national highways

Lower Thames Crossing

6.1 Environmental Statement Chapter 9 – Marine Biodiversity

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Lower Thames Crossing

6.1 Environmental Statement
Chapter 9 – Marine Biodiversity

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9.1 Introduction

9.1.1 This chapter presents the assessment of the likely significant effects of the A122 Lower Thames Crossing ('the Project') on marine biodiversity during construction and operation. The assessment considers marine benthic habitats such as saltmarsh and mudflats; benthic invertebrates; plankton; fish such as flounder and lamprey; and marine mammals such as seals, porpoises and dolphins.

9.1.2 The assessment follows the methodology set out in Design Manual for Roads and Bridges (DMRB) LA 108 Biodiversity (Highways England, 2020a), and relevant guidance including Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in the UK and Ireland (2019).

9.1.3 This chapter is supported by Figures 9.1 to 9.3 (Application Document 6.2) and Appendices 9.1 and 9.2 (Application Document 6.3).

9.2 Legislative and policy framework

9.2.1 This assessment has been undertaken in accordance with relevant legislation and having regard to national and local plans and policies.

9.2.2 Appendix 9.2 sets out how the Applicant has considered and addressed those policies in the NPSs which relate to the assessment of effects considered in this chapter of the Environmental Statement. Policies in the NPSs which relate to decision making in relation to matters of relevance to this topic of the ES are addressed in the Planning Statement (Application Document 7.2).

National policy

9.2.3 Nationally Significant Infrastructure Projects (NSIPs) are determined in accordance with the decision-making framework in the Planning Act 2008 (as amended) and relevant National Policy Statements (NPSs), as well as any other matters that are both important and relevant (which may include the National Planning Policy Framework (NPPF)) (Ministry of Housing, Communities and Local Government, 2021).

9.2.1 The National Policy Statement for National Networks (NPSNN) (Department for Transport, 2014) sets out the Government's policies to deliver NSIPs on the national road and rail networks in England. Modifications to the nationally significant energy infrastructure are required as part of the Project. Four utilities diversions constitute NSIPs in their own right, and therefore the Project will also be assessed against the following energy policy statements:

a. Overarching National Policy Statement for Energy (EN-1) (Department of Energy and Climate Change, 2011a)

b. National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) (Department of Energy and Climate Change, 2011b)

c. National Policy Statement for Electricity Network Infrastructure (EN-5) (Department of Energy and Climate Change, 2011c).

9.2.2 However, the NPSNN forms the 'case-making' basis for the Project, and the need for nationally significant utilities diversions arises solely from the need for the road element of the Project.

9.2.3 The NPPF sets out the Government's planning policies. It provides a framework within which locally prepared plans for housing and other development can be produced.

The NPPF does not contain specific policies for NSIPs. However, the NPPF advises that local authorities' planning policies should take into account NSIPs which are located within their local areas. Paragraph 1.17 of the NPSNN states that the NPS and NPPF are consistent, and paragraph 1.18 explains that the NPPF is an important and relevant consideration, *'but only to the extent relevant to* [the] *project'*.

9.2.4 Appendix 9.2: Marine Biodiversity Legislation and Policy (Application Document 6.3) lists the planning policies at a national level and the Project response.

9.2.5 Further information on the how the application has responded to national planning policies is available in the Planning Statement (Application Document 7.2).

Local policy framework

9.2.6 Consideration has been given to county policies within Kent and Essex, the updated London Plan (GLA, 2021) and local policies relating to Marine Biodiversity within the following local authorities within the study area: Maidstone, Tonbridge and Malling, Gravesham, Thurrock, Havering, and Brentwood. These are outlined in Appendix 9.2: Marine Biodiversity Legislation and Policy (Application Document 6.3) and are considered further within the Planning Statement (Application Document 7.2).

9.3 Assessment methodology

Standards and guidance

9.3.1 The following standards and guidance documents have been used in devising the methodology for data collection and assessment of marine biodiversity impacts:

a. Design Manual for Roads and Bridges (DMRB) LA 108 Biodiversity (Highways England, 2020a)

b. Guidelines for Environmental Impact Assessment (Institute of Environmental Management and Assessment, 2004)

c. Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2019)

d. Marine Monitoring Handbook (Davies *et al*., 2001)

Scope of the assessment

9.3.2 All potential Project-related effect pathways on marine biodiversity receptors have been considered.

9.3.3 No aspects have been scoped out for the assessment of impacts on marine biodiversity as a result of the Project.

9.3.4 This assessment is informed by Chapter 8: Terrestrial Biodiversity; Chapter 5: Air Quality; Chapter 12: Noise and Vibration; Chapter 14: Road Drainage and the Water Environment; Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3) of the Environmental Statement (ES); and the Preliminary Navigational Risk Assessment (Application Document 7.15).

Temporal scope

9.3.5 The environmental assessment uses defined temporal scopes to characterise the duration of potential effects. The temporal scope refers to the time periods over which impacts may be experienced by receptors.

9.3.6 Temporary (short- and medium-term) effects are typically those associated with demolition and construction works, and permanent (long-term) effects are typically those associated with the completed and operational development.

9.3.7 The response of marine ecological receptors to potential impacts can vary temporally. For example, short-term temporal impacts on receptors with relatively short life cycles can result in much greater impacts than on receptors with longer life cycles. As a result, the temporal characteristics of potential impacts has been considered on a receptor-by-receptor basis in the assessment.

Limits of deviation and Rochdale Envelope

9.3.8 The Project's application of the Rochdale Envelope is summarised in Chapter 2: Project Description. The limits of deviation (LOD) for the project (defined in the Draft Development Consent Order (DCO) (Application Document 3.1)) represent an 'envelope' within which the Project would be constructed and have informed the reasonable worst case approach to assessment for the purposes of this chapter. For example, where intertidal habitat loss has been estimated, this is the maximum that may occur as a consequence of the design, and in reality is likely to be less.

Use of the River Thames

9.3.9 Based on the predicted vessel movements associated with the construction of the Project, as outlined in Chapter 2: Project Description, this chapter considers the requirement for assessment of the use of the river and a qualitative assessment has been undertaken. Material supply vessels have been excluded from the preliminary Navigation Risk Assessment (pNRA) (Application Document 7.15), although Project vessels were included. Project vessels are those that would be used for temporary works site investigations and during temporary construction works. The reason for the exclusion of material supply vessels from the pNRA is that the imports would be to existing established facilities. The use of established facilities would not give rise to the use of any vessels or any additional vessel movements that would not otherwise be likely

to occur in the absence of the Project. Therefore, these movements would be in the scope under existing navigational risk assessments of the Port of London Authority (PLA) and any other Statutory Harbour Authority (eg Port of Tilbury London Limited (PoTLL) if movements enter their limits). This position was agreed with the PLA and PoTLL in a meeting on 10 May 2021.

Scoping Opinion

9.3.10 A Scoping Report (Highways England, 2017) was submitted to the Planning Inspectorate on 2 November 2017, setting out the proposed approach to this EIA. A Scoping Opinion was received from the Secretary of State on 13 December 2017, which included comments on the scope of assessment from the Planning Inspectorate and statutory environmental bodies. These comments have been taken into account in the preparation of this chapter, and the Project response is set out in Appendix 4.1: The Inspectorate's Scoping Opinion and Highways England's Responses (Application Document 6.3).

9.3.11 Subsequent to receiving the Scoping Opinion, the proposed programme of monitoring and modelling was further revised and agreed through consultation with the relevant statutory bodies (see Table 9.1).

Consultation

Project consultation

9.3.12 Statutory Consultation under Section 42 of the Planning Act 2008 was undertaken on the Project from 10 October 2018 to 20 December 2018. This provided an opportunity for consultees to comment on the Preliminary Environmental Information Report (PEIR) (Highways England, 2018). A summary of the responses to the Statutory Consultation can be found in the Consultation Report (Application Document 5.1). Consultees comprised prescribed bodies, local authorities, people with an interest in land affected by the Project and local communities.

9.3.13 The Project design continued to be developed, which resulted in changes in the Project. These formed the basis for the Supplementary Consultation, which was undertaken from 29 January 2020 to 2 April 2020. A Design Refinement Consultation was undertaken from 14 July 2020 to 12 August 2020.

9.3.14 A Community Impacts Consultation was undertaken from 14 July 2021 to 8 September 2021. This sought feedback on the impacts of the Project at a local ward level, as well as the mitigation proposed for those impacts. Changes to the Project since the Design Refinement Consultation were also presented, along with a summary of how feedback to earlier consultation had shaped the development of the Project.

9.3.15 Prior to the submission of this DCO application, Local Refinement Consultation was held between 12 May 2022 and 20 June 2022. This provided local communities with the opportunity to comment on proposed refinements to the Project.

9.3.16 These consultations all included information about the environmental impacts associated with the refinements presented for consultation. A summary of the responses to these consultation stages can also be found in the Consultation Report (Application Document 5.1).

Stakeholder engagement

9.3.17 A summary of stakeholder engagement specific to marine biodiversity during the EIA process is provided in Table 9.1.

Table 9.1 Stakeholder engagement

Stakeholder	Date of meeting/ communication	Summary of discussions
Marine Management Organisation	18 October 2018	Presentation of the proposed marine monitoring and modelling programme.
Marine Management Organisation	09 May 2019	Update meeting – discussion around the marine monitoring and modelling programme and the approach to marine licensing. Modelling proposals accepted.
Marine Management Organisation	3 October 2019	Update meeting – discussion around the need for Marine Conservation Zone (MCZ) and Marine Strategy Framework Directive (MSFD) assessments and the incorporation of dewatering discharges/structures in the Project design. Agreement that MCZ and MSFD assessment not required.
Marine Management Organisation	29 January 2020	Update meeting – provision of more detail around the proposed dewatering discharges/structures in the Project design.
Marine Management Organisation	2 April 2020	Update meeting – outlined programme for draft Deemed Marine Licence submission.
Marine Management Organisation	28 April 2020	Update meeting – informed Marine Management Organisation (MMO) of decision not to include a new jetty option and tabled a number of queries around the tunnel exemption and the potential need to include tunnel construction/operation in the Deemed Marine Licence (DML).
Marine Management Organisation	2 July 2020	Draft Deemed Marine Licence discussion meeting.
Marine Management Organisation	3 February 2021	Update meeting – outlined DCO re-submission programme, action to develop Navigational Risk Assessment and draft Deemed Marine Licence submission timelines.
Marine Management Organisation	29 March 2021	Informed MMO that the Project jetty had now been removed from the Order Limits, with no intertidal works to the west of the tunnel alignment.
Marine Management Organisation	3 November 2021	DML update call – MMO's comments on the DML updated.
Marine Management Organisation	22 February 2022	DML update call – MMO's comments on the DML updated. Agreed the proposed amendments for inclusion in the DCO.

Stakeholder	Date of meeting/ communication	Summary of discussions
Natural England	9 October 2019	General update on the marine elements of the Project, and implications in terms of designated sites.
Natural England	1 June 2020	Meeting with Environment Agency and Natural England to discuss WFD marine compensatory habitat proposals.
Environment Agency	1 June 2020	Meeting with Environment Agency and Natural England to discuss WFD marine compensatory habitat proposals.
Port of London Authority	02 May 2018	Presentation of proposed baseline marine modelling and monitoring data collection.

Study area

9.3.18 The study area for Marine Biodivesity is illustrated in Figure 9.1 (Application Document 6.2).

Construction

9.3.19 The construction study area was determined in consultation with the MMO and includes an area extending 11km both up and downstream of the Order Limits to account for the movement of water and sediments within an average tidal excursion and is confined to the area below mean high water springs. The area above this point is covered in Chapter 8: Terrestrial Biodiversity. The extent of the construction study area is presented in Figure 9.1: Nationally and internationally designated sites within 11km of the Order Limits (Application Document 6.2).

9.3.20 Owing to the transient nature and mobility of certain marine receptors, notably fish and marine mammals, the review has considered the full extent of the tidal Thames (from Teddington Lock in the west, to Sheerness in the east) as being an important area for mobile species. This allows a full assessment of effects on these species and represents a worst case. The review has explored possible links to populations from distant protected areas, including Special Areas of Conservation (SACs) that have been designated for Annex II species, i.e., the Southern North Sea SAC, which is approximately 90km to the east.

Operation

9.3.21 Operational effects would be limited to the immediate vicinity of the tunnel crossing and portal areas, and as such the construction study area is considered adequate to inform the assessment of operational effects. This is because of the small-scale nature of the proposed marine design elements, and the significant and rapid dilution and dispersion capacity of the River Thames in the vicinity of the proposed drainage discharges.

Impact assessment methodology

9.3.22 The assessment follows the general approach described in Chapter 4: EIA Methodology. This section provides topic-specific information regarding the methodology used for establishing the baseline conditions, and the methods used for the construction and operational phase assessments.

Method of establishing baseline conditions

Existing baseline

9.3.23 The existing baseline in relation to marine biodiversity was established based on data collection, consultation, modelling studies and site surveys.

Desk-based studies

9.3.24 A desk-based review of the following data sources has been undertaken to determine the baseline conditions across the Project study area:

a. The Department for Environment, Food and Rural Affairs (Defra) Multi-Agency Geographic Information for the Countrfyside (MAGIC) tool

b. Zoological Society of London (ZSL) data and reports

c. Environment Agency (and predecessor) data and reports

d. Tidal Thames Habitat Action Plan (Thames Estuary Partnership Biodiversity Action Group, 2002)

e. Benthic Ecology of the Thames Estuary (ABPmer Marine Environmental Research Ltd, 2007)

f. London Gateway Container Terminal Environmental Statement (DP World, 2006)

g. Thames Estuary 2100 (TE2100) plan (Environment Agency, 2012)

h. Tilbury2 ecology and assessment reports (Thomson Ecology, 2017)

i. Environmental Statement for Proposed Port Terminal at former Tilbury Power Station, Tilbury2 (Port of Tilbury London Ltd, 2017)

j. Thames Tideway Tunnel Jetty (East Tilbury) ecology reports (Physalia, 2017)

k. Clean Safe Seas Environmental Monitoring Programme (CSEMP) (formerly known as the National Marine Monitoring Programme) (Natural Environmental Research Council, 2018)

l. UK Biodiversity Action Plan list, Section 41 of the Natural Environment and Rural Communities Act 2006) (NERC Act 2006)

m. Thames Tideway Tunnel Environmental Statement (Thames Water Utilities Ltd 2013)

n. RWE unpublished data (2008 to 2018)

o. The London Resort, Preliminary Environmental Information Report (July 2020)

Fieldwork

9.3.25 The extent of existing baseline data for the area allowed the fieldwork for the Project to be concentrated on specific areas. A summary of existing data and proposed survey programme was agreed with the Environment Agency and MMO prior to any data collection.

9.3.26 Benthic macroinvertebrate samples were collected as part of a marine ground investigation programme in 2019. The data was used to supplement recent studies completed in this area (RWE, 2018), to help improve the Project's understanding of the quality of the benthic habitats and communities in and adjacent to the Order Limits.

9.3.27 The field data was also used to improve the understanding of the presence of the protected tentacled lagoon worm *Alkmaria romijni* in the vicinity of the Order Limits.

9.3.28 The results are presented in Section 9.4.

Modelling

9.3.29 Modelling has been used to predict underwater noise levels associated with construction (arising from use of the tunnel boring machines (TBMs)) of the Project. The resulting underwater noise levels have been compared against known injury and disturbance thresholds for fish, marine mammals and invertebrates to assess the potential for significant effects. These results are presented in Section 9.6.

9.3.30 The need for other modelling, such as hydrodynamic and sediment transport modelling, was discussed with the MMO and it was agreed that it would not be required. This is because the scope and scale of the marine works is such that there is a limited footprint of works in intertidal and subtidal areas with no dredging operations, and therefore modelling was not considered to be necessary.

Future baseline ('Without Scheme' scenario)

9.3.31 It is likely that the extent and distribution of the marine ecological receptors would remain largely the same as at present in a 'Without Scheme' scenario. However, developments such as Tilbury2, Thurrock Flexible Energy Plant and The London Resort have the potential to affect existing hydrodynamic and sedimentation patterns in the River Thames adjacent to the Order Limits.

9.3.32 Although Tilbury2 and the Thurrock Flexible Energy Plant developments have the potential to directly and indirectly affect benthic infauna and fish receptors, assessments determined that changes to marine communities would likely be minor or negligible. The design attributes of The London Resort proposal have yet to be fully assessed, however they do have the potential to affect benthic infauna and fish receptors. Due to the scale of the proposal and the proposed mitigation (The London Resort, PEIR, 2020), it is likely that there would be some local minor or negligible impacts on marine receptors. Therefore, populations in the vicinity of the Order Limits would likely remain the same.

Determining significance of effects

9.3.33 As described in Chapter 4: EIA Methodology, the significance of environmental effects was determined by taking into account the value (sensitivity) of the receptor and the magnitude of the impact.

9.3.34 Data from desk-based studies and field survey has been used to characterise the marine ecological receptors that have the potential to be affected by the Project. Survey procedures followed guidance methods outlined in the Marine Monitoring Handbook (Davies *et al*., 2001).

9.3.35 A source-pathway-receptor approach has been used to provide a logical approach to identify potentially significant effects. Each activity was considered in turn to determine the potential sources (origins) of an effect. The pathway (the means by which the effect could reach a receptor) was then determined, for example, changes to water quality from land drainage and dewatering (land drainage and dewatering are the sources, and the change in water quality is the pathway).

9.3.36 The assessment draws on baseline data and specifically considers the effects in relation to published thresholds and criteria or defined guidelines (e.g. for sediment quality or noise parameters) as discussed in Section 9.6: Assessment of likely significant effects.

9.3.37 Ecological Impact Assessment is a form of EIA used for ecological receptors. In assessing the effects of the Project, it is necessary to define the ecological receptors likely to be affected, the level of impact and the significance of the effect on the receiving environment. The approach used in this chapter follows the DMRB LA 108 Biodiversity (Highways England, 2020a) guidelines. In making this assessment, the following definitions have been used:

a. The ecological receptor is defined as the habitat, species, ecosystem and their functions/processes that may be influenced by the effect.

b. The activity is defined as the potential source of an effect (e.g. construction of drainage discharge).

c. The effect represents the change to the environment, which can then influence a receptor (e.g. loss of habitat).

d. The impact represents actions resulting in changes to the ecological receptor (e.g. direct mortality of species).

e. The value of the receptor refers to its importance in terms of ‘nature conservation value’ or its economic/recreational importance to a community, e.g. commercial or recreational fishery.

f. The influence of the effect on the receptor is defined as the level of impact, e.g. permanent loss of a species in an environment. The level of impact can be positive or adverse and is quantified where possible (e.g. area, intensity and volume). The level of impact is assigned using this information and professional judgement.

g. The significance of effect is a function of the importance of the receptor and the predicted level of impact.

9.3.38 The following paragraphs set out the importance and level of impact criteria used in this assessment, based on DMRB LA 108 Biodiversity. Significance of effect was then determined using the matrix approach shown in Table 4.3 of Chapter 4: EIA Methodology.

9.3.39 The assessment of significance undertaken in this chapter is used as the basis for identifying effects which are considered significant in the context of the Town and Country Planning (Environmental Impact Assessment) Regulations 2011.

Defining value/importance of resources and/or receptors

9.3.40 The value (importance) of the identified receptors/resources was determined using the criteria shown in Table 9.2. These criteria have regard to the CIEEM guidelines (2019) and DMRB LA 108 (Highways England, 2020a) and have had marine-specific elements added. They are supported by the use of professional judgement and where this applied, justification for the assigned value is provided within the text.

Table 9.2 Criteria for determining the value (sensitivity) of marine ecological receptors

Importance	Criteria
International or European importance	European sites: • Sites of Community Importance • Special Protection Areas (SPAs) • Potential Special Protection Areas (pSPAs) • SACs • Candidate or possible SACs (cSACs or pSACs) • Wetlands of International Importance (Ramsar sites) • Water Framework Directive (WFD) water bodies Biogenetic Reserves, World Heritage Sites (where recognised specifically for their biodiversity value) and Biosphere Reserves. Areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such. Resident or regularly occurring populations of species which can be considered at an international or European level where any of the following apply: • The loss of these populations would adversely affect the conservation status or distribution of the species at an international or European scale. • The population forms a critical part of a wider population at this scale. • The species is at a critical phase of its lifecycle at an international or European scale.
UK or national importance	Sites including: • Sites of Special Scientific Interest (SSSIs) • National Nature Reserves (NNRs) • National Parks • Marine Protected Areas including MCZs • Areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such.

Importance	Criteria
	Habitats including: • Areas of UK Biodiversity Action Plan priority habitats • Habitats included in the relevant statutory list of priority species and habitats. (The species are listed in accordance with the requirements of Section 41 of the NERC Act 2006.) • Areas of irreplaceable habitats including: – Ancient woodland – Ancient or veteran trees – Blanket bog – Limestone pavement – Sand dunes – Salt marsh – Lowland fen • Areas of habitat which meet the definition for habitats listed above but which are not themselves designated or listed as such. Resident, or regularly occurring, populations of species which can be considered at a UK or national level where any of the following apply: • The loss of these populations would adversely affect the conservation status or distribution of the species at a UK or national scale. • The population forms a critical part of a wider population at this scale. • The species is at a critical phase of its life cycle at a UK or national scale.
Regional	Designated sites (non-statutory) including heritage coasts. Areas of habitats identified (including for restoration) in regional plans or strategies (where applicable). Species including resident, or regularly occurring populations of species which can be considered at an international European, UK or national level where any of the following apply: • The loss of these populations would adversely affect the conservation status or distribution of the species at a regional scale. • The population forms a critical part of a wider regional population. • The species is at a critical phase of its life cycle. Species identified in county or equivalent authority area plans or strategies.
County or equivalent authority importance	Wildlife/nature conservation sites designated at a county (or equivalent) level including: • Local Wildlife Sites • Local Nature Reserves (LNRs) • Sites of Importance for Nature Conservation (SINCs) • Sites of Nature Conservation Importance (SNCIs) • County Wildlife Sites (CWSs) Areas of habitats identified in county or equivalent authority plans or strategies (where applicable). Species including resident, or regularly occurring populations of species which can be considered at an international, European, UK or national level where any of the following apply:

Importance	Criteria
	• The loss of these populations would adversely affect the conservation status or distribution of the species at a county or unitary authority scale. • The population forms a critical part of a wider county or equivalent authority area population, e.g. metapopulation. • The species is at a critical phase of its life cycle. Species identified in county or equivalent authority area plans or strategies.
Local importance	Wildlife/nature conservation sites designated at a local level including: • Local Wildlife Sites • Local Nature Reserves (LNRs) • Sites of Importance for Nature Conservation (SINCs) • Sites of Nature Conservation Importance (SNCIs) Areas of habitats considered to appreciably enrich the habitats resource within the local context including features of importance for migration, dispersal, or genetic exchange. Populations/communities of species considered to appreciably enrich the habitat resource within the local context including features of importance for migration, dispersal or genetic exchange.

Defining level of impact

9.3.41 The magnitude of impact on receptors/resources was determined using the criteria outlined in Table 9.3 and follows DMRB LA 108 guidelines (Highways England, 2020a), with marine-specific definitions also given.

Table 9.3 Criteria for determining the magnitude of impacts for marine ecological receptors

Magnitude of impact (change)		Description
Major	Adverse	• Permanent/irreversible damage to a biodiversity resource. • The extent, magnitude, frequency, and/or timing of an impact negatively affects the integrity or key characteristics of the resource.
	Beneficial	• Permanent addition of, improvement to, or restoration of a biodiversity resource. • The extent, magnitude, frequency, and/or timing of an impact positively affects the integrity or key characteristics of the resource.
Moderate	Adverse	• Temporary/reversible damage to a biodiversity resource. • The extent, magnitude, frequency, and/or timing of an impact negatively affects the integrity or key characteristics of the resource.
	Beneficial	• Temporary addition of, improvement to, or restoration of a biodiversity resource. • The extent, magnitude, frequency, and/or timing of an impact positively affects the integrity or key characteristics of the resource.

Magnitude of impact (change)		Description
Minor	Adverse	• Permanent/irreversible damage to a biodiversity resource. • The extent, magnitude, frequency, and/or timing of an impact does not affect the integrity or key characteristics of the resource.
	Beneficial	• Permanent addition of, improvement to, or restoration of a biodiversity resource. • The extent, magnitude, frequency, and/or timing of an impact does not affect the integrity or key characteristics of the resource.
Negligible	Adverse	• Temporary/reversible damage to a biodiversity resource. • The extent, magnitude, frequency and/or timing of an impact does not affect the integrity or key characteristics of the resource.
	Beneficial	• Temporary addition of, improvement to, or restoration of a biodiversity resource. • The extent, magnitude, frequency, and/or timing of an impact does not affect the integrity or key characteristics of the resource.
No change		No observable impact, either positive or negative.

Methodology for assessing impact significance

9.3.42 Where an impact was identified, the level of significance of an effect was determined using the matrix outlined within DMRB LA 108 (Highways England, 2020a) as described in Chapter 4 and shown in Table 9.4. This matrix accounts for the level of impact in relation to the importance of receptors using an evidence-based approach.

Table 9.4 Significance matrix

		Level of impact				
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
Resource importance	International or European	Neutral	Slight	Moderate or large	Large or very large	Very large
	National	Neutral	Slight	Slight or moderate	Moderate or large	Large or very large
	Regional	Neutral	Neutral or slight	Slight	Moderate	Moderate or large
	County	Neutral	Neutral or slight	Neutral or slight	Slight	Slight or moderate
	Local	Neutral	Neutral	Neutral or slight	Neutral or slight	Slight

9.3.43 The assessment has taken into account embedded and good practice mitigation. The assessment reported in Section 9.6 assumes the implementation of all these mitigation measures, which are summarised in Section 9.5, to determine residual effects.

Assumptions and limitations

9.3.44 General assumptions used throughout the ES, and limitations affecting the assessments, are set out in Chapter 4: EIA Methodology. Relevant assumptions and any other limitations encountered during the Marine Biodiversity assessment are as described below. Acknowledging the assumptions and limitations identified below and in Chapter 4: EIA Methodology, the ES is considered robust and in line with relevant legislation, policy, and guidance.

9.3.45 There are limitations associated with the use of survey data from estuarine and marine environments due to the characteristics of receptors, many of which are highly mobile with distributions that vary spatially and temporally. There is natural variability in the distribution of habitats and species in the Thames Estuary, which are influenced by a multitude of factors such as salinity, temperature, hydrodynamic patterns and sediment transport. To account for this, desk-based data has been used to supplement field data and larger study areas were assessed where highly mobile species could be affected.

9.3.46 There are limitations associated with the predictions of underwater noise effects (e.g. the extent of transmission through the bedrock and superficial sediments into the overlying water column) as this requires assumptions to be made in relation to the noise source, background levels, nature (e.g. continuous or intermittent) and duration. The assessment has taken a precautionary approach by assessing worst-case noise levels which could result in an overestimation of the effect.

9.3.47 The DCO application has been developed on the basis of a 2030 opening year. This assumes consent is granted in 2024. Following the grant of development consent, there would be preparatory works, referred to in the draft DCO as preliminary works taking place in 2024. The main construction period for Project would start in early 2025, with the road being open for traffic in late 2030. Construction may take approximately six years, but as with all large projects there is a level of uncertainty over the construction programme, which will be refined once contractors are appointed and as the detailed design is developed. The 2030 opening year has been selected as the basis for the assessments and is representative of the reasonable worst-case scenario. This has been used consistently across the environmental assessments, transport assessments and the economic appraisal of the Project.

Nitrogen deposition compensation sites

9.3.48 The DCO application documents identify the locations of habitat creation sites proposed as compensation for the effects of nitrogen deposition. Consideration of these sites is not relevant to this chapter due to a lack of pathways to effects on marine biodiversity receptors. Assessment of these sites has therefore been excluded from the scope of this Chapter.

Assumptions on future trends

9.3.49 Future trends in relation to climate change have not been considered for marine ecological receptors because long-term effects associated with operation of the Project are not anticipated due to the lack of effect pathways to marine ecological receptors. Given the absence of pathways, community changes relating to coastal squeeze and increased water temperatures in the Thames Estuary which may result from changes in the climate, have not been considered in the assessment.

9.4 Baseline conditions

Existing baseline

9.4.1 The baseline conditions for the marine biodiversity study are described from south to north of the Order Limits.

Designated sites

European designated sites

9.4.2 The nearest SAC with a marine interest feature that could be directly affected by the marine works is the Southern North Sea SAC, which is approximately 90km to the east. This site is designated for harbour porpoise, individuals of which frequent the Thames Estuary.

9.4.3 Indirect effects such as loss of supporting habitats and food resources have been assessed for these mobile receptors, as well as others (such as birds that are components of other designated sites). Other designated sites are included in the assessment based on their locality within the average tidal excursion of the Thames Estuary, i.e. within 11km of the Order Limits, in order to take account of any effects which may occur as a result of hydrodynamic connectivity (Figure 9.1: Nationally and internationally designated sites within 11km of the Order Limits (Application Document 6.2)).

9.4.4 The Thames Estuary and Marshes SPA (and Ramsar site) (1.2km downstream of the Project's marine elements) is designated for a number of overwintering and on-passage bird populations, including an assemblage of overwintering waterfowl. These birds are reliant on mudflat and saltmarsh habitats that extend for 15km along the estuary including an area within the Order Limits.

9.4.5 Designated sites with bird interest features that are reliant upon marine habitats (e.g. saltmarsh and mudflats) within the estuary, namely SPAs and Ramsar sites are specifically assessed in Chapter 8: Terrestrial Biodiversity. To help inform that assessment, cognisance was taken of the discussions in this chapter concerning intertidal habitats, benthic invertebrates and the physical environment.

9.4.6 Table 9.5 summarises the European designated sites and their qualifying ecological features that have been considered in the assessment.

Table 9.5 European designated sites and their qualifying features

Designated site	Important ecological feature (qualifying feature of designated site)
Southern North Sea SAC	• Harbour porpoise (*Phocoena phocoena*). This site supports approximately 17.5% of the harbour porpoise present in the North Sea Management Unit and persistently contains densities of porpoises which are within the top 10% of those for the Management Unit (Joint Nature Conservation Committee, 2019).
Thames Estuary and Marshes Ramsar site	Key ecological features: • Saltmarsh • Grazing marsh • Floodplain grazing marsh and ditches • Saline lagoons • One endangered plant species; 14 nationally scarce wetland plant species • 20 Red Data Book invertebrates • Over winter: dunlin *Calidris alpina*, red knot *Calidris canutus*, grey plover *Pluvialis squatarola*, redshank *Tringa totanus* • On passage: ringed plover *Charadrius hiaticula* and black-tailed godwit *Limosa limosa* Assemblage of 45,118 waterfowl over winter.
Thames Estuary and Marshes SPA	This site qualifies under Article 4.1 of the Directive (79/409/EEC) by supporting populations of avocet *Recurvirostra avosetta* and hen harrier *Circus cyaneus* over winter. This site also qualifies under Article 4.2 of the Directive by supporting populations of ringed plover *Charadrius hiaticula* on passage and over winter. Also qualifies by regularly supporting at least 20,000 waterfowl.

National sites

9.4.7 The Swanscombe MCZ is situated approximately 7.5km upstream of the Order Limits and is designated as an important area for intertidal mud and the nationally rare tentacled lagoon worm *Alkmaria romijni*, which has been recorded at several locations along the north and south shore (mainly the south) within the MCZ boundary. This species is found in intertidal and subtidal soft sediments and is sensitive to changes in habitat.

9.4.8 Due to the distance and lack of pathways to impact on MCZ features, it has been agreed with the MMO that an MCZ assessment is not required to consent the activities of the Project. For completeness, the designated elements of the MCZ are still considered in the assessment of effects presented in Section 9.6.

9.4.9 The South Thames Estuary and Marshes SSSI (less than 1.5km south-east of the Order Limits) has been designated for its importance as an estuarine habitat. The site consists of an extensive mosaic of grazing marsh, saltmarsh and mudflats. The site supports outstanding numbers of waterfowl with many species present in nationally important numbers and some species in internationally important numbers. The breeding bird community is of interest. The diverse habitats within the site support a number of nationally rare and scarce invertebrate species and an assemblage of nationally scarce plants; for example, the Allhallows region of the site has areas of vegetated shingle with the nationally scarce sea kale *Crambe maritima* present. The mudflats support eelgrass beds including *Zostera angustifolia* and *Z. noltii*.

9.4.10 The Mucking Flats and Marshes SSSI (approximately 2km downstream of the Order Limits) contains extensive stretches of mudflats and saltmarsh, along with sea wall grassland. It is internationally and nationally important for wintering wildfowl and waders. The mudflats constitute the largest intertidal feeding area for wintering wildfowl and waders west of Canvey Island on the north bank of the Thames. There is a type of high-level saltmarsh present which is uncommon in Essex. The vegetation is dominated by sea couch *Elymus pycnanthus* and sea purslane *Halimione portulacoides*. The saltmarsh has high invertebrate interest.

9.4.11 Holehaven Creek SSSI (approximately 11km downstream of the Order Limits) contains intertidal mudflats and saltmarsh habitats which support internationally and nationally important numbers of black-tailed godwit *Limosa limosa islandica*. There are two of the three types of basic saltmarsh communities present, which are characteristic of south-east and east England saltmarsh communities.

9.4.12 West Thurrock Lagoon and Marshes SSSI (approximately 9km upstream of the Order Limits) is one of the most important sites for wintering waders and wildfowl on the Inner Thames Estuary. It contains extensive intertidal mudflats. Stone Ness saltmarsh is notable for the size and character of its high marsh plant community.

9.4.13 The Swanscombe Peninsula SSSI was designated in March 2021, and as such has been scoped into the assessment of effects. The site is situated approximately 7km upstream of the Order Limits and is designated as an important area which supports a unique mosaic of habitats and species. These include coastal and estuarine habitats such as intertidal muds, and protected species such as the tentacled lagoon worm.

9.4.14 Table 9.6 summarises the nationally designated sites and their qualifying ecological features that have been considered in the assessment.

Table 9.6 Nationally designated sites and their qualifying features

Designated site	Important ecological feature (qualifying feature of designated site)
Swanscombe MCZ	Tentacled lagoon worm *Alkmaria romijni* Intertidal mud
South Thames Estuary and Marshes SSSI	Outstanding numbers of waterfowl regularly exceeding 20,000 including redshank *Tringa totanus*, knot *Calidris canuta* and dunlin *Calidris alpina*. Supporting marine habitats, including mudflats and saltmarsh.
Mucking Flats and Marshes SSSI	Wintering wildfowl and waders in nationally and internationally important numbers, including ringed plover *Charadrius hiaticula*, shelduck *Tadorna tadorna*, and grey plover *Pluvialis squatarola*. Supporting marine habitats, including mudflats and saltmarsh.
Holehaven Creek SSSI	Nationally important numbers of black-tailed godwit *Limosa limosa islandica*, and over 8,000 waterfowl. Supporting marine habitats, including mudflats and saltmarsh.
West Thurrock Lagoon and Marshes SSSI	Nationally important numbers of waders, also regularly used as a low tide roost by migrant common tern *Sterna hirundo*, black tern *Chlidonias niger* and Arctic tern *Sterna paradisaea.* Supporting marine habitats, including extensive intertidal mudflats and saltmarsh.
Swanscombe Peninsula SSSI	Mosaic of important terrestrial and estuarine habitats, including intertidal mud Tentacled lagoon worm

Designated sites summary

9.4.15 The Southern North Sea SAC, Thames Estuary and Marshes Ramsar and the Thames Estuary and Marshes SPA are considered to be of **European importance**. The Swanscombe MCZ and five SSSI designations (Table 9.6) are considered to be of **national importance.**

Physical environment

9.4.16 The Thames Estuary extends from Teddington Weir in the west, to the seaward limit in the east, the latter being defined by a straight line between Havengore Creek in Essex to Warden Point in Kent.

9.4.17 The estuary in the vicinity of the Order Limits has a width of approximately 900-1,000m. At low water, intertidal mud/sand flats are exposed both on the northern and southern shores. The depth of the main channel in this area ranges between 13-14m below chart datum.

9.4.18 The Thames Estuary is macrotidal with a mean spring tide range of 5.2m at Sheerness, which gradually increases upstream to 5.9m at Tilbury and 6.6m at London Bridge. Maximum tidal flow speeds in the vicinity of the Order Limits are reported to be in the region of $2ms^{-1}$, approximately two hours after high water on spring tides. Minimum flow speeds are reported in the region of $0.1\text{-}0.75ms^{-1}$ as low water approaches (RWE, 2012). Actual tides and flows can prove to be highly variable, with strong winds and prolonged periods of heavy rainfall affecting predictions.

9.4.19 The average tidal excursion in the lower reaches of the estuary is approximately 10-11km (13-14km on spring tides), with a summer average net daily seaward movement of approximately 1-2km (RWE, 2012).

Physico-chemical water quality

9.4.20 Freshwater input to the estuary at Teddington Weir averages 800 million litres per day though it may fall as low as 200 million litres during periods of low flow and much greater during periods of high rainfall. Significant freshwater flows enter the estuary via wastewater effluent streams from the major sewage treatment works at Beckton and Crossness.

9.4.21 The estuary is considered to be a fully mixed water body, and as such salinity progressively increases with distance from Teddington. The location where salinity reaches full seawater is heavily dependent on time of year and freshwater flows into the estuary.

9.4.22 Environment Agency data recorded at Gravesend gave a mean salinity value of 17.69 with a standard deviation of 3.91. The lowest salinity values recorded were 6.68 and the highest 24.07.

9.4.23 Suspended solids loading in the Thames Estuary is influenced by factors such as location in the estuary, state of tide, freshwater flows and degree of mixing. In a HR Wallingford study for the Port of London Authority (PLA) (undated(a)) suspended solids concentrations were measured downstream of Gravesend Reach. A marked concentration gradient was observed with spring tide near-bed levels up to 2,000mg/l in Lower Hope Reach decreasing to 1,000mg/l at Coryton and 100mg/l at Southend-on-Sea. Levels at Lower Hope Reach reached up to 500mg/l on neap tides, again with lows of less than 100mg/l at

Southend-on-Sea. A vertical gradient was also evident; bed concentrations at high water were an order of magnitude greater than mid-depth concentrations. Concentrations at other states of the tide were several times higher.

9.4.24 Surface water temperature in the estuary varies between 6 and 20ºC and is highly dependent on the time of year and the freshwater flows entering the estuary (Crane, 2006).

9.4.25 Levels of dissolved oxygen in the estuary are highly variable and are primarily influenced by the freshwater and sewage effluent inputs and temperature. The rate of oxygen consumption increases during the summer months when temperatures are at their highest and can increase during periods of heavy rainfall when combined sewer overflow events discharge large volumes of dilute, nutrient-rich, untreated sewage effluent into the tideway (Crane, 2006).

Chemical water quality

9.4.26 Environment Agency water quality data for the area off Gravesend close to the Project has been obtained, with samples taken between 1995 and 2018 at approximately monthly intervals (sampling dates and number of samples differed between years) (Environment Agency, 2018a).

9.4.27 Suspended solids concentrations ranged from very turbid to clear, although the overall average concentration was 113.7mg/l, which corresponds to a turbid classification.

9.4.28 This long-term dataset shows that some of the specific pollutant/priority substances tested for are at levels exceeding or approaching WFD Environmental Quality Standard (EQS) limits.

9.4.29 The maximum reported dissolved concentration of mercury was 0.38µg/l which is higher than the maximum allowable concentration EQS of 0.07µg/l (average mercury concentrations were 0.03µg/l). Maximum lead concentrations (13.4µg/l, dissolved) were very close to the 14µg/l maximum allowable concentration (average concentrations of lead were 0.47µg/l, which is less than the annual average EQS). The average zinc concentration over the monitoring period was 17.50µg/l (dissolved), which is higher than the long-term EQS value of 6.8µg/l (without the background concentration of 1.1µg/l added). Average cadmium concentrations were 0.08µg/l (dissolved), which is below the annual average EQS of 0.2µg/l.

9.4.30 Cyanide concentrations were well over the 0.5µg/l EQS, with maximum reported concentrations of 500µg/l (it is unclear whether these high values are errors in reporting units). Various polyaromatic hydrocarbons (PAHs) reported maximum concentrations that exceeded the relevant EQSs; these included benzo(b)fluoranthene, benzo(g,h)perylene and benzo(k)fluoranthene.

9.4.31 The Environment Agency dataset is a reflection of the urbanised/industrialised nature of the lower Thames Estuary. Some of the substances reported are persistent in the environment and bioaccumulate in organisms, which can pose a risk to health and fecundity.

Sediment quality

9.4.32 Sediment transport in the Thames Estuary is complex. Modelling of fine sediment transport in the estuary downstream of Gravesend found a net spring and neap tide sediment flux out of the estuary (i.e. export of sediment). The model also showed that tidal currents transported the majority of the sediment with negligible wave influence (HR Wallingford, 2002).

9.4.33 Mean sediment particle size becomes markedly smaller in the inner estuary. Mucking Flats are typified by mud sediments, whereas Blyth Sands are muddy towards the high-water mark becoming sandy towards the low water mark, with a transition zone between the two (HR Wallingford, 2002). These findings concur with the relative mud/sand ratios that were reported during the East Tilbury jetty works (Thomson Ecology, 2017).

9.4.34 Sediment quality in the Thames Estuary is highly variable. The estuary has been exposed to various industries, and as a result, certain areas have been exposed to a variety of contaminants. Much of this legacy contamination is bound within the sediments but can be at risk of release to the water column, if disturbed during activities such as dredging. Historically, tributyltin (TBT) has been recorded in deeper sediments near to the Port of Tilbury East Lead-in jetty. A buffer layer of uncontaminated sediment was required to be in place during dredging operations and TBT has not been found to be elevated in sediment sampling subsequent to 2003 (PLA, 2009).

9.4.35 Sediment samples collected in the vicinity of Tilbury Port and tested by the Port of London to provide a baseline for their maintenance dredging programme reported some samples as exceeding the Centre for Environment, Fisheries & Aquaculture Science (Cefas) Action level 1 (PLA, 2007). Exceedances were mainly for TBT, chromium, copper, mercury, nickel, lead and zinc.

9.4.36 Cefas sediment Action levels (1 and 2) relate to the suitability for disposal of dredged sediments, with those exceeding level 2 being considered unsuitable for marine disposal. Sediments with contaminant levels between Action levels 1 and 2 require further consideration and testing, and those levels below level 1 require no additional action prior to disposal (PLA, undated(b)).

9.4.37 Samples taken in the vicinity of demolished Tilbury Power Station have been found to be above Cefas Action level 1 for cadmium and mercury, with elevated concentrations of lead. Elevated lead and mercury, for example, are considered representative of the background in this area of the Thames Estuary (PLA, 2009).

9.4.38 Sediment samples collected more recently (RWE, 2018) in the vicinity of the RWE Tilbury site showed that sediments in the intertidal zone had levels above Cefas Action level 1 in the majority of samples taken for lead, cadmium, chromium, nickel, zinc and mercury. Levels were above Action level 1 for a small number of samples in relation to arsenic and copper. None were above Action level 2, although one sample was approaching this level with respect to mercury (2.75mg/kg, compared to a Cefas Action level 2 of 3mg/kg).

9.4.39 As there are no Cefas Action levels for PAHs, reference has been made to the Canadian Interim Sediment Quality Guidelines (ISQG) for an indication of the degree of contamination and potential for impact on marine ecology. The Canadian ISQGs consist of threshold effect levels (TELs) and probable effect levels (PELs). The TELs and PELs are used to identify the ranges of chemical concentrations with regard to biological effects (PLA, undated(c)). Nearly all PAHs which have Canadian ISQG levels associated with them were above the TELs in the intertidal zone, with up to five samples in the area exceeding the PEL for that compound. These were:

a. Acenaphthene
b. Acenaphthylene
c. Anthracene
d. Fluorene
e. Fluoranthene
f. Phenanthrene
g. Benzo(a)anthracene
h. Chrysene
i. Benzo(a)pyrene
j. Naphthalene
k. Dibenzo (a,h) anthracene

9.4.40 Subtidal sediments sampled in 2017 (RWE, 2018) also show that several areas exceeded Cefas Action level 1. These were in relation to mercury, cadmium, chromium, copper, nickel, lead, and zinc concentrations. All were below Action level 2. With respect to PAHs, subtidal sediments showed a similar trend to the intertidal sediments with nearly all areas exceeding the TEL and some exceeding the PEL.

Underwater noise

9.4.41 The underwater noise environment in the Thames Estuary is a function of natural and anthropogenic noise sources such as tidal flows, sediment movement, shipping noise, and dredging operations. All of these sources create underwater noise that is either continuous or impulsive and creates the background noise levels that ecological communities are habituated to. Understanding these background or ambient levels allows for more accurate assessments of construction and operational activities as some noise sources may not be audible against the existing ambient conditions.

9.4.42 The Thames Estuary is one of the busiest inland waterways in the UK and is subject to a large number of vessel movements from freight, fishing and pleasure boats. These vessel movements generate continuous noise in the underwater environment therefore adding to the background noise levels. A study undertaken in 2016 to look at the underwater noise levels in UK waters in the southern North Sea reported the 90th percentile noise levels ranging from 93.3dB re 1µPa (at 500Hz) to 102.0dB re 1µPa (also at 63Hz) (Merchant *et al*. 2016).

9.4.43 Sound levels have been documented for a number of vessel types (Whale and Dolphin Conservation Society, 2004) with supertankers producing the highest noise emissions (185-190dB re 1µPa at frequencies between 7 and 8Hz). Empty and loaded barges, which are common in the Thames Estuary, were shown to produce sound levels of between 145 and 170dB re 1µPa within a frequency range of 1,000 to 5,000Hz

9.4.44 Background underwater noise levels at Belvedere upstream of the Order Limits were monitored as part of a study assessing piling activities (Edmonds and Moore, 2009). The measurements reported showed that at Belvedere, background noise levels ranged between 153 to 158dB re 1µPa.

9.4.45 Nedwell *et al*. (2003) took underwater noise measurements in Southampton Water between and during piling operations. Southampton Water is also a busy waterway, with high levels of shipping and tidal flows and the noise levels reported in the study are relevant to the Thames Estuary. The sound levels recorded during the study ranged between 130 and 150dB re 1µPa at a distance of 400m. The study showed that the actual piling operations were not discernible above background underwater noise levels.

Physical environment summary

9.4.46 Overall, the quality of the physical environment in the vicinity of the Order Limits is variable. It is evident that the estuary has been, and is still currently, subject to a number of anthropogenic pressures that have the potential to influence the quality and extent of marine ecological receptors.

9.4.47 The individual attributes of the physical environment have not been valued but have been incorporated into the ecological receptor valuations where relevant, and into the assessment of effects.

Marine benthic habitats and species

9.4.48 The marine benthic habitats of the Thames Estuary in the vicinity of the Order Limits have been extensively described in the literature, including the Environment Agency's Thames Estuary Benthic Programme (various), the Thames Estuary Partnership's Habitat and Species Audit for the tidal Thames (2002) and various project Environmental Statements – notably, the recent EIAs carried out for the Thames Gateway container terminal and Tilbury2 port developments (PLA, 2017). In addition, an extensive programme of marine survey works has been completed for RWE's proposed Tilbury Energy Centre (RWE, 2018).

9.4.49 Recent published work very relevant to the Order Limits is the study completed on behalf of the Thames Tideway Tunnel project for the temporary East Tilbury jetty at the Goshems Farm site (Thames Water Utilities Ltd, 2013). The benthic studies commissioned to support the planning application and marine licence for the East Tilbury jetty are of particular relevance and are considered to provide comprehensive coverage of the marine habitats within the vicinity of the Order Limits.

9.4.50 The estuary in the vicinity of the Order Limits is characterised by extensive areas of intertidal habitat. These intertidal habitats, i.e. areas of mudflats, sandflats and saltmarsh, provide key foraging, breeding and nursery habitat for aquatic invertebrates and fish which, in turn, support bird and mammal populations.

9.4.51 The importance of these habitats is recognised by the designation of large parts of the estuary as protected areas. Intertidal mudflats and saltmarsh are all Habitats of Principal Importance listed under the NERC Act 2006.

9.4.52 The intertidal areas of the Thames Estuary are typically characterised by mixed coarse sediments, mud and sandflats backed by seawalls, with some areas of saltmarsh.

9.4.53 The habitat components of the designated sites within the Project study area (Thames Estuary and Marshes SPA/Ramsar site, Holehaven Creek SSSI and Swanscombe Peninsula SSSI) include extensive areas of intertidal mudflats and saltmarsh. Subtidal habitats include areas of mixed coarse sediments, sand and mud.

9.4.54 Phase 1 habitat surveys carried out in support of the Tilbury2 Development Consent Order application in 2017 along a 2.2km stretch of the estuary west of the Order Limits, described the intertidal habitats as including areas of mud and sand, shingle and cobbles, boulders and rocks, eelgrass beds and areas of dense saltmarsh (Thomson Ecology, 2017). Intertidal mud was found in a continuous band along the breadth of the lower extent of the intertidal zone.

9.4.55 In 2017, a desk study and field surveys were completed to support the planning and marine licence applications for the East Tilbury jetty at Goshems Farm. This work included marine habitat mapping, and benthic invertebrate and sediment sampling (Physalia, 2017).

9.4.56 The East Tilbury jetty survey work was specifically designed to address the nature and value of the benthic habitats, and the potential presence and distribution of the protected tentacled lagoon worm (as per the Swanscombe MCZ designation), in the vicinity of Goshems Farm location. The outputs of the study provide a good level of confidence as to the likely habitat and community composition along the northern intertidal area within the Order Limits.

Mud and sandflats

9.4.57 The intertidal zone adjacent to the existing East Tilbury jetty at Goshems Farm has formed in response to training groynes constructed by the PLA to help maintain the navigable channel. The area is described as an area of elevated mud and sandbanks, intersected by tidal channels (Physalia, 2017). Sediment cores collected from across the intertidal zone were all found to comprise a significant component of sand (fine (125 – 250µm) and very fine (63 – 125µm)). In 10 of the 16 samples collected, sands accounted for over 50% of the total sediment dry weight.

9.4.58 Mud and silt fractions (sediment particles <63µm) dominated six of the 16 samples at between 50% and 70% of total sediment dry weight. Samples with a <63µm fraction in excess of 95% total dry weight are not uncommon in Thames estuarine muds. The report also concluded that the sediments in this reach of the estuary are not accumulating muds (Physalia, 2017).

Brown algal beds

9.4.59 Patches of rock armour that exist within the intertidal zone in the vicinity of the East Tilbury jetty at Goshems Farm were colonised by bladder wrack (*Fucus vesiculosus*). The width of this feature was variable and covered an area of >2ha (Thomson Ecology, 2017).

Saltmarsh

9.4.60 The saltmarsh habitats around Tilbury comprise species-poor communities. Salt pans are present although they appear occasional as not readily observed through the dense vegetation (RWE, 2018).

9.4.61 The Tilbury2 Phase 1 habitat survey reported the presence of saltmarsh habitat in the vicinity of the Order Limits. Species recorded included sea-purslane *Atriplex portulacoides*, sea couch *Elytrigia atherica*, sea plantain *Plantago maritima*, sea arrowgrass *Triglochin maritima*, sea aster *Aster tripolium*, cord-grass *Spartina* sp. and greater sea-spurrey *Spergularia media* (Thomson Ecology, 2017).

9.4.62 In the area of the East Tilbury jetty at Goshems Farm, sea-purslane was recorded as being dominant, sea couch as abundant, sea aster, sea plantain and sea arrowgrass as frequent, and saltmarsh rush *Juncus gerardii*, common saltmarsh-grass *Puccinellia maritima*, cord-grass and greater sea-spurrey as occasional, and English scurvygrass *Cochlearia anglica*, sea-milkwort *Glaux maritima*, dittander *Lepidium latifolium* and common sea-lavender *Limonium vulgare* as rare (Thomson Ecology, 2017).

9.4.63 The saltmarsh community showed clear zonation, with the upper shore areas being dominated by sea couch facies and the mid-shore by sea-purslane and sea plantain. In addition, where there was no rock armour present, patches of cord-grass were identified in the lower shore areas (Thomson Ecology, 2017).

9.4.64 Saltmarsh quadrat surveys conducted during 2017 (RWE, 2018) around the RWE site frontage and in the vicinity of the Order Limits recorded seven species present in the area to the east near the East Tilbury jetty. Sea purslane and sea aster covered the greatest proportion of the quadrat area with sea plantain, common glasswort *Salicornia europaea,* and several individuals of cord-grass and annual seablite *Suaeda maritima* present. A few thrift *Armeria maritima* individuals were also recorded here and filamentous green algae was also present.

9.4.65 Towards the eastern boundary of the RWE site, golden samphire *Inula crithmoides* and sea lavender also occurred along with common saltmarsh grass. Golden samphire is listed as nationally scarce in Britain, based on its distribution (NBN Atlas, 2018). A total of 22 species were recorded across the whole survey area, from downstream of Coalhouse Fort in the east to upstream (west) of the former Tilbury Power Station site.

9.4.66 Previous RWE data (RWE, 2018) recorded 18 saltmarsh plant species along this stretch of shore. The sediments adjacent to the Order Limits (immediately east of the East Tilbury jetty) were described as eroding, exposing a former glass bottle dump with the sediment having been replaced by broken glass. Scattered areas of glasswort *Salicornia* sp. dominated communities were recorded. Small patchy areas of dominant lesser sea spurrey *Spergularia*

marina and dominant greater sea spurrey were also present. To the west of the East Tilbury jetty, the area supported an approximately 15m wide strip of sea plantain and sea purslane marsh which gave way to a narrow strip of cord-grass at the sea wall. Sea aster was frequent along with occasional lesser sea spurrey, and sea lavender was recorded as rare.

Benthic habitats summary

9.4.67 Mudflats and sandflats in the vicinity of the Order Limits have been assessed as being of **national importance** as intertidal mudflats provide feeding resource and habitat for other species such as wading birds; and those in the vicinity of the Order Limits support invertebrate communities which are of moderate value to associated predators (e.g. wading birds).

9.4.68 Brown algal beds have been assessed as being of **local importance**, owing to their widespread presence in the Thames Estuary as a whole and their provision of additional habitat and shelter to species.

9.4.69 Saltmarsh has been assessed as being of **national importance**, owing to it supporting scarce species (golden samphire) and having an important role in supporting the wider ecosystem (for example as juvenile fish habitat) and providing regional level ecosystem services such as coastal protection by trapping sediments and absorbing wave energy.

Benthic invertebrates

9.4.70 The benthic invertebrate assemblage of the Thames Estuary has been well documented through regulatory monitoring programmes such as the Thames Estuarine Benthic Programme and the CSEMP (formally known as the UK National Marine Monitoring Programme). The regulatory monitoring programmes provide a good baseline for macroinvertebrate communities throughout the estuary.

9.4.71 More recently, the lower Thames Estuary has been subject to numerous marine studies in support of major infrastructure developments, including those associated with London Gateway, Tilbury2, Lower Thames Crossing and RWE's Tilbury site.

9.4.72 The macroinvertebrate community composition in estuarine water bodies is driven largely by salinity conditions and by sediment type. Salinity conditions in the vicinity of the Order Limits are typically variable, being largely dependent on the relative freshwater input into the estuary. As outlined in the previous section, the intertidal habitats in the area are dominated by muds and sands.

9.4.73 Estuarine benthic invertebrate communities are typically characterised by low numbers of species, but high abundance counts. This is due to the wide range of physical conditions, including salinity, temperature, suspended sediments and dissolved oxygen, that are experienced in estuaries, with few species being able to adapt to the wide-ranging environmental conditions.

9.4.74 The Tilbury2 survey data corresponded with Environment Agency monitoring data which indicated that the estuarine sediments between West Thurrock and Mucking support a benthic community dominated by the cirratulid polychaete *Tharyx* sp.; Tubificid oligochaetes (*Tubifex* spp.); the spionid polychaete *Streblospio shrubsolii*; the amphipod crustacean *Corophium volutator*; and the

nereid polychaete *Hediste diversicolor,* recorded in large numbers. The Tilbury2 samples collected from the Gravesend shore indicate that the benthic community is dominated by tubificid oligochaetes, and *C. volutator* (PLA, 2017).

9.4.75 The sediments along the Tilbury shore were described as supporting a typical estuarine mud assemblage and being relatively impoverished with a total of 29 species identified in the intertidal samples and a total of 47 species identified in the subtidal samples. The intertidal samples were dominated by the presence of *Tubificoides* and the numbers of *Corophium* increased in the seaward transect samples (PLA, 2017).

9.4.76 In more recent studies (RWE, 2018; PLA, 2019), the intertidal area between Tilbury Ferry Terminal and East Tilbury was found to be dominated by the amphipod shrimp, *C. volutator* and the Oligochaete worms *Tubificoides benedii* and *Baltidrilus costatus,* all of which occurred in high abundances. Other species prevalent in the samples include the ragworm *H. diversicolor*, the Baltic clam *Limecola balthica* and nematode worms.

9.4.77 Data from the Tilbury Energy Centre survey (RWE, 2018) shows that communities are similar across the Tilbury area, but the abundance of key species varies. Samples taken from transects closest to the Order Limits (T2 and T3) had, on average, lower abundances than the other transects except for T4 (Table 9.7). Highest total biomass was recorded at T4, next to the Tilbury2 port. Lowest biomass was recorded at T3 just to the east of the Order Limits.

9.4.78 Faunal communities together with sediment types most resembled the biotope '*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud', with low abundances of molluscs and extremely high abundances of the amphipod shrimp *C. volutator and* Oligochaete worms across the area. However, other studies (PLA, 2017) found a mix of different sandy mud *Hediste* dominated biotopes.

Table 9.7 Abundances of key taxa recorded at each transect for the Thames Energy Centre (RWE, 2018)

Transect (west to east)	**T5 (Tilbury Fort)**	**T6 (Tilbury2)**	**T4 (Tilbury2)**	**T1 (Tilbury2)**	**T2 (Jetty)**	**T3 (Jetty)**	**T7 (Outfall pipe)**
Species	**Average abundance (number per m^2)**						
Corophium volutator	63,100	78,800	10,900	11,900	2,500	3,200	45,000
Tubificoides benedii	18,500	27,200	6,500	6,400	17,900	15,700	11,300
Baltidrilus costatus	23,800	5,500	2,900	26,800	6,500	100	8,900
Hediste diversicolor	9,700	200	3,100	2,700	600	400	1,700
Limecola balthica	1,000	3,000	400	200	300	200	2,600
All species	133,600	137,500	26,600	58,500	30,400	21,100	86,500
	Average total biomass (grams per m^2)						
All species	17.08	15.96	23.48	16.85	15.27	3.80	12.75

9.4.79 The intertidal areas in the vicinity of the Order Limits, as described in Physalia (2017), are dominated by the muddy macroinvertebrate community characterised by the *Hediste diversicolor* and *Scrobicularia plana* biotope, and by the sandy mud community dominated by the *Hediste diversicolor* and *Macoma* (*Limecola*) *balthica* biotope.

9.4.80 In the East Tilbury jetty work at Goshems Farm (Physalia, 2017), a total of 38 invertebrate taxa were recorded. Table 9.8 provides a summary of the principal taxa recorded from the surveys. Abundances were generally low with the exception of the upper and mid-shore approximately 150m west of the jetty, which contained high abundances of *C. volutator* and oligochaete worms.

Table 9.8 Principal benthic taxa recorded at the East Tilbury jetty at Goshems Farm (Physalia, 2017)

Group	No. of taxa	Example species recorded
Oligochaetes	3	*Tubificoides benedii*
Polychaetes	12	*Nephtys hombergii; Hediste diversicolor*
Bivalve molluscs	4	*Limecola balthica; Abra alba; Scrobicularia plana; Mytilus edulis*
Amphipod shrimps	1	*Corophium volutator*

9.4.81 The East Tilbury jetty study reported that the densities and distributions of the macroinvertebrate community varied considerably across the intertidal area. Much of this variance was attributed to the sediment characteristics, which varied in terms of relative contributions of mud and sand fractions. Overall, the benthic invertebrate resource in the vicinity of the jetty was assigned a moderate value as a resource for wading and migratory birds.

9.4.82 A survey conducted in June 2019 for the Project (PLA, 2019), which sampled the same stations as the East Tilbury study, also showed low abundance and diversity, especially when compared to nearby areas.

9.4.83 Given the abundances of prey species such as annelid worms, crustaceans and molluscs found in various studies (Thomson, 2019; PLA, 2017; RWE, 2018; and Physalia, 2017), the Tilbury-East Tilbury intertidal area appears to vary between moderate and high value for wading and migratory birds.

Tentacled lagoon worm

9.4.84 The tentacled lagoon worm is a tube-dwelling bristleworm that requires muddy sediments in brackish water and is generally found in sheltered estuaries and lagoons. It is a nationally scarce marine organism, safeguarded under Schedule 5 of the Wildlife and Countryside Act 1981 and is listed under Section 41 of the NERC Act 2006.

9.4.85 The worm has previously been reported in the Thames Estuary. The Swanscombe MCZ (to the west of the Order Limits) and the Medway Estuary MCZ (to the east of the Order Limits) are designated for the protection of the worm.

9.4.86 A primary objective of the East Tilbury jetty study was to confirm the presence or absence of the tentacled lagoon worm in the vicinity of the jetty location. No specimens of the worms were identified in the 48 samples collected as part of the study for the jetty. The tentacled lagoon worm was not recorded when the same locations were sampled again in June 2019 (PLA, 2019).

9.4.87 During consultation on the MCZ assessment completed as part of the Tilbury2 Development Consent Order submission, it was agreed with the MMO, Natural England and Environment Agency that there were currently no records of the worm in the Thames Estuary as far downstream as the Gravesend/Tilbury area, and that there was a low risk of the worm colonising areas close to Tilbury.

9.4.88 No specimens of the worm were identified during the Project survey work (PLA, 2019).

Other species of conservation concern

9.4.89 A number of other benthic invertebrate species of conservation concern have been recorded in the lower Thames Estuary. The desk-based work completed for the East Tilbury jetty at Goshems Farm flagged two species. These were the lagoon sea slug (*Tenellia adspersa*) and the amphipod mudshrimp (*Corophium lacustre*) (Physalia, 2017). Both species are listed under Section 41 of the NERC Act 2006 as priority species.

9.4.90 No specimens of either species were identified during survey work for the East Tilbury jetty (Physalia, 2017), Tilbury2 (PLA, 2017), Thames Energy Centre (RWE, 2018) or Lower Thames Crossing (PLA, 2019). Both species are primarily associated with epifaunal communities on hard substrata, which is a limited resource in the vicinity of the Order Limits.

Invasive Non-Native Species

9.4.91 A number of estuarine/marine Invasive Non-Native Species (INNS) have been documented in the Thames Estuary. It is thought that these species have been introduced to the estuary either accidentally by the transport and discharge of ballast water, and to a lesser extent by transport of fouling organisms on hulls, or deliberately through aquaculture.

9.4.92 Confirmed INNS in the Thames Estuary include:

a. Chinese mitten crab *Eriocheir sinensis*

b. Slipper limpet *Crepidula fornicata*

c. Polychaete *Boccardiella ligerica*

d. Carpet sea squirt *Didemnum vexillum*

e. Pacific oyster *Crassostrea gigas*

9.4.93 The Chinese mitten crab is known to be present in the vicinity of the Order Limits, having been previously recorded on the cooling water intake screens of the RWE Tilbury Power Station (RWE, 2012). The species was first recorded in the Thames Estuary in the early 20th century and is thought to have been introduced via ballast water. The crab is a voracious predator and also burrows into soft banks, resulting in negative effects on native species, habitats and flood defences (NBN Atlas, 2018). Recent surveys in the vicinity of the Order Limits (RWE, 2018) recorded a maximum of 61 individuals during trawl surveys in May, with single figures present in the remaining months surveyed.

Benthic invertebrate summary

9.4.94 Benthic invertebrate fauna in the vicinity of the Order Limits have been assessed as being of **national importance** as the wider populations have an important role in support of the ecosystem (e.g. providing food for wading birds).

Plankton

9.4.95 A number of zooplankton and phytoplankton surveys have been carried out in the Thames Estuary adjacent to Tilbury, including work by RWE in 2007/08 (RWE, 2012) and 2017/18 (RWE, 2018).

9.4.96 The zooplankton surveys carried out between 2007 and 2008 yielded 51 taxa, with the highest number of species being recorded in the summer months. Calanoid (10 species), cyclopoid and harpacticoid copepods were present along with four species of mysid. There were also representatives of Cirripedia, Decapoda, Ctenophora, Gastropoda, Bivalvia, Isopoda and Cumacea. The 10 most abundant species were:

a. Calanoid copepod *Eurytemora affinis*
b. Calanoid copepod *Temora longicornis*
c. Calanoid copepod *Acartia* spp.
d. Calanoid copepod *Centropages hamatus*
e. Gastropoda *Littorina littorea* egg capsule
f. Calanoid copepod *Pseudocalanus elongatus*
g. Mysid shrimp *Mesopodopsis slabberi*
h. Mysid shrimp *Neomysis integer*
i. Harpacticoid copepod *Euterpina acutifrons*
j. Bivalve larvae *Bivalvia veliger*

9.4.97 During the 2007 and 2008 RWE zooplankton programme, Copepoda was the dominant group. This result is in line with the majority of estuarine population studies, as copepods are known to be the dominant group in terms of zooplankton biomass (Klein Breteler, 1982). Calanoid copepods were the most abundant order in all seasons with *Eurytemora affinis*, *Temora longicornis*, *Acartia* spp. and *Centropages hamatus* being most common.

9.4.98 Data from surveys carried out in 2017/18 showed similar trends with respect to copepod species abundance (RWE, 2018). Harpacticoid copepods were recorded in all seasons with *Euterpina acutifrons* being most common. Cyclopoid copepods were less common than calanoid and harpacticoid copepods, being present in summer and autumn samples only.

9.4.99 Mysid (opossum) shrimps were the next most abundant group, with the highest numbers reported in autumn. *Mesopodopsis slabberi* were recorded in the highest abundances, followed by *Neomysis integer* which was present throughout the year.

9.4.100 In the meroplankton, larval stages were present throughout the year showing seasonal changes in the appearance of different groups.

9.4.101 A total of 54 phytoplankton taxa were recorded during the 2007/08 survey, of which 38 were Bacillariophyta (diatoms), three were Dinophyta (dinoflagellates), two were Chlorophyta (green algae) and one was Cyanophyta (blue-green algae).

9.4.102 Diatoms were the most abundant and diverse group of the phytoplankton community recorded throughout the study period, representing between 97.3-99.7% of the total composition. The summer samples recorded the highest phytoplankton abundances, with cell counts in the order of 105 cells l^{-1} for diatoms. Low numbers of dinoflagellates were recorded in the samples, representing only 0.02% and 0.06% (RWE, 2012).

9.4.103 Data from surveys carried out in 2017/18 again recorded diatoms as being the most diverse group, with *Skeletonema* often the most abundant species. *Asteroplanus karianus* and *Navicula* sp. were also found to be abundant, the latter in spring 2018. Microflagellates were also very abundant in the samples. Both freshwater and marine diatoms were found to be present in the samples, which would reflect the nature of the estuarine environment (RWE, 2018).

Plankton summary

9.4.104 The zooplankton and phytoplankton communities in the vicinity of the Order Limits have been assessed as of **local importance** as they are relatively common and wide ranging throughout the estuary but are an essential part of the ecosystem.

Fish

9.4.105 The Thames Estuary is considered an important habitat for a variety of fish species. A list compiled by the Environment Agency details 125 species of fish that have been caught in the Thames Estuary between Fulham and Tilbury since 1964 (ZSL, 2016). Reports of fish within the estuary include species of conservation importance and migratory species that use the river as a conduit to transit between the marine and freshwater environments. In addition, a number of commercially important species have been identified.

9.4.106 Species diversity in the estuary is driven by the seasonal movement of fish, with high species numbers in the autumn and winter, and low numbers in the summer (Thomas, 1998). Annual cooling water intake screen surveys were undertaken at West Thurrock power station between 1974 and 1991, and the fish categorised into the following groups (Thomas, 1998):

a. Migratory (those species moving between the sea and fresh water for spawning)

b. Freshwater (occurring and breeding in freshwater)

c. Estuarine (spending most of their life in the estuary)

d. Marine-estuarine dependent (require an estuarine stage in lifecycle)

e. Marine stragglers (abundant in marine and uncommon in estuaries)

9.4.107 The Environment Agency conducts fish monitoring in the Thames Estuary that has been ongoing since 1994. A number of programmes make up the available dataset, which includes the WFD transitional water body monitoring (for fish, previously known as the Tideway Monitoring Programme), the CSEMP (previously known as the National Marine Monitoring Programme) and the joint Cefas-Environment Agency bass survey programme. The monitoring sites for these combined programmes extend from Teddington in the west to the Medway estuary approaches in the east, with a total of 26 sites.

9.4.108 In the vicinity of the Order Limits, the Environment Agency's Tideway Monitoring Programme has recorded 23 species of fish in the area around West Thurrock, Gravesend and Greenhithe, using conventional sampling methods such as seine netting and beam trawling.

9.4.109 More up to date cooling water intake screen monitoring was undertaken by the ZSL at the Tilbury Power Station between 2006 and 2010, data from which yielded 63 species of fish. Species ranged from fully marine to freshwater species with no estuarine requirement. Gobies *Pomatoschistus* spp., sprat *Sprattus sprattus*, bass *Dicentrarchus labrax*, and smelt *Osmerus eperlanus* were caught in the highest numbers, with sprat, flounder *Platichthys flesus* and Dover sole *Solea solea* being caught throughout the year. Other species caught included tadpole fish *Raniceps raninus*, red gurnard *Chelidonichthys cuculus* and brill *Scophthalmus rhombus*.

9.4.110 Baseline fish surveys were undertaken around Tilbury B Power Station (Gravesend Reach) between 2007 and 2010 to support a planning application (RWE, 2012), with surveys undertaken in the subtidal and intertidal areas in the vicinity of the station and Gravesend in order to characterise the fish community.

9.4.111 A total of 33 fish species were identified in the subtidal trawls (beam and otter trawls). A mixed assemblage was reported from the surveys which included the following species:

a. Atlantic cod *Gadus morhua*

b. European eel *Anguilla anguilla*

c. Plaice *Pleuronectes platessa*

d. Bass

e. Smelt

f. Flounder

g. Dover sole

h. Sprat

i. Bib *Trisopterus luscus*

j. Whiting *Merlangius merlangus*

k. Herring *Clupea harengus*

l. River lamprey *Lampreta fluviatilis*

m. Dab *Limanda*

n. Sand goby *Pomatoschistus minutus*

o. Common goby *Pomatoschistus microps*

p. Lozano's goby *Pomatoschistus lozanoi*

q. Painted goby *Pomatoschistus pictus*

r. Transparent goby *Aphia minuta*

9.4.112 In terms of abundance, gobies dominated the subtidal trawls. Dover sole was also abundant, although other species such as bib, herring, smelt, whiting and sprat were also recorded in relatively high numbers.

9.4.113 More recent quarterly trawl surveys in 2017-2018 (RWE, 2018) undertaken in the subtidal waters off Tilbury yielded 34 species, comparable to those described above. Three types of trawl gear were used, targeting benthic, demersal and pelagic species.

9.4.114 The community composition changed according to season. During late spring (May) the benthic fish communities sampled were dominated by Dover sole, the demersal communities dominated by smelt and Dover sole, and pelagic communities dominated by smelt. River lamprey was also caught in all trawl types (five individuals ranging from 135 to 180mm long) along with other species such as red mullet *Mullus surmuletus*.

9.4.115 The summer (August) fish communities were all dominated by sand goby, making up over 80% of the catch composition. River lamprey (three individuals ranging from 157 to 189mm long) and conger eel *Conger conger* were among the other species caught.

9.4.116 The autumn (October) was the most diverse of the four seasons sampled in terms of species (26 were recorded). All communities were dominated by gobies (sand and Lozano's) with other species including horse mackerel *Trachurus trachurus*, anchovy *Engraulis encrasicolus*, thornback ray *Raja clavata*, as well as herrings (clupeids) and cods (gadoids) present.

9.4.117 The winter (February) fish communities were dominated by Lozano's goby; demersal communities also reported abundant smelt and sand goby, and sprat, herring were abundant in the pelagic community. The largest smelt was caught during February (265mm total length).

9.4.118 Intertidal fyke and push net surveys up and downstream of Tilbury Power Station site (RWE, 2012) recorded a number of species which are known to utilise the nearshore area of the Thames around Tilbury, including the saltmarsh creeks:

a. Common goby

b. Bass

c. Three-spined stickleback *Gasterosteus aculeatus*

d. Flounder

e. Mullet (Mugilidae)

f. Sand goby

g. European eel

h. Sprat

9.4.119 More recent fyke net data (RWE, 2018) from the upper to lower shore areas around Tilbury have recorded additional species using the intertidal zone, including gurnard (Triglidae), rockling (Lotidae), dogfish (*Scyliorhinus canicula*), smelt, Dover sole and flounder, as well as sprat and herring. Bass dominated all months, being most abundant in the lower shore samples during the winter and more abundant in the upper shore samples during the summer months. European eel was also recorded. Seine and push net data for the same period recorded fewer species, with common goby dominant, and bass also abundant. Catches were highest during summer and autumn months.

9.4.120 Fish species inhabiting the estuarine reaches of the River Thames are subject to varying environmental conditions. Araújo *et al*. (2000) studied assemblages around West Thurrock (approximately 8km upstream of the Order Limits) during the 1980s and found that high abundances of flounder were associated with high temperatures. High abundances of poor cod *Trisopterus minutus*, sprat, herring and three-spined stickleback were associated with high dissolved oxygen concentrations and low temperatures. High abundances of plaice, whiting, sand goby, bass and dab were associated with high salinity and suspended solids. The fish communities exhibited seasonal peaks in abundance:

a. December-March for herring, sprat, three-spined stickleback and poor cod

b. July-August for flounder

c. September to December for sand goby, whiting, bass, plaice and dab.

9.4.121 Other species exhibited two peaks per year, such as Dover sole and Nilsson's pipefish *Syngnathus rostellatus*.

9.4.122 The Thames Estuary is an important larval and nursery habitat for various fish species. It is one of the largest Dover sole nurseries around the UK (Colclough *et al*., 2002), with adults spawning downstream of Tilbury and Gravesend in April and May. Juvenile bass travel up the estuary in waves during June, July and August from their offshore spawning areas, and thin-lipped mullet *Liza ramada* enter the estuary in September. Flounder post-larvae (>8mm) appear in the estuary in early May.

9.4.123 Ichthyoplankton surveys undertaken in 2017-18 (RWE, 2018) confirm the use of these waters by fish larvae and identified 21 species of fish larvae as well as eggs (including anchovy) in the water column around Tilbury. Common goby

and sprat were present in the highest abundances. Sprat had a maximum average density during April, with 0.62 per m^3. Other species/taxa recorded included smelt, pilchard *Sardina pilchardus*, herring, sandeels (lesser *Ammodytes tobianus*, smooth *Gymnammodytes semisquamatus* and Raitt's sandeel *Ammodytes marinus*), bass, dragonets *Callionymus* spp., gobies, sea scorpions Cottidae, poor cod, bib*,* plaice*,* flounder and solenette *Buglossidium luteum*.

9.4.124 Other ichthyoplankton surveys undertaken (RWE, 2012) yielded species that were not present in the 2017-18 surveys. These included Dover sole, two-spot clingfish *Diplecogaster bimaculata*, butterfish *Pholis gunnellus,* Nilsson's pipefish, European eel and three-spined stickleback. In 2007/08, Gobiidae, Pleuronectidae and Clupeidae were the most abundant families in the samples. High level comparisons between the month of May in both 2008 and 2017 show that in the 2008 samples, flounder, sprat and gobies dominated and in the 2017 samples, gobies, herring and sprat dominated. The increase in clupeid abundance in spring and early summer can be attributed to the spring spawning stock of the Blackwater and Medway estuaries in the outer reaches of the Thames Estuary. The inshore migration of the species starts in early November with fish concentrating within 10 miles (16km) of the coast in preparation for spawning the following spring (Fox *et al.*, 1999). Many species exhibit inter-annual peaks in abundance, which may account for the relative differences in community compositions between years.

Species of conservation importance

9.4.125 Certain fish species are protected under a range of legislation including the Conservation of Habitats and Species Regulations 2017 (Habitats Regulations, 2017) , the Wildlife and Countryside Act 1981 (and amendments) and the Bern Convention, as well as being on the OSPAR threatened species list, the International Union for Conservation of Nature (IUCN) red list and the Priority species list under Section 41 of the NERC Act 2006.

9.4.126 A review of the fish communities in the Thames Estuary was undertaken as part of the Tilbury2 development (Thomson Ecology, 2017), which highlighted a number of species of conservation importance, including Allis shad *Alosa alosa*, twaite shad *Alosa fallax*, short-snouted seahorse *Hippocampus hippocampus*, Raitt's sandeel *Ammodytes marinus*, European eel, herring, cod, angler fish *Lophius piscatorius*, whiting, smelt, plaice, Atlantic salmon, sea trout *Salmo trutta*, mackerel *Scomber scombrus*, and Dover sole.

Shads

9.4.127 Allis and twaite shads (listed in Annex II and V of the Habitats Directive) are anadromous species, spending their adult life at sea and moving up into rivers to spawn around May. At sea, shads are mainly pelagic and remain in coastal waters. They have been recorded at depths of 10–150m (with records to 200-300m) but have a preference for water 10–20m deep (Taverny; Roule; in Maitland and Hatton-Ellis, 2003). Allis shad are generally planktivorous, whilst twaite shad also prey upon small fish such as sprat. These species therefore require suitable estuarine habitats which would be important for adult passage and juvenile nursery areas.

9.4.128 Both species are found in the UK and continental Europe; however, in the UK the main twaite shad spawning populations are in rivers on the west side of the country, i.e. the Rivers Severn, Wye, Usk and Tywi, as well as in Ireland (Maitland and Hatton-Ellis, 2003). Although Allis shad is found in UK waters, the only spawning site recorded in UK waters is in the River Tamar (Cotterell and Hillman, 2016). There have been sporadic records of shad (mainly twaite shad) in the Thames around Tilbury, including on the Power Station intake screens (three individuals have been identified during ZSL surveys).

European eel

9.4.129 European eel is a catadromous species, with adults spawning in the Sargasso Sea and the resulting larvae travelling via currents to Europe and arriving in estuaries in early April at around 65mm in length (Colclough *et al*., 2002). Individuals then move upstream into the freshwater catchment and after a period, migrate back out to sea as adults to spawn.

9.4.130 Annual recruitment of European eel into rivers has declined by over 90% in the past 30 years across its geographic range. In 2008, the IUCN classified the European eel as Critically Endangered. Although European eel recruitment has declined massively since the 1960s, there was a small increase in recruitment between 2012 and 2014 in the North Sea as well as more widely in Europe. However, numbers have since declined back to less than 2% of the 1960s recruitment level.

9.4.131 In a UK context, the Thames Estuary is considered to be particularly important for eel as the upstream catchment contains 11% of the UK's freshwater and riverine habitat. As demonstrated in the intertidal surveys for RWE Tilbury B power station, European eel have been found to use the shallow waters (<1m depth) upstream and downstream of the RWE site, including the adjacent saltmarsh creeks and the area around the East Tilbury jetty at Goshems Farm (RWE, 2012). The subtidal trawl and cooling water intake screen data shows that this species is present in the waters adjacent to the Order Limits. The Mardyke River, which flows into the Thames at Purfleet, west of Tilbury, has been found to support European eel, with individuals recorded in Environment Agency surveys during 1998, 2005 and 2012 (Environment Agency, 2018b).

Smelt

9.4.132 Smelt are listed as a NERC Act Section 41 species. Smelt is an anadromous species tolerant of wide salinity changes but very sensitive to hypoxia/pollution and is therefore an indicator of the status of the water quality. Smelt used to be an abundant species but has been in decline since the 1800s. Since the late 1970s smelt have begun returning to the Thames and are found in increasing numbers each year. Smelt numbers in the Thames are known to fluctuate dramatically owing to anthropogenic and natural factors (Maitland, 2003). In the past, smelt migration strategies in the Thames have been driven by short-term variations in the suitability of thermal habitat (Power and Attrill, 2007).

9.4.133 Cefas data shows the Thames Estuary to contain more smelt per 1,000m^2 than any other estuary around the south and east coasts of Britain (Rogers *et al*., 1998). In 1967-73, smelt were reported at all power stations on the Thames Estuary during the power station cooling water screen surveys undertaken by Cefas (English Nature, 2003). The Thames Estuary smelt population is now

considered to be one of the largest breeding populations in the UK (ZSL, 2015a). The Thames Estuary accounts for one of the strongest and most permanent smelt stocks, making it a site of national importance for the conservation of this species (Maitland, 2003). Smelt was described as the most abundant roundfish species between Chelsea Embankment and Cremorne Wharf during autumn 2010 (Thames Water Utilities Ltd, 2013). Furthermore, for the monitoring period 2011 to 2015, smelt was the most abundant pelagic species recorded by the Environment Agency during WFD TraC fish monitoring at Woolwich and Greenwich (Environment Agency, 2018c).

9.4.134 Smelt were sampled over all seasons in trawl samples off Tilbury and Gravesend (RWE, 2012), with the highest abundances occurring during October 2009 and February 2010. The wide range in number and size class of smelt found fluctuated, but the general trend appeared to be that of an increase in smelt population within the Thames Estuary. Seasonal fluctuations of abundance occur, and length measurements taken indicate that at least two cohorts of smelt exist in the Thames with the larger size classes almost completely absent in the spring and summer.

9.4.135 Smelt have been described as spawning in sublittoral gravels upstream of Battersea during March and April (Colclough *et al.* in Thames Water Utilities Ltd, 2013) and their larvae drift seaward during early spring. It is recognised that smelt, as a migratory species, will pass the Order Limits during their migrations through the estuary.

Sea lamprey

9.4.136 Sea lamprey *Petromyzon marinus* is listed as a priority species in Section 41 of the NERC Act 2006 and is present in Annex II of the Habitats Directive and Appendix III of the Bern Convention. Sea lamprey is an anadromous, jawless, eel-like species which spends the marine phase of its life attached to a host fish. This species migrates from the sea through the estuary to spawning grounds upstream (thought to be downstream of Teddington (Thames Water Utilities Ltd, 2013)) during April and May. Spawning occurs in late May and June with the larvae spending around five years within the freshwater reaches of the river. They then metamorphose into adults and move downstream into the marine environment during July to September. In the marine phase, sea lamprey feed upon anadromous and marine species of fish including herring, cod, haddock *Melanogrammus aeglefinus*, sea trout and salmon (Maitland, 2003). Records of this species have been increasing in the Thames Estuary with improved water quality, with records of dead post-spawning individuals being found near Chiswick and Kew in 2001-02 (Colclough *et al*., 2002).

River lamprey

9.4.137 River lamprey is listed as a priority species in Section 41 of the NERC Act 2006 and is present in Annex II and V of the Habitats Directive and Appendix III of the Bern Convention. As described above, there are some records of river lamprey in the Thames Estuary at Tilbury from the power station's cooling water intake screen surveys and trawl surveys (RWE, 2012). River lamprey spend their adult phase in the marine environment (mainly in estuaries). Once mature, they stop feeding and migrate through estuaries (October to December) into freshwater catchments to spawn the following spring. Larvae spend several years buried in silt beds before metamorphosing and moving into estuaries during July to

September (Maitland, 2003). Colclough *et al*. (2002) state that as with sea lamprey, river lamprey numbers in the Thames are increasing, with records in the estuary from a number of separate locations.

Salmonids

9.4.138 Atlantic salmon is listed in Annexes II and V of the Habitats Directive (when in freshwater only) and sea trout is listed on Section 41 of the NERC Act 2006. Both species are known to migrate through the Thames Estuary to reach the spawning grounds in the freshwater catchment. Both species are anadromous, with much of their feeding and growth occurring in the marine environment. Adults return to their natal streams to spawn, migrating through the Thames Estuary between May and November each year. Juveniles remain in freshwater for between one and three years before undergoing a number of physiological changes then migrating to sea as smolts. This seaward migration typically occurs between April and May of each year.

9.4.139 Thames Water Utilities Ltd (2013) examined Thames salmon and sea trout catches from several sources (such as fish trap data from weirs). The numbers of returning adults for both salmon and sea trout have been relatively low in recent years, having dropped off markedly since 1997 (annual salmon numbers were in low single figures and sea trout records were around ten in 2010-11 although there was a peak record of 60 in 2009). Peak returns for salmon were in July and August, whereas sea trout showed an earlier peak in June.

9.4.140 Issues such as low flows, barriers to migration, poor water quality and loss of freshwater habitat are thought to be contributing to the low returns/poor spawning success. Thames Water Utilities Ltd (2013) also state that salmon present in the Thames are likely to be strays from other catchment stocks in the south-east or as a result of Environment Agency stocking of early life stages. It was noted that the Environment Agency has ceased stocking in the Thames. Salmon and sea trout were sampled by ZSL on the intake screens at Tilbury, though in low numbers.

Seahorses

9.4.141 Short-snouted seahorses (listed on Section 41 of the NERC Act) can be found in shallow waters in estuaries or associated with seagrass meadows; they are poor swimmers. Short-snouted seahorses have been recorded in the Thames for over a decade (including on Tilbury Power Station cooling water intake screens, as described above) in increasing numbers (it should be noted that the long-snouted seahorse *Hippocampus guttulatus* may have been reported within these records). In 2017, there were six records from the Thames Estuary in two months, which is more than previous annual totals (projectseahorse.org, 2019). Individuals have historically been recorded from Tilbury, Dagenham and Southend (New Scientist, 2008), with a colony having been found as far upstream as Greenwich (Science X, 2011).

Species of commercial importance

9.4.142 Of the fish species previously described as being present in the Thames Estuary, a number are targeted commercially. These include:

a. Herring

b. Dover sole

c. Grey mullet (Mugilidae)

d. Sprat

e. Dab

f. Eel

g. Cod

h. Bass

i. Whiting

9.4.143 In 2002, approximately 50 commercial fishing vessels were in operation in the Thames Estuary (Colclough *et al*., 2002). The lower estuary currently supports a low level commercial fyke net fishery for adult silver eels (ZSL, 2017) and a grey mullet gillnet fishery at Woolwich. Recreational fishing for species such as Dover sole, bass, flounder, whiting and eel also occurs downstream of Woolwich (Colclough *et al*., 2002).

9.4.144 The International Council for the Exploration of the Sea (2017) reported that between 2012 and 2016, the total amount of herring caught in the Thames Estuary annually had reduced from 63 to 1 tonne. The estuary provides important nursery grounds for commercial species, and is a major nursery ground for flatfish, as well as bass.

Fish summary

9.4.145 The fish species of conservation importance in the Thames Estuary in the vicinity of the Order Limits have been assessed as being of **European importance** as they comprise species that are of international importance or are rare or uncommon.

9.4.146 Fish species of commercial importance have been assessed as being of **national importance** (NERC Act Section 41) and medium economic value e.g. Dover sole and herring.

9.4.147 The remaining fish species are considered to be of **local importance** as they are relatively widespread within the estuary and support the wider ecosystem as food sources to other species.

Marine mammals

9.4.148 Several species of marine mammal have been recorded in the Thames Estuary. Some of these are known to be present year-round, whilst others are considered as occasional visitors.

9.4.149 Many cetacean species are known to have large home ranges and evidence suggests that certain coastal populations might exploit food resources up to 200km from their residence (Stockin *et al*., 2006), with a core foraging area of 86km^2 in some instances for certain offshore species (Corkerton and Martin, 2004). Harbour porpoises *Phocoena phocoena*, part of the North Sea population (which includes the Southern North Sea SAC) frequent the Thames Estuary year-round (ZSL, 2015b), whilst bottlenose dolphins *Tursiops truncatus* and some whale species are also present, but much less frequently (ZSL, 2015b).

9.4.150 Increasing populations of common seal *Phoca vitulina* and grey seal *Halichoerus grypus* have been reported throughout the estuary, as far as Richmond Lock.

9.4.151 The most notable programme of monitoring (and reporting) for marine mammals in the Thames Estuary has been undertaken by ZSL. ZSL has been monitoring cetaceans in the estuary since the early 2000s using aerial, boat and land-based transects and GPS tagging.

Designations

9.4.152 The Habitats Directive and Habitats Regulations provide the primary basis for the regulatory protection of cetaceans. All species are listed in Annex IV of the Directive, meaning that a strict protection regime must be applied across their entire range.

9.4.153 Common seal, grey seal, harbour porpoise and bottlenose dolphin are also listed in Annex II of the Habitats Directive affording them protection within designated (Natura) sites (SACs), managed in accordance with the specific requirements of the species. The assessment of potential impacts on European designated sites under the Habitats Directive are addressed in the Habitats Regulations Assessment (Application Document 6.5) for the Project.

9.4.154 All cetaceans are also protected under Schedule 5 of the Wildlife and Countryside Act 1981. This makes it illegal to kill or injure or take the wild mammals listed on that Schedule. Section 9(4)(b) further prohibits the disturbance of any such mammal while it is occupying a place it uses for shelter or protection.

9.4.155 Marine mammals are also protected by the Conservation of Seals (England) Order 1999 and the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS).

Common seal

9.4.156 Common seals haul out on sandbanks or mud flats after foraging, and during moulting and breeding. They are naturally gregarious and tend to haul out in large groups. Intertidal haul-out sites are used throughout the year, with seals moving high up the shore during breeding so to avoid the drowning of pups. On the east coast of England, grey seals breed in June (Special Committee on

Seals in ZSL, 2015c). Blyth Sands is a known haul-out site for common seal. Large groups of common seals have also been observed hauled-out on other sandflat sites within the Thames Estuary (ZSL, 2008).

9.4.157 Common seals normally forage within 50km of a haul-out site (Smoult *et al*.; Special Committee on Seals (SCOS), in ZSL, 2015c). They feed on fish and molluscan taxa including sandeels, gadoids, flatfish, herring, sprat, octopus and squid (Svensson; SCOS in ZSL (2015c)). ZSL carried out a tagging project where individuals were shown to travel considerable distances. Individuals foraging close to Canvey Island moved out to Margate in the south and to Clacton-on-Sea in the north. Other individuals moved much greater distances, being tracked from Southend-on-Sea towards Dover in the south and Grimsby in the north (ZSL, 2019a).

9.4.158 The Greater Thames Estuary (from Gravesend in the west to Felixstowe in the north and Deal in the south) has a common seal population resident throughout the year. The population seems relatively stable, with very similar counts during the 2013 and 2014 seasons, giving a population estimate of 669 common seals in 2013 and 679 common seals in 2014 (ZSL, 2015b). In 2013 it was estimated that the Greater Thames Estuary population represented approximately 2% of the common seal population count of the British Isles and 10% of the English population count, based on the nationwide count by the Sea Mammal Research Unit (SCOS, in ZSL, 2014). Seals are among the most commonly reported marine mammal strandings in the region. Although some of the reports turn out to be ‘false’ in the sense that the animals are not in danger, a number of individuals such as newborn seal pups were confirmed as stranded (British Divers Marine Life Rescue, 2010).

9.4.159 During the surveys conducted by ZSL, a common seal colony was recorded off East Tilbury in August 2014, with a further three colonies recorded downstream towards Canvey Island and the Isle of Grain. In the previous year’s survey, the closest colony to Tilbury was recorded off the Isle of Grain (Figure 9.2: Comparison of common seal locations in the vicinity of the Thames Estuary over three surveys (2013-14) (Application Document 6.2)). Public sightings have recorded common seal all the way up the Thames to Teddington Lock, with activity recorded directly off Tilbury and Gravesend in 2004, 2007, 2013, 2014, 2017 and 2018. In 2019 (to May), there were 55 common seal sightings in the Thames Estuary (ZSL, 2019b). Activities observed ranged from feeding and interacting to resting (ZSL, 2015b).

Grey seal

9.4.160 As with common seals, grey seals haul out on sandbanks or mud flats and move higher up the shore during the breeding season. On the east coast of England, grey seals breed between November and January (SCOS in ZSL, 2015c).

9.4.161 Grey seals spend several weeks ashore during the moulting season which occurs in late spring. When feeding they remain within 75-100km of their haul-out sites; although overall home ranges vary from 1,090 to 6,400km^2 (Reeves *et al*., 2002 and Smoult *et al*. and SCOS, in ZSL (2015c)). As with common seals, they feed on fish and molluscan taxa.

9.4.162 During the ZSL grey seal breeding survey, three major haul-out sites were identified: Pegwell Bay, Dengie Flats and Hamford Water (ZSL, 2015c). Grey seals have been recorded in the Thames Estuary, but often as solitary animals (ZSL, 2008). As with common seal, Blyth Sands is a known haul-out site for grey seal. The grey seal breeding survey concluded that it was unlikely that grey seal breed in the Greater Thames Estuary and that they are seasonal visitors only. Over twice the numbers of grey seals were recorded in the 2014 population survey compared to the 2013 survey (449 and 203 respectively). It was suggested that the number of grey seals using the Greater Thames Estuary in the summer months may be increasing, in line with the grey seal breeding populations along the east coast of England, which are also increasing.

9.4.163 In 2019 (to May), there have been 119 sightings of grey seal activity by the general public in the Thames Estuary, with 1,240 sightings since 2004. Many sightings have been far upstream, with records from between Teddington and Molesey Weir (during 2015). Public sightings of grey seal activity directly off Tilbury and Gravesend have been recorded during 2004, 2010-11, 2013-14 and 2016-19 (ZSL, 2019b). Three grey seals were observed in May 2019 opposite East Tilbury near Higham Saltings. As outlined for common seal, activities observed in grey seals in general ranged from feeding and interacting to resting (ZSL, 2015b).

Harbour porpoise

9.4.164 SCANS-III surveys conducted in summer 2016 estimated that there were between 0.6 and 0.7 harbour porpoises per km^2 in the North Sea assessment unit off the Greater Thames Estuary. The estimated abundance in this unit was 19,064 (Hammond *et al*., 2016), with the overall distribution similar to that observed in 2005. Harbour porpoise is one of the most commonly reported marine mammal strandings in the region, along with seals.

9.4.165 Harbour porpoise are known to feed on a variety of fish species including herring, whiting, sprat, Dover sole and flounder.

9.4.166 Harbour porpoise are the most regularly sighted cetacean in the Thames Estuary (322 since 2004 (ZSL, 2019b)). Harbour porpoise are also the most frequently stranded cetacean species in the estuary. ZSL's monitoring has shown that harbour porpoise are present in the estuary year-round with some evidence of seasonal movements into the Thames region, with peaks in abundance between April and August (ZSL, 2017).

9.4.167 There were seven sightings of harbour porpoise in the Thames Estuary during 2019 (to May). Public sightings have historically been upstream as far as Hampton Court (in 2015). Harbour porpoise activity has been sighted off Tilbury in 2014-15 and 2017-18. Activities observed ranged from feeding and interacting to resting (ZSL, 2015b).

Bottlenose dolphin

9.4.168 Bottlenose dolphins have a worldwide distribution; found in both tropical and temperate seas. The greatest numbers of this species occur offshore along the edge of the European continental shelf (Evans and Baines, 2010). A study carried out by Stockin, *et al*. (2006) and data from the SCANS I/II surveys (Hammond *et al*., 2002 and Hammond, 2008) indicate that resident populations occur in the coastal waters and estuaries of the British Isles; in particular the Moray Firth. In these coastal waters, the bottlenose dolphin often favours river estuaries, headlands or sandbanks in strong tidal currents or uneven seabed relief (Lewis and Evans 1993; Liret *et al*., 1994; Wilson *et al*., 1997; Pesante *et al*., 2008; and Baines and Evans, 2009; all in Evans and Baines, 2010).

9.4.169 No bottlenose dolphins were observed in the assessment unit in the North Sea adjacent to the Greater Thames Estuary in summer 2016 (Hammond *et al*., 2016); the distribution observed was similar to that in 2005.

9.4.170 Bottlenose dolphin tend to form pods of various ages with between two and 10 individuals although in the late summer months, group sizes increase and have been known to form pods of 10s of individuals (Evans and Baines, 2010) and in the Irish Sea, up to 100 individuals at a time have been sighted during the winter months (Pesante *et al*., 2008 in Evans and Baines, 2010). Food resources for bottlenose dolphin tend to be benthic and mid-water species of fish, for example, flounder, dab, Dover sole, bass and herring (Evans and Baines, 2010).

9.4.171 Bottlenose dolphins have been recorded in the Thames Estuary (ZSL, 2015b). 'Dolphin' sightings have been made by the untrained general public, reportedly as far upstream as Richmond (ZSL acknowledge the limitations of this form of data collection, but each record is followed up and extra information requested for clarification, where appropriate). The nearest sighting of activity in the vicinity of Tilbury was off Gravesend in May 2017. There have been 73 sightings (reported by the general public) of dolphins in the Thames since 2004. As outlined above, activities in general observed for cetaceans ranged from feeding and interacting to resting (ZSL, 2015b).

Other species

9.4.172 Other cetacean species have been recorded in the Thames Estuary; these are the white-beaked dolphin *Lagenorhynchus albirostris* and the minke whale *Balaenoptera acutorostrata* (Evans and Baines, 2010). The white-beaked dolphin generally occurs in offshore waters around the British Isles and is found most abundantly in the central and northern North Sea. The coastal waters of south-east England tend to be an occasional site for the white-beaked dolphin, peaking in June and August; they are rarely seen between winter and spring (Evans and Baines, 2010). Minke whale has been sighted in the southern margins of the Thames Estuary and along the Kent coast; these tend to be occasional occurrences and likely to be when hunting for food.

9.4.173 Other whale species have also been infrequently recorded in the Thames Estuary. In 2018/19, a beluga whale *Delphinapterus leucas* was recorded over a number of months in the Thames Estuary (seawatchfoundation.org.uk, 2018), including off Gravesend. It was thought to have left the estuary in late spring 2019.

Marine mammal summary

9.4.174 Densities of marine mammals (both seal and cetacean species) in the vicinity of the Order Limits are low compared to other sea areas of the UK. However, due to their international designation and importance, they have been considered as of **international importance**.

Use of the River Thames

9.4.1 The baseline data used in this topic assessment include information relating to existing vessel movements on the River Thames. The relevant baseline dataset is outlined in the preliminary Navigational Risk Assessment (Application Document 7.15), which shows over 900 vessel transits per month in some sections of the authorised channel within the Order Limits, as well as some use of the navigable water on the north side of the channel within the Order Limits.

Future baseline ('Without Scheme' scenario)

9.4.2 The future baseline identifies anticipated changes to the existing baseline over time in the absence of the Project, and is used as a basis against which to assess the impacts of the Project. A description of how the future baseline has been considered within the assessment is provided in Chapter 4: EIA methodology.

9.4.3 This section reviews the implications of natural changes in the local environment in relation to climate change as well as other developments.

9.4.4 It is likely that the extent and distribution of the marine ecological receptors would remain largely the same as at present in a 'Without Scheme' scenario. However, developments such as Tilbury2, Thurrock Flexible Energy Plant and The London Resort have the potential to affect existing hydrodynamic and sedimentation patterns in the Thames adjacent to the Order Limits.

9.4.5 Assessment of Tilbury2 (Port of Tilbury London Ltd, 2017) have determined that changes to marine communities would be minor or negligible, however assessments of Thurrock Flexible Energy Plant determined significant and irreversible effects on saltmarsh and intertidal mudflat habitats beneath the footprint of the proposed causeway. However, the assessment suggests that 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. The design attributes of The London Resort proposal have yet to be assessed, however they do have the potential to result in changes to marine communities. Due to the scale of the proposal and the proposed mitigation (The London Resort, PEIR, 2020), it is likely that there would be some local impacts on marine communities. Overall, it is likely that there would be some localised changes to the distribution and make-up of marine habitats in the vicinity of the Order Limits.

9.4.6 The UK climate change predictions (UKCP18) are suggesting increased summer temperatures, continued variability in rainfall, and continued sea level rise. These factors have the potential to impact the more transitional species such as saltmarsh which may be impacted by increasing sea level, reducing the area of available habitat. The baseline data for saltmarsh in the area of the Order Limits shows reduced saltmarsh areas along the north shore that represent species-poor communities. Other marine receptors are unlikely to be affected significantly as no species are at the northern or southern limits of their distribution and therefore community change in response to increased temperatures is unlikely.

9.5 Project design and mitigation

9.5.1 Environmental considerations have influenced the Project throughout the design development process, from early route options assessment through to refinement of the Project design (Chapter 3: Assessment of Reasonable Alternatives). An iterative process has facilitated design updates and improvements, informed by environmental assessment and input from the Project engineering teams, stakeholders and public consultation.

9.5.2 The Project includes a range of environmental commitments. Commitments of relevance to marine biodiversity are set out in this section under the following categories:

a. Embedded mitigation: measures that form part of the engineering design, developed through the iterative design process summarised above.

b. Good practice: standard approaches and actions commonly used on infrastructure development projects to avoid or reduce environmental impacts, typically applicable across the whole Project.

c. Essential mitigation: any additional Project-specific measures needed to avoid, reduce or offset potential impacts that could otherwise result in effects considered significant in the context of the EIA Regulations. Essential mitigation has been identified by environmental topic specialists, taking into account the embedded and good practice mitigation.

9.5.3 Embedded mitigation is included within the Design Principles (Application Document 7.5) or as features presented on Figure 2.4: Environmental Masterplan (Application Document 6.2). Design Principles relevant to mitigation of effects on marine biodiversity are described below, each with an alpha-numerical reference code (LSP. XX). Good practice and essential mitigation are included in the Register of Environmental Actions and Commitments (REAC). The REAC forms Chapter 7 of Appendix 2.2: Code of Construction Practice (CoCP) (Application Document 6.3). Each entry in the REAC has an alpha-numerical reference code (REAC Ref. MB0XX) to provide cross reference to the secured commitment. Relevant good practice and essential mitigation to reduce marine biodiversity effects are identified below.

9.5.4 The Design Principles, Environmental Masterplan, CoCP and REAC, all form part of the Project control plan. The control plan is the framework for mitigating, monitoring and controlling the effects of the Project. It is made up of a series of ‘control documents’ which present the mitigation measures identified in the application that must be implemented during design, construction and operation to reduce the adverse effects of the Project. Further explanation of the control plan and the documents which it comprises is provided in the Introduction to the Application (Application Document 1.3).

9.5.5 Enhancement measures have been directly incorporated into the Project as part of the application of ‘good design’ principles. Enhancements are measures that are considered to be over and above any measures to avoid, reduce or remediate adverse impacts of the Project. Relevant beneficial effects arising as a consequence of this good design process are provided below.

Embedded mitigation

Construction phase

9.5.6 Construction phase embedded mitigation of relevance to marine biodiversity is as follows:

a. Construction of the main tunnels with a layer of cover above of at least 0.9 tunnel diameter (14.4m). This avoids the need for works within the River Thames to provide additional scour protection, which would have otherwise required modelling and mitigation to reduce effects on a number of marine ecological receptors.

Operational phase

9.5.7 Operational phase embedded mitigation of relevance to marine biodiversity is as follows:

a. The drainage design minimises the risk of causing flooding elsewhere by using attenuation features as presented on Figure 2.4: Environmental Masterplan (Application Document 6.2). Runoff from areas of new construction would be attenuated to rates in line with the policy requirements of the relevant Lead Local Flood Authorities. This attenuation would protect receiving watercourse flow regimes as well as prevent the potential for increased scour local to drainage outfalls and changes to sediment deposition/accretion in downstream reaches.

Good practice

Construction phase

9.5.8 Construction phase good practice of relevance to marine biodiversity is as follows:

a. Work site drainage systems would incorporate pollution control systems designed in line with Control of Water Pollution from Construction Sites C532 (CIRIA 2001) or as agreed with National Highways. Watercourses near work sites would be regularly inspected for signs of siltation or other forms of pollution in line with CIRIA C741 guidance (CIRIA, 2015) and pumped groundwater, process effluents and construction site runoff would be tested to ensure compliance with discharge consent requirement (REAC Ref. RDWE023).

b. Work site drainage systems would be inspected and maintained to ensure they continue to operate to their design standard, safeguarding surface and groundwater quality (REAC Ref. RDWE002).

c. Wastewater generated from the compound welfare facilities would be discharged to sewer, subject to the agreements with the utility providers, or in locations where a sewer connection is not reasonably practicable, collected and tankered off site for disposal at a licensed treatment facility (REAC Ref. RDWE005).

d. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and would be subject to treatment prior to discharge to any surface watercourse or drain. Rainfall runoff from areas of low contamination risk would be captured and re-used where reasonably practicable e.g. to supply wheel wash facilities or for dust suppression, to reduce consumptive water use (REAC Ref. RDWE006).

e. In accordance with the Project CoCP, Contractors will develop and implement appropriate measures to control the risk of pollution due to construction activities, materials and extreme weather events. This will be included in Contractors' EMP2s or Environmental Incident Control Plans as most appropriate in line with the nature and scope of works. Equipment such as spill kits and absorption mats would be made easily accessible on-site, and personnel would be trained in using them. Clear protocols and communication channels would be provided to ensure that any spillages are dealt with as soon as they are identified. This would prevent large areas of soil potentially becoming contaminated and in turn, protect surface water quality.

f. Construction site compounds where chemical, waste oils or fuel storage and refuelling activities take place would be managed in line with the following measures, where appropriate:

    i. Within the construction site compounds, specific areas would be designated for the storage of chemicals, waste oils and fuel and refuelling activities.

    ii. These designated areas would be bunded to provide capacity for at least 110% of the largest container and placed on hardstanding to prevent downward migration of contaminants.

    iii. These designated areas would be designed with drainage to include measures for isolating spillages.

    iv. Any transfer of fuel or other potentially contaminated liquids would only take place within a designated transfer area.

    v. Drip trays would be provided to reduce the risk of spillages (REAC Ref. GS004).

Operational phase

9.5.9 Operational phase good practice of relevance to marine biodiversity is as follows:

a. Drainage infrastructure and treatment systems would be maintained in accordance with the DMRB GS 801: Asset Delivery asset inspection requirements (Highways England, 2020b) and DMRB GM 701: Asset delivery asset maintenance requirements (ADAMr) (Highways England, 2020c) as applicable, to ensure they continue to operate to their design standard to safeguard surface and groundwater quality (REAC Ref. RDWE012).

Essential mitigation

Potentially significant effects

9.5.10 An iterative appraisal of the Project design taking into account the design principles and good practice was undertaken to identify any potentially significant effects that would require essential mitigation. Effects on marine biodiversity that could be significant, and therefore required further consideration for essential mitigation, were identified as follows:

a. Changes to marine environment water quality and hydrodynamics

b. Loss of marine habitats and species

c. Underwater noise impacts on marine receptors

d. Introduction of INNS

Construction phase

9.5.11 Construction phase essential mitigation of relevance to marine biodiversity is as follows:

a. To mitigate potential effects on water quality and hydrodynamics within the River Thames, the discharge arrangement described in REAC Ref. RDWE028 would be constructed and operational in advance of the excavation of the North Portal and tunnelling works and would be used as the temporary discharge for treated construction phase effluents. All effluents would receive treatment prior to discharge into the Thames to ensure compliance with any limits detailed in the conditions of discharge as agreed with the Environment Agency (REAC Ref. RDWE023).

b. Potential effects arising from the construction, operation, maintenance and decommissioning of the northern tunnel entrance compound drainage pipeline and outfall, and the Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure, would be controlled by the measures agreed with the MMO as detailed in the Deemed Marine Licence (REAC Ref. RDWE024).

c. Drainage from the northern tunnel entrance construction compound is proposed to outfall from the north side of the River Thames. The design of the pipeline and outfall to the River Thames would provide for a subtidal mid-water discharge for effective dilution and dispersal, and to reduce disturbance to the intertidal zone. The discharge infrastructure would be designed in accordance with measures agreed with the MMO as detailed in the Deemed Marine Licence (DCO Schedule 14) (REAC Ref. RDWE028).

d. Works to construct the northern tunnel entrance compound drainage pipeline and outfall, including any piling, must not be undertaken when the work area is either fully submerged, or partially covered by water where this would result in the transmission through the water column of noise and vibration or the generation of suspended sediments in accordance with the conditions set out by the MMO in the Deemed Marine Licence. (DCO Schedule 15) (REAC Ref. MB001). Additional control measures would include:

    i. Techniques such as soft start/ramp-up would be used for the first 20 minutes of piling operations and should piling activities cease for more than 10 minutes, the soft start/ramp-up technique would be repeated. Vibro-piling will be used until first refusal; thereafter impact piling being used to toe-in the piles. Hammer energy would be reduced once an acceptable drive rate is observed (REAC Ref. MB002).

    ii. Prior to the commencement of works below mean high water springs, proposals for lighting of marine construction works subject to the Deemed Marine Licence that require 24-hour working will be developed and submitted to the MMO. This would include an assessment of the effects of measures such as directional lighting and controls on lux levels to mitigate effects on waterfowl during 24-hour operations. (REAC Ref. MB003).

    iii. Works within the intertidal area to construct and decommission the temporary northern outfall would be undertaken during April, May, June, July and August only to avoid disturbance to passage and overwintering birds associated with European designated sites unless otherwise agreed with SoS in consultation with Natural England (REAC Ref. HR002).

e. The permanent Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure would be constructed and operational in advance of the excavation of the North Portal and tunnelling works, and would be used as a source of water for the HRA and ecology mitigation area. Works to construct the cofferdam, including any piling, must not be undertaken when the work area is either fully submerged, or partially covered by water where this would result in the transmission through the water column of noise and vibration or the generation of suspended

sediments in accordance with the conditions set out by the MMO in the Deemed Marine Licence. (DCO Schedule 15) (REAC Ref. MB001). Additional control measures would include:

i. Techniques such as soft start/ramp-up would be used for the first 20 minutes of piling operations and, should piling activities cease for more than 10 minutes, the soft start/ramp-up technique would be repeated. Vibro-piling will be used until first refusal; thereafter impact piling being used to toe-in the piles. Hammer energy would be reduced once an acceptable drive rate is observed (REAC Ref. MB002).

ii. Prior to the commencement of works below mean high water springs, proposals for lighting of marine construction works subject to the Deemed Marine Licence that require 24-hour working will be developed and submitted to the MMO. This would include an assessment of the effects of measures such as directional lighting and controls on lux levels to mitigate effects on waterfowl during 24-hour operations. (REAC Ref. MB003).

iii. Works within the intertidal area to construct the structure would be undertaken during April, May, June, July and August only to avoid disturbance to passage and overwintering birds associated with European designated sites unless otherwise agreed with SoS in consultation with Natural England (REAC Ref. HR002).

f. A marine biosecurity plan will be prepared in line with best practice UK guidance (Payne *et al*, 2015) ahead of any marine works to prevent the introduction and spread of Invasive Non-Native Species. Where a risk of introducing INNS is identified, then suitable control measures will be implemented, and may include control measures as per the International Maritime Organisation's (IMO) Convention for the Control and Management of Ships' Ballast Water and Sediments (2017). For example, where vessels servicing the development originate from high-risk origins, IMO ballast water exchange and sediment disposal measures would be implemented (REAC Ref. MB006).

Operational phase

9.5.12 Operational phase essential mitigation of relevance to marine biodiversity is as follows:

a. The permanent drainage system would include provision for the capture and isolation of contaminated waters to prevent pollution of the receiving watercourse. Operational discharges would be restricted to high tide conditions in order to maximise available dilution and mixing and to prevent scour/erosion of the intertidal zone (REAC Ref. RDWE026).

b. The permanent Coalhouse Point water inlet with self-regulating valve would be of a design that facilitates eel passage (REAC Ref. HR010).

Enhancement

9.5.13 There are no specific enhancement measures included in the Project for Marine Biodiversity.

9.6 Assessment of likely significant effects

9.6.1 This section presents the assessment of likely significant effects on marine biodiversity resulting from the construction and operational phases of the Project. This is based on the design of the Project and takes into account the mitigation as presented in Section 9.5 of this chapter.

9.6.2 The assessment takes into account the importance and level of impact criteria as presented in Table 9.2 and Table 9.3 respectively, and the significance of effects has been determined in accordance with the matrix provided in Table 4.4 of Chapter 4: EIA Methodology and through the use of professional judgement.

9.6.3 It has been assumed that the North Portal operational discharge outfall would be located on/through the existing flood defence and would be constructed from the landward side and would not result in construction-related impacts on the Thames or permanent habitat loss in the intertidal zone. As such, potential construction phase impacts related to this structure have not been considered further.

Construction phase

Impact pathway: changes to water quality from land drainage, and dewatering

General context

9.6.4 This pathway covers the potential changes in water quality relating to physico-chemical, biological and chemical parameters during construction from all discharges including land drainage, dewatering and process water disposal. The deposition of sediment from these sources and associated effects is considered separately.

9.6.5 The drainage associated with the development is extensive owing to the size of the Project, however, this chapter only considers the drainage, dewatering and process water elements that discharge directly to the Thames. The effects on freshwater environments are assessed separately in Chapter 8: Terrestrial Biodiversity and Chapter 14: Road Drainage and the Water Environment.

9.6.6 The land drainage for the Project would be managed using the good practice measures outlined in Section 9.5. The northern tunnel entrance compound drainage pipeline and outfall is to the north of the River Thames and forms a pipeline constructed through the intertidal zone with a subtidal outfall structure. This discharge would be the primary route for the TBM launch portal and tunnel dewatering (at a peak of 64l/s), TBM slurry plant effluent (at a peak of 48l/s) and surface water runoff (at a peak of 607l/s, based on a 1 in 30-year rain event falling at peak rate for 24 hours over the entire site). These sources will not be discharged at the same time, however for the purposes of the assessment a peak volume of 719l/s has been assumed for the discharge.

9.6.7 Pump test water quality from the North Portal work area has been completed and shows that the groundwater is affected by saline intrusion with elevated parameters such as sodium, sulphate, boron, and calcium (Table 9.9).

Table 9.9 North Portal work area – groundwater quality data (taken from Appendix 10.9 Generic Quantitative Risk Assessment Report for the Phase 2 Investigation (Annex A-F), Application Document 6.3)

Parameter	Units	Max. conc.	Parameter	Units	Max. conc.
Benzene	µg/L	2	Acenaphthene	µg/L	2.3
Toluene	µg/L	2	Acenaphthylene	µg/L	0.15
Xylene (m & p)	µg/L	3	Fluoranthene	µg/L	0.93
Xylene (o)	µg/L	2	Anthracene	µg/L	0.45
Xylene Total	µg/L	84	Phenanthrene	µg/L	2.4
Arsenic	µg/L	840	Fluorene	µg/L	1.36
Arsenic (Filtered)	µg/L	146	Chrysene	µg/L	0.4
Boron	µg/L	46,300	Pyrene	µg/L	0.71
Boron (Filtered)	µg/L	17,200	Benzo(a)anthracene	µg/L	0.37
Cadmium	µg/L	13.42	Benzo(b)fluoranthene	µg/L	0.88
Cadmium (Filtered)	µg/L	1.75	Benzo(k)fluoranthene	µg/L	0.3
Chromium (hexavalent) (Filtered)	µg/L	191	Benzo(a)pyrene	µg/L	1.07
Chromium	µg/L	594	Dibenz(a,h)anthracene	µg/L	0.37
Chromium (Filtered)	µg/L	43	Benzo(g,h,i)perylene	µg/L	0.8
Chromium (Trivalent)	µg/L	594	Indeno(1,2,3-c,d)pyrene	µg/L	0.45
Chromium (Trivalent) (Filtered)	µg/L	40	>C8-C10 Aliphatics	µg/L	144
Cobalt (Filtered)	µg/L	56	>C10-C12 Aliphatics	µg/L	32
Copper	µg/L	510	>C12-C16 Aliphatics	µg/L	32
Copper (Filtered)	µg/L	75	>C16-C21 Aliphatics	µg/L	27
Iron (Filtered)	µg/L	47,500	>C21-C35 Aliphatics	µg/L	1,120
Lead	µg/L	3	>C8-C40 Aliphatics	µg/L	1,200
Lead (Filtered)	µg/L	13	>EC8-EC10 Aromatics	µg/L	14
Manganese	µg/L	28,840	>EC10-EC12 Aromatics	µg/L	27
Manganese (Filtered)	µg/L	8,820	>EC12-EC16 Aromatics	µg/L	96
Mercury	µg/L	0.99	>EC16-EC21 Aromatics	µg/L	482

Parameter	Units	Max. conc.	Parameter	Units	Max. conc.
Mercury (Filtered)	µg/L	0.2	>EC21-EC35 Aromatics	µg/L	725
Nickel	µg/L	877	>C7-C8	µg/L	114
Nickel (Filtered)	µg/L	102	>C8-C10	µg/L	251
Selenium	µg/L	51	Gasoline Range Organics'	µg/L	423
Strontium (Filtered)	µg/L	8,030	Trihalomethanes	µg/L	4
Vanadium	µg/L	118	Chloroform	µg/L	1
Zinc	µg/L	3,673	Hexachlorobenzene	µg/L	0.04
Zinc (Filtered)	µg/L	2	Trimethylphenols	µg/L	1.5
Sulphur as Sulphate, SO4 (Filtered)	%	2,730	Trimethylphenols (Filtered)	µg/L	392.1
Alkalinity (Bicarbonate as $CaCO_3$)	mg/L	7,150	Cresol Total	µg/L	3.6
Alkalinity (Carbonate as $CaCO_3$)	mg/L	233	Cresol Total (Filtered)	µg/L	447
Total Hardness (Filtered)	mg/l	4,510	Dimethylphenols	µg/L	6.2
Alkalinity (total) as $CaCO_3$	mg/L	7,620	Dimethylphenols (Filtered)	µg/L	582.6
Ammoniacal Nitrogen as N	mg/L	50.9	Phenol	µg/L	33.6
Ammoniacal Nitrogen as N (Filtered)	mg/L	470	Phenol (Filtered)	µg/L	2,789.4
Bromide	mg/L	28,600	Temperature	°C	19.7
Bromide (Filtered)	mg/L	31.5	Biochemical Oxygen Demand (5-day test)	µg/L	783,400
Calcium	mg/L	625	Conductivity @ 25°C	mS/cm	30.7
Calcium (Filtered)	mg/L	1,130	Total Dissolved Solids (Filtered)	mg/L	20,520
Chloride	mg/L	1,580	Biological Oxygen Demand	mg/L	234.8
Chloride (Filtered)	mg/L	11,000	Chemical Oxygen Demand	mg/L	9,030
Cyanide Total	µg/L	130	Dissolved Organic Carbon (Filtered)	µg/L	3,000,000
Fluoride	µg/L	1,300	pH (Lab)	pH Units	10.5

Parameter	Units	Max. conc.	Parameter	Units	Max. conc.
Magnesium	mg/L	267	Salinity	parts per thousand	20.3
Magnesium (Filtered)	mg/L	1,030	Tecnazene	µg/L	0.02
Nitrate (as N) (Filtered)	mg/L	2	Chlordane (cis)	µg/L	0.11
Phosphate (as P) (Filtered)	µg/L	1,230	Chlorothalonil	µg/L	0.08
Phosphorus	µg/L	9,600	Dichlobenil	µg/L	0.01
Phosphorus (Filtered)	µg/L	1,100	cis-Permethrin	µg/L	0.01
Potassium (Filtered)	mg/L	442	Ethion	µg/L	0.02
Sodium	mg/L	3,300	Fenthion	µg/L	0.01
Sodium (Filtered)	mg/L	6,140	Mevinphos (Phosdrin)	µg/L	0.21
Sulphate	mg/L	1,810	Pendimethalin	µg/L	0.01
Sulphate (Filtered)	mg/L	4,280	Pirimphos-ethyl	µg/L	0.02
Naphthalene	µg/L	8.17	Triclopyr	µg/L	0.08

9.6.8 Other parameters showing elevated levels are those for ammoniacal nitrogen and zinc (Table 9.9), both of which would require pre-treatment prior to discharge. Further information on the groundwater quality data can be found in the Phase 2 Preliminary Geo-environmental Contaminated Land Risk Assessment report (Phase 2 Preliminary Geo-environmental Contaminated Land Risk Assessment Technical Note HE540039-CJV-GEN-GEN-TNT-GEO-00215).

9.6.9 The data in Table 9.9 is provided as pre-treatment levels, it being noted that there is a commitment to provide treatment prior to discharge into the River Thames to ensure compliance with any limits detailed in the conditions of discharge as agreed with the Environment Agency (REAC Ref. RDWE023).

Effects on designated sites

9.6.10 Whilst there will be additional freshwater flow discharged to the River Thames from the North Portal during the construction phase of the Project, the volumes are insignificant in relation to the size of the Thames Estuary which has reported tidal discharges (flood and ebb tide) in the region of 15,000m3s-1 (HR Wallingford, 2002). In addition to the large dilution factor, the estuary is characterised by strong tidal flows and mixing, which will rapidly disperse the discharged water. It is therefore considered that the discharge will not lead to any changes in the physico-chemical characteristics of the Thames. Where there is no change to the Thames, it is considered that there is not the potential to impact on designated sites of European and national importance and therefore there would be no change to designated sites and the effect would be neutral and **not significant**.

Effects on marine water quality

Freshwater input

9.6.11 The discharge of water from the North Portal work area would result (as a worst case) in approximately 719l/s of water entering the River Thames for the duration of construction of the North Portal ramp and tunnels. A large proportion of this volume is rainfall, and only 112l/s comprises TBM process water and dewatering water.

9.6.12 Discharges of treated runoff from the South Portal would be controlled through attenuation ponds and discharged to an existing ditch network and there is a commitment to provide sufficient volumes to allow discharge rates to be controlled to green field runoff rates. Therefore, there would be no additional freshwater input from the south.

9.6.13 Considering the limited effects from discharges to the River Thames it is considered that there will be negligible impacts on the WFD water bodies of European importance as impacts would be temporary and reversible and would not affect the integrity of the WFD water body. It is therefore considered that effects would be slight adverse and **not significant**.

Suspended solids

9.6.14 The discharge of suspended solids would be controlled through the Project's commitment to provide treatment of the surface, groundwater and process water prior to discharge into the River Thames to ensure compliance with any limits detailed in the conditions of discharge as agreed with the Environment Agency (REAC Ref. RDWE023). The Thames has a naturally high background level of suspended sediment; baseline suspended solids levels are variable with an average reported as 113.7mg/l which falls under the medium turbid water classification for WFD of 100 to 300mg/l. In addition to this, the high tidal flows in the area are such that any additional suspended sediments would be rapidly dispersed.

9.6.15 The level of impact in suspended solids as a result of the discharge is predicted to be negligible on WFD water bodies of European importance as they are temporary and will not affect the integrity of the water body. As a result, effects would be slight adverse and **not significant**.

Changes in water chemistry

9.6.16 The pump test groundwater quality data for the North Portal area has shown that there is contamination which is likely attributable to the historic landfill activities that took place in the area. The biggest contaminant is ammonia, as well as metals such as copper, iron, lead, nickel and zinc. Whilst this groundwater contamination exists, the Project has committed to provide treatment of the surface and groundwater prior to discharge into the River Thames to ensure compliance with any limits detailed in the conditions of discharge as agreed with the Environment Agency (REAC Ref. RDWE023).

9.6.17 Owing to the commitment to control contaminant levels in discharge waters, the level of impact on water chemistry as a result of the discharge is predicted to be negligible with respect to WFD water bodies of European importance as levels would be temporary and would not affect the integrity of the water body. As a result, the effects would be slight adverse and **not significant**.

Effects on phytoplankton and zooplankton

9.6.18 Phytoplankton and zooplankton could be affected by Project discharges through changes in salinity, changes in suspended solids and changes to water chemistry. These effects would be restricted to the immediate area around the outfall location. Within this very small area there could be some inhibition of phytoplankton and zooplankton growth. However, this would not have any effect on the abundance and diversity of phytoplankton or zooplankton within the wider estuary. Due to the rapid mixing and dispersion of any discharges, any effects would be very small scale and are unlikely to be detectable above the ranges of natural variability.

9.6.19 Phytoplankton and zooplankton communities are widespread and common in the estuary and are of local importance, therefore the level of impact is predicted to be negligible and the effect from the discharge considered to be neutral and **not significant**.

Effects on intertidal and subtidal habitats and communities

Changes to freshwater flows

9.6.20 The discharge outfall would be sited at the edge of the intertidal zone to facilitate dispersion and mixing of the discharge subtidally, into the deep-water channel. The discharge is likely to be quickly dispersed by the strong tidal currents, therefore any effects would be limited to the immediate vicinity of the discharge point.

9.6.21 The level of impact is predicted to be negligible on intertidal and subtidal mudflat habitats of national importance. The effects from discharges are therefore considered to be slight adverse and **not significant**.

Changes to suspended solids

9.6.22 Intertidal and subtidal habitats and species could be affected by an increase in suspended solids concentrations as elevated levels can reduce feeding efficiency and reduce the growth rates of filter feeders. The estuary is already subject to a high sediment loading, and many of the habitats and species are adapted to survive in such conditions. In addition, any suspended solids would be rapidly dispersed by the tide owing to rapid tidal flows.

9.6.23 The level of impact is predicted to be negligible on intertidal and subtidal habitats, species and communities (including those of conservation importance) of national and local importance as a result of increased suspended solids from the discharge. It is therefore considered that effects would be slight adverse and **not significant**.

Effects on invertebrates (including species of conservation importance)

9.6.24 The effects of the discharge on intertidal and subtidal habitats and species have been assessed as being negligible. There are no invertebrates of conservation importance within the direct vicinity of the discharge. As a result of the predicted rapid mixing by the tides, it is considered that effects on these species of national importance would be slight adverse and **not significant**.

Effects on fish (including species of conservation importance)

Freshwater flow

9.6.25 The predicted discharge into the estuary is unlikely to affect fish as the flows are low in comparison to the discharge of the Thames. The discharge would be rapidly dispersed, and any effects would be highly localised around the outfall and very small compared to the available habitat for fish in the wider context of the estuary.

9.6.26 The level of impact to fish of European to local importance is predicted to be negligible and it is considered that effects would be neutral to slight adverse and **not significant**.

Changes to suspended solids

9.6.27 High turbidity or suspended solids levels can diminish visibility, affect feeding behaviours as well as migration, and potentially cause physical harm to fish. Fish that rely on sight and speed to catch their prey are especially affected by high turbidity and may choose to avoid these areas. Suspended sediment can begin to physically affect the fish that remain in the turbid environment, for example by clogging of gill membranes. In general, fish are unlikely to suffer mortality from suspended sediments as they are able to move away from areas of higher concentrations with effects more likely to be stress responses such as avoidance or temporary changes in feeding behaviour (Kjelland *et al*., 2015).

9.6.28 Predicted suspended solids levels within the River Thames as a result of the discharge are unlikely to be discernible above the naturally high background concentrations. Therefore, the level of impact on fish species of European to local importance is predicted to be negligible and the effect would be neutral to slight adverse and **not significant**.

Changes in water chemistry

9.6.29 As stated in paragraph 9.6.15 there is not predicted to be any effect on water chemistry because the Project has committed to provide treatment prior to discharge into the River Thames to ensure compliance with any limits detailed in the conditions of discharge as agreed with the Environment Agency (REAC Ref. RDWE023).

Impact pathway: changes to water quality from construction and decommissioning of the northern tunnel entrance compound drainage

General context

9.6.30 Construction of the northern tunnel entrance compound drainage pipeline and outfall for discharge of the construction drainage would involve creation of a 300-400m long shallow sheet-piled trench across the intertidal zone, within which a 1,000mm (maximum) diameter pipe would be buried by cut and cover. Sheet piling would be installed on either side of a 2m-wide trench using vibro-piling techniques. The trench would then be excavated and material side cast (working width assumed to be a maximum of 10m wide to accommodate side casting) with sections of pipe then installed and backfilled as the pipeline progressed. The works would be carried out from barges during periods of low water.

9.6.31 The buried pipeline would terminate in a precast outfall or diffuser head on the subtidal riverbed slope to the west of Diver Shoal Groyne. For the purposes of the assessment, it has been assumed as a worst case that a small cofferdam would be required for construction of the outfall or diffuser head (see Chapter 2: Project Description and Appendix 2.1: Construction Supporting Information (Application Document 6.3) for further details). The construction works for both the pipeline and the outfall would be completed over an eight-week period, assuming a seven-day working week.

9.6.32 Decommissioning of the pipeline and outfall would be the reverse of the construction process described above and is therefore assumed to be completed over eight weeks, working seven days a week.

9.6.33 During these works there is the potential for sediments to be mobilised which may release sediment-bound contaminants into the water column with potential indirect effects on marine organisms. The baseline assessment (Section 9.4) shows that sediments within the Thames Estuary have areas of historic contamination owing to its industrial nature.

Effects on designated sites

9.6.34 Construction and decommissioning of the northern tunnel entrance compound drainage pipeline would be undertaken during periods of low water which would result in minimal resuspension of sediments. The trench would be excavated and the pipeline buried and backfilled in sections. This would limit the amount of backfilled material available for resuspension on any one tide. Any material resuspended by the flooding tide would be rapidly dispersed and diluted. The level of impact as a result of changes to water quality from resuspended sediments and release of sediment-bound contaminants to designated sites of European and national importance is predicted to be negligible as effects are temporary and will not affect the integrity of sites. As a result, the effect is considered to be slight adverse and **not significant**.

Effects on phytoplankton and zooplankton

9.6.35 Construction and decommissioning of the northern tunnel entrance compound drainage pipeline and outfall would result in minimal resuspension of sediment with rapid dispersion. Hence, effects on phytoplankton and zooplankton such as inhibition of growth by the release of sediment-bound contaminants, would be restricted to the immediate areas around the works, and would not have any effect on the wider abundance and diversity of phytoplankton or zooplankton within the estuary. Any effects would be small scale and are unlikely to be detectable above changes as a result of natural variability.

9.6.36 The level of impact on phytoplankton and zooplankton communities of local importance is predicted to be negligible and the effect from changes to water quality are considered to be neutral and **not significant**.

Effects on intertidal and subtidal habitats and communities (including species of conservation importance)

9.6.37 Construction and decommissioning of the northern tunnel entrance compound drainage pipeline and outfall would result in minimal resuspension of sediment, therefore the risk of releasing sediment-bound contaminants would be minimal. The level of impact on intertidal and subtidal habitats and communities of

national to local importance is therefore predicted to be negligible and the effects considered to be neutral to slight adverse and **not significant**.

Effects on fish (including species of conservation importance)

9.6.38 The resuspension of sediments and the release of sediment-bound contaminants is unlikely to be significant due to the low-water working, the limited working sections exposed in any one tide cycle and the dilution capacity of the River Thames. Therefore, the level of impact on fish species ranging from European to local importance is predicted to be negligible as effects are considered temporary and would not affect the integrity of the resource. The effect is therefore considered to be neutral to slight adverse and **not significant**.

Effects on marine mammals

9.6.39 The resuspension of sediments and the release of sediment-bound contaminants is unlikely to be significant due to the low-water working, the limited working sections exposed in any one tide cycle, and the dilution capacity of the Thames. Therefore, the level of impact on marine mammals of international importance is predicted to be negligible as effects are temporary and will not affect the integrity of the resource. The effect from changes to water quality is therefore considered to be slight adverse and **not significant**.

Impact pathway: direct loss of habitats and species resulting from construction of the northern tunnel entrance compound drainage pipeline and outfall

General context

9.6.40 Direct loss of habitats and species would occur from construction of the northern tunnel entrance compound drainage pipeline across the intertidal zone, and the outfall structure in the subtidal zone.

9.6.41 The discharge would comprise a pipeline buried within the intertidal zone, terminating at an outfall structure of pre-cast concrete of approximately 2.5m by 4m providing a subtidal discharge point. The discharge pipeline would extend 300-400m across the intertidal zone and would require a 2m-wide piled trench, and a working width of approximately 10m resulting in the temporary direct loss of approximately 0.4ha. The outfall structure itself would result in the direct loss of approximately 0.001ha.

9.6.42 The construction of the discharge structures would result in the temporary direct loss of intertidal and subtidal habitat and mortality of species within the construction footprint. There is no risk of fragmentation of habitats and isolation of species and communities as the structure would not form a complete barrier across the intertidal zone, therefore allowing the movement of species. There would be no loss of beneficial ecosystem processes provided by the intertidal habitats, including nutrient cycling, primary production and regulation of water quality. There may be temporary indirect effects to species which rely on these habitats for food or refuge, leading to potential indirect effects on survival, growth, reproduction or displacement of individuals.

9.6.43 Recolonisation of disturbed areas in estuarine environments has been shown to be rapid (Hiscock *et al*., 2002). These habitats are subject to regular stress based on the tidal environment in which they reside and communities are of low diversity as a result. These species are adapted to a changing environment. The physical characteristics of the site are not changing as the sediment removed for the construction of the pipeline would be returned, along with any fauna still within it.

9.6.44 Decommissioning of the northern tunnel entrance compound drainage pipeline and outfall would also result in the temporary loss and disturbance of intertidal and subtidal habitats. As outlined above, recolonisation of reinstated areas in estuarine environments has been shown to be rapid (Hiscock *et al*., 2002), hence any effects would be short lived.

Effects on designated sites

9.6.45 The temporary loss of intertidal habitats and communities (including those of conservation importance) would have an indirect effect on designated sites, through the temporary loss of habitat, feeding resource and refuge, for species which are qualifying features.

9.6.46 None of the intertidal habitats, associated invertebrate or fish species identified as being either directly or indirectly affected by the footprint of the marine works are qualifying features of any nearby designated sites and their temporary loss will not affect the integrity of sites. It is therefore predicted that the level of impact on designated sites of European and national importance would be negligible and the effect from the temporary direct loss of habitats and species under the footprint of the marine works would be slight adverse and **not significant**.

Effects on intertidal habitats and communities

9.6.47 A total of 0.4ha of habitat would be temporarily lost under the footprint of the marine works in the intertidal area on the north shore of the River Thames during the construction of the northern tunnel entrance compound drainage pipeline and outfall. The intertidal areas affected primarily comprise mudflats and sandflats, with adjoining areas of saltmarsh and patches of brown algal beds. The faunal communities and sediment types resemble the Joint Nature Conservation Committee marine biotope '*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud'.

9.6.48 The intertidal habitat on the north side of the River Thames predominantly comprises elevated mud and sandbanks intersected by tidal channels (Physalia, 2017), with the communities characterised by low species diversity but high abundance. The communities are dominated by the muddy macroinvertebrate community characterised by the *Hediste diversicolor* and *Scrobicularia plana* biotope, and by the sandy mud community dominated by the *Hediste diversicolor* and *Macoma* (*Limecola*) *balthica* biotope. It has been identified in the baseline assessment that the densities and distributions of the macroinvertebrate communities are considerably variable across the shore owing to the sediment characteristics.

9.6.49 Direct habitat and species loss within the footprint of the marine works has been assessed as a temporary effect, as following re-establishment, intertidal substrate would be available for colonisation. Once habitats have become re-established through the action of the tides, invertebrate fauna would be expected to move into the area rapidly from adjacent habitats. The early stages of recolonisation are likely to occur quickly with mobile species such as the mud snail moving into the area followed by worm species (Hiscock *et al*., 2002).

9.6.50 None of the intertidal habitats and communities that would be temporarily lost during construction are considered to be of conservation importance in their own right (i.e. are not designated). However, they are considered of national importance as they provide key foraging, breeding and nursery habitat for bird populations. The area of intertidal habitats in the Thames Estuary is extensive on both a local and regional scale, and there would be recovery of communities following completion of construction in the short term. It is therefore predicted that this temporary loss of intertidal habitat would result in a minor impact because the integrity of the intertidal communities as a resource would not be affected and the area impacted is a tiny proportion of available habitat. The effect from the temporary direct loss of intertidal habitats and communities of national importance under the footprint of the marine works would be slight adverse and **not significant**.

Effects on subtidal habitats and communities

9.6.51 A total of 0.001ha of habitat would be lost under the footprint of the marine works in the subtidal area of the River Thames. The subtidal area affected primarily comprises an area of mixed sand and mud. Subtidal communities in this area of the Thames are generally of the biotope SS.SMu.SmuVS.PolCvol- i.e. variable salinity clay and firm mud characterised by a turf of the polychaete *Polydora ciliata* along with the amphipod *Corophium volutator* (PLA, 2017).

9.6.52 Direct habitat and species loss within the subtidal footprint of the marine works has been assessed as a temporary effect, as following completion of the construction phase, the outfall structure would be removed, and the subtidal habitat left to re-establish.

9.6.53 None of the subtidal habitats and communities that would be temporarily lost during the construction phase are considered to be of conservation importance. It is therefore predicted that this loss of subtidal habitat of local importance would result in a negligible impact and the effect from the direct loss under the footprint of the marine works would be neutral and **not significant**.

Effects on invertebrates (of conservation importance)

9.6.54 The temporary loss of intertidal habitat would have a direct effect on invertebrates of conservation importance from mortality under the footprint of the marine works.

9.6.55 The tentacled lagoon worm is a feature of the Swanscombe MCZ and Medway Estuary MCZ. However, the baseline assessment confirmed that there are no records of the worm in the Thames Estuary as far downstream as the Gravesend/Tilbury area. No other invertebrates of conservation or commercial importance were identified in the vicinity of the Order Limits.

9.6.56 Therefore, there are no predicted effects on invertebrates of conservation importance from the marine works associated with the Project.

Effects on fish

9.6.57 Direct mortality of fish from the marine works is unlikely as fish are highly mobile. However, the temporary loss of intertidal habitat would have an indirect effect on fish due to the loss of habitat, feeding resource and refuge, resulting in displacement.

9.6.58 Fish assemblages in the Order Limits are reflective of a typical estuarine community with the dominant taxa showing a seasonal shift in composition. Dominant taxa include gobies, Dover sole, smelt, and clupeids, with gobies dominant across all seasons. The Thames Estuary is recognised as an important spawning and nursery area for juvenile fish such as Dover sole.

9.6.59 The Thames Estuary has a wide availability of habitat and food resource outside of the Order Limits, and the level of impact is predicted to be negligible. Therefore, it is considered that effects on general fish and fisheries of local importance from the direct loss of either individuals or key habitats under the footprint of the marine works would be neutral and **not significant**.

9.6.60 Fish of conservation importance recorded within the Order Limits are not restricted to that area and are common across the estuarine reaches of the River Thames. Therefore, given the low numbers of fish that are likely to be affected and the fact that the integrity of the resource will not be affected, the level of impact is predicted to be negligible and the effect on fish of national and European importance from the direct loss of either individuals or key habitat under the footprint of the marine works is considered to be slight adverse and **not significant**.

Impact pathway: changes to water quality from construction of the permanent Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure

General context

9.6.61 Construction of the permanent Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure would require a working area of 50m by 35m located in the upper intertidal zone. A sheet-piled cofferdam (approximately 10m x 15m) would be constructed within the working area to isolate the section of the flood defence in which the structure is to be installed. Isolation via the cofferdam would allow the flood defence to be ‘breached’ for the installation of the structure.

9.6.62 Piling works for the cofferdam would be undertaken from a dumb barge with spud legs or anchors on winches, with a 30 to 50 tonne, 360° excavator and a multicat with a 5 tonne lifting capacity to set anchors as required. The main piling barge may also be serviced by a second dumb feeder barge carrying the sheet piles. It has been assumed that any barges would be floated into position during high tide periods.

9.6.63 The short sheet piles would be vibro-piled into place (circa 6m 'driven' in 4m below trench base) with a small vibrating hammer. Sheet piling would be installed along either side of the proposed working area forming the cofferdam. Excavation of the section of flood defence would take place within the cofferdam to the required depth.

9.6.64 Excavated arisings would be retained within the cofferdam or stored on a support barge or on land. Arisings would not be side cast within the intertidal area.

9.6.65 The proposed structure would be installed in the location of the flood defence 'breach'. Due to uncertainty over ground conditions, this may require additional foundation works and therefore piling has been assumed.

9.6.66 Following the installation of the structure the flood defence would be reinstated/ backfilled to maintain continuity of the defence around the new structure. The sheet-piled cofferdam would be removed and any areas excavated backfilled as required. The total duration of the works is estimated to be approximately 12 weeks.

9.6.67 It has been assumed that the structure would be permanent, due to its role in supporting HRA and ecology mitigation. Therefore, decommissioning of the asset has not been assessed.

Effects on designated sites

9.6.68 Construction of the cofferdam required to install the Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure would be undertaken during low water periods which would result in minimal resuspension of sediments. All other works would be undertaken within the cofferdam, limiting impacts as a result of changes to water quality from resuspended sediments and release of sediment-bound contaminants to designated sites of European and national importance. As such, any impacts are predicted to be negligible as effects are temporary and will not affect the integrity of sites. As a result, the effect is considered to be slight adverse and **not significant**.

Effects on phytoplankton and zooplankton

9.6.69 Construction of the Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure would result in minimal resuspension of sediment due to the use of a cofferdam for the works. Hence, any effects would be small scale, very localised and are unlikely to be detectable above changes as a result of natural variability.

9.6.70 The level of impact on phytoplankton and zooplankton communities of local importance is predicted to be negligible and the effect from changes to water quality are considered to be neutral and **not significant**.

Effects on intertidal habitats and communities (including species of conservation importance)

9.6.71 Construction of the Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure would result in minimal resuspension of sediment, therefore the risk of releasing sediment-bound contaminants would be minimal. The level of impact on intertidal habitats and communities of national to local importance is therefore predicted to be negligible and the effects considered to be neutral to slight adverse and **not significant**.

Effects on fish (including species of conservation importance)

9.6.72 The resuspension of sediments and the release of sediment-bound contaminants is unlikely to be significant due to the low-water/cofferdam working. Therefore, the level of impact on fish is predicted to be negligible, and as such the effect is considered to be neutral to slight adverse and **not significant**.

Effects on marine mammals

9.6.73 The resuspension of sediments and the release of sediment-bound contaminants is unlikely to be significant due to the low-water/cofferdam working. Therefore, the level of impact on marine mammals is predicted to be negligible, and as such the effect is considered to be neutral to slight adverse and **not significant**.

Impact pathway: direct loss of habitats and species resulting from construction of the water inlet with self-regulating valve structure within the intertidal zone

General context

9.6.74 Direct, temporary loss of habitats and species would occur as a result of construction of the Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure within the intertidal zone. The construction period is estimated to take place over a 12-week period, hence there would be recovery of the habitats once the work is complete.

Effects on designated sites

9.6.75 The temporary loss of intertidal habitats and communities (including those of conservation importance) would have an indirect effect on designated sites, through the temporary loss of habitat, feeding resource and refuge, for species which are qualifying features.

9.6.76 None of the intertidal habitats, associated invertebrate or fish species identified as being either directly or indirectly affected by the footprint of the marine works are qualifying features of any nearby designated sites and their temporary loss will not affect the integrity of sites. The siting of the working area and proposed barge drying-out areas would avoid any areas of saltmarsh, and would mainly impact intertidal mud, sand and coarse sediments. It is predicted that the level of impact on designated sites of European and national importance would be negligible and the effect from the temporary direct loss of habitats and species under the footprint of the marine works would be slight adverse and **not significant**.

Effects on intertidal habitats and communities

9.6.77 A total of 0.175ha of habitat has the potential to be temporarily impacted within the footprint of the working area in the intertidal area on the north shore of the River Thames during the construction of the Coalhouse Point water inlet with self-regulating valve. The intertidal areas affected primarily comprise mud, sand and coarse sediments, with adjoining areas of saltmarsh and patches of brown algal beds. The faunal communities and sediment types resemble the Joint Nature Conservation Committee marine biotope '*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud'.

9.6.78 The intertidal habitat on the north side of the Thames predominantly comprises elevated mud and sandbanks intersected by tidal channels (Physalia, 2017), with the communities characterised by low species diversity but high abundance. The communities are dominated by the muddy macroinvertebrate community characterised by the *Hediste diversicolor* and *Scrobicularia plana* biotope, and by the sandy mud community dominated by the *Hediste diversicolor* and *Macoma* (*Limecola*) *balthica* biotope. It has been identified in the baseline assessment that the densities and distributions of the macroinvertebrate communities are considerably variable across the shore owing to the sediment characteristics.

9.6.79 Direct habitat and species loss within the footprint of the works has been assessed as a temporary effect, as following re-establishment, intertidal substrate would be available for colonisation. Once habitats have become re-established through the action of the tides, invertebrate fauna would be expected to move into the area rapidly from adjacent habitats. The early stages of recolonisation are likely to occur quickly with mobile species such as the mud snail moving into the area followed by worm species (Hiscock *et al*., 2002).

9.6.80 None of the intertidal habitats and communities that would be temporarily lost during construction are considered to be of conservation importance in their own right (i.e. are not designated). However, they are considered of national importance as they provide key foraging, breeding and nursery habitat for bird populations. The area of intertidal habitats in the Thames Estuary is extensive on both a local and regional scale, and there would be recovery of communities following completion of construction in the short term. It is therefore predicted that this temporary loss of intertidal habitat would result in a minor impact because the integrity of the intertidal communities as a resource would not be affected and the area impacted is a tiny proportion of available habitat. The effect from the temporary direct loss of intertidal habitats and communities of national importance under the footprint of the marine works would be slight adverse and **not significant**.

Effects on invertebrates (of conservation importance)

9.6.81 The temporary loss of intertidal habitat would have a direct effect on invertebrates of conservation importance from mortality under the footprint of the marine works.

9.6.82 The tentacled lagoon worm is a feature of the Swanscombe MCZ and Medway Estuary MCZ. However, the baseline assessment confirmed that there are no records of the worm in the Thames Estuary as far downstream as the Gravesend/Tilbury area. No other invertebrates of conservation or commercial importance were identified in the vicinity of the Order Limits.

9.6.83 Therefore, there are no predicted effects on invertebrates of conservation importance from the marine works associated with the Project.

Effects on fish

9.6.84 Direct mortality of fish from the marine works is unlikely as fish are highly mobile. However, the temporary loss of intertidal habitat would have an indirect effect on fish due to the loss of habitat, feeding resource and refuge, resulting in displacement.

9.6.85 Fish assemblages in the Order Limits are reflective of a typical estuarine community with the dominant taxa showing a seasonal shift in composition. Dominant taxa include gobies, Dover sole, smelt, and clupeids, with gobies dominant across all seasons. The Thames Estuary is recognised as an important spawning and nursery area for juvenile fish such as Dover sole.

9.6.86 The Thames Estuary has a wide availability of habitat and food resource outside of the Order Limits, and the level of impact is predicted to be negligible. Therefore, it is considered that effects on general fish and fisheries of local importance from the direct loss of either individuals or key habitats under the footprint of the marine works would be neutral and **not significant**.

9.6.87 Fish of conservation importance recorded within the Order Limits are not restricted to that area and are common across the estuarine reaches of the River Thames. Therefore, given the low numbers of fish that are likely to be affected and the fact that the integrity of the resource will not be affected, the level of impact is predicted to be negligible and the effect on fish of national and European importance from the direct loss of either individuals or key habitat under the footprint of the marine works is considered to be slight adverse and **not significant**.

Impact pathway: physical disturbance of habitats from land-based sources (including from scour, smothering and air pollutant deposition)

General context

9.6.88 Air pollutants released from construction plant and process machinery can be deposited into the marine environment either by dry or wet deposition processes. Deposition of air pollutants, particularly nitrogen and sulphur compounds can cause disturbance to marine habitats and species through acidification. An assessment of air quality effects on marine designated sites of nature conservation importance and supporting features is presented within Chapter 5: Air Quality. This assessment concluded that with best practice mitigation measures proposed to minimise dust effects on receptors, a significant air quality effect is not expected.

9.6.89 The release of suspended solids from land sources such as dewatering, can lead to subsequent sediment deposition on the bed and therefore physical disturbance through the effects of smothering. Similarly, the release and subsequent deposition of airborne dust from land-based construction activities may also cause physical disturbance to intertidal habitats and species.

9.6.90 The deposition of suspended solids can smother the bed potentially resulting in changes to bed geomorphology, sediment structure and habitats. This could have effects on species that currently rely on these habitats for food or refuge, leading to potential indirect effects on survival, growth, reproduction or displacement of individuals. Smothering can prevent photosynthesis, leading to lower growth rates of flora and photosynthetic benthic diatoms and flagellates, potentially leading to mortality if conditions persist.

9.6.91 The temporary North Portal construction discharge to the River Thames has the potential to alter local flow patterns and therefore scour. The Thames naturally has high tidal flow velocities (maximum of $2ms^{-1}$ on a spring tide (RWE, 2012)) and the outfall structure would be designed to direct flows mid-water (Section 9.5). As a result, it is considered that scour from the discharge would not result in physical disturbance to marine receptors.

Effects on intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh)

9.6.92 According to the Marine Life Information Network (MarLIN) Marine Evidence based Sensitivity Assessment (MarESA) criteria, deposition of up to 5cm in a single event is classified as light smothering, with heavy smothering being up to 30cm in a single discrete event (Tillin and Tyler-Walters 2015a, 2015b).

9.6.93 Deposition of up to 1cm in a single event is assumed to represent smothering comparable to natural events and is therefore considered to be of negligible magnitude. This assumption is based on extensive literature which contains studies relating to natural sedimentation processes and ecological effects (Miller *et al.,* 2002).

9.6.94 It is predicted that there would be very little deposition of suspended sediment as a result of the discharge as the Project has committed to provide treatment prior to discharge into the River Thames to ensure compliance with any limits detailed in the conditions of discharge as agreed with the Environment Agency (REAC Ref. RDWE023). Any sediments that do settle out on to intertidal habitats and communities, are likely to be resuspended by tidal currents and deposited over a wide area. Owing to this fact, any deposition would be negligible in the context of having an impact on benthic habitats and fauna and would likely be within the range currently experienced by intertidal communities in the Thames Estuary. Therefore, it is considered that the level of impact to intertidal habitats and communities of national to local importance would be negligible and the overall effect from physical disturbance would be slight adverse to neutral and **not significant**.

Effects on subtidal habitats and communities

9.6.95 As noted above with respect to smothering of intertidal habitats and communities, the suspended solids loading of the discharge would be controlled by the Project's commitment to provide treatment prior to discharge into the River Thames to ensure compliance with any limits detailed in the conditions of discharge as agreed with the Environment Agency (REAC Ref. RDWE023). Any subsequent discharge of suspended solids is likely to be dispersed and deposited over a wide area. It is therefore considered that the level of impact to subtidal habitats and communities of national importance would be negligible and the overall effect from physical disturbance would be slight adverse and **not significant**.

Effects on invertebrates (of conservation importance)

9.6.96 Acknowledging that there is predicted to be a slight effect of physical disturbance to intertidal habitats and communities from smothering, it is also considered that there would be a negligible impact on invertebrates of national importance. Impacts from smothering would be within the normal ranges experienced by intertidal communities and the integrity of the communities would not be affected. The effect is therefore considered to be slight adverse and **not significant**.

Impact pathway: physical disturbance of habitats from construction of the northern tunnel entrance compound drainage pipeline and outfall (smothering)

General context

9.6.97 As discussed in paragraph 9.6.30, construction of the northern tunnel entrance compound drainage pipeline would use cut and cover within a sheet-piled trench 300-400m long, terminating in a precast outfall or diffuser head.

Effects on intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh)

Smothering

9.6.98 The construction and decommissioning of the northern tunnel entrance compound drainage pipeline and outfall would be undertaken during periods of low water, therefore, excess backfilled material would only be resuspended during the next flood tide and would be limited to the active working section of the pipeline. The Thames Estuary has high tidal flows and therefore any material resuspended is likely to be deposited over a wide area. It is estimated that the works would at most result in localised areas of light smothering within areas of habitat characterised by mudflats and sandflats. Constituent biotopes of these habitats include *Hediste diversicolor* and *Scrobicularia plana* biotope, and the *Hediste diversicolor* and *Macoma* (*Limecola*) *balthica* biotope. These biotopes have high resilience to both light and heavy smothering (Tillin and Rayment, 2016). Hence, the level of impact from smothering is predicted to be negligible on intertidal habitats and communities of national to local importance, and therefore any effects are predicted to be slight adverse to neutral and **not significant**.

Effects on subtidal habitats and communities

9.6.99 As per the intertidal habitats, any material resuspended is likely to be deposited over a wide area. The subtidal biotopes of the River Thames have a high resilience to both light and heavy smothering (Tillin and Rayment, 2016). Hence, the level of impact from smothering is predicted to be negligible, and for subtidal habitats and communities of national to local importance, the level of impact from the construction of the dewatering discharge and its effects are predicted to be slight adverse to neutral and **not significant**.

Effects on invertebrates (of conservation importance)

9.6.100 Acknowledging the negligible impact from smothering on intertidal habitats and communities, the level of impact and overall effect on invertebrates of national importance is also considered as slight adverse and **not significant**.

Effects on designated sites

9.6.101 The smothering of intertidal habitats and communities (including those of conservation importance) would have an indirect effect on designated sites, through loss of habitat, feeding resource and refuge, for species which are qualifying features.

9.6.102 None of the habitats, associated invertebrate or fish species identified as being either directly or indirectly affected by the construction of the northern tunnel entrance compound drainage pipeline and outfall are qualifying features of any nearby designated sites. It is therefore considered that there would be a negligible impact on current and proposed designated sites of European and national importance from physical disturbance in the footprint of the marine works. These impacts are considered to be within the natural range of experienced by the communities in the estuary and the integrity of the resources would not be affected. It is therefore considered that effects would be slight adverse and **not significant**.

Impact pathway: physical disturbance of habitats from construction of the permanent Coalhouse Point water inlet with self-regulating valve (smothering)

General context

9.6.103 As discussed in paragraph 9.6.61, construction of the permanent Coalhouse Point water inlet with self-regulating valve would be within a sheet-piled cofferdam (10m x 15m) within in an overall working area of 50m x 35m.

Effects on intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh)

Smothering

9.6.104 Construction of the structure within the cofferdam would be undertaken from barges during low water periods, therefore, any disturbed material would only be resuspended during the next flood tide and would be limited to the area of disturbance. The main works would be undertaken within the cofferdam, thus avoiding the release of any materials.

9.6.105 The Thames Estuary has high tidal flows and therefore any material resuspended is likely to be deposited over a wide area. It is estimated that the works would at most result in localised areas of light smothering within areas of habitat characterised by mudflats and sandflats. Constituent biotopes of these habitats include *Hediste diversicolor* and *Scrobicularia plana* biotope, and the *Hediste diversicolor* and *Macoma* (*Limecola*) *balthica* biotope. These biotopes have high resilience to both light and heavy smothering (Tillin and Rayment, 2016). Hence, the level of impact from smothering is predicted to be negligible on intertidal habitats and communities of national to local importance, and therefore any effects are predicted to be slight adverse to neutral and **not significant**.

Effects on invertebrates (of conservation importance)

9.6.106 Acknowledging the negligible impact from smothering on intertidal habitats and communities, the level of impact and overall effect on invertebrates of national importance is also considered as slight adverse and **not significant**.

Effects on designated sites

9.6.107 The smothering of intertidal habitats and communities (including those of conservation importance) would have an indirect effect on designated sites, through loss of habitat, feeding resource and refuge, for species which are qualifying features.

9.6.108 None of the habitats, associated invertebrate or fish species identified as being either directly or indirectly affected are qualifying features of any nearby designated sites. It is therefore considered that there would be a negligible impact on current and proposed designated sites of European and national importance from physical disturbance in the footprint of the marine works. These impacts are considered to be within the natural range of experiences by the communities in the estuary and the integrity of the resources would not be affected. It is therefore considered that effects would be slight adverse and **not significant**.

Impact pathway: introduction of non-native species

General context

9.6.109 Invasive, non-native, alien or exotic species are those that have been released into an environment beyond their native bio-geographic range or habitat, either by accident or intentionally (Barton and Heard, 2004). On release into a new environment, a non-native species may or may not become established depending on its tolerance of the prevailing conditions and/or other random events such as predation.

9.6.110 A species is classed as ‘invasive’ when it establishes in the new environment and out-competes native species resulting in a detrimental impact on native habitats. The Great Britain Non-Native Species Secretariat (2017) defines Invasive Non-Native Species (INNS) as ‘*any non-native animal or plant that has the ability to spread causing damage to the environment, the economy, our health and the way we live*’.

9.6.111 The most likely pathway for non-natives to be introduced to the Order Limits is from marine plant and vessels which can transport invasive non-natives, as fouling on hulls and in ballast water. General marine traffic associated with the marine construction works also has the potential to transfer INNS that are currently present within the Order Limits, to other areas.

9.6.112 Newly established substrates and artificial structures are often colonised by INNS owing to the absence of competition and predation; their presence can facilitate the establishment and spread of newly introduced INNS (Gittenberger and Van der Stelt, 2011). New substrates can also serve as ‘stepping stones’ in an otherwise inhospitable area (e.g. hard structures placed on soft sediment habitats can support the establishment of species associated with hard substrates), which can assist with the expansion of a species distribution (Keith et al., 2011; Mieszkowska et al., 2006).

9.6.113 There are several pathways by which conditions could alter during construction in favour of non-native species, including the following:

a. Changes to the physical conditions (e.g. hydrodynamics) which can disrupt native species therefore allowing potential establishment of INNS.

b. Disturbance of established communities containing INNS increasing the risk of releasing fragments into the marine environment which may then spread on currents or attach to vessels and establish elsewhere.

9.6.114 Essential mitigation has been proposed to reduce the likelihood of transmitting non-native species during the construction phase. A marine biosecurity plan will be prepared in line with best practice UK guidance (Payne et al, 2015) ahead of any marine works to prevent the introduction and spread of INNS. Where a risk of introducing INNS is identified, then suitable control measures will be implemented, and may include control measures as per the International Maritime Organisation's (IMO) Convention for the Control and Management of Ships' Ballast Water and Sediments (2017). For example, where vessels servicing the development originate from high risk origins, IMO ballast water exchange and sediment disposal measures would be implemented (REAC Ref. MB006).

Effects on intertidal and subtidal habitats and communities

9.6.115 The introduction of INNS has the potential to alter the structure and function of existing ecological communities. Potential effects on native species include competition for space and resources; alteration of substrata and water conditions; predation and depletion of native species; smothering of native species; consumption of pelagic larvae and loss of prey and refuge (Sewell *et al*., 2008).

9.6.116 All INNS detailed in paragraph 9.4.92 represent benthic species, the introduction and spread of which would have a direct effect on intertidal and subtidal habitats and species.

9.6.117 The sensitivity of intertidal habitats and species to non-native introductions varies from low to moderate depending on the potential for non-native species to compete with native species for space and food. INNS already known to be present within intertidal areas of the Order Limits do not represent a significant risk, although the introduction of new substrate could allow these species to proliferate within the area.

9.6.118 INNS already present in the Order Limits or in the estuary could facilitate the spread of newly introduced non-natives. To help prevent the introduction or spread of INNS during construction, a marine biosecurity plan will be prepared and implemented in line with best practice UK guidance (REAC Ref. MB006), therefore the probability of transmission is low.

9.6.119 Based on the presence of non-native species and the low risk of transfer and establishment of non-native species, the level of impact is predicted to be negligible on intertidal and subtidal habitats and communities of national to local importance. Therefore, it is considered that there would be a neutral to slight adverse effect from the introduction and spread of invasive non-natives during construction, that is **not significant**.

Impact pathway: underwater noise and vibration

General context

9.6.120 Over the past 20 years it has become increasingly evident that noise and vibration from human activities in and around underwater environments can have an impact on marine species. The extent to which intense underwater sound might have an adverse environmental impact on a particular species is dependent upon the incident sound level, frequency, duration, and/or repetition rate of the sound wave.

9.6.121 The impacts of underwater sound can be broadly summarised into three categories:

a. Physical traumatic injury or fatality

b. Auditory damage (either permanent or temporary)

c. Behavioural disturbance

9.6.122 Underwater noise and vibration generated during marine construction has the potential to impact upon fish, marine mammals and some macroinvertebrates. In terms of the marine works associated with the Project, the following construction activities are considered as sources of underwater noise and vibration:

a. Piling operations associated with the construction water management discharge and Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure

b. TBM operations

c. Vessel movements

9.6.123 For the purpose of this assessment, each of these activities will be assessed separately for each of the receptors taking into consideration good practice mitigation.

9.6.124 Sound or vibration are defined in terms of their frequency (pitch) and amplitude (level or loudness). Frequency is measured in Hertz (Hz) (1Hz = 1 cycle per second), amplitude is measured in units of velocity, e.g. millimetres per second (mm/s), but is often expressed in decibels (dB) in biological applications. Sound pressure level is usually reported in decibels (dB) which is a logarithmic scale that compresses the wide-ranging potential source pressures to ease description.

9.6.125 An animal's sensitivity to sound varies according to the sound frequency. The response to sound depends on the presence and levels of noise within the range of frequencies to which an animal is sensitive. For most fish, sound above 1kHz is not audible. Marine mammals such as pinnipeds and cetaceans typically hear best between 1kHz and 100kHz (Nedwell and Howell, 2004).

9.6.126 Sound may be expressed in many different ways depending on the particular type of noise, and the parameters of the noise that will allow it to be evaluated in terms of a biological effect.

9.6.127 The attenuation of sound in the water as it propagates from the noise source must be considered in an impact assessment. As the measurement or receiver point moves away from the source, the sound pressure measured will decrease due to spreading. To standardise all source levels, regardless of where they are measured, they are referred back to a conceptual point 1m away from the point of origin of the noise.

9.6.128 The sound pressure level (SPL) is normally used to characterise noise and vibration of a continuous nature such as drilling, boring, or background sea levels. To calculate the SPL, the variation in sound pressure is measured over a specific time period to determine the root mean square (RMS) level of the time varying acoustic pressure. The SPL_{RMS} can therefore be considered to be a measure of the average unweighted level of the sound over the measurement period.

9.6.129 The peak sound pressure level (SPL_{peak}) is the maximum level of sound. This form of measurement is often used to characterise noise where there is a clear positive peak following the sound.

9.6.130 The sound exposure level (SEL) is used when assessing the noise from transient sources such as impact piling. The SEL sums the acoustic energy over a measurement period, and effectively takes account of both the SPL of the sound source and the duration for which the sound is present in the acoustic environment.

9.6.131 The above measurements refer to sound pressure, which is one component of sound of relevance to marine receptors. The other element of importance is that of particle velocity, expressed as mms^{-1}. This is of importance to some fish species and is believed to be of importance to invertebrate fauna which are more sensitive to this form of sound (Popper and Hawkins, 2018).

Modelling

9.6.132 Modelling of the noise and vibration from tunnel construction was carried out using the Rupert Taylor Finite Difference Time Domain model *FINDWAVE*® which is reported in Appendix 9.1: Assessment of Ground-borne Noise and Vibration, and Underwater Noise from the Tunnel Boring Machine at marine receptors (Application Document 6.3). The model predicts the vibration within the tunnel face from which the transfer to water and marine habitats can be made.

9.6.133 The modelling has been completed using geotechnical data from ground investigations, with details of tunnel lengths and soil parameters (Appendix 9.1, Application Document 6.3). The intended construction methodology is for there to be a lag between the construction of the two tunnels, therefore the modelling assumes one TBM for the purposes of generating levels of underwater noise.

9.6.134 The modelling has been undertaken to provide both the sound pressure level and particle velocity, at the following locations:

a. At a point above the TBM representing the worst case

b. At the edge of the mudflats on the north and south of the river above the tunnel alignment

9.6.135 The results of modelling show that the highest levels of underwater noise associated with TBM operations are 130dB re 1µPa (SPL), at a frequency of 100Hz. This result is from a point in the river directly above the TBM head and represents the worst-case noise level which will diminish with increasing distance. Cumulative noise levels (SEL_{cum}) were derived from the modelling, and at worst-case sound levels this reached 150dB re 1µPa.

9.6.136 In terms of particle velocity, the worst-case levels from above the TBM head were 0.01mms^{-1} reducing to 0.001mms^{-1} at the edge of the intertidal mudflats.

Effects on invertebrates (of conservation importance)

9.6.137 Marine invertebrate responses to noise are poorly understood, however it is thought that they have a number of internal organs and structures that would make them susceptible to particle motion (or velocity) (Popper and Hawkins, 2018). Many marine invertebrates are relatively sedentary and therefore do not have the capacity to avoid sound like fish and marine mammals (Solan *et al*., 2016). Therefore, the effects of sound may not be lethal but could affect the fitness and function of invertebrate species (Solan *et al*., 2016).

9.6.138 Studies have examined the effect of exposure to continuous and impulsive noise on the physiology and behaviour of invertebrates (clam, *Nephrops* and a brittlestar). One study by Solan *et al*. (2016) examined noise effects on invertebrates and noted effects including changes in the vertical positioning in the sediment, and valve closing in bivalves or altered burrowing activity in crustaceans and brittlestars.

9.6.139 The noise levels used in the study were based on shipping (continuous) at SPLs of 135-140dB re 1µPa, and piling operations (impulsive) at an SEL of 150dB re 1µPa^2 s. Results of the study showed differing results for the species observed. For the crustacean (*Nephrops*) both continuous and impulsive sound repressed burrowing and irrigational activity with reduced locomotion also observed. For the clam, sound resulted in a change in position within the sediment such that suspension feeding ceased. No responses to sound were observed in the brittlestar (Solan *et al*., 2016).

9.6.140 Other data available around particle velocity and effects on invertebrates is concentrated around offshore wind farms. These studies have looked at response values across different species and have indicated threshold values of between 0.11ms^{-1} and 0.29ms^{-1} for hermit crabs (Roberts, 2015), 0.0002ms^{-1} and 0.81ms^{-1} for crabs and shrimp (Roberts and Breithaupt, 2016) and 0.0003ms^{-1} to 1.1ms^{-1} for cephalopods (Cook, 2017).

9.6.141 Modelling for the Project has shown that the peak frequency for the sound is at 100Hz with SPLs of 130dB re 1µPa. This represents the worst-case noise levels associated with tunnel construction using the TBM. Little is known about the frequencies of noise affecting marine invertebrates; however, these sources' levels are outside the noise levels identified by Solan *et al*. (2018) as affecting *Nephrops*, and clams.

9.6.142 With respect to particle velocity the worst-case levels (above the TBM) were modelled at 0.01mm s^{-1} reducing to a maximum of 0.001mm s^{-1} at the edge of the intertidal mudflats. These values are lower than the sensitivity thresholds in the various studies reported above.

9.6.143 As a result of the noise levels being below published thresholds for invertebrates of national importance, the impact on species is negligible and it is considered that the effect would be slight adverse and **not significant**.

Effects on subtidal and intertidal habitats and communities

9.6.144 The subtidal and intertidal habitats in the Tilbury area of the Thames Estuary are dominated by several species of worm and small amphipod crustaceans. There is a paucity of data relating to the effects of noise on species of worm, with research focusing on large crustaceans, fish and molluscs.

9.6.145 Despite this, the modelling undertaken for the TBM operations has shown that peak sound levels and peak particle velocity fall outside of the published sensitivity thresholds for marine invertebrates. In addition to this, the background underwater noise environment within the River Thames is high because of the level of industry and shipping, therefore invertebrates would be habituated to higher sound levels.

9.6.146 As a result of the higher levels of background noise, and the low levels of noise generated from the TBM operations, the level of impact from underwater noise on subtidal and intertidal communities (including those of conservation importance) which are of national to local importance is negligible, and it is considered that there would be slight adverse to neutral effects on the community overall, that are **not significant**.

Effects on fish

9.6.147 Fish responses to noise are in part related to the anatomy of their hearing mechanisms. The presence of a swim bladder enhances hearing sensitivity as the bladder acts as a pressure transducer, converting sound pressure to particle velocity. Those species where the swim bladder is near to or connected to the ear have increased hearing sensitivity (Popper *et al*., 2014). The hearing range of fish varies extensively among species, and it is not only related to anatomy; cod and Atlantic salmon both have a swim bladder, yet cod are more sensitive to pressure at higher frequencies (Popper *et al*., 2014).

9.6.148 Hearing sensitivity in larval fish and eggs is poorly researched. However, evidence suggests that the hearing frequency range in larvae is similar to that of adults with similar startle thresholds (Popper *et al*., 2014).

Thresholds and criteria used for marine fish

9.6.149 A review of hearing sensitivity in fish developed categories that can be used when assessing the effects of sound (Popper *et al*., 2014). The categories are based on the presence or absence of a swim bladder and the potential for the swim bladder to enhance hearing sensitivity. The relevant categories are listed below:

a. Fishes with no swim bladder or other gas chamber – e.g. flatfish. These species generally only detect particle motion and are less sensitive to sound pressure.

b. Fishes with swim bladders, whose hearing does not involve the swim bladder or other gas volume – e.g. Atlantic salmon. These species hear through particle motion.

c. Fishes whose hearing involves a swim bladder or other gas volume – e.g. herring and cod. These species detect sound pressure and particle velocity.

d. Fish eggs and larvae.

9.6.150 The presence of a swim bladder makes these species more susceptible to pressure-related injury (such as rupture of the swim bladder) associated with sudden changes in hydrostatic pressure (water depth) or sound pressure. Those species lacking a swim bladder (elasmobranchs, flatfish etc.) are less vulnerable to pressure changes.

9.6.151 Guideline criteria have been established by Popper et al. (2014) for the assessment of underwater noise on fish, based on extensive literature review, and are provided based on the type of noise source (e.g. explosives, piling, continuous noise source). The criteria adopted in this assessment are shown in Table 9.10. Where actual data is not available, criteria have been set based on the risk to species at different distances from the source (near is tens of metres, intermediate is hundreds of metres and far is thousands of metres).

Table 9.10 Summary of criteria used in the assessment of underwater noise on fish relating to shipping and continuous noise sources

Effect	Criteria	Metric	Species
Mortality and potential mortal injury	Low risk at near, intermediate and far field	n/a	All adult fish categories Larvae and eggs
Recoverable injury	170dB re 1µPa for 48 hours	Unweighted SPL_{RMS}	Fish with swim bladder associated with hearing
	Low risk at near, intermediate and far field	n/a	Fish with no swim bladder Fish with swim bladder not involved in hearing Larvae and eggs
Temporary Threshold Shift (TTS)	158dB re 1µPa for 12 hours	Unweighted SPL_{RMS}	Fish with swim bladder associated with hearing
	Moderate risk at near field and low risk at intermediate and far field	n/a	Fish with no swim bladder Fish with swim bladder not involved in hearing Larvae and eggs
	Low risk at near, intermediate and far field	n/a	Larvae and eggs
Behaviour	Moderate risk at near and intermediate field and low risk at far field	n/a	Fish with no swim bladder Fish with swim bladder not involved in hearing Larvae and eggs
	High risk at near field; moderate risk at intermediate field; and low risk at far field	n/a	Fish with swim bladder associated with hearing

9.6.152 The fish in the vicinity of the Order Limits are a mixed estuarine community with species of conservation and/or commercial importance, and other more common species. The dominant species varies seasonally, including gobies, Dover sole, smelt, and clupeids, with gobies dominant across all seasons.

9.6.153 Several species of conservation interest were identified, including salmonids, lamprey, European eel, and smelt. Salmonids are assessed as being generalists (fish with swim bladder not associated with hearing), whilst smelt are considered to be specialists (fish with swim bladder associated with hearing).

9.6.154 Lamprey and European eel are considered to be, at the most, hearing generalists, with little in the way of anatomical adaptation to assist hearing (Popper, 2005). There has been no research to date on the response of lamprey to sound, and Popper (2005) presented that sound may not be biologically important for lamprey. Owing to the lack of research into the hearing of lamprey, the criteria from Popper (2005) for fish with no swim bladders have been adopted for the assessment.

9.6.155 The hearing ability of European eel is also poorly documented with only one known study that looked specifically at hearing in the eel (Jerko *et al*., 1989). The anatomy of the eel is such that the swim bladder is positioned some distance from the ear. Therefore, for the purposes of this assessment, eel are considered to be hearing generalists and the criteria from Popper *et al*. (2014) for fish with no swim bladders have been adopted.

9.6.156 The noise emissions from the activities of the TBMs and vessel movements are continuous sounds and therefore the criteria defined by Popper *et al*. (2014) can be used for the assessment of effect.

Underwater noise effects associated with piling operations

9.6.157 Installation of the northern tunnel entrance compound drainage pipeline and outfall on the northern shore of the River Thames would require sheet piling to facilitate excavation of the pipeline trench. Installation of the outfall structure may require the construction of a minor cofferdam, and the structure itself may be placed on top of small mono-piles for support or be connected to longer piles used for the cofferdam. Construction of the water inlet with self-regulating valve structure would also require sheet piling to construct a cofferdam. The gate structure itself may also require piling dependent on ground conditions. These operations would take place at low water at which point the transfer of noise into the water column would be minimal (MB001). In addition to this, piling operations would use vibro-piling techniques which are recognised as generating lower noise levels (MB002). The piling operations for the pipeline trench would also be completed over a relatively short, 3-4 week programme, assuming seven-day working. Piling for the cofferdams would be completed over a few days.

9.6.158 The Thames Estuary is a busy commercial waterway with a high level of shipping and construction activity. Baseline noise conditions have been monitored in the estuary and are known to be in the region of 153 to 158dB re 1µPa. This indicates that communities in the area are already habituated to underwater noise levels.

9.6.159 As a result of the higher levels of background noise, and the restrictions of using vibro-piling and limiting piling operations to low water, the level of impact from underwater noise on marine fish (including those of conservation importance) is negligible. Impacts identified on fish species are considered temporary as the works are short-term and species are already habituated to elevated noise levels, and the integrity of the resource will not be affected. It is therefore considered that there would be neutral to slight adverse effects that are **not significant**, on the fish community which includes species of European, national and local importance**.**

Underwater noise effects associated with TBM operations

9.6.160 The modelling in Appendix 9.1 (Application Document 6.3) has shown that the peak sound level associated with TBM operations is an SPL of 130dB re 1µPa and an SEL_{cum} of 150dB re 1µPa at a position in the river directly above the TBM operations. This sound level diminishes with increasing distance from the source and therefore is a worst-case SPL for construction of the tunnel.

9.6.161 Using the criteria defined by Popper *et al*. (2014) (shown in Table 9.10) this sound level is below the trigger for Temporary Threshold Shift (TTS) in fish that are the most sensitive to sound (fish with swim bladder associated with hearing). The effect of the noise is likely to be temporary and to cause fish to move away from the vicinity of the TBM.

9.6.162 In addition, the Thames Estuary is a busy commercial waterway with high levels of background noise which fall above the noise levels generated by TBM operations.

9.6.163 As a result of the high levels of background noise, and the low noise levels associated with TBM operations, the level of impact from underwater noise on marine fish (including those of conservation importance) is negligible, and it is considered that for the fish community, which includes species of European, national and local importance, there would be neutral to slight adverse effects that are **not significant**.

Effects on marine mammals

Marine mammal hearing

9.6.164 The auditory system in marine mammals is similar to that of land mammals, in that the hearing apparatus can be divided into the outer ear, an air-filled middle ear and a liquid-filled inner ear. In odontocetes (toothed cetaceans), sound is channelled to the middle ear through the lower jaw (Nedwell and Edwards, 2004 (b)), whilst in mysticetes (baleen whales) sound is channelled in two ways, either through the soft tissue or through the skull itself (Farrell, 2015).

9.6.165 Pinniped (seals) hearing capabilities both in air and water have been reviewed by the United States Department of Commerce (2008) which stated that the hearing range for this group is greatly reduced in air to 1kHz to 22kHz with sensitivity at 12kHz, compared to 1kHz to 180kHz in water with peak sensitivity at around 32kHz. Phocid seals have a hearing range from 1kHz to 60kHz (Richardson *et al*., 1995) with sensitivity between 8kHz and 35kHz.

9.6.166 The absolute hearing threshold is the minimum sound level at a specific frequency that can be heard in the absence of any other sounds. In mammals, exposure to sound levels above absolute hearing thresholds can result in either a TTS when hearing sensitivity returns to normal after temporary loss, or a Permanent Threshold Shift (PTS) when hearing is lost permanently. In the past, reliable information on the levels of sound that cause damage in marine mammals was not available and therefore common practice was to apply human damage risk criteria (Richardson *et al*., 1995).

9.6.167 Applying damage risk criteria to marine mammals, it would be predicted that at low frequencies (<500Hz), TTS would occur at around 165dB re 1µPa to 180dB re 1µPa in seals, and at around 180dB re 1µPa to 210dB re 1µPa in small dolphins (Hammond *et al*., 2006).

Thresholds and criteria used for marine mammals

9.6.168 There have been various studies looking at the effects of noise on marine mammals from which criteria have been established that set noise levels at which PTS and TTS are likely to occur. Southall *et al*. (2007) presented a set of interim criteria for noise levels that may result in PTS or TTS for marine mammals. The criteria are generally based on marine mammals grouped by their hearing sensitivity, based on frequency ranges, as follows:

a. Low-frequency cetaceans (7Hz to 35kHz)

b. Mid-frequency cetaceans (150Hz to 160kHz)

c. High-frequency cetaceans (275Hz to 180kHz)

d. Pinnipeds in water (50Hz to 86kHz)

e. Pinnipeds in air (75Hz to 30kHz)

9.6.169 There have been multiple studies looking at the effects of underwater noise on marine mammals with criteria developed and re-published. Studies of these have included work by the National Marine Fisheries Service (2018). This work built on the original work by Southall et al., (2007) and developed updated criteria for marine mammals. This work has subsequently been updated again by Southall et al. (2019) and represents the most up to date set of criteria for TTS and PTS in marine mammals. The criteria for those groups of marine mammals likely to be present in the River Thames are shown in Table 9.11.

Table 9.11 Weighted criteria for PTS and TTS (Southall *et al*., 2019)

Criteria	Effect	Species	Source
173dB re 1µPa^{2}s	PTS	Harbour porpoise (very high frequency species)	Non-pulsed (continuous) SEL (weighted)
155dB re 1µPa^{2}s			Impulsive
153dB re 1µPa^{2}s	TTS		Non-pulsed (continuous) SEL (weighted)
140dB re 1µPa^{2}s			Impulsive
198dB re 1µPa^{2}s	PTS	Dolphin species (high frequency)	Non-pulsed (continuous) SEL (weighted)
185dB re 1µPa^{2}s			Impulsive
178dB re 1µPa^{2}s	TTS		Non-pulsed (continuous SEL (weighted)

Criteria	Effect	Species	Source
170dB re 1μPa^{2}s			Impulsive
201dB re 1μPa^{2}s	PTS	Seal species (Pinnipeds in water)	Non-pulsed (continuous) SEL (weighted)
185dB re 1μPa^{2}s			Impulsive
181dB re 1μPa^{2}s	TTS		Non-pulsed (continuous) SEL (weighted)
170dB re 1μPa^{2}s			Impulsive

9.6.170 Behavioural responses of marine mammals to noise are highly variable and dependent on a suite of internal and external factors. Behavioural responses can include changes in surfacing patterns, cessation of vocalisations, and active avoidance of, or exit from, the area (Richardson *et al*., 1995). It is likely that responses are context-specific, and internal factors include the following:

a. Individual hearing sensitivity and tolerance

b. Activity pattern

c. Motivational and behavioural state at the time of exposure

d. Past exposure of the animal to the noise (which may have led to habituation or sensitisation)

e. Predation risk

f. Demographic factors such as age, sex and presence of dependent offspring.

9.6.171 External factors that influence behavioural responses of marine mammals can include the size of the sound source and whether the sound source is stationary or moving (e.g. a vessel). Physical habitat characteristics can also influence sound transmission, such as being in a confined location or in proximity to a shoreline.

9.6.172 To assess the behavioural avoidance of marine mammals, criteria from Finneran and Jenkins (2012) have been used. These criteria use several different weightings listed as ‘Type I’, which is the same as M-weighting from Southall et al. (2007) and ‘Type II’, which is a modified version of the filter based on an alternative weighting function.

9.6.173 These criteria are presented in Table 9.12 and have been based on a modelled stationary animal subject to multiple explosions over a 24-hour period. As a result of this, the criteria are only used in the assessment of piling.

Table 9.12 Behavioural avoidance criteria

Criteria	Weighting	Species
167dB re 1μPa^{2}s SEL	Type II weighting	Mid-frequency cetacean
141dB re 1μPa^{2}s SEL	Type II weighting	High-frequency cetacean
172dB re 1μPa^{2}s SEL	Type I weighting	Pinnipeds (in water)

9.6.174 Of the three cetacean species frequently observed, the harbour porpoise is considered a high-frequency species, and the bottlenose dolphin is considered a mid-frequency species (Southall *et al.,* 2007).

Underwater noise effects associated with piling operations

9.6.175 As noted in paragraph 9.6.22, piling would be associated with the installation of the northern tunnel entrance compound drainage pipeline and outfall, and the permanent Coalhouse Point HRA and ecology water inlet with self-regulating valve structure on the north shore. The mitigation measures outlined in Section 9.5 would minimise the potential for underwater noise on marine mammals as they would limit the transfer of noise into the water column.

9.6.176 As a result of the higher levels of background noise, and the restrictions of using vibro-piling and piling operations at low water, the level of impact from underwater noise from piling on marine mammals of international importance is negligible, and it is considered that the effects from underwater noise would be slight adverse and **not significant**.

Underwater noise effects associated with TBM operations

9.6.177 The modelling (Appendix 9.1, Application Document 6.3) has shown that noise is generated at lower frequencies (2 to 500Hz) and is therefore at the lower end of the frequency ranges for marine mammals. The cumulative noise levels from the modelling show a worst case of 150dB re 1µPa SEL which is below the threshold criteria for TTS in relation to continuous noise (Table 9.11). Therefore, potential effects from TBM operations are limited to behavioural only.

9.6.178 With reference to the behavioural avoidance criteria in Table 9.12, the noise levels associated with TBM operations have the potential to affect high frequency cetaceans, therefore harbour porpoise. Whilst this is the case, the background noise levels in the Thames Estuary are high and the modelled levels from TBM operations fall below this level. It is therefore considered that any marine mammals in the vicinity of the works would be unable to detect TBM operations above background levels.

9.6.179 As a result of this, the level of impact from underwater noise from the TBM on marine mammals of international importance is negligible, and it is considered that the effects from underwater noise would be slight adverse and **not significant**.

Impact pathway: visual disturbance

General context

9.6.180 The land-based and marine-based construction activities that would lead to an increase in visual stimuli include construction and decommissioning of the northern tunnel entrance compound drainage pipeline and outfalls, and construction of the Coalhouse Point HRA and ecology water inlet with self-regulating valve structure. As with noise, a change in visual stimuli could potentially lead to avoidance behaviour and could affect the breeding or foraging activities of certain species, which could have wider implications for populations.

Effects on fish

9.6.181 Marine-based construction activities and the presence of humans, vessels, construction plant and artificial lighting, would result in direct visual disturbance to marine fish receptors. This could lead to a variety of behavioural responses, including displacement and/or disruption to feeding and reproduction, leading to a decline in fitness and productivity.

9.6.182 Most fish species are photoreceptive, with key activity rhythms and behavioural patterns (e.g. feeding) stimulated by light. Daytime feeders, which are typically planktivorous, detritivorous or grazers, are generally attracted to light (Marchesan *et al*., 2005). Conversely, nocturnal species, which are typically carnivores, show a strong avoidance of light. Crepuscular species that show peaks of activity during the twilight periods are likely to exhibit a varied behavioural response (Marchesan *et al*., 2005).

9.6.183 For species that are deterred from an area due to the presence of a visual disturbance source, displacement is unlikely to affect the integrity of populations (i.e. no reduction in fitness and productivity through effects on reproduction and feeding) given the availability of alternative habitats within the Thames Estuary.

9.6.184 The distribution of fish species attracted to artificial lighting is also likely to be influenced by other factors such as the availability of resources (e.g. food and refuge). It is unlikely that species typically attracted to artificial lighting would significantly increase in abundance within the vicinity of the works. Any localised increase is unlikely to affect the integrity of wider populations. The majority of lighting would be designed to reduce light spill and therefore any effects would be intermittent and localised.

9.6.185 Prior to the commencement of works below mean high water springs, proposals for lighting would be developed and submitted to the MMO. This would include an assessment of the effects of measures such as directional lighting and controls on lux levels to mitigate effects on marine ecology receptors during 24-hour operations (MB003). Visual disturbance is therefore considered to have a negligible impact on fish receptors, of European to local importance. Therefore, the effect on marine fish receptors from visual disturbance during the construction phase is considered to be slight adverse to neutral and **not significant**.

Effects on marine mammals

9.6.186 Pinnipeds (e.g. grey seals) that have surfaced or have hauled-out could be affected by changes to visual stimuli from marine-based construction activities. Visual disturbance could potentially cause grey seals to stop feeding, resting, travelling and/or socialising, with possible long-term effects of repeated disturbance including permanent displacement and/or a decline in fitness and productivity.

9.6.187 As described in the baseline section, the nearest seal haul-out site to the Order Limits is at Blyth Sands, and sightings are low compared with other areas. The likelihood of seals hauling-out within the immediate vicinity of the Order Limits (i.e. within 500m) is considered extremely low. The level of impact as a result of visual disturbance due to construction activity on marine mammals of international importance is therefore considered to be negligible as there may be some localised displacement of species if they are in the vicinity of the works, however the integrity of the population would not be affected. The overall effect is therefore slight adverse and **not significant**.

Impact pathway: physical injury to marine mammals from vessel strikes

General context

9.6.188 Moving marine plant and vessels could strike marine mammals, resulting in physical injury (e.g. corkscrew injuries) and, in the worst case, mortality (Pace, Miragliuolo and Mussi, 2006).

9.6.189 Marine construction would require plant, barges, workboats and safety boats to be brought to site with movement occurring within the Order Limits during the construction phase. These activities would be limited to the construction and decommissioning of the northern tunnel entrance compound drainage pipeline and outfall and the permanent Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure.

9.6.190 Marine mammals are considered to be agile species possessing quick reflexes, good sensory capabilities and fast swimming abilities (over 6m/s for harbour porpoise) (Carter, 2007; Hoelzel, 2002). However, there have been a number of reported incidents of mortality or injury of cetaceans from vessel strikes in UK waters (Whale and Dolphin Conservation Society, 2009). In addition, several cases of seal injury, thought to be caused by propellers and thrusters (used for the dynamic positioning of vessels), have also been reported in recent years (Thompson *et al*., 2010; Bexton *et al*., 2012).

9.6.191 Marine mammals are relatively robust to potential strikes as they have a thick subdermal layer of blubber which would protect their vital organs from minor strikes or collisions (Wilson *et al*., 2007). Consequently, incidents of mortality or injury of marine mammals caused by vessels are recognised as being a very rare occurrence in UK waters (ABP Research, 1999; CSIP, 2011). However, a direct strike from a sharp object such as a moving propeller blade would have significant potential to cause injury to marine mammals. Juvenile grey seal pups, which are inexperienced in the water, are likely to be particularly vulnerable to vessel strikes. Inquisitive species such as bottlenose dolphins would also be vulnerable. Marine mammals distracted by activities such as foraging and social interactions may not perceive the threat of moving vessels and could therefore be vulnerable to vessel strikes (Wilson *et al*., 2007).

Effects on marine mammals

9.6.192 Prior to construction and on completion of the marine works, marine plant and vessels would be required to transit to and from the Order Limits. The numbers of vessels are predicted to be small in comparison to the vessel density using the Thames Estuary on a day-to-day basis (Application Document 7.15). Once on site, much of the marine plant would be travelling at slow speeds. Marine mammals have been recorded in low abundance within and adjacent to the Order Limits (Section 9.4), and the risk of vessel strikes from marine plant and vessels transiting to and from site and while onsite, is therefore considered to be negligible.

9.6.193 Marine traffic would primarily comprise slow-moving tugs and barges required to transport plant and materials for construction of the North Portal construction water management discharge and the Coahouse Point HRA and ecology mitigation water inlet with self-regulating valve structure (Application Document 7.15). Marine mammals have been recorded in low abundance within

and adjacent to the Order Limits with observations generally being of solitary animals. On this basis, coupled with the slow travelling speeds of these vessels, the likelihood of marine mammal strikes is considered to be low and therefore the level of impact is predicted to be negligible. The effect on marine mammals of international importance from vessel strikes is slight adverse and **not significant** as the integrity of the mammal populations will not be affected.

Use of the River Thames

9.6.194 The conclusion in respect of vessel movement on the River Thames was that there would be no significant effects due to the relatively small increase in the number of movements due to the Project, and the low speeds involved with those supporting the in-river construction works.

9.6.195 The baseline data used in this topic assessment include information relating to existing vessel movements on the River Thames. The relevant baseline dataset is outlined in the Preliminary Navigational Risk Assessment (Application Document 7.15), which details over 900 vessel transits per month in some sections of the authorised channel within the Order Limits, as well as some use of the navigable water on the north side of the channel within the Order Limits.

9.6.196 Based on the predicted vessel movements associated with the construction of the Project, as outlined in Chapter 4, a qualitative assessment of the use of the River Thames by the Project has been carried out. The conclusion of this assessment was that there would be no significant effects on marine ecology receptors because of the relatively small increase in the number of movements due to the Project, and the low speeds involved with those supporting the in-river construction works.

Operational phase

Impact pathway: underwater noise – HGV use in tunnel

9.6.197 A road tunnel involves very low vibration generation in the operational phase due to the isolating effect of rubber tyres. Vibration from rubber-tyred vehicles only requires consideration in cases such as roadways on elevated structures or where there are defects in the pavement and/or supporting formation. In the case of well-maintained roads in underground tunnels, vibration and underwater sound due to the passage of HGVs in the tunnel, are considered insignificant. For this reason, no underwater noise modelling was undertaken and there is considered no pathway to effect from HGV use of the tunnel during the operational phase.

Impact pathway: changes to water quality from drainage from the operation of the tunnel

General context

9.6.198 This pathway covers the potential changes in water quality relating to physico-chemical, biological and chemical parameters of the tunnel discharge during operation.

9.6.199 The drainage system for water generated through the operation of the tunnel would include provision for the capture and isolation of contaminated waters to prevent pollution of the receiving watercourse. In addition, discharges would be restricted to high tide conditions to maximise available dilution and mixing (REAC Ref. RDWE026). Volumes discharged would be relatively small, in the order of 5l/s.

9.6.200 Owing to the control around the contaminated waters to prevent pollution, and the restriction to discharge only at high water, there will be no discernible change to the water quality of the tidal Thames and therefore effects to all marine receptors (varying in importance from international to local) would be neutral and **not significant**.

Impact pathway: physical disturbance of habitats from tunnel discharge during operation (scour)

General context

9.6.201 As indicated in paragraph 9.6.199 above, the tunnel discharge of 5l/s would be controlled to prevent pollution and would be restricted to release around high water (REAC Ref. RDWE026).

Effects on intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh)

9.6.202 Owing to the control around prevention of pollution, and the restriction to discharge only at high water, scour effects on the intertidal mudflats would be negligible. The discharge volume is minimal relative to the tidal discharge of the River Thames and would not be discernible.

9.6.203 Therefore, there would be no change to intertidal habitats and communities of national to local importance, and effects would be neutral and **not significant**.

Effects on invertebrates (of conservation importance)

9.6.204 Acknowledging that there is predicted to be no change from physical disturbance to intertidal habitats and communities from scour, it is also considered that invertebrates of national importance would not be impacted, and the effect would be neutral and **not significant**.

Impact pathway: entrainment of eel into the Coalhouse Point HRA and ecology mitigation area via the water inlet with self-regulating valve structure

General context

9.6.205 The Coalhouse Point water inlet with self-regulating valve structure is being constructed to facilitate a water source from the River Thames to feed the proposed HRA and ecology mitigation area to the east of the North Portal.

9.6.206 The mitigation area will encompass a newly created network of ditches and shallow wetland scrapes. The system requires a regulated water level, hence the construction of the water inlet with self-regulating valve.

9.6.207 To ensure connectivity with the existing fluvial system, the mitigation area has been designed to connect into the surface water catchment system of the wider area.

Effects on fish

9.6.208 The water inlet with self-regulating valve will operate to allow water into the newly created mitigation area behind the flood defence during certain states of the tide. As such, there is a risk that juvenile eel (glass eel) will be entrained into the mitigation area during their annual migration into the River Thames.

9.6.209 Movement of juvenile eel into the newly created system may be considered as a positive benefit, as eel habitat is under threat across the Thames catchment, and the mitigation area is likely to provide good quality habitat for eel.

9.6.210 A common issue for eel in the minor catchments connected to the tidal Thames is the lack of a migratory route back into the Thames for adults heading to sea to spawn. As the mitigation area has been designed to link with the existing surface water catchment, a potential route for adult eel to migrate back to the Thames is available.

9.6.211 Although juvenile eel will be at risk of entrainment into the mitigation area, the design and connectivity of the area allows for migrating adults to access the existing surface water catchment and the Thames. As such, effects on eel would be slight positive but **not significant**.

9.7 Cumulative effects

Intra-project effects

9.7.1 Cumulative effects of the Project can occur as a result of interrelationships between different environmental topics, which are referred to as 'intra-project effects'. For marine biodiversity, interrelationships are identified with air quality (Chapter 5: Air Quality), road drainage and the water environment (Chapter 14: Road Drainage and the Water Environment), and terrestrial biodiversity (Chapter 8: Terrestrial Biodiversity) and are summarised below:

a. Air quality – degradation of intertidal habitats and species close to construction works, resulting from increased deposition of nitrogen or fine dust

b. Road drainage and the water environment – potential for pollution of controlled waters that support marine habitats and biodiversity

c. Terrestrial ecology – impacts to intertidal habitats and species of the River Thames which may alter the prey availability for birds

9.7.2 The above interrelationships have been considered as part of the assessment reported in this chapter, and no additional cumulative impacts are identified.

Inter-project effects

9.7.3 In addition to intra-project effects, cumulative effects can also occur due to the Project in combination with other proposed developments. These are known as 'inter-project' effects and are considered separately in Chapter 16: Cumulative Effects Assessment.

9.8 Monitoring

9.8.1 No likely significant adverse residual effects have been identified, and no specific monitoring is required for Marine Biodiversity receptors.

9.9 Summary

9.9.1 Table 9.13 provides a summary of all the predicted impacts in this chapter, taking into account the Project design and mitigation set out in Section 9.5.

9.9.2 Assessments were undertaken in accordance with the procedures as previously outlined in the DMRB LA 108 Biodiversity (Highways England, 2020a).

9.9.3 Potential effects related to construction, operation and decommissioning of the northern tunnel entrance compound drainage pipeline and outfall; permanent Project water management outfall; tunnel boring operations; and tunnel operation, have been assessed in relation to relevant marine receptors.

9.9.4 A number of embedded, essential and good practice mitigation measures have been considered as part of the assessment. Application of these measures resulted in no likely significant effects being identified.

Table 9.13 Marine biodiversity impact table

Impact description	Importance	Level of impact	Effect	Significance
Construction				
Impact pathway: changes to water quality from land drainage and dewatering				
Designated sites No discernible change to water quality of River Thames.	European/ national	No change	Neutral	Not significant
WFD water bodies No discernible change to hydrodynamics, chemical and physical quality of the River Thames owing to large dilution factor and rapid mixing.	European	Negligible	Slight adverse	Not significant
Plankton Localised impact that would be rapidly dispersed and unlikely to be detectible above natural variation.	Local	Negligible	Neutral	Not significant
Intertidal and subtidal habitats and communities Localised impact from freshwater flows and suspended sediments owing to rapid dispersal.	National/ local	Negligible	Slight adverse	Not significant

Impact description	Importance	Level of impact	Effect	Significance
Invertebrates (including species of conservation importance) No invertebrates of importance in the direct vicinity of the discharge and rapid dispersion and mixing.	National/ local	Negligible	Slight adverse	Not significant
Fish (including species of conservation importance) Discharge rapidly dispersed and any effects highly localised to outfall.	European/ local	Negligible	Neutral/ slight adverse	Not significant
Impact pathway: changes to water quality from construction and decommissioning of northern tunnel entrance compound drainage pipeline and outfall				
Designated sites Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	European	Negligible	Slight adverse	Not significant
Plankton Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	Local	Negligible	Neutral	Not significant
Intertidal and subtidal habitats and communities Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	National/ local	Negligible	Slight adverse	Not significant
Invertebrates (including species of conservation importance) Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	National/ local	Negligible	Slight adverse	Not significant
Fish (including species of conservation importance) Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	European/ local	Negligible	Neutral/ slight adverse	Not significant
Marine mammals Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	International	Negligible	Slight adverse	Not significant
Impact pathway: direct loss of habitats and species resulting from the construction of the northern tunnel entrance compound drainage pipeline and outfall				
Designated sites No indirect or direct effects to qualifying features within footprint of works.	European/ national	Negligible	Slight adverse	Not significant

Impact description	Importance	Level of impact	Effect	Significance
Intertidal habitats and communities 0.4ha of intertidal habitat lost under footprint of marine works, temporary in nature.	National	Minor	Slight adverse	Not significant
Subtidal habitats and communities 0.001ha of subtidal habitat temporarily lost during construction period, and no areas of conservation importance.	Local	Negligible	Neutral	Not significant
Fish (including species of conservation importance) Direct mortality of fish unlikely owing to high motility. Indirect effect from loss of food source, however there is extensive available habitat elsewhere.	European/ national/ local	Negligible	Neutral/ slight adverse	Not significant
Impact pathway: changes to water quality from construction of the permanent Coalhouse Point HRA and ecology mitigation water inlet with self-regulating valve structure				
Designated sites Construction of cofferdam limited to low water and any resuspended sediment rapidly dispersed and diluted.	European	Negligible	Slight adverse	Not significant
Plankton Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	Local	Negligible	Neutral	Not significant
Intertidal and subtidal habitats and communities Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	National/ local	Negligible	Slight adverse	Not significant
Invertebrates (including species of conservation importance) Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	National/ local	Negligible	Slight adverse	Not significant
Fish (including species of conservation importance) Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	European/ local	Negligible	Neutral/ slight adverse	Not significant
Marine mammals Construction limited to low water and any resuspended sediment rapidly dispersed and diluted.	International	Negligible	Slight adverse	Not significant
Impact pathway: direct loss of habitats and species resulting from construction of the water inlet with self-regulating valve structure within the intertidal zone.				

Impact description	Importance	Level of impact	Effect	Significance
Designated sites No indirect or direct effects to qualifying features within footprint of works.	European/ national	Negligible	Slight adverse	Not significant
Intertidal habitats and communities 0.175ha of intertidal habitat lost under footprint of marine works which is temporary in nature.	National	Minor	Slight adverse	Not significant
Invertebrates (including species of conservation importance) Temporary loss of intertidal habitat would have a direct effect on invertebrates. No species of conservation identified, and habitat loss temporary in nature.	National/ local	Negligible	Slight adverse	Not significant
Fish (including species of conservation importance) Direct mortality of fish unlikely owing to high motility. Indirect effect from loss of food source, however there is extensive available habitat elsewhere.	European/ national/ local	Negligible	Neutral/ slight adverse	Not significant
Impact pathway: physical disturbance of habitats from land-based sources (scour, smothering, air pollutant deposition)				
Intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh) Suspended solids loading would be controlled and any subsequent discharge rapidly dispersed and deposited over a wide area, therefore not resulting in smothering.	National/ local	Negligible	Neutral/ slight adverse	Not significant
Subtidal habitats and communities Suspended solids loading would be controlled and any subsequent discharge rapidly dispersed and deposited over a wide area, therefore not resulting in smothering.	National	Negligible	Slight adverse	Not significant
Invertebrates (including species of conservation importance) Suspended solids loading would be controlled and any subsequent discharge rapidly dispersed and deposited over a wide area, therefore not resulting in smothering.	National	Negligible	Slight adverse	Not significant
Impact pathway: physical disturbance of habitats from construction of the Project water management pipeline and outfalls (smothering)				
Intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh)	National/ local	Negligible	Neutral/ slight adverse	Not significant

Impact description	Importance	Level of impact	Effect	Significance
Undertaken during low tide, therefore limited resuspension of sediments that would be rapidly dispersed and deposited over a wide area.				
Subtidal habitats and communities Undertaken during low tide therefore limited resuspension of sediments that would be rapidly dispersed and deposited over a wide area.	National	Negligible	Slight adverse	Not significant
Invertebrates (including species of conservation importance) Undertaken during low tide therefore limited resuspension of sediments that would be rapidly dispersed and deposited over a wide area.	National	Negligible	Slight adverse	Not significant
Designated sites No impact to qualifying features of designated sites.	European/ national	Negligible	Slight adverse	Not significant
Impact pathway: physical disturbance of habitats from construction of the permanent Coalhouse Point water inlet with self-regulating valve (smothering)				
Intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh) Installation of cofferdam during low tide, therefore limited resuspension of sediments that would be rapidly dispersed and deposited over a wide area.	National/ local	Negligible	Neutral/ slight adverse	Not significant
Invertebrates (including species of conservation importance) Undertaken during low tide therefore limited resuspension of sediments that would be rapidly dispersed and deposited over a wide area.	National	Negligible	Slight adverse	Not significant
Designated sites No impact to qualifying features of designated sites.	European/ national	Negligible	Slight adverse	Not significant
Impact pathway: introduction of non-native species				
Intertidal and subtidal habitats and communities Already present non-native species; low risk of transfer and establishment because of control measures.	National/ local	Negligible	Neutral/ slight adverse	Not significant
Impact pathway: underwater noise				

Impact description	Importance	Level of impact	Effect	Significance
Invertebrates (including species of conservation importance) Modelled noise levels are below those published in literature as having an effect on invertebrates. High natural background noise levels.	National	Negligible	Slight adverse	Not significant
Subtidal and intertidal habitats and communities Modelled noise levels are below those published in literature as having an effect on invertebrates. High natural background noise levels.	National/ local	Negligible	Neutral/ slight adverse	Not significant
Fish (including those of conservation importance) Piling operations for the northern tunnel entrance compound drainage pipeline and outfall will be completed at low water to minimise transfer or noise. Good practice techniques and vibro-piling will be used. Modelled noise levels for TBM below TTS thresholds for fish, however localised avoidance may be observed.	European/ national/ local	Negligible	Neutral/ slight adverse	Not significant
Marine mammals Piling operations for the northern tunnel entrance compound drainage pipeline and outfall will be completed at low water to minimise transfer or noise. Good practice techniques and vibro-piling will be used. Modelled noise levels for TBM at lower end of hearing frequencies and below TTS thresholds, however localised avoidance may be observed.	International	Negligible	Slight adverse	Not significant
Impact pathway: visual disturbance				
Fish (including those of conservation importance) Potential for small-scale localised displacement of species in vicinity of works, but extensive available habitat elsewhere. Mitigation in place to control light spill for marine receptors.	European/ national/ local	Negligible	Neutral/ slight adverse	Not significant
Marine mammals Nearest haul out site at Blyth Sands where sightings are low. Extremely unlikely for seals to haul out close to works and mitigation measures in place to control light.	International	Negligible	Slight adverse	Not significant

Impact description	Importance	Level of impact	Effect	Significance
Impact pathway: physical injury to marine mammals from vessel strike				
Marine mammals Slow-moving marine plant in an already busy waterway. Mobile species able to move away quickly.	International	Negligible	Slight adverse	Not significant
Operation				
Impact pathway: underwater noise – HGV use in tunnel				
All receptors No pathway to effect from use of the tunnel during the operational phase. In the case of well-maintained roads in underground tunnels, vibration and underwater sound due to the passage of HGVs in the tunnel, are considered insignificant.	International /national/ local	No change	Neutral	Not significant
Impact pathway: changes to water quality from drainage from the operation of the tunnel				
Marine receptors Control measures in place around potential for pollution; and restriction to discharge around high water only.	International /national/ local	No change	Neutral	Not significant
Impact pathway: physical disturbance from tunnel discharge during operation (scour)				
Intertidal habitats and communities (including mudflats, sandflats, brown algal beds and saltmarsh) Small volume discharge restricted to operate around high water only.	National/ local	No change	Neutral	Not significant
Invertebrates (including conservation importance) Controls around pollution prevention and minimal discharge volumes restricted to high water release.	National	No change	Neutral	Not significant
Impact pathway: entrainment of eel into the Coalhouse Point HRA and ecology mitigation area via the water inlet with self-regulating valve				
Eel (juvenile ascending life stage) Juvenile eels (glass eels) may be entrained into the mitigation area through the self-regulating valve. As the mitigation area will be connected to the existing surface water catchment, this would allow migrating adults to exit the system. Overall, the ability for eel to access the mitigation area via the structure could be seen as a positive benefit.	National	Negligible	Slight positive	Not significant

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