Galloper Wind Farm Project

Environmental Statement – Chapter 10: Marine Water and Sediment Quality

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10 MARINE WATER AND SEDIMENT QUALITY

10.1 Introduction

10.1.1 This Chapter of the Environmental Statement (ES) identifies the marine water and sediment quality characteristics of the study area and assesses the magnitude and significance of any impacts arising from the proposed Galloper Wind Farm (GWF) development. Mitigation measures are also detailed where potentially significant impacts have been identified. Considerations of onshore water quality are detailed in **Chapter 22 Geology, Hydrogeology, Land Quality and Flood Risk**.

10.1.2 Other Chapters within this ES that are of relevance to the assessment of, and impacts upon, marine water and sediment quality include **Chapter 9 Physical Environment, Chapter 12 Marine and Intertidal Ecology, Chapter 13 Fish and Shellfish Resource, Chapter 15 Commercial Fisheries** and **Chapter 18 Other Human Activities**.

10.2 Guidance and Consultation

Legislation, policy and guidance

10.2.1 National Policy Statements (NPS) provide the primary basis on which the Infrastructure Planning Commission (IPC) is required to make its decisions. In preparing this Chapter the following NPS's are of relevance to marine water and sediment quality:

- Overarching NPS for Energy (EN-1); and
- NPS for Renewable Energy Infrastructure (EN-3)

10.2.2 The specific assessment requirements for marine water and sediment quality, as detailed within the NPSs, are repeated in the following paragraphs. Where any part of the NPS has not been followed within this assessment, it is stated within in the ES why the requirement was not deemed relevant or has been met in another manner.

10.2.3 The Overarching NPS for Energy (EN-1) (July 2011) (Department of Energy and Climate Change (DECC), 2011a) highlights the potential for adverse effects on the water environment as a result of infrastructure development. Section 4.30 of EN-1 states that these effects "*could lead to adverse impacts on health or on protected species and habitats and could, in particular, result in surface waters, groundwaters or protected areas failing to meet environmental objectives established under the Water Framework Directive (WFD)*".

10.2.4 In addition EN-1 states that "*where the project is likely to have adverse effects on the water environment, the applicant should undertake an assessment of the existing status of, and impacts of the proposed project on* *water quality, water resources and physical characteristics of the water environment as part of the Environmental Statement (ES) or equivalent*".

10.2.5 Paragraph 2.6.189 of the NPS for Renewable Energy Infrastructure (EN-3) (July 2011) (see **Chapter 2 Project Need, Policy Framework and Guidance**) notes that the construction, operation and decommissioning of offshore energy infrastructure can affect marine water quality through the disturbance of seabed sediments or the release of contaminants, with subsequent indirect effects on habitats, biodiversity and fish stocks (DECC, 2011b). The relevance of this for the proposed GWF project is addressed in **Sections 10.6** to **10.8** of this Chapter.

10.2.6 Of further relevance to water and sediment quality are paragraphs 2.6.191 and 2.6.192 of EN-3 where it is stated that:

"*The Environment Agency (EA) regulates emissions to land, air and water out to 3nm. Where any element of the wind farm or any associated development included in the application to the Infrastructure Planning Commission (IPC) is located within 3nm of the coast, the EA should be consulted at the pre-application stage on the assessment methodology for impacts on the physical environment*."

and that,

"*Beyond 3nm, the Marine Management Organisation (MMO) is the regulator. The applicant should consult the MMO and Centre for Environment, Fisheries & Aquaculture Science (Cefas) on the assessment methodology for impacts on the physical environment at the pre-application stage*" (DECC, 2011b).

10.2.7 Details on consultation undertaken, including responses from the MMO, Cefas and EA, are provided in **Table 10.1**.

10.2.8 Water quality is inextricably linked to other parameters assessed within the GWF EIA, as shown throughout EN-3 by the references to impacts associated with increases in suspended sediments:

- Paragraph 2.6.189 (within the section referring to physical environment) states that the release of sediment during construction and decommissioning can "*cause indirect effects on marine ecology and biodiversity*" (assessed in **Chapter 9** and **12**).
- Paragraph 2.6.81 (within the section referring to impacts on the intertidal environment) states that an assessment of the effects of installing cable across the intertidal zone should include "*information, where relevant, about increased suspended sediment loads in the intertidal zone during installation*" (assessed in **Chapter 12**)
- Paragraph 2.6.113 (within the section referring to impacts on the subtidal environment) states that "*where necessary, assessment of the effects on the subtidal environment should include increased*

suspended sediment loads during construction" (assessed in **Chapter 12**)

- Paragraph 2.6.73 (within the section referring to impacts upon fish) states that there is the "*potential for the construction and decommissioning phases, including activities occurring both above and below the seabed, to interact with seabed sediments and therefore have the potential to impact fish communities, migration routes, spawning activities and nursery areas of particular species* " (assessed in **Chapter 13**).

10.2.9 Paragraph 1.61 of EN-3 identifies that all of the energy NPSs have been subject to an Appraisal of Sustainability (AoS) in order to incorporate the requirements of the regulations that implement the Strategic Environmental Assessment Directive. The EN-3 AoS noted that offshore wind has the potential to have negative effects on water quality (DECC, 2011b).

The Water Framework Directive

10.2.10 The WFD (200/60/EC) is designed to produce an integrated approach to the protection, improvement and sustainable use of Europe's water bodies, which requires surface freshwater and groundwater bodies, such as lakes, streams, rivers, estuaries, and coastal waters to be ecologically sound by 2015. In England, water quality under the WFD is monitored out to 1 nautical mile (nm) in coastal waters.

10.2.11 Under the WFD, the EA is responsible for monitoring water quality and reports the data against Environmental Quality Standards (EQS), which are designed to protect the environment and human health, targeting areas that need improvement. EQS have been developed for the WFD under the requirements of the Dangerous Substances Directive (76/464/EEC), which classifies substances as List I and List II (depending upon toxicity within aqueous environments).

10.2.12 Standards for List I substances have been defined in 'daughter' Directives to the Dangerous Substances Directive. These will be incorporated into the revised WFD, which will also incorporate the Bathing Waters Directive (76/160/EEC) (as amended by Directive 2006/7/EC) (to be revised by the WFD in 2015) and the Shellfish Waters Directive (2006/113/EEC) (to be revised by the WFD in 2013).

10.2.13 The WFD EQS have also been guided by legislation set out within the Convention for the Protection of the Marine Environment in the North-East Atlantic of 1992 (further to earlier versions of 1972 and 1974), known as the Oslo and Paris Convention (OSPAR).

Other relevant Directives

10.2.14 Also of relevance to this Chapter is the monitoring of bathing waters, which is undertaken by the EA. Bathing water quality is assessed by the standards listed in the Bathing Waters Directive, which is implemented through the Bathing Waters Regulations 2008. The Bathing Waters Directive sets a number of microbiological and physicochemical standards that bathing waters must either comply with (‘mandatory’ standards) or endeavour to meet (stricter ‘guideline’ standards). The two main standards used to assess the quality of bathing water are total coliforms and faecal coliforms, both of which are indicators of faecal pollution. Bathing water standards are further detailed in **Section 10.4** of this Chapter.

10.2.15 Maintaining water quality standards is also vital for shellfish production and consumption. The Shellfish Waters Directive (2006/113/EEC) is implemented in the UK by the Surface Waters (Shellfish) (Classification) Regulations 1997 (as amended) and the Surface Waters (Shellfish) Directions 2010.

10.2.16 The Shellfish Waters Directive sets environmental standards for the quality of the waters where shellfish live in order to promote healthy shellfish growth. The quality of commercially harvested shellfish intended for human consumption must comply with the EU Food Hygiene Regulations (852 / 853 / 854). These regulations lay down specific hygiene rules for food of animal origin, including shellfish. The Food Standards Agency is responsible for implementing the regulations, which are enacted by The Food Hygiene (England) Regulations 2006.

10.2.17 The aim of the Shellfish Waters Directive is to protect or improve shellfish waters in order to support shellfish life and growth, therefore contributing to the high quality of shellfish products directly edible by man. It sets physical, chemical and microbiological water quality requirements for designated shellfish waters that they must either comply with (‘mandatory’ standards) or endeavour to meet (‘guideline’ standards). Shellfish waters of relevance to the proposed GWF project are discussed further in **Section 10.4**.

10.2.18 Water quality is also an important part of the European Union Marine Strategy Framework Directive (2008/56/EC, July 2008) (MSFD) which has been adopted to protect the marine environment across Europe. It aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine related economic and social activities depend. The MSFD does not state a specific programme of measures that member states should adopt to achieve GES (except for the establishment of Marine Protected Areas). However, the MSFD does outline high level descriptors of GES in Annex I. With respect to the UK, key requirements of the Directive and GES determination should be defined by 2012.

10.2.19 The UK is a signatory to the International Convention for the Prevention of Pollution from Ships (the MARPOL Convention 73/78) and all ships flagged under signatory countries are subject to its requirements, regardless of where they sail. The Convention includes regulations aimed at preventing and minimising pollution from ships - both accidental pollution and that arising from routine operations.

10.2.20 Details of the consultation undertaken for GWF which has given due consideration to the above paragraphs is summarised within the 'consultation section' below.

Consultation

10.2.21 Consultation on the survey strategy to help inform the baseline conditions was undertaken with Cefas, the Joint Nature Conservation Committee (JNCC) and the MMO. Further consultation with these bodies, and the EA, was undertaken through the scoping process and through formal section 42 consultation under the Planning Act 2008 (see **Chapter 7 Consultation**) via the submission of a Preliminary Environmental Report (PER). Responses received are presented in the IPC Scoping Opinion report (IPC, 2010) and the Consultation Report that accompanies this Development Consent Order (DCO) application.

10.2.22 A summary of those comments that are considered of relevance to this Chapter, are included in **Table 10.1**.

10.2.23 Throughout the consultation process no specific issues of concern have been raised by those organisations with regard to the assessment of marine water and sediment quality.

Table 10.1 Summary of consultation and issues relevant to sediment and water quality

Date	Consultee	Summary of issue	Section where addressed
Aug 2010	IPC (Page 22 of Scoping Opinion)	Development to consider the intertidal and subtidal habitat and the impacts of dredging and sediment type and quality	10.4 and 10.6
Aug 2010	EA (Scoping Opinion)	Concerns over the proximity to the dump site for capital and maintenance dredges carried out by Harwich Haven Authority (HHA). Consultation with HHA over the timings of dredging works is recommended to establish potential for cumulative impacts.	10.4
Oct 2009	Hanson Aggregates Ltd	Hanson Aggregates Ltd are not progressing their interest in the	10.4

Date	Consultee	Summary of issue	Section where addressed
		aggregate area to the west of GWF and, the rights have been returned to The Crown Estate	
March 2011	Harwich Haven Authority (HHA)	HHA do not currently have an active programme of dredging/disposal	N/A
2009-2011	CEMEX UK Marine Ltd (CEMEX)	Consultation with CEMEX with regard to their aggregate activities adjacent to the site and the potential for conflict with GWF activities has been ongoing throughout the EIA process (see further details in **Chapter 18**). Discussions are ongoing with CEMEX in order to agree the final location of GWFL's export cables in relation to this area. CEMEX has confirmed that it has no objections to GWFL submitting a planning application that includes reference to potential cable routes both in and adjacent to Area 507/5, subject to future agreements being reached.	10.4, 10.9 and **Chapter 18**.
July - 2011	MMO (Section 42)	The levels of contaminants in sediments should be compared to Cefas Action Levels These determine whether or not material is suitable for sea disposal and we would have expected results to be displayed in this manner.	10.4 and 10.9
July - 2011	MMO (Section 42)	The methods of analysing sediments for contaminants should be detailed within the ES to allow comparison of these results to Cefas Action Levels.	10.3 and Appendix 10.A

10.3 Methodology

Study area

10.3.1 Impacts on the marine environment, especially in regard to water quality, have the potential to be far reaching therefore the study area, with regard to water and sediment quality comprises the Outer Thames Estuary and southern extents of the southern North Sea.

Characterisation of existing environment

10.3.2 Regional context is provided through data collected from previous studies as well as for statutory monitoring and reporting processes, including:

- Benthic studies completed for the Greater Gabbard Offshore Wind Farm (GGOWF) included 14 benthic grab samples obtained from across the wind farm development area that were analysed for contaminants (Greater Gabbard Offshore Wind Limited (GGOWL), 2005);
- Coastal processes studies carried out by ABPmer (2011a/b) to inform the GWF EIA;
- Marine Aggregate Levy Sustainability Fund (MALSF) Regional Environmental Characterisation (REC) study for the Outer Thames Estuary (MALSF, 2009);
- OSPAR Commission Quality Status Report 2010 (OSPAR, 2010);
- Monitoring at Sizewell power station from the Radioactivity in the Food and Environment Report, 2009 (EA *et al.*, 2010); and
- EA statutory monitoring programs (EA online resource).

10.3.3 The offshore location of GWF and much of the export cable corridor means that water quality information is limited in spatial extent, as monitoring programmes for water quality undertaken by the EA mainly cover inshore areas.

10.3.4 Water quality sampling is not a formal requirement for offshore wind farm development and as such no dedicated water quality sampling was undertaken for the proposed GWF project, although suspended sediment concentrations were measured at the adjacent Greater Gabbard Offshore Wind Farm (GGOWF) as part of their consenting studies, and have been used in the assessment (see **Section 10.4**). Characterisation of the water quality baseline has therefore primarily been based on information obtained through a desk study.

Site specific survey

10.3.5 A benthic survey campaign was undertaken to characterise the physical, biological and chemical nature of the seabed around the proposed GWF site and export cable corridor (Centre for Marine and Coastal Studies (CMACS), 2010) (**see Chapter 12 Technical Appendix 12.A**). The surveys were carried out in accordance with a Scope of Works which was agreed in consultation with the JNCC, Natural England and the Centre for Environment, Fisheries and Aquaculture Science (Cefas).

10.3.6 The survey plan included sub-sampling for subsequent analysis of metals and hydrocarbons from 11 of the 97 grab samples, with one additional sample for the hydrocarbon analysis. The samples were taken from the proposed offshore development area and cable route.

10.3.7 During the survey a mini Hamon grab ($0.1m^2$ sample area) was used to collect samples from the seabed to be used for sediment analysis. Every attempt was taken to ensure contaminant samples were taken from the top 2cm of sediment.

10.3.8 Samples for hydrocarbon analysis were collected with an acetone washed metal scoop and stored in glass containers. Samples for metal contaminant testing were taken using a plastic spoon and then stored in plastic containers.

10.3.9 Samples were analysed for the following metals and hydrocarbons:

- Arsenic;
- Cadmium;
- Copper;
- Lead;
- Mercury;
- Nickel;
- Zinc;
- Polyaromatic hydrocarbons (PAH);
- Petroleum hydrocarbons;
- Tributyl tin (TBT); and
- Polychlorinated Biphenyls (PCB).

10.3.10 Consultation with MMO has highlighted the need to include further details pertaining to contaminant analysis techniques used to detect levels of metals and hydrocarbons (see **Table 10.1**). The certificate of analysis presenting further information on methodology is included as **Technical Appendix 10.A**.

Assessment of impacts

10.3.11 The assessment of impacts within this Chapter follows the methodology set out in **Chapter 4 EIA Process**.

10.3.12 For the assessment of water quality, the description of the baseline environment is based on the standards outlined in the WFD and Bathing Waters Directive (and in line with the EA approach).

10.3.13 The context of the contaminants found within the sediments of the proposed GWF development area in terms of implications for water and sediment quality are established through the use of recognised standards and action levels.

10.3.14 The Canadian / United States approach has been used to help inform this assessment (Cole *et al*, 1999, CMACS, 2010). This approach involves the derivation of Interim marine Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PEL) from an extensive database containing direct measurements of toxicity of contaminated sediments to a range of aquatic organisms exposed in laboratory tests and under field conditions (Cole *et al*, 1999).

10.3.15 Another assessment tool that has been used for determining sediment quality is Cefas Action Levels. Action levels are derived from a combination of chemical and ecotoxicological data sets to establish a range of contaminant concentrations suitable for sea disposal. Action levels are currently used to assess the chemical quality of the dredged material that is proposed to be disposed at sea, however their use in this assessment has been suggested through consultation with the MMO (**Table 10.1**).

10.3.16 The potential for release and dispersion of contaminated sediments has been informed by a coastal processes assessment undertaken by ABPmer for the GWF site. This study describes the potential interaction of the proposed GWF development on wave, tidal and sediment regimes (ABPmer, 2011b) and establishes volumes of sediments released during construction and operation phases of the development, followed by a prediction of their subsequent dispersion and settlement profile. Further details on the potential effects on the physical are presented in **Chapter 9**.

10.4 Existing Environment

Water quality

10.4.1 With regard to water quality in the wider North Sea, the OSPAR Commission Quality Status Report has evaluated the quality status of the North-East Atlantic during a 10 year monitoring and assessment programme (OSPAR, 2010). The Greater North Sea region summary, within which the proposed GWF project is located, highlights that eutrophication caused by nutrient inputs is a problem along the east coast of the North Sea from Belgium to Norway, and in some small estuaries and bays of eastern England and north-west France (although this problem is mostly confined to coastal areas in the eastern North Sea and not the coast of the UK). In addition, concentrations of metals (cadmium, mercury and lead) and persistent organic pollutants are above typical background in some offshore waters of the North Sea, and unacceptable in some coastal areas (OSPAR, 2010).

10.4.2 Within the study area, the main responsibility for inshore water quality lies with the EA and Anglian Water Authorities. Substantial investment to provide better sewage treatment by Anglian Water Services, together with work by Local Authorities and the EA, has meant that the quality of waters off the Suffolk coast has improved (GGOWL, 2005). This is supported by the bathing water monitoring results and beach awards off the coast of Suffolk.

10.4.3 There are 15 classified Sewage Water Company Discharges within 10km of Sizewell, the most significant being Aldeburgh Sewage Treatment Works (permit No. AW4CS12011) which flows directly into the North Sea; this is located over 8km south of the proposed GWF landfall site (**Figure 10.1**)

10.4.4 A number of activities influence water quality in the coastal areas adjacent to the proposed GWF site. There are 107 live discharge outlets within 10km of Sizewell, the majority of which are private/domestic discharges (EA, 2011). Discharge outlets are directed into the region's rivers (Stour, Gipping, Deben and Alde) and are monitored and licensed by the EA. Diffuse pollution (i.e. from agricultural run off) is also inevitably carried to the coast via inland river systems.

10.4.5 Fully treated sewage effluent from Sizewell A and B nuclear power stations is discharged with the cooling water from Sizewell B. Sizewell B nuclear power station is also consented to discharge low level radioactive liquid effluent into the North Sea, which is subject to monitoring by the EA. The locations of Sizewell power station outlet pipes are shown in **Figure 10.1**, the nearest being approximately 500m north of the proposed GWF cable landfall.

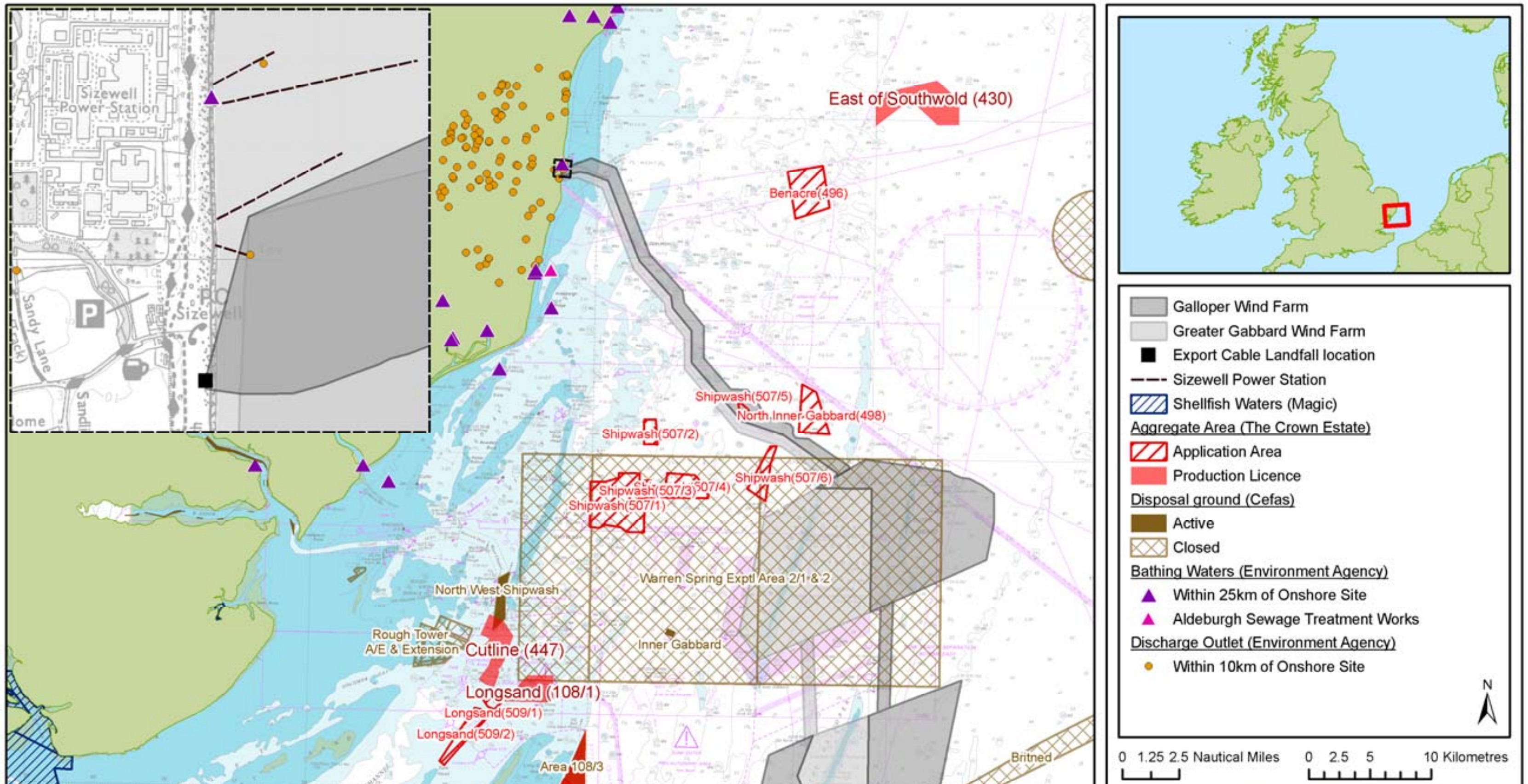
10.4.6 Continuous monitoring at Sizewell, and other installations, results in an annual Radioactivity in Food and the Environment (RIFE) report which gives a detailed assessment of radioactivity in food and the environment in the UK as well as the potential for public exposure to radiation.

10.4.7 The most recent results of the analysis of seafood, sediment, sand and seawater, and measurements of gamma dose rates in intertidal areas around Sizewell are detailed in the 2010 RIFE report which summarises data from the preceding year (EA *et al*, 2010). Concentrations of artificial radionuclides were low, with measured gamma dose rates in intertidal areas difficult to distinguish from the natural background, including at Sizewell beach (EA *et al*, 2010).

10.4.8 Aggregate extraction and marine disposal activities can also influence marine water quality. The closest active regulated disposal of dredged material to the proposed GWF project area occurs at Inner Gabbard located 12km to the west of the proposed GWF site (**Figure 10.1**). The Scoping Opinion response from the EA raised the potential for disposal of material by HHA (see **Table 10.1**). However following consultation with the HHA it is apparent that they are not currently carrying out a dredging programme and had no existing formal plans to dispose of material at either site during the GWF timeframe (see **Table 10.1**).

10.4.9 The nearest active aggregate extraction activity to the proposed GWF site is at Area 108/3, approximately 15km to the west of the site, and Area 108/1 18km from the site. All other active extraction is located over 22km from the proposed GWF site.

10.4.10 There are a number of aggregate extraction application areas both within, and in close proximity to, the proposed export cable corridor (Shipwash 507 and North Inner Gabbard 498), however as these are in the application stage no extraction is currently taking place at these sites.



Galloper Wind Farm

Figure 10.1

Areas of relevance to water quality

Draw ing Number: GWF_429_R9		Rev: 9
Date: 27/10/11	Created: LW	Checked: SS
Scale: 1:500,000	Page: A4	
Datum: WGS1984	Projection: UTM Zone 31N	

Suspended sediment concentrations

10.4.11 Suspended sediment is transported within the water column and comprises the relatively fine fraction of the mobile sediment. Increases in suspended sediment concentrations (SSC) can affect water quality and can mobilise contaminants that may be present in the sediments. SSC were measured at four locations as part of the Metocean data collection at GGOWF (see **Chapter 9** and **Appendix 9.A**). Results indicate that the temporal variation of SSC correlates with corresponding parameters of water depth, wave and tidal activity (ABPmer, 2011a). A correlation between tidal state, current speed and SSC is apparent at the greater water depths (30m), where higher levels of SSC can be observed immediately after the time of high water (ABPmer, 2011a).

10.4.12 The maximum concentration of suspended sediment was recorded as 85mg/l with a mean concentration of 20mg/l (ABPmer, 2011a). Regional suspended sediment concentrations have been published by HR Wallingford *et al*., (2002): offshore regional summer concentrations range from 1-10mg/l and winter concentrations from 1-20mg/l.

10.4.13 Whilst there are no project specific SSC measurements along the proposed export cable route, it is considered that the deeper water levels are comparable to those present within the wind farm site (ABPmer, 2011b). The shallower water concentrations can be inferred from surface measurements which indicate a range of 32 to 64 mg/l for the summer period and 64 to >250 mg/l for the winter period (ABPmer, 2011b).

Designated bathing waters

10.4.14 Bathing water standards are applied at designated beaches, where microbiology is the principal concern. **Figure 10.1** shows the designated bathing waters in the vicinity of the proposed GWF project, the closest to the cable landfall being at Southwold which is 15km from the landfall site.

10.4.15 As outlined in **Section 10.2**, the Bathing Waters Directive sets standards that bathing waters must either comply with (mandatory' standards) or endeavour to meet (stricter 'guideline' standards).

10.4.16 The five microbiological and six physico-chemical parameters used in the assessment of bathing waters are outlined, with their standard values, in **Table 10.2**.

10.4.17 For the purposes of the Bathing Water Directive, samples are currently taken on a weekly basis throughout the bathing season (May to September). The samples are analysed and the data used to classify bathing waters as excellent, good or poor. Bathing waters classified as 'poor' fail to meet the Bathing Waters Directive's minimum standards.

10.4.18 The nearest EA monitoring stations to the cable landfall at Sizewell are at Southwold, approximately 15km to the north of the GWF landfall, and

Felixstowe some 40km to the south (**Figure 10.1**). Bathing water quality at Felixstowe and Southwold for the period of 2000 to 2010 is shown in **Table 10.3**. The four sample stations have exhibited good or excellent quality in the last ten years. Additionally, in Felixstowe and Southold (the Denes), there have been no failures in the mandatory standards since 1990 when the EA began monitoring these sites (Southwold (the Pier) has only been monitored since 2000).

Table 10.2 Imperative and Guideline Standards according to EC Bathing Waters Directive (76/160/EEC)

Parameter	Mandatory Standards	Guideline Standards
Microbiological		
Faecal coliforms	2,000/100 ml	100/100 ml
Total coliforms	10,000/100 ml	500/100 ml
Faecal streptococci	-	100/100 ml
Salmonella/litre	0	-
Enteroviruses PFU/10 litres	0	-
Physico-chemical		
PH	6-9	-
Colour	No abnormal change in colour	-
Mineral oils	No film visible on the surface of the water and no odour	≤0.3 mg/l
Surface active substances	No lasting foam	≤0.3 mg/l
Phenols	No specific odour ≤0.05 mg/l	≤0.005 mg/l
Transparency	Secchi extinction depth of 1m	Secchi extinction depth of 2m
Dissolved oxygen	-	80-120% saturation
Tarry residues and persistent floating solids	-	Must be absent

Source: EA, 2011[1]

- 95 % of the samples must confirm with the mandatory value.
- 90 % of the samples must conform with the Guideline value (80 % in the case of total coliform and faecal coliform parameters)
- The 10 (or 20) % not complying with the Guideline values must not allow consecutive samples taken at statistically valid intervals to not exceed the "G" value, i.e. "G" value failures should be of short duration.

Table 10.3 Bathing water quality at 2000 – 2010 (Classifications: E=Excellent, G=Good, P=Poor)

Station	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
North Felixstowe	E	E	E	E	E	E	E	E	E	E	G
South Felixstowe	E	E	E	E	E	E	E	E	E	E	E
Southwold (The Denes)	E	G	G	E	E	E	G	E	E	G	G
Southwold (The Pier)	E	G	G	E	E	E	E	E	E	E	E

Source: EA, 2011

10.4.19 A revised Bathing Water Directive was adopted into UK law in March 2008 and will take effect in stages from 2011 until it fully replaces the previous legislation in 2015. This new legislation introduces stricter water quality standards and contains a requirement to provide more detailed and standardised information about bathing waters across Europe.

10.4.20 The revised Directive has updated the way in which water quality is measured, focusing on fewer microbiological indicators, and setting different standards for inland and coastal bathing sites:

- Tighter microbiological standards – to be met by 2015;
- Two microbiological parameters – Intestinal enterococci and *Escherichia coli*;
- Water quality classification based on three or four years monitoring data, using 95 or 90 percentiles; and
- Four new classification categories:
    - o Excellent – approximately twice as stringent as the current guideline standard;

[1] www.environment-agency.gov.uk

- o Good – similar to the current guideline standard;
- o Sufficient – tighter than the current mandatory standard; and
- o Poor – normally non-compliant.

Beach awards

10.4.21 Another indicator of coastal water quality is the Blue Flag Programme[2] which is active in over 40 countries and works towards sustainable development at beaches and marinas. The award of a Blue Flag beach is based on compliance with 32 criteria covering the aspects of water quality, environmental education and information, environmental management, and safety and services.

10.4.22 The nearest Blue Flag beaches to the proposed GWF site are Southwold Pier (approximately 14km from GWF landfall) and Felixstowe South (approximately 33km from GWF landfall); both are sand and shingle beaches which are popular with tourists.

10.4.23 The Marine Conservation Society (MCS), through its annual "Good Beach Guide", recommends beaches which have had excellent water quality in the latest tests (Summer 2009) and are not affected by badly treated, continuous waste water discharges. Felixstowe north and south were recommended by the MCS in the 2010[3].

Designated Shellfish waters

10.4.24 Water quality is also important for shellfish production areas, with areas of the Outer Thames Estuary being designated for this purpose.

10.4.25 The Shellfish Waters Directive is designed to protect the aquatic habitat of bivalve and gastropod molluscs, including oyster, mussel, cockle, scallop and clam. It does not cover crustaceans such as crab, crayfish and lobster.

10.4.26 Shellfish waters are monitored for various parameters based on water quality standards set by the Shellfish Waters Directive (see **Section 10.2**). These parameters include for Mandatory standards: pH, salinity, dissolved oxygen (DO), organo-halogenated substances (e.g. organochlorine pesticides), metals and guideline values for coliforms in shellfish flesh. Only salinity, DO and faecal coliforms in shellfish flesh have Guideline Standards.

10.4.27 The designated Shellfish areas within 45 km of the proposed GWF development are listed in Table 10.4, with the closest being Butley River (see Figure 10.1). All, including Butley River, are a significant distance from the proposed GWF site (well in excess of a single tidal excursion which extends 11.7km to the south of Areas B/C and 17.5km north from Area A).

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[2] www.blueflag.org

[3] MCS Good Beach Guide at www.goodbeachguide.co.uk

Table 10.4 Nearest shellfish waters to the GWF site

Designated Shellfish Area	Distance from GWF
Outer Thames	38km
Walton Backwaters (south of Harwich)	43km
Butley River	32km
Alde (Aldeburgh)	38km

Contaminants in sediments

10.4.28 Sediment characteristics and physical processes in and around the proposed GWF site and which are relevant to this section are discussed in detail within **Chapter 9**.

10.4.29 Marine sediment quality in general is affected by contaminants, which may enter the marine environment either directly from rivers, sewage effluent or industrial discharges or arrive on currents from sources further afield. Metals also occur naturally as a consequence of geological weathering processes and subsequent land run off. However, inputs are increased as a consequence of mining and industrial activities.

10.4.30 Other contaminants, which also act to affect sediment quality in general, include man-made compounds such as pesticides and contaminants arising from the oil and gas industry. Harbours, marinas and busy waterways can also be highly contaminated with persistent organic contaminants such as TBT due to historic inputs.

10.4.31 Regional evidence from GGOWF (GGOWL, 2005) and the MASLF REC study (MALSF, 2009) would suggest that, in general within the Outer Thames Estuary, inshore estuarine locations have the highest levels of chemical contamination as a result of industrial activity, whereas sediments offshore are significantly less contaminated. The exception to this is arsenic contamination, which occurs at elevated levels in the region due to a history of arsenic waste disposal, inputs from estuaries (GGOWL, 2005), and due to geological inputs and seabed rock weathering (CMACS, 2010).

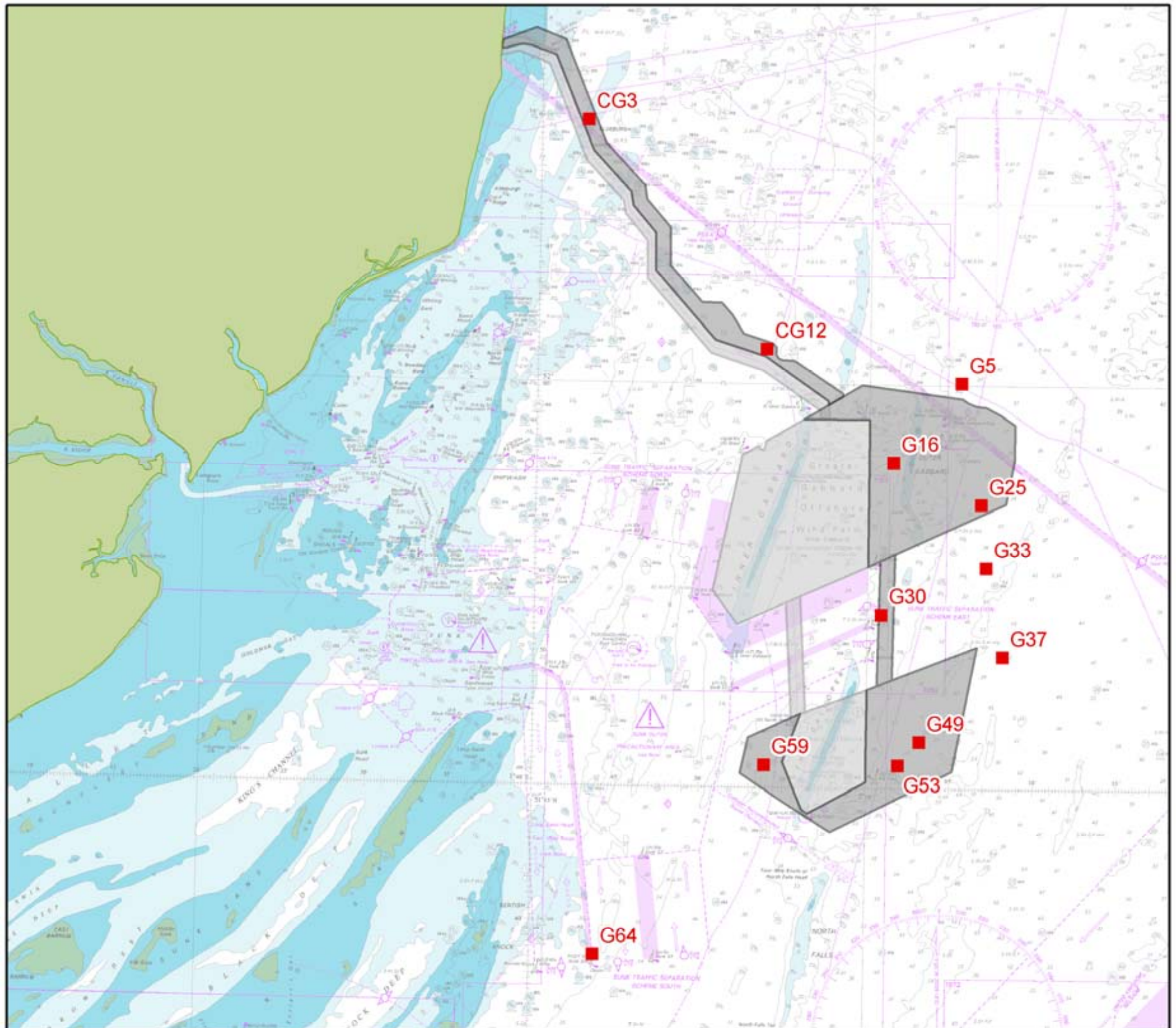
10.4.32 A dedicated sampling survey was undertaken for the proposed GWF site (CMACS, 2010) as part of the wider benthic survey campaign. As part of these surveys, 97 grab stations within and outwith the proposed GWF development area were sampled. The locations of the 12 stations from which contaminant analysis was carried out are shown in **Figure 10.2** (where metal and hydrocarbon analysis was carried out from 11 of the stations, and one station (CG3) where only hydrocarbon analysis was completed).

10.4.33 Sediment contaminant data for metal contaminants are summarised in **Table 10.5** (station number 12 was analysed for hydrocarbons only and is not included in the table). **Table 10.6** outlines the sediment quality parameters as defined by Cole *et al*., (1999) and utilised by CMACs (2010) within their contamination comparison analysis. The guidelines comprise two assessment levels; the lower level is referred to as the interim sediment quality guideline (ISQG) and represents a concentration below which adverse biological effects are expected to occur rarely, and the higher level, known as the PEL, defines a concentration above which adverse effects are expected to occur frequently. **Table 10.7** provides the results of the hydrocarbon contaminant analysis.

10.4.34 Cefas's Action Levels have also been used to assess the sediments at the proposed GWF site; these are detailed in **Table 10.8**. The action levels are used along with other assessment methods to make management decisions regarding the fate of dredged material. However, they are a useful set of guidelines which can be used to supplement the parameters as defined by Cole *et al*., (1999). However the action levels do not constitute simple pass or fail criteria, as they are used as part of a weight of evidence approach to decision-making on the disposal of dredged material to sea.

10.4.35 The two action levels form the following three management decision making responses:

- Below action level 1 contaminants in the dredged material are generally of no concern and are unlikely to influence the licensing decision about sea disposal. For example, action level 1 acts as a nominal background concentration for metals and a primary anthropogenic impact detection concentration for TBT;
- Between action levels 1 and 2 contaminants in the dredged material require further consideration and testing before a decision can be made about sea disposal; and
- Above action level 2 contaminants in the dredged material are generally considered unsuitable for sea disposal. This situation most often applies only to a part of a proposed dredging area and this may result in part of the proposed dredging area being excluded from disposal at sea and requiring disposal of dredged material by other routes (e.g. landfill).



Galloper Wind Farm
Greater Gabbard Wind Farm
Contaminant analysis (CMACS 2009)

N

0 1.25 2.5 5 Nautical Miles 0 2.5 5 Kilometres

Galloper Wind Farm		
Figure 10.2		
Benthic grab survey locations where contaminant analysis was carried out		
Draw ing Number: GWF_379_R8		Rev: 8
Date: 27/10/11	Created: LW	Checked: SS
Scale: 1:450,000	Page: A4	
Datum: WGS1984	Projection: UTM Zone 31N	

Table 10.5 Results of sediment analysis for metal contamination (highlighted cells correspond to failures of levels outlined in Table 10.5)

Contaminant	Station										
	G5	G16	G25	G30	G33	G37	G49	G53	G59	G64	CG12
Arsenic	28.3*	22.7*	27.7*	29.2*	12.8	11.1	27.6*	16.9	27*	29*	50.9*
Cadmium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Copper	2.12	11.8	15.2	8.1	3.09	1.65	12.9	4.59	17.5	8.43	3.4
Lead	6.4	7.16	12.9	6.51	2.84	1.57	7.76	4.13	11.7	11.9	3.8
Mercury	0.175	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
Nickel	2.93	24.2*	29.1*	18.9	5.8	2.72	22.4*	8.46	32.7*	26.3*	10.5
Zinc	21.7	48.9	46	35.9	11.9	5.82	41.9	16.4	66.1	38.7	19.2

Source: CMACS, 2010

*Exceeds Cefas Action Level 1

Table 10.6 ISGQ (Interim Sediment Quality Guidelines) and PEL (Probable Effect Level)*

Contaminant	ISGQ	PEL
Arsenic	7.24	41.6
Cadmium	0.7	4.2
Copper	18.7	108
Lead	30.2	112
Mercury	0.13	0.7
Nickel	n/a	n/a
Zinc	124	271

Source: CMACS, 2010

Table 10.7 Results of sediment analysis for hydrocarbon contamination

Determinant	Station											
	G5	G16	G25	G30	G33	G37	G49	G53	G59	G64	CG12	CG3
Total Poly Aromatic Hydrocarbon (ng g^{-1})	<118	<118	<118	<118	<118	<118	<118	<118	<118	132	<118	<118
Total Petroleum Hydrocarbon (µg g^{-1})	66.1	75.2	87.4	108	54.5	<35	<35	<35	<35	<35	43	61.9
TBT (µg g^{-1})	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total PCB ICES 7 (µg g^{-1})	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Chlorinated Pesticides (ng g^{-1})	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Source: CMACS, 2010

*values given in µg. g^{-1} dry weight (from Cole *et al.,* 1999.)

Table 10.8 Cefas Action Levels (µg g^{-1})

Contaminant	Action Level 1	Action Level 2
Arsenic	20	100
Cadmium	0.4	5
Copper	40	400
Lead	50	500
Mercury	0.3	3
Nickel	20	200
Zinc	130	800
Organotins (i.e. TBT)	0.1	1
PCB's (ICES 7)	0.01	None

10.4.36 In parallel with the GGOWF sediment contaminant analysis, arsenic was the most common metal contaminant to be found at elevated levels during the

2009/2010 benthic surveys. Arsenic was present at levels in excess of the 7.24mg/kg ISQG standard in all 11 samples and one sample contained arsenic in excess of the PEL. Eight samples contained levels in excess of the Cefas Action Level 1 standards, with none of the results exceeding the Level 2 Standard (**Tables 10.5**, **10.6** and **10.8**).

10.4.37 As outlined in paragraph 10.4.28, elevated arsenic levels are expected in this region, and as high levels of arsenic are widespread it is unlikely that there is an anthropogenic or point source causing the higher concentrations of this metal.

10.4.38 Copper, lead, and zinc were present in all samples but all levels were below quoted ISQG levels, and the Cefas Action 1 Levels, these results are also similar to the analysis carried out for GGOWF (GGOWL, 2005). Cadmium levels were below detectable levels at all stations and mercury was found at only one station, this level was above the ISQG level but below the PEL level. Neither metals exceeded the Cefas Action 1 Levels.

10.4.39 Five samples contained nickel at concentrations above Cefas Action Level 1, but significantly lower than Action Level 2. Most nickel is used for the production of stainless steel and other nickel alloys with high corrosion and temperature resistance. Entry into the aquatic environment is by removal from the atmosphere, by surface run-off, by discharge of industrial and municipal waste, and also following natural erosion of soils and rocks. Nickel is known to accumulate in sediments with toxicity in aquatic invertebrates varying considerably according to species and abiotic factors, however this metal shows little capacity for bioaccumulation[4].

10.4.40 As shown in **Table 10.7** Hydrocarbons were also analysed in the grab sample sediments. PAH concentrations were below detectable levels throughout (<118 μg g^{-1}) with the exception of one station which still contained very low levels (135 μg g^{-1}). Petroleum hydrocarbons were found in stations in some areas such as the cable route corridor and the interconnecting cable route (**Table 10.7**). TBT concentrations were below detectable levels throughout all samples tested (<0.02μg g^{-1}) which is also below the Cefas Action Level 1 (**Table 10.7** and **Table 10.8**). .

10.4.41 PCBs were below detectable levels (<3μg g^{-1}) (**Table 10.7**), however this leaves the possibility that concentrations recorded were above Cefas Action Level 1. In the aquatic environment, PCBs are usually found in much higher concentrations in sediments than in the overlying water as they have a high affinity for suspended solids. PCBs are some of the most ubiquitous and resistant pollutants in the global ecosystem, they are toxic to wildlife and have a high bioaccumulation capacity. PCBs have been widely used in industrial applications, with releases occurring during their manufacture and use in industry. The principal transportation route of PCB's into the marine environment is from waste streams to receiving waters, downstream

[4] http://www.ukmarinesac.org.uk/activities/water-quality/wq8_8.htm

movement by means of solution and re-adsorption onto particles and by the transport of the sediment itself, until eventually reaching estuaries and coastal waters[5]. There is no evidence to suggest that the sediments surrounding GWF would contain concentrations of PCB that would be of concern. The proposed GWF project is not situated in close proximity to any significant industrial centres and for this reason offshore sediments particularly tend to have lower concentrations of PCBs[6].

10.4.42 Commonly the sediments in the North Sea are continually modified by wave and current action and sediment transport is not only regulated by regular events, but can also be greatly influenced by occasional extreme storm events (MALSF, 2009). In the Outer Thames Estuary, suspended sediment concentrations are generally higher in estuaries than farther offshore. Concentrations quoted in MALSF (2009) are in the region of 0.2 – 977 mg/l in estuaries and from 1.7 – 219 mg/l in offshore areas. The River Thames discharges up to 700,000 tonnes of fine suspended sediments per year at the mouth of the estuary and some areas exhibit higher concentrations during the summer such as Orford Ness, where possible sources are from the Orford area, or from increased biological activity. In the winter, concentrations are double those in the summer, and there is often an area of increased suspended sediment off the Suffolk coast at Orford Ness (MALSF, 2009).

10.4.43 From the information and data presented above, it can be concluded that the baseline water quality for the marine and coastal areas surrounding the proposed GWF site is generally good and sediment contaminant conditions for the area around GWF and the export cable corridor are generally below levels at which adverse effects on the benthos are seen, with the levels of arsenic considered typical for the region.

10.5 Assessment of Impacts - Worst Case Definition

10.5.1 Identification of the worst case scenario for each receptor ensures that impacts of greater adverse significance would not arise should any other development scenario (as described in **Chapter 5**) to that assessed, be taken forward in the final scheme design.

10.5.2 For the purpose of the marine water and sediment quality, the worst case scenario, taking into consideration these options, is detailed in **Table 10.9**.

10.5.1 It is noted that only those design parameters detailed under each specific impact have the potential to influence the level of impact experienced by the relevant receptor. Therefore, if the design parameter is not discussed then it is considered not to have a material bearing on the outcome of the assessment.

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[5] http://www.ukmarinesac.org.uk/activities/water-quality/wq8_42.htm

[6] http://www.cefas.co.uk/publications/posters/25844.pdf

10.5.2 The worst case scenarios identified below are also applied to the assessment of cumulative impacts. In the event that the worst case scenarios for the project in isolation do not result in the worst case for cumulative impacts, this is addressed within the cumulative assessment section of the Chapter (see **Section 10.10**).

Table 10.9 Worst case project design for marine water and sediment quality

Impact	Realistic worst case scenario	Justification
Construction		
Deterioration on water quality due to re-suspension of sediments Deterioration in water quality due to re-suspension of contaminants	101 (45m base diameter) GBS foundations for WTG structures, three (45m base diameter) GBS foundations for met masts, four 7m monopile foundations for ancillary infrastructure (providing a total volume of 500,800m^3). Seabed preparation for GBS comprises mechanical levelling of the seabed to a depth of approximately 2m. Turbine installation - two GBS foundations installed simultaneously over a three day period. Cable installation in the marine environment by jetting methods to install up to three export cables a representative average depth of 1.5m deep and 0.5m wide over a total of 190 export cable kilometres. Inter and intra-array cabling will be a total length of 300km and have similar	The worst case scenario is represented by that which could result in the maximum volume of arisings (and therefore, maximum volume of material that could brought into suspension). For the WTG foundations 101 (45m) GBS foundations represent worst case volume (484,800m^3). Other options result in less volume released: 140 35m GBS foundation resulting in 445,340m^3, 140 7m monopiles 224,000m^3, 140 space frame foundations 182,000m^3, 140 4-legged space frames founded with suction cans 43,960 m^3 and 140 monopod buckets 70,000m^3. For the met masts where all foundation types are available, again the 45m GBS foundations represent worst case. For the four ancillary structures, where GBS are not an option, the worst case is represented by the 7m monopile as this structure results in higher levels of spoil material (1,600m^3 per foundation). Ploughing, trenching and jetting were assessed by ABPmer (2011b), see **Chapter 9** and **Technical Appendix 9.Aiii**, with jetting considered to represent the worst case scenario, the assumption being that all sediment disturbed would be fluidised and therefore, made available for re-suspension.

Impact	Realistic worst case scenario	Justification
	burial characteristics to the export cable.	
Deterioration in water and / or sediment quality due to accidental spillage of construction materials	Construction taking place all year, 24 hours a day using vessels comprising foundation installation via HLV / jack-up barge, possible grouting vessel, possible foundation transportation vessel, substation installation vessel and possible support vessels within a construction window of 56 months (notionally assuming a Q2 or Q3 2015 commencement).	Higher likelihood of an incident occurring as a result of more activities taking place over a longer time period. It should be noted that there are no significant discharges associated with wind farm construction.
Operation		
Deterioration in water and sediment quality due to accidental spillages and discharges of grey water from up to one accommodation platform	Access to installations by boat and use of a mothership. Bi-annual maintenance and inspection visits. Requirement for retrofitting and upgrading works using jack up rigs. 5 vessels per day travelling to/from the wind farm site Unscheduled repair activities equal to one visit per turbine per month.	This worst case scenario provides for the maximum level of operational activity and therefore, the highest likelihood of an incident occurring due to increased vessels / activities. It should be noted that there are no significant discharges associated with wind farm operation activities.

Impact	Realistic worst case scenario	Justification
	Maximum of one accommodation platform with associated grey water discharge	
Deterioration of water and sediment quality as a result of scour effects at WTG structures	104 GBS foundations for WTG structures (see **Section 9.5**), three (45m base diameter) GBS foundations for met masts, four (7m) monopile foundations for ancillary infrastructure. Total volume of released material from scour of 446,864m^3. No scour protection measures.	The indirect impacts on subtidal ecology are driven by scour events (from changes to current regime) around foundation structures and the subsequent release of sediments. GBS results in increased scour as a consequence of the larger surface area and hence interaction with hydrodynamic flows. 104 x 45m diameter GBS foundations result in the release in 432,952m^3 of sediment while 143 x 35m diameter GBS foundations result in 65,231m^3 of sediment release. Individual foundations sediment release rates via scour: 45m GBS = 4,163m^3; 35m GBS = 1,517m^3; 7m Monopile = 3,478m^3; space frame (jacket) = 1,097 m^3,see **Technical Appendix 9.Aiii**) Therefore, 104 conical 45m diameter GBS foundations (WTGs and met masts) and four monopile foundations (ancillary structures, which can only use monopiles or space frame foundations) represent the 'worst case' scenario This scenario results in the release of 446,864m^3 of materials with maximum suspension of fine sediment during operation due to scour

Impact	Realistic worst case scenario	Justification
		effects at the turbine structures.
Decommissioning		
Impacts due to re-suspension of sediments and contaminants	Removal of all structures associated with the wind farm.	Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with DECC. Until the arrangements have been clarified, the worst case scenario is that all structures will be removed.

10.6 Assessment of Impacts during the Construction Phase

Deterioration in water quality due to re-suspension of sediments

10.6.1 During construction, seabed sediments may be re-suspended as a result of activities such as seabed preparation, foundation installation, installation of inter and intra-array and / or export cables, the placement of scour material on the seabed and / or construction vessel activity (i.e. from the placement of anchors or jack up barge feet). This could result in direct impacts on water quality associated with decreased light levels and water clarity, and indirect impacts upon biological receptors. The potential impacts of a deterioration in water quality are discussed further within **Chapters 12, 13** and **15**.

10.6.2 Sediments in the region are regularly disturbed by the action of tidal and wave induced currents (see **Chapter 9**). Assessments carried out by ABPmer on the influence of tidal and wave regimes (see **Chapter 9**) suggest that effects will be in line with those predicted at GGOWF (ABPmer, 2011a/b). Therefore, any construction works that may serve to elevate suspended sediment concentrations will be temporary in nature and be localised to specific areas of activity (i.e. they will not occur concurrently across the whole site). In addition, the site is dominated by medium and coarse sand with many of the samples containing a significant proportion of gravel and shell (CMACS, 2010), which further reduce the potential for re-suspension of fine sediments.

10.6.1 With regard to the potential increase in SSC as a result of foundation installation activities, the studies undertaken by ABPmer (2011a/b) indicate that SSC will be highest close to the point of foundation installation (0.5-1.4mg/l above background levels) for fine sands as a result of their lower sediment transport potential due to their increased size. The dispersal of sediment occurs along the main axis of tidal current flow (southwest-northeast) with elevated concentrations being of short-term, duration, typically lasting for only three days as per phase of installation (see **Figure 9.9** of **Chapter 9**).

10.6.2 As detailed in **Chapter 9**, **Technical Appendix 9.Aiii** (ABPmer, 2011b) and **Technical Appendix 9.Aiv**, the export, inter and intra-array cable installation could potentially elevate SSC temporarily in the immediate vicinity of any installation activity. The mobilised material may then be transported away from the disturbance by tidal and wave regimes. The assessment undertaken by ABPmer (20011b) (detailed in **Technical Appendices 9.Aiii** and **9.Aiv** that support **Chapter 9**) considers three sediment sizes over the entire period of cable installation works, assuming a representative average burial depth of 1.5m. The model used assumed that the cable installation process would occur without any disruptions and at a rate of 1km/hr.

10.6.3 The maximum distance of the increased SSC levels can be observed approximately 14km form the export cable route; however the concentrations at these distances from the cable route are typically less that 0.2 mg/l.

Results show that the SSC values, at a time of peak flow, remain less than 0.5 mg/l above natural background levels, with the greater magnitudes typically observed for the larger sediment sizes (ABPmer, 2011b).

10.6.4 It should be noted that the sediment volumes upon which these estimates are based provide an over-estimation of the volume of material to be released as a result of the installation of each structure, as a result this is a highly conservative assessment (as detailed in **Chapter 9**, **Section 9.6**).

10.6.5 **Chapter 9**, **Section 9.6** (and supported by **Technical Appendices 9.Aiii** and **9.Aiv**) assesses the potential increases in SSC for both cable and foundation installation are likely to be of negligible significance in terms of change to existing conditions, as a result the magnitude of the effect on water quality is anticipated to be low. The sensitivity of the receptor is also considered to be low as the nearest sensitive water quality features (namely, shellfish waters and designated bathing sites) are all at significant distance from the proposed GWF site and, therefore, well removed from the areas where suspended sediments levels may be temporarily increased. The impact of re-suspension of sediments during construction at the proposed GWF site is therefore considered to be of **negligible** significance.

10.6.6 As detailed in **Chapter 5**, seabed preparation (which might include mechanical levelling) will be required during installation of the foundations at GWF. GWFL recognises that activities associated with seabed preparation may come under the Marine and Coastal Access Act 2009 definition of dredging[7]. GWFL intend to apply for a dredging licence if, and when, it is deemed necessary.

Deterioration in water quality due to re-suspension of contaminants

10.6.7 The re-suspension of seabed sediments could also lead to the release of contaminants present within them, which may affect compliance with water quality standards. Similarly, should any pathogens be associated with the sediment, these may also be released into the water column with the potential to cause direct impacts on bathing water, designated shellfish water quality and other biological receptors. The data in **Tables 10.5, 10.6** and **10.7** shows that the levels of most contaminants in the sediments are below the ISQG, PER and Cefas Action levels with the only metal contaminants present in elevated levels in more than one sample being arsenic and nickel. With regard to arsenic this is considered typical for the region due to historic inputs and geological processes. In addition, the limited fine sediments and low organic content at the site (0.5 – 2.95%) (CMACS, 2010) further reduces the potential for arsenic accumulation in the sediments.

[7] Marine and Coastal Access Act 2009 Part 66 Item 9 states that it is a licensable activity "to carry out any form of dredging within the UK marine licensing area (whether or not involving the removal of any material from the sea or sea bed).", further an additional note states that "in item 9, "dredging" includes using any device to move any material (whether or not suspended in water) from one part of the sea or sea bed to another part"

10.6.8 Nickel concentrations were detected at levels above Cefas Action Level 1, and there is the possibility of concentrations of PCBs exceeding this level as a result of the lowest detectable concentration being above the Cefas Action Level. In regard to PCBs there is no evidence to suggest that concentrations at the proposed GWF site are be present in concentrations of concern due to the lack of historically anthropogenic activity at the site combined with its distance from industrial centres. In addition, the coastal processes assessment report undertaken for GWF (ABPmer, 2011b) indicates that disturbance to the sediments as a result of foundation installation will, under a worst case scenario, be discrete and short term, with only small increases in suspended sediment concentrations (see paragraph 10.6.3). The export, inter and intra-array cable installation could potentially elevate suspended sediment concentrations temporarily, although this will occur only in the immediate vicinity of the cable installation and will also be of negligible significance in terms of change to existing conditions (see paragraph 10.6.3).

10.6.9 As a result of these short term and localised effects, any contaminants present in the sediments will not be dispersed widely into the marine environment, further reducing the potential for impact on the surrounding water quality profile.

10.6.10 The potential impacts of the deterioration in water quality on biological receptors are discussed further within **Chapters 12, 13** and **15**.

10.6.11 No statutory water quality monitoring has been stipulated for the neighbouring GGOWF under its Food and Environment Protection Act (FEPA) licence conditions, reflective of the lack of perceived significant impact from this source and that the nearest sensitive receptors (shellfish waters and designated bathing sites) are well beyond the distance of such localised affects, at almost 40km and 15km, respectively. Sampling at the proposed GWF site has established that there is similar sediment contaminant levels to those recorded at GGOWF.

10.6.12 In light of these factors and given the low level of contaminants at the site the magnitude of the effect is considered to be low. As detailed in the previous section, the nearest sensitive water quality features are all at considerable distance from the proposed GWF site, therefore the sensitivity of the receptor is also considered to be low. Therefore the impact of re-suspension of contaminated sediments from construction activities at the GWF will be of **negligible** significance.

Deterioration in water and / or sediment quality due to accidental spillage of construction materials

10.6.13 There is potential for pollution from spills or leaks of fuel, oil and lubricants during construction and from construction materials that may enter the water column and subsequently the sediments. The risk of pollution events will be minimised by adherence to the MARPOL Convention regulations, as well as following standard good practice, such as the Pollution Prevention Guidelines issued by the EA. Additionally, any chemicals used during construction will be in line with the Offshore Chemicals (Amendment) Regulations 2010 and any lubricants will be non toxic, biodegradable and capable of dispersal in sea water.

10.6.14 If any accidental spillages were to occur, the impact has the potential to be of medium magnitude (as a worst case, although this will be dependant on the materials spilled). In regard to sensitivity, although the nearest sensitive water quality features are all at considerable distance from the proposed GWF site, there is the potential for sediments to become contaminated with subsequent effects on other receptors (i.e. marine ecology), therefore the sensitivity of the receptor is considered to be medium. Therefore, there is potential for an impact of **minor adverse** significance on water quality.

Mitigation and residual impact

10.6.15 The installation contractors will be required by GWFL to put in place appropriate plans as detailed in the Project Environmental Management and Monitoring Plan (EMMP), that will be agreed with the Regulatory Authorities prior to offshore construction activities commencing. These plans will act to reduce the potential for accidental pollution and in the unlikely event of a pollution incident, would ensure a rapid and appropriate response.

10.6.16 Following the best practice, plans and guidance put in place, there is assessed to be a **negligible** residual impact on sediment or water quality from accidental spillage of construction materials.

10.7 Assessment of Impacts during the Operational Phase

Deterioration in water and sediment quality due to accidental spillages and discharges of grey water from up to one accommodation platform

10.7.1 There are a number of materials which could enter the marine environment during the operational phase of the proposed development and potentially cause deterioration of marine water and sediment quality. Lubricants, oils and greases will be required to ensure the operational parts of the WTG work efficiently and there is the potential that accidental spillages of these materials may occur. In addition vessels used during maintenance will have their own associated fuels and lubricants which could also enter the marine environment. The risk of pollution events will be minimised by adherence to the MARPOL Convention regulations, as well as following standard good practice, such as the Pollution Prevention Guidelines issued by the EA.

10.7.2 The activities associated with the routine operation of an offshore wind farm are unlikely to introduce significant volumes of contaminants to the marine environment; therefore the potential impacts on water and sediment quality during this phase are likely to be restricted to accidental spillages during maintenance activities.

10.7.3 In regard to waste produced if an accommodation platform is installed, waste will be segregated on the platform before being returned to shore, with any generated waste recycled where possible. The only discharges produced will be associated with grey water which will be treated and discharged in line with the relevant legislation, primarily MARPOL 73/78 Annex IV[8] (Regulations for the Prevention of Pollution by Sewage from Ships (revised)). In addition the grey water will be minimal and will be discharged and diluted rapidly in the marine environment.

10.7.4 If any accidental spillages were to occur, the impact has the potential to be of medium magnitude (as a worst case, although this will be dependant on the type and volume of materials spilled). In regard to sensitivity, although the nearest sensitive water quality features are all at considerable distance from the proposed GWF site, there is the potential for sediments to become contaminated with subsequent effects on other receptors (i.e. marine ecology), therefore the sensitivity of the receptor is considered to be medium. The potential impact from accidental spillages will be, at worst, of **minor adverse** significance.

Mitigation and residual impact

10.7.5 As described in paragraphs 10.6.15 and 10.6.16, best practice for pollution prevention will be implemented during the operational activities of GWF to mitigate the risk from such occurrences; therefore it is considered that there will be **negligible** on water quality during operation of the GWF.

Deterioration of water and sediment quality as a result of scour effects at WTG structures

10.7.6 There is potential for impacts upon water and sediment quality as a result of scour occurring around the bases of the WTG and ancillary infrastructure foundations caused by local acceleration of tidal current flow. The depth of scour will depend on the physical conditions, the thickness of the mobile layer and the cohesiveness of the substrate. It should be noted that the scour volumes stated as a worst case scenario (**Table 10.9**) will never actually be realised because in engineering terms, it is not acceptable to allow scour to occur around WTG foundations. As a result scour protection will be necessary and will be used to remove this potential effect.

10.7.7 Potential impacts as a result of a deterioration in water quality associated with scour effects are assessed further in **Chapter 9**, **Chapter 12** and **Chapter 13**.

10.7.8 The predicted largest scour volume (4,163m^3) released from gravity base foundations is a smaller volume than that associated with the preparation activities for foundation installation (4,752m^3 per foundation), and changes in

[8] MARPOL 73/78 also defines a ship to include "floating craft and fixed or floating platforms" and these are required where appropriate to comply with the requirements similar to those set out for vessels. Thus for sewage the basic equipment and operational requirements set out for other vessels will apply to offshore installations. (http://www.ukooaenvironmentallegislation.co.uk/contents/topic_files/offshore/sewage_foodwaste.htm)

suspended sediment concentrations will be localised (ABPmer, 2011b) (see **Chapter 9** and **Appendix 9.Aiii**). In addition, given that the predicted impact on deterioration of water and sediment quality due to increases in suspended sediment and re-suspension of contaminants during preparation activities are negligible it follows that the effects from scour (a lower release volume per foundation) will also be of **negligible** significance.

10.7.9 It has been assumed (see **Chapter 5**) that should GBS foundations be used then all would be subject to scour protection and subsequently scour of the level described above would not occur (see **Chapter 9**, **Section 9.7**). For other foundation options the level of scour protection would be commensurate to the level of scour risk posed by the option (as detailed in **Chapter 5**).

10.7.10 Therefore, significant scour events will be avoided by the use of scour protection; consequently large scour pits around foundations will not develop. Scour will be limited to secondary scour around the scour protection itself, which will be substantially lower than that described above for an unprotected scenario (which will never occur). The volume of material and area of any secondary scour will be determined in the scour protection plan that will be undertaken prior to construction, based on further survey and detailed design.

10.8 Assessment of Impacts during the Decommissioning Phase

Impacts due to re-suspension of sediments and contaminants

10.8.1 During decommissioning it is anticipated that both inter and intra-array and export cables will be left in situ, reflecting current regulatory thinking. The foundation structures will be removed which could result in disturbance to sediments and any contaminants present. WTG structures will contain fluids and oils, with any leakages that have occurred over the operational life of the project being contained with the structure itself (see **Section 6.10** in **Chapter 5**). Upon removal there is, therefore, a potential for accidental release of any leaked fluids and oils. With careful operating procedures and management, any such releases will be unlikely and will be subject to monitoring and control where if necessary, in addition they will be highly localised and will dissipate rapidly into the receiving environment. As detailed in **Chapter 5**, a decommissioning plan will be established and agreed with the regulators that will ensure that work associated with this phase of the project will fully assess all potential impacts and put in place mitigation measures, where necessary. It is therefore considered that any impacts from decommissioning activities will be **negligible**.

10.9 Inter-relationships

10.9.1 The inter-relationships between the marine water and sediment quality and other physical, environmental and human receptors are inherently considered throughout the Chapter (**Sections 10.6** and **10.7**) as a result of the receptor lead approach to the assessment. For example, sediment and water quality has the potential to be influenced by changes in physical processes as a result of the proposed development. The potential impacts as a result of this indirect effect have been discussed within this Chapter based on the findings of the assessments made in **Chapter 9**.

10.9.2 Similarly any impact on the water and sediment quality from the proposed development has the potential to impact on a number of other receptors, such as benthic ecology and fish resource. The information provided in this Chapter is used in turn by these relevant receptor lead Chapters to establish the potential for and significance of inter-related impacts.

10.9.3 **Table 10.10** summarises where inter-relationships are considered to occur throughout this Chapter.

Table 10.10 Water and sediment quality inter-relationships

Inter-relationship	Section where addressed	Linked Chapters
Construction		
Potential impacts as a result the deterioration in water quality due to the re-suspension of sediments during construction	Section 10.6	Influencing parameter: Chapter 9 Physical Environment Affected parameters: Chapter 12 Marine and Intertidal Ecology, Chapter 13 Fish and Shellfish Resource, Chapter 15 Commercial Fisheries
Potential impacts as a result the deterioration in water quality due to the re-suspension of contaminants during construction	Section 10.6	Influencing parameter: Chapter 9 Physical Environment Affected parameters: Chapter 12 Marine and Intertidal Ecology, Chapter 13 Fish and Shellfish Resource, Chapter 15 Commercial Fisheries
Operation		
Potential impacts as a result the deterioration in water quality due to scour during	Section 10.7	Influencing parameter: Chapter 9 Physical Environment

Inter-relationship	Section where addressed	Linked Chapters
operation		Affected parameters: Chapter 12 Marine and Intertidal Ecology, Chapter 13 Fish and Shellfish Resource
Decommissioning		
Potential impacts due to resuspension of sediments and or contaminants during decommissioning	Section 10.8	Influencing parameters: Chapter 9 Physical Environment Affected parameters: Chapter 12 Marine and Intertidal Ecology and Chapter 13 Fish and Shellfish Ecology

10.9.4 **Chapter 29 Assessment of Inter-relationships** provides a holistic overview of all of the inter-related impacts associated with the project.

10.10 Cumulative Impacts

10.10.1 The unmitigated impacts identified during the construction (**Section 10.6**), operation (**Section 10.7**) and decommissioning phases (**Section 10.8**) of the proposed GWF project that have the potential to result in cumulative effects comprise:

- Deterioration in water and or sediment quality due to accidental spillage of construction fluids, lubricants and or oils; and
- Deterioration in water and or sediment quality due to accidental spillage of fluids, lubricants and or oils during operation.

10.10.2 Cumulative impacts associated with the proposed GWF project may occur on the following levels:

- Interactions between different aspects of the proposed GWF project with other wind farms; and
- Interactions with other activities occurring in the region.

10.10.3 The following paragraphs provide an assessment of the potential for cumulative impact over these varying levels. **Chapter 30 Cumulative Impact Assessment** provides further details specific to the cumulative assessment.

GWF and other wind farm projects

GGOWF

10.10.4 By the time GWF enters construction GGOWF will be fully operational. No significant impacts on water and sediment quality as a result of re-suspension of sediments and contaminants have been identified, and as identified in **Chapter 9** the presence of the GWF together with the GGOWF will have insignificant effects upon the existing hydrodynamic, wave and sedimentological regimes both locally and over a wider area. As a result no cumulative impacts on marine water and sediment quality are anticipated as a result of increases in suspended sediments or mobilisation of contaminants.

10.10.5 In regard to accidental spillages, if these were to occur at both GWF and GGOWF simultaneously there is the potential for a combined and greater impact on marine water and sediment quality. However, with the application of the Project EMMP and adherence to relevant guidance no significant impacts are anticipated at GWF, and it is safe to assume that the same management and control measures will be applied during the operation of GGOWF. Therefore no cumulative impacts are anticipated as a result of accidental spillages at GWF and GGOWF.

Interactions between GWF and other wind farms

10.10.6 No significant impacts on marine water and sediment quality have been identified that have the potential to extend sufficient distance to result in potential cumulative impacts with other wind farm development, the nearest being London Array (19km to the southwest).

Interactions between GWF and other development

10.10.7 Of most relevance to potential cumulative impacts on marine water and sediment quality is marine aggregate extraction, particularly related to the effects associated with any overlaps in dredging activities at the extraction site and installation of turbines and export cables at the proposed GWF site.

10.10.8 The nearest active extraction area to the proposed GWF site is located over 14km away (Long Sand 108/3). Given the localised nature of the effects identified within this Chapter, it is considered that these active aggregate extraction sites are located a sufficient distance from the proposed GWF site so as not to impact upon marine water and sediment quality cumulatively with GWF either during construction, operation or decommissioning.

10.10.9 The only potential source for cumulative impact is from the activities of the aggregate extraction sites that lie in close proximity to the export cable corridor (further discussed in **Chapter 18 Other Human Activities**), those being Area 498 and Area 507 (comprising several sub areas). The closest of these are Area 498 and Area 507/5 which are located less 500m from the GWF export cable corridor. Volker Dredging Ltd and Britannia Aggregates Ltd (Area 498) plan to commence operations in 2013/2014 and will continue for 15 years, so there may be an overlap in their activity and the construction / operation phase of GWF. With regard to Area 507/5 discussions are ongoing with CEMEX in order to agree the final location of GWFL's export cables in relation to this area and no further information is available at the time of writing (October 2011) in regard to the plans for aggregate extraction at Area 507/5.

10.10.10 In regard to construction activities, as discussed in **Section 10.6** cable installation will result in small scale and localised effects on suspended sediment concentrations and therefore even if activities occurred simultaneously or concurrently construction at GWF is unlikely to act cumulatively with aggregate extraction to impact upon marine water and sediment quality . In addition, there is no evidence to show that contaminant concentrations at the site are at levels which have the potential to significantly effect the marine environment.

10.10.11 During operation there is potential for scour effects at GWF and aggregate extraction to cumulatively impact upon marine water and sediment quality. However the impact as a result of potential scour is anticipated to be of negligible significance as a result of relatively localised and small scale effects on suspended sediment concentrations. Therefore there is no pathway for cumulative impacts to occur.

10.10.12 It is not known what aggregate activity will be taking place during decommissioning at GWF, however effects are anticipated to be of a similar nature to the construction phase and if cables are left in situ the potential impacts will be further reduced.

10.10.13 Further evidence of the limited potential for cumulative impacts between GWF and aggregate extraction activities has come from studies to support the GGOWF ES (ABPmer, 2005). Analysis was undertaken on the potential for cumulative effects between the foundation installation process at the GGOWF and aggregate dredging licence areas located approximately 7km from the GGOWF site. A modelling exercise was undertaken which showed that overlapping plumes will be unlikely to occur if aggregate dredging and foundation installation were synchronous (ABPmer, 2005).

10.10.14 Studies show limited contamination levels in the sediments surrounding GWF, with arsenic being the exception. However as discussed in **Section 10.6** elevated levels are expected in this region and are linked to past industrial activities. Water quality in the region has clearly not been effected by the elevated arsenic levels (shown by good water quality results discussed in **Section 10.4**) even though there is a high level of existing activities in the region that could result in mobilisation of arsenic (i.e. dredging, aggregate extraction, other wind farms).

10.10.15 Sizewell A power station (which is in the process of being decommissioned) and Sizewell B have inlet and outlet pipes that extend out to a maximum of 650m from shore (see **Chapter 18**). In addition EDF Energy is currently in the planning stages of the new Sizewell C power station, however there has been no scoping exercise undertaken and no details of the construction programme are available. Impacts associated with cooling water outfalls are primarily related to thermal increases and chemical contaminants, these are unlikely to overlap with the sphere of influence associated with the offshore components of the proposed GWF development. Inshore, only aspects of the construction phase are likely to impact upon marine water and sediment quality (particularly the export cable installation). The assessment presented in this Chapter indicates that impacts during this phase will be of negligible significance with a localised and temporary nature. It is therefore unlikely that there will be any interaction between the two impacts that will result in a significant cumulative impact.

10.10.16 Given the lack of significant and / or problematic contaminant levels at the GWF site and the localised and / or temporary nature of potential disturbance to these sediments from the development phases of GWF (as discussed in **Section 10.6**), no significant cumulative impacts on marine water and sediment quality are anticipated.

10.11 Transboundary Effects

10.11.1 This Chapter has considered the potential for transboundary effects to occur on marine water and sediment quality as a result of the construction, operation or decommissioning of the proposed GWF project. In all cases it is concluded that the potential impacts arising, by virtue of the predicted spatial and temporal magnitude of the effects, would not give rise to significant transboundary effects on the environment of another European Economic Area (EEA) member state. A summary of the likely transboundary effects of the proposed GWF are summarised in **Chapter 31 Transboundary Effects.**

10.12 Monitoring

10.12.1 It is considered that it will not be necessary to carry out any water quality monitoring during the construction, operation and decommissioning of GWF. This is in part due to the impact assessment concluding minimal impacts as a result of the proposed GWF project, together with the absence of compulsory water quality monitoring at the adjacent GGOWF.

10.13 Summary

10.13.1 This Chapter discusses the existing water and sediment quality within the vicinity of the proposed GWF site. No designated bathing waters or shellfish waters are identified in the project vicinity. Existing water and sediment quality are considered in the main to be good, with generally low levels of contamination, with the exception of elevated arsenic levels, which are widespread throughout the southern North Sea.

10.13.2 **Table 10.11** summarises the predicted impacts, mitigation measures and residual impacts from the construction, operation and decommissioning phases of the proposed GWF project. The impacts represent the maximum potential adverse impact as a result of having assessed the worst case (development) scenario for each receptor. Therefore, the predictions made would not be worse (more adverse) should any other development scenario (in line with those provided in **Chapter 5**), to that assessed within this Chapter, be taken forward in the final scheme design.

Table 10.11 Summary of impacts on marine and coastal water quality

Description of Impact	Impact	Mitigation Measures	Residual impact
Construction phase			
Re-suspension of sediments	Negligible	N/A	N/A
Re-suspension of contaminants	Negligible	N/A	N/A
Accidental spillage of construction materials	Minor Adverse	Project EMMP and relevant guidance adhered to.	No Impact
Operation phase			
Accidental spillages	Minor Adverse	Project EMMP and relevant guidance adhered to.	Negligible
Deterioration of water and sediment quality as a result of scour effects at the WTG structures	Negligible	N/A	N/A
Decommissioning phase			
Re-suspension of sediments and contaminants	Negligible	N/A	N/A
Accidental spillages	Minor Adverse	Project EMMP and relevant guidance adhered to.	Negligible

10.13.3 No significant cumulative impacts are anticipated between GWF and other developments / activities and GWFL do not envisage that there will be any requirement for further monitoring of water quality during any phase of the proposed GWF development.

10.14 References

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