Sizewell C Project

Water Discharge Activity Permit Application Appendix D – WFD Compliance Assessment

CONTENTS

TABLES

FIGURES

1 BACKGROUND

1.1 Introduction

1.1.1. SZC Co.[1] is currently developing proposals to build and operate a new nuclear power station, comprising two UK European Pressurised Reactors™ (EPRs), at Sizewell in Suffolk, north of the existing Sizewell B power station; 'the Sizewell C Project'.

1.1.2. The Environmental Permitting (England and Wales) Regulations 2016 define water discharge activities under Schedule 21 Regulation (3)(1)(a) as: the discharge or entry to inland freshwaters, coastal waters or relevant territorial waters of any (i) poisonous, noxious or polluting matter, (ii) waste matter or (iii) trade effluent or sewage effluent. Given the need to discharge trade effluent (cooling water/process effluent), treated sewage effluent and water containing moribund flora and fauna from the fish recovery and return system (FRR)) to surface waters during commissioning and operational phases, the Sizewell C Project requires a Water Discharge Activity (WDA) Permit.

1.1.3. This report is provided in support of SZC Co.'s WDA Permit application to the Environment Agency for the operational phase of the power station, from hot functional testing (HFT) onwards. It assesses whether the proposed commissioning (HFT only) and operational water discharge activities are compliant with the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (SI 2017/407), which implement Directive of the European Parliament and of the Council 2000/60/EC establishing a framework for community action in the field of water policy (generally known as the Water Framework Directive (WFD)) in the UK. SZC Co. will make a separate application for construction discharges.

1.1.4. In addition to this WFD compliance assessment, the WDA Permit application is accompanied by separate **Information for the Habitats Regulations Assessment** (presented as **Appendix C** of the permit application).

1.1.5. The objectives of this WFD compliance assessment are to:

- identify the WFD water bodies that potentially could be affected by the commissioning (HFT) and operational water discharge activities;

[1] NNB Generation Company Limited, whose registered office is at 90 Whitfield Street, London, W1T 4EZ; referred to in this document as 'SZC Co.'.

- assess the potential for the commissioning (HFT) and operational water discharge activities to result in a deterioration in the status of WFD water bodies or prevent status objectives being achieved in the future; and
- determine whether the commissioning (HFT) and operational water discharge activities are compliant with the requirements of the WFD.

1.2 The Water Framework Directive Compliance Assessment Process

1.2.1. The WFD was transposed into national law by means of the Water Environment (WFD) (England and Wales) Regulations 2003. These regulations have recently been updated by the Water Environment (WFD) (England and Wales) Regulations 2017. The WFD Regulations implement the WFD, from designation of all surface waters (rivers, lakes, transitional (estuarine) waters, coastal waters (out to one nautical mile) and ground waters) as water bodies, to the requirement for every water body to achieve good ecological status (GES) or good ecological potential (GEP) for heavily or artificially modified water bodies (A/HMWBs).

1.2.2. Unlike the EU Birds and Habitats Directives (EC Directive 2009/147/EC on the Conservation of Wild Birds and EC Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, respectively), which apply only to designated sites, the WFD applies to all bodies of water, including those that are man-made.

1.2.3. Given that the commissioning and operational discharges are to the marine environment only, this assessment focusses on transitional and coastal water bodies (TRaC). Where there is the potential for effects on adjoining fresh water bodies, consideration is given within an additional section to the further assessment.

1.2.4. Some surface waters require special protection under other European legislation. The WFD therefore brings together the planning processes of a range of other European Directives, such as the Bathing Waters Directive. These Directives establish protected areas to manage, where applicable, water, nutrients, chemicals, economically significant species and wildlife, and have been brought in line with the planning timescales of the WFD.

1.2.5. The Sizewell C Water Framework Directive Compliance Assessment Strategy (Ref. 1.1) (**WFD Compliance Assessment Part 1**, **Appendix 1A** (Doc Ref. 8.14)) set out the proposed approach to developing and providing the information required for the WFD compliance assessment. However, as the strategy was produced and agreed in 2015, necessary updates have been made to the method contained within this document. This includes updates in response to comments received from the Environment Agency during several periods of consultation and new guidance now available (see **section 3**).

1.3 Roles and Responsibilities

1.3.1. The Environment Agency is the competent authority for WFD implementation in England, and therefore must assess plans and projects to ensure that they are compliant with the requirements of the WFD.

1.3.2. Consultation on the technical work to support this assessment has been undertaken through the Sizewell C Marine Technical Forum[2], of which the Environment Agency is a member. A number of specific WFD workshops (with the Environment Agency specifically) have also been undertaken and comments received have been fed into the development of this report.

1.4 Structure of the WFD Compliance Assessment

1.4.1. The report is divided into seven sections:

- **Section 1** (this section) describes the purpose of the assessment.
- **Section 2** provides details of the proposed commissioning and operational water discharge activities.
- **Section 3** sets out the guidance requirements for the WFD compliance assessment.
- **Section 4** presents the results of the screening and scoping exercise undertaken for Stage 1 and Stage 2 of the WFD compliance assessment.
- **Section 5** presents the results of Stage 3 of the WFD compliance assessment.
- **Section 6** provides a cumulative effects assessment.
- **Section 7** presents a summary of the WFD compliance assessment.

[2] The Marine Technical Forum is an independently chaired forum made up of the Environment Agency, Marine Management Origination, Natural England and East Suffolk Council. The Royal Society for the Protection of Birds and Eastern Inshore Fisheries Conservation Authority frequently attend as ‘guest members’.

2 PROJECT DESCRIPTION

2.1 Introduction

2.1.1. The following subsections describe the main elements of the permanent development which are relevant to the commissioning (HFT) and operational WDA Permit application.

2.2 Cooling water infrastructure, pumphouse and associated buildings

a) Cooling water intake and outfall tunnels and associated headworks

2.2.1. Seawater for cooling the power station would be abstracted via a series of intake structures and tunnels. Each UK EPR^{TM} reactor unit would have a single dedicated 6m internal diameter intake tunnel extending approximately 3km out under the seabed. At the seaward end of each tunnel, two vertical shafts would extend upwards to provide a connection to the sea via a seabed-mounted intake head (one head per shaft). Each of the intake heads would comprise concrete and steel headworks designed to abstract seawater at a depth of only a few metres above the seabed. A ‘velocity capped’ design, or a simplified version of the Hinkley Point C design, is proposed.

2.2.2. A single 8m internal diameter outfall tunnel serving both reactor units would return the cooling water to sea, with either one or two vertical shafts at its seaward end each leading upwards to a single outfall headworks, again mounted on the seabed.

b) Forebay

2.2.3. There would be one forebay for each UK EPR^{TM} reactor unit, each served by an intake tunnel. The forebays serve to smooth the water flow into the cooling water system accounting for the tidal range of Greater Sizewell Bay (GSB).

c) Cooling water pumphouses

2.2.4. There would be one cooling water pumphouse for each UK EPR^{TM} reactor unit, which would draw water from the forebays. The cooling water pumphouses would contain equipment supplying seawater as coolant for:

- The nuclear and conventional islands’ auxiliary and safety cooling water systems.

- The condenser cooling system that cools the turbine exhaust steam and condenses it to liquid water for reuse as feed water within the secondary circuit.

2.2.5. Each cooling water pumphouse would incorporate screening systems including drum and band screens specifically designed to prevent the blockage of key elements of plant further downstream within Sizewell C.

2.2.6. Each drum screen would be made up of a horizontal axis drum whose outer circumference would be made up of panels of a smooth ('fish friendly') fine mesh. The inner circumference of each drum screen would have "fish-friendly" elevator ledges or 'buckets', which would lift debris and marine organisms including fish. Continuous wash-water sprays would then flush the collected material into collection troughs which in turn flush into a gutter for onward flow to the filtering debris recovery pit. In normal operation, the drum screens would rotate at a low speed but if there is any indication of blockage both the rate of rotation and the flow rate of wash-water would be increased.

2.2.7. Each of the cooling water pumphouses would also have two sets of rotating band screens to remove finer debris from the lateral train, prior to passage through the fine bore heat exchanger systems that follow. The band screens would be made up of a continuous belt of linked mesh plates which are rotated around two horizontal rollers, one positioned at the foot of the waterway and one above, and similarly aligned with a catch bucket and gully for fish return that discharges into the filtering debris recovery pit.

d) Filtering debris recovery and fish recovery and return system

2.2.8. There would be plant for managing screen debris positioned near to each cooling water pumphouse. It would consist of a pre-discharge section and a pre-discharge basin. The pre-discharge section would involve the continuation of the series of washwater gullies that would run from the drum and band screens to collect fish and other marine organisms directed from the screens, together with materials from the raking screens.

2.2.9. Recovered fish and debris would be returned to the sea under gravity via a dedicated FRR tunnel for each EPR™. The FRR system would be fully integrated within the cooling water infrastructure and its purpose would be to recover and return fish and other marine organisms that are entrapped in the cooling water system and caught on both the drum and band screens.

e) Outfall pond (surge chamber)

2.2.10. All abstracted sea water, which has served its cooling function and would thus have been warmed, would be conveyed back to the marine environment via an outfall pond (surge chamber), open to atmosphere that discharges into an outfall tunnel. The outfall tunnels leading from each of the outfall ponds (one per UK EPR™ reactor unit) would then join to form a single outfall tunnel, discharging to sea.

2.3 Other plant

2.3.1. Other development relevant to the WDA permit application is covered in Table 2.4.1 of the main WDA permit application (Document Ref. 100232385).

2.3 Operational Discharges

a) Cooling water system

2.3.1. Sizewell C would require a continuous supply of seawater via the two intake tunnels at $132 m^3 s^{-1}$ at mid tide level for cooling, of which approximately 91% would supply the main cooling water systems and the remainder would supply the essential and auxiliary cooling water systems. After being used within the power station, the seawater would then be discharged back to the GSB, via the outfall tunnel, with a mean excess temperature of 11.6°C above ambient background.

2.3.2. Returned abstracted water would be the main waste stream from Sizewell C and would represent approximately 99.9% by volume of the total overall daily discharge of non-radioactive effluent. Several smaller waste streams would be combined with the returned abstracted cooling water before being discharged and these (alongside the cooling water) are detailed in **Table** 2.1. Note that all operational liquid effluents listed A to G would be discharged to the sea via the outfall ponds and the cooling water outfall. The seawater volumes (waste stream H) associated with the FRR system would use two dedicated discharge lines to the sea, closer inshore.

Table 2.1 Proposed waste streams

Waste Stream	Effluent type	Brief overview
A. Cooling water	Trade – returned abstracted water	Cooling water return – characterised by thermal content and seasonally dosed chlorine from an electro-chlorination plant to prevent biofouling of the condensers and essential plant. A small flow from the abstracted sea water serves the FRR and

Waste Stream	Effluent type	Brief overview
		will be discharged through separate outfalls as Stream H.
B. Nuclear island	Trade – known volume	From operations within the nuclear island – excludes steam generator blowdown system; includes reactor boron water make-up system. Discharged with Stream A.
C. Steam generator blowdown	Trade – known volume	Effluent from steam generator blowdown system. Could potentially contain hydrazine, ammonia, morpholine and ethanolamine to prevent corrosion and control pH. Discharged with Stream A.
D. Conventional island	Trade – known volume	Effluent from turbine hall and uncontrolled area floor drains, excluding effluent from the steam generator blowdown system. Discharged with Stream A.
E. Site drainage	Trade – known volume	Includes drainage from the road and roof surface together with atmospheric condensate from chiller and uncontaminated water from the oily water network. Discharged to the forebay. Penstocks closed in event of significant oil/chemical spill or fire. Waste separated from various process streams sent for offsite disposal. Combines with the main cooling water of Stream A at the forebay and consequently a small proportion discharges to Stream H
F. Production of demineralised water	Trade – known volume	Effluent from the production of demineralised water. Would generate effluents characterised by high alkaline or acidity as a result of use of sulphuric acid and sodium hydroxide to regenerate resins. Batch treatment using acids and alkalis would result in a neutral pH. Includes liquid from the processing system. Discharged with Stream A.
G. Domestic sewage	Domestic sewage – known volume	Sanitary effluent from administration and mess facilities which would be treated before joining the main discharge. Discharged with Stream A.
H. Effluent from the FRR system	Trade – known volume	Comprises water used to operate the FRR system that returns fish and other organisms to the sea via a dedicated fish

Waste Stream	Effluent type	Brief overview
		return outfall, one for each EPR™ unit. Includes the return of dead and moribund biota. Contains uncontaminated inputs from Stream E, which is discharged to the forebay.

2.3.3. Process effluent would be produced to remove waste from the plant systems and to maintain the best operating conditions and maximise efficiency. There may be a requirement to discharge sediment due to periodic desilting of the forebays. Should desilting be required, the preferred option would be to return the sediment to the cooling water system for discharge back out to sea.

2.3.4. Various treatment systems to reduce contaminant concentrations and to enable recycling of boron and water in the primary circuit would be in place. Each effluent would be received in monitoring tanks and then sampled before being discharged. If the sample exceeds environmental permit limits then the effluent would be re-circulated through the treatment system and either discharged when within environmental permit specification or tankered offsite for licensed disposal.

2.3.5. The operation of Sizewell C includes several scenarios. These can be summarised as follows:

- Standard operation – this refers to the situation when both units are operating normally at their full capacity with all four cooling water pumps operational.
- Outage – this refers to the situation when one unit is shut down for planned routine maintenance and/or refuelling. An outage would be expected to take place every 18-22 months and typically last for two weeks.
- Maintenance test – this refers to a theoretical situation where both units are operating at 100% with only a single cooling water pump serving each unit – that is only 50% cooling water capacity. Note that the waste heat from the reactors remains approximately the same, causing the excess temperature at the outfall to rise from 11.6°C to 23.2 °C. This is unlikely to occur but represents a worst case in terms of cooling water flow and is used to characterise short term (24 hour) discharges.

b) Chlorination

2.3.6. Based on the risk of biofouling at Sizewell, chlorination of the cooling water system and critical plant would be required. Operational policy is to continuously dose during the growing season to achieve a minimum Total Residual Oxidant (TRO) dose of 0.2mgl^{-1} in critical sections of the plant and at the inlet to the condensers. Testing of this system would be undertaken during commissioning but it is assumed that this would only occur once the full cooling water system is in place and operational.

2.3.7. The chlorination strategy is likely to be continuous dosing during the growing season using an electrochlorination plant (rather than intermittent dosing) as part of waste stream. It is currently expected that the Sizewell C intake heads, tunnels and forebays would not be chlorinated. The expected discharges from the chlorination process include:

- Residual oxidants in the form of free chlorine and chlorinated compounds; and
- trihalomethanes, which are present as bromoform.

2.3.8. For Sizewell C, the TRO concentration at the outfall would depend on the chlorination strategy applied within the power station. BEEMS Technical Report TR316 (Ref. 1.2) presents an analysis of the possible chlorination options for Sizewell C and a recommendation for a preferred strategy that is based upon minimising environmental effects whilst maintaining the safe operation of the plant. Chlorination would only be undertaken when sea water temperatures are above 10ºC, and therefore the risk of biofouling is greater.

c) Commissioning

2.3.9. HFT tests the system under high temperature and pressure prior to the loading of nuclear fuel into the reactor. The chemical substances discharged during the hot functional testing would be the same as those discharged during the normal operation of Sizewell C and would be discharged via the cooling water outfall. There would not be any radioactive effluents produced.

d) FRR system

2.3.10. The FRR would provide a safe return of the more robust organisms from the drum and band screens directly into the marine environment and would be designed to minimise impacts on impinged fish and invertebrate populations. However, some species such as clupeids are highly sensitive to mechanical damage caused by impingement on the screens and incur high mortality rates. This material would be returned to sea via the FRR outfalls.

2.4 Summary of source terms for the assessment of water quality effects

a) Flows

2.4.1. The mean cooling water intake flow required is $132m^3s^{-1}$. For the discharge associated with this, it is assumed that the maximum annual loadings of any parameters from the waste streams outlined in **section 2.3** would be discharged at a constant rate over the course of a year and be mixed in the cooling water flows prior to discharge to the environment.

2.4.2. For screening purposes (the first stage of assessment for chemical parameters – see **section 5.5** for further details) and under normal operational flow, it is assumed that the worst-case cooling water intake (and therefore discharge) flow, into which all discharges would be mixed, would be $116m^3s^{-1}$. This is based on a single EPR^{TM} unit having a minimal operational cooling water flow of $58m^3s^{-1}$ under low tide conditions. Screening also considers the maintenance scenario RF2 (**section 2.3**) which refers to a theoretical situation where both units are operating at 100% with only a single cooling water pump serving each unit; that is only 50% cooling water capacity. This equates to $66m^3s^{-1}$ at mid tide level. Where parameters fail the screening tests, detailed modelling is undertaken for more realistic flow scenarios.

2.4.3. Earlier versions of the modelled parameters (i.e. those that failed the screening test) were based on an unconfirmed flow of $125m^3s^{-1}$ (with a 24-hour loading equivalent $62.5m^3s^{-1}$). Where increased loadings of parameters have been identified with the increase in confirmed flow to $132m^3s^{-1}$, the modelling has been revisited and outputs recalculated. For example, chlorination modelling using the value of $125m^3s^{-1}$ as a maximum discharge did not account for inputs from all circuits within the system, some of which were chlorinated; so, chlorine related inputs were remodelled for the increased $132m^3s^{-1}$ to allow for the additional inputs. However, for hydrazine, the additional $7m^3s^{-1}$ does not contain any additional hydrazine so the original modelling represents a potential worst case and this modelling was not redone.

2.4.4. The assessment for the thermal discharge has also not been revisited. This is because the small increase in flow associated with a $132m^3s^{-1}$ intake flow would not significantly alter the thermal output modelled based on the $125m^3s^{-1}$ intake flow. On this basis, the thermal uplift in the discharged cooling water is assumed to be 11.6˚C ($125 m^3 s^{-1}$) and 23.2˚C for the maintenance scenario ($62.5 m^3 s^{-1}$).

b) Chemical Substances

2.4.5. Full detail on the source terms for the assessment undertaken on the potential effects of all discharges to the marine environment is provided in BEEMS Technical Report TR306 (Ref. 1.3).

2.4.6.

2.4.7. **Table** 2.2 shows the proposed loading of the different chemicals to be used during operation as 24-hour and annual loads. The thermal uplift in the discharged cooling water is assumed to be 11.6˚C for normal operational flow and 23.2˚C for the maintenance scenario.

Table 2.2 Summary of source terms used to inform the WFD compliance assessment for the operation of the power station (Ref. 1.3)

Substance	Circuit conditioning (kg y^{-1})	Sanitary waste discharge kg y^{-1})	Producing demineralised water (kg y^{-1})	Maximum annual loading (kg y^{-1})	Maximum 24 hour loading (kg d^{-1})
Boric acid[3]	14000	-	-	14000	5625
Boron	2448	-	-	2448	984
Lithium hydroxide	8.8	-	-	8.73	4.4
Hydrazine	24.3	-	-	24.3	3
Morpholine	1680	-	-	1674	92.3
Ethanolamine	920	-	-	919	24.75
Nitrogen as N	10130	1595	-	11725	332
Unionised ammonia (NH_3)	-	-	-	958	27
Phosphates	800	-	-	790	352.5

[3] Dissociation boric acid in seawater so equivalent boron concentration in discharge is presented and assessed

Substance	Circuit conditioning (kg y^{-1})	Sanitary waste discharge kg y^{-1})	Producing demineralised water (kg y^{-1})	Maximum annual loading (kg y^{-1})	Maximum 24 hour loading (kg d^{-1})
Detergents		-	624	624	-
Suspended solids	2800	2080	88000	92879	870
BOD	-	1387	-	1387	3.8
Chemical Oxygen Demand (COD)	5050	-	-	5050	330
Aluminium	5.26	-	-	5.26	1.1
Copper	0.42	-	-	0.42	0.08
Chromium	8.37	-	-	8.37	1.7
Iron	34.97	-	46000	46035	257
Manganese	3.33	-	-	3.33	0.67
Nickel	0.44	-	-	0.44	0.09
Lead	0.3	-	-	0.3	0.07
Zinc	5.6	-	-	6.0	1.2
Chloride	-	-	87100	87100	450
Sulphates	-	-	98400	98400	2000
Mercury[4]	-	-	-	0.099	0.001
Cadmium[4]	-	-	-	0.37	0.005
Sodium	-	-	52400	52400	855
Amino Tri-Methylene Phosphonic Acid (ATMP)	-	-	9100	9100	45

[4] Cadmium and mercury loading are derived from trace contamination of raw materials.

Substance	Circuit conditioning (kg y^{-1})	Sanitary waste discharge kg y^{-1})	Producing demineralised water (kg y^{-1})	Maximum annual loading (kg y^{-1})	Maximum 24 hour loading (kg d^{-1})
Hydroxyethane diphosphonic Acid (HEDP)	-	-	890	890	4.5
Acetic acid	-	-	14	14	0.1
Phosphoric acid	-	-	12	12	0.1
Sodium polyacrylate	-	-	8030	8030	40
Acrylic acid	-	-	165	165	1
Chlorine TRO	-	-	-	-	150ugl^{-1}
Chlorine bromoform	-	-	-	-	190ugl^{-1}

c) Discharges from the FRR system

2.4.8. Calculation of the total biomass of moribund biota that potentially would be discharged from the FRR system is based on the level of abstraction (pump rates) for the planned Sizewell C intakes and information on the seasonal distribution of species, as well as the length weight distribution of the species impinged for Sizewell B (Ref. 1.4 and Ref. 1.5).

2.5 Supporting information

2.5.1. There are a number of technical reports which provide the majority of the information used to inform this compliance assessment. These reports are summarised in **Table** 2.3.

Table 2.3 Summary of the main sources of data/information used in this assessment

Title	Technical Report reference	Description	Application to the WFD
Synthesis of evidence for Sizewell C Water Framework Directive (WFD) and Habitats Regulations Assessment (HRA) marine assessments BEEMS Technical Report TR483 (Ref. 1.6)	TR483	Contains a summary of specific evidence to inform the HRA and this WFD compliance assessment	Summary of WFD information relevant to this assessment
Thermal Standards for cooling water from new build nuclear power stations BEEMS Science Advisory Report SAR008 (Ref. 1.7)	SAR008	Considered interim temperature guidelines for assessing thermal plumes in UK Technology for Agriculture and Genetics (UKTAG)	Acceptance of proposed standards as outlined in guidance with the exception of high status to be modified from 20°C to 23°C
Sizewell C Discharges H1 Assessment – supporting data report, BEEMS Technical Report TR193 (Ref. 1.8)	TR193	Predicted no effect concentration calculations for parameters which are not included under WFD legislation Screening and detailed assessment of all potential chemicals in discharge. Source term derivation and ssessment in relation to decaying fish discharged from the FRR system (specifically appendix H)	Whilst some parameters are not included in WFD legislation there is still the potential that they could impact on other WFD compliance parameters, such as biology, and are therefore relevant to this compliance assessment
Sizewell supplementary water quality monitoring data 2014/15, BEEMS Technical Report TR314 (Ref. 1.9), and Sizewell Marine Water Quality monitoring	TR189 and TR314	The water quality monitoring campaigns (defined periods of monitoring) for marine water quality are described in detail within TR189 and TR314 (an update to TR189 that includes data on selected	Provides baseline against which parameters are assessed

Title	Technical Report reference	Description	Application to the WFD
Final Summary Report, BEEMS Technical Report TR189 (Ref. 1.10)		determinands from monitoring conducted in 2014/15)	
Sizewell Thermal Plume Modelling Stage 2A Review; Selection of Preferred Sizewell C Cooling Water Configuration, BEEMS Technical Report TR301 (Ref. 1.11)	TR301	Provides background to temperature baseline and output of General Estuarine Transport Model (GETM) modelling for both operational and maintenance scenarios	Provides extent of potential plume which informs areas over which cooling water discharge would impact
Sizewell Thermal Plume Modelling: GETM Stage 3 results with the preferred Sizewell C cooling water configuration, BEEMS Technical Report TR302 (Ref. 1.12)	TR302	Provides background to temperature baseline and output of GETM modelling for both operational and maintenance scenarios	Provides extent of potential plume which informs areas over which cooling water discharge would impact
Sizewell Water Quality Literature BEEMS Technical Report TR131 (Ref. 1.13)	TR131	Provides historic information on background water quality for the Suffolk coastal waterbody This document also provides details of all the relevant Screening EQS values for saltwater and the legislation and guidance documents from which they are derived	Details of water quality sampling and derivation of baseline values against which WFD assessment is undertaken
Sizewell benthic ecology characterisation/Coralline Crag Characterisation, BEEMS Technical Reports TR348 (Ref. 1.14) and TR473 (Ref. 1.15)	TR348/ TR473	Characterises the benthic fauna of the Greater Sizewell Bay area based on data collected from a series of onshore and offshore surveys implemented between 2008 and 2017 Features of the system are identified and information is provided on their natural variability to establish a baseline for assessing impacts	Details of habitats within the WFD water body

3 ASSESSMENT METHOD

3.1 Overall method

3.1.1. The assessment included herein has been carried out in line with the Environment Agency's 'Clearing the Waters for All' Guidance (Ref. 1.17) and takes into account Planning Inspectorate Advice Note 18: The WFD (Ref. 1.18).

3.1.2. As required by both sets of guidance, this assessment includes the following three stages:

- Stage 1: Screening;
- Stage 2: Scoping; and
- Stage 3: Further assessment.

3.1.3. These stages are summarised in **Table** 3.1.

Table 3.1 Summary of WFD stages

Stage	Name	Description
Stage 1	Screening	Initial screening to identify relevant water bodies in the study area and activities to be assessed. Water bodies will be selected for inclusion in the early stages of the compliance assessment with reference to the 2015 River Basin Management Plans (RBMP) (as presented in the online Catchment Data Explorer (Ref. 1.16).
Stage 2	Scoping	Identifies whether there is potential for deterioration in water body status or failure to comply with WFD objectives for any of the water bodies identified in Stage 1. This scoping assessment is usually undertaken separately for each water body and each activity and adheres to the scoping questions detailed within the Environment Agency's 'Clearing the Waters for All' Guidance (Ref. 1.17). In all cases, the water body and activity under assessment will be progressed to further assessment (Stage 3) if the answer to one or more of the scoping questions is 'Yes', but only for those quality elements that could potentially be impacted. Conversely, if the answer to a scoping question is 'No' or enough information can be provided at this stage to scope the issue out, the quality element is scoped out of further assessment. Note that activities will only be scoped out if there is clear, definitive evidence that they will not adversely affect a particular quality element. Where the quality element under consideration is fish (i.e. a mobile species covering a large area), a wider geographical area is considered.
Stage 3	Further assessment	The Stage 3 assessment determines whether the activities and/or project components that have been put forward from the Stage 2 scoping assessment will cause deterioration and whether this deterioration will have a significant non-temporary effect on the status of one or more WFD quality elements at water body level. If it is established that an activity and/or project component is likely to affect status at water body level (that is, by causing deterioration in status or by preventing achievement of WFD objectives and the implementation of mitigation measures for HMWBs), or that an opportunity may exist to contribute to improving status at a water body level, potential measures to avoid the effect or achieve improvement must be investigated. This stage considers such measures and, where necessary, evaluates them in terms of cost and proportionality. Note that this stage is referred to as a WFD Impact Assessment in the Planning Inspectorate guidance. Consideration of the potential for cumulative impacts is also included in this stage.

3.2 Determination of Deterioration

3.2.1. Any deterioration identified must be considered within the context of the water body, in terms of the scale and magnitude of the impact as well as the timescales over which the impact would occur. However, there is currently no definitive technical guidance on how deterioration in the status of water bodies should be assessed. Where applicable, therefore, expert judgement based on the information provided in technical reports is used for this assessment.

3.2.2. Should deterioration be predicted, it must be considered in line with the findings of the 2015 EU Court of Justice ruling (the 'Bund' ruling) which precludes the authorisation of a project which may cause the deterioration of the status of a body of water and/or jeopardise the attainment of good overall status[5]. The court also advised the deterioration of status is established as soon as the status of at least one of the quality elements falls by one class, even if the change does not result in a fall in classification of the water body as a whole (note that this applies unless the water body is already in the lowest status class in which case any deterioration is considered to be deterioration in status under WFD).

3.2.3. Since the Environment Agency's policy of 'no deterioration' applies to WFD compliance assessments, it is important to consider all levels of deterioration from short term impacts to potentially long-term changes to water body status classifications. This assessment has, therefore, considered the potential for between class, within class and temporary deterioration in water body status.

3.2.4. In the event that an activity is assessed as likely to cause a deterioration in class status, and no suitable measures can be identified to mitigate the potential adverse impacts of the project assessed in Stage 3, it may be necessary to undertake an Article 4.7 assessment (noting that the overall ethos of the project is to prevent deterioration in water body status and avoid the need for an application for an exemption under Article 4.7 of the WFD). To determine the scope of this assessment, consultation with the Environment Agency would be required and will include:

- an assessment of whether the project can be classified as being of imperative overriding public interest and if the benefits to society resulting from the project outweigh the local benefits of WFD implementation;

[5] Bund fur Umwelt und Natursutz Deutschland eV v Bundesrepubllk Deutschland (2015) EUECJ C-461-13

- an assessment of whether all practicable steps to avoid adverse impacts have been taken. These steps are defined as those that are technically feasible, not disproportionately costly, and compatible with the overall requirements of the project; and
- an assessment of whether the project can be delivered by an alternative, environmentally better option. This option will need to be technically viable and not disproportionately costly to be deemed as feasible.

3.2.5. In the event that no suitable measures can be identified to mitigate the potential adverse impacts, it may be necessary to apply for a derogation under Article 4.7 of the WFD. Consultation with the Environment Agency would be required to determine the scope of this assessment and the scope of reporting that is required to be incorporated into the RBMP, but following the guidance presented in Planning Inspectorate (PINS) (1.18), it will demonstrate that:

- All practicable steps are to be taken to mitigate the adverse impacts on the water body concerned;
- The reasons for modifications or alterations are specifically set out and explained in the RBMP;
- (1) There is an overriding public interest in the proposed development, and/or (2) its benefits outweigh the benefits of the WFD objectives; and
- The benefits of the project cannot be achieved by a significantly better environmental option.

3.2.6. Any requirements for an Article 4.7 derogation will be identified during Stage 3 and discussed in detail with the Environment Agency prior to the permit application submission.

4 STAGES 1 AND 2: SCREENING AND SCOPING

4.1 Stage 1: Screening

4.1.1. This section identifies the individual activities that potentially could impact on WFD compliance parameters as a result of WDA activities. It also describes the baseline characteristics of the WFD water bodies against which potential impacts on WFD compliance will be assessed.

a) Identification of activities to be assessed

4.1.2. The WDA activities that could potentially impact on WFD compliance parameters have been identified as follows:

- discharge of seawater at elevated temperature (waste stream A – thermal properties only);
- discharge of process chemicals during commissioning/operation (trade effluents) (waste streams A to F – chemical parameters only);
- discharge of sewage effluent during operation (waste stream G); and
- discharge of polluting matter from the FRR system (waste stream H).

4.1.3. Note that the first three activities would all discharge via the cooling water outfall and, therefore, all from the same location. As a result, the activities have been combined for the purposes of the scoping assessment. A second activity has been identified relating to discharges of polluting matter from the FRR system. Two activities, therefore, have been carried forward to scoping as follows:

- O1 Operational discharge from cooling water outfall (waste streams A to G).
- O2 Operational discharge of polluting matter from the FRR system (waste stream H).

b) Identification of water bodies

4.1.4. It is acknowledged that the potential area over which quality elements could be impacted is potentially much larger geographically than WFD water body boundaries. To address this, the assessment commences with the selection of the WFD water body within which the activities would occur. Should no pathway for effect be identified within this WFD water body, then no pathway for effect can be concluded for adjoining water bodies. Where a potential pathway for effect is identified, adjacent WFD water bodies are considered in the 'Further Assessment' stage (Stage 3).

4.1.5. The WFD water body within which the activities occur is the Suffolk coastal WFD water body (GB650503520002) shown in **Figure 4.1**. Protected Areas for this water body are also shown in **Figure 4.2**.

4.1.6. Data for this water body have been obtained directly from the Environment Agency to ensure the most up to date information has been used for this assessment. This was supplemented with information presented online in the Catchment Data Explorer (Ref. 1.16) and the 'Cycle 2 Extended Water Body Summary Report' produced for the water body[6]. The information gathered is presented in **Table** 4.1.

Table 4.1 Summary of data for Suffolk Coastal water body

Parameter	Information
WFD water body name	Suffolk
Water body ID	GB650503520002
River basin district name	Anglian
Water body type	Coastal
Water body total area (hectares (ha))	14653.27
Overall water body status (2016)	Moderate
Ecological status	Moderate
Chemical status	Good
Target water body status and deadline	Moderate (2027)
Hydromorphology status of water body	Not assessed
Heavily modified water body and for what use	Coast protection and flood protection

[6] Data Catchment Explorer. Environment Agency. Accessed 26th June 2019. Available online at http://environment.data.gov.uk/catchment-planning/

Parameter	Information
Higher sensitivity habitats present[7]	Polychaete reef (11.56ha) and saltmarsh (197.48ha)
Lower sensitivity habitats present[8]	Cobbles, gravel and shingle (1929.57 ha), intertidal soft sediment (816.45 ha), rocky shore (1.77ha) and subtidal soft sediments (10568.95ha)
Phytoplankton status	Good
History of harmful algae	Not monitored
Mitigation measures	None identified
WFD protected areas within 2km (this also includes sites which could potentially be within 2km of any plume)	See **Figure 4.2**

4.2 Stage 2: Scoping

4.2.1. This section presents the scoping assessment undertaken for the WFD water body, Suffolk, identified in **section 4.1** of this report.

4.2.2. **Table 4.2** (activity O1) and **Table 4.3** (activity O2) present the outcome of the scoping stage as required by the 'Clearing the Waters for All' Guidance (Ref. 1.17). In all cases, the water body and activity under assessment will be progressed to Stage 3 if the answer to one or more of the scoping questions is "Yes", but only for those quality elements that potentially could be impacted.

4.2.3. Conversely, if the answer to a scoping question is "No", the quality element is scoped out of Stage 3. Note that quality elements have only been scoped out if there is clear, definitive evidence that they would not be affected (i.e. there is no pathway for effect).

4.2.4. Based on **Table 4.2**, the following WFD compliance parameters have been scoped in for O1:

[7] For WFD assessment purposes, higher sensitivity habitats are: chalk reef; clam, cockle and oyster beds; intertidal seagrass; maerl; mussel beds, including blue and horse mussel; polychaete reef; saltmarsh; subtidal kelp beds; and subtidal seagrass.
[8] Lower sensitivity habitats are: cobbles, gravel and shingle; intertidal soft sediments like sand and mud; rocky shore; subtidal boulder fields; subtidal rocky reef; and subtidal soft sediments.

- Biology – habitats and fish (indirect effects on transitional water bodies only);
- Water quality – physico-chemistry and chemicals (includes phytoplankton);
- Invasive non-native species (INNS); and
- Protected Areas – European Designated Sites, Nitrate Sensitive Areas and Bathing Waters.

4.2.5. Based on **Table 4.3**, the following WFD compliance parameters have been scoped in for O2:

- Biology – habitats and fish (indirect effects on transitional water bodies only);
- Water quality – physico-chemistry (includes phytoplankton); and
- Protected Areas – European Designated Sites, Nitrate Sensitive Areas and Bathing Waters.

Table 4.2 Output of scoping phase for O1 (waste streams A to G)

WFD quality element	Scoping question	Yes	No	Comment
Hydromorphology	Could the activity impact on the hydromorphology (for example morphology or tidal patterns) of a water body at high status?		✓	The discharge of commissioning, cooling and waste water would not impact on hydromorphological parameters
	Could the activity significantly impact the hydromorphology of any water body?			
	Is the activity in a water body that is heavily modified for the same use as your activity?		✓	The water discharge is not related to flood or coastal protection
Biology (habitats)	Is the footprint (a footprint may be a temperature or sediment plume) of the activity 0.5 km^2 or larger?	✓		There is the potential that the plume from the cooling water outfall could be greater than 0.5km^2 and could affect lower and higher sensitivity habitats
	Is the area of the activity greater than 1% or more of the water body's area?			
	Is the activity within 500m of any higher sensitivity habitat?			
	Is the activity 1% or more of any lower sensitivity habitat?			

WFD quality element	Scoping question	Yes	No	Comment
Biology (Fish)	Is the activity 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 migrating through the estuary?	✓		Although ‘fish’ is not a compliance parameter for coastal water bodies, this is ‘scoped in’ so the potential risk associated with an impact on fish migrating between transitional water bodies either side of the coastal water body can be assessed
	Could the activity 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)?			
	Could the activity cause entrainment or impingement of fish?		✓	The discharge would not lead to entrainment or impingement
Water Quality (Phytoplankton and harmful algae)	Could the activity affect water clarity, temperature, salinity, oxygen levels, nutrients or microbial patterns continuously for longer than a spring neap tidal cycle (about 14 days)?	✓		The proposed discharge could increase temperature and potentially introduce nutrients/bacteria and additional suspended solids concentrations for greater than 14 days (the operational timeframe for the station is 60 years)
	Is the activity in a water body with a phytoplankton status of moderate, poor or bad?		✓	The water body is at good status
	Is the activity in a water body with a history of harmful algae?		✓	Not monitored; the potential for impacts on water quality, however, is considered as part of the

WFD quality element	Scoping question	Yes	No	Comment
				consideration of effects on the water quality elements
Water Quality (question has been selected which relates to point source discharges and mixing zones)	Are the chemicals released are on the Environmental Quality Standards Directive (EQSD) list?	✓		A number of substances on the EQSD would be released within the discharge
Protected Areas	Is the activity within 2km of any WFD protected area?	✓		European Designated Sites, nitrate sensitive areas and bathing waters could be located within 2km of the plume
INNS	Could the activity introduce or spread INNS?	✓		There is the potential that INNS species growth within the thermal footprint could be exacerbated where present.

Table 4.3 Output of scoping phase for O2 (waste stream H)

WFD quality element	Scoping question	Yes	No	Comment
Hydromorphology	Could the activity impact on the hydromorphology (for example morphology or tidal patterns) of a water body at high status?		✓	The operational discharge of polluting matter from the FRR system would not impact hydromorphological parameters
	Could the activity significantly impact the hydromorphology of any water body?			
	Is the activity in a water body that is heavily modified for the same use as your activity?		✓	The discharge is not related to flood or coastal protection
Biology (habitats)	Is the footprint (a footprint may be a temperature or sediment plume) of the activity 0.5 km^2 or larger?	✓		The footprint of the discharge could potentially be greater than 0.5km^2.
	Is the area of the activity greater than 1% or more of the water body's area?			
	Is the activity within 500 m of any higher sensitivity habitat?			
	Is the activity 1% or more of any lower sensitivity habitat?			

WFD quality element	Scoping question	Yes	No	Comment
Biology (Fish)	Is the activity 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 migrating through the estuary?	✓		There is the potential that effects on water quality could present a barrier to migrating fish due to the potential for effects on water quality parameters such as dissolved oxygen and nutrients for example. Included to allow assessment of indirect effects on transitional water bodies only.
	Could the activity 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)?			
	Could the activity cause entrainment or impingement of fish?		✓	The discharge would not lead to entrainment or impingement

WFD quality element	Scoping question	Yes	No	Comment
Water Quality (Phytoplankton and harmful algae)	Could the activity affect water clarity, temperature, salinity, oxygen levels, nutrients or microbial patterns continuously for longer than a spring neap tidal cycle (about 14 days)?	✓		The proposed discharge could potentially introduce nutrients/bacteria for greater than 14 days (the operational timeframe for the station is 60 years). The potential for effects on water clarity are not scoped in given that the breakdown of the material will occur slowly over a period of weeks. Additionally, losses will occur due to predation and consumption. As a result, contributions to natural variability of the suspended solids concentration within the water body are unlikely to be distinguishable from baseline variation.
	Is the activity in a water body with a phytoplankton status of moderate, poor or bad?		✓	The water body is at good status
	Is the activity in a water body with a history of harmful algae?		✓	Not monitored; the potential for impacts on water quality, however, is considered as part of the consideration of effects on the water quality elements
Water Quality (question has been selected which relates to point source discharges and mixing zones)	Are the chemicals released are on the EQSD list?	✓		There is the potential to impact on ammonia concentrations
Protected Areas	Is the activity within 2km of any WFD protected area?	✓		European Designated Sites, nitrate sensitive areas and bathing waters could potentially be located within 2km of any plume

WFD quality element	Scoping question	Yes	No	Comment
INNS	Could the activity introduce or spread INNS?		✓	There is no risk that the discharge would release or spread INNS

5 STAGE 3: FURTHER ASSESSMENT

5.1 Introduction

5.1.1. The following sections summarise the relevant baseline information for the Suffolk coastal water body and the WFD quality elements at risk from the Sizewell C Project proposed WDA activities.

5.1.2. An assessment is provided that assumes Sizewell B forms part of the baseline (given its current operational status) and, therefore, predicts impacts based on the combined influence of the Sizewell B and Sizewell C plumes. In time, Sizewell B will no longer operate, but the combined scenario represents the worst case.

5.2 Baseline water quality

a) Temperature

5.2.1. Seawater temperature data are not available for the Suffolk Coastal water body on the Environment Agency's Data Catchment Explorer (Ref. 1.16). As a result, BEEMS Technical Report TR306 (Ref. 1.3) uses information from the Cefas Coastal Temperature Network.

- Seawater temperature trends at Sizewell follow a seasonal cycle with winter minimum temperatures of approximately 4ºC occurring in February. Temperatures rise throughout the spring and peak in summer with temperatures in August reaching a maximum of 20ºC in 2014.
- Yearly average temperatures were derived from years with complete sets of monthly values at locations in the Suffolk coastal waterbody (1963-2013). The 98th percentile, temperature for the five-year period from 2009-2013 is 19.4°C.

b) Dissolved oxygen

5.2.2. Monitoring of dissolved oxygen levels at Sizewell has shown levels range between 7 and 11mgl^{-1}. Minimum summer dissolved oxygen values were recorded in July 2015 (6.96–7.04mgl^{-1}) but remained well above the WFD threshold for 'high' (Ref. 1.3).

c) Nutrients

5.2.3. The availability of inorganic nutrients influences the growth of phytoplankton populations. Nitrate and phosphate are the primary limiting nutrient, silicate is also important for diatoms, which dominate the phytoplankton off Sizewell.

5.2.4. Inshore waters off Sizewell have higher nutrient concentrations than waters further offshore. The highest nitrate and silicate concentrations occur between January and March at Sizewell, nitrate concentrations of 30µmoll-1 (equivalent to 420µgl^{-1} NO_3-N) have been reported. In July and August, the concentrations of nitrates were the lowest (5µmoll^{-1}). All nutrients decrease in concentration in the summer and autumn months and show peak concentrations in the winter and spring months (Ref. 1.3).

5.2.5. During the winter months, light is limited, and phytoplankton growth occurs in spring when nutrients are available, temperature increases, and light is no longer limiting.

5.2.6. At Sizewell, a Combined Phytoplankton and Macroalgae (CPM) model determined that light limitation is the primary factor limiting growth until mid-May, at which point nutrients start to become limiting. Initially phosphate is the primary limiting factor, however, this is very short-term, and the system enters a period of nitrate limitation until August when light limitation reoccurs as the primary limiting factor controlling phytoplankton growth (Ref. 1.3).

5.2.7. The WFD classifies water bodies based on the 99th percentile winter DIN[9] concentration in relation to the turbidity of the water body. However, it should be noted that the WFD Suffolk coastal water body is classified as 'moderate' potential for DIN.

5.2.8. The mean phosphate concentration is 33.48µgl^{-1} (Ref. 1.3).

d) Suspended solids concentrations

5.2.9. Suspended sediment concentrations (SSC) from seabed mounted instrumentation deployed 500m off the coast adjacent to the proposed Sizewell C station recorded the daily minimum, mean and maximum SSCs (**Table** 5.1). High levels of SSC are driven by both high wave energy events and peak spring tidal currents. Minimum observations are observed when neap tides coincide with low wave energy. The difference between daily

[9] DIN refers to a German standard, from the German Institute for Standardisation.

maximum and minimum suspended load is approximately 300mg/l at 1m above the seabed and 500mgl^{-1} at 0.3m above the seabed.

Table 5.1 Suspended solids concentrations within the WFD water body (Ref. 1.3)

Parameter	Suspended solid concentrations 0.3m above the bed (mgl^{-1})	Suspended solid concentrations 1m above the bed (mgl^{-1})
Minimum	24-28	15-19
Daily mean	103-161	72-105
Daily maximum	357-609	266-459

e) Biological oxygen demand

5.2.10. Background concentrations of Biological Oxygen Demand (BOD) are from the 2010 monitoring and equate to a mean value of 2mgl^{-1} (Ref. 1.10).

f) Chemistry

5.2.11. Under the WFD, chemical status is assessed by compliance with environmental standards for the priority chemicals that are listed in the EC Environmental Quality Standards Directive (2008/105/EC), as amended by Directive 2013/39/EU (implemented by the WFD (Standards and Classification) Directions (England and Wales) 2015) which increased the list of priority chemicals to 45. Chemical status is recorded as 'good' or 'fail'. The chemical status classification for the water body is determined by the worst scoring chemical.

5.2.12. For the WFD, certain substances that are regarded as the most polluting were identified in 2001 as Priority Hazardous Substances by a Decision of the European Parliament and the Council of Ministers (Decision 2455/2001/EC). This first list of substances became Annex X of the WFD. This was replaced by Annex II of the Directive on Environmental Quality Standards (Directive 2008/105/EC) (EQSD), also known as the Priority Substances Directive, and this was further updated in 2013 by Directive 2013/39/EU. For these substances, Environmental Quality Standards (EQS) are determined at the European level and these apply to all Member States.

5.2.13. For other substances, standards may be derived by each Member State. This list of compounds or Specific Pollutants is defined as substances that can have a harmful effect on biological quality, and which may be identified by Member States as being discharged to water in “significant quantities”.

5.2.14. Relevant substances for the Sizewell C Project are as follows:

- ammonia;
- cadmium and its compounds;
- lead and its compounds;
- nickel and its compounds;
- chromium VI;
- copper;
- iron;
- zinc;
- boron; and
- chlorine.

5.2.15. In the marine environment, ammonia in both its ionised NH_4 and unionised NH_3 form may contribute to toxicity, although it is the unionised form that is the most toxic. Ammonia may be lost from water by volatilisation or under aerobic conditions may be oxidised to nitrite and then nitrate. Various water quality parameters influence the toxicity of ammonia, mainly by increasing the proportion of the most toxic, unionised NH_3 form.

5.2.16. The chemical status of the Suffolk coastal water body on the Environment Agency's Catchment Data Explorer (Ref. 1.16) (cf. **Table** 4.1) is listed as not requiring assessment in 2015 and 2016. Prior to this, the Catchment Data Explorer lists a chemical status of good.

5.2.17. The baseline data used in BEEMS Technical Report TR306 (Ref. 1.3) to inform this WFD compliance assessment were derived from historic data contained in the scientific literature, water quality data from the Environment Agency and project specific monitoring collected to inform the Sizewell C Project environmental assessments. Of the data collated by the Environment Agency, four locations are specifically monitored for WFD compliance within the Suffolk coastal WFD water body (see purple sites on **Figure 5.1**).

5.2.18. A project specific survey was undertaken at 12 stations extending approximately 12km to the north and south of the Sizewell B cooling water outfall and 3km offshore during 2010-2011 and 2014-2015. Samples were collected at the surface and at the seabed (see green sites on **Figure 5.1**) and spatial, tidal and seasonal surveys were undertaken.

5.2.19. Except for zinc, the mean measured concentrations of all the priority metals in the water samples were below their respective EQS' (see **Table** 5.2) (Ref. 1.10).

5.2.20. TRO concentrations from the surveys varied between 0.01 and 0.16mgl^{-1}. Analysis for hydrazine indicated that concentrations are below the limit of detection (0.01µl^{-1}). Bromoform was detected at station 5 (near the cooling water outfall of Sizewell B) at concentrations of 2–10µgl^{-1} and the majority of stations produced negative results for morpholine. The other conditioning product, ethanolamine, was not detected in any of the samples.

5.2.21. The EQS for un-ionised ammonia is 21µgl^{-1} as an annual mean concentration. The mean background concentration of un-ionised ammonia in Sizewell seawater was 0.2µgl^{-1} (calculated from average background salinity, temperature and pH and an NH_4-N concentration of 11.4µgl^{-1}) and is well below EQS concentrations. The 95th percentile NH_4-N concentration is 26.3µgl^{-1} (with a calculated un-ionised equivalent of 0.5µgl^{-1} NH_3-N).

5.2.22. Overall, the results of the water quality monitoring programme show that the concentrations are relatively uniform in the Suffolk coastal water body and the majority of contaminants do not exceed their EQS. The exception being zinc which significantly exceeds EQS.

Table 5.2 Summary of marine water quality data for heavy metals against EQS (taken from Ref. 1.3)

Parameter	Sizewell background concentration µg/l	Marine EQS Annual average µgl^{-1}	Marine EQS Maximum allowable concentration µgl^{-1}
Arsenic	1.07	25	-
Cadmium	0.05	0.2	-
Chromium	0.57	0.6	32 (95th percentile)
Copper	2.15	3.76	-
Lead	-	1.3	14
Zinc	15.12	6.8	-
Mercury	0.02	-	0.07
Iron	50	1000	-

5.3 Baseline biology

a) Benthic ecology

5.3.1. To inform the biological baseline, data were collected during a series of onshore and offshore surveys implemented between 2008 and 2018 (see Ref. 1.14 for further detail). These included the following surveys:

- eleven subtidal grab and trawl surveys carried out over a seven-year period with quarterly sampling in 2008 and 2011/2012, annual sampling in June for 2009 and 2010 and in September for 2014; a total of 890 grab samples, 295 2m-beam trawl samples and 64 otter trawl samples were obtained;
- one survey of the shallow sublittoral area undertaken in September 2011 (40 grab samples);
- one survey of the intertidal undertaken in August 2011 (12 quadrat samples);
- 202 collection dates on which estimates of the number of invertebrates impinged on the cooling water screens were made as part of the Comprehensive Impingement Monitoring Programme undertaken at Sizewell B between February 2009 and October 2017;
- the continuous monitoring of the salinity in a coastal lagoon in Minsmere between July 2014 and May 2015;
- three surveys carried out between 2016 and 2018 using an ARIS 3000 acoustic imaging camera to provide high resolution surface imaging in highly turbid waters to assess the presence of *Sabellaria* reef; and
- an additional multibeam echosounder survey was completed in September 2018 to provide comprehensive benthic surface data for the extent of Coralline Crag habitat.

5.3.2. To summarise, the intertidal beaches of the area are predominantly coarse sediment with ephemeral sand veneers harbouring a reasonably broad range of sediment-dwelling organisms.

5.3.3. A total of 51 benthic taxa were recorded during the study, but many taxa were found infrequently (between 9 and 21 taxa found per location). *Turbellaria*, juvenile gammarid amphipods, nemerteans and juvenile *Mytilus edulis* dominate the macrobenthic assemblages, comprising 94% of the total abundance. The total density of macrofauna organisms varied from about

100 to 8500 individuals per m^2 between the sampling locations and showed high natural variability in each sampling area.

5.3.4. Comparison with historical data (Ref. 1.19) suggested no notable change in the fauna of the beaches over time, thus, the overall picture is of moderate energy shores composed of a matrix of gravel and sand, populated by patchy, low abundance and low biomass infauna assemblages more tolerant of the dynamic physical environment. The beaches are very dynamic, and the proportions of surface sand will change with tides and weather events. Consequently, the biology can be expected to be patchy and unstable over time, particularly in the southern half of the bay, south of Thorpeness, where there is no coastal sandbank to protect the shore from wave energy.

5.3.5. The subtidal surveys indicate that there is one overall infaunal and epifaunal community spanning most of the bay, but there is some evidence that a subset of taxa, recorded in very high abundances, have spatial affinity for specific localities within the study area, i.e. samples with higher abundance value of a given taxon are found across a restricted area within the study area. The distributions of these taxa appear to be structured in part by sediments, local morphological features and dynamic coastal processes.

5.3.6. The epifauna data suggest that different environmental drivers, likely related to the water column, affect hyperbenthic organisms (living in the water column above the seabed). Indeed, these taxa are ubiquitous, compared to the epibenthic taxa and the infauna taxa, which show spatial affinities within the bay. Both the infauna and epifauna communities are typical in a regional context as they are part of a larger community distributed across the south of the North Sea 'infralittoral region', corresponding to the subtidal areas within 50m depth. The abundant taxa found in the GSB have a high reproduction rate suggesting that infaunal populations are resilient.

5.3.7. Note that benthic algae are not present to any notable degree in southern East Anglian coastal waters (Ref. 1.14).

5.3.8. Two habitats of potential conservation interest have been identified in the study area. First, the Coralline Crag deposits located off Thorpeness are a hard substrate habitat characterised by bryozoan and mollusc debris and sometimes overlain with an ephemeral sand veneer, which is locally unusual amongst the sands and gravels of the GSB. Second, grab samples and high-resolution acoustic images collected in the area suggest the presence of *Sabellaria spinulosa*. The benthic infauna living in the Sizewell-Dunwich sandbank shows low species richness and low abundances, as well as a low level of variability. However, settlement events, associated with an important increase in secondary production over the spring and summer months, have been recorded in the trough and on the flanks of the sandbank, suggesting a potential important feeding area for higher trophic levels.

5.3.9. Acoustic remote sensing (swath bathymetry and backscatter data – 2008/2009 surveys) and grab sampling (2008-2012) were combined within a Geographical Information System (GIS) to derive the benthic habitat maps for the GSB (Ref. 1.14). This found that most of the seabed was covered by a layer of fine sand. More muddy sediments were found in the deeper area between the shoreline and the Sizewell-Dunwich (sand) Bank and coarse sediment (mixed with fine sand) was found inshore close to the shoreline. Bedrock was observed off Thorpeness extending in a north-easterly direction. In the southern part of the survey area exposed clay deposits and areas of coarse sediment occur.

5.3.10. The distribution of these seabed characteristics has been integrated under the Level 4 European Nature Information System (EUNIS) habitats maps and include the following six classes (see **Figure 5.2**):

- A4.13 - Mixed faunal turf communities on circalittoral rock;
- A5.13 - Infralittoral coarse sediment;
- A5.23 - Infralittoral fine sand;
- A5.26 - Circalittoral muddy sand;
- A5.33 - Infralittoral sandy mud; and
- A3.43 - Infralittoral mixed sediments.

5.3.11. The presence of *S. spinulosa* was assessed in BEEMS Technical Report TR473 (Ref. 1.15). This work concluded that *S. spinulosa* polychaete reef structures are likely to be present upon and around the Coralline Crag and that these formations show a degree of temporal persistence. There is insufficient evidence to say conclusively whether these reef structures meet the three criteria to be classed as Annex I Reef habitat. However, on the balance of evidence and based on the temporal persistence of the *S. spinulosa* structures, it is likely that biogenic reef habitats exist.

5.3.12. Survey data were used also to compute the WFD benthic infaunal status of coastal waters at Sizewell using the approach developed by the UKTAG as a status classification for benthic invertebrates is not available on the Environment Agency's Catchment Data Explorer (Ref. 1.16). The Infaunal Quality Index (IQI) is a multi-metric index expressing the ecological health of benthic macroinvertebrate (infauna) assemblages. The metric encompasses a high amount of information on how macroinvertebrate assemblage changes within the marine environment as its calculation relies on selected metrics and incorporates each metric as a ratio of the observed value to that expected under reference conditions.

5.3.13. The index operates on a scale of zero to one: zero reflecting ecological quality under extreme anthropogenic disturbance and one representing ecological quality where anthropogenic disturbance is absent or negligible (1.20). The IQI is the recommended indicator to assess the ecological status of the macrobenthic invertebrate and infaunal assemblages of sediment habitats in UK coastal and transitional water bodies. According to the WFD Ecological Quality Ratios (EQRs) scale, the results show that the GSB community is classified as having moderate to good status.

5.3.14. WFD baseline information on the Environment Agency's Catchment Data Explorer (Ref. 1.16) indicates that the Suffolk Coastal water body supports the habitats shown in **Table** 5.3. Given the above biotope assessment, the habitats potentially at risk are the lower sensitivity habitat 'subtidal soft sediments' and higher sensitivity habitat, 'polychaete reef'.

Table 5.3 Summary of WFD habitats in the Suffolk coastal water body

Higher sensitivity habitats	Areas (ha)	Lower sensitivity habitats	Areas (ha)
Polychaete reef	11.57	Cobbles, gravel and shingle	1929.57
Saltmarsh	197.49	Intertidal soft sediment	816.46
-	-	Rocky shore	1.78
-	-	Subtidal soft sediments	10568.96

b) Phytoplankton

5.3.15. Information presented in BEEMS Technical Report TR385 (Ref. 1.21) outlines that there is a strong seasonal signal in phytoplankton concentration in the area; the peak of the spring bloom occurs in early May, with a period of rapid growth beforehand and rapid mortality thereafter. The seasonal cycle of phytoplankton standing stocks at Sizewell can be characterised as follows:

- Winter - nutrient availability is high but phytoplankton biomass is limited in a sediment dominated system with low light and low water temperatures.

- Spring – Sediment loading decreases, and temperature and light availability increases. Phytoplankton are then able to effectively utilise the nutrients which have accumulated during the winter. Phytoplankton biomass increases quickly until a peak is reached in late May (the "spring bloom"), at which point essential nutrients become limiting, even in the relatively nutrient-rich coastal waters. During the spring bloom, chlorophyll a can reach 10µgl^{-1} around Sizewell with mean cell abundance peaking at 2x10^{6} cells per litre. Following the peak in biomass, reductions in nutrient availability and grazing cause reductions in the standing stock.

- Summer / Autumn – Phytoplankton populations persist and grazing and nutrient recycling occurs. Late summer storms can recycle nutrients but lead to increases in turbidity. A secondary bloom may occur if sufficient light is available before biomass declines towards Winter.

5.3.16. Monthly phytoplankton monitoring data from the GSB has been collected to characterise the baseline environment and is detailed in BEEMS Technical Report TR476 (Ref.1.22). As the nearest WFD monitoring locations are approximately 29km to the north and 12.5km to the south of Sizewell B, the new data was used to compute the WFD phytoplankton status of coastal waters at Sizewell, using the approach developed by the UKTAG as a cross check against the Environment Agency's index for the wider area. Phytoplankton measurements from two sites were used; a site located approximately 5.8km north of Sizewell B; and a site close to the Sizewell B intakes.

5.3.17. Phytoplankton status was assessed using data collected from March 2014 to January 2017. The phytoplankton tool combines metrics for chlorophyll a during the growing season (March to October, inclusive), elevated counts, and seasonal succession.

5.3.18. Averaging all three metrics gave an overall final score of 0.69 for the reference site, which equates to an assessment outcome of 'Good' status and 0.80 for the intake site which equates to high status. It is therefore concluded that the data obtained are very similar to the recent assessments of the phytoplankton element carried out by the Environment Agency at sites to the north and south of Sizewell between 2013 and 2016, which ranged between 0.71 and 0.74 with a classification of 'Good' status (Ref.1.22).

c) Fish

i. Data

5.3.19. Full details of the data collected and their analysis can be found in BEEMS Technical Report TR345 (Ref. 1.23), which provides a comprehensive study of the fish fauna of the GSB area based on data collected during impingement sampling from the Sizewell B cooling water system and from a series of coastal fishing surveys. The datasets used within the report are as follows:

- impingement sampling at Sizewell B between February 2009 and February 2013;
- ten demersal fishing surveys carried out over a 4-year period; quarterly in 2008, once each in June 2009 and June 2010, and quarterly between June 2011 and March 2012. Sampling was conducted using two different fishing gears – a 2m beam trawl and a commercial otter trawl;
- a coastal pelagic fish survey carried out in March and June 2015; and
- additional information from sources such as sampling undertaken during the operation of the Sizewell A station, characterisation studies for other marine developments in the local area, inshore fishing surveys off the Suffolk coast and international stock assessments.

5.3.20. A total of 88 fish taxa were identified in the GSB area. 40 species were identified in the 2m beam trawl catches, 25 in the commercial otter trawl catches and 71 species were identified during impingement sampling.

ii. Demersal community

5.3.21. Of the demersal species recorded, Dover sole *Solea solea* and whiting were extremely frequent in the impingement dataset, occurring in over 90% and 96% of the impingement samples, respectively. Gobies, dab *Limanda limanda* and flounder *Platichthys flesus* were also generally common: all three taxa were recorded in over 90% of the impingement samples. Other demersal species occurring in more than 80% of the impingement samples were Nilsson's pipefish *Sygnathus rostellatus*, lesser weever *Trachinus vipera*, and bass *Dicentrarchus labrax*.

5.3.22. In the offshore samples, Dover sole was the most commonly occurring species overall, present in 68% of beam trawls and all the otter trawl samples. Whiting was found in a third of the beam trawls and 60% of the otter trawls. Gobies, dab and flounder were also generally common: dab were recorded in two thirds of otter trawls and 13% of beam trawls, gobies in nearly half of the beam trawls and flounder in 75% of the otter trawls. Thornback rays *Raja clavata*, were common in the otter trawls, being found in 75%, though they were rarely captured in the beam trawls.

5.3.23. Cephalopods were not common in either the offshore or onshore samples. Only a single species (the European common squid *Alloteuthis subulata*) was recorded in the coastal surveys; it occurred in 17 and 7 of the beam and otter trawl samples, respectively. Four species were impinged in Sizewell B, namely the little cuttlefish *Sepiola atlantica*, the European common squid, the cuttlefish *Sepia officinalis* and the common squid *Loligo vulgaris*, but only the little cuttlefish was present in more than 30% of the samples.

5.3.24. The most abundant taxa were also generally the most common. Of the demersal species in the impingement sampling, the four most abundant species were whiting (11% by abundance), bass (9%), sand gobies (4%) and Dover sole (2%). Both bass and the thin-lipped grey mullet *Liza ramada* were impinged in reasonably large numbers but were not a significant feature of the coastal surveys. However, the abundance of bass is seasonal with the majority of catches in the impingement dataset being made in the winter months.

5.3.25. In the offshore surveys, Dover sole dominated overall; it accounted for 28% and 39% of all fish caught in the 2m beam trawls in the original (2008-2010) and expanded (2011-2012) survey series and 48% and 25% in the otter trawl in the original and expanded series, respectively. Gobies were also highly abundant in the beam trawls (39% and 22% by abundance of the original and expanded survey series), but were not abundant in the otter trawl surveys, due to the large mesh size of the gear and small body size of the individuals. Whiting contributed 3% and 11% respectively, to the abundance of beam trawl samples in the original and extended survey areas. In the otter trawls, flounder, dab and thornback rays were also highly abundant.

5.3.26. Statistical analysis shows that there is very little evidence of consistent spatial patterns in the demersal fish community, suggesting that the fishes of the GSB form one large homogenous community. The analysis showed that there was very little obvious spatial pattern or consistency over time and that the species mix found at each site changed over time but not in a predictable way.

iii. Pelagic community

5.3.27. The sampling gear used to characterise the demersal fish community may catch pelagic fish, particularly during deployment and retrieval; however, that gear is not specifically designed for this purpose. During the surveys, the following species were recorded:

- Atlantic herring *Clupea harengus*;
- European sprat *Sprattus sprattus*;
- anchovy *Engraulis encrasicolus*;

- mackerel *Scomber scombrus*;
- horse mackerel (scad) *Trachurus trachurus*; and
- pilchard *Sardina pilchardus.*

5.3.28. All six species were recorded in the Sizewell B impingement monitoring; collectively, they accounted for approximately 65% of the total numbers of fish caught, suggesting pelagic fish are common in the GSB area. Sprat was the most abundant, at 49% of the total fish catch, then herring at 16%.

5.3.29. From the acoustic data, pelagic fish were more abundant in waters further north off Minsmere than around Sizewell itself, although good numbers were found at Sizewell throughout the year. The fish appeared to aggregate in larger schools mainly at the edge of sandbanks during the winter and during the summer were more evenly distributed across the area, although the highest densities were consistently found more offshore. Schools were denser and smaller during the summer and, although variable between surveys and subareas, more than half of the pelagic fish biomass was found in the near surface waters (2-5m depth).

5.3.30. Analysis carried out for the East Anglia ONE offshore wind farm surveys of winter 2010/2011 (Ref. 1.24) suggests that while the species present in the bay mirror those found in the wider offshore region, there may be differences in relative distribution, at least at certain times of year. Anchovy was much more dominant in the wider region than in the Sizewell data, comprising 29% of the total catch (including non-target species) versus <1% of the Sizewell impingement catch, while at 14% offshore versus 49% in the Sizewell catch, sprat was much less prevalent.

5.3.31. Pilchard was also more prevalent in the wider region, at least in November 2010. Only two pelagic species were caught in the February 2011 East Anglia ONE survey; sprat, which dominated the catch (more similarly to the Sizewell data), and anchovy. On the basis of this evidence, herring and sprat are the most prevalent pelagic fish species around Sizewell.

5.4 Future baseline

5.4.1. Because the development is likely to remain operational for a long period (e.g. up to 2100), there is therefore a need to consider the potential for changes to the baseline and account for them within this assessment.

a) Water quality and temperature

5.4.2. The southern North Sea is shallower with a faster warming rate than other areas of the UK. Climate predictions assume a linear increase in temperature which will be subject to increased uncertainty further into the future. Removal of the Sizewell B station will reduce the baseline temperatures.

5.4.3. Towards the end of the 21st century, ocean acidification causing a decrease in pH will influence chemical speciation and e.g. partitioning of ionised and unionised ammonia favouring the less toxic ionised form.

5.4.4. It is not anticipated, that concentrations of other substances will increase. There is the potential with the removal of the Sizewell B station that various parameters would reduce within the coastal water body.

b) Biology

5.4.5. The southern North Sea has seen cold water plankton species decline. Warmer water species have replaced some of the colder water species although they remain less abundant. It is acknowledged that whilst the exact species composition is likely to change, the effects on the structure and functioning of the community remain unknown.

5.4.6. In addition to distribution shifts, there has also been a change in the phenological cycles of plankton. It is therefore feasible that the spring bloom and peaks in plankton abundance at Sizewell may advance under a warming climate. However, climate driven trends advancing phenological cycles would be limited by day length and solar elevation preventing primary production in the relatively turbid coastal waters at Sizewell in the early spring. This may, however, potentially extend the duration of the year that seasonal chlorination may need to be applied.

5.4.7. Phytoplankton growth in the permanently mixed regions of the North Sea, off the East Anglian coast have been least affected by temperature rises due to natural mixing (i.e. stratification is reduced) and the overriding effects of turbidity therefore annual primary productivity has been relatively consistent. Therefore, the baseline productivity of the system is not expected to change due to warming alone. The occurrence of some harmful algal bloom species is also considered more likely in the future due to climate change, driven by projected increasing sea temperatures

5.4.8. Biodiversity loss due to temperature rise is not expected in the southern North Sea and, therefore, the key taxa used in benthic ecology assessments are expected to be present in a future, warmer climate. The higher sensitivity habitat *Sabellaria spinulosa* reef is considered to have a low sensitivity to temperature rise in the UK, as it forms reefs in much warmer climates. However, warming is predicted to induce distributional shifts, with taxa moving northward as they follow shifts in their thermal niche. This is likely to increase the species pool in the southern and coastal areas of the North Sea due to northerly range expansions of southern species, thus potentially increasing the number of benthic invertebrate species.

5.4.9. Changes to hydrodynamics associated with increased storminess can influence the composition and functioning of benthic communities by altering larval dispersal patterns, causing mortality (e.g. disturbance during storm events, possibly associated with climate change) and modifying primary and secondary production. S. *spinulosa* reef is also considered to be susceptible to storms and may therefore be more or less prevalent if storminess changes in the future. Declines in water clarity in the southern North Sea due to increases in suspended sediments could also be exacerbated by increased storminess.

5.4.10. Rising sea levels have the potential to induce coastal-squeeze effects across the UK, with beaches becoming increasingly trapped between the sea and terrestrial barriers. Currently, sea-level rise on the Suffolk coast induces shoreline retreat and the release of sediment from the soft cliffs in the area between Lowestoft and Southwold, while the beaches of the GSB alternate between trends of erosion and accretion on the shoreline associated with the circulation of the sediment on the various littoral cells. The Sizewell-Dunwich Bank is likely to protect the coastline from major changes by attenuating the impact of wave energy in the long-term.

5.4.11. The 2017 Marine Climate Change Impacts Partnership (MCCIP) review on fisheries describes the changes expected in fish and fisheries with climate change. To summarise warm-affinity species are likely to increase in abundance and cold-affinity species to decrease in abundance, with many cold-water species moving northwards. There are exceptions to this general trend, such as sole which has shifted distribution southwards and are able to remain in shallow North Sea waters all year around. Except for sole and whiting, the southerly distribution of all species is predicted to move northwards around the UK.

c) INNS

5.4.12. The spread of INNS with preferences for warmer water may also be encouraged where introduction has already occurred.

5.5 Further assessment O1 cooling water (waste streams A to G)

5.5.1. This assessment considers waste streams A to G which would be discharged out of the cooling water outfall and assesses the implications of the thermal and chemical properties of the discharge on WFD water bodies.

5.5.2. It is considered that HFT would have the same effects as running the systems under normal operating conditions and, therefore, the assessment for operational discharges also applies to HFT discharges. As a result, HFT is not specifically referred to in the assessment that follows, but the outputs are relevant to this stage of commissioning.

5.5.3. The potential effects scoped in at the end of Stage 2 are summarised in **Table** 5.4. This table also identifies the potential adjoining water bodies and protected areas that could be at risk.

Table 5.4 Summary of quality elements and protected areas scoped in for further assessment for O1

Activity	Water body	Quality elements	Adjoining water bodies	RBMP mitigation measures	Protected areas
O1 Operational discharge via the cooling water system	Suffolk	Water quality – chemical and physico-chemical	Leiston Beck Minsmere Old River Walberswick Marshes Blyth (S) Alde and Ore	None identified within the River Basin Management Plan (RBMP) for Suffolk	661 Southwold The Denes Southwold The Pier
		Biology – Habitats and Fish. INNS			

a) Physico-chemical: Temperature

i. Methodology

5.5.4. To undertake the compliance assessment, guidance issued by UKTAG (Ref. 1.25 and Ref. 1.26) recommends that maximum temperatures at the edge of the mixing zone should not exceed 23˚C (representative of Good Status) and, that outside the mixing zone, temperature rises above ambient should be limited to 3˚C (see **Table** 5.5).

Table 5.5 Recommended interim thermal standards in the UKTAG 2008b (Ref. 1.25) and 2008c (Ref. 1.26)

Standard	High	Good	Moderate	Poor
Maximum temperatures (as an annual 98th percentile allowed at the edge of the mixing zone)	20˚C	23˚C	28˚C	30˚C
Deviation from ambient outside of mixing zone	2°C	3˚C	3˚C	3˚C

5.5.5. BEEMS Science Advisory Report SAR008 (Ref. 1.7) considered the interim thermal standards outlined above and concluded that the UKTAG 2008b (Ref. 1.25) and 2008c (Ref. 1.26) WFD recommendations should be adopted, with the exception that the maximum temperature for High Status should be set at 23˚C not 20˚C due to naturally higher summer temperatures in southern parts of the United Kingdom.

5.5.6. Hydrodynamic modelling was then undertaken to calculate the area over which the values set out above would be exceeded (Ref. 1.11, Ref. 1.12 and Ref. 1.3). The water to be discharged back to the marine environment was assumed to be 11.6˚C above ambient temperatures with a flow of $125m^3s^{-1}$ for the operational scenario and 23.2˚C above ambient temperatures with a flow of $62.5m^3s^{-1}$ for the maintenance scenario (see **section 2.4**).

5.5.7. Modelling was undertaken using the validated Sizewell General Estuarine Transport Model (GETM) (Ref. 1.11) and looked at indicative locations for the outfall to determine the worst case scenario for thermal effects (see Ref. 1.11 for further detail). The modelling also assumed that Sizewell B would be operational until at least 2035 and, therefore, this is accounted for (as part of the baseline) in the results of the assessment. Four intake heads and two outfall heads were included in the model as a realistic representation of the final design.

5.5.8. Four scenarios were considered; the first with no power stations present, the second with only Sizewell B operating, the third with both Sizewell C and B operating simultaneously and the fourth with Sizewell C under maintenance. A further set of model runs considered the effects of Sizewell C alone under normal operating conditions.

5.5.9. The effect of the power stations was evaluated by calculating the difference in temperature between the station(s) operating runs and the run which had no power station discharge. The difference was calculated for each hourly snapshot and the annual mean and the 98th percentile were calculated from the difference. For the assessment against absolute thermal standards, it was determined that the GETM overestimates absolute temperatures and, therefore, a more reliable prediction of the 98th percentile is derived by adding the predicted mean temperature uplift due to the plume (i.e. the annual mean excess plume temperature) to the observed 98th percentile seawater background temperature (19.4°C).

ii. Maintenance scenario

5.5.10. The proposed Sizewell C power station has two pump systems that can work independently. When one of the pump systems is under maintenance the flow of cooling water would be halved but the heat content would remain approximately the same, raising the temperature at the outfall from 11.6°C to 23.2°C. The concern with this scenario is whether the warmer water at the outfall would lead to a larger, hotter plume which caused greater environmental impacts than the normal operation of Sizewell C. This would be of particular concern during the spring bloom when biological activity is at a peak, so a maintenance scenario was run for the month of May.

5.5.11. The results of the modelling indicate that the warmer plume loses heat faster to the atmosphere, resulting in less heat being mixed down into the water column. This reduces the size of the excess temperature plume compared to that arising during normal operation with all pumps running. As a result, the maintenance scenario is not considered further as the thermal plume effects of any maintenance would be within the extent of the effects experienced during normal operation (see Ref. 1.3 for further detail).

iii. Operational scenario

5.5.12. The tides at Sizewell are strong (>1ms^{-1}) and interaction with the bathymetry dominates the shape of the thermal plume and determines its effect at the seabed (Ref. 1.12). The general conceptual model of heat loss from a plume in a tidal environment is that, initially, the discharge plume will be buoyant and it will be advected by the current flows and lose heat to the atmosphere. There will come a point when the heat loss is sufficient that the difference in buoyancy between the surface and bed (stratification) does not overcome the vertical mixing due to the tides. The remaining heat energy is then mixed down and raises the temperature of the water body.

5.5.13. The two stations considered herein have different discharge depths, 5m and 16m for Sizewell B and Sizewell C respectively. As vertical tidal mixing is from the seabed, the Sizewell B discharge inshore in 5m water depth is mixed down more quickly than the offshore Sizewell C discharge would be in 16m water depth. As a result, much of the total thermal uplift from the scenario with both stations operational is dominated by the Sizewell B discharge and the Sizewell C discharge only produces very small thermal effects at the seabed.

5.5.14. The Sizewell C and Sizewell B plumes are separate at high plume temperatures but at lower temperatures the Sizewell C plume increases the size and temperature of the Sizewell B plume at the surface and seabed. Note that the Sizewell C plume is smaller and guidelines are only exceeded outside of the 1nm offshore limit of the WFD water body (see **Table** 5.6, **Table** 5.7 and **Figure 5.3**, **Figure 5.4** and **Figure 5.5** for surface temperatures and **Figure 5.6**, **Figure 5.7** and **Figure 5.8** for seabed temperatures). A differential plot of the difference in thermal uplifts between Sizewell B operating alone and the addition of Sizewell C is provided in **Figure 5.9** (seabed temperatures) and **Figure 5.10** (surface temperatures). This further demonstrates that the main effects in the coastal zone are associated with Sizewell B and Sizewell C only increases temperatures by very small amounts in the coastal area.

Table 5.6 Areas where the WFD temperature standards are predicted to be exceeded within the Suffolk coastal water body

Model run	Position	98th percentile >23°C (moderate status) hectares	98th percentile >28°C (poor status) hectares
Sizewell B alone	Surface	43.77 (0.3%)	0
	Seabed	8.63 (0.06%)	0
Sizewell C alone	Surface	0	0
	Seabed	0	0
Sizewell B and Sizewell C	Surface	87.66 (0.6%)	0.11 (<0.01%)
	Seabed	23.81 (0.16%)	0

Table 5.7 Areas where the WFD uplift temperature standards would be exceeded within the Suffolk coastal water body

Model run	Position	Excess temperature >2°C <3°C as a 98th percentile (good status) hectares	Excess temperature >3°C as a 98th percentile (moderate status) hectares
Sizewell B alone	Surface	2428 (17%)	1263 (8%)
	Seabed	2121 (15%)	660 (5%)
Sizewell C alone	Surface	0	0
	Seabed	0	0
	Surface	4123 (28%)	2200 (13%)

Model run	Position	Excess temperature >2°C <3°C as a 98th percentile (good status) hectares	Excess temperature >3°C as a 98th percentile (moderate status) hectares
Sizewell B and Sizewell C	Seabed	3758 (26%)	1553 (11%)

5.5.15. Given that the thermal standards outlined above are not evidence based in relation to biological effects (Ref. 1.27), interpretation as to whether the predictions outlined above could cause a deterioration the water body (for the combined effects of Sizewell C and Sizewell B only) is undertaken for parameters that can respond to changes in seawater temperature. These are as follows:

- water quality parameters (ammonia and dissolved oxygen);
- biology (habitats and fish);
- INNS (in terms of encouragement of spread); and
- phytoplankton.

5.5.16. These parameters are considered below.

b) Physico-chemical: other parameters

i. Ammonia

5.5.17. Ammonia is considered as part of the chemical assessment below.

ii. Dissolved oxygen

5.5.18. At a constant salinity, temperature has a direct effect on the concentration of dissolved oxygen (near linear). However, in sea water, there are several biological processes which affect oxygen concentration through either consumption (respiration) or production (primarily photosynthesis). The dominant effect on oxygen concentration in the thermal plume comes from the change in temperature and the likely saturation of the warm plume. The plume as it comes out of the power station would be warmer than the intake and would, therefore, have less capacity to carry oxygen.

5.5.19. If the original intake water was fully saturated, then the hotter water would be supersaturated (as the oxygen has nowhere to go) and escape to the atmosphere soon after discharge. Subsequent to this the plume would remain on the surface and equilibrate (in the absence of biological processes) to the atmospheric concentration and remain at approximately 100% saturation. The plume would mix and cool; as it mixes it would reduce the dissolved oxygen carrying capacity of the water it mixes with as the resultant temperature of the mixed water would be higher than that of the background. As the plume cools and whilst it is at the surface and still in contact with the atmosphere, it would be able to absorb oxygen from the atmosphere. Thus, maps of the spatial extent of the plume which incorporate both the mixing and cooling processes are reliable indicators of the maximum oxygen content when at 100% saturation. However, in some water bodies, due to biological oxygen demand, the observed oxygen values are reduced below those of saturation.

5.5.20. In GSB there is no evidence of high biological oxygen demand and there are no apparent oxygen deficits, the minimum oxygen saturation from 83 observations was 91% and the average was 101% saturation (Ref. 1.10).

5.5.21. Calculations of the concentration of dissolved oxygen at saturation have been derived from the GETM output using mean salinity values (33.27) taken from the annual data obtained during 2010, and the derived temperature fields from each run using the method of Benson and Krause (Ref. 1.28). A biological demand has not been applied to the results given the survey results.

5.5.22. GETM runs show the area calculated that is beneath various dissolved oxygen concentrations for the entire model domain. The spatially average dissolved oxygen concentration for both Sizewell B and Sizewell C and Sizewell B alone is >7mgl^{-1} as a 5th percentile, which is considerably above the WFD threshold for High Status of 5.7mgl^{-1}. As a result, a deterioration in class status is not predicted.

c) Chemistry

i. Screening potential for deterioration

5.5.23. To determine the potential impacts to water quality from Sizewell C operational discharges, Environment Agency guidance has been used (Ref. 1.29). To undertake the assessment, the guidance requires the use of EQS. For chemicals where there are no available EQS, a surrogate value has been derived. These chemicals include hydrazine, morpholine and ethanolamine, and naturally present parameters such as manganese and suspended solids for example.

5.5.24. Two main approaches have been used to develop surrogate quality standard values either based on the review of toxicity data to develop a predicted no effect concentration (PNEC) (discussed in more detail in Ref. 1.3) or by referring to environmental backgrounds identified during recent monitoring work (Ref. 1.10).

5.5.25. For chemicals associated with sequestering agents used in the demineralisation plant, there are currently no EQS or PNEC values available. Therefore, data available in the literature have been adopted. Further information on the source of each EQS and derived alternative is provided in BEEMS Technical Report TR193 (Ref. 1.8). Baseline concentrations for other parameters is provided in **section 5.2**. The relevant EQS and derived alternatives are summarised in **Table** 5.8.

Table 5.8 Summary of EQS and derived surrogates where not available (taken from Ref. 1.8)

Parameter	Annual average EQS	Maximum allowable concentration EQS	Maximum allowable concentration as 95th percentile EQS
	Units µgl^{-1} unless otherwise stated		
Cadmium and its compounds (dissolved)	0.2	-	-
Lead and its compounds (dissolved)	1.3	14	-
Mercury and its compounds (dissolved)	-	0.07	-
Nickel and its compounds (dissolved)	8.6	34	-
Chromium VI (dissolved)	0.6	-	32
Arsenic (dissolved)	25	-	-
Copper (dissolved)	3.76 (2.677 x ((dissolved organic carbon/2) - 0.5)) µgl^{-1} dissolved, where (DOC) > 1mgl^{-1}	-	-
Iron (dissolved)	1000	-	-
Zinc (dissolved plus ambient background concentration)	6.8	-	-

Parameter	Annual average EQS	Maximum allowable concentration EQS	Maximum allowable concentration as 95th percentile EQS
	Units µgl^{-1} unless otherwise stated		
Boron	7000	-	-
Chlorine (total residual oxidant)	-	-	10
Unionised ammonia (NH_3)	21	-	-
DIN (winter)	-	980[10]	-
Escherichia coli	≤500 colony forming units/100ml (from bathing waters directive)		
Intestinal enterococci	≤200 colony forming units/100ml (from bathing waters directive)		
Hydrazine	Acute PNEC 0.004 and chronic PNEC 0.0004		
Ethanolamine	Acute and chronic PNEC 160		
Morpholine	Acute PNEC 28 and chronic PNEC 17		
ATMP	Ecotoxicity testing. 74 for acute concentration (24 hour load) and 74 for chronic concentration (annual load)		

[10] EQS for nitrogen is based on WFD 99th percentile standard for Good status for an intermediate turbidity waterbody.

Parameter	Annual average EQS	Maximum allowable concentration EQS	Maximum allowable concentration as 95th percentile EQS
	Units µgl^{-1} unless otherwise stated		
HEDP	Ecotoxicity testing. 13 for acute concentration and 13 for chronic concentration		
Acetic Acid	Ecotoxicity testing. 301 for acute concentration and 62.8 for chronic concentration		
Phosphoric acid	Ecotoxicity testing. 200 for acute concentration and 20 for chronic concentration		
Sodium Polyacrylate	Ecotoxicity testing. 180 for acute concentration and 11.2 for chronic concentration		
Acrylic Acid	Ecotoxicity testing. 1.7 for acute concentration, 0.34 for chronic concentration		
Lithium hydroxide	65 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
Phosphates	33 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
Suspended solids	74000 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
BOD	2000 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
COD	239000 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		

Parameter	Annual average EQS	Maximum allowable concentration EQS	Maximum allowable concentration as 95th percentile EQS
	Units μgl^{-1} unless otherwise stated		
Aluminium	12 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
Manganese	2 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
Sulphates	2778000 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
Sodium	10400000 mean background (see Appendix E of BEEMS Technical Report TR193 for raw data (Ref. 1.8))		
Chlorine TRO	10 (95th percentile maximum allowable concentration – EQS)		
Chlorine bromoform	5 (95th percentile maximum allowable concentration – EQS)		

5.5.26. In line with the Environment Agency guidance (Ref. 1.29) described above, the above parameters have been assessed using an initial screening process (as follows) for annual average EQS:

- average background concentration for substance multiplied by average cooling water flow (to determine background load);
- average load of substance in process stream added to above load;
- divide above result by total of average cooling water discharge volume and average process stream volume combined; and
- compare result to the annual average annual average EQS.

5.5.27. These steps are repeated for maximum allowable concentrations as follows:

- maximum background concentration for substance multiplied by minimum cooling water flow (to determine background load);
- maximum load of substance in process stream added to above load;
- divide above result by total of minimum cooling water discharge volume and average process stream volume combined; and
- compare result to the EQS maximum allowable concentration.

5.5.28. The calculations for the maximum 24 hour loadings are based on a discharge volume of $66m^3s^{-1}$ under maintenance conditions with a single operational UK EPR™. The maximum annual discharge of $116m^3s^{-1}$ is based on a single UK EPR™ unit having a minimal operational cooling water flow of $58m^3s^{-1}$ under low tide conditions (the worst-case scenario for 'standard operation').

5.5.29. The results of the screening exercise are provided in **Table** 5.9. Any parameters with a discharge / EQS ratio of greater than 1 have been screened in and are highlighted in bold text in the table.

Table 5.9 Summary of output from screening assessment (Ref. 1.8)

Substance	EQS or surrogate ($\mu g l^{-1}$ unless otherwise stated) and surrogate source	24 hour loadings		Maximum annual loadings	
		Discharge concentration ($\mu g l^{-1}$) based on daily discharge of $66 m^3 s^{-1}$	Discharge /EQS <1	Discharge concentration ($\mu g l^{-1}$) on daily discharge of $116 m^3 s^{-1}$	Discharge /EQS <1
Boron (derived from boric acid discharge concentration)	7000 (Pre WFD EQS)	4656	0.67	4145.67	0.59
Lithium hydroxide	65 (mean background)	90.2	**1.39**	65	**1.0**
Hydrazine	0.004 (Acute PNEC for 24 hour loads) and 0.0004 (Chronic PNEC for annual loadings)	0.53	**131.5**	0.01	**16.6**
Morpholine	28 (Acute PNEC for 24 hour loads) and 17 (Chronic PNEC for annual loads)	16.18	0.58	0.46	0.03
Ethanolamine	160 (Acute PNEC)	4.34	0.03	0.25	0.001
Nitrogen as N	980 (WFD 99%)	484.3	0.49	360.12	0.37
Unionised ammonia (NH_3)	21 (annual average EQS)	7.34	0.35	0.96	0.05
Phosphates	33.5 (mean background)	127	**3.79**	33.57	**1.00**

Substance	EQS or surrogate ($\mu g l^{-1}$ unless otherwise stated) and surrogate source	24 hour loadings		Maximum annual loadings	
		Discharge concentration ($\mu g l^{-1}$) based on daily discharge of $66 m^3 s^{-1}$	Discharge /EQS <1	Discharge concentration ($\mu g l^{-1}$) on daily discharge of $116 m^3 s^{-1}$	Discharge /EQS <1
Detergents	-	-	-	0.17	0.2
Suspended solids	74000 (mean background)	154	0.002	25.4	0.0003
BOD	2000 (mean background)	0.67	0.0003	0.38	0.0002
COD	239000 (mean background)	57.87	0.0002	1.38	0.00001
Aluminium	12 (mean background)	20.19	**1.68**	12	**1.00**
Copper	3.76 (annual average EQS)	4.76	**1.27**	2.15	0.57
Chromium	32 (95th percentile maximum allowable concentration EQS for 24 hour loadings) and 0.6 (annual average EQS for annual loadings)	2.48	0.08	0.57	0.95
Iron	1000 (annual average EQS)	302	0.3	132.58	0.13
Manganese	2 (mean background)	-	-	-	-
Nickel	34 (maximum allowable concentration EQS for 24 hour loadings) and 8.6 (annual	1.17	0.03	0.79	0.09

Substance	EQS or surrogate (μgl⁻¹ unless otherwise stated) and surrogate source	24 hour loadings		Maximum annual loadings	
		Discharge concentration ($\mu g l^{-1}$) based on daily discharge of $66 m^3 s^{-1}$	Discharge /EQS <1	Discharge concentration ($\mu g l^{-1}$) on daily discharge of $116 m^3 s^{-1}$	Discharge /EQS <1
	average-EQS for annual loadings)				
Lead	14 (maximum allowable concentration EQS for 24 hour loadings) and 1.3 (annual average EQS for annual loadings)	3.94	0.28	1.0	0.76
Zinc	6.8 (annual average EQS)	46	**6.77**	14.7	**2.16**
Mercury	0.07 (maximum allowable concentration EQS)	0.02	0.29	0.02	0.29
Cadmium	1.5 (maximum allowable concentration EQS) and 0.2 (annual average concentration EQS)	0.13	0.09	0.05	0.25
Chloride	14128000 (mean background)	78.9	0.00	23.81	-
Sulphates	2778000 (mean background)	350.7	0.00	26.90	-
Sodium	10400000 (mean background)	150	0.00	14.32	-

Substance	EQS or surrogate ($\mu g l^{-1}$ unless otherwise stated) and surrogate source	24 hour loadings		Maximum annual loadings	
		Discharge concentration ($\mu g l^{-1}$) based on daily discharge of $66 m^3 s^{-1}$	Discharge /EQS <1	Discharge concentration ($\mu g l^{-1}$) on daily discharge of $116 m^3 s^{-1}$	Discharge /EQS <1
ATMP	74 for both 24 hour loadings and annual loadings (No observable effect concentration (NOEC))	7.89	0.11	2.49	0.03
HEDP	13 for both 24 hour loadings and annual loadings (EC_{50}[11])	0.79	0.06	0.24	0.02
Acetic acid	301 (LC_{50}[12]) for 24 hour loadings and 62.8 for annual loadings (NOEC)	0.02	0.00006	0.004	0.0001
Phosphoric acid	200 (LC_{50}) for 24 hour loadings and 20 for annual loadings (LC_{50})	0.02	0.0001	0.003	0.0002
Sodium polyacrylate	180 for 24 hour loadings (LC_{50}) and 11.2 for annual loadings (NOEC)	7.01	0.04	2.20	0.2

[11] The EC_{50} is the concentration of a contaminant that gives half-maximal response.
[12] an LC_{50} is the median lethal concentration and is the concentration predicted to kill 50% of the population within the specified time period.

Substance	EQS or surrogate (μgl^{-1} unless otherwise stated) and surrogate source	24 hour loadings		Maximum annual loadings	
		Discharge concentration (μgl^{-1}) based on daily discharge of $66m^3s^{-1}$	Discharge /EQS <1	Discharge concentration (μgl^{-1}) on daily discharge of $116m^3s^{-1}$	Discharge /EQS <1
Acrylic acid	1.7 (EC_{50}) for 24 hour loadings and 0.34 for annual loadings (NOEC)	0.18	0.1	0.05	0.13
Chlorine (TRO)	10 (95^{th} percentile maximum allowable concentration EQS)	150	**15**	-	-
Chlorine bromoform	5 (95^{th} percentile maximum allowable concentration EQS)	190	**38**	-	-

5.5.30. **Table** 5.10 summarises the output of the screening assessment for 24 hour loads for those substances with a ratio of greater than 1.

Table 5.10 Summary of output for 24 hour assessment

Substance failing screening assessment	Comment	Modelling required
Hydrazine	Potential for deterioration identified	Yes
Chlorine produced TROs	Potential for deterioration identified	Yes
Bromoform	Potential for deterioration identified	Yes
Copper	Discharge concentrations are at least 30 times below relevant annual average EQS – high background concentrations are responsible for exceedance	No
Zinc		
Lithium hydroxide	Background baseline has caused the exceedance - lithium in the discharge is approximately 300 times below the background concentration	No
Phosphate	The phosphate input is several times above background and as phosphate can contribute to nutrient status further consideration is required	Yes
Aluminimum	Again, background baseline has caused exceedance – discharge only contributes a 60th of the background concentration	No

5.5.31. Although unionised ammonia was 35% of its EQS, increases in temperature could influence the relative amount of unionised ammonia. As a result, modelling has been undertaken to assess this effect.

5.5.32. **Table** 5.11 summaries the output of the screening assessment for the annual loadings for those substances with a ratio of 1 or greater.

Table 5.11 Summary of the screening output for annual loading assessment

Substance failing screening assessment	Comment	Modelling required
Hydrazine	Potential for deterioration identified	Yes
Zinc	High background (source unknown) responsible for exceedance and actual discharge concentration would be below detection limits;	No

Substance failing screening assessment	Comment	Modelling required
	therefore, this input would not give rise to a deterioration	
Lithium hydroxide Aluminimum	Discharge concentrations are below the detection limit and are several orders of magnitude below the site background, so discharge concentrations will not give rise to a deterioration	No
Phosphate	Although the discharge concentration is very low the input can contribute to nutrient status – considered in phytoplankton assessment	Yes

5.5.33. DIN was 37% of the EQS and increases in temperature could influence the relative amount and, therefore, potentially impact on Protected Areas related to nutrient effects. As a result, further consideration is given to this in the Protected Areas section below.

ii. Assessment of potentially significant parameters

5.5.34. Modelling was undertaken using the validated GETM of Sizewell used for thermal plume studies. The water quality parameters described below were modelled as fully coupled GETM runs with hydrodynamical parameters:

- Chlorination of the power station cooling water system to avoid bio-fouling. The TRO resulting from the combination of chlorine and organic material in the water was modelled using an empirical demand/decay formulation derived from experiments with Sizewell seawater, coupled with the GETM Sizewell model (Ref. 1.30).

- Chlorination by-products (CBPs) as a result of complex chemical reactions in seawater. Many products are formed, the number and type being dependent on the composition and physical parameters of the seawater. The dominant CBPs are, in order, bromoform, dibromochloromethane (DBCM), bromodichloromethane (BDCM), monobromaceitic acid, dibromoaceitic acid (DB annual average), dibromoacetonitrile (DBAN) and 2,4,6 tribromophenol. Laboratory studies carried out with chlorinated Sizewell seawater only detected bromoform (Ref. 1.31). Bromoform is lost through volatilization to the atmosphere, with the loss rate being a function of the thermal stratification and values obtained from the literature (see Ref. 1.32).

- The addition of hydrazine to control the oxygen concentration in the power station secondary circuit. Hydrazine is an oxygen scavenger that is used in power plants to inhibit corrosion in steam generation circuits. Hydrazine is used to condition the secondary circuit and in the primary circuit during start up. During normal operation most of the hydrazine injected daily into the secondary circuit would be broken down by the high temperatures present, but trace amounts would be present in the power station effluent discharged via the cooling water system. Based on a conservative assessment of residual hydrazine concentrations, the screening assessment indicates that following discharge and initial dilution the PNEC will be exceeded in this case. Therefore, hydrazine was modelled by using an empirical decay formulation derived in the laboratory coupled with the GETM Sizewell model (Ref. 1.33).

5.5.35. Although these chemicals are not listed in the WFD lists for Priority and Priority hazardous substances, they are assessed to determine whether they could have an indirect effect on any WFD water body by impacting on other WFD quality elements such as biology, for example.

Total residual oxidants

5.5.36. A worst-case TRO concentration of $0.15mgl^{-1}$ at the outfalls has been used for plume modelling purposes (Ref. 1.3). The TRO plume areas at the EQS ($10\mu gl^{-1}$ as a 95^{th} percentile) in the Suffolk coastal water body have been calculated and show that there is no interaction between the Sizewell C TRO plume (above the EQS) and the Suffolk coastal water body (**Figure 5.11**). As a result, deterioration within the WFD water body is not predicted.

Chlorinated by-products (bromoform)

5.5.37. The amount of bromoform that would be discharged would largely depend on the amount of chlorine to be added, but also on the amount of mixing. Like the TRO plume, the bromoform plume would be a long, narrow feature parallel to the coast. The Sizewell B plume is always within the channel inshore of the Sizewell-Dunwich Bank and does not overlap with the Sizewell C plume that is outside the Bank. The results of the modelling show that there would be no interaction between the Sizewell C TRO plume (above the EQS) and the Suffolk coastal water body (**Figure 5.12**). As a result, deterioration within the WFD water body is not predicted.

Hydrazine

5.5.38. There is no established EQS for hydrazine and so a chronic PNEC of $0.4ngl^{-1}$ has been calculated for long term discharges (calculated as the mean of the concentration values) and an acute PNEC of $4ngl^{-1}$ for short term discharges (represented by the 95^{th} percentile). To understand the impact of different discharge rates from the treatment tanks two discharge scenarios were investigated: the first one considered a hydrazine discharge of 69ngl^{-1} in daily pulses of 2.32 hours starting at 12pm, and the second one 34.5ngl^{-1} of hydrazine discharged in daily pulses of 4.63 hours starting at 12pm.

5.5.39. The results of the modelling show that there is no interaction between the hydrazine plume and the Suffolk coastal water body (**Figure 5.13**). As a result, deterioration within the WFD water body is not predicted.

d) Biology

i. Phytoplankton

Nutrients

5.5.40. The maximum number of people on site would occur when there are refuelling outages. During this time nitrate and phosphate loads would increase above background concentrations and these contributions are represented in the modelling by the peak 24-hour loading during operation. The refuelling outages would typically last four to six weeks but could occur at any time of year.

5.5.41. During the winter period light is limiting and no effect, resulting from the additional supply of nutrients to marine waters, is predicted. It is only in summer that the discharge needs to be considered further (Ref. 1.3).

5.5.42. Maximum daily nitrate discharges represent approximately 2% of the total mass (based on annual average nitrogen concentration) exchanged within the tidal system. The daily average is 0.2% of the mass in the daily exchange rate. For phosphates, maximum daily loadings reach 5% of the total mass exchanged, whilst average annual loadings contribute a very small proportion of the daily mass exchange (0.03%). Phosphate is not a limiting nutrient within the GSB system and therefore the addition of more phosphate would not be expected to influence phytoplankton growth. Maximum loadings would be short term and small relative to the daily exchange of nutrients.

5.5.43. The CPM model was used to predict the effects of nutrients on the annual gross primary production within the tidal excursion accounting for entrainment from Sizewell B and Sizewell C during the operational phase. The model predicted annual nutrients loadings would increase production within the GSB by 0.14%. Such changes are orders of magnitude below the natural variation in chlorophyll a biomass.

Thermal

5.5.44. Thermal discharges may result in acute and chronic effects on phytoplankton at different positions within the discharge plume. Sensitivity of phytoplankton has been shown to be seasonal, highly site specific and depend on the interplay of local hydrodynamics and ambient temperatures.

5.5.45. At Sizewell, light limitation is the primary factor controlling photosynthesis up to mid-May. The rate of photon absorption limits photosynthesis during periods of light limitation, during which time increases in temperature are not predicted to enhance productivity. Therefore, thermal uplifts are not predicted to enhance the onset of the spring bloom or dramatically enhance productivity at Sizewell during periods of light limitation.

5.5.46. During the growing season when light is not a limiting factor (mid-May to mid-August), thermal uplifts may influence growth rates. A statistical approach has been applied to predict the theoretical maximum growth rate of marine phytoplankton (µmax, per day) as a function of temperature. According to the equation, a 1°C uplift results in an approximate 6.5% increase in µmax, whereas a theoretical 13% increase in maximum growth rates is possible following a 2°C uplift.

5.5.47. These empirical results indicate that thermal uplifts may enhance growth rates in the mid- and far-field of the plume during the growth season particularly when ambient water temperatures at Sizewell are below 18ºC. Increases in growth rates in the field would be mediated by the overriding factors of nutrient availability and the light climate. Furthermore, the hydrodynamics of the open coastal site at Sizewell means water exchange with the wider environment would reduce the potential for the formation of phytoplankton blooms.

5.5.48. As a result, effects on phytoplankton communities are considered to be within natural variation and therefore a non-temporary effect on the WFD water body is not predicted.

ii. Fish

5.5.49. Given that chemical parameters are unlikely to affect the Suffolk coastal water body, this section focuses on the potential effects of the thermal plume.

5.5.50. There are no thermal standards to assess potential migration barriers for fish in coastal waters. However, if fish have to pass through a coastal plume on their migration route to or from an estuary there remains the possibility of the plume acting as a barrier to migration.

5.5.51. In BEEMS Technical Report TR302 (Ref. 1.12) the results from available laboratory thermal preference experiments were used and examination of the modelling results shows that smelt, sea trout, glass eel and silver eel, with avoidance thresholds of ≥3˚C, would not experience a barrier to migration in a transect from the coast to the Sizewell C Project outfalls.

5.5.52. Similarly, the Sizewell thermal plumes are not predicted to present a barrier to migration for sea and river lampreys, given the high percentage of the transect that would be available for a Sizewell transit (Ref. 1.12). It is, therefore, concluded that the presence of thermal plumes would not present a barrier to migrating fish (Ref. 1.12) within the Suffolk coastal water body. The consideration of the potential effects on adjoining transitional water bodies is presented below.

iii. Habitats

5.5.53. Given that chemical parameters are unlikely to affect the Suffolk coastal water body, this section focuses on the potential effects of the thermal plume. The main species present in the lower and higher sensitivity habitats identified in the baseline are considered individually to assess the potential overall effect of the thermal plume on the habitats at risk as biological responses to increases in temperature are species specific (Ref. 1.6).

5.5.54. The potential effects of thermal discharge on benthic organisms fall under three categories (Ref. 1.7):

- chronic effects due to the long-term effect of an increase in mean temperature on biological processes (growth, reproduction);
- acute effects where absolute temperatures approach lethal levels; and
- short-term fluctuations caused by the passage of large magnitude thermal fronts.

5.5.55. This assessment draws on experimental and observational evidence regarding the response of species to temperature uplifts, as well as documented information on the latitudinal and depth distributions of species presented in BEEMS Technical Report TR483 (Ref. 1.6). Regarding latitudinal distributions, a species has been considered to be less sensitive to mean thermal uplifts if its range extends to low latitudes (i.e. warm waters) and more sensitive if its range is restricted to high latitudes (i.e. cold waters). Regarding depth distributions, a species has been considered less sensitive to temperature fluctuations if it occupies shallow waters (intertidal and shallow subtidal zones; where temperatures fluctuate daily) and more sensitive if it only occupies deeper waters (where temperature is relatively stable).

5.5.56. As a result, the sensitivity of benthic invertebrates found within the WFD water body to thermal discharges ranged from ‘not sensitive’ to ‘low sensitivity’ (see **Table** 5.12). However, some cold-water species, such as *Limecola balthica*, are predicted to incur chronic effects associated with reduced growth and/or reproduction over a limited spatial area; while species that prefer relatively warm water, such as *Crangon crangon*, may experience increases in physiological processes.

5.5.57. Based on this it is concluded that differences in species responses to the thermal plume may lead to minor changes in community composition, but such changes are unlikely to alter the overall structure or functioning of benthic communities within the habitats present within the WFD water body. Consequently, a deterioration within class or between classes for benthic invertebrates is not predicted for either the higher or lower sensitivity habitats.

Table 5.12 Summary of species and sensitivity to thermal plume (taken from Ref. 1.6)

Species	Summary of description as provided in TR483	BEEMS conclusion on sensitivity to thermal plume
Baltic tellin *Limecola balthica*	Present along the European coast from the south of the White Sea to Portugal. Evidence to suggest that it is sensitive to warmer winter temperatures but has naturally high fecundity and there is the potential for recruitment from outside the zone of influence of the plume.	Low sensitivity
Common mussel *Mytilus edulis*	Widespread and common around the British Isles and it has been observed from Arctic waters to the Mediterranean. A few mussel beds can be found along the Suffolk coast, but their occurrence is low. Increases in temperature do not impact on scope for growth, as it can adapt.	Low sensitivity
Bivalves *Nucula nitidosa* and *N. nucleus*	Widespread around British Isles. Naturally high fecundity and are common in Suffolk region. Temperature tolerances correlate with distribution – i.e. lower tolerances in individuals associated with less sheltered areas. Found in the subtidal area at Sizewell but not in shallow areas or in the intertidal.	Low sensitivity
Common whelk *Buccinum undatum*	Distributed widely throughout the North Atlantic. Species adapts to temperatures above those it currently experiences in its natural environment. Recorded within the thermal plume from Bradwell. Also potential for recruitment from outside the zone of influence of the plume.	Low sensitivity
Brown crab *Cancer pagurus*	Widespread around British Isles. Encountered across the subtidal to intertidal, which suggests that it can tolerate chronic effects of temperature fluctuation. This species is highly mobile.	Not sensitive
Lobster *Homarus gammarus*	Widespread along the British coast. Low abundance in Sizewell sediments. Increases in temperature can change its behaviour as well as bring forward its spawning period. Mobile species so can move away from impacts of the thermal plume.	Low sensitivity
Brown shrimp *Crangon crangon*	Part of a larger population and thought to prefer warmer conditions. Recruitment potentially higher when mean temperatures are higher. Species is adaptable to a wide range of environmental temperatures.	Not sensitive

Species	Summary of description as provided in TR483	BEEMS conclusion on sensitivity to thermal plume
Pink shrimp *Pandalus montagui*	Range extending from Greenland and Iceland to the British Isles where it is present on all coasts. Common at Sizewell but considered to be relatively close to southern limit of distribution, which suggests a low tolerance to acute increases in temperature. The species is, however, highly mobile and has been observed moving to reach its preferred temperature range (Ref. 1.37). This would lead to a very localised reduction in population density.	Low sensitivity
Sand digger shrimp *Bathyporeia elegans*	Widespread around the British coast. Large geographical area coverage which suggests tolerance to increases in mean temperatures as well as temperature fluctuations. Growth rate of amphipods is regulated by temperature, as moulting frequency increases in warmer water. Amphipods reach sexual maturity after a fixed number of moults, so an increase in temperature could enhance the onset of sexual maturity for the population within the area of distribution of the thermal plume.	Low sensitivity
Sand shrimp *Gammarus insensibilis*	Species is more commonly found on the south coast of Britain to the Mediterranean. Found in the saline lagoons and offshore. Given this geographical spread, it is likely to be able to tolerate temperature fluctuations.	Not sensitive
Mud shrimp *Corophium volutator*	Wide distribution range across American and European coasts from Norway to the Mediterranean. Also found on all of the British coast, from intertidal areas to the sublittoral fringe. Evidence to show species is tolerant of chronic temperature uplifts. Potential for reduced reproductive output for organisms within the plume footprint. One of the most abundant species on estuarine mudflats in Suffolk.	Low sensitivity
Catworm *Nephtys hombergii*	Present on all British coasts and has been recorded from the Barents Sea to the Mediterranean. The wide distribution of the species across the northern Atlantic suggests a tolerance to a chronic increases in temperature. Commonly found in shallow mud, which suggests tolerant to temperature fluctuations. Low temperatures could impact on spawning.	Low sensitivity

Species	Summary of description as provided in TR483	BEEMS conclusion on sensitivity to thermal plume
Bristleworm *Notomastus sp.*	Found all around Britain. Inhabits a variety of estuarine environments, in shallow littoral, where temperature can show large fluctuations. High fecundity and opportunistic with rapid increases in abundance during favourable periods.	Not sensitive
Polychaete worm *Scalibregma inflatum*	Widespread in Britain. Dominant at Sizewell with high fecundity. Wide geographical spread indicates tolerance to temperature variations. Can move downwards into sediment, therefore, potentially could avoid temperature fluctuations.	Not sensitive
Bristleworm *Spiophanes bombyx*	Found on most British coasts and recorded in the Mediterranean. This range of distribution suggests that the species is likely to be tolerant to a chronic increase in temperature. Opportunistic species with a short life span, high dispersal potential and high reproductive rates.	Not sensitive
Ross worm *Sabellaria spinulosa*	Wide geographical spread from Iceland to Indian Ocean. Given the widespread distribution of the species it is unlikely that this species would be sensitive to a chronic increase in temperature. More sensitive to extreme cold-water events, creating mass mortality. Can respond to environmental changes by increasing their rate of reproduction.	Not sensitive
Brittle star *Ophiura ophiura*	Found across north-west Europe from Norway to south Spain and the Mediterranean, as well as along all the British coast from the lower shore to about 200m offshore. Under chronic temperature changes, up-regulates metabolism. Considered to be mobile enough to move away from disturbance.	Low sensitivity

e) INNS

5.5.58. Only one INNS was recorded during the Sizewell C benthic baseline surveys, the American jacknife *Ensis leei* which was found in a single grab sample. In the North Sea, 274 INNS and cryptogenic (of uncertain origin) have been recorded. The main vector for primary introduction is vessels (ballast of hull fouling).

5.5.59. This burrowing species is thought to have been introduced to Europe at a similar latitude (German Bight) to the GSB, within the cooler part of its thermal niche. The distribution of *E. leei* in the North Sea (and the north-west Europe) is predicted to expand this century due to an increase in sea temperature. Therefore, it is possible that the cooling water discharge would hasten its climate change-induced geographic spread. It should be noted, however, that this species has been recorded in the UK at sites north of the GSB, therefore this species has already reached areas to which the GSB could act as a steppingstone. As a result, the effect of the thermal plume on this species is unlikely to significantly affect its spread over and above that anticipated to be due to climate change.

f) Interaction of effects within this activity

Chemical parameters as influenced by temperature

5.5.60. Increase in temperature is known to increase chemical toxicity including that of chlorine. For example, a 5°C increase in temperature more than halved the effect concentration of free chlorine and chloramine for various marine species. The main potential for synergistic effects of temperature and toxicity of the chlorinated seawater is to species experiencing entrainment. The acute effects of this exposure would be expected to diminish rapidly upon discharge of the cooling water with rapid loss of temperature and reduction in oxidant concentration as the plume mixes and reaches the sea surface. The thermal uplift in combination with the toxicological effects of chlorination is therefore not expected to change the assessment of the chlorination discharge or thermal plume alone.

Unionised ammonia as influenced by temperature

5.5.61. Unionised ammonia concentrations have been calculated using the Environment Agency calculator (Ref. 1.38), the GETM output for temperature elevation and observed values for background temperature, salinity, pH and background ammonia levels. The regulatory approach for ammonia considers an annual average. The model runs replicate an annual cycle.

Therefore, results have been derived using an average temperature and average ammonia values.

5.5.62. Data presented in BEEMS Technical Report TR193 (Ref. 1.8) indicate that the predicted values are very low under the influence of the thermal plume, even in more extreme conditions and no areas in the model domain (and, therefore, the WFD water body) exceed the EQS of 21µgl^{-1} as an annual mean.

Synergistic effects of chlorinated discharges and ammonia from treated sewage

5.5.63. The synergistic effects of chlorination and ammonia discharges may result in the formation of additional combined products.

5.5.64. Seawater chlorination with the ammonia present is likely to form different residual oxidants dependent on the ammonia to chlorine ratio. Dibromamine is one of the primary formation products and has a generally higher toxicity than uncombined oxidants of chlorine or bromine although it is of very low persistence. However, as total ammonia is very low and only around one third of the background ammonia, any increase in toxicity above that due to chlorination alone is expected to be very small. As a result, additional water quality effects are not predicted.

Interaction effects on biology

Habitats

5.5.65. The impact magnitude for the thermal and TRO plumes in combination depends on the area where the two pressures overlap at ecologically relevant concentrations. Benthic invertebrates could be exposed to TROs both as adults and as planktonic eggs and / or larvae, the assessment therefore considers EQS exceedance both at the seabed and sea surface. The spatial extent of the TRO plume, based on EQS exceedance, represents a very small area of 2.1ha at the seabed which is outside of the WFD water body. Therefore, the potential for overlap with the thermal plume at the seabed would be limited to this area and outside of the WFD water body boundary.

5.5.66. Additionally, the sessile invertebrate taxa found near the outfall are present throughout most of the GSB. Therefore, even if toxicity of TROs were substantially increased by the thermal plume, only a very small proportion of any sessile benthic invertebrate population would be affected by this pressure. In terms of egg and/or larvae, numbers produced are very high and experience a high level of natural mortality. Moreover, sharp environmental gradients would form as thermal uplifts and chemical concentrations rapidly reduce from the point of discharge. It is likely that deleterious effects of the discharges would be in a localised area of water near the outfall and would affect only a small proportion of any plankton group.

5.5.67. *S. spinulosa* reefs are not present in the area of the seabed where thermal and TRO plumes overlap. Therefore, there would be no direct effect of these combined pressures on this receptor. The planktonic eggs and larvae would, however, be exposed to the thermo-chemical plume in the water column, which could indirectly affect reef formation and development if it influences recruitment. The combined effects of the two pressures on *S. spinulosa* eggs and larvae are unknown, but as with other benthic invertebrates it is assumed that any potential losses would be minimal at the population level due to high levels of natural mortality (mainly through predation).

5.5.68. In terms of hydrazine, the only area over which the effect could occur is outside of the WFD water body and is very small at the seabed and the concentrations to which adult benthic invertebrates would be exposed are orders of magnitude below observed effect thresholds. Therefore, even if elevated temperature uplifts substantially increased the toxicity of the hydrazine plume, effects on benthic invertebrates are unlikely. In terms of eggs and larvae, while synergistic effects of hydrazine and temperature uplifts on the early life-stages of benthic invertebrates are unknown, the tolerance of the larvae of a sensitive species to concentrations above what would be experienced at the outfall suggests that effects on benthic invertebrate larvae within the GSB are unlikely at the population level.

5.5.69. *S. spinulosa* reefs are not present in the area of the seafloor where thermal and hydrazine plumes overlap. Therefore, there would be no direct effect of these combined pressures on this receptor.

Fish

5.5.70. TRO toxicity may increase with the near-field of the thermal plume. However, limited acute (lethal) effects are predicted to be localised and mobile species and life history stages would demonstrate avoidance behaviours reducing exposure.

g) Protected Areas

i. Bathing waters

5.5.71. During operation the maximum number of staff on site is estimated at 1900. Mixing of the treated sewage effluent with the cooling water flow from one EPR™ ($66m^3s^{-1}$) will achieve a dilution of approximately 33000. The application of secondary treatment alone alongside the predicted dilution will therefore achieve compliance with the bathing water standards at the point of discharge. (Ref. 1.3).

ii. Nitrates Directive

5.5.72. See assessment for phytoplankton above.

iii. European Designated Sites

5.5.73. The potential for effects on the European Designated sites to arise due to water discharge activities is considered within **Appendix C** of the **WDA Permit Application** (**Information for the Habitats Regulations Assessment**). As a result, no further consideration of these sites is undertaken here.

h) Adjoining WFD water bodies

5.5.74. **Figure 5.14** shows the adjoining WFD water bodies to the Suffolk coastal WFD water body that could potentially be at risk as a result of this activity. These include:

- Leiston Beck River water body GB105035046271 – small volumes of seawater can enter many of the ponds within the Minsmere Royal Society for the Protection of Birds (RSPB) reserve by passing though Minsmere sluice and into Leiston Drain at high tide (through a slow-close flap valve) (Ref. 1.39).
- Minsmere Old River water body GB105035046270 - seawater can enter many of the ponds within the Minsmere RSPB reserve (and located in this water body catchment) if the penstock at the downstream end of Scott's Hall Drain (part of the Minsmere Sluice structure) is opened as part of the management of the reserve (Ref. 1.39).
- Walberswick Marshes Coastal water body GB610050076000 – this water body could be affected where water exchange occurs through or over the dunes.

- Blyth (S) Transitional water body GB510503503700– this water body is located to the north of the outfall and adjoins the Suffolk Coastal water body.

- Alde and Ore Transitional water body GB520503503800 – this water body is located to the south of the outfall and adjoins the Suffolk Coastal water body.

i. Coastal water bodies

5.5.75. A monitoring programme was implemented to ascertain the potential for plume-water incursion into the lagoons nearest to Sizewell (at Minsmere) and to provide evidence of potential future exposure during the construction, commissioning and operational phases of the Sizewell C Project (Ref. 1.40) (**Figure 5.15**).

5.5.76. A small brackish pond isolated and adjacent to the coast with no direct connection to the Leiston Drain was identified for monitoring to determine if there is connectivity between the pond and the sea, either via overtopping during periods of elevated tidal levels or high wave conditions or via percolation through the dune system. This pond was selected because it was the closest pond to the sea and the only pond to lie outside of the flood protection for the Minsmere reserve. This pond, therefore, is the local water body most likely to exhibit marine connectivity with the Suffolk coastal water body and is located close to the Walberswick Marshes Coastal WFD water body.

5.5.77. Automated salinity and water temperature monitoring was undertaken between 30 July 2014 and 5 May 2015. No indications of overtopping were observed. The brackish nature of the pond water indicates that there is some limited seawater input and the measured changes in salinity indicate that saline water enters the pond slowly, mostly likely via slow percolation through the dune system that lies between the pond and the coast. As a result, there is the potential for an effect to arise due to Sizewell C if the plume (either chemical or thermal) affects the waters percolating through the dunes.

5.5.78. The modelling for the chemical plume has shown that the operational Sizewell C TRO, bromoform and hydrazine plumes do not intersect with the Suffolk coastal water body at concentrations above the EQS or surrogate value. Additionally, any chemical concentration in the Suffolk coastal water body is likely to be reduced after percolation through the dune system (Ref. 1.40). As a result, no effects are predicted on the Walberswick Marshes coastal water body as a result of the chemical plume.

5.5.79. In relation to the thermal plume, **Figure 5.3** indicates that Sizewell C would have an effect at the coast of between 1°C and 1.5°C. When added to the thermal influence of Sizewell B, the increase would be around 4°C. Therefore, the adjoining marshes already experience the effect of an uplift in coastal water temperature and Sizewell C would increase this by approximately 1°C. However, given the slow percolation of coastal water through the dunes, it is likely that some or all of the excess heat would dissipate during this transfer. Additionally, the increase associated with Sizewell C would be small. As a result, within class or between class deterioration within the WFD water body Walberswick Marshes is not predicted.

ii. Fresh water bodies

5.5.80. No effects are predicted on freshwater bodies in relation to chemical discharge from Sizewell C, as the predicted chemical plumes associated with Sizewell C would not reach the Minsmere Sluice.

5.5.81. As outlined above, **Figure 5.3** indicates a potential uplift in water temperature at the sluice of between 1°C and 1.5°C due to the Sizewell C plume on top of the baseline increases already experienced due to the operation of Sizewell B. However, for Leiston Beck, this would only occur at high tide. For Minsmere Old River this would only occur if Scott's Hall Drain is open. As a result, there would not be a continuous supply of warmer water into either of these WFD water bodies, thus reducing the potential effect on biology. As a result, within class or between class deterioration in fresh water bodies is not predicted.

iii. Transitional water bodies

5.5.82. It is known from laboratory thermal preference experiments that fish species can choose to avoid areas of high temperature and there is, therefore, a possibility that thermal plumes could act as barriers to migration; principally in transitional waters.

5.5.83. As a precautionary measure, existing thermal standards for transitional waters specify that an estuary's cross section should not have an area larger than 25% with a temperature uplift above 2°C, for more than 5% of the time (Ref. 1.7). For Sizewell B and C, the predicted thermal plume only intersects the mouth of the Alde-Ore at excess temperatures in the 0^{o}C to 1^{o}C range as 98^{th} percentiles and the standard for thermal barriers in estuarine waters, therefore, would not be exceeded.

5.5.84. The Sizewell B and Sizewell C thermal plume intersects the Blyth estuary at temperatures in the 2°C to 3°C range as 98th percentiles and there is, therefore, a potential for the estuarine thermal standard to be exceeded and an impact to arise with regard to the movement of migratory fish. Consequently, the temperatures in the cross section across the estuary mouth were extracted from the GETM Sizewell B and Sizewell C model outputs. Over the annual cycle the condition was exceeded in 307 hourly episodes or 3.50% of the time. This is below the 5% threshold included in the standard and, therefore, no barriers to fish migration in the estuary are predicted.

i) Assessment against possible future baseline

i. Thermal effects

5.5.85. The interaction between sea temperature warming as a result of climate change and thermal discharges is based on the assessment detailed in Ref. 1.3. Future climate is considered relative to current thermal standards of thermal uplifts above ambient and absolute temperature.

5.5.86. To ascertain absolute temperatures in the future, the influence of climate change was added to the predicted thermal uplifts due to the proposed development. The approach considered Sizewell B and the proposed development, Sizewell C, operating together up until 2055 as a worst-case. Sizewell C operating alone in 2055 and 2085 were also considered as well as an extreme (2110) hypothetical operating scenario.

5.5.87. The results indicate that future climate change is not predicted to significantly increase the absolute areas in exceedance of 28ºC, which remain under 1ha for all scenarios tested. Following the decommissioning of Sizewell B, 28ºC as an absolute temperature is not predicted to be exceeded as a 98th percentile even under the extreme climate case of the proposed development operating in 2110. Therefore, acute thermal effects in the receiving waters are predicted to remain minimal.

5.5.88. In the likely event Sizewell B is no longer operational in 2055 there are no exceedances of the absolute 23ºC threshold within the WFD water body, either at the surface or at the seabed. The same applies to 2085 towards the end of the likely operational life-cycle of Sizewell C. In 2110, however, large areas of the WFD water body could exceed the absolute 23ºC threshold both at the surface and at the seabed. However, the influence by due to climate change is estimated to be +3.045 across the model domain, hence a station uplift of just 0.56°C is sufficient to exceed contemporary thermal standards (Ref. 1.3).

ii. Chemical

Chlorination, TRO and CBPs

5.5.89. Increases in temperature may also result in small increases in chlorination duration. The seasonal chlorination strategy for the proposed development involves chlorination during the period of the year when water temperatures exceed 10ºC. In 2030, predicted water temperatures at the intakes of the proposed development would exceed 10ºC for 219 days per annum, from the beginning of May until the start of December. Towards the end of the operational life-cycle of the proposed development in the year 2085, climate change is predicted to result in temperatures exceeding 10ºC from late April until late December, for a total of 244 days per annum. However, light limitation would limit the duration of the potential growing season and increases in the duration of annual chlorination is likely to be within the order of weeks at most.

5.5.90. TRO decay will increase at elevated temperatures, but dosing is adjusted to ensure that the target TRO of 0.2mgl^{-1} is achieved. The residual oxidant level at the point of discharge is therefore unlikely to be reduced under climate change. The relative increase in temperature background in the wider environment is also unlikely to significantly increase TRO decay and consequently a conservative assessment is that the discharge plume size and magnitude are likely to be comparable to those predicted for the current baseline.

5.5.91. A pH reduction of 0.14 units below present values by 2050 and 0.3–0.4 below present units in 2100 is predicted. The ratio of oxidant chemicals formed upon chlorination of seawater is influenced by pH: the percentage of hypochlorous acid is likely to increase relative to hypobromous acid following a pH reduction from a present baseline mean of 8.0 to around 7.8 to 7.6 for future baselines at 2055 to 2085. Although there may be some differences in the toxicity of the different oxidants this difference in relative proportions is unlikely to be significant.

5.5.92. For bromoform, increased temperatures are expected to have minimal influence on CBP decay and consequently the discharge plume magnitude and extent are conservatively assessed to be like those predicted for the current baseline.

5.5.93. Bromoform is likely to occur at similar concentrations or possibly slightly reduce following a pH reduction. For other CBPs there may be a small relative increase with lowering pH. The difference in terms of the extent and magnitude of any effects is however, predicted to be small in scale and unlikely to impact on the WFD water body.

Hydrazine

5.5.94. For hydrazine, the primary fate processes are oxygen dependent chemical breakdown and biodegradation. The former is dependent on the presence in water of appropriate catalysts e.g. copper and other factors with e.g. higher ionic strength, temperature and pH reducing the time taken for hydrazine to degrade. Biodegradation is also influenced by temperature with increasing temperature generally reducing the chemical concentration in a shorter time. Hydrazine half-life (time taken for concentration to decrease by 50% of its starting concentration) in natural seawater from Sizewell is very short (ca. 38 minutes), therefore increasing seawater temperatures is likely to reduce the discharge plume magnitude and extent, but a conservative assessment is that they remain comparable to those predicted for the current baseline.

5.5.95. Although low pH is shown to reduce hydrazine decay rate this is only demonstrated at values below 4 so projected average reductions of future baseline pH are not expected to influence hydrazine discharge plume. As a result, effects on the WFD water body are not predicted.

iii. Biology

Phytoplankton

5.5.96. Whilst the duration of the growing season is likely to extend, temperature driven changes in phenology would be moderated by day length and solar elevation thus restricting the total growth period. High levels of turbidity in the winter and early spring also limit biological production. Increases in the duration of annual chlorination may occur but are likely to be in the order of weeks at most and would occur at the shoulders of the growth period when temperatures are lower (i.e. reduced temperature dependant effects). Effects on phytoplankton in the WFD water body are therefore not predicted.

Benthic ecology

5.5.97. While climate change would act in-combination with the proposed development to increase areas over which thermal standards are exceeded, the key benthic invertebrate taxa are generally considered to be insensitive or to have low sensitivity to temperature increases. Therefore, the increased extent of absolute temperature exceedance is unlikely to have population-level effects. It is also worth noting that benthic invertebrate taxa within the GSB in a future, warmer climate would be acclimatised to a modified thermal baseline, while any taxa not currently in the GSB but part of the future benthic ecology baseline due to climate-induced distributional shifts would likely be adapted to warm temperatures.

5.5.98. However, once Sizewell B is decommissioned the thermal footprint from the proposed development is predicted to be smaller than that of Sizewell B at present. Predictions of effects based on current baselines are therefore considered valid in light of future climate change.

Fish

5.5.99. With the combined stations operating, predicted changes in absolute seabed and sea surface temperatures, exposure of cold-water taxa to acute (lethal) effects may increase. Furthermore, the station may contribute to climate driven effects with elevated temperatures exceeding thermal preferences of sensitive species resulting in further localised chronic effects or changes in distribution.

5.5.100. However, taxa exposure would be influenced by climate-related shifts including higher background temperatures. Adaptation to elevated background temperatures and changes in geographic distribution, would occur in response to climate change. Furthermore, thermal tolerance and thermal preference in fish varies with acclimation temperature. This infers that taxa within the GSB exposed to future temperature scenarios would have differential sensitivities to absolute thermal thresholds applied in current standards. Furthermore, once Sizewell B ceases to operate the combined effects of climate change and thermal discharges from Sizewell C would be considerably smaller and further offshore than the contemporary absolute thermal exceedance of Sizewell B alone.

5.5.101. Thermal uplifts above ambient are predicted to be largely independent of the background sea temperature therefore, predicted thermal uplift areas would remain similar under future climate scenarios. Fish (including migratory species) adapted to future thermal baselines, would experience the same relative temperature differences as in the contemporary assessment. It is feasible that the elevated background temperatures may interplay with thermal uplifts to greater effect in cold-water species with potential implication for migration. However, as thermal uplifts from Sizewell C operating alone are predicted to cover a smaller spatial extent further offshore than the existing Sizewell B plumes, disruption to migratory routes is considered unlikely. Additional effects over and above those already assessed within the WFD water body are therefore not predicted.

INNS

5.5.102. The distribution of *E. leei* in the North Sea is predicted to expand this century due to an increase in sea temperature. Therefore, it is possible that cooling water discharges from the proposed development would hasten its climate change-induced geographic spread. It should be noted, however, that this species has been recorded in the UK at sites north of the GSB, including other sites in East Anglia therefore this species has already reached areas to which the GSB could act as a steppingstone, and any effect on the spread of this species would likely be minimal beyond that of climate driven processes.

5.6 Further Assessment O2 (waste stream H)

5.6.1. The potential effects scoped in at the end of Stage 2 are summarised in **Table** 5.13. This table also identifies the potential adjoining water bodies and Protected Areas that could be at risk.

Table 5.13 Summary of quality elements and protected areas scoped in for further assessment for O2

Activity	Water body	Quality elements	Adjoining water bodies	RBMP mitigation measures	Protected areas
O2 Operational discharge of polluting matter from the FRR system (waste stream H).	Suffolk	Water quality – chemical and physico-chemical	None	None identified within the RBMP for Suffolk	661
		Biology – Habitats and Fish.			

5.6.2. The FRR system is designed to minimise impacts on impinged fish and invertebrate populations. However, some species are highly sensitive to mechanical damage caused during passage through the cooling water intakes, drum screens and FRR channels and incur high mortality rates.

5.6.3. The return of dead and moribund biota retains biomass within the marine system but represents a source of organic loading, with potential to increase nutrient inputs, increase un-ionised ammonia and reduce dissolved oxygen.

5.6.4. The total biomass of moribund biota that potentially may be discharged from the FRR is estimated based on the level of abstraction (pump rates) for the planned Sizewell C intakes and the information on seasonal distribution of species and length-weight distribution of the species impinged for the existing Sizewell B (Ref. 1.4 and Ref. 1.5). The numbers have been updated based on headwork design and are summarised in **Table** 5.14 (Ref. 1.41). The nutrient release assessment is based on a whole year and therefore uses an annual mean daily biomass.

Table 5.14 Summary of biomass calculations for FRR system assessment

Time period	Kg per day wet weight (mean daily discharges from both FRR systems directly extrapolated from Sizewell B)	Comment
January to March	873.60	Highest daily discharge value in the year. Accounts for LVSE intake heads.
95 percentile loading	1187.47	The highest biomass of moribund fish occurs in December to April when clupeids are most abundant. This represents the more conservative value.
Daily average (Jan to Dec)	347.44	Represents the mean annual daily biomass with LVSE intake heads in place.

a) Water quality

i. Nutrients (and potential implications for phytoplankton)

5.6.5. Nitrogen and phosphorous loadings based on the biomass figures as outlined in **Table** 5.14 are shown in **Table** 5.15. These figures assume all biomass is available as nitrogen and phosphorus sources i.e. no predation was assumed.

Table 5.15 Loadings of nitrogen and phosphorous associated with the FRR system

Time period	Average Kg per day (wet weight)	N (kg)	P (kg)
Daily average (Jan to Dec)	347.44	12.16	1.74

5.6.6. Discharges from an operational Sizewell (includes all discharges, not just the FRR system) would result in a very small elevation in dissolved inorganic nitrogen (DIN) in the receiving water body representing 0.3% of the mass making up the daily volume exchange for Sizewell Bay (with around 27% of this from the FRR system) (Ref. 1.41).

5.6.7. The daily phosphate input would represent approximately 0.1% of the mass of phosphate making up the daily exchange for Sizewell Bay (with 71% of this from the FRR system) (Ref. 1.41).

5.6.8. This assessment is considered to be conservative as it assumes that the fish are not consumed by other species and that the tissue nutrient content makes a direct contribution to nutrient levels when, in fact, it would take several days for the tissue to decay and to release nutrients. The input loading of phosphorus and nitrogen from biomass discharged from the FRR system is, therefore, not predicted to cause a deterioration in water quality within the WFD water body in terms of nutrient concentrations but further consideration is given with the section considering the potential effects on phytoplankton given that these parameters can contribute to blooms.

ii. Unionised ammonia

5.6.9. Unionised ammonia contribution from decaying biomass was calculated using the unionised ammonia calculator and ammonia contributions from tissues based on values in literature along with relevant site background conditions for pH, temperature and salinity to indicate the potential unionised ammonia contribution from decaying biomass at Sizewell (Ref. 1.8).

5.6.10. Based on the daily average biomass of fish discharged during quarter 1, the LVSE intake heads being in place and average pH, salinity and temperature, the estimated NH_3 loading is predicted to be at or above the EQS over an area of 0.004ha around the FRR system.

5.6.11. Temperature elevation of 2°C that might occur around the FRR due to the added thermal influence of Sizewell C will elevate the proportion of un-ionised ammonia relative to the influence of natural background temperatures alone. A 2°C elevation above Q1 natural background temperature at Sizewell, a lower salinity 31.7 (5th percentile) and high pH 8.23 (95th percentile) were used to recalculate the area over which the EQS would be exceeded. This equated to an area of 0.006 ha.

5.6.12. This is a worst-case assessment as it assumes no predation and no remobilisation of partially decayed fish. In practice both effects will take place further reducing the predicted area above the EQS. As a result, effects on water quality of the water body are not predicted on a water body scale

iii. Biological Oxygen Demand (BOD)

5.6.13. The decaying fish biomass discharged from the FRR system is also likely to contribute to the biological oxygen demand (BOD). Based on the oxygen demand of organic matter inputs from fish cages coupled to the annual average daily biomass loading an estimate of BOD was made.

5.6.14. The average daily BOD contributed by decaying fish tissue is estimated to be 1187.47kg per day with the LVSE intakes in place which is calculated to result in an oxygen draw down of 498.74kg per day. This potential oxygen requirement is equivalent to 0.20% of the daily exchange and deficits would be met by daily reaeration at the sea surface. Given that the water body is well mixed and the reaeration rate is high, effects on water quality of the water body are not predicted on a water body scale.

b) Biology

i. Habitats

5.6.15. Modelling indicates that dead and moribund biota discharged from the FRR system would primarily settle onto the seabed in the vicinity of the two FRR outfalls (Ref. 1.42). This assessment therefore focuses on scavengers, predators and surface deposit feeders, as these taxa are the most likely to respond to discharges of dead and dying organisms from the FRR outfalls.

5.6.16. Few benthic invertebrates within the WFD water body obtain their nutrition from scavenging, with <5% of infaunal and epifaunal individuals exhibiting this feeding mode (Ref. 1.14). Sixteen of the twenty key taxa exhibit one or more of these feeding modes (Ref. 1.14), which includes all taxa except for *Ensis spp*., *Mytilus edulis*, *Notomastus spp*. and *Sabellaria spinulosa*.

5.6.17. It is possible that these taxa, along with other benthic invertebrates with the same feeding modes, would benefit from increased food availability due to discharges of dead and moribund biota from the FRR. Their population densities may increase and their spatial distributions may shift to reflect increased concentrations of food resources around FRR outfalls. Such effects on benthic invertebrates are likely to be most pronounced from December to April, when mean daily discharges are expected to be relatively high.

5.6.18. The response of scavengers, predators and surface deposit feeders, to this pressure is expected to be positive, but any population-level effects would likely be small at the scale of the water body. As a result, effects on a water body scale are not predicted.

5.6.19. In terms of water quality effects, the spatial scale of the EQS failures for the water quality parameters assessed is small and differs seasonally. Additionally, the wide distributions of benthic invertebrate species with the WFD water body mean that a very small fraction of any population would be exposed to any concentrations above EQS. As a result, effects on a water body scale are not predicted.

ii. Phytoplankton

5.6.20. The CPM predicted that annual nutrients loadings due to operational nutrient discharges from Sizewell B and the proposed development would increase annual gross production within the GSB by less than 0.3%. Environment Agency data collected from the area from 1992 to 2013 indicates annual chlorophyll a values vary by 45% of the mean (Ref. 1.21).

5.6.21. As a result, a non-temporary effect on the WFD water body is not predicted. The assessment is highly precautionary as it assumes that the fish are not predated upon by other species and that the tissue nutrient content makes an immediate contribution to nutrient levels when nutrients would be released over longer periods of time following tissue to decay. Additionally, the input figures for nitrogen and phosphorus are based on previous estimates which did not account for reductions in discharge weight due to the LVSE intake heads.

c) Assessment against future baseline

5.6.22. Given that there are no changes associated with impingement in the future, the parameters assessed for the FRR system are unlikely to change from those presented for the current baseline.

5.7 Summary of outcome of Stage 3

5.7.1. The Stage 3 assessment did not indicate any parameters at risk of deterioration such that class status for any of the parameters would decrease. As a result, alone, the proposed activities as detailed in the WDA permit application are considered compliant with the requirements of the WFD.

6 CUMULATIVE EFFECTS ASSESSMENT

6.1 Introduction

6.1.1. This section considers whether any of the identified effects associated with the individual water discharge activities of the Sizewell C Project could combine in such a manner that they could lead to a change in a WFD water body beyond the effect predicted for the individual components alone. It also considers whether the identified effects associated with the combined water discharge elements of the Sizewell C Project could combine with activities of 'other projects' in such a manner that they could lead to a change in a WFD water body beyond the effect predicted for the Sizewell C Project alone.

6.1.2. Following the overall approach used in the Cumulative Effects Assessment that forms part of the ES (**Volume 10**, **Chapter 1** (Doc Ref. 6.11)), the assessment presented in this section will consider:

- Project-wide effects (intra-project): Effects that occur when environmental impacts from different elements of the Sizewell C Project combine, resulting in the potential for a significant effect (for example, from the combination of construction of one element and road traffic noise from another Sizewell C project on a residential receptor). If considered in isolation, the individual environmental impacts may not lead to significant effects.
- Cumulative effects with other projects: Cumulative effects arise when impacts from the proposed development combine with impacts from other third party projects (normally in the vicinity of the site), resulting in a change to the overall magnitude of impact acting on a receptor and potentially resulting in a significant effect.

6.2 Project-wide effects

6.2.1. The compliance assessment provided in **section 5** considers all operational water-based discharges to the marine environment and, where applicable, considers the effects of one discharge parameter on the other (for example the effects of the thermal plume on physico-chemical parameters such as dissolved oxygen).

6.2.2. All other potential project-wide effects, that is the combined effect of O1 and O2, are considered in **Table** 6.1**.**

Table 6.1 Potential project-wide effects

Potential effect	Comment on potential for cumulative effect	Output of assessment
Between O1 and O2. Effect of the operational discharge of polluting matter via the FRR system cumulatively with the operational discharge from the cooling water outfall	The combined effect of the operational cooling water discharge and the FRR is considered in **section 5.5** in water quality parameters. To summarise, the additional loading of nutrients phosphorus and nitrogen added to the waters off Sizewell by the decaying biomass are considered low enough so as not to affect the assessment of negligible influence on phytoplankton growth when considered in addition to the cooling water discharge input of these nutrients. For the combined nutrient data a model run over an annual cycle predicts a less than 0.3% difference in annual gross production of carbon and this level of change would not be discriminated above natural background variation. Evaluation of the daily average unionised ammonia loading contributed by decaying biomass following discharge from the FRR estimates that it could be at or above the unionised ammonia annual average EQS of 21µgl^{-1} NH_3-N, (taking account of natural background and input from the cooling water discharge with thermal influence included) for only a very small area of the WFD water body. The influence of biomass decay on the BOD was also assessed and daily re aeration would be enough to meet this additional demand when considered with that of the operational discharge and this takes no account of water exchange for the GSB. Therefore, biomass decay is expected to have a negligible influence on dissolved oxygen concentration. Given the above, additional effects on fish and marine ecology are not predicted on a water body scale.	No project-wide effect.

6.2.3. This demonstrates that any cumulative effects on WFD water bodies resulting from multiple water discharge activities at the main development site would not be greater than those effects predicted for each activity alone.

6.3 Cumulative effects with other projects

a) Screening other projects

6.3.1. This section considers whether any of the identified water discharge effects associated with the Sizewell C Project overall could combine in such a manner with the effects of other plans and projects such that they could lead to a greater effect on water quality within a WFD water body. For the purposes of the WDA Permit application, this cumulative assessment considers only those projects that are predicted to include effects on water.

b) Method

6.3.2. A staged process has been followed to assess cumulative effects, which has been aligned with the Environmental Impact Assessment (EIA) Cumulative Effects Assessment (CEA) methodology provided in **Volume 10** of the Environmental Statement (ES) (Doc Ref. 6.11). This method includes the following four stages:

- Stage 1 Establishing a Zone of Influence (ZOI) and long list of non-Sizewell C projects.
- Stage 2 Establishing a short list of projects.
- Stage 3 Information gathering.
- Stage 4 Assessment.

6.3.3. The results of this process are described in **section 6.3c)**.

c) Assessment of Sizewell C Project WDA activities and other projects

6.3.4. The 'long list' of projects (stage 1) agreed as part of the DCO EIA process is included in **Appendix 1A** of **Volume 10** of the ES (Doc Ref. 6.11). This section presents the outcomes of stages 2 and 3 which were carried out with specific regard to WFD quality elements.

6.3.5. **Table** 6.2 lists the projects included within the DCO EIA short list (stage 2) that could potentially impact upon marine waters and collates information where available (stage 3) to inform an assessment as to whether the project should be screened in for further consideration (further consideration constitutes stage 4). Each project has therefore been considered against the output of **section 5** to determine whether there is the potential for a cumulative effect.

6.3.6. **Table** 6.2 demonstrates that there is no potential for cumulative effects with other projects to arise on WFD water bodies.

Table 6.2 Cumulative impact assessment of screened in projects with the potential to affect WFD water bodies

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
Greater Gabbard Offshore Wind Ltd	Ongoing maintenance of the wind farm – including interarray cable maintenance, operations and maintenance	Approved	Yes	Yes	0km cable corridor; 39km windfarm site	Suffolk	Out	Licences are for small scale operational maintenance activities which could lead to temporary increases in suspended sediment concentrations only. There is therefore no potential for an in combination effect with the Sizewell C project.
EDF Energy Nuclear Development Ltd	SZB Nuclear Power Station Decommissioning Planned decommissioning of SZB power station. Decommissioning is anticipated to commence in 2035.	Consented – this licence expires December 2035	Yes	Yes	Adjacent	Suffolk	Out	The desilting activity is normally carried out during statutory outages at a 3-year interval frequency. It takes approximately 12 days to complete the work, with de-silting occurring intermittently during this period. Whilst the activity could give rise to increases in suspended

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
	Current licence for de-silting and maintenance works							solids concentrations, the effect are likely to be small scale and localised to the discharge location. Additionally, the operational discharges of sediment associated with Sizewell C are very low compared to naturally varying baseline.
Scottish Power Renewables (UK) Ltd	East Anglia ONE Offshore Wind Farm. Operations and Maintenance Marine Licence applications for Generation and Transmission Assets. Licence to commence on 1st August 2019 and expire by May 2045	Submitted (in progress). Would be operational until 2045.	Yes	Yes	11km cable corridor; 50km windfarm site	Export cable in Suffolk Coastal water body	Out	Only small scale effects during cable maintenance. Temporary and localised increases in suspended solid concentrations only.

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
Scottish Power Renewables (UK) Ltd	East Anglia ONE Offshore Wind Farm Development of an offshore wind farm consisting of up to 325 wind turbine generators and associated infrastructure, with an installed capacity of 1200MW	Consented- Onshore construction commenced in Q2 2017 and offshore in 2018.	Yes	Yes	9km cable corridor; 50km windfarm site	Export cable in Suffolk Coastal water body	Out	The East Anglia ONE project is currently under construction and is anticipated to be completed by the end of 2020. Therefore, the only anticipated cumulative effects would be from the operation and decommissioning phases of the project. Only the export cable is within the Suffolk WFD water body boundary (1nm). The array is located offshore, outside of WFD water body boundaries. All effects on water quality were predicted to not be significant. A Marine Pollution Contingency Plan would be implemented to reduce any potential risk of pollution (East Anglia

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
								Offshore Wind Limited, 2012). Given the very low significance of the effects predicted and the parameters likely to be impacted, it is considered that there is no potential for cumulative effects to arise.
Scottish Power Renewables (UK) Ltd	East Anglia ONE North Offshore Wind Farm. An offshore wind farm which could consist of up to 115 turbines, generators and associated infrastructure, with an installed capacity of 600MW to 800MW	EIA Scoping Opinion issued 08.12.2017. Registration of interest to PINS closed as of 27.01.20.	Yes	Yes	0km cable corridor; 48km windfarm site	Export cable in Suffolk Coastal water body	Out	Only the export cable element is within the Suffolk Coastal WFD water body boundary (1nm). The array is located offshore, outside of WFD water body boundaries. The potential effects of the proposed East Anglia ONE North project will be highly localised and small scale (Ref. 1.43). Given the very low significance of the effects predicted and the parameters likely to be

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
								impacted, it is considered that there is no potential for cumulative effects to arise
Scottish Power Renewables (UK) Ltd	East Anglia TWO Offshore Wind Farm An offshore wind farm which could consist of up to 115 turbines, generators and associated infrastructure, with an installed capacity of 600MW to 800MW	EIA Scoping Opinion issued 08.12.2017. Registration of interest to PINS closed as of 27.01.20.	Yes	Yes	0km cable corridor; 31km windfarm site	Export cable in Suffolk Coastal water body	Out	Only the export cable element of the proposals is within the Suffolk Coastal WFD water body boundary (1nm). The array is located offshore, outside of WFD boundaries. Through the construction, operation and decommissioning phases of the project, there would be limited potential for adverse effects on water quality, due to the implementation of the Project Environmental

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
								Management Plan. The potential effects of the proposed East Anglia TWO project will be highly localised and small scale and cumulative impacts are unlikely to occur (Ref. 1.44). Given the very low significance of the effects predicted and the parameters likely to be impacted, it is considered that there is no potential for cumulative effects to arise
East Anglia THREE Ltd	East Anglia THREE Offshore Wind Farm Development of an offshore windfarm with an approximate capacity of 1200MW off the	Development consent was granted in August 2017. Construction expected to commence in 2021.	Yes	Yes	11km cable corridor; 84km windfarm site	Export cable in Suffolk coastal water body	Out	Only the export cable element of the proposals is within the Suffolk Coastal WFD water body boundary (1nm). The array is located offshore, outside of WFD boundaries. Impacts would mostly be temporary, small scale and localised for the proposed

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
	coast of East Anglia							East Anglia THREE project. Given the distances to other activities and the localised nature of the impacts predicted. there is no pathway for interaction between impacts cumulatively. Whilst it is recognised that across the East Anglia Zone or southern North Sea there would be additive impacts, the overall combined magnitude of these would be negligible relative to the scale of the wider area (Ref. 1.45). Given the very low significance of the effects predicted and the parameters likely to be impacted, it is considered that there is no potential for cumulative effects to arise

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
National Grid Ventures	Nautilus Interconnector Proposed second interconnector between Great Britain and Belgium. It would create 1.4 gigawatts high voltage direct current. Elia and NGIHL are conducting a bilateral feasibility study and more information will be available in the future development plans. Connecting in the Leiston area is the preferred option for	Pre-application Application is expected to be submitted to the Planning Inspectorate Q2 2022	No	Yes	Landfall options between 1km and 2.7km from MDS	Proposed export cable in Suffolk coastal water body.	Out	The Nautilus and Eurolink Interconnectors are in early planning stage and therefore limited information is available on construction works, including schedules. The preferred option for the landfalls of the Nautilus and Eurolink Interconnectors is at Leiston. There could be a temporary effect associated with the construction of the cable corridor and associated landfall infrastructure. It is assumed that the project will implement measures to minimise the risk to geomorphology and water quality.

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
	connection. Further detailed consideration of siting options are being considered. The project is currently at the scoping stage. Installation may commence in 2026 with connection in 2028							
National Grid Ventures	Eurolink Interconnector. Proposed interconnector between UK and the Netherlands. Connecting in the Leiston area is the preferred option for connection.	No further information currently available.	No	Yes	Landfall options between 1km and 2.7km from MDS	Proposed export cable in Suffolk coastal water body.	Out	

Developer	Project title and description	Current status and availability of information	Spatial link to the project	Temporal link to the operational phase of the project	Distance to project site	WFD water body at risk	Screened in to or out of the assessment	Justification for screening decision
	Further detailed consideration of siting options Are being considered. The Project is currently at the scoping stage. Likely to connect in 2025							

7 SUMMARY OF ASSESSMENT

7.1 Purpose of this section

7.1.1. This section summarises the results of the WFD compliance assessment. A description of the proposed mitigation measures that are required to address any impacts and prevent a deterioration in status or failure to meet the WFD objectives set for the relevant water bodies is also provided.

7.2 Summary of assessment

7.2.1. The results of the screening exercise identified two activities to be considered against the requirements of the WFD; the operational discharge from the cooling water system (O1) and the operational discharge of polluting matter from the FRR system (O2). One WFD water body, the Suffolk coastal water body, was identified for consideration; against which the scoping stage was completed. Adjoining water bodies were then considered if an effect was identified on the Suffolk coastal water body as part of Stage 3 (further assessment).

7.2.2. The results of the scoping exercise indicated that the operational cooling water discharge potentially could lead to a deterioration in the chemical status, biological status (fish, habitats and phytoplankton via effects on physico-chemical parameters) and Protected Areas (Nitrates Directive, Bathing Waters and European Designated Sites). For the operational discharge of polluting matter from the FRR system, it was identified that the activity potentially could lead to a deterioration in biology status (fish and phytoplankton via effects on physico-chemical parameters) and Protected Areas (Nitrates Directive, Bathing Waters and European Designated Sites). As a result, both activities were carried through to further assessment for these specific compliance parameters.

7.2.3. The output of the further assessment for the operational discharge from the cooling water system (O1) concluded that for both physico-chemical and chemical parameters for Sizewell C operating alone, that either the parameter passed the screening stage (would not lead to an EQS failure within the discharge itself) or, when further modelling was carried out, did not indicate any area of EQS (or equivalent) exceedance within the Suffolk Coastal water body.

7.2.4. When considered cumulatively with the plume for Sizewell B, modelling indicates that the majority of the effect in the WFD water body relates to the existing Sizewell B plume. The only parameter altered by the addition of

Sizewell C is the thermal plume, which serves to elevate temperatures at the edges of the Sizewell B thermal plume which increases the areas over which guideline standards are exceeded. When considered against the biological baseline and, specifically, the low sensitivity of the species located within area predicted to be affected, the potential for a non-temporary effect either within or between classes is not predicted. Additionally, given the very small scale water quality effects associated with Sizewell C, impacts on fish, phytoplankton and Protected Areas (Nitrates Directive, Bathing Waters) are not predicted. The consideration of relevant European Designated sites is undertaken within the HRA submitted alongside this WFD compliance assessment.

7.2.5. With respect to the operational discharge of polluting matter from the FRR system (O2), effects are predicted in the WFD water body but these are very small scale and localised to the FRR outfall location. As a result, the potential for a non-temporary effect either within or between classes is not predicted; and neither are impacts on Protected Areas (Nitrates Directive and Bathing Waters).

7.2.6. Given the prediction of very small scale effects within or outside the water body, risks to adjoining water bodies and cumulative effects for either the O1 or O2 activity were not identified.

7.2.7. Therefore, it can be concluded that the Sizewell C Project WDA permitted activities would not cause non-compliance with the WFD either alone or cumulatively with other plans and projects. Additional mitigation was not identified as being required.

8 REFERENCES

1.1 Royal HaskoningDHV. Marine Strategy for Sizewell C Water Framework Directive Assessment. 2015a.

1.2 BEEMS Technical Report TR316; Sizewell- Evaluation of chlorination dosing options for Sizewell C - Edition 5.

1.3 BEEMS Technical Report TR306 Sizewell C Marine Sediment and Water Quality Synthesis Report.

1.4 BEEMS Technical Report TR339 Sizewell Comprehensive Impingement Monitoring Programme 2014 – 2017.

1.5 BEEMS Technical Report TR381 Acoustic surveying of pelagic fish off Sizewell (2016). Cefas, Lowestoft.

1.6 BEEMS Technical Report TR483 Synthesis of evidence for SZC Water Framework Directive (WFD) and Habitats Regulations Assessment (HRA) marine assessments Version 4.

1.7 Cefas SAR008 (2011) BEEMS scientific advisory Report SAR008. BEEMS Expert Panel. Thermal standards for cooling water form new build nuclear power stations. Cefas.

1.8 BEEMS Technical Report TR193 Ed2 Sizewell C discharges H1 type assessment supporting data report.

1.9 BEEMS Technical Report TR314 Sizewell supplementary water quality monitoring data 2014/2015. Cefas, Lowestoft.

1.10 BEEMS Technical Report TR189 Sizewell C Water Quality Monitoring Report

1.11 BEEMS Technical Report TR301 SZ Thermal Plume Modelling Stage 2A Review; Selection of Preferred SZC CW Configuration.

1.12 BEEMS Technical Report TR302 Sizewell C Thermal Plume Modelling GETM Stage 3. Edition 3.

1.13 BEEMS Technical Report TR131 Sizewell Water Quality Literature Report.

1.14 BEEMS Technical Report TR348 Sizewell C Benthic Ecology characterisation report.

1.15 BEEMS Technical Report TR473 Coralline Crag Characterisation.

1.16 Environment Agency. Catchment Data Explorer (undated) (Online) Available from: http://environment.data.gov.uk/catchment-planningReference 2 (accessed 05/02/19).

1.17 Environment Agency. Clearing the Waters for All. Water Framework Directive assessment: estuarine and coastal waters. How to assess the impact of your activity in estuarine and coastal waters for the Water Framework Directive (WFD). 2016. (Online) Available from https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters (accessed 29/05/19).

1.18 The Planning Inspectorate. Planning Inspectorate Advice Note 18: The Water Framework Directive. London. 2017.

1.19 Bamber, R., (1988). Sizewell "C" environmental studies: Marine invertebrates interim report, October 1988.

1.20 Phillips, G.R., Anwar, A. Brooks, L., Martina, L.J., Miles, A.C, Prior, A. Infaunal quality index: Water Framework Directive classification scheme for marine benthic invertebrates. Report: SC080016. Environmental Agency, Bristol. 2014.

1.21 BEEMS Technical report TR385 Modelling the effect of Sizewell C entrainment on the phytoplankton of Sizewell Bay.

1.22 BEEMS Technical Report TR476 Sizewell Phytoplankton status under the Water Framework Directive (WFD).

1.23 BEEMS Technical Report TR345 Sizewell Characterisation – Fish.

1.24 Scottish Power Renewables, East Anglia ONE Offshore Windfarm Environmental Statement. Volume 2 Offshore. Chapter 10 - Fish Ecology. 2012.

1.25 UKTAG. UK Environmental Standards and Conditions Phase 1. UK Technical Advisory Group on the Water Framework Directive. (2008b).

1.26 UKTAG. UK Environmental Standards and Conditions Phase 2. UK Technical Advisory Group on the Water Framework Directive. (2008c).

1.27 Wither, A.W., Bamber, R., Colclough, S.R., Dyer, D., Elliott, M., Holmes, P., Jenner H.A., Taylor, C.J.L., Turnpenny, A.W.H. Setting new thermal standards for transitional and coastal (TraC) waters. Marine Pollution Bulletin, 2012, 64: (1564–1579).

1.28 Benson, B.B. and Krause, D Jr. The concentration and isotopic fractionation of oxygen dissolved in freshwater and seawater in equilibrium with the atmosphere. Limnol. Oceanogr., 1984, 29(3) 620-632.

1.29 Environment Agency. Surface water pollution risk assessment for your environmental permit. 2018. (Online) Available from: https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit (Accessed 08/12/2019).

1.30 BEEMS Technical Report TR143 Ed. 2: Calibration of a Model of Total Residual Oxidant (TRO) Using Laboratory Data on Seawater Samples Collected in the Vicinity of Sizewell Nuclear Power Station. Cefas.

1.31 BEEMS Technical Report TR217 Experimental Studies to Identify Key Chlorination by-products (CBPs) in Cooling Water Discharge from Sizewell C.

1.32 Mackay, D. and Leinonen P.J., Rate of evaporation of low-solubility contaminants from water bodies to atmosphere. Environ. Sci. Technol. 1975. 9:1178-1180.

1.33 BEEMS Technical Report TR145 Sizewell: Laboratory studies of the decay of Hydrazine measured in sea water samples. Cefas, Lowestoft.

1.34 Poornima, E. H., Rajadurai, M., Rao, V. N. R., Narasimhan, S. V, and Venugopalan, V. P.. Use of coastal waters as condenser coolant in electric power plants : Impact on phytoplankton and primary productivity, 2006, 31: 556–564.

1.35 Chuang, Y., Yang, H., and Lin, H. Effects of a thermal discharge from a nuclear power plant on phytoplankton and periphyton in subtropical coastal waters. Journal of Sea Research, 2009. 61: 197–205. Elsevier B.V.

1.36 Underwood, G. J. C., and Kromkamp, J., Primary Production by Phytoplankton and Microphytobenthos in Estuaries. Advances in Ecological Research, 1999, 29: 93–139.

1.37 Stevenson, D. K., and Pierce, F.. Life history characteristics of Pandalus montagui and Dichelopandalus leptocerus in Penobscot Bay, Maine. Fishery Bulletin, 1985. 88: 219–233.

1.38 Clegg S. L. and Whitfield, M. A chemical model of seawater including dissolved ammonia, and the stoichiometric dissociation constant of ammonia in estuarine water and seawater from -2° to 40 °C. Geochim. et Cosmochim. Acta, 1995. 59, 2403-2421.

1.39 Atkins, Hyder, Royal HaskoningDHV. Sizewell C SSSI Crossings: Environmental appraisal of options under consideration. November 2015

1.40 BEEMS Technical Report TR354 Sizewell Brackish ponds salinity monitoring. Cefas, Lowestoft.

1.41 Technical Report TR520 Cefas BEEMS Technical Report TR520 Sizewell C Water Quality Effects of the fish recovery and return system. SZC – SZ0200-XX-000-REP-100127

1.42 TR511 BEEMS Technical Report TR511. Particle Tracking Study of Impinged Sprat from the Proposed Sizewell C Fish Recovery and Return. Cefas, Lowestoft.

1.43 Scottish Power Renewables, East Anglia ONE North Scoping Report. 2017.

1.44 Scottish Power Renewables, East Anglia TWO Scoping Report. 2017.

1.45 Scottish Power Renewables, East Anglia THREE Scoping Report. 2015.