OIKOS MARINE & SOUTH SIDE DEVELOPMENT

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT
VOLUME 2

Appendix 8.1: Preliminary Water Framework Assessment

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1 Introduction – Preliminary Water Framework Assessment

Project Overview

1.1 Oikos Storage Ltd (Oikos) proposes to undertake marine works and develop additional storage capacity at its existing oil, fuel and bulk liquid harbour facility on Canvey Island in Essex.

1.2 The project, known as the Oikos Marine and South Side Development (OMSSD) project, will provide additional marine loading arms and infrastructure on the two existing operational jetties, Jetty 1 and Jetty 2, at the Oikos Facility and include a capital dredge of the berth pocket to service Jetty 2, as well as a potential marine firewater system for the site. The OMSSD project will also include the redevelopment of the south side of the Oikos Facility to provide new storage tanks and associated operational infrastructure.

1.3 The Oikos Facility has been used for marine-fed fuel and associated product storage for over 80 years. It is a key component of the UK's energy infrastructure and a long-established part of the economy and environment of Canvey Island. Vessels from across the world berth at either of the facility's two operational jetties. Their cargo – consisting of various fuel, oil and petroleum-based products – is transferred from berthed vessels by marine loading arms and pipelines along the jetties into a series of specially constructed storage tanks. The products are then distributed from the Oikos Facility either via underground pipeline or by road tanker to various inland locations. Oikos is therefore seeking to strengthen and consolidate the harbour facility's operational capability and resilience through the works proposed as part of the OMSSD project.

1.4 The OMSSD project is a Nationally Significant Infrastructure Project (NSIP) for which Oikos will apply for development consent. Oikos intends to submit an Environmental Statement (ES) with the application for a Development Consent Order (DCO), reporting the assessment of likely significant effects of the OMSSD project. To support the application for a DCO, noting that a 'deemed Marine Licence' will be included within the DCO, a Water Framework Directive (WFD) compliance assessment will be prepared to determine whether the marine elements of the OMSSD project comply with the objectives of the WFD.

1.5 Prior to submitting the DCO application, Oikos has prepared a Preliminary Environmental Information Report (PEIR) to support pre-application consultation. This appendix forms part of the PEIR, providing an initial WFD compliance assessment based on currently known details of the OMSSD project. Figure 1 shows the location of the proposed dredge area, potential site for the disposal of dredge arisings and surrounding WFD water bodies.

Water Framework Directive

1.6 The WFD (2000/60/EC) came into force in 2000 and establishes a framework for the management and protection of Europe's water resources. It was implemented in England and Wales through the Water Environment (WFD) (England and Wales) Regulations 2003 (the Water Framework Regulations). These Regulations were revoked and replaced in April 2017 by the Water Environment (WFD) (England and Wales) Regulations 2017. While the UK left the EU on 31 January 2020, the UK continues to be committed to meeting high environmental standards. The main provisions of the WFD have been retained in English law through the Floods and Water (Amendment etc.) (EU Exit) Regulations 2019[1].

1.7 The overall objective of the WFD is to achieve good status (GS) in all inland, transitional, coastal and ground waters by 2021, unless alternative objectives are set and there are appropriate reasons for time limited derogation.

1.8 The WFD divides rivers, lakes, lagoons, estuaries, coastal waters (out to one nautical mile from the low water mark), man-made docks and canals into a series of discrete surface water bodies. It sets ecological as well as chemical targets (objectives) for each surface water body. For a surface water body to be at overall GS, the water body must be achieving good ecological status (GES) and good chemical status (GCS). Ecological status is measured on a scale of high, good, moderate, poor or bad, while chemical status is measured as good or fail (i.e. failing to achieve good).

1.9 Each surface water body has a hydromorphological designation that describes how modified a water body is from its natural state. Water bodies are either undesignated (i.e. natural, unchanged), designated as a heavily modified water body (HMWB) or designated as an artificial water body (AWB). HMWBs are defined as bodies of water which, as a result of physical alteration by human use activities (such as flood protection and navigation) are substantially changed in character and cannot therefore meet GES. AWBs are artificially created through human activity. The default target for HMWBs and AWBs under the WFD is to achieve good ecological potential (GEP), a status recognising the importance of their human use while ensuring ecology is protected as far as possible.

1.10 The ecological status/potential of surface waters is classified using information on the biological (e.g. fish, benthic invertebrates, phytoplankton, angiosperms and macroalgae), physico-chemical (e.g. dissolved oxygen and dissolved inorganic nitrogen) and hydromorphological (e.g. hydrological regime) quality of the water body, as well as several specific pollutants (e.g. copper and zinc). Compliance with chemical status objectives is assessed in relation to environmental quality standards (EQS) for a specified list of 'priority' and 'priority hazardous' substances. These substances were first established by the Priority Substances Directive (PSD) (2008/105/EC) which entered into force in 2009.

1.11 The PSD sets objectives, amongst other things, for the reduction of these substances

[1] The Floods and Water (Amendment etc.) (EU Exit) Regulations 2019. Available at: https://www.legislation.gov.uk/uksi/2019/558/contents/made (Accessed February 2021).

through the cessation of discharges or emissions. As required by the WFD and PSD, a proposal to revise the list of priority (hazardous) substances was submitted in 2012. Subsequently, an updated PSD (2013/39/EU) was published in 2013, identifying new priority substances, setting EQSs for those newly identified substances, revising the EQS for some existing substances in line with scientific progress and setting biota EQSs for some existing and newly identified priority substances. The updated PSD is transposed into UK legislation through the Water Environment (WFD) (England and Wales) (Amendment) Regulations 2015, which entered into force in September 2015, and explained in the WFD (Standards and Classification) Directions (England and Wales) 2015.

1.12 In addition to surface water bodies, the WFD also incorporates groundwater water bodies. Groundwaters are assessed against different criteria compared to surface water bodies since they do not support ecological communities (i.e. it is not appropriate to consider ecological status of a groundwater). Therefore, groundwater water bodies are classified as good or poor quantitative status in terms of their quantity (groundwater levels and flow directions) and quality (pollutant concentrations and conductivity), along with chemical (groundwater) status.

1.13 River Basin Management Plans (RBMPs) are a requirement of the WFD, setting out measures for each river basin district to maintain and improve quality in surface and groundwater water bodies where necessary. In 2009, the Environment Agency published the first cycle (2009 to 2015) of RBMPs for England and Wales, reporting the status and objectives of each individual water body. The Environment Agency subsequently published updated RBMPs for England as part of the second cycle (2015 to 2021), as well as providing water body classification results from 2015 and interim classifications via the Catchment Data Explorer[2]. The marine elements of the OMSSD project are located within the Thames Lower transitional water body and the Essex coastal water body (see Figure 1). The Thames Lower transitional water body is within the Thames river basin district which is reported in the Thames RBMP (Environment Agency, 2016a) and the Essex coastal water body is within the Anglian river basin district which is reported in the Anglian RBMP (Environment Agency, 2016b).

1.14 Consideration of WFD requirements is necessary for developments which have the potential to cause deterioration in ecological, quantitative and/or chemical status of a water body or to compromise improvements which might otherwise lead to a water body meeting its WFD objectives. Therefore, it is necessary to consider the potential for the proposed works to impact WFD water bodies, specifically referring to the following environmental objectives of the WFD:

- Prevent deterioration in status of all surface water bodies (Article 4.1 (a)(i));
- Protect, enhance and restore all surface water bodies with the aim of achieving good surface water status by 2015 or later assuming grounds for time limited derogation (Article 4.1 (a)(ii));

[2] https://environment.data.gov.uk/catchment-planning (Accessed November 2020).

- Protect and enhance all HMWBs/AWBs, with the aim of achieving GEP and GCS by 2015 or later assuming grounds for time limited derogation (Article 4.1 (a)(iii));
- Reduce pollution from priority substances and cease or phase out emissions, discharges and losses of priority hazardous substances (Article 4.1 (a)(iv));
- Prevent or limit the input of pollutants into groundwater and prevent deterioration of the status of all groundwater water bodies (Article 4.1 (b)(i));
- Protect, enhance and restore all groundwater water bodies and ensure a balance between abstraction and recharge of groundwater (Article 4.1 (b)(ii));
- Ensure the achievement of objectives in other water bodies is not compromised (Article 4.8); and
- Ensure compliance with other community environmental legislation (Article 4.9).

1.15 In 2016, the Environment Agency published guidance, referred to as Clearing the Waters for All[3], regarding how to assess the impact of activities in transitional and coastal waters. The guidance sets out the following three discrete stages to WFD compliance assessments:

- Screening: excludes any activities that do not need to go through the scoping or impact assessment stages (Section 2);
- Scoping: identifies the receptors and quality elements that are potentially at risk from an activity and need further detailed assessment (Section 3); and
- Assessment: considers the potential impacts of an activity, identifies ways to avoid/minimise impacts, and indicates if it may cause deterioration or jeopardise the water body achieving GS (Section 4).

1.16 An advice note on the WFD has also been published by PINS (2017) which seeks to provide:

- An introduction to the legal context and obligations placed on both the decision maker and the Applicant by the WFD and the 2017 Regulations (the main provisions of the WFD have been retained by the Floods and Water (Amendment etc.) (EU Exit) Regulations 2019 since the UK left the EU on 31 January 2020);
- An explanation of the relationship between the WFD assessment, the Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA);
- Advice regarding the relevant bodies that should be consulted by the Applicant during the process of preparing a DCO application in respect of the WFD, and the suggested timing and level of that engagement;
- A clarification of the process and information to be provided with a DCO application with respect to WFD; and
- Advice on the presentation of the information using optional screening and assessment matrices.

[3] https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters (Accessed November 2020).

2 Screening

Project Description

2.1 Oikos operate an existing harbour facility on Canvey Island in Essex. Oikos is seeking to strengthen and consolidate the harbour facility's operational capability and resilience through the provision of landside and marine works, known as the OMSSD project.

2.2 This preliminary WFD compliance assessment, forming part of the PEIR, considers the marine elements of the OMSSD project. The project comprises a capital dredge to deepen the existing berth pocket at Jetty 2 to a level of -16.5 metres relative to Chart Datum (m CD). The proposed dredge area is located on the edge of the main navigation channel of the Thames (Figure 1), at existing depths of around -14.5 to -16 m CD. The total dredge volume is approximately 25,000 m^3 and covers an area approximately 27,000 m^2 including an appropriate provision for side slopes.

2.3 The final dredge method has not yet been confirmed and could be different for the capital and maintenance dredge works. Relevant dredge depths at the facility (at Jetty 1) are currently maintained using water injection dredging (WID), although this technique may not be viable for the capital dredge element of the OMSSD due to material types. Instead, it is anticipated that trailing suction hopper dredging (TSHD) will be required to undertake the capital dredge.

2.4 To provide a worst-case scenario in respect of potential environmental impacts to the marine environment, this WFD compliance assessment has assumed that the capital dredge arisings will be deposited at an existing licensed marine disposal site, subject to the Waste Hierarchy Assessment (WHA).

2.5 The only presently open licensed marine disposal sites in the local area are understood to be in the Outer Thames Estuary. The closest location is the North Edinburgh Channel site (TH080) and for the purposes of this PEIR it is this site which has been assumed to be the disposal location (if marine disposal is required).

2.6 There are currently two options being considered for the firewater system; one involves the use of water stored in tanks, which will have no effects on the water environment. The second is a marine option. This second option is proposed to comprise an intake pipe situated near the estuary bed at a location along the Jetty 1 approach. The outlet (discharge) will be a pipe attached to one of the piles of the jetty head (platform). Diffusers will be attached to the pipes which will reduce/spread the flows at the intake and outfall. At the time of this assessment, exact locations or specifications have not been confirmed. The proposed water circulation through the system will be at a rate of 2,100 m^3 per hour when required for a fire emergency. The system will, however, be tested weekly for approximately an hour – each pump running for a 20 minute period. The firewater system is assessed based on the worst case potential intake and discharge volumes with respect to the local hydrodynamics and potential scour of the bed.

2.7 It is likely that WID will be the optimal method for any maintenance dredging of the Jetty 2 berth pocket. This method has been assessed for the operational phase as WID is considered a realistic worst case given the intensity and form of sediment disturbance. WID will not require the disposal of any dredge arisings and therefore the potential impacts at the marine disposal site (as outlined above) have only been assessed for the capital dredge during construction.

2.8 The proposed programme for the capital dredge has yet to be confirmed and is subject to the determination of the DCO application which will be submitted in 2021. It is anticipated that the capital dredging works could be completed in about a week.

Potentially Affected Water Bodies

2.9 To determine which water bodies could potentially be affected by the proposed activities, all surface and groundwater water bodies located within 5 km of the dredge area and North Edinburgh Channel (TH080) licensed disposal site were recorded (see Figure 1). The following water bodies were initially screened in:

- Proposed dredge area:
  - Thames Lower transitional water body (ID: GB530603911401);
  - Essex Gravels groundwater water body (ID: GB40503G000400); and
  - South Essex Lower London Tertiaries groundwater water body (ID: GB40602G401000).
- North Edinburgh Channel (TH080) licensed disposal site:
  - Essex coastal water body (ID: GB650503520001); and
  - Kent North coastal water body (ID: GB650704510000).

2.10 Should the option to dispose of dredge arisings at a land-based licensed disposal site be taken forward, it is noted that appropriate considerations may be necessary. For example, it is noted that the RSPB's Cliffe Pools site, which has historically accepted dredge material to manage and enhance the site's existing saline lagoons and supporting habitats for birds, forms part of the Higham Marshes transitional water body (ID: GB560604017600).

2.11 Sections of the Essex Gravels groundwater water body are located approximately 4 km to the west and north of the proposed dredge area, while the South Essex Lower London Tertiaries groundwater water body is also located approximately 4 km to the west. Given the distance from the proposed dredge area, it is considered highly unlikely that there would be a significant non-temporary effect on these two groundwater water bodies. Therefore, the Essex Gravels and South Essex Lower London Tertiaries groundwater water bodies have been screened out of the assessment and will not be discussed further.

2.12 Table 2.1 provides a summary of the Thames Lower transitional water body, within which the proposed dredge area is located, including current water body status (overall, ecological and chemical) and parameters currently failing to achieve good status. The Thames Lower transitional water body is a HMWB and currently (2019) has an overall moderate status, based on moderate ecological potential and failing chemical status. The overall, ecological and chemical status/potential is determined by the "one-out, all-out" principle, whereby the poorest individual parameter classification defines the assessment level. Therefore, if any parameter is assessed as less than good (e.g. moderate), then the status for that water body is reported at that level. Moderate ecological potential is due to the biological quality element Angiosperms, the physico-chemical quality element Dissolved inorganic nitrogen and the Mitigation measures assessment (physical modification). Chemical status is failing due to the priority hazardous substances Cypermethrin, Polybrominated diphenyl ethers (PBDE), Benzo(g-h-i)perylene, Mercury and its Compounds and Tributyltin compounds.

Table 2.1: Thames Lower transitional water body summary

Water Body ID	GB530603911401
Water Body Type	Transitional
Water Body Area	201.037 km^2
Hydromorphological Designation (Reasons for Designation)	HMWB (Flood protection; Navigation, ports and harbours)
Protected Area Designations	Habitats Directive; Birds Directive; Shellfish Water Directive; Bathing Water Directive; Nitrates Directive
Overall Status (2019)	Moderate
Ecological Status (2019)	Moderate
Chemical Status (2019)	Fail
Parameters Not At Good Status (2019)	Angiosperms; Dissolved inorganic nitrogen; Mitigation measures assessment; Cypermethrin; Polybrominated diphenyl ethers (PBDE); Benzo(g-h-i)perylene; Mercury and its Compounds; Tributyltin compounds
Higher Sensitivity Habitats	Intertidal seagrass (1.90 km^2); Polychaete reef (2.75 km^2); Saltmarsh (4.27 km^2)
Lower Sensitivity Habitats	Cobbles, gravel and shingle (1.39 km^2); Intertidal soft sediment (77.77 km^2); Rocky shore (0.005 km^2); Subtidal soft sediments (130.18 km^2)
Phytoplankton Status (2019)	Good
History of Harmful Algae	Yes

2.13 The North Edinburgh Channel (TH080) licensed disposal site is partially within the Essex coastal water body (otherwise beyond the seaward extent of WFD coastal water bodies). In addition, the Kent North coastal water body is located less than 2 km to the south of the North Edinburgh Channel (TH080) licensed disposal site and could potentially be influenced during disposal operations (e.g. sediment plume, redistribution of contaminants); therefore, this water body has also been screened into the assessment.

2.14 Table 2.2 and Table 2.3 provide summaries of the Essex and Kent North coastal water bodies, respectively. Both coastal water bodies are heavily modified and currently (2019) at overall moderate status, based on moderate ecological potential and failing chemical status. Moderate ecological potential is due to the Mitigation measures assessment, while chemical status is failing due to the priority hazardous substances PBDEs and Mercury and its Compounds. The Essex coastal water body is also at moderate ecological potential due to the physico-chemical quality element Dissolved inorganic nitrogen.

Table 2.2: Essex coastal water body summary

Water Body ID	GB650503520001
Water Body Type	Coastal
Water Body Area	1,195.906 km^2
Hydromorphological Designation (Reasons for Designation)	HMWB (Coastal protection; Flood protection)
Protected Area Designations	Habitats Directive; Birds Directive; Shellfish Water Directive; Bathing Water Directive
Overall Status (2019)	Moderate
Ecological Status (2019)	Moderate
Chemical Status (2019)	Fail
Parameters Not At Good Status (2019)	Dissolved inorganic nitrogen; Mitigation measures assessment; Polybrominated diphenyl ethers (PBDE); Mercury and its Compounds
Higher Sensitivity Habitats	Intertidal seagrass (0.47 km^2); Mussel beds, including blue and horse mussel (0.013 km^2); Polychaete reef (282.46 km^2); Saltmarsh (4.59 km^2); Subtidal kelp beds (0.0001 km^2)
Lower Sensitivity Habitats	Cobbles, gravel and shingle (11.54 km^2); Intertidal soft sediment (56.50 km^2); Rocky shore (0.013 km^2); Subtidal rocky reef (0.041 km^2); Subtidal soft sediments (5,889.57 km^2)
Phytoplankton Status (2019)	High
History of Harmful Algae	Yes

Table 2.3: Kent North coastal water body summary

Water Body ID	GB650704510000
Water Body Type	Coastal
Water Body Area	450.006 km^2
Hydromorphological Designation (Reasons for Designation)	HMWB (Coastal protection)
Protected Area Designations	Habitats Directive; Birds Directive; Shellfish Water Directive; Bathing Water Directive
Overall Status (2019)	Moderate
Ecological Status (2019)	Moderate
Chemical Status (2019)	Fail
Parameters Not At Good Status (2019)	Mitigation measures assessment; Polybrominated diphenyl ethers (PBDE); Mercury and its Compounds
Higher Sensitivity Habitats	Chalk reef (122.25 km^2); Mussel beds, including blue and horse mussel (0.59 km^2); Saltmarsh (0.008 km^2); Subtidal kelp beds (5.17 km^2)

Lower Sensitivity Habitats	Cobbles, gravel and shingle (108.52 km^2); Intertidal soft sediment (17.10 km^2); Rocky shore (75.28 km^2); Subtidal rock reef (27.41 km^2); Subtidal soft sediments (251.85 km^2)
Phytoplankton Status (2019)	Good
History of Harmful Algae	Not monitored

Protected Areas

2.15 The WFD requires that activities are also in compliance with other relevant legislation, such as the Habitats Directive (92/43/EEC as amended), Birds Directive (2009/147/EC), Ramsar Convention, Bathing Water Directive (2006/7/EC), Nitrates Directive (91/676/EEC), Urban Waste Water Treatment Directive (91/271/EEC) and the provisions of the Shellfish Waters Directive (2006/113/EC) (now repealed and integrated into the WFD).

Nature Conservation Designations

2.16 Article 3 of the Habitats Directive (92/43/EEC as amended) requires the establishment of a European network of important high-quality conservation sites known as Special Areas of Conservation (SAC) that will contribute to conserving habitats and species identified in Annexes I and II of the Directive. The listed habitat types and species are those considered to be most in need of conservation at a European level (excluding birds). In accordance with Article 4 of the Birds Directive (2009/147/EC), Special Protection Areas (SPA) are strictly protected sites classified for rare and vulnerable birds (Annex I of the Directive), and for regularly occurring migratory species. Ramsar sites are wetlands of international importance designated under the Ramsar Convention (adopted in 1971 and came into force in 1975), providing a framework for the conservation and wise use of wetlands and their resources.

2.17 The proposed dredge area at Oikos does not directly overlap an international nature conservation designated site. However, the Thames Estuary and Marshes SPA and Ramsar site are located approximately 1.2 km from the proposed dredge area on the opposite (south) bank of the Thames (Figure 2). The nearest SAC to the proposed dredge area is located approximately 15 km to the east, namely the Essex Estuaries SAC.

2.18 The North Edinburgh Channel (TH080) licensed disposal site is situated within the Margate and Long Sands SAC and Outer Thames Estuary SPA (Figure 2). Should the option to dispose of dredge arising at a land-based licensed disposal site be taken forward, it is noted that other international designated sites may need to be considered. For example, the RSPB's Cliffe Pools site overlaps the Thames Estuary and Marshes SPA and Ramsar site.

Bathing Water Directive

2.19 The revised Bathing Water Directive (2006/7/EC) was adopted in 2006, updating the microbiological and physico-chemical standards set by the original Bathing Water Directive (76/160/EEC) and the process used to measure/monitor water quality at identified bathing waters. The revised Bathing Water Directive focuses on fewer microbiological indicators, whilst setting higher standards, compared to those of the Bathing Water Directive. Bathing waters under the revised Bathing Water Directive are classified as excellent, good, sufficient or poor according to the levels of certain types of bacteria (intestinal enterococci and *Escherichia coli*) in samples obtained during the bathing season (May to September).

2.20 The Bathing Water Directive was repealed at the end of 2014 and monitoring of bathing water quality has been reported against revised Bathing Water Directive indicators since 2015. The new classification system considers all samples obtained during the previous four years and, therefore, data has been collected for revised Bathing Water Directive indicators since 2012. The UK Government's target under the revised Bathing Water Directive is to achieve 'sufficient' for all bathing waters by 2015, as described under the Bathing Water Regulations 2013 (as amended)[4] which transposes the revised Bathing Water Directive into UK law.

2.21 There are no coastal bathing waters situated within 2 km of the proposed dredge area at Oikos; the nearest designated bathing water is Leigh Bell Wharf approximately 7 km to the northeast (Figure 3). Similarly, there are no coastal bathing waters situated within 2 km of the North Edinburgh Channel (TH080) licensed disposal site with the nearest approximately 20 km to the south on the north Kent coastline (e.g. Margate). Should the option to dispose of dredge arisings at a land-based licensed disposal site be taken forward, it is noted that other bathing waters may need to be considered (although it is unlikely that a land-based disposal site would be situated in the vicinity of a bathing water).

Shellfish Waters Directive

2.22 The Shellfish Waters Directive (2006/113/EC) was repealed in December 2013 and subsumed within the WFD. However, the Shellfish Water Protected Areas (England and Wales) Directions 2016 require the Environment Agency (in England) endeavour to observe a microbial standard in all 'Shellfish Water Protected Areas'. The microbial standard is 300 or fewer colony forming units of *E. coli* per 100 ml of shellfish flesh and intravalvular liquid. The Directions also requires the Environment Agency to assess compliance against this standard to monitor microbial pollution (75% of samples taken within any period of 12 months below the microbial standard and sampling/analysis in accordance with the Directions).

2.23 There are no Shellfish Water Protected Areas situated within 2 km of the proposed dredge area at Oikos; the nearest is Southend over 3.5 km to the east (Figure 3). The North Edinburgh Channel (TH080) licensed disposal site is located within the Outer Thames Shellfish Water Protected Area (Figure 3). Should the option to dispose of dredge arisings at a land-based licensed disposal site be taken forward, it is noted that other Shellfish Water Protected Areas may need to be considered (although it is unlikely that a land-based disposal site would be situated in the vicinity of shellfish waters).

[4] From 31 January 2020, this was replaced by The Floods and Water (Amendment etc.) (EU Exit) Regulations 2019.

Nitrates Directive

2.24 The Nitrates Directive (91/676/EEC) aims to reduce water pollution from agricultural sources and to prevent such pollution occurring in the future (nitrogen is one of the nutrients that can affect plant growth). Under the Nitrates Directive, surface waters are identified if too much nitrogen has caused a change in plant growth which affects existing plants and animals and the use of the water body.

2.25 The Thames Lower transitional water body, within which the proposed dredge area is located, is designated under the Nitrates Directive; however, the nearest coastal area designated as a Nitrate Vulnerable Zone (NVZ) is greater than 2 km to the south, namely '665 – Coastal Streams to Lower Thames NVZ'[5]. The Essex and Kent North coastal water bodies are not designated under the Nitrates Directive. Should the option to dispose of dredge arising at a land-based licensed disposal site be taken forward, it is noted that other NVZs may need to be considered.

Urban Waste Water Treatment Directive

2.26 The Urban Waste Water Treatment Directive (91/271/EEC) aims to protect the environment from the adverse effects of the collection, treatment and discharge of urban waste water. It sets treatment levels on the basis of sizes of sewage discharges and the sensitivity of waters receiving the discharges. In general, the Urban Waste Water Treatment Directive requires that collected waste water is treated to at least secondary treatment standards for significant discharges. Secondary treatment is a biological treatment process where bacteria are used to break down the biodegradable matter (already much reduced by primary treatment) in waste water. Sensitive areas under the Urban Waste Water Treatment Directive are water bodies affected by eutrophication due to elevated nitrate concentrations and act as an indication that action is required to prevent further pollution caused by nutrients.

2.27 There are no Sensitive Areas within 2 km of the proposed dredge area, with the Sheerness Bathing Water Sensitive Area and Sheppey Shellfish Water Sensitive Area greater than 15 km to the southeast[6]. Similarly, there are no Sensitive Areas within 2 km of North Edinburgh Channel (TH080) licensed disposal site. Should the option to dispose of dredge arising at a land-based licensed disposal site be taken forward, it is noted that other Sensitive Areas designated under the Urban Waste Water Treatment Directive may need to be considered.

Sediment Quality

2.28 There are no formal quantitative Environmental Quality Standards (EQS) for the concentration of contaminants in sediments, although the WFD has introduced optional standards for a small number of priority (hazardous) substances. The Centre for

[5] https://environment.data.gov.uk/farmers (Accessed November 2020).

[6] https://www.gov.uk/government/publications/urban-waste-water-treatment-updated-sensitive-areas-maps-2019 (Accessed November 2020).

Environment, Fisheries and Aquaculture Science (Cefas) has prepared a series of Guideline Action Levels to assist in the assessment of dredged material (and its suitability for disposal to sea). In general, contaminant levels in dredged material below Guideline Action Level 1 (AL1) are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above Guideline Action Level 2 (AL2) is generally considered unsuitable for disposal at sea. Dredged material with contaminant levels between AL1 and AL2 may require further consideration before a decision can be made. The Cefas Guideline Action Levels should not be viewed as pass/fail thresholds. However, these guidelines provide an appropriate context for consideration of contaminant levels in sediments and are used as part of a 'weight of evidence' approach to assessing dredged material.

Dredge Area

2.29 Chemical analysis for metals, organotins, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) were undertaken for the construction of Jetty 2 (EA-NLS, 2015). The results for metals showed levels slightly above AL1 for cadmium, chromium and mercury at the surface and at depth (1.50 m and 3.0 m depth samples) in only one sample (BH05) located adjacent to Jetty 2. The total sum of PAHs above AL1 occurred in 12 out of 20 samples analysed, with individual PAHs congeners above AL1 in four locations, in surface and depth samples. Despite these exceedances of AL1, the sediments were considered acceptable for marine disposal.

2.30 In February 2019, four sediment samples were collected from the proposed dredge area in support of a capital and maintenance dredge licence application at Oikos' Jetty 2 that has since been withdrawn (Case Ref: MLA/2019/00250). The dredge methodology that was proposed was WID and the total proposed dredge volume was 10,000 m^3. The four samples were tested for metals, organotins, PAHs, PCBs and particle size analysis (PSA). Organotins and PCBs were below AL1. Most metals were below AL1, except for mercury (one sample) and arsenic (three samples), which were marginally above AL1 (Cefas, 2019).

2.31 Just over half of the 2019 results for PAHs were elevated above AL1, including Fluoranthene, which had the highest value (2.13 mg/kg, AL1 = 0.1 mg/kg). Cefas applied the Gorham-Test *et al.* (1999) method of analysis to the sample results. The results showed two samples were below the observed low range effects and all were below the median number of observed effects. The results indicated that the levels of PAHs in the sediment did not present a significant risk to the marine environment. The results were assessed by the Marine Management Organisation (MMO) (and Cefas) and no concerns were raised regarding the levels of sediment contamination and the potential disposal of this material at sea. The proposed dredging activity adjacent to Jetty 2 by WID (10,000 m^3) was considered acceptable at that time.

2.32 To support the DCO application, Oikos submitted a sample plan request to the Port of London Authority (PLA), as the Statutory Harbour Authority (SHA) for the Thames, and the MMO. In September 2020, a sample plan was provided by the PLA, followed by the MMO in October 2020 (SAM/2020/00058), prepared in consultation with Cefas. In December 2020, based on a review of the existing bathymetry within the berth pocket at Jetty 2 and in line with the requirements of the PLA/MMO sample plans, surface sampling was undertaken at six stations, with at depth sampling (mid and full depth) also undertaken at one of these stations. Therefore, in total, eight sediment samples were collected, analysed for PSA, metals, organotins, PAHs, THC, PCBs and PBDEs. See Figure 4 for sample locations.

2.33 Table 2.4 presents the PSA summary from samples collected in December 2020 (analysed by Ocean Ecology Ltd; MMO-approved laboratory), confirming the material is relatively coarse. To the west (sample locations 1 and 2), sediments are predominantly sand (>70%), with the remaining fraction comprised of silt/mud (no gravel component). There is a slight increase in sand composition with depth at sample location 1. In the centre and to the east of the proposed dredge area (sample locations 3, 4, 5 and 6), a significant gravel fraction is observed (>60%), with comparatively small sand (>15%) and silt (<10%) fractions.

Table 2.4: Particle size analysis (PSA) of sediment samples collected from the proposed dredge area in December 2020

Sample (Depth)	Visual Appearance	Total Solids (%)	Particle Size Distribution (%)		
			Gravel (>2 mm)	Sand (<2 mm – >63 µm)	Silt (<63 µm)
1 (0 m)	Odourless brown muddy sand with shell fragments	55.2	0.0	72.1	27.9
1 (1 m)	Odourless brown muddy sand with shell fragments	75.4	0.0	74.7	25.3
1 (2 m)	Odourless brown muddy sand	66.7	0.0	94.3	5.7
2 (0 m)	Odourless brown muddy sand with shell fragments	62.7	0.0	79.7	20.3
3 (0 m)	Odourless brown muddy sandy gravel with shell fragments	79.3	80.9	15.3	3.8
4 (0 m)	Odourless brown muddy sandy gravel with shell fragments	81.0	61.2	33.8	5.1
5 (0 m)	Brown muddy sandy gravel with shell fragments and organic matter and a sea odour	86.6	69.6	25.5	4.9
6 (0 m)	Brown muddy sandy gravel with shell fragments and organic matter and a peaty odour	69.3	67.7	23.0	9.3

2.34 Sediment samples collected from the proposed dredge area in December 2020 were sent to MMO-approved laboratories for chemical analysis (Socotec and Cefas). Results are presented in Table 2.5. The results show that metals, organotins and PCBs are well below the respective AL1 in all samples. PAH values were below AL1 for all locations except in the west of the proposed dredge area (sample location 1) where some small exceedance of AL1 occurred at 1 and 2 m depth, particularly for Chrysene, Pyrene, Flouranthene, Phenanthrene and the Benzo determinands. All samples were lower in contaminant content than the 2019 analysis. At the time of writing, the PBDE results from Cefas were not available. This data will be included and analysed in the final WFD assessment.

Table 2.5: Chemical analysis of sediment samples collected from the proposed dredge area in December 2020

Parameter	Unit	Cefas Guideline Action Level		Sample Concentration							
		AL1	AL2	1 (0 m)	1 (1 m)	1 (2 m)	2 (0 m)	3 (0 m)	4 (0 m)	5 (0 m)	6 (0 m)
Arsenic	mg/kg	20	100	10.8	14.3	13.5	10.2	7.6	10.2	9.4	14.1
Cadmium	mg/kg	0.4	5	0.17	0.18	0.25	0.12	0.07	0.08	0.07	0.1
Chromium	mg/kg	40	400	18.8	13.6	25.5	15.1	6.6	7.8	7.9	13.5
Copper	mg/kg	40	400	14.8	12	21.9	11.2	8.1	7.8	10.5	11.2
Mercury	mg/kg	0.3	3	0.13	0.11	0.26	0.11	0.02	0.02	0.03	0.04
Nickel	mg/kg	20	200	11.5	9.7	16.2	9	7.5	8.7	9.2	14.4
Lead	mg/kg	50	500	22.1	20.4	36.3	18.1	6.9	7.5	9.4	10.9
Zinc	mg/kg	130	800	56.3	53.8	80.6	46.3	20.7	27.7	27.3	35.3
Dibutyltin (DBT)	mg/kg	0.1	1	<0.005	0.007	0.014	<0.005	<0.005	<0.005	<0.005	<0.005
Tributyltin (TBT)	mg/kg	0.1	1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Acenapthene	µg/kg	100	-	3.28	25.2	5.5	3.92	1.04	2.12	<1	1.12
Acenapthylene	µg/kg	100	-	9.5	12.5	11.8	14	2.2	2.52	1.6	3.25
Anthracene	µg/kg	100	-	13	77.1	25.2	17.7	4.01	5.76	2.92	6.46
Benz[a]anthracene	µg/kg	100	-	26.9	213	68.4	43	7.26	20.5	6.69	17.8
Benzo[a]pyrene	µg/kg	100	-	50.6	264	108	77	13.3	27.2	11.5	24.7
Benzo[b]fluoranthene	µg/kg	100	-	55.5	208	98.1	75.3	12	32.7	11.4	23
Benzo[g,h,i]perylene	µg/kg	100	-	44.7	150	80.9	64.2	11.8	23	9.89	19.1
Benzo[e]pyrene	µg/kg	100	-	50.4	177	87.7	67.7	12.9	26.6	11.4	22.6

Parameter	Unit	Cefas Guideline Action Level		Sample Concentration							
		AL1	AL2	1 (0 m)	1 (1 m)	1 (2 m)	2 (0 m)	3 (0 m)	4 (0 m)	5 (0 m)	6 (0 m)
Benzo[k]fluoranthene	µg/kg	100	-	34.3	138	67.8	32.5	7.61	18	4.94	9.26
C1-Napthalenes	µg/kg	100	-	25	32.1	27.6	26.6	6.87	5.48	5.74	9.02
C1-Phenanthrenes	µg/kg	100	-	21.3	109	47.1	36.5	7.22	8.08	6.26	10.7
C2-Napthalenes	µg/kg	100	-	20.2	35.9	25.1	27.3	5.55	4.84	5.3	7.78
C3-Napthalenes	µg/kg	100	-	14.3	45.6	23.2	23.5	4.61	4.38	4.96	6.32
Chrysene	µg/kg	100	-	31.9	180	70.9	48.1	7.52	26.4	7.64	21.3
Dibenz[a,h]anthracene	µg/kg	100	-	7.32	30.3	14.7	12.2	2.17	4.91	1.81	3.85
Fluoranthene	µg/kg	100	-	57.9	366	136	83.1	15.4	39	13.7	26
Fluorene	µg/kg	100	-	4.71	27.1	8.26	7.5	1.39	1.64	<1	2.08
Indeno[123-c,d]pyrene	µg/kg	100	-	42.6	168	90.9	71.8	11.7	25.8	9.67	19
Napthalene	µg/kg	100	-	9.55	17.1	13.1	15.1	3.6	3.81	2.51	4.28
Perylene	µg/kg	100	-	22.9	84.1	53.4	37.9	8.12	13.5	7.76	13.7
Phenanthrene	µg/kg	100	-	25	203	52.9	40.4	8.55	13.8	6.26	11.4
Pyrene	µg/kg	100	-	58.3	337	132	82.1	15.3	39.1	16.3	26.2
Total Hydrocarbon Content (THC)	mg/kg	-	-	33.9	15.9	19.225	32.8	58.7	6.26	18.6	14.8
PCB 28	µg/kg	-	-	0.11	0.11	0.2	0.12	0.08	<0.08	<0.08	0.12
PCB 52	µg/kg	-	-	0.14	0.16	0.28	0.22	0.15	0.09	0.15	0.24
PCB 101	µg/kg	-	-	0.18	0.15	0.21	0.22	0.1	0.1	0.1	0.28

Parameter	Unit	Cefas Guideline Action Level		Sample Concentration							
		AL1	AL2	1 (0 m)	1 (1 m)	1 (2 m)	2 (0 m)	3 (0 m)	4 (0 m)	5 (0 m)	6 (0 m)
PCB 118	µg/kg	-	-	0.17	0.09	0.11	0.1	<0.08	<0.08	<0.08	<0.08
PCB 138	µg/kg	-	-	0.25	0.17	0.19	0.15	0.15	<0.08	0.2	0.34
PCB 153	µg/kg	-	-	0.3	0.22	0.28	0.15	0.08	<0.08	0.11	0.27
PCB 180	µg/kg	-	-	0.11	0.09	0.09	<0.08	<0.08	<0.08	0.11	0.09
PCBs – Sum of ICES 7 congeners	µg/kg	10	-	1.26	0.99	1.36	0.96	0.56	0.19	0.67	1.34
PCB 18	µg/kg	-	-	0.11	0.12	0.23	0.12	0.12	<0.08	0.15	0.17
PCB 31	µg/kg	-	-	0.18	0.13	0.28	0.15	0.12	0.11	0.15	0.24
PCB 44	µg/kg	-	-	0.11	<0.08	0.18	0.11	0.1	<0.08	<0.08	0.12
PCB 47	µg/kg	-	-	<0.08	<0.08	1.62	<0.08	<0.08	<0.08	<0.08	<0.08
PCB 49	µg/kg	-	-	0.11	0.1	0.18	0.14	0.09	<0.08	<0.08	0.11
PCB 66	µg/kg	-	-	0.17	0.09	0.19	0.19	0.09	<0.08	<0.08	0.09
PCB 105	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB 110	µg/kg	-	-	0.23	0.2	0.28	0.29	0.12	0.13	0.12	0.28
PCB 128	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.1	<0.08
PCB 141	µg/kg	-	-	<0.08	<0.08	0.1	<0.08	<0.08	<0.08	<0.08	<0.08
PCB 149	µg/kg	-	-	0.2	0.16	0.18	0.2	<0.08	<0.08	0.14	0.29
PCB 151	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB 156	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.09	<0.08

Parameter	Unit	Cefas Guideline Action Level		Sample Concentration							
		AL1	AL2	1 (0 m)	1 (1 m)	1 (2 m)	2 (0 m)	3 (0 m)	4 (0 m)	5 (0 m)	6 (0 m)
PCB 158	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB 170	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCB 183	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.09	<0.08
PCB 187	µg/kg	-	-	0.16	<0.08	<0.08	<0.08	<0.08	<0.08	0.15	0.1
PCB 194	µg/kg	-	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PCBs – Sum of 25 congeners	µg/kg	20	200	2.53	1.79	4.6	2.16	1.2	0.43	1.66	2.74
Key	No Cefas Guideline Action Level										
	Below AL1										
	Above AL1, Below AL2										
	Above AL2										

Marine Disposal Site

2.35 The closest licensed marine disposal site to the Oikos facility is the North Edinburgh Channel site (TH080) and, for the purposes of this PEIR, it is this site which has been assumed to be the marine disposal location (if required). Chemical sampling was undertaken for the original characterisation of the North Edinburgh Channel (TH080) disposal site (PLA, 2004)[7]. This analysis showed that the seabed material was predominantly fine sand. For the most part, the analysis showed that for a large majority of the 16 sample sites metals, organotins, pesticides, organic compounds and microbiological parameters were below the limits of detection and/or below the respective AL1. Mean concentrations of arsenic, however, were greater than AL1, albeit the maximum concentration (75 mg/kg dry weight) was still less than AL2 (100 mg/kg).

2.36 Further chemical sampling in the North Edinburgh Channel took place in 2008 (PLA, 2016)[8] at 22 locations following most of the disposal from the Princes Channel. The results obtained showed similar results to the earlier sampling, again with only arsenic having concentrations above AL1 at a number of sites. The maximum, however, was lower at 54 mg/kg. Isolated low magnitude exceedances of AL1 occurred for nickel and zinc. One location recorded tributyltin (TBT) at 4.9 mg/kg, well above AL2 (1 mg/kg) but this was not characteristic of the rest of the samples. For this set of samples, PAHs were also analysed; again, for the most part, the contaminant determinands were well below limits of detection. One exception was the same site that the high TBT concentration was detected.

[7] PLA (2004*). Princes Channel Development. Placement of Dredged Sand in the North Edinburgh Channel. Environmental Characterisation Report.*

[8] PLA (2016). *Thames Estuary Channel Management - Waste Hierarchy Assessment*

3 Scoping

3.1 The Environment Agency's "Clearing the Water for All" guidance provides a scoping template to record findings and consider potential risks for several key receptors, specifically:

- Hydromorphology;
- Biology (habitats);
- Biology (fish);
- Water quality;
- Protected areas; and
- Invasive non-native species (INNS).

3.2 Each receptor is considered in the following sections and summarised in a table. Potential risks that have been scoped into the assessment are highlighted in red and considered within the impact assessment stage (Section 4), while those scoped out of the assessment are highlighted in green.

Hydromorphology

3.3 Hydromorphology is the physical characteristics of estuaries and coasts, including the size, shape and structure of the water body and the flow and quantity of water and sediment. Table 3.1 presents a summary of hydromorphological considerations and associated risk issues for the proposed works. As the proposed works are considered to pose a risk on one or more of the hydromorphological considerations, this receptor has been scoped into the impact assessment. It is noted that this receptor is specifically scoped in due to the proposed dredge and marine firewater system option (not the disposal) and, therefore, the impact assessment will only consider these elements of the OMSSD project (see Section 4).

Table 3.1: Hydromorphology scoping summary

Hydromorphology Considerations	Hydromorphology Risk Issue(s)		
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
Consider if your activity could impact on the hydromorphology (for example morphology or tidal patterns) of a water body at high status?	No (hydromorphology status not assessed). Impact assessment not required.	No (hydromorphology status not assessed). Impact assessment not required.	No (hydromorphology status not assessed). Impact assessment not required.
Consider if your activity could significantly impact the hydromorphology of any water body?	Yes (potential changes to hydromorphology as a result of the proposed dredging works and potential marine firewater system option). Requires impact assessment.	No (disposal activity unlikely to result in significant impact to hydromorphology). Impact assessment not required.	No (disposal activity unlikely to result in significant impact to hydromorphology). Impact assessment not required.
Consider if your activity is in a water body that is	Yes (hydromorphological designation related to	No (hydromorphological designation related to	No (hydromorphological designation related to

Hydromorphology Considerations	Hydromorphology Risk Issue(s)		
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
heavily modified for the same use as your activity?	Navigation, ports and harbours, as well as Flood protection). Requires impact assessment.	Coastal protection and Flood protection). Impact assessment not required.	Coastal protection). Impact assessment not required.

Biology (Habitats)

3.4 It is necessary to consider the impact of the physical footprint of an activity on nearby marine and coastal habitats. This specifically refers to habitats of higher sensitivity (e.g. intertidal seagrass, maerl and saltmarsh) and lower sensitivity (e.g. cobbles, gravel and shingle, subtidal rock reef and intertidal soft sediments like sand and mud). Table 3.2 presents a summary of biology (habitats) considerations and associated risk issues for the proposed works. As biology (habitats) considerations indicate that a risk could be associated with the proposed works, this receptor has been scoped into the assessment. It is noted that this receptor is specifically scoped in due to the proposed disposal (not the dredge or potential marine firewater system) and therefore the impact assessment will only consider this element of the OMSSD project (see Section 4).

Table 3.2: Biology (habitats) scoping summary

Biology (Habitats) Considerations	Biology (Habitats) Risk Issue(s)		
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
Is the footprint of the activity 0.5 km² or larger?	No (footprint of proposed dredge area multiplied by 1.5 is 0.04 km²). Impact assessment not required.	Yes (footprint of proposed disposal activity is approximately 1 km²). Requires impact assessment.	No (footprint of proposed disposal activity does not overlap with Kent North coastal water body). Impact assessment not required.
Is the footprint of the activity 1% or more of the water body's area?	No (proposed dredge area multiplied by 1.5 is <0.02% of water body area). Impact assessment not required.	No (footprint of proposed disposal activity is <0.1% of water body area). Impact assessment not required.	No (footprint of proposed disposal activity does not overlap with Kent North coastal water body). Impact assessment not required.
Is the footprint of the activity within 500 m of any higher sensitivity habitat?	No (the nearest higher sensitivity habitat (saltmarsh) is located approximately 1.3 km to the west of the proposed dredge area; Defra's MAGIC Interactive Map). Impact assessment not required.	No (there are no higher sensitivity habitats located within 500 m of the potential disposal site). Impact assessment not required.	No (there are no higher sensitivity habitats located within 500 m of the potential disposal site). Impact assessment not required.

Biology (Habitats) Considerations	Biology (Habitats) Risk Issue(s)		
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
Is the footprint of the activity 1% or more of any lower sensitivity habitat?	No (the Environment Agency's water body summary table (Excel spreadsheet) indicates 1.39 km^2 of cobbles, gravel and shingle habitat within the Thames Lower water body; thus, the proposed dredge area would equate to around 2.9% of this lower sensitivity habitat extent. However, Defra's MAGIC Interactive Map suggests a much greater extent, >10 km^2, in the immediate vicinity of the proposed dredge area, thus the proposed dredge area would equate to <1%). Impact assessment not required.	No (large expanse of subtidal soft sediment habitat within the Essex water body, >5,000 km^2, thus the proposed disposal activity equates to <1% of this lower sensitivity habitat). Impact assessment not required.	No (footprint of proposed disposal activity does not overlap with Kent North coastal water body). Impact assessment not required.

Biology (Fish)

3.5 Activities occurring within an estuary could impact on normal fish behaviour such as movement, migration or spawning. Table 3.3 presents a summary of biology (fish) considerations and associated risk issues for the proposed works. As at least one biology (fish) consideration indicates that a risk could be associated with the proposed works, this receptor has been scoped into the detailed assessment. It is noted that this receptor is specifically scoped in due to the proposed dredge (not the disposal or potential marine firewater system option) and, therefore, the impact assessment will only consider this element of the OMSSD project (see Section 4).

Table 3.3: Biology (fish) scoping summary

Biology (Fish) Considerations	Biology (Fish) Risk Issue(s)	Biology (Fish) Risk Issue(s)	Biology (Fish) Risk Issue(s)
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
Consider if your activity is in an estuary and could affect fish in the estuary, outside the estuary but could delay or prevent fish entering it or could affect fish	Yes. "Continue with questions".	No (coastal water bodies are not assessed for fish and disposal activity unlikely to result in significant impact in upstream waters).	No (coastal water bodies are not assessed for fish and disposal activity unlikely to result in significant impact in upstream waters).

Biology (Fish) Considerations	Biology (Fish) Risk Issue(s)	Biology (Fish) Risk Issue(s)	Biology (Fish) Risk Issue(s)
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
migrating through the estuary?			
Consider if your activity could impact on normal fish behaviour like movement, migration or spawning (for example creating a physical barrier, noise, chemical change or a change in depth or flow)?	Yes (potential for fish to be disturbed by dredging activity). Requires impact assessment.	Not applicable.	Not applicable.
Consider if your activity could cause entrainment or impingement of fish?	No (unlikely for dredging activity to result in significant risk of entrainment or impingement for fish). Impact assessment not required.	Not applicable.	Not applicable.

Water Quality

3.6 Consideration should be made regarding whether phytoplankton status and harmful algae could be affected by the proposed works, as well as identifying the potential risks of using, releasing or disturbing chemicals. Table 3.4 presents a summary of water quality considerations and associated risk issues of the proposed works. As water quality considerations indicate that a risk could be associated with the proposed works, this receptor has been scoped into the impact assessment (see Section 4).

Table 3.4: Water quality scoping summary

Water Quality Considerations	Water Quality Risk Issue(s)	Water Quality Risk Issue(s)	Water Quality Risk Issue(s)
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
Consider if your activity could affect water clarity, temperature, salinity, oxygen levels, nutrients or microbial patterns continuously for longer than a spring neap tidal cycle (about 14 days)?	No (the dredging activity at Jetty 2 will take place for up to 8 hours per day and will be completed in about a week. The sediment plume is only likely to be evident during the 3 to 4 hour period of each dredge load and for an additional period of about 0.5 hours following the completion of each dredge load. The marine firewater system option will only be operational	No (the disposal activity at the North Edinburgh Channel disposal site will take place intermittently and will be completed in about a week. The sediment will be deposited from the hull of the dredger and will take up to about 10 minutes to dispose. Changes in suspended sediment concentrations (SSC) will not be discernible from background SSC within	No (the disposal activity at the North Edinburgh Channel disposal site will take place intermittently and will be completed in about a week. The sediment will be deposited from the hull of the dredger and will take up to about 10 minutes to dispose. Changes in suspended sediment concentrations (SSC) will not be discernible from background SSC within

Water Quality Considerations	Water Quality Risk Issue(s)	Water Quality Risk Issue(s)	Water Quality Risk Issue(s)
	Thames Lower transitional water body	**Essex coastal water body**	**Kent North coastal water body**
	for 20 minutes each week and during a fire emergency. Any sediment plume will be short term and temporary). Impact assessment not required.	around 15 to 30 minutes of each dredger load that is disposed). Impact assessment not required.	around 15 to 30 minutes of each dredger load that is disposed). Impact assessment not required.
Consider if your activity is in a water body with a phytoplankton status of moderate, poor or bad?	No (phytoplankton classification is good). Impact assessment not required.	No (phytoplankton classification is high). Impact assessment not required.	No (phytoplankton classification is good). Impact assessment not required.
Consider if your activity is in a water body with a history of harmful algae?	Yes (history of harmful algae in Thames Lower transitional water body). Requires impact assessment.	Yes (history of harmful algae in Essex coastal water body). Requires impact assessment.	No (history of harmful algae is not monitored in Kent North coastal water body). Impact assessment not required.
If your activity uses or releases chemicals (for example through sediment disturbance or building works) consider if the chemicals are on the Environmental Quality Standards Directive (EQSD) list?	Yes (there is potential for sediment-bound chemicals on EQSD list to be disturbed during the proposed dredge). Requires impact assessment.	Yes (there is potential for sediment-bound chemicals on EQSD list to be dispersed during potential marine disposal). Requires impact assessment.	Yes (there is potential for sediment-bound chemicals on EQSD list to be dispersed during potential marine disposal). Requires impact assessment.
If your activity uses or releases chemicals (for example through sediment disturbance or building works) consider if it disturbs sediment with contaminants above Cefas Action Level 1?	Yes (there is potential for sediment-bound chemicals above Cefas AL1 to be disturbed during the proposed dredge). Requires impact assessment.	Yes (there is potential for sediment-bound chemicals above Cefas AL1 to be dispersed during potential marine disposal). Requires impact assessment.	Yes (there is potential for sediment-bound chemicals above Cefas AL1 to be dispersed during potential marine disposal). Requires impact assessment.
If your activity has a mixing zone (like a discharge pipeline or outfall) consider if the chemicals released are on the Environmental Quality Standards Directive (EQSD) list?	No (not applicable). Impact assessment not required.	No (not applicable). Impact assessment not required.	No (not applicable). Impact assessment not required.

Protected Areas

3.7 Consideration should be made regarding whether WFD protected areas are at risk from your activity, including SACs and SPAs (Natura 2000 sites), as well as bathing waters, shellfish waters and nutrient sensitive areas. Table 3.5 presents a summary of protected area considerations and associated risk issues of the proposed works. As the protected areas considerations indicate that a risk could be associated with the proposed works, this receptor has been scoped into the impact assessment (see Section 4).

Table 3.5: Protected areas scoping summary

Protected Areas Considerations	Protected Areas Risk Issue(s)		
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
Consider if your activity is within 2 km of any WFD protected area?	Yes (Thames Estuary and Marshes SPA and Ramsar site is located approximately 1.2 km from the proposed dredge area and potential marine firewater system option). Requires impact assessment.	Yes (the potential disposal site is situated within the Outer Thames Estuary SPA, the Margate and Long Sands SAC and Outer Thames Shellfish Water Protected Area). Requires impact assessment.	Yes (the potential disposal site is situated within the Outer Thames Estuary SPA, the Margate and Long Sands SAC and Outer Thames Shellfish Water Protected Area). Requires impact assessment.

Invasive Non-Native Species (INNS)

3.8 Consideration should be made regarding whether there is a risk the activity could introduce or spread INNS. Risks of introducing or spreading INNS include materials or equipment that have come from, had use in or travelled through other water bodies, as well as activities that help spread existing INNS, either within the immediate water body or other water bodies. Table 3.6 presents a summary of INNS considerations and associated risk issues of the proposed works. As the INNS considerations indicate that a risk could be associated with the proposed works, this receptor has been scoped into the detailed assessment (see Section 4).

Table 3.6: Invasive non-native species (INNS) scoping summary

Invasive Non-Native Species (INNS) Considerations	Invasive Non-Native Species (INNS) Risk Issue(s)		
	Thames Lower transitional water body	Essex coastal water body	Kent North coastal water body
Consider if your activity could introduce or spread INNS?	Yes (potential for introduction or spread of INNS). Requires impact assessment.	Yes (potential for introduction or spread of INNS). Requires impact assessment.	Yes (potential for introduction or spread of INNS). Requires impact assessment.

4 Assessment

4.1 A detailed assessment should be conducted for each receptor identified during the scoping stage as being at risk from an activity. As highlighted in Section 3, the following receptors have been scoped into the detailed assessment:

- Hydromorphology (due to the proposed dredge and marine firewater system option only);
- Biology (habitats) (due to potential disposal only);
- Biology (fish) (due to the proposed dredge only);
- Water quality;
- Protected areas; and
- Invasive non-native species (INNS).

4.2 Each of these WFD parameters has been evaluated in order to determine whether the OMSSD project might cause deterioration in the status of the relevant water body (defined as a non-temporary effect on status at water body level), or an effect that prevents the water body from meeting its WFD objectives.

Hydromorphology

Changes in seabed bathymetry and processes – dredge location

Understanding of potential impact

4.3 The proposed dredged pocket at Jetty 2 is being deepened to 16.5 m below CD. The dredging works (*circa* 25,000 m^3) that could affect the water environment is small relative to the size of the Thames Estuary and the current Thames Estuary maintenance dredging practice. The average depth to be removed is in the order of 1 m over the area of the berth pocket (range 0 – 3 m depth change). The existing hydrodynamic model which was developed for the previous ES that was undertaken for the construction of Jetty 2 in 2015 has been used to determine the worst-case effects on the estuary dynamics at the time of peak flood and ebb spring tide flows (Figures 8.3 and 8.4 in Volume 2 of the PEIR). A time series has also been extracted from this existing model throughout the tide near the location of greatest change at the north west corner of the dredge pocket (Figure 8.5 in Volume 2 of the PEIR).

4.4 The plots indicate that all changes are small, generally less than 0.1 m/s (< 10%) of the ambient flows and are confined to a relatively small area within, around and behind the berth pocket. Within the berth, reductions in flow are confined to the western 100 m of the pocket. Behind the jetty, flow speed reductions are between 0.025 and 0.05 m/s and extend *circa* 280 m to the outer edge of the intertidal area. This area is predominantly confined to up estuary of the jetty head approach on the ebb, but behind the whole length of the pocket on the flood. Small areas of increased flow by up to 0.05 m/s occur outside each end of the berth pocket on both the flood and ebb as additional flow is drawn through the deepened berth pocket.

4.5 Figure 8.5 in Volume 2 of the PEIR shows that the small reduction in flow speed is evident throughout the tide with a very small reorientation in the flow direction (< 5 °). The plot also indicates the maximum change in the bed shear stress (BSS) resulting from the deepening. On the flood, the reduction in BSS was about 0.05 N/m² and 0.07 N/m² on the ebb, representing *circa* 10% of the existing BSS. This change has a negligible effect on the ability of the flows to transport the sand/silts in motion within estuary. As a result, sedimentation within the berth area is unlikely to change from the natural estuary sediment regime. The new configuration of the pocket will, however, provide increased potential for some initial sedimentation as a result of the increased supply of sand arising from the existing maintenance dredging of Jetty 1. Most of the material is expected to disperse on subsequent tides although some may accumulate at the base of the western end slope in the north west corner of the berth.

4.6 The modelling indicates that maintenance dredging at the Jetty 2 berth under the current flow regime is likely to be minimal with only small amounts requiring to be removed infrequently, possibly as an extension to the Jetty 1 WID maintenance dredge requirement.

4.7 The areas of reduced flow behind the Jetty 2 berth are in areas where sedimentation is already occurring back to an equilibrium level. The small reduction in flow is likely to cause a marginal increase to the sedimentation rate until the ongoing sedimentation reaches a natural equilibrium for the current hydrodynamic regime.

4.8 The small changes to the bathymetry and their local effect on physical processes mean there will be no measurable changes to estuary dynamics including tidal propagation, water levels or effects on saline intrusion.

Assessment conclusion

4.9 In conclusion, the proposed capital and maintenance dredge works associated with the OMSSD project are not expected to lead to a deterioration of the assessed hydromorphological elements within the Thames Lower transitional water body, nor prevent this water body from meeting its WFD objectives.

Changes in seabed bathymetry and processes – firewater system

Understanding of potential impact

4.10 The marine firewater system option has the potential to result in a change to seabed and disturbance of sediment. At the present time, the method for the construction of the intake and outlet pipework is not yet detailed. The worst case change in the seabed would result from the use of a jack-up barge with its legs resting on the seabed adjacent to Jetty 1. Should this be the case, the legs will create ‘pock marks’ in the bed and scour of fine sediments would occur in close proximity to the legs.

4.11 Existing tidal flows in the area of the Jetty 1 approach (the site of the intake) and at the rear of the Jetty 1 head (site of the outlet) are low. Given the small scale nature of the works, with plant (jack-up barge) on site no more than a few days, the potential for scour is considered to be small to negligible at the intake location and slightly more (small) at the outlet. The potential for scour is predicted to be contained within 2 diameters of the legs of the jack-up barge. The depth of change would depend on the density of the bed and the material type but would be expected to be no more than about 0.2 m around each leg. Such effects will not occur if the works are undertaken from the existing structure or floating plant.

4.12 Change in the seabed and disturbance of sediment as a result of the construction of the marine firewater system option will therefore be highly localised and unlikely to be measurable against background variability.

4.13 During operation, the marine firewater system option has the potential to scour the seabed and release sediment into the water column due to acceleration of flows in front of the intake and from the outlet. Existing flow speeds in and around the potential locations of the intake and outlets are low. Localised change in flow patterns around the structures are, therefore, likely to result during the weekly testing of the systems and if ever required during an emergency.

4.14 In the worst case (without diffusers), maximum intake and outlet velocities at the end of the pipe will be about 2 m/s and 4.5 m/s respectively, i.e. considerably faster than the natural flows. These flows will, however, reduce quickly with distance from the pipe or diffuser. Whilst in operation there is potential for scour of the bed close to the structures which will release sediment to the water column. The distance of travel of this plume, however, will be small due to the low flows and the silty/sand nature of the sediment.

4.15 The likely changes to the seabed due to erosion from the water being drawn into the intake and released as a jet from the outlet, has the potential to cause erosion within about 10 m of the respective pipes. This erosion will occur relatively quickly, over a few weeks and an equilibrium morphology will develop, reducing further erosion rates. The impact will only occur at worst for 20 minutes every week. The overall magnitude of the change is, therefore, considered to be small initially reducing to a negligible impact within a few weeks. Given the slow ambient flow and the sediment size, any sediment plumes will be short- lived and sediment will be quickly returned to the seabed. Plumes with high suspended load are not expected to disperse beyond the Oikos frontage, particularly once an equilibrium morphology has developed.

Assessment conclusion

4.16 In conclusion, the proposed marine firewater system option associated with the OMSSD project is not expected to lead to a deterioration of the assessed hydromorphological elements within the Thames Lower transitional water body, nor prevent this water body from meeting its WFD objectives.

Biology (Habitats)

Changes to habitats and species as a result of sediment deposition – potential disposal location

4.17 It is currently assumed that a total of about 25,000 m³ *in situ* material will be deposited at the

North Edinburgh Channel disposal site from up to 13 dredger loads at a rate of one load per tide (capital dredge works). At least 80 to 90% of the material will settle directly to the bed and cause a mound beneath the dredger, which could initially be three to four metres high, but would flatten out with the channel flows. Good practice will be followed by spreading the individual loads throughout the deposit area. Sedimentation at the site is, therefore, unlikely to be discernible from background variability within *circa* 3 months after the end of the disposal activity.

4.18 Analysis of previous dredge disposal data indicates that the site has previously accommodated disposal rates of up to 1.2 million m^3 per month (i.e. a 48 times greater disposal rate than currently proposed for the OMSSD project) without significant long-term changes to the channel depths. Bathymetric survey analysis indicates the total to be deposited is also less than 0.5% of the sand estimated to be in motion naturally through the area in a year.

4.19 The disposal site is situated in a deep, highly mobile channel within both the Outer Thames Estuary SPA and the Margate and Long Sands SAC. This dynamic channel forms part of a complex sandbank system of the Outer Thames Estuary and borders the large sandbank known as Long Sand. Seabed sediments comprise mobile sands with low levels of fine sediment with sparse faunal communities representative of dynamic sand habitat.

4.20 As noted above, the disposal of material is expected to cause some temporary local sedimentation within the North Edinburgh Channel disposal site. However, the impoverished assemblage in this area is already considered to be highly disturbed as a result of the dynamic nature of this area. Fine sediment is likely to be rapidly dispersed and spread out by ambient tidal currents within a very short period of time.

4.21 High energy sand areas such as those associated with the disposal site are characterised by a lack of sedentary species (especially bivalve molluscs) and the dominance of more mobile infauna (such as errant polychaetes, e.g. *Nephtys* spp.) and amphipods (such as *Bathyporeia* spp.) which are able to burrow through sediment. They are therefore considered tolerant to some sediment deposition. In addition, characterising species typically have opportunistic life history strategies, with short life histories (typically two years or less), rapid maturation and the production of large numbers of small propagules which makes them capable of rapid recoverability following disturbance events. On this basis, any effects are considered to be temporary and short term (Tillin and Garrard, 2019)

4.22 Deposition in the wider area surrounding the disposal ground is expected to be in the order of millimetres. Sedimentation of this scale is unlikely to result in significant smothering effects to most faunal species with recoverability expected to be high.

Indirect changes to seabed habitats and species in changes to hydrodynamic and sedimentary processes – potential disposal location

4.23 Existing depths at the disposal site are for the most part in excess of -14 m CD with deeper pockets. Good practice is to distribute each load throughout the site, thus minimising the initial reduction in depth. Assuming this occurs, the maximum reduction in depth would be about 3 to 4 m; a maximum percentage reduction of around 30% at any location. This will result in an increase in flow around each mound and subsequent erosion and redistribution will take place particularly for the sand material. The mounds and associated changes in flows are anticipated to be a temporary feature evident for an estimated three months.

4.24 Such changes are unlikely to result in any significant changes to local sediment transport in the region, although some localised changes to seabed bathymetry and the morphology of nearby subtidal and intertidal sandbanks could occur.

4.25 The predicted changes in flow rates and subtidal seabed morphology are not expected to modify existing subtidal habitat types found in the area (i.e. mobile sand habitats characterised by an impoverished infaunal assemblage).

4.26 Given the offshore location of the disposal site, no changes in wave regime are predicted. In addition, no changes to intertidal mudflats and saltmarsh along the Essex and Kent coast will occur as a result of dredge disposal.

Assessment conclusion

4.27 In conclusion, the potential disposal of dredge material at the North Edinburgh Channel disposal site is not expected to lead to a deterioration of the assessed habitats within the Essex coastal water body or Kent North coastal water body, nor prevent these water bodies from meeting their WFD objectives.

Biology (Fish)

Direct changes to fish populations and habitat – dredge location

4.28 Habitat change could potentially impact on critical habitats including spawning and nursery grounds that have an important ecological function for fish and shellfish. However, the dredge footprint is considered unlikely to provide important nursery or spawning functions for the fish species as a result of the disturbed nature of this habitat despite known nursery areas for fish such as seabass occurring in the wider Outer Thames Estuary area. Furthermore, the nearest shellfish beds are located more than 4 km east of Jetty 2 and, therefore, this receptor will not be affected by the proposed dredge.

4.29 The benthic resource within the berth footprint is considered to be very low in biomass and species diversity. In addition, impacts from dredging in the study area on benthic species and habitats were considered to be insignificant (see marine ecology assessment, Chapter 9 of the PEIR). This impoverished habitat provides a limited prey resource for demersal and flatfish species. Furthermore, most fish species are opportunistic and generalist feeders, which means that most are not reliant on a single prey item. Fish are also mobile species and will easily be able to move away from the zone of influence and return following the cessation of dredging activity.

4.30 During dredging by TSHD (assumed for capital dredge works only), there is the potential for fish along with roe (eggs) of these species to be directly taken up by the action of the draghead. However, there is considered to be a low likelihood of significant spawning or nursery grounds being present within the proposed dredge area given that it is an operational berth.

Changes in suspended sediment concentration – dredge location

4.31 The temporary and highly localised increases in suspended sediment concentration (SSC) during the capital dredge (e.g. TSHD) will be of a magnitude comparable to that which occurs naturally in Thames Estuary. Thus, in physical terms, the plumes resulting from the proposed dredging activities are expected to have a minimal and local effect on SSC (and associated dissolved oxygen levels) in the vicinity of the proposed development.

4.32 Elevated suspended sediment concentrations as a result of WID maintenance dredging are expected to occur temporarily. In order to minimise the environmental effects, existing maintenance dredging in the Thames Estuary is required to be undertaken on an ebb tide to provide maximum dispersion and minimise sedimentation. The small maintenance dredge requirement at Jetty 2 is likely to be undertaken as an extension of the existing Jetty 1 maintenance dredge campaign. This existing practice of maintenance dredging on an ebb tide will be adhered to as part of any maintenance dredging by WID at Jetty 2 during operation.

4.33 Previous sediment modelling has found that WID results in peak SSC of up to 200 mg/l above background levels for up to 20 minutes before gradually decaying to normal background levels (PLA, 2020).

4.34 These estimates of the increased SSC from WID are generally low when compared with existing background levels of near bed SSC in the Thames Estuary. Measurements within the main navigation channel are highly variable, between 500 and 3,000 mg/l, whilst background near bed SSC measured inshore of Jetty 2 can naturally reach 400 mg/l.

4.35 Commercial shellfish beds do not overlap with the plumes generated during dredging and will therefore not be affected by the proposed capital and maintenance dredge.

4.36 As noted in the preceding section, fish within Thames Estuary are well adapted to living in an area with variable and sometimes relatively high suspended sediment loads. Fish feed on a range of food items and, therefore, their sensitivity to a temporary change in the availability of a particular food resource is considered to be low. Their high mobility enables them to move freely to avoid areas of adverse conditions and to use other food sources in the local area.

4.37 Increases in SSC through the proposed capital and maintenance dredging activity will be brief and localised and there is not expected to be a significant reduction in dissolved oxygen.

Underwater noise and vibration

4.38 The dredging process involves a variety of sound generating activities which can be broadly divided into sediment excavation, transport and placement of the dredged material at the disposal site (CEDA, 2011; Thomsen *et al.*, 2013; Jones and Marten, 2016). For most dredging activities, the main source of sound relates to the vessel engine noise. Dredging activities produce broadband and continuous sound[9], mainly at lower frequencies of less than 500 Hz and moderate source sound pressure levels from around 150 to 188 dB re 1 μPa m (Thomsen *et al.*, 2009; 2013; CEDA, 2011; Robinson *et al.*, 2011; MMO, 2015; Jones and Marten, 2016).

4.39 The most intense sound emissions from the TSHDs are in the low frequencies, up to and including 1,000 Hz in most cases (Robinson *et al.*, 2011; De Jong *et al.*, 2010). For most dredging activities, the main source of noise relates to the vessel engine noise. Differences in sound levels are mainly a result of the difference in size between the dredging vessels observed rather than the materials dredged.

4.40 The noise output of dredging vessels is considered similar to a 'noisy merchant vessel' at frequencies less than 500 Hz and is substantially lower in intensity, in terms of acoustic energy output, than some other anthropogenic noise sources, such as seismic airguns and marine pile driving (Robinson *et al.,* 2011). Dredgers generate higher levels of noise at frequencies above 1 kHz than a typical merchant vessel. High frequency components of the broadband sound are generated by sand and gravel movement through the suction pipes, the movement of the draghead on the seabed, splashing from the spillways, cavitation and use of positioning thrusters. Also, gravelly sand extraction resulted in higher levels of this sound than sandy gravel when comparing the same dredging vessel (Robinson *et al.*, 2011).

4.41 There is a wide diversity in hearing structures in fish which leads to different auditory capabilities across species (Webb *et al.*, 2008). All fish can sense the particle motion[10] component of an acoustic field via the inner ear as a result of whole-body accelerations (Radford *et al.*, 2012), and noise detection ('hearing') becomes more specialised with the addition of further hearing structures. Particle motion is especially important for locating sound sources through directional hearing (Popper *et al.*, 2014; Hawkins *et al.*, 2015; Nedelec *et al.*, 2016). Although many fish are also likely to detect sound pressure[11], particle motion is considered equally or potentially more important (Hawkins and Popper, 2017).

4.42 From the few studies of hearing capabilities in fish that have been conducted, it is evident that there are potentially substantial differences in auditory capabilities from one fish species to another (Hawkins and Popper, 2017). Since it is not feasible to determine hearing sensitivity for all fish species, one approach to understand hearing has been to distinguish fish groups on the basis of differences in their anatomy and what is known about hearing in other species with comparable anatomy. Popper *et al.* (2014) proposed the following three categories of fish which are described below:

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9 Continuous sound is defined here as a sound wave with a continuous waveform, as opposed to transient/pulsed sounds such as pile driving that start and end in a relatively short amount of time.

10 Particle motion is a back and forth motion of the medium in a particular direction; it is a vector quantity that can only be fully described by specifying both the magnitude and direction of the motion, as well as its magnitude, temporal, and frequency characteristics.

11 Pressure fluctuations in the medium above and below the local hydrostatic pressure; it acts in all directions and is a scalar quantity that can be described in terms of its magnitude and its temporal and frequency characteristics.

- Fish with a swim bladder or air cavities that aid hearing;
- Fish with a swim bladder that does not aid hearing; and
- Fish with no swim bladder.

4.43 The first category comprises fish that have special structures mechanically linking the swim bladder to the ear. These fish are sensitive primarily to sound pressure, although they also detect particle motion (Hawkins and Popper, 2016). They are sensitive to a wider frequency range, extending to several kHz, and generally show higher sensitivity to sound pressure than fish in the other categories. Fish species in the study area that fall within this first category include allis shad (*Alosa alosa*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and twaite shad (*Alosa fallax*).

4.44 The second category comprises fish with a swim bladder where the organ does not appear to play a role in hearing. Some of the fish in this category are considered to be more sensitive to particle motion than sound pressure (see below) and show sensitivity to only a narrow band of frequencies, namely the salmonids (Salmonidae) (Hawkins and Popper, 2016). This second category also comprises fish with swim bladders that are close, but not intimately connected, to the ear, such as codfishes (Gadidae) and eels (Anguillidae). These fish are sensitive to both particle motion and sound pressure, and show a more extended frequency range, extending up to about 500 Hz (Popper and Coombs, 1982; Jerkø *et al.*, 1989; Popper and Fay, 2011; Hawkins and Popper, 2016). Fish species in the study area that fall within this second category include Atlantic salmon (*Salmo salar*), European eel (*Anguilla anguilla*), European seabass (*Dicentrarchus labrax*), smelt (*Osmerus eperlanus*) and whiting (*Merlangius merlangus*).

4.45 The third category comprises fish lacking swim bladders that are sensitive only to sound particle motion and show sensitivity to only a narrow band of frequencies (e.g. flatfishes, sharks, skates and rays). Particle motion rather than sound pressure is considered to be potentially more important to fish without swim bladders and salmonids. There is very limited information available on the hearing abilities of elasmosbranch fishes (sharks, rays and skates). The hearing abilities among sharks have demonstrated a high sensitivity to low frequency sound (40 Hz – 800 Hz). Overall sensitivity, however, is low compared to other taxa (Thomsen *et al.,* 2009). Fish species in the study area that fall within this third category include lemon sole (*Microstomus kitt*), plaice (*Pleuronectes platessa*), river lamprey (*Lampetra fluviatilis*), sea lamprey (*Petronmyzon marinus*), sole (*Solea solea*) and thornback ray (*Raja clavata*).

4.46 Acoustic particle motion in the water and seabed, for example, has been shown to induce behavioural reactions in sole (Mueler-Blenkle *et al*., 2010). However, there is no published literature on the levels of particle motion generated during construction activities (e.g. pile-driving and dredging) and the distance at which they can be detected. This may be due to the fact that there are far fewer devices (and less skill in their use) for detection and analysis of particle motion compared to hydrophone devices for detection of sound pressure (Martin *et al*., 2016). Direct measurements of particle motion have also been hampered by the lack of guidance on data analysis methods.

4.47 Particle velocity can be calculated indirectly from sound pressure measurements using rather simple models (MacGillivray *et al*., 2004). However, such estimates of sound particle velocity are only valid in environments that are distant from reflecting boundaries and other acoustic discontinuities. These conditions are rarely met in the shelf-sea and shallow-water habitats that most aquatic organisms inhabit and that are applicable to the study area (Nedelec *et al*., 2016).

4.48 Steps that are required to improve knowledge of the effects of particle motion on marine fauna have recently been set out (Popper and Hawkins, 2018). However, at present there continues to be a lack of particle motion measurement standards, lack of easy to use and reasonably priced instrumentation to measure particle motion, and lack of sound exposure criteria for particle motion. As such, the scope for considering particle motion in underwater noise assessments is currently limited (Faulkner *et al*., 2018). The underwater noise assessment has therefore been based on the latest available evidence which have focused on the effects of sound pressure on marine fauna.

4.49 Auditory and non-auditory injuries in fish have not been observed or documented to occur in association with dredging (Thomsen *et al.,* 2009). Wenger *et al.* (2017) highlight that impacts on fish from dredging-generated noise are likely to be Temporary Threshold Shift (TTS) in some species, behavioural effects and increased stress-related cortisol levels.

4.50 If the practical spreading law model (15log10(R)) is applied to predict the range at which the Popper *et al.* (2014) quantitative instantaneous peak sound pressure level (SPL) thresholds for pile driving are reached, this indicates that there is no risk of mortality, potential mortal injury or recoverable injury in all categories of fish even at the very source of the dredger noise. This seems to correlate with the Popper *et al.* (2014) recommended qualitative guidelines for continuous noise sources (such as dredging and shipping) which consider that the risk of mortality and potential mortal injury in all fish is low in the near, intermediate and far-field.

4.51 According to Popper *et al.* (2014), the risk of recoverable injury is also considered low for fish with no swim bladder and fish with a swim bladder that is not involved in hearing. There is a greater risk of recoverable injury in fish where the swim bladder is involved in hearing whereby a cumulative noise exposure threshold is recommended (170 dB root mean squared (rms) for 48 h). However, given that the TSHD will be present intermittently within the dredge area at Jetty 2, as it undertakes the dredging process (3 to 4 hours of dredging is likely to be required to load the dredger) and travel to and from the disposal site (the dredger round trip including disposal time would take between 5.5 to 7 hours depending on the tides), the potential risk of an effect on this more sensitive category of fish is also considered low.

4.52 Popper *et al.* (2014) advise that there is a moderate risk of TTS to occur in the nearfield (i.e. tens of metres from the source) in fish with no swim bladder and fish with a swim bladder that is not involved in hearing and a low risk in the intermediate and far-field. There is a greater risk of TTS in fish where the swim bladder is involved in hearing whereby a cumulative noise exposure threshold is recommended (158 dB rms for 12 h). However, as discussed above, given that the TSHD will be present intermittently within the dredge area at Jetty 2, the potential risk of a TTS effect on this more sensitive category of fish is also considered to be moderate in the nearfield and low in the intermediate and far-field.

4.53 Popper *et al.* (2014) guidelines suggest that there is considered to be a high risk of potential behavioural responses occurring in the nearfield (i.e. tens of metres from the source) for fish species with a swim bladder involved in hearing and a moderate risk in other fish species. At intermediate distances (i.e. hundreds of metres from the source) there is considered to be a moderate risk of potential behavioural responses in all fish and in the farfield (i.e. thousands of metres from the source) there is considered to be a low risk of a response in all fish.

4.54 In the absence of any published quantitative behavioural thresholds, an empirical behavioural threshold can be adopted using *in situ* observed responses of fish to similar sound sources (Faulkner et al., 2018). Work has been undertaken by Hawkins *et al.* (2014) reporting behavioural responses of schools of wild sprat and mackerel to playbacks of pile driving. At a single-pulse peak-to-peak SPL of 163 dB re 1 µPa (equivalent to peak SPL of 157 dB re 1 µPa), schools of sprat and mackerel were observed to disperse or change depth on 50 % of presentations. Sprat and mackerel have specialised hearing structures. Fish species in the study area also include species that lack this specialisation or do not have a swim bladder and therefore this threshold is likely to be an indicator of minor behavioural responses in these other fish (e.g. subtle change in swimming speed or direction). In the absence of similar data for other categories of fish, this threshold can be applied for all fish species on a worst case basis.

4.55 The practical spreading law model (15log10(R)) can be applied to predict the range at which the Hawkins *et al.* (2014) quantitative instantaneous peak SPL behavioural threshold is reached. This indicates that there is a risk of a behavioural response in fish within around 117 m from the TSHD, noting that this will be a moderate behavioural response in fish with a swim bladder or air cavities that aid hearing and a minor behavioural response in fish with a swim bladder that does not aid hearing and fish without a swim bladder. This broadly correlates with the Popper *et al.* (2014) qualitative behavioural guidelines discussed above.

4.56 Overall, based on the above review of the available scientific evidence, there is considered to be a potential risk of temporary hearing damage in all fish that are in the direct vicinity of the TSHD during dredging and disposal activities and less of a risk at greater distances. Behavioural responses are anticipated to be largely limited to within around 100 m from the dredger for all fish. The dredging activity will be intermittent and the TSHD will be continually moving both at the site of dredging and to and from the disposal site over the period of these marine works (about a week). Furthermore, fish will not be physically constrained either at the Jetty 2 berth (where the estuary is more than 2.3 km wide) or at the potential disposal location in the Outer Thames. In other words, they will be able to move away and avoid the source of the noise and return once dredging and disposal activity has ceased.

Assessment conclusion

4.57 In conclusion, the OMSSD project is not expected to lead to a deterioration of fish within the Thames Lower transitional water body, nor prevent this water body from meeting its WFD objectives in the future.

Water Quality

Changes in SSC from dispersal plumes

Capital dredge

4.58 Dredging by TSHD into the sand and gravel substrate will cause disturbance of the seabed sediment from the draghead and from overflow through the dredger hull during the process of 'bulking' the load. This material will advect and disperse with the ambient flows and be further disturbed by the dredger propellers. As a result, the SSC of the surrounding marine environment will be increased above background levels during the period of filling the dredger.

4.59 The suction dredging is likely to be undertaken in a series of 'runs' along the length of the berth followed by the dredger backing up whereby no suction activity takes place. Each load of the dredger will cause a series of 'pulses' of increased SSC in the water column lasting circa 5 to 7 minutes then with a gap of a similar period of time throughout the 3 to 4 hour loading period. During the approximately the first hour of loading all the disturbance will be from the draghead (near the seabed), whilst the remaining period will be a combined effect from the draghead and the overflow.

4.60 Based on the above dredge scenario 9,850 kg of dry sand will be disturbed into the water column over the circa 375 m of dredged pocket for each of the circa 16 individual 'runs' required to fill the dredger, thus creating a series of sediment 'pulses' during the circa 3 to 4 hour dredger loading phase. This material, if it all remains in suspension, would be dispersed in the estuary flows which peak at about 0.9 m/s on the flood and 1.1 m/s on the ebb of spring tides causing the greatest dispersion of sediment. Initial SSC beneath the dredger are likely to be around 200 mg/l above background, reducing to an average of around 100 mg/l over the area of the dredge.

4.61 The material to be dredged ranges predominantly from the finest sand through to gravel, with on average 30% less than 125 μm and 20% less than 63 μm in size. The average particle size is around 350 μm. As a result, a large proportion of the disturbed material (estimated as much as 80%) is likely to return to the bed beneath the dredger and remain in the locality of the pocket to be re-dredged. SSC dispersing beyond the dredge area, on average are unlikely to be in excess of 40 to 50 mg/l and will predominantly be in the lower water column. The very finest sediments disturbed are unlikely to travel more than about 1.75 km up or down estuary. At that distance the SSC are likely to be below 10 mg/l. The plume is only likely to be evident during the 3 to 4 hour period of each dredge load and for an additional period of about 0.5 hours following the completion of each dredge load. Most of the sediment will have settled to the bed and merged with the background concentrations within 500 m of each end of the dredge pocket (east-west aligned) with a maximum plume width of about 100 m (north-south aligned). The flow regime indicates the plume will be predominantly confined to the shallow subtidal area.

4.62 These estimates of the increased SSC from the proposed dredge are generally low when compared with existing background levels of near bed SSC. Measurements within the main navigation channel are highly variable, between 500 and 3,000 mg/l, whilst background near bed SSC measured inshore of Jetty 2 can naturally reach 400 mg/l.

4.63 Comparing these background concentrations with the estimates that are predicted in this assessment, it is possible to conclude that any increase in SSC due to capital dredging by TSHD will be within the natural variability of the system, very localised (with the majority of effects less than 500 m down flow of the dredger) and are unlikely to be evident about 30 minutes following the cessation of dredging each load.

Firewater system

4.64 The marine firewater system option has the potential to result in an increase in SSC in the water column from marine plant during installation of the intake and outfall structures. At the present time, the method for the construction of the intake and outlet pipework is not yet detailed. The worst case change in SSC would result from the use of a jack-up barge with its legs resting on the seabed adjacent to Jetty 1. Should this be the case, the legs will result in the scour of fine sediments in close proximity to the legs (see Chapter 8 of the PEIR).

4.65 Existing tidal flows in the area of the Jetty 1 approach (the site of the intake) and at the rear of the Jetty 1 head (site of the outlet) are low. Given the small scale nature of the works, with plant (jack-up barge) on site no more than a few days, the potential for scour is considered to be small to negligible at the intake location and slightly more (small) at the outlet. The volume of sediment released would be small and would redeposit close by as a result of the low estuary flows. Such effects will not occur if the works are undertaken from the existing structure or floating plant.

4.66 Release of SSC as a result of the construction of the marine firewater system option will therefore be highly localised and unlikely to be measurable against background variability. Magnitude of change is therefore assessed as negligible to small.

4.67 During operation, the likely changes to the seabed resulting from the water being drawn into the intake and released as a jet from the outlet, include the potential to cause erosion within about 10 m of the respective pipes and the resuspension of material. This erosion will occur relatively quickly, over a few weeks and an equilibrium morphology will develop, reducing further erosion rates. The impact will only occur at worst for one hour every week. The overall effect is, therefore, considered to be small initially reducing to a negligible impact within a few weeks. Given the slow ambient flow and the sediment size, any sediment plumes will be short- lived and sediment will be quickly returned to the seabed. Plumes with high suspended load are not expected to disperse beyond the Oikos frontage, particularly once an equilibrium morphology has developed.

Disposal site

4.68 The proposed capital dredge of the OMSSD project is likely to be undertaken by a TSHD with a capacity of up to about 2,500 m of *in situ* material. The complete dredge will therefore be undertaken in 10 to 13 loads. The distance between the dredge area at Jetty 2 and the North Edinburgh Channel disposal site means the frequency of disposal will be restricted to one load per tide. The water depths at the site and in the navigation channels to the site mean disposal can take place at any state of the tide, both on springs and neaps. The material to be disposed of will comprise predominantly sand and gravel which will be non-cohesive in nature. The dredged sediment has a low proportion of fines, much of which will be 'winnowed' out during the dredge process. The sediment will be deposited from the hull of the dredger and will take up to about 10 minutes to dispose.

4.69 The worst case with respect to the dispersal SSC would arise from the disposal occurring on spring tides and at the time of peak flows. On the basis that each load contains 2,500 m^3 of *in situ* material, about 3,158 dry weight tonnes of sand and gravel will be deposited at the site per load, at a rate of the order of 5.62 t/s. On the assumption that the disposal takes place at the shallowest location, at about 10 m below CD at mean tide level, and the dredger has a 6 m laden draught then the initial average concentration passing through the water column beneath the dredger would be of the order of 65,000 mg/l.

4.70 At least 80 to 90% of the material will settle directly to the bed and cause a mound beneath the dredger, which could initially be 3 to 4 m high, but would flatten out with the channel flows. Some of the finest sediment will be immediately dispersed on spring tide flows which would redistribute the finer fractions of the disposal. The sediment remaining in the water column, within the passive plume, is likely to have initial concentrations in excess of 650 mg/l but would be settling to the bed at up to 0.045 m/s. Most of this suspended sediment would result from the physical impact disturbance with the bed and therefore would be in the lower half of the water column. On this basis, the majority of sediment would settle out within about 200 m down flow of the disposal location.

4.71 Given the existing flow speeds, a small proportion of the sediment could reach about 1.5 km from the disposal site, but concentrations are likely to be less than 10 mg/l above the background at these greater distances from the site.

Maintenance dredge

4.72 Elevated suspended sediment concentrations as a result of WID maintenance dredging are expected to occur temporarily. WID involves the injection of high volumes of water at low pressure into recently deposited seabed sediments. This re-fluidises the silts and fine sands, which then flow by gravity or current from the dredge site. The water is injected at low pressures, ensuring the sediment material is re-energised as a density current at the bed, rather than being re-suspended into the full water column. To be effective, the technique requires a flow gradient away from the dredge site, so material is transported to locations from which it is subsequently re-distributed by natural currents. The technique therefore promotes relocation of material based on local dispersion rather than removal to licensed marine or land (terrestrial) disposal sites.

4.73 In order to minimise the environmental effects, existing maintenance dredging in the Thames Estuary is required to be undertaken on an ebb tide to provide maximum dispersion and minimise sedimentation. The small maintenance dredge requirement at Jetty 2 is anticipated to be undertaken as an extension of the existing Jetty 1 maintenance dredge campaign. This existing practice of maintenance dredging on an ebb tide will be adhered to as part of any maintenance dredging by WID at Jetty 2 during operation.

4.74 Previous sediment modelling has found that WID results in peak SSC of up to 200 mg/l above background levels for up to 20 minutes before gradually decaying to normal background levels (PLA, 2020).

4.75 These estimates of the increased SSC from WID are generally low when compared with existing background levels of near bed SSC in the Thames Estuary. Measurements within the main navigation channel are highly variable, between 500 and 3,000 mg/l, whilst background near bed SSC measured inshore of Jetty 2 can naturally reach 400 mg/l.

4.76 The predicted increases in SSC will be temporary and of a similar magnitude to those which occur naturally in Thames Estuary. Thus, in physical terms, the plumes resulting from any maintenance dredging activities are expected to have a minimal and very localised effect on SSC in the vicinity of Jetty 2.

Release of contaminants

Capital dredge

4.77 The proposed development has the potential to remobilise contaminants that may be trapped within the sediments. The likelihood of mobilising sediments and contaminated sediments and the magnitude of any effect is dependent upon the level of contamination and the volume of material being removed; the proximity of the activity to the feature; the type of activity occurring; the manner in which that activity is pursued (including the extent and duration); the particle size of the disturbed sediments (contaminants tend to be associated with finer particles) and the hydrodynamic conditions. The Thames Lower transitional water body is currently (2019) failing its chemical status due to the priority substance Cypermethrin and the priority hazardous substances PBDEs, Benzo[g,h,i]perylene, Mercury and its compounds and TBT compounds.

4.78 An overview of existing chemical analysis from eight sediment samples collected from the proposed dredge area in December 2020 is included in Section 2, with full results presented in Table 2.5. However, it is noted that the results of the analysis of PBDEs were not available at the time of writing, but will be included in the final WFD assessment at the ES stage.

4.79 As sediment is disturbed and re-distributed into the water column, any sediment-bound contaminants may be partitioned from the solid phase (i.e. bound to sediments or suspended matter), to the dissolved or aqueous phase (i.e. dissolved in pore water or overlying water) (Luoma, 1983). To determine the maximum dissolved fraction of contaminants released into the water column, it is necessary to consider the relative potential for each contaminant to change from one phase to another (i.e. contaminant adsorbed to sediment surfaces to dissolved in the water), referred to as the partition coefficient. Partition coefficients describe the ratio between the freely dissolved concentration in water and another environmental phase (e.g. sediment-bound) at equilibrium. It should be noted that desorption rates of contaminants from suspended sediments into the water column are highly regulated by hydrodynamics, biogeochemical processes, and environmental conditions (redox, pH, salinity and temperature) (Eggleton and Thomas, 2004). Due to the variability in environmental conditions, a wide range of partition coefficients are reported in the literature.

4.80 There is potential for sediment-bound contaminants to be re-mobilised in the water column following an increase in SSC during the proposed capital dredging using TSHD. Sediment disturbance will be caused at the bed by abrasion pressure from the draghead. As noted above, initial SSC beneath the dredger are likely to be around 200 mg/l above background, reducing to an average of around 100 mg/l over the area of the dredge. This estimated maximum incremental SSC (200 mg/l) is used in the calculations below.

4.81 It is possible to estimate in-water contaminant concentrations as a result of the dredging based on a number of simple assumptions. Using the maximum concentration of contaminants in sediment samples and an approximate sediment release rate from the dredging activity (described above), the dissolved fraction of contaminants released into the water column can be estimated. To do this, it is necessary to use contaminant partition coefficients. This assessment is presented in Table 4.1 for contaminants that exceed AL1 during sediment sampling in December 2020 and those that are currently (2019) classified as failing chemical status for the Thames Lower transitional water body; however, the assessment is limited to those contaminants where EQSs have been defined and partition coefficients are available. This includes mercury, TBT, benzo[g,h,i]perylene and several other PAHs.

4.82 Due to the variability in environmental conditions, the partition coefficient values used here are indicative only and subject to uncertainty. However, for each contaminant, the lower end of any range has been used to provide a conservative approach. The sediment-water partition coefficient for most contaminants has been sourced from the relevant EQS dossier, prepared by the Sub-Group on Review of the Priority Substances List (2011) under Working Group E of the Common Implementation Strategy for the WFD (Sub-Group on Review of the Priority Substances, 2011a; 2011b), Department of Environmental Science and Analytical Chemistry (ACES, 2018) and the US Environment Protection Agency (USEPA; Allison and Allison, 2005).

4.83 Due to the temporary nature of the capital dredging works, short-term EQS values, referred to as Maximum Allowable Concentration (MAC), can generally be considered. However, in cases where it is available, the Annual Average (AA) EQS is also presented to take account of a worst-case scenario where elevated concentrations persist long enough to affect long-term EQS values. As shown in Table 4.1, the maximum additional dissolved phase concentration for each contaminant is several orders of magnitude below the relevant EQS, suggesting minimal potential for capital dredging works to impact water quality.

4.84 While the potential change in concentration of contaminants due to dredging activities at Oikos suggests very small increases may occur in isolation, it is necessary to consider the resultant concentration in comparison with, and in addition to, background levels (see Table 4.2). As shown in Table 4.1, compared with maximum background concentrations reported at four Environment Agency monitoring sites since 2018 (see Figure 5 for locations), the increase in dissolved contaminant concentrations caused by dredging activity represents a very small percentage; consistently less than 0.1 % (and one to two orders of magnitude below 0.1 % for the majority of contaminants assessed). It is noted, however, that any increase to the concentration of mercury, TBT and various PAHs which are dissolved in the water column following disturbance of sediment-bound contaminants would lead to a further deterioration of these parameters which are already failing at the water body level. Nevertheless, it is considered unlikely that the proposed capital dredging activity at Oikos would cause even a short-term deterioration in status or present a material impact to parameters already failing respective EQS values.

Table 4.1: Potential contaminant concentrations as a result of capital and maintenance dredging in the Thames Lower transitional water body

Parameter	Max. Sediment Concentration (mg/kg)	Max. Suspended Concentration (mg/l)	Partition Coefficient (l/kg)	Max. Dissolved Concentration (Dredging) (µg/l)	EQS (µg/l)	Max. Dissolved Concentration (Background) (µg/l)	Max. Dissolved Concentration (Background and Dredging) (µg/l)	Max. Concentration Increase Due to Dredging (%)
Mercury	0.26	0.000052	6,310	0.00000824	0.07 (MAC)	0.017	0.017008	0.0485
TBT	0.005	0.000001	1,000	0.00000100	0.0002 (AA); 0.0015 (MAC)	0.0022	0.002201	0.0455
Benzo(a)pyrene	0.264	0.0000528	20,795	0.00000254	0.00017 (AA); 0.027 (MAC)	0.05	0.050003	0.0051
Benzo(b)fluoranthene	0.208	0.0000416	20,795	0.00000200	0.00017 (AA); 0.017 (MAC)	0.05	0.050002	0.0040
Benzo(g,h,i)perylene	0.15	0.00003	25,583	0.00000117	0.00017 (AA); 0.00082 (MAC)	0.05	0.050001	0.0023
Benzo(k)fluoranthene	0.138	0.0000276	19,859	0.00000139	0.00017 (AA); 0.017 (MAC)	0.05	0.050001	0.0028
Fluoranthene	0.366	0.0000732	2,444	0.00002995	0.0063 (AA); 0.12 (MAC)	0.05	0.050030	0.0599
Indeno(123-c,d)pyrene	0.168	0.0000336	58,607	0.00000057	0.00017 (AA)	0.05	0.050001	0.0011

Table 4.2: Water quality data collected between 2018 and 2020 from Environment Agency monitoring sites in the vicinity of Oikos

Parameter	Units	Environment Agency Monitoring Site			
		Thames At Ovens Buoy	Thames At Mucking	Thames At Chapman Buoy	Thames At No.2 Sea Reach
Mercury	µg/l	<0.01 – 0.017 (*n* = 12)	<0.01 (*n* = 12)	- (*n* = 0)	<0.01 – 0.0161 (*n* = 12)
TBT	µg/l	0.00031 – 0.0022 (*n* = 12)	0.0002 – 0.00073 (*n* = 12)	< 0.0002 – 0.00062 (*n* = 25)	<0.0002 (*n* = 10)
Benzo(a)pyrene	µg/l	0.00317 – >0.05 (*n* = 11)	0.0029 – 0.0383 (*n* = 10)	0.00035 – 0.0176 (*n* = 24)	0.00012 – 0.0018 (*n* = 9)
Benzo(b)fluoranthene	µg/l	0.00312 – >0.05 (*n* = 11)	0.00273 – 0.0378 (*n* = 10)	0.00035 – 0.0197 (*n* = 24)	0.00014 – 0.00173 (*n* = 8)
Benzo(g,h,i)perylene	µg/l	0.00345 – >0.05 (*n* = 11)	0.00349 – 0.0405 (*n* = 11)	0.00048 – 0.02 (*n* = 25)	0.00016 – 0.0023 (*n* = 10)
Benzo(k)fluoranthene	µg/l	0.00169 – >0.05 (*n* = 11)	0.0014 – 0.0197 (*n* = 10)	0.00018 – 0.0102 (*n* = 24)	0.00006 – 0.00087 (*n* = 8)
Fluoranthene	µg/l	0.00528 – >0.05 (*n* = 10)	0.0041 – 0.0258 (*n* = 11)	0.0013 – 0.0128 (*n* = 25)	0.00107 – 0.00246 (*n* = 9)
Indeno(123-c,d)pyrene	µg/l	0.00341 – >0.05 (*n* = 11)	0.00307 – 0.0441 (*n* = 11)	0.00044 – 0.0205 (*n* = 25)	0.00013 – 0.00232 (*n* = 10)
Source: Environment Agency Water Quality Archive (https://environment.data.gov.uk/water-quality/view/landing)					

Disposal

4.85 The closest licensed marine disposal site to the Oikos facility is the North Edinburgh Channel site (TH080) and, for the purposes of this PEIR, it is this site which has been assumed to be the marine disposal location (if required). The Essex coastal water body, within which this licensed disposal site is located, and the adjacent Kent North coastal water body are currently (2019) failing its chemical status due to the priority hazardous substances PBDEs and Mercury and its compounds.

4.86 There is potential for sediment-bound contaminants to be dispersed in the water column during the disposal of capital dredge material at a licensed marine disposal site. As noted above, the sediment remaining in the water column following release from the hopper, and thus within the passive plume, is likely to have initial concentrations in excess of 650 mg/l. This estimated incremental SSC (650 mg/l) is used in the calculations below, noting at the immediate point of release the SSC uplift could be significantly greater (albeit this would rapidly reduce as the material is dispersed).

4.87 Using the same method as applied to the proposed capital dredge, it is possible to estimate in-water contaminant concentrations as a result of the disposal activity based on a number of simple assumptions. Using the maximum concentration of contaminants in sediment samples and an approximate sediment release rate from the disposal activity (i.e. SSC uplift of 650 mg/l), the dissolved fraction of contaminants released into the water column can be estimated. To do this, it is necessary to use contaminant partition coefficients. This assessment is presented in Table 4.3 for contaminants that exceed AL1 during sediment sampling in December 2020 and those that are currently (2019) classified as failing chemical status for the Essex coastal water body and Kent North coastal water body; however, the assessment is limited to those contaminants where EQSs have been defined and partition coefficients are available. This includes mercury and several PAHs. As shown in Table 4.3, the maximum additional dissolved phase concentration for each contaminant is several orders of magnitude below the relevant EQS, suggesting minimal potential for disposal of dredge arisings to impact water quality.

4.88 While the potential change in concentration of contaminants due to dredging activities at Oikos suggests very small increases may occur in isolation, it is necessary to consider the resultant concentration in comparison with, and in addition to, background levels. In the absence of contemporary data in the vicinity of the North Edinburgh Channel disposal site (TH080), the same monitoring data collated for the Thames Lower transitional water body has been used (see Table 4.2). The increase in dissolved contaminant concentrations caused by disposal activity would represent a very small percentage compared to background levels; consistently less than 0.2%. It is considered unlikely that the marine disposal activity (if required) would cause even a short-term deterioration in status or would present a material impact to parameters already failing respective EQS values for the Essex coastal water body and Kent North coastal water body.

Table 4.3: Potential contaminant concentrations as a result of disposal activity in the Essex coastal water body and Kent North coastal water body

Parameter	Max. Sediment Concentration (mg/kg)	Max. Suspended Concentration (mg/l)	Partition Coefficient (l/kg)	Max. Dissolved Concentration (Disposal) (µg/l)	EQS (µg/l)	Max. Dissolved Concentration (Background) (µg/l)	Max. Dissolved Concentration (Background and Disposal) (µg/l)	Max. Concentration Increase Due to Disposal (%)
Mercury	0.26	0.000169	6,310	0.00002678	0.07 (MAC)	0.017	0.017027	0.1575
Benzo(a)pyrene	0.264	0.00000325	20,795	0.00000325	0.00017 (AA); 0.027 (MAC)	0.0022	0.002203	0.1477
Benzo(b)fluoranthene	0.208	0.0001716	20,795	0.00000825	0.00017 (AA); 0.017 (MAC)	0.05	0.050008	0.0165
Benzo(g,h,i)perylene	0.15	0.0001352	25,583	0.00000650	0.00017 (AA); 0.00082 (MAC)	0.05	0.050007	0.0130
Benzo(k)fluoranthene	0.138	0.0000975	19,859	0.00000381	0.00017 (AA); 0.017 (MAC)	0.05	0.050004	0.0076
Fluoranthene	0.366	0.0000897	2,444	0.00000452	0.0063 (AA); 0.12 (MAC)	0.05	0.050005	0.0090
Indeno(123-c,d)pyrene	0.168	0.0002379	58,607	0.00009734	0.00017 (AA)	0.05	0.050097	0.1947

Maintenance dredge

4.89 Any maintenance dredging by WID has the potential to remobilise contaminants that may be trapped within the sediments. The likelihood of mobilising sediments and contaminated sediments and the magnitude of any effect is dependent upon the level of contamination and the volume of material being removed; the proximity of the activity to the feature; the type of activity occurring; the manner in which that activity is pursued (including the extent and duration); the particle size of the disturbed sediments (contaminants tend to be associated with finer particles) and the hydrodynamic conditions.

4.90 As noted above, previous sediment modelling has found that WID results in peak SSC of up to 200 mg/l above background levels for up to 20 minutes before gradually decaying to normal background levels (PLA, 2020). Therefore, the same basic assumptions and calculations used to assess the proposed capital dredge (see Table 4.1) also apply to potential maintenance dredging. Overall, it is considered unlikely that the proposed maintenance dredging activity at Oikos would cause even a short-term deterioration in status with regards to mercury or presents a material impact to parameters already failing respective EQS values within the Thames Lower water body.

Organic enrichment and oxygen depletion

4.91 The resuspension of sediments containing organic material can cause oxygen depletion within the water column. The subsequent settling of this organic rich sediment can deplete the sediments of oxygen and affect shellfish and benthic prey items used by fish. The response of fish to low concentrations of dissolved oxygen is determined by a range of factors, including the duration of exposure, water temperature and the presence of other pollutants. The duration of any low dissolved oxygen event is a key factor in determining its effect. Most fish would survive an extremely low concentration of dissolved oxygen, such as 2 mg/l, for a few minutes, but a longer exposure would start to have sub-lethal and eventually lethal effects (ABP Research, 2000).

4.92 Increases in SSC during dredging and disposal activities associated with the OMSSD project will be brief and localised and there is not expected to be a significant reduction in dissolved oxygen.

Assessment conclusion

4.93 In conclusion, the proposed dredge (capital and maintenance) activity and disposal of dredge material at the North Edinburgh Channel disposal site are not expected to lead to a deterioration in water quality within the Thames Lower transitional water body, the Essex coastal water body or the Kent north coastal water body, nor prevent these water bodies from meeting their WFD objectives.

Protected Areas

Changes in SSC from dispersal plumes

Capital dredge

4.94 The proposed dredge at Jetty 2 is located approximately 1.2 km from the Thames Estuary and Marshes SPA and Ramsar site. The potential impact on these WFD protected areas has been assessed based on the outcomes of the analysis of the capital dredge effects set out above.

4.95 The maximum extent of the sediment plume during dredging is approximately 1.75 km up and down estuary. At that distance the SSC are likely to be below 10 mg/l. The plume is only likely to be evident during the 3 to 4 hour period of each dredge load and for an additional period of about 0.5 hours following the completion of each dredge load.

4.96 This assessment has been undertaken on the basis that the dredge could be undertaken on either the flood or ebb tide, whilst also taking account of maximum flow rates, and thus provides an assessment of the worst-case potential for sediment dispersion.

4.97 Given the intermittent and temporary nature of the work (lasting about a week), and the negligible magnitude of the changes in SSC at the Thames Estuary and Marshes SPA and Ramsar site, the overall exposure to change is considered negligible. There potential impact of the capital dredge works on these WFD protected areas is therefore unlikely to be significant.

Disposal

4.98 The Edinburgh North Channel disposal site (TH080) is located within the Outer Thames Estuary SPA, the Margate and Long Sands SAC and the Outer Thames Shellfish Water Protected Area. The potential impact on these WFD protected areas has been assessed based on the outcomes of the analysis of the disposal effects set out above.

4.99 The maximum worst-case extent of the potential dispersion from the disposal site is estimated to be about 1.5 km down flow of each disposal load and would be predominantly confined to the orientation of the channel.

4.100 Up to *circa* 90% of the material is likely to initially remain within 200 m of each disposal load location, before being further redistributed over time by the natural variability of physical processes occurring at that location. Changes in SSC would not be discernible from background SSC within around 15 to 30 minutes of each dredger load that is disposed.

4.101 Peak SSC away from immediately under the dredger could exceed 650 mg/l for a short period (few minutes) but would rapidly settle out. The North Edinburgh Channel disposal site was initially characterised to accommodate greater than an order of magnitude of more material than the 25,000 m^3currently proposed to be disposed and was reassessed in 2016. Dredge disposal returns indicate the site has previously accommodated up to 1.18 million wet tonnes of similar material in a month. Bathymetric calculations in a period without dredging also indicate the natural variability of volumetric change at the site is in the order of over 6 million m³ in a year.

4.102 The overall magnitude of the change in terms of SSC at the disposal site is assessed as small only lasting for a period of up to 30 minutes on the 10 to 13 consecutive tides required for the disposal.

Firewater system

4.103 The potential marine firewater system option at Jetty 1 is located approximately 1.2 km from the Thames Estuary and Marshes SPA and Ramsar site. The potential impact on these WFD protected areas has been assessed based on the outcomes of the analysis of the firewater system effects set out above.

4.104 Existing tidal flows in the area of the Jetty 1 approach (the site of the intake) and at the rear of the Jetty 1 head (site of the outlet) are low. Given the small scale nature of the works, with plant (jack-up barge) on site no more than a few days, the potential for scour is considered to be small to negligible at the intake location and slightly more (small) at the outlet. The volume of sediment released would be small and would redeposit close by as a result of the low estuary flows. Such effects will not occur if the works are undertaken from the existing structure or floating plant.

4.105 Release of SSC as a result of the construction of the marine firewater system option will therefore be highly localised and unlikely to be measurable against background variability.

4.106 During operation, the likely changes to the seabed resulting from the water being drawn into the intake and released as a jet from the outlet, include the potential to cause erosion within about 10 m of the respective pipes and the resuspension of material. This erosion will occur relatively quickly, over a few weeks and an equilibrium morphology will develop, reducing further erosion rates. The impact will only occur at worst for one hour every week. The overall effect is, therefore, considered to be small initially reducing to a negligible impact within a few weeks. Given the slow ambient flow and the sediment size, any sediment plumes will be short- lived and sediment will be quickly returned to the seabed. Plumes with high suspended load are not expected to disperse beyond the Oikos frontage, particularly once an equilibrium morphology has developed.

4.107 Given the negligible magnitude of the changes in SSC at the Thames Estuary and Marshes SPA and Ramsar site, the overall exposure to change is considered negligible. The potential impact of the firewater system on these WFD protected areas is therefore unlikely to be significant.

Maintenance dredging

4.108 The proposed dredge at Jetty 2 is located approximately 1.2 km from the Thames Estuary and Marshes SPA and Ramsar site. The potential impact on these WFD protected areas has been assessed based on the outcomes of the analysis of the maintenance dredge effects set out above.

4.109 In order to minimise the environmental effects, existing maintenance dredging in the Thames Estuary is required to be undertaken on an ebb tide to provide maximum dispersion and minimise sedimentation. The small maintenance dredge requirement at Jetty 2 is anticipated to be undertaken as an extension of the existing Jetty 1 maintenance dredge campaign. This existing practice of maintenance dredging on an ebb tide will be adhered to as part of any maintenance dredging by WID at Jetty 2 during operation.

4.110 Previous sediment modelling has found that WID results in peak SSC of up to 200 mg/l above background levels for up to 20 minutes before gradually decaying to normal background levels (PLA, 2020).

4.111 These estimates of the increased SSC from WID are generally low when compared with existing background levels of near bed SSC in the Thames Estuary. Measurements within the main navigation channel are highly variable, between 500 and 3,000 mg/l, whilst background near bed SSC measured inshore of Jetty 2 can naturally reach 400 mg/l.

4.112 The predicted increases in SSC will be temporary and of a similar magnitude to those which occur naturally in Thames Estuary. Thus, in physical terms, the plumes resulting from any maintenance dredging activities are expected to have a minimal and very localised effect on SSC in the vicinity of Jetty 2.

4.113 Given the intermittent and temporary nature of the maintenance dredging in the context of the existing maintenance dredge campaign at Jetty 1, and the negligible magnitude of the changes in SSC at the Thames Estuary and Marshes SPA and Ramsar site, the overall exposure to change is considered negligible. There potential impact of the capital dredge works on these WFD protected areas is therefore unlikely to be significant.

Changes in seabed bathymetry – potential disposal location

4.114 The disposal site is situated in a deep highly mobile channel within the WFD protected areas. Seabed sediments comprise mobile sands with low levels of fine sediment with sparse faunal communities representative of dynamic sand habitat.

4.115 As noted above, the disposal of material is expected to cause some temporary local sedimentation within the North Edinburgh Channel marine disposal site. However, the impoverished assemblage in this area is already considered to be highly disturbed as a result of the dynamic nature of this area. Fine sediment is likely to be rapidly dispersed and spread out by ambient tidal currents within a very short period of time.

4.116 Deposition in the wider area surrounding the disposal ground is expected to be in the order of millimetres. Sedimentation of this scale is unlikely to result in significant smothering effects to most faunal species with recoverability expected to be high.

4.117 All effects are unlikely to be discernible from background variability within *circa* 3 months after the end of the disposal activity providing good practice is carried out by spreading the individual loads throughout the deposit area. As a result, any changes above the natural variability will be of a temporary nature.

Assessment conclusion

4.118 In conclusion, the proposed dredge and disposal of dredge material are not expected to lead to a deterioration of the assessed WFD protected areas, nor prevent the water bodies from meeting their WFD objectives.

Invasive Non-Native Species (INNS)

The potential introduction and spread of non-native species

4.119 Non-native species have the potential to be transported into the study area on ships' hulls during dredging. Non-native invasive species also have the potential to be transported via ship ballast water. Seawater may be drawn into tanks when the ship is not carrying cargo, for stability, and expelled when it is no longer required. This provides a vector whereby organisms may be transported long distances.

4.120 In view of existing legislation, the probability of the introduction and spread of non-native species from the construction and operational phase of the OMSSD project is considered to be low. However, the magnitude of this potential impact should it occur is unknown.

4.121 In order to manage potential non-native species risks as a result of the proposed development, a Biosecurity Plan will be produced. Within England and Wales, best practice guidance has been developed on how to manage marine biosecurity risks at sites and when undertaking activities through the preparation and implementation of biosecurity plans (Cook *et al.*, 2014). This guidance will be followed when developing the Biosecurity Plan.

5 Conclusion

5.1 Based upon the current known details of the OMSSD project and existing available information, this initial WFD compliance assessment concludes that the proposed dredge, potential marine firewater system and potential disposal of dredge material at the North Edinburgh Channel disposal site (TH080) are not likely to have a permanent (i.e. non-temporary) effect on the status of WFD parameters that are significant at water body level. Therefore, deterioration to the current status of the Thames Lower transitional water body, the Essex coastal water body or the Kent North coastal water body is not predicted, nor is a prevention of these water bodies achieving future WFD status objectives.

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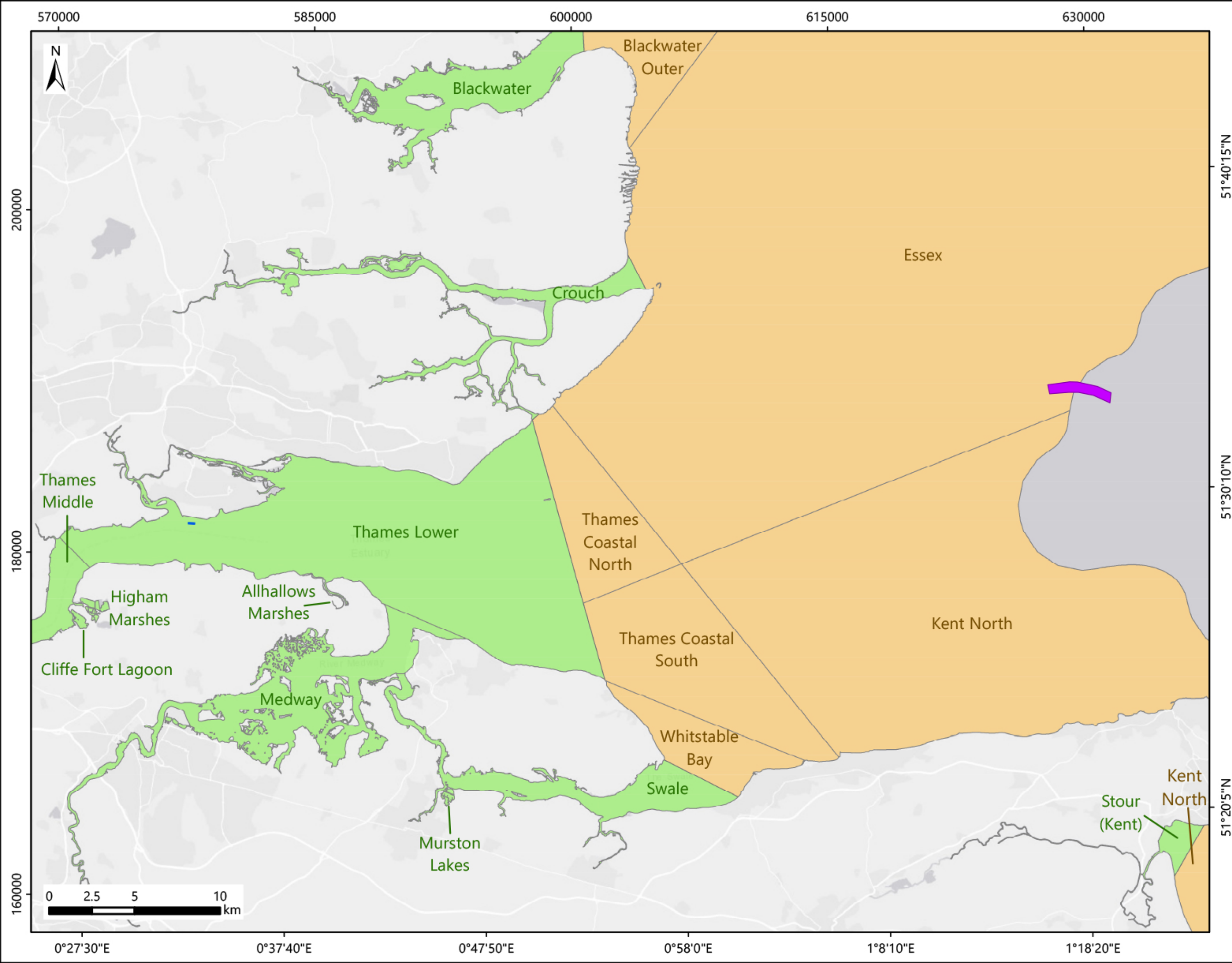
Figures

Figure 1



- Area to be dredged (including side slopes)
- North Edinburgh Channel Disposal Site
- WFD Transitional Water body
- WFD Coastal Water body

Date	By	QA
Nov20	CRB	DLW

Coordinate System
British National Grid

Projection
Transverse Mercator

Project no. 4916
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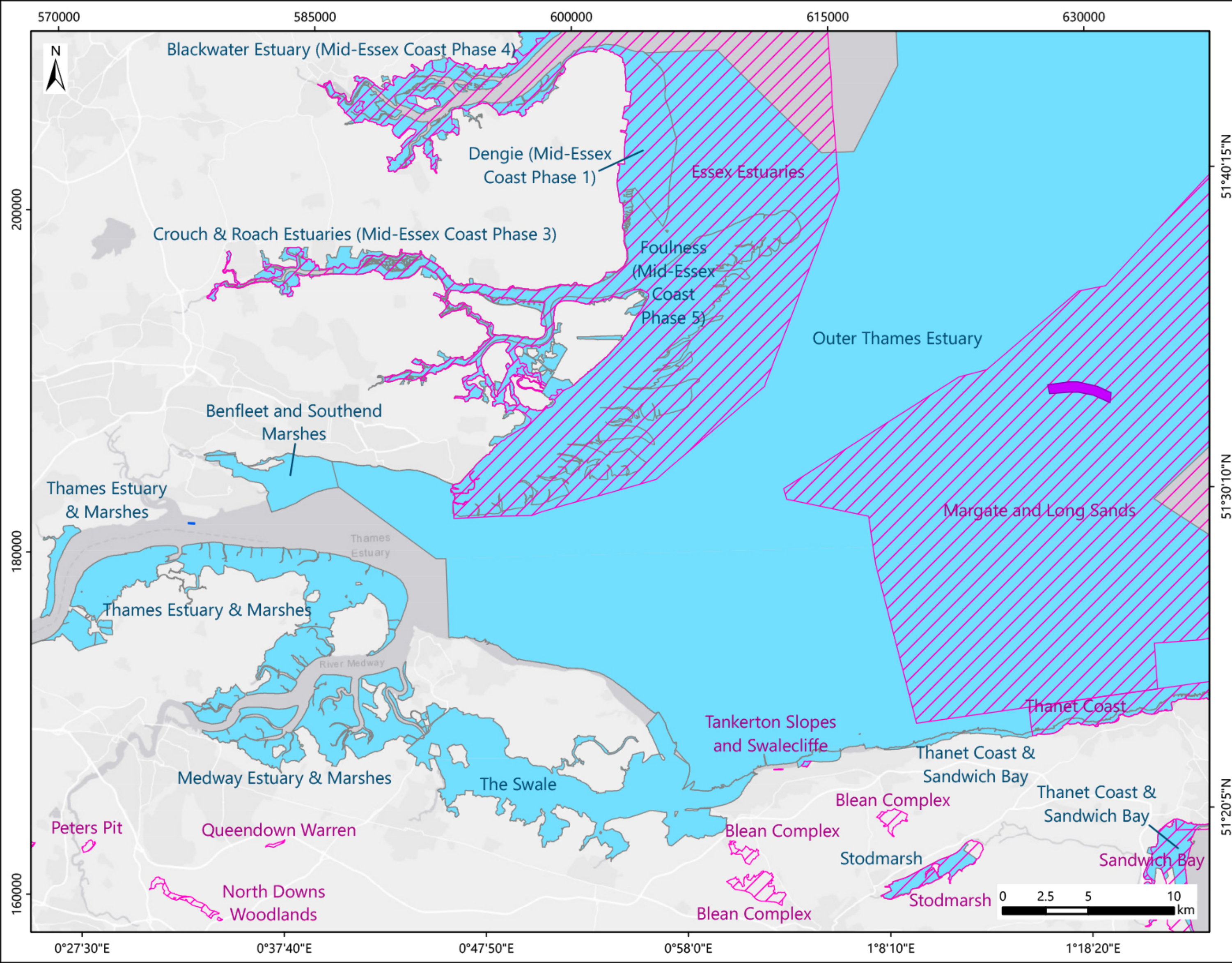

Figure 2

Area to be dredged (including side slopes)
North Edinburgh Channel Disposal Site
Special Protection Area
Special Area of Conservation

Date	By	QA
Nov20	CRB	DLW

Coordinate System
British National Grid

Projection
Transverse Mercator

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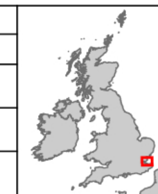

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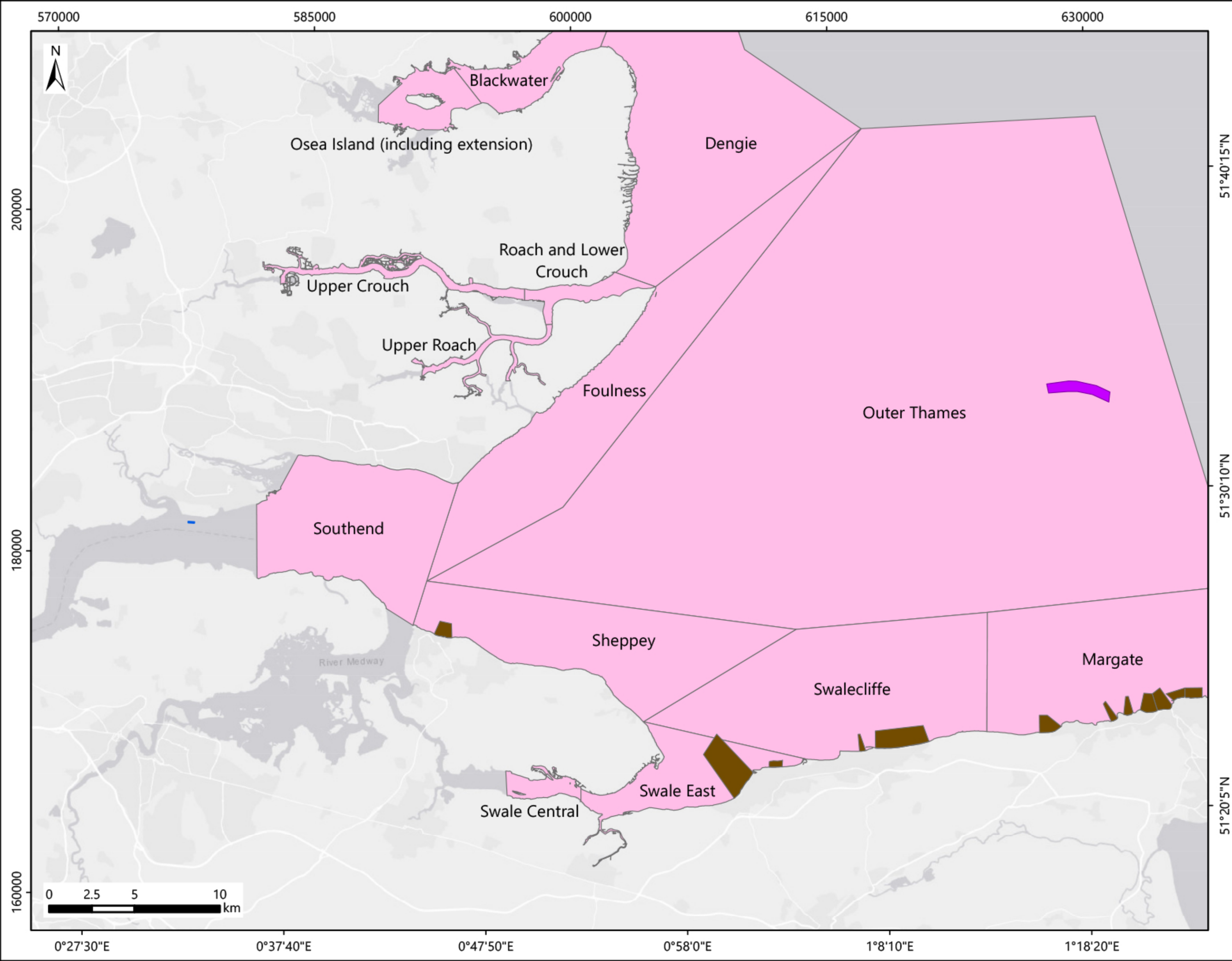
Figure 3



Area to be dredged (including side slopes)

North Edinburgh Channel Disposal Site

WFD Shellfish Water Protected Areas

EA Bathing Waters

Date	By	QA
Nov20	CRB	DLW

Coordinate System
British National Grid

Projection
Transverse Mercator

Project no. 4916
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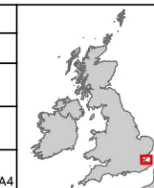

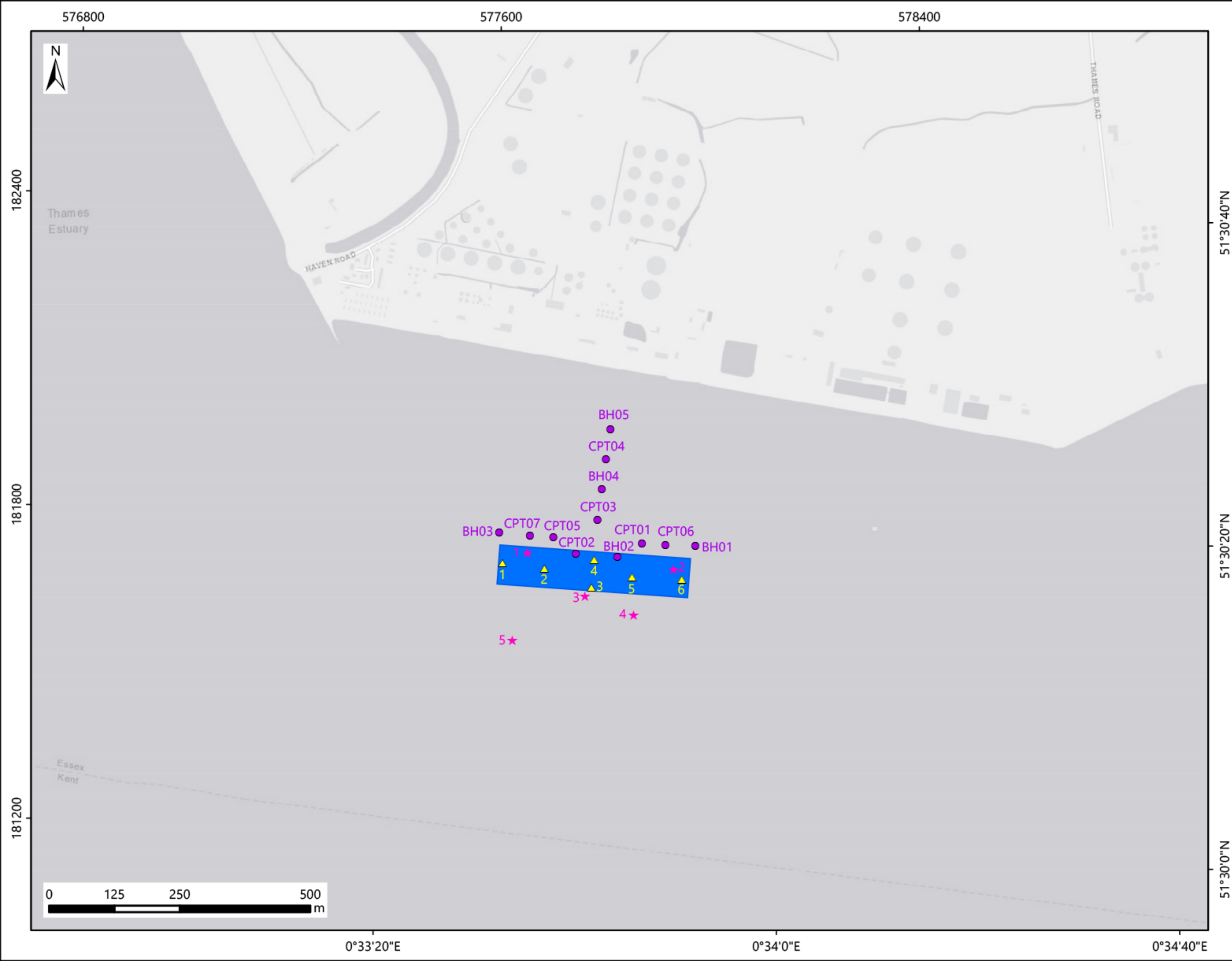

Figure 4

Area to be dredged (including side slopes)

Sediment sample site locations

2020

Historic sediment sample site locations

2019

2015

Basemap: Esri et al.

Date	By	QA
Nov20	CRB	DLW

Coordinate System
British National Grid

Projection
Transverse Mercator

Project no. 4916
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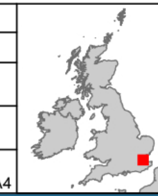

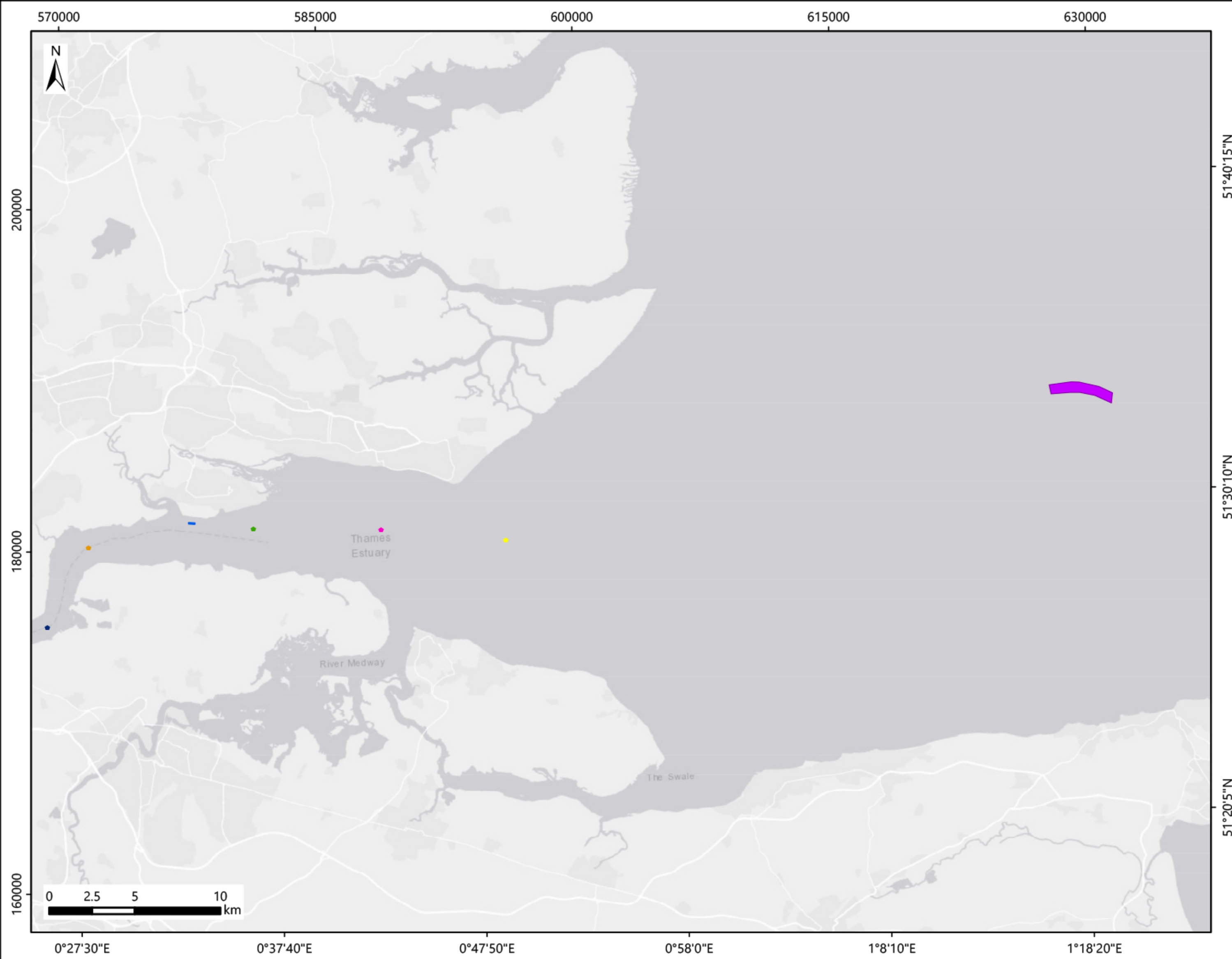

Figure 5

Area to be dredged (including side slopes)

North Edinburgh Channel Disposal Site

EA Water Quality Monitoring Points

- Thames at Chapman Buoy
- Thames at Mucking
- Thames at No.2 Sea Reach
- Thames at Ovens Buoy
- Thames at Southend

EA, 2020, Cefas, 2020. Contains public sector information licensed under the Open Government Licence v3.0. Basemap: Esri et al.

Date	By	QA
Nov20	CRB	DLW

Coordinate System
British National Grid

Projection
Transverse Mercator

Project no. 4916
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