.1.15 *et seq*., the presence of the causeway structure will lead to the accretion of sediments on the landward side of it, due to the small reductions in hydrodynamic regime in this area. As sediments build up in the lee of the causeway and the level of the mudflat increases to the level of the saltmarsh (see Section 3 of Volume 6, Appendix 17.1: Phase 1 Intertidal Survey Report and Benthic Ecology Desktop Review), it is expected that pioneer saltmarsh species will colonise the newly accreted mudflats (see Volume 6, Appendix 17.2: Hydrodynamic Modelling and Sediment Assessment). A Saltmarsh Enhancement and Maintenance Plan (application document A8.10) has been developed for the project to encourage the extension of saltmarsh habitats into the mudflats in the lee of the proposed causeway structure, in order to deliver Biodiversity Net Gain, offsetting for the loss of intertidal mudflat and saltmarsh habitats outlined above. This would lead to the extension of saltmarsh habitats beyond the current extents (see Figure 3.7), with up to 11,000 m^2 of saltmarsh habitat potentially becoming established in the lee of the causeway which would compensate for the loss of approximately 5,380 m^2 of intertidal habitat beneath the footprint of the causeway.

Residual effect

4.2.8 The residual effect following further the enhancement of saltmarsh habitats as outlined above, is predicted to be **minor adverse** in the short term (i.e. up to 5 years), as the saltmarsh colonises and develops over the accreting mudflat. However, in the longer term and with the expansion of saltmarsh habitats in the lee of the causeway is expected that effects will be **neutral to minor beneficial**, which is **not significant** in EIA terms.

Changes in flow conditions through the presence of the causeway

4.2.9 This impact assessment considers effects on the physical hydrodynamic regime, seabed sediment receptors and local maritime infrastructure due to the causeway during the operational phase. Direct effects (i.e. habitat loss and disturbance) of construction and operation of the causeway on marine ecological receptors (including intertidal habitats) are considered in paragraph 4.1.28 *et seq*. and paragraph 4.2.1 *et seq.*, respectively.

4.2.10 During the operation of the Thurrock Flexible Generation Plant, the causeway will remain. However, vessels would only be berthing under exceptional circumstances (e.g. for replacement of major components). The assessment, therefore, uses the results of the hydrodynamic runs using the causeway infrastructure only (causeway and vessel grounding pocket).

Magnitude of impact

4.2.11 The modelling results as provided in Volume 6, Appendix 17.2 show that the effects of the causeway without the vessel. This will be the dominant condition during the operation phase. The overall effect will be broadly the same as described above, although the sedimentation with time will increase the flows marginally back to levels similar to the baseline in the area behind the berth as the new equilibrium develops. When the vessel arrives, there will be a temporary local acceleration of flow (up to 0.08 m/s) on the flood tide beneath the vessel, but the reduced flow will remain on the ebb. The maximum extent of change will remain the same as for the construction phase.

4.2.12 The magnitude of change in the estuary flow regime is predicted to be **negligible** with a noticeable change limited within proximity of the causeway. This is a reduced magnitude from the construction phase as a result of less vessel movements and the change back to an equilibrium flow regime.

Sensitivity of the receptor

4.2.13 The sensitivity of the intertidal receptor remains the same as the construction phase and the sensitivity of the intertidal and subtidal substrate to changes in the local flow conditions is considered **negligible.**

Significance of effect

4.2.14 Overall, it is predicted that the **negligible** magnitude of impact on the **negligible** sensitivity intertidal and subtidal receptor will result in a **negligible** significance of effect. This is **not significant** in EIA terms.

Changes in sediment transport processes through the presence of the causeway

4.2.15 This impact assessment considers effects on the physical seabed sediment receptors and local maritime infrastructure due to the causeway during the operational phase. Direct effects (i.e. habitat loss and disturbance) of construction and operation of the causeway on marine ecological receptors (including intertidal habitats) are considered in paragraph 4.1.28 *et seq*. and paragraph 4.2.1 *et seq.*, respectively.

4.2.16 Modelling has shown that there is slightly less potential for sedimentation shoreward without the vessel. However, these effects are unlikely to be noticeable, given the short periods of time and frequency of vessel movements.

Magnitude of impact

4.2.17 The magnitude of impact remains **negligible** from an estuary wide perspective. Locally, the new equilibrium is likely to have developed over the *circa* 5 years of the construction phase, therefore there will be **negligible** further local effect during operation.

Sensitivity of the receptor

4.2.18 As per the construction phase, the sensitivity of the physical intertidal sediments is considered **low**.

Significance of effect

4.2.19 Overall, it is predicted that the **negligible** magnitude of impact on the **low** sensitivity intertidal and subtidal receptor will result in a **negligible** significance of effect both on an estuary wide and local scale. This effect is **not significant** in EIA terms.

Future monitoring

4.2.20 Monitoring of intertidal mudflat and saltmarsh habitats in the lee of the causeway structure would be undertaken following construction of the causeway and implementation of the Saltmarsh Enhancement and Maintenance Plan (application document A8.10). The purpose of this is to determine the level of change to intertidal habitats and to monitor the success of the saltmarsh creation and the rate of expansion of saltmarsh communities into the mudflat (see Saltmarsh Enhancement and Maintenance Plan for further details).

4.3 Decommissioning phase

4.3.1 It is assumed that the causeway would be left in situ in perpetuity and not decommissioned. As such, the effects on marine environmental receptors during the operation and maintenance phase would continue beyond the decommissioning phase.

4.4 Transboundary effects

4.4.1 Screening of transboundary impacts has been carried out and is presented in Volume 6, Appendix 4.1: Transboundary Impacts Screening Note. This screening exercise identified that there was no potential for likely significant transboundary effects with regard to the marine environment from Thurrock Flexible Generation Plant on the interests of other European Economic Area (EEA) States.

4.5 Inter-related effects

4.5.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the construction, operation and maintenance, or decommissioning of Thurrock Flexible Generation Plant on the same receptor. The following assessments have been made and a description of the likely inter-related effects on the marine environment is provided in Volume 5, Chapter 31: Summary of Inter-Related Effects.

Project lifetime effects

4.5.2 Assessment of the potential for effects that occur during more than one stage of the development's lifetime (construction, operation or decommissioning) to interact such that they may create a more significant effect on a receptor than when assessed in isolation for each stage.

Receptor-led effects

4.5.3 Assessment of the potential for effects via multiple environmental or social pathways to interact, spatially and temporally, to create a greater inter-related effect on a receptor than is predicted for each pathway (in its respective topic chapter) individually.

5. Conclusion

5.1.1 The construction, operation and maintenance, and decommissioning of the Thurrock Flexible Generation Plant have been assessed and are summarised in Table 5.1. When considering the estuarine processes, only the causeway and associated vessel movements were identified as having the potential to impact upon estuarine receptors (flow conditions and sediment transport processes). These have been assessed using numerical hydrodynamic modelling and empirical assessments of sediment mobilisation. Existing studies have been used to support assessments of sediment transport and the potential extent of a dredge plume.

5.1.2 The effects of the causeway during construction and operation and maintenance will be insignificant and most likely unmeasurable within the natural variability of the Thames Estuary. All effects of note will remain over the mudflats inshore of the causeway where accretion to a new equilibrium is likely to occur.

5.1.3 Similarly, the majority of impacts on marine ecological receptors and water quality were predicted to be short term, temporary and reversible and therefore not significant in EIA terms. The only exception is the loss of saltmarsh and intertidal mudflat habitats beneath the footprint of the causeway, which would result in irreversible effects on these receptors, which are predicted to be significant in EIA terms. However, the accretion of muddy sediments in the lee of the causeway has the potential to result in the expansion of saltmarsh habitats beyond the current extent, particularly when considering further measures proposed to encourage and enhance this process (e.g. deposition of dredged sediment in the lee of the causeway). As such, with the implementation of these measures, effects will be of minor adverse significance in the short term (i.e. not significant in EIA terms) and in the long term, any losses will be offset through creation of new saltmarsh habitat, with a neutral to minor beneficial effect predicted.

Table 5.1: Summary of potential environment effects, mitigation and monitoring.

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Construction							
Changes in flow conditions through the construction, presence and operation of the causeway may have effects on seabed sediments and maritime infrastructure	n/a	Minor	Negligible	Negligible (not significant in EIA terms)	None	Negligible (not significant in EIA terms)	None
Changes in sediment transport processes through the construction, presence and operation of the causeway may have effects on seabed sediments and maritime infrastructure	n/a	Negligible (Gravesend Reach); Locally moderate	Low	Negligible (Gravesend Reach) or locally minor adverse (not significant in EIA terms)	None	Negligible and locally minor adverse (not significant in EIA terms)	None
Temporary habitat loss/disturbance during construction activities may have effects on marine ecology receptors	n/a	Minor	Low	Minor adverse (not significant in EIA terms)	None	Minor adverse (not significant in EIA terms)	None
Increases in SSC and associated deposition during construction activities (including dredging) may have effects on water quality and marine ecology receptors	n/a	Negligible	Low	Negligible (not significant in EIA terms)	None	Negligible (not significant in EIA terms)	None
Release of sediment bound contaminants during dredging operations may have effects on water quality and marine ecology receptors	n/a	Minor	Low	Minor adverse (not significant in EIA terms)	None	Minor adverse (not significant in EIA terms)	None
Underwater noise during construction (e.g. dredging activities) may have effects on marine ecology receptors	n/a	Negligible	Low	Negligible (not significant in EIA terms)	None	Negligible (not significant in EIA terms)	None
Accidental release of pollution (e.g. due to spillage) may have effects on water quality and marine ecology receptors	Measures relating to pollution prevention (see Table 2.10 in Volume 3 Chapter 17)	Minor	Low	Minor adverse (not significant in EIA terms)	None	Minor adverse (not significant in EIA terms)	None

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Operation and maintenance							
Long term/permanent habitat loss due to presence of causeway	n/a	Minor	High	Minor to moderate (significant in EIA terms)	Measures to encourage expansion of saltmarsh habitat across the intertidal mudflat to offset localised loss of intertidal habitats (see Saltmarsh Enhancement and Maintenance Plan; application document A8.10)	Minor adverse (short term) Neutral to minor beneficial (long term)	Post construction monitoring of saltmarsh habitats (see Saltmarsh Enhancement and Maintenance Plan; application document A8.10)
Changes in flow conditions through the presence of the causeway	n/a	Negligible	Low	Negligible (not significant in EIA terms)	None	Negligible (neither adverse or beneficial)	None
Changes in sediment transport processes through the presence of the causeway	n/a	Negligible	Negligible	Negligible (not significant in EIA terms)	None	Negligible (neither adverse or beneficial)	None

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