Permitting new nuclear power stations

Environmental permitting of NNB Generation Company (Sizewell C) Limited

Consultation document: water discharge activities

July 2022

Version 1

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This consultation – at a glance

Topic

This consultation is about the Environment Agency's proposed decision on the application NNB Generation Company (SZC) Limited for an environmental permit.

The application has been made under the Environmental Permitting (England and Wales) Regulations 2016 (EPR 2016) to carry out water discharge activities associated with the operation of a new nuclear power station at the proposed Sizewell C site, near Leiston, in Suffolk.

Geographical scope

England only.

Audience

This consultation is aimed at:

- members of the public
- communities who reside in an area near the site
- statutory consultees
- academics with an interest in nuclear power, energy production or the environment
- non-governmental organisations (NGOs)

Comments from any other interested parties are also welcome.

Duration

12 weeks.

Contact details

Please complete the online response form on our consultation hub. Alternatively, you can email your response to: psc-waterquality@environment-agency.gov.uk or write to us at:

Sizewell C Consultation Environment Agency
Permit Support Centre
Quadrant 2
99 Parkway Avenue
Parkway Business Park
Sheffield
S9 4WF

If you have any queries, or would like a hard copy of this document, please email us at: psc-waterquality@environment-agency.gov.uk

Next steps

Our determination of NNB Generation Company (SZC) Limited's application continues and we have not yet reached any final decision. We will complete our determination, including carefully considering all relevant comments made during consultation and will produce a final decision document that:

- sets out our decision on whether or not to issue a permit to NNB Generation Company (SZC) Limited
- summarises the consultation responses and issues raised
- set out our views on those issues

We expect to:

- publish our final decision document at the end of our determination, which we are targeting to complete in early 2023

Opportunities to have your say on other Sizewell C permits

NNB Generation Company (SZC) Limited has also applied for 2 other environmental permits required to operate the Sizewell C power station. These permits are to carry out radioactive substances activities (application reference EPR/HB3091DJ/A001) and combustion activities for the operation of the standby diesel generators to be used to provide backup electrical supplies to the site (application reference EPR/MP3731AC/A001). We are also currently consulting on our proposed decisions for these 2 permit applications at the same time as this consultation relating to the WDA permit application. Details of these consultations can be found on our dedicated Sizewell pages and our consultation hub.

Executive summary

This document is prepared for public consultation on our proposed decision on the application NNB Generation Company (SZC) Limited made for an environmental permit. The application is made under the Environmental Permitting (England and Wales) Regulations 2016 (EPR 2016) to operate water discharge activities associated with the operation of a new nuclear power station at the Sizewell C (SZC) site, near Leiston in Suffolk. These activities are the discharge of returned abstracted seawater used as cooling water, returned abstracted seawater via the two fish recovery and return (FRR) systems, and process generated liquid trade effluents from the operational site.

We advertised the application and consulted the public and other stakeholders between 6 July and 2 October 2020. We have assessed the application, considered the consultation responses we received, and have made a proposed decision to grant the application subject to the conditions in the draft permit that accompanies this document. Our processes require further public consultation on our proposed decision and draft environmental permit. The purpose of this consultation is to seek your views on our proposed decision and draft permit to help us come to a final decision.

We will not make a final decision about this application until we have carefully considered the responses to this public consultation.

The proposed SZC nuclear power station has 2 pressurised water reactors based on EDF and AREVA's UK European Pressurised Reactor (EPR™) design. The total expected net electrical capacity is 3,260MW (with each EPR™ reactor capable of producing 1,630MW of electricity (MW_E) for export to the national grid).

The site-specific application NNB Generation Company (SZC) Limited made builds on information provided during the generic design assessment (GDA) of the UK EPR™ reactor design. We have already assessed the UK EPR™ reactor in our generic design assessment (GDA) process, and issued a final Statement of Design Acceptability (SoDA) in December 2012.

In March 2013, we completed the assessment of an application from NNB Generation Company (GenCo) Limited, now called NNB GenCo (HPC) Limited, to operate water discharge activities at the Hinkley Point C (HPC) nuclear licensed site in Somerset, which is currently under construction. The granted operational water discharge activity (WDA) permit reference for HPC is EPR/HP3228XT, and the HPC construction related WDA permit is EPR/JP3122GM.

NNB Generation Company (SZC) Limited is a sister company of NNB Generation Company (HPC) Limited. The nuclear power station at HPC is of the same design, and NNB Generation Company (SZC) Limited proposes to replicate, so far as is practicable, the HPC development at the SZC site.

The Sizewell site is located on the east coast of the United Kingdom, approximately 1.5km north-east of the town of Leiston in the county of Suffolk. NNB Generation Company (SZC) Limited proposes to construct a new nuclear power station at a location immediately north of the existing Sizewell B (SZB) and Sizewell A (SZA) power stations. The proposed new power station is known as Sizewell C (SZC), see Figure 1.

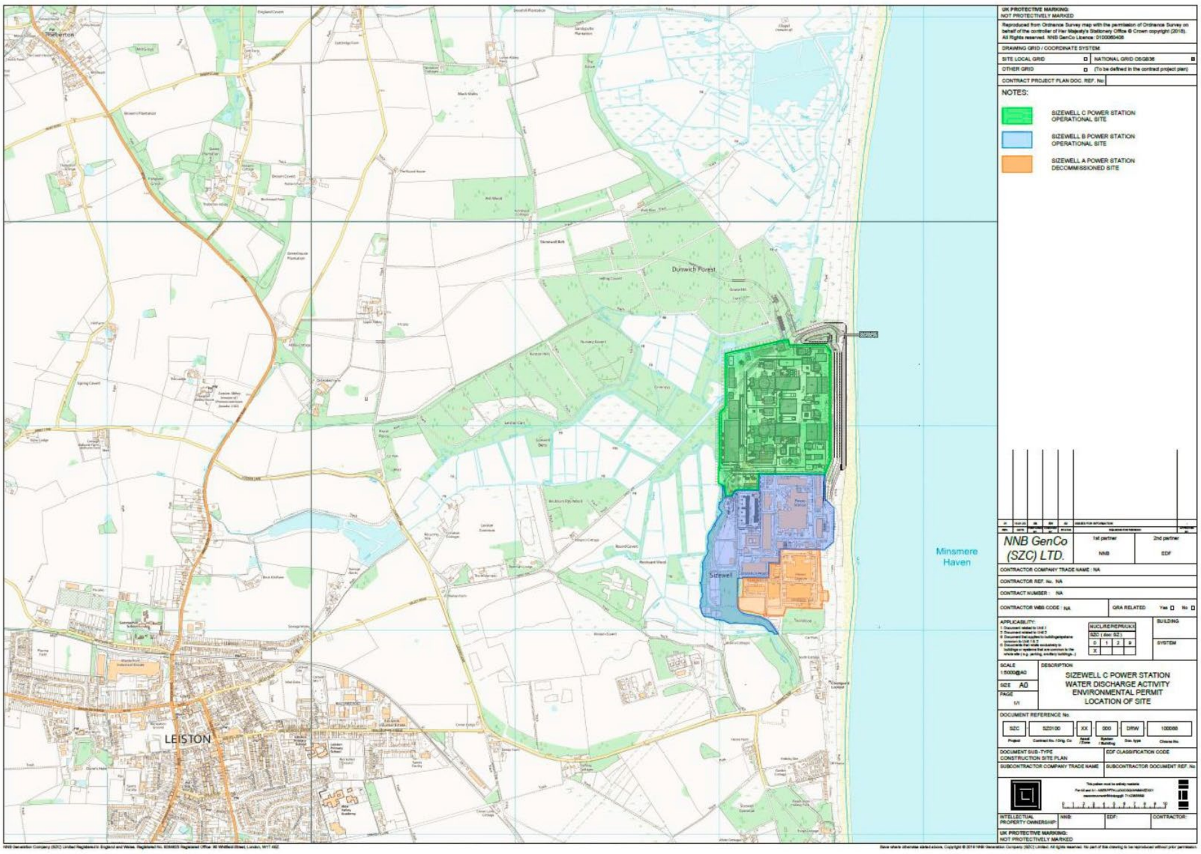

Figure 1. Location of the operational SZC site (green) in comparison with SZB (blue) and SZA (orange). Reproduced from figure 1.4.1 in NNB GenCo (2020g, SZC project – Water discharge activity permit application submission Sizewell C and Appendix A – 100232385).

The company has applied for operational environmental permits many years ahead of planned operations beginning. It is expected that any operational water discharge activities would not take place at SZC before the mid-2030s. However, we consider that there are significant benefits in regulating at an early stage of site-specific design and during the development of the operator’s organisational capabilities. We recognise that the detailed arrangements for operations and compliance are not yet fully developed. However, we still require suitable arrangements and resources to be in place for each phase of the project. This will help ensure that, when operations begin, the power station, its arrangements and resources are ready and suitable to maintain compliance with the requirements of our permits.

SZC will be constructed immediately to the north of the existing Sizewell B (SZB) power station (Figure 1). Construction of SZB started in 1988 and it began producing electricity in 1995. To the south of SZB lies the Sizewell A (SZA) power station site, which is currently undergoing decommissioning. It was operational for 40 years between 1966 and 2006.

SZC will be ‘direct-cooled’ (also known as ‘open-cycle cooling’), with each of the 2 UK EPR™ units having its own dedicated cooling water (CW) intake tunnel extending approximately 3.0 to 3.5km offshore. Seawater will then be abstracted from the Greater Sizewell Bay in the North Sea via 2 dedicated intake heads and tunnels, one for each reactor, located approximately 500m apart.

In its operational phase, SZC will require a continuous supply of cooling water at a rate of 132 cubic metres per second (m^3/s) at mid-tide level of seawater which will vary between 125 and 140m^3/s.

The offshore cooling water intakes will be located at I3 and I4, as indicated by the green circles in Figure 2. Three location options were identified for the intake heads; I3a, b and c, and I4a, b and c. I3a and I3b, and I4a and I4b, were selected as the preferred options for the intakes, with I3c and I4c as reserve location options.

After being used within the power station, the seawater would then be discharged back to the Suffolk coast via a long outfall tunnel, with a mean excess temperature of 11.6°C above ambient background. In practice, both the temperature and volume would vary tidally due to the variable load on the cooling water pumps themselves. Where pumping rates are reduced towards higher tidal levels, there would be a corresponding increase in discharge temperature.

An extended set of options for the selection of the SZC cooling water outfall locations were modelled and then analysed, and a preferred location identified on the basis of minimising recirculation and environmental concerns. Location O9 offshore of the Sizewell-Dunwich Bank, the furthest west that a SZC CW outfall could be built (TR306), was identified for 2 cooling water outlets (O9a and O9b). Their location is shown in Figure 2:

- cooling water outfall 1, O9a: TM 51080 64125
- cooling water outfall 2, O9b: TM 51155 64125

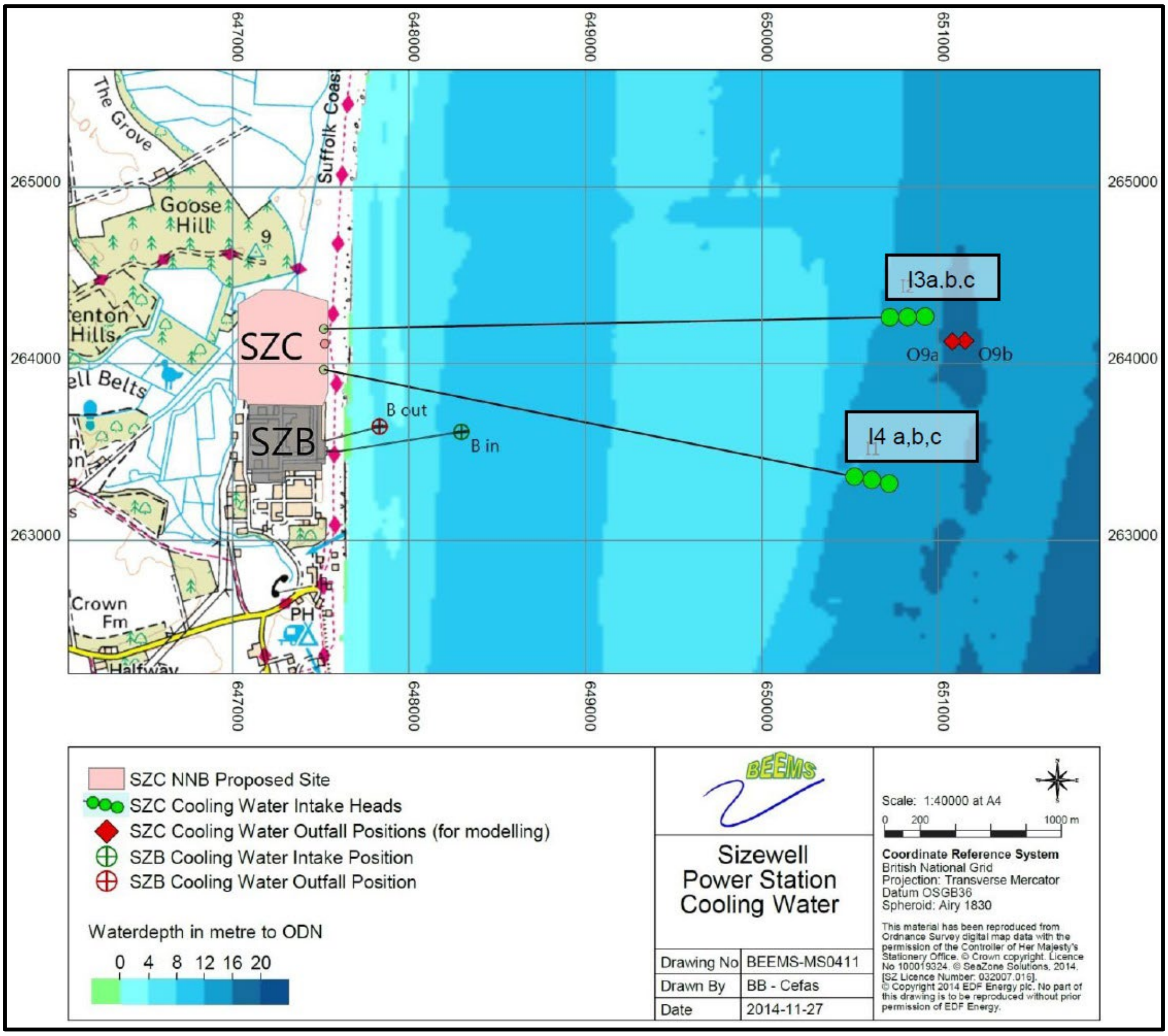

Figure 2. Location of the preferred SZC cooling intake and outfall structures in proximity to those at SZB (reproduced from figure 1 in NNB GenCo, 2020a; TR302)

As a result of the direct cooling of the SZC power station with seawater, the UK EPR™ units at SZC will incorporate 2 fish recovery and return (FRR) systems to minimise the risk of injury to fish that are drawn into the cooling water system and return them to the Greater Sizewell Bay, but at a location where they are not likely to be returned to the cooling water intakes.

The 2 FRR system outlets are proposed to be located at the following National Grid references (NGRs) Figure 3:

- FRR outlet 1: TM 47980 64000
- FRR outlet 2: TM 47980 64254

The specific design details of the 2 SZC FRR systems will largely replicate the HPC FRR system design, considering the design best practice guidance, and will comply with marine licence conditions, when granted.

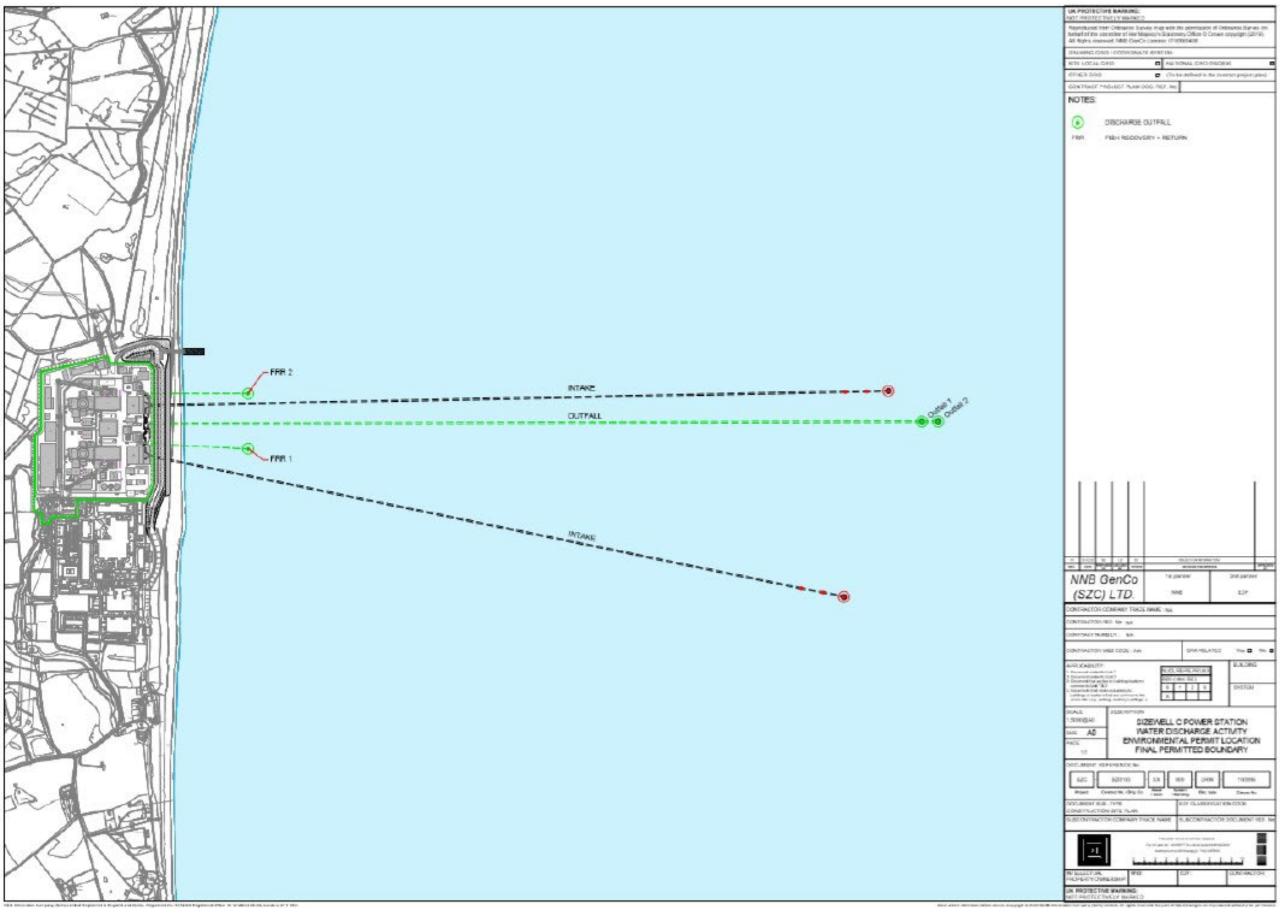

Figure 3. Location of the proposed cooling water inlets, discharge outlets and FRR system outlets. Reproduced from figure 1.4.3 in NNB GenCo (2020g, SZC project – Water discharge activity permit application submission Sizewell C and Appendix A – 100232385).

The proposed permit application will cover the operational water discharge activities (WDAs) from hot functional testing (HFT) during commissioning, through operation and up until site decommissioning begins once production of electricity ceases.

The sources contributing to each of the proposed WDAs via waste streams A to H are described in some detail within section 4.9 of this draft permit decision document and are assessed within section 4.11.

The WDAs relate to the discharge of non-radioactive liquid effluent, which can be attributed to the following main sources:

- returned abstracted cooling water from the turbine condensers and other cooling systems
- control of biological fouling of the cooling systems
- process effluent from the various plant systems, including those that maintain water purity and chemistry
- treated sewage effluent from staff welfare facilities

- returned abstracted seawater via 2 fish recovery and return (FRR) systems

The returned abstracted cooling water is the main emission (or waste stream) associated with this WDA permit application. The cooling water (waste stream A) represents approximately 99% by volume of the total overall daily discharges of non-radioactive effluent from SZC. The maximum daily discharge volume of cooling water would be approximately 11.4 million cubic metres (m^3). During standard operation, cooling water would be returned to the Greater Sizewell Bay at a maximum temperature of 11.6°C above the ambient seawater temperature, having passed through the steam turbine condensers.

Several much smaller waste streams (B to G) would be combined with the returned abstracted cooling water before being discharged to the Greater Sizewell Bay. Process effluents would be produced mainly as a result of removing waste from the SZC plant systems, to maintain the best operating conditions and maximise efficiency.

The trade effluent type and discharge volume of each proposed SZC waste stream can be summarised as follows:

Waste stream A

- Trade effluent composed of abstracted seawater that is used within the power station as cooling water, which will be characterised by thermal content and will potentially be dosed with sodium hypochlorite to prevent biofouling of the cooling water infrastructure. This will be the most significant discharge in terms of flow and will be discharged, in admixture with the other trade effluents generated via waste stream B to G, back to the Greater Sizewell Bay via a dedicated cooling water tunnel and 2 outlets.
- Discharge rate of 132m^3/s (as a tidal mean).

Waste streams B and C

- Trade effluent generated by operations within the nuclear island waste monitoring and discharge system (waste stream B), combined with trade effluent generated by the steam generator blowdown system and that cannot be recycled (waste stream C). The combined effluents generated by waste streams B and C will be discharged together in admixture with the continuous flow of cooling water generated by waste stream A via the outfall pond.
- Maximum daily discharge volume of waste streams B and C combined is 1,500m^3/day.

Waste stream D

- Trade effluent generated from the turbine hall and uncontrolled area floor drains (excluding blowdown from the steam generator blowdown system). Waste stream D will be discharged in an admixture with the continuous flow of cooling water generated by waste stream A via the outfall pond.
- Maximum daily discharge volume of 1,500m³/day.

Waste stream E

- Trade effluent generated from the site drainage system, including drainage from road and roof surfaces, uncontaminated water from oily water network and atmospheric condensate from chillers. Waste stream E will be discharged on an intermittent basis via the forebay into the abstracted seawater that forms the continuous flow of cooling water generated by waste stream A.
- Maximum daily discharge volume of 35,000m³/day.

Waste stream F

- Trade effluent generated from the production of demineralised water, which will be treated to neutralise extremes of pH before being discharged with the continuous flow of cooling water generated by waste stream A via the outfall pond.
- Maximum daily discharge volume of 4,000m³/day.

Waste stream G

- Sanitary effluent from administration and mess facilities, which will be treated in an appropriately designed sewage treatment plant (STP). The waste stream G treated sewage effluent will be discharged via one of the site's 2 outfall ponds (1 per UK EPR™ unit) into the main cooling water flow of waste stream A.
- Maximum daily discharge volume of 190m³/day.

Waste stream H

- Trade effluent composed of returned abstracted seawater via the 2 fish recovery and return (FRR) systems, operating on a continuous basis, which discharge via 2 dedicated FRR outfalls (one outfall per FRR system).
- Maximum daily discharge volume of 25,920m³/day per FRR system (two FRR systems in total.

The chemicals and substances associated with each of SZC waste stream are summarised as follows:

Waste stream A

- Total residual oxidant (TRO): as a result of adding biocide in the form of sodium hypochlorite to the incoming cooling water.
- Chlorination by-products (CBPs): from the reaction of residual oxidants with seawater, which produces bromoform.
- In addition to TRO and CBPs, waste stream A will also result in increased temperature from removing waste heat from the power station's condensers.

Waste streams B and C

- Ammonia, morpholine and ethanolamine: Used to obtain, maintain and adjust the relevant pH to levels where minimum levels of corrosion occur.
- Hydrazine: used to eliminate oxygen in the steam generator feedwater to prevent fouling by corrosion products (principally iron oxides). Hydrazine decomposes when heated to produce ammonia.
- Boric acid: used as a neutron absorber within the primary circuit to control reactivity.
- Lithium hydroxide: dosed into the primary circuit coolant in small amounts to counteract any changes in pH to maintain alkalinity to prevent equipment corrosion (to offset the acidity of boric acid).
- Trisodium phosphate: dosed into cooling and heating circuits to inhibit corrosion of circuits on contact with air (where an all-volatile treatment cannot be used).
- Zinc acetate to inhibit corrosion.
- Metals arising from wear in the circuits and associated equipment, including aluminium, copper, chromium, iron, lead, manganese, nickel and zinc.
- Hydrogen peroxide: to produce an oxidising environment during shutdown.
- Potential metal contaminants in process chemicals that are present in only trace amounts (cadmium and mercury).
- Chemical oxygen demand (COD) will be included, generated from the organic compounds, particularly detergents, to be used, and also from oxidisable mineral salts in the water used.
- Floor and equipment drains may be contaminated with cement dust (calcium compounds), possibly small concentrations of soaps and detergents, chemicals from closed cooling systems leaks or spills, decontamination water and other sources. The floor drains may also be high in dissolved organic materials and salts.

Waste stream D

- Ammonia, morpholine and ethanolamine: Used to obtain, maintain and adjust the relevant pH to levels where minimum levels of corrosion occur.
- Hydrazine: used to eliminate oxygen in the steam generator feedwater to prevent fouling by corrosion products (principally iron oxides). Hydrazine decomposes when heated to produce ammonia.

- Trisodium phosphate: dosed into cooling and heating circuits to inhibit corrosion of circuits on contact with air (where an all-volatile treatment cannot be used).
- Potential metal contaminants in process chemicals that are present in only trace amounts (cadmium and mercury).
- Metals will arise from corrosion and erosion in the circuits where coolant and other process waters contact equipment. Metals used in the UK EPR™ equipment include aluminium (Al), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn). Suspended solids, largely arising from collected effluent that may be polluted by dust.
- Chemical oxygen demand (COD) will be included, generated from the organic compounds (particularly detergents) to be used and also from oxidisable mineral salts in the water used.
- Floor and equipment drains may be contaminated with cement dust (calcium compounds), possibly small concentrations of soaps and detergents, chemicals from closed cooling systems leaks or spills, decontamination water and other sources. The floor drains may also be high in dissolved organic materials and salts.

Waste stream E

- Oils.
- Hydrocarbons.
- Suspended solids.

Waste stream F

- Iron, predominantly introduced as ferric chloride into the demineralisation plant.
- Suspended solids, present in the slurry and filter back-washings from the demineralisation plant.
- Sulphates, introduced as sulphuric acid to (a) clean the resins and membranes within the demineralisation plant; and (b) treat effluent within the neutralisation pit.
- Sodium, introduced as sodium hydroxide to (a) clean the resins and membranes within the demineralisation plant; and (b) treat effluent within the neutralisation pit.
- Chlorides, introduced as ferric chloride or sodium hypochlorite in the demineralisation plant.
- Trace metal contamination of raw materials such as sodium hydroxide and sulphuric acid used in the demineralisation process. Contamination usually includes cadmium and mercury.
- Detergents.
- Sequestering agents, used to prevent mineral deposits forming and blocking reverse osmosis membranes.

Waste stream G

- Suspended solids.
- Ammonia.
- Nitrate.
- Phosphate.
- BOD (biochemical oxygen demand).

Waste stream H

- Moribund biota: A proportion of the biota abstracted with the cooling water will not survive transit through the 2 FRR systems. The discharge of this moribund biota presents a potential source of polluting matter. The decay of this matter will contribute additional nutrients, unionised ammonia, organic enrichment, biochemical oxygen demand (BOD) and deoxygenation to the receiving water body.

In this draft decision document for the SZC operational WDAs, we have set out our preliminary conclusions on NNB GenCo (SZC)'s application and considered:

- the proposed emissions to surface water and their potential impact on water quality
- proposed emissions to surface waters and their potential impact on the nationally and internationally important designated habitats and species
- our GDA conclusions, to make sure that NNB GenCo (SZC) has dealt with any issues as part of the permitting process that were not covered by GDA
- whether the proposed strategy and discharge of total residual oxidant (TRO) are acceptable for controlling biological fouling of the cooling water system
- whether the discharge of dead or damaged fish via the 2 fish recovery and return (FRR) systems are acceptable
- the matters raised during the consultation

We have assessed the impact of the WDAs in relation to a wide range of legislation, including the Habitats Directive and the Water Framework Directive.

In considering the Habitats Directive, we carried out an assessment of potential impacts on the Outer Thames Estuary SPA and the Southern North Sea Severn Estuary SAC, SPA and Ramsar, as well as several other designated European conservation sites. The main areas of concern were (i) thermal impacts due to the discharge of cooling water at a higher than ambient temperature, (ii) toxic contamination due to process chemicals, including the use of biocide to control biofouling, and (iii) nutrient enrichment to determine if these could lead to an adverse effect on the features of the European sites.

We have concluded that we are satisfied there would be no adverse effect on the integrity of the European sites from the discharges associated with the proposed operational WDAs from SZC on the designated features of the relevant European sites or functionally linked land and features.

In considering the Water Framework Directive (WFD), we carried out an assessment of the potential impacts on the WFD water bodies that could be affected. Our assessment of the potential impact of the proposed discharge addressed both physico-chemical parameters, as well as the ecological elements that form the basis of the ecological classification of these water bodies.

We concluded that the proposed WDAs would not cause the current status of the WFD water bodies to deteriorate, nor prevent them from achieving their objectives.

Our assessment of the impact of proposed discharges from waste streams A to G indicated that apart from temperature, TRO, bromoform and hydrazine, the levels of all other permitted substances contained within the waste streams do not exceed the relevant environmental quality standard or target before being discharged to the Greater Sizewell Bay. Our assessment of the impact of the proposed discharges from waste stream H (via FRR systems 1 and 2) indicated that that the combined moribund biomass discharged from the two FRR system outfalls will require control.

The draft permit requires NNB GenCo (SZC) to operate the SZC power station in a way that ensures the maximum loading of substances in the waste stream discharges does not exceed those levels stated in its application.

We have therefore included compliance limits for temperature, TRO and hydrazine and moribund biomass in our draft permit that would make sure that the environment is protected. The compliance limits for TRO will also ensure that bromoform (CBP) is controlled.

At this stage, we consider that there was no reason why we should not grant an environmental permit for the proposed WDAs from the operational SZC power station. We considered that the limits and conditions in the draft permit are suitable to protect people and the environment.

The aim of our consultation regarding our proposed decision and draft permit is to seek views to help us reach a final decision, in particular whether there are any errors, omissions or new relevant information that has not already been considered.

1. About this consultation document

This is a document setting out our proposed decision and is accompanied by a draft environmental permit document. It explains how we have considered NNB Generation Company (SZC) Limited's (afterwards referred to as NNB GenCo (SZC)) application and why we have included the specific conditions in the draft permit we are proposing to issue. It is our record of our decision-making process so far, to show how we have considered relevant matters in reaching our proposed decision.

The document sets out our proposed decision because we have yet to make a final decision. Before we make this decision, we want to explain our thinking to the public and other interested parties, to give them an opportunity to understand that thinking and, if they wish, to make comments to us. We will make our final decision only after carefully considering any relevant matters raised in the responses we receive. At that time, we will make our final decisions about whether a permit should be issued for Sizewell C and, if so, the conditions that it should place on the operator.

Unless we receive information that leads us to change the conditions in the draft permit, or to reject the application altogether, we will issue the permit in its current form.

This document includes:

- a description of how we process and determine applications (Section 2)
- a summary of the application and brief details of our consultation on the application (Section 3)
- a description of our assessment (Section 4)
- a statement of our proposed decision (Section 5)
- a summary of consultation responses (Appendix 1)

1.1 The Environment Agency

Our corporate strategy 'creating a better place 2025' sets out our aims and describes the role we play in being part of the solution to the environmental challenges society faces.

Our strategy aims to champion sustainable development, support our work to create better places and challenge us to tackle the climate emergency and provide a green economic recovery for everyone, in 3 long-term goals:

- a nation resilient to climate change
- healthy air, land and water
- green growth and a sustainable future

1.2 Our role in environmental regulation

We regulate the environmental impacts of nuclear sites, such as nuclear power stations, nuclear fuel production plants and plants for reprocessing spent nuclear fuel, through a number of environmental permits. These permits may be needed during the site preparation, construction, operation and decommissioning phases of the plant's lifecycle.

The permits we issue include conditions and limits. In setting these, we take into account all relevant national and international standards and legal requirements, to ensure that people and the environment will be properly protected. These standards and requirements are described in GOV.UK at:

- Environmental permitting guidance: Core guidance (UK Parliament, 2020)
- Check if you need an environmental permit (Environment Agency, 2016a)

We inspect sites to check that operators are complying with the conditions and limits, and that they have arrangements in place to help ensure compliance. We may take enforcement action (for example, issuing an enforcement notice or taking a prosecution) if they are not compliant.

We regularly review permits, and vary (change) them if necessary, to ensure that the conditions and limits are still effective and appropriate. Where significant changes are required, we may consult on these changes.

We work closely with the Office for Nuclear Regulation (ONR), which regulates the safety, security and nuclear material safeguards and transport aspects of nuclear sites.

1.3 Our regulatory role in the development of new nuclear power stations

As with existing nuclear sites, any new nuclear power station will require environmental permits from us to cover specific aspects of site preparation, construction, operation and eventually decommissioning. In the light of government and industry expectation that plants of almost the same design might be built on a number of sites and potentially be run by different operating companies, we have split our process for assessing and permitting the operational stage of new nuclear power stations into 2 phases.

In the first phase, generic design assessment (GDA), we carry out a detailed assessment of the features of a generic reactor design that can affect those aspects of its environmental performance that we regulate. If we are fully content with the environmental aspects of the generic design, we provide a Statement of Design Acceptability (SoDA). If we are largely content, but there are GDA Issues (that is, significant but resolvable outstanding matters), we issue an interim Statement of Design Acceptability (iSoDA). In both cases, we also identify Assessment Findings. These are matters, which a future operator will need to address, at the appropriate stage of a new build project, that is, during detailed design, procurement, construction, commissioning or early operation. Where an iSoDA has been issued, we expect the designer to provide further information as it implements its resolution plan. We close GDA Issues only once we are satisfied that they have been resolved. Once all GDA Issues are closed, we will consider issuing a full SoDA.

We carried out GDA of the UK EPR™ design from Électricité de France SA and AREVA NP SAS ('EDF and AREVA') and issued a final SoDA for the UK EPR™ in December 2012.

In the second phase, operators wishing to construct and operate nuclear power stations at specific sites are required to make applications for environmental permits. In determining these applications, we take account of the work we have already done during GDA. In this way, our efforts are focused on operator-specific and site-specific matters, including how the operator has addressed any relevant matters arising from GDA and any changes to the GDA design arising from the site-specific considerations or operator required modifications.

Operators can apply to the Environment Agency for a new permit or a variation (change) to an existing permit at any time. We expect GDA to be concluded prior to site-specific permit application, but recognise that this will not always be the case. Where an applicant wishes to take credit for the GDA process, we require a SoDA or iSoDA to be issued prior to consulting on a proposed decision on the permit application. Where only an iSoDA has been issued, we would expect the GDA Issues to be resolved before we would issue a permit.

In the case of Sizewell C, NNB GenCo (SZC)'s proposal is to replicate the station under construction at HPC so far as possible, subject to the site's different characteristics and other relevant matters. Our considerations will include the work we carried out in the GDA for the UK EPR™ and for the NNB GenCo (HPC) project in Somerset, for which we issued permit EPR/ZP3238FH in March 2013. Although the 2 projects are being run by separate legal entities, they both have a significant shareholding by the EDF group of companies, and have arrangements in place to share the design, knowledge and experience to benefit both. NNB GenCo (SZC) is aiming to replicate the design being deployed at HPC.

2. How we process and determine applications

The Environment Agency is responsible under The Environmental Permitting (England and Wales) Regulations 2016 (EPR 2016) (UK Parliament, 2016) for regulating certain activities on nuclear sites in England and Wales. This draft decision document details our assessment of an application for water discharge activities (WDAs), namely the discharge of non-radioactive liquid effluent, which can be attributed to the following main sources:

- returned abstracted cooling water from the turbine condensers and other cooling systems
- control of biological fouling of the cooling systems
- process effluent from the various plant systems, including those that maintain water purity and chemistry
- treated sewage effluent from staff welfare facilities
- returned abstracted seawater via 2 fish recovery and return (FRR) systems

We regulate these sites to protect members of the public from harm from the discharge and disposal of the release of pollutants into surface waters, and to protect the wider environment. We regulate within a framework of extensive government policy, strategy and guidance. This framework is summarised in the environmental permitting guidance. This guidance sets out the government's position on how environmental permitting should be applied and implemented, and how both we and operators in England and Wales should interpret particular terms. In summary, the aim of the environmental permitting system is to:

- protect the environment so that statutory and government policy environmental targets and outcomes are achieved
- carry out permitting and achieve compliance with permits and certain environmental targets in a more open way, minimising the administrative burden on both the regulator and the operators
- encourage regulators to promote best practice in operating facilities

2.1 Our process

We follow a 2-stage process for assessing and permitting new nuclear power stations:

1. Requesting Parties may apply to the Department for Business, Energy and Industrial Strategy (BEIS) for ministers to request that regulators (i.e. the Environment Agency and Office for Nuclear Regulation (ONR)) carry out a

generic design assessment (GDA) of their design. If the GDA is carried out, the regulators will assess the design for its acceptability for use.

2. A prospective operator of a nuclear reactor that wishes to carry out a water discharge activity, combustion activity and radioactive substances activity, must apply for any site-specific environmental permits.

2.1.1 Generic design assessment

Our decision is documented in our 2011 UK EPR™ decision document and 2012 Supplement to the Decision Document. Our Assessment Findings from GDA and how they will be addressed at Sizewell C (SZC) are discussed in section 4.8.3

2.1.2 Site specific permitting

As part of the second stage, we receive applications for environmental permits for specific sites. In determining these applications, we take full account of the work we have done during GDA so that our efforts are focused on operator and site-specific matters, including how the operator has addressed GDA Assessment Findings and any changes to the GDA design arising from the site-specific considerations or operator required modifications.

Operators can apply to the Environment Agency for a new permit or a variation to an existing permit at any time. We recommend that GDA is concluded prior to site-specific permit applications, but recognise that this may not always be the case. Where an application is based on a GDA, we require a SoDA or iSoDA to be issued prior to consulting on a proposed decision on the permit application. Where an iSoDA has been issued, we would expect the GDA Issues to be resolved before we would issue a permit.

In the case of Sizewell C, NNB GenCo (SZC) proposes to replicate the station under construction at HPC so far as possible, subject to the site's different characteristics and other relevant matters.

Our considerations will include the work we carried out in the GDA for the UK EPR™ and for NNB Generation Company (HPC) Limited (hereafter called NNB GenCo (HPC)) project in Somerset, for which we issued permit EPR/ZP3690SY in March 2013 for the resulting operational HPC WDAs. Although the 2 projects are being run by separate legal entities, they both have a significant shareholding by the EDF group of companies and have arrangements in place to share the design, knowledge and experience to the benefit of both. NNB GenCo (SZC) is aiming to replicate the design being deployed at HPC.

2.1.3 Our permitting process

The process we follow in assessing an application is described in the government's EPR core guidance (UK Parliament, 2013).

Operators can apply to the Environment Agency for a new permit or a variation to an existing permit at any time. The process we follow in assessing applications is outlined here.

1. Pre-application - We encourage applicants to discuss applications with us before submission.
2. Receive and consult on the application - The applicant makes an application, providing the information as set out in the application form and supporting guidance. We advertise and consult on all applications for new permits.
3. Assess the application and propose a decision for consultation - We carefully assess the application and any responses to our consultation and come to a preliminary conclusion i.e. a “draft decision” on whether to grant the permit and, if so, the appropriate permit conditions.
4. Consultation on proposed decision - We may choose to carry out further consultation on our proposed decision and draft permit, depending on the nature of the proposals and the likely degree of public interest. We do this using a document that explains our proposed decision and a draft permit.
5. Review consultation responses and issue of decision - Where we consult on our proposed decision, we carefully consider all relevant information we have received during and after that second consultation, together with existing information. We make a decision whether a permit should be issued and, if so, what its conditions should be. We publish a document that explains our decision.

2.2 Legal, policy and regulatory considerations

2.2.1 Principal considerations

The following section lists the principal considerations and associated guidance we have taken into account in coming to our draft determination.

Management and operator competence

- Develop a management system: environmental permits (Environment Agency, 2016c)
- Control and monitor emissions for your environmental permit (Environment Agency, 2016d)

- Legal operator and competence requirements: environmental permits (Environment Agency, 2016e)

Technical assessment

- Surface water pollution risk assessment for your environmental permit (Environment Agency, 2016f)
- Modelling: surface water pollution risk assessment (Environment Agency, 2014a)
- Oil storage regulations for businesses (Environment Agency, 2015)

Monitoring

- Monitoring discharges to water: guidance on selecting a monitoring approach (Environment Agency, 2020a)
- Monitoring discharges to water: environmental permits (Environment Agency, 2020b)
- Monitoring discharges to water: analytical quality control charts (Environment Agency, 2020c)
- MCERTS: performance standard for organisations undertaking sampling and chemical testing of water (Environment Agency, 2014b)

Other statutory requirements

We also take into account other requirements, see section X for details of these.

Our assessment of the application is set out in sections 4.1 to 4.21 in a structure that reflects the layout and questions in the application form. Section 4.11 identifies the main issues we need to consider when making decisions on the proposed water discharge activities. In sections 4.15 to 4.18 and section 5, we explain how we have reached our proposed decision against these and any other relevant considerations.

2.2.1 Role of the Secretary of State

Although we will normally determine an application, the Secretary of State can require any application to be referred to them for determination (regulation 63 of EPR 2016). As noted in the EPR core guidance (UK Parliament, 2020), this would be an exceptional step and likely to be taken only if the application involves issues of more than local importance, for example, if the application:

- is of substantial regional or national significance
- is of substantial regional or national controversy
- may involve issues of national security or of foreign governments

The core guidance also says that any decision on the need for determination by the Secretary of State would be made solely on those grounds, with no consideration of the substantive merits of the application itself. The Secretary of State has not requested that this application be referred to them for determination.

In specific circumstances and within statutory timescales, appeals regarding the determination of an application must be made to the Secretary of State. They may appoint another person, generally within the Planning Inspectorate (PINS) to determine an appeal on their behalf. Further details regarding appeals can be found in The Environmental Permitting: Core Guidance for the Environmental Permitting (England and Wales) Regulations 2016 (SI2016 No 1154).

2.3 Public and stakeholder engagement

It will always remain the responsibility of the regulator to make decisions about the permits. However, we want our decisions to be better informed through good engagement. We want to be aware of and understand peoples' comments and views. Where relevant, we can use these to help inform our assessments of the permit applications.

We advertised and consulted on this application in accordance with our Public participation statement (Environment Agency, 2019) and the government's published consultation principles. In view of the nature of the application and the degree of public interest, we have decided to carry out further consultation on our proposed decision and draft permit. We have not made any final decision about this application until we have considered the responses to our public consultations.

Aarhus Convention

The UK is a signatory to the United Nations Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, known as the Aarhus Convention. The Convention sets out an individual's rights to public participation in decision-making and the requirements on a public body to make sure that public participation in decision-making is carried out properly. The relevant requirements of the Convention are given effect by the public participation duties placed on us by the EPR 2016, including informing people about applications that we consider they are likely to be interested in or affected by, and inviting them to make representations. How we decide who to involve is described in our Public participation statement (Environment Agency, 2019), which we are required to publish by Regulation 60 of the EPR 2016.

Espoo Convention

The UK is a signatory to the United Nations Convention on Environmental Impact Assessment in a Transboundary Context, usually known as the Espoo Convention. The Convention requires the parties signed up to it at state level to:

- notify each other as early as possible of any transboundary impacts
- prevent, reduce and control the impact of any proposed measures
- allow the public, in areas likely to be affected, to participate in relevant environmental impact assessment procedures

In the UK, the Department for Business, Energy and Industrial Strategy (BEIS) is the government department responsible for making any notification, as required in the current context by the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.

3. The application and our consultation on the application

3.1 Receipt of application

The permit application was duly made on 26 June 2020. This means we considered it was in the correct form and contained sufficient information for us to begin our determination, but not that it necessarily contained all the information we would need to complete that determination.

NNB GenCo (SZC) has applied for a permit to operate water discharge activities (WDAs) at the Sizewell C (SZC) site in Suffolk. These activities are the discharge of returned abstracted cooling water, returned abstracted water via the fish recovery and return systems, and process generated liquid trade effluents from the operational site.

The permit application was deemed to be considered high public interest following the initial advertising period based on the level of public interest shown.

NNB GenCo (SZC) (Company number 09284825) was incorporated in 2014. It is a wholly owned subsidiary of NNB Holding Company (SZC) Limited, which, in turn, is owned by EDF Energy Holdings Limited (80% share) and General Nuclear International Limited (20% share). The relative shareholdings and shareholders in NNB Holding Company (SZC) Limited may change during the project phases (preparations, construction, and operation). EDF Energy Holdings Limited and General Nuclear International Limited are ultimately owned by EDF SA and China General Nuclear Power Corporation (CGN) respectively. NNB GenCo (SZC) is known locally, and for some of the planning applications, as 'EDF SZC Co'.

NNB GenCo (SZC's) application consists of the relevant water discharge activity (WDA) environmental permit application forms and a submission of information to provide the required detailed technical information. NNB GenCo (SZC) provided the following permit application documents as supporting information:

- Main WDA application support document (includes non-technical summary) and Appendix A (site maps, plans and drawings). SZC reference 100232385
- Appendix B: H1 screening assessment report (technical report TR193). SZC reference 100232388
- Appendix C: Information report for the habitats regulations assessment report and supporting figures. SZC reference 100232391
- Appendix D: Water Framework Directive (WFD) compliance assessment report and supporting figures. SZC reference 100232392

- Appendix E: Supporting information. SZC reference 100233916
- Appendix F: Environment Agency bespoke environmental permit application forms. SZC reference 100286568

The further information provided during our assessment of the WDA permit application also forms part of the application.

Construction of the proposed Sizewell C power station has not yet commenced. There are a number of areas where the organisation or the detailed design of the facilities will need to be developed. NNB GenCo (SZC) proposed a forward action plan to deal with these matters within its application.

3.2 Site location

The proposed facility would be located on the east coast of the United Kingdom approximately 1.5km north-east of the town of Leiston in the county of Suffolk. The proposed location of the new nuclear power station is immediately north of the 2 existing Sizewell B and Sizewell A power stations, as shown in Figure 1.

The proposed site is situated within the Suffolk Coast and Heaths Area of Outstanding Natural Beauty (AONB) and there are a number of international and national environmentally designated sites close to it. These are:

- Southern North Sea Special Area of Conservation (SAC)
- Orfordness-Shingle Street SAC
- Minsmere to Walberswick Heaths and Marshes SAC
- Alde, Ore and Butley Estuaries SAC
- Sandlings Special Protection Area (SPA)
- Outer Thames Estuary SPA
- Minsmere-Walberswick SPA
- Alde-Ore Estuary SPA
- Minsmere-Walberswick Ramsar
- Alde-Ore Estuary Ramsar
- Minsmere to Walberswick Heaths and Marshes Site of Special Scientific Interest (SSSI)
- Leiston-Aldeburgh SSSI
- Sizewell Marshes SSSI

3.3 Other environmental permits

NNB GenCo (SZC) has applied to the Environment Agency for 2 other environmental permits required to operate the facility. These permits are for the discharge and disposal of radioactive wastes from the site (application reference EPR/HB3091DJ/A001) and the operation of the standby diesel generators (application reference EPR/MP3731AC/A001). We are consulting on all 3 of these applications at the same time.

3.4 Consultation on the application

We advertised and consulted on the NNB GenCo (SZC) application from 6 July until 2 October 2020, in accordance with our public participation statement (Environment Agency, 2019) and the government's published consultation principles (Cabinet Office, 2012).

We carried out an equality analysis to inform our public engagement activities. We subsequently published our engagement plan for Sizewell C's environmental permits. We will continue to monitor the effectiveness of this engagement plan as the permit determination continues.

Our consultation was open to everyone. We invited the public, the energy industry, academics with an interest in nuclear power, energy or the environment, non-governmental organisations and other organisations and public bodies, to take part.

We have placed the responses to our consultation on the application, on the public register, except where the person making the response asked us not to do so. We can provide copies of documents available on public registers. We had one response that supported the development, some that were opposed in principle to new nuclear development, and some that raised specific issues about the proposed WDA permit application. Some of the responses were outside our remit, and are instead linked to the planning application for the SZC site development.

We are currently transforming our public register capability to be available online, but if this service is not available at the time of any request, you can still contact us and request documents by telephone or email. We also published responses made using our e-consultation tool online.

We received responses from our consultation on the application from organisations we have 'working together' agreements with, other organisations and members of the public. These responses and how we have addressed them are contained within Appendix 1.

Promoting the consultation

We asked national and local stakeholders for their views on the consultation process before our consultation began. They provided feedback about their communities, the channels they use to read information and their preferred methods of engagement.

We considered their responses and the extra challenges of consultation during coronavirus restrictions and published our consultation plan.

We believe that the level of local and national engagement was proportionate for the application consultation. We are confident that we did all we reasonably could and consulted properly during the period of coronavirus restrictions. We are also confident that this consultation was accessible to, and targeted at, the people and organisations it was intended for.

To raise awareness and encourage participation, we:

- e-mailed contacts on our stakeholder database. Our database includes national organisations and people who live near to the Sizewell site such as parish and local councils, non-government organisations (NGOs), environmental groups, professional institutions, nuclear and environmental academics, the nuclear industry and trade unions
- published information and documents on GOV.UK and our e-consultation tool (known as 'CitizenSpace') which hosted our documents and enabled an online response
- provided a plain English, high-level summary. In this, we were clear about the consultation process and the scope of consultation
- worked with NNB GenCo (SZC) to make copies of the application available on USB memory sticks
- updated local MPs through briefings
- advertised the consultation in local print and online newspapers (East Anglian Daily Times and the Ipswich Star), which could be read by people living near to the Sizewell site in Suffolk and nationally
- issued a press release to trade, national and local media. This resulted in some coverage in print and online media
- posted information on social media (Twitter) to promote links to our consultation pages
- worked with third parties and advocates such as local parish, town and county councils, NGOs and environmental groups, securing their support to raise awareness
- added information to the company's newsletters which are sent to all households in the area and an email subscriber list
- provided information about the consultation to the company for it to use in its communications to stakeholders and the public (such as its newsletter)
- provided information to our staff closest to the site so they would be able to answer questions from the public in the area

To engage directly with stakeholders during consultation, we:

- organised a public question and answer session by phone. We provided speakers from the Environment Agency with expert technical knowledge. We also put in place processes to enable people to respond to the consultation on the application over the telephone
- advertised the events widely online and sent details to our stakeholder database
- highlighted the consultation to members of the Department for Business, Energy and Industrial Strategy (BEIS) NGO forum
- informed attendees of our bi-annual nuclear regulator local engagement meetings which we hold with stakeholders in Essex and Suffolk
- provided a postal address for those who did not want to, or couldn't use email or the e-consultation tool

Appendix 1 of this consultation report provides further details of our consultation on the application. It also summarises the comments we received in response to our initial consultation on NNB GenCo (SZC)'s water discharge activities permit application, along with how we have considered them in coming to a proposed decision.

3.5 Further information

The application was duly made on 26 June 2020 (that is, we considered it was in the correct form and contained sufficient information for us to begin our determination of the permit application). We requested some further information on minor issues by email and telephone.

When we are considering an application and find we need further information, we can serve a notice on the applicant in accordance with Schedule 5 (under paragraph 4 of part 1) of the EPR 2016. We refer to these notices as 'Schedule 5 notices' (notice of request for more information).

During the determination of NNB GenCo (SZC)'s application, we found that we needed further information on several occasions. We therefore served a total of 6 Schedule 5 notices on NNB GenCo (SZC), who then supplied responses to our information requests. We have placed copies of our notices and the information NNB GenCo (SZC) supplied in response on our public register, as well as made them available via our consultation webpages for this proposed decision.

We issued our 6 Schedule 5 notices to NNB GenCo (SZC) on the following dates:

- No.1 issued on 02/10/2020
- No.2 issued on 18/01/2021
- No.3 issued on 15/03/2021
- No.4 issued on 23/04/2021

- No.5 issued on 18/10/2021
- No.6 issued on 19/10/2021

NNB GenCo (SZC) provided an updated company manual in January 2022. We have put this on the public register as well as made it available via our consultation webpages for this proposed permit decision.

3.6 Other permit applications

NNB GenCo (SZC) has also applied for 2 other environmental permits for the SZC power station when it is operational. These are for the operation of the standby diesel generators under a combustion activity permit application (reference EPR/MP3731AC/A001) and for the disposal of radioactive waste under a radioactive substances activity permit application (reference EPR/HB3091DJ/A001). We are consulting on all 3 draft decision documents for the operational permits at the same time.

4. Our assessment

4.1 Introduction

This section sets out our proposed decision following our assessment of the application and consideration of the responses to the consultations on the application. There are a number of matters we needed to consider before deciding whether to grant a permit and, if so, subject to what conditions.

In reaching our proposed decision, we have taken into account the relevant legislation, government policy and guidance, our own guidance and the responses to the consultations on the application.

There are also a number of issues that are outside our area of responsibility and which we have not considered in reaching our proposed decision. We have set out these issues at the end of this section.

4.2 Overview

This application for an environmental permit relates to the discharge of trade effluent (cooling water and process effluents), treated sewage effluent, and discharges from the two FRR systems from the commissioning and operational phases of a new nuclear power station at Sizewell C (SZC). The legal framework that supports our assessment of the application for these water discharge activities is explained in sections 2.2 and 4.3.

The operation of SZC would require a continuous supply of water to serve the steam turbine condensers, removing waste heat from the system. The proposed direct cooling system would abstract seawater from the Greater Sizewell Bay via 2 intake tunnels, one for each UK EPR™ reactor unit. Each intake tunnel includes 2 low velocity side entry (LVSE) intake heads.

The 2 intake tunnels will extend approximately 3.2km from the site into the Greater Sizewell Bay beneath the seabed. At their seaward extent, the 2 cooling water intake tunnels would be around 500m apart. There would be 2 intake heads on each tunnel, located about 200m apart, and sitting just above the sea bed.

After being used within the plant, the seawater would then be discharged back to the Greater Sizewell Bay at a higher temperature via a single outfall cooling water tunnel (serving both UK EPR™ units), approximately 3.5km long.

Each UK EPR™ unit will also include a fish recovery and return (FRR) system. The 2 FRRs each have their own outfall tunnel, each approximately 400m to 600m in length, and will also discharge back to the Greater Sizewell Bay.

Figure 4 shows where the above cooling water intake and discharge infrastructure would be located at SZC.

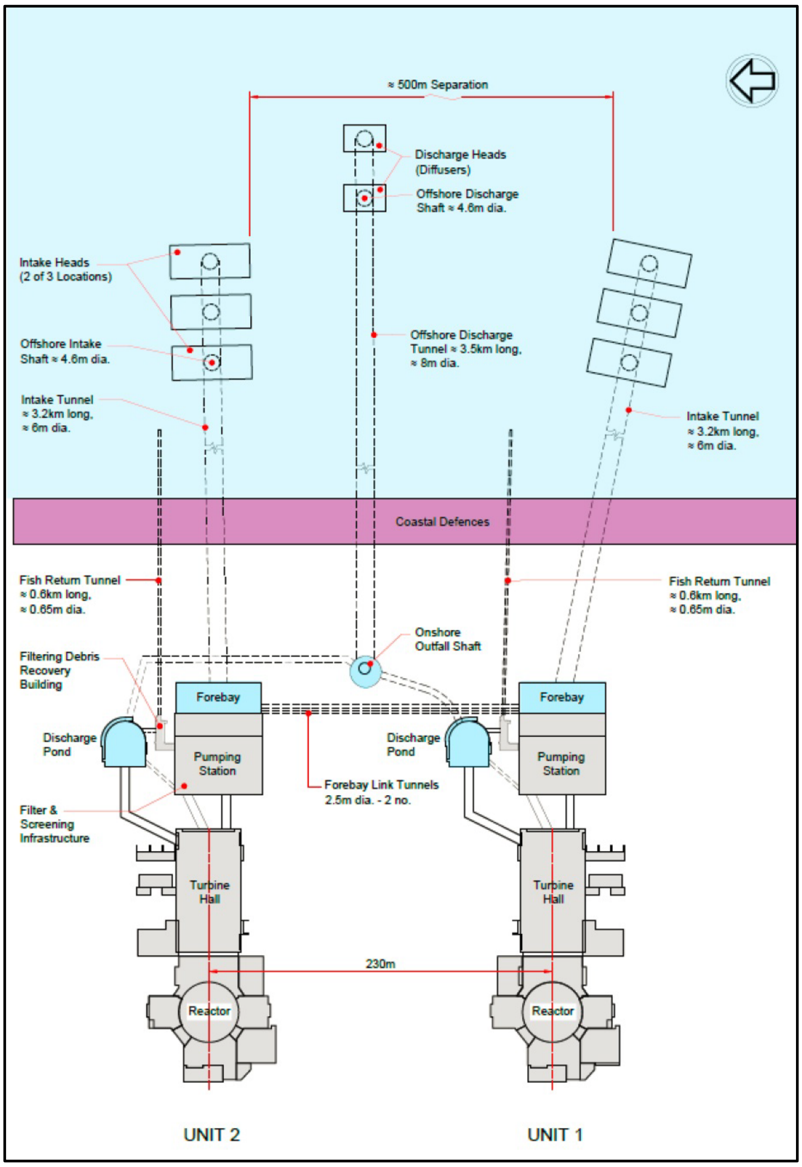

Figure 4. Schematic of cooling water intake and discharges to the GSB via the two cooling water outlets and two FRR system outlets. Reproduced from figure 2.5.1 IN NNB GenCo (2020g, SZC project – Water discharge activity permit application submission Sizewell C and Appendix A - 100232385)

When operating normally, the UK EPR™ reactor needs a maximum of around 66m³/s (5.7million m³/d) of cooling water. This would result in a maximum cooling water discharge from SZC of 132m³/s (or 11.4million m³/d). Returned abstracted cooling water would account for approximately 99% of the overall discharges from SZC, with the remainder made up of process effluents from various supporting systems, rainfall dependent site drainage, treated sewage effluent from staff welfare facilities and the 2 FRR systems.

4.3 Legal framework

NNB GenCo (SZC) has applied for an environmental permit under the Environmental Permitting (England and Wales) Regulations 2016 (EPR 2016), to carry out water discharge activities at Sizewell C power station. The following definitions from EPR 2016 set out the legal context for the application and our determination of it.

Water discharge activity is defined under Schedule 21, paragraph (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."

The requirement for an environmental permit is set out in Part 2, Chapter 1, Regulation 12(1) as:

"A person must not, except under and to the extent authorised by an environmental permit, (a) operate a regulated facility or; (b) cause or knowingly permit a water discharge activity or groundwater activity."

Part 2, Chapter 2, Regulation 13 (1) (a) additionally states that:

"On the application of an operator, the regulator may grant the operator a permit (an 'environmental permit') authorising the operation of a regulated facility." This emphasises the discretionary nature of the granting of an environmental permit.

Regulated facility is a collective term used to describe all the different kinds of operations that require a permit under EPR 2016. A water discharge activity is a particular kind of regulated facility as defined under Part 1, Regulation 8 (1) (f):

"In these Regulations, 'regulated facility' means: (f) a water discharge activity"

The regulated facility includes all the equipment essential to carry out that activity and the site (of the regulated facility) is the footprint of that equipment, including the discharge pipe and outlet. The site includes control equipment, control rooms and utility areas serving them. In many cases, as with this permit application, the discharges to surface water will be made outside the boundary of the development site via the 2 cooling water outfalls, and 2 FRR system outfalls.

We have considered that several storage areas are to be included as part of the regulated facility. These areas will be used for storing substances used across the site, but mainly in processes or systems associated with the WDAs. This will include (a) hydrazine and ammonia storage, (b) chemical products storage, and (c) oil and grease storage. We have specified a pre-operational measure condition (PO17) for these locations to be confirmed to us and a site plan provided to include within the draft permit.

NNB GenCo (SZC) has proposed a range of best practice measures to minimise the risk of pollution from accidents, incidents and/or spillages. In terms of the draft permit, the storage areas, as part of the regulated facility, are subject to the following standard condition, to prevent pollution of the water environment:

“All oils or chemicals stored in containers, whose emission to water or land could cause pollution, shall be provided with secondary containment, unless the operator has used other appropriate measures to prevent or where that is not practicable, to minimise, leakage and spillage from the primary container.”

4.4 The site

We considered the extent and nature of the facility at the site in accordance with regulatory guidance note 2 (RGN2) ‘Understanding the meaning of regulated facility’. The extent of the facility is defined in the site plan and in the permit. The activities are defined in Table S1.1 of the permit.

NNB GenCo (SZC) has provided a plan which we consider to be satisfactory. This shows the extent of the site of the facility, including the discharge points. The plan is included in the draft permit via Schedule 7. For the purposes of EPR 2016, the regulated facility will lie both within and outside the SZC nuclear licensed site, as the single cooling water outfall tunnel will extend some 3.5km offshore out into the Greater Sizewell Bay

While we consider the site plans are satisfactory to determine the application, we acknowledge that due to the early submission of the application, detailed design work is still ongoing. The application contains enough information to identify the buildings, treatment facilities, storage facilities and the outlet point(s) associated with the water discharge activities, but not all of the interconnecting pipework.

NNB GenCo (SZC) has stated that this detail is not yet available, but has made a commitment in its permit application to provide this information when the final design is completed. Given the lengthy time frames involved with the design and construction process, we consider this to be acceptable. We have included a pre-operational measure in the draft permit, stating that this information must be submitted to us for approval before any discharges can begin.

For waste streams A to G, the discharges will be made to the Greater Sizewell Bay via 2 diffuser heads on the cooling water outfall tunnel. NNB GenCo (SZC) has provided National Grid references (NGRs) for each outlet, at TM 51080 64125 and TM 51155 64125 respectively.

For waste stream H from the 2 FRR systems, the discharges will also be made to the Greater Sizewell Bay via 2 separate outfall tunnels. NNB GenCo (SZC) has provided

NGRs for each FRR system outlet, at TM 47980 64000 (FRR system 1) and TM 47980 64254 (FRR system 2).

The location of the NGRs for 2 cooling water outlets and 2 FRR system outlets are displayed in Figure 3.

These NGRs include a 50 metre (m) limit of deviation to allow for any tunnel drilling contingencies. We have included a pre-operational measure (PO13) in the draft permit that states that confirmation of the final NGRs must be submitted to us before any discharges can begin.

4.5 The UK EPR™

The UK EPR™ is a pressurised water reactor (PWR) based around a primary circuit, a secondary circuit and a tertiary (or cooling) circuit. The primary circuit and nuclear steam supply system, which is part of the secondary circuit, are located within the reinforced concrete containment (or reactor) building, located on the area known as the ‘nuclear island’. The turbine hall, located on the area sometimes referred to as the ‘conventional island’ houses the turbo generator sets for producing electricity. There are also numerous support buildings and infrastructure associated with the operation of the UK EPR™, which in the context of this WDA application, includes the cooling water forebays and pumphouses, the outfall ponds, the demineralisation plant, the sewage treatment plant, and 2 fish recovery and return systems (FRRs). SZC will include 2 UK EPR™ units.

Figure 5 shows the basic operation of the UK EPR™.

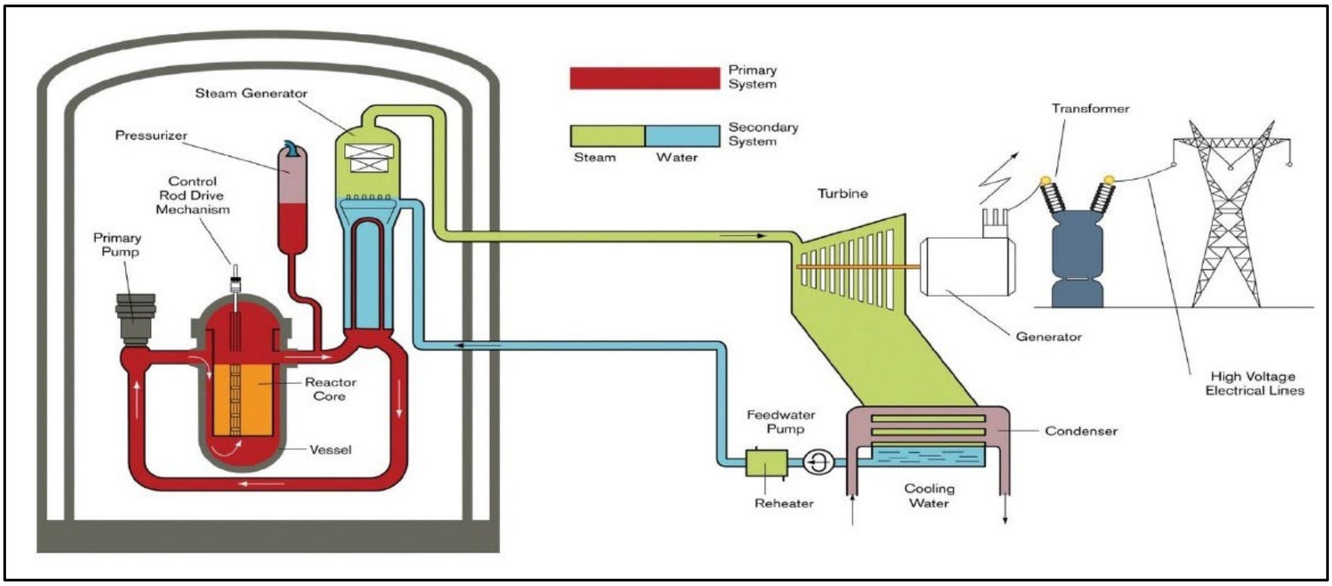

Figure 5. Conceptual diagram of the proposed SZC power station. Source: Reproduced from Figure 2.1.1 in NNB GenCo (2020g, SZC project – Water discharge activity permit application submission Sizewell C and Appendix A - 100232385)

In a pressurised water reactor, uranium oxide fuel in the reactor core undergoes fission which generates heat. The reactor core is cooled by water in a pressurised circuit. Heat is transferred from the primary pressurised circuit to an isolated secondary circuit where it is used to produce steam. The steam produced is used to drive a turbine generator to produce electricity.

4.5.1 The primary circuit

The primary circuit is a closed, water-filled pressurised system (installed in a leak tight concrete enclosure known as the reactor building) consisting of the reactor (a steel vessel containing the fuel within the reactor core) and up to 4 coolant loops, with each having its own steam generator and coolant (primary) pump, and a pressuriser. The heat produced by the nuclear (fission) reaction inside the reactor vessel is extracted by pressurised water (the coolant of the primary circuit system), which circulates around the primary circuit. The heated water passes to the steam generators, where the heat is transferred to the secondary circuit system which flows between the steam generators tubes.

4.5.2 The secondary circuit

The secondary circuit is a closed, independent system (that is, it is independent of the primary system) that supplies steam to the turbo generator within the turbine hall. The heated steam produced by the evaporation of water (secondary coolant) in the steam generators drives the turbine, which spins a generator to produce electricity. After passing through the turbine, the steam is then condensed (cooled) by the water circulating in the tertiary circuit. The condensate is returned to the steam generators, and the cycle continues.

4.5.3 The tertiary (or cooling) circuit

Cooling water is required to remove ‘waste heat’ from the power station. The tertiary circuit is independent of the primary and secondary circuit systems. Its purpose is to condense the steam of the secondary circuit, dissipating waste heat to the environment in the process. The majority of the abstracted cooling water is pumped through the main cooling water system to the condensers, with the balance used primarily within the auxiliary cooling circuits necessary for operating the reactors safely. The Sizewell C condensers will be directly cooled by seawater from the Greater Sizewell Bay area. Each UK EPR™ unit is served by 2 main cooling water pumps (CRF pumps), and a number of smaller pumps serving these auxiliary systems. This system is an open system at SZC. An open system refers to circulating water which is directly drawn from, and discharged back into, the sea.

4.5.4 Additional features

In addition to the 2 UK EPR™ reactors, the proposed SZC nuclear power station would have a number of additional features, including:

- turbines and generators which convert the thermal energy from the reactors into electricity
- a pumping station (one for each UK EPR™ unit) for the sea water used for condensing the steam once it has passed through the turbines
- standby diesel generators for providing power in the event of loss of grid supplies
- a radioactive waste management facility in which solid radioactive waste will be processed and packaged
- an interim storage facility for intermediate level waste in which higher activity solid radioactive waste will be stored and monitored until it can be disposed of to a dedicated waste management facility
- a spent fuel pool where spent fuel will be cooled for a period once it has been removed from the reactor core
- an interim storage facility for spent fuel in which used spent fuel will be stored and monitored once it is removed from the spent fuel pool. The fuel will be stored in a dry fuel store until it can be disposed of to a dedicated waste management facility
- electricity distribution systems
- offices, workshops and welfare facilities

4.6 Commissioning of the UK EPR™ units

Commissioning of the UK EPR™ reactor is proposed to take place in 2 stages, namely (i) cold flush testing (CFT) and (ii) hot functional testing (HFT). The commissioning process for each reactor unit would last for about 24 months. Both CFT and HFT processes will produce liquid effluents.

4.6.1 Cold flush testing

Cold flush testing (CFT), which mainly involves cleansing and flushing the various plant systems with demineralised water to remove surface deposits and residual debris from installation, is outside the scope of this permit application. NNB GenCo (SZC)’s intention is for CFT effluent to be discharged to the Greater Sizewell Bay via the foreshore outfall (known as the combined drainage outfall or CDO) serving the SZC construction site. The discharges resulting from CFT will be subject to a separate, water discharge activity permit application. This has yet to be applied for, and for which permit pre-application discussions between us and NNB GenCo (SZC) are anticipated to commence during 2022.

4.6.2 Hot functional testing

Hot functional testing (HFT) begins following completion of CFT and when all the required systems are available. It takes place before fuelling the reactor and only once the cooling water infrastructure is in place and operational. The objective of HFT is to test the reactor and associated systems under pressure, temperature, flow and chemical conditioning as close to normal operating conditions as practicable without putting nuclear fuel at risk. The effluent produced during HFT would be diluted within the cooling water system before being discharged via the outfall tunnel to the Greater Sizewell Bay.

NNB GenCo (SZC) has stated that due to the current stage of the project and the long lead time until commissioning takes place, detailed information on the nature of the discharges during HFT is limited, but that HFT can be considered as running the systems under normal operating conditions. It states that there are no plans to dose the primary circuit with anything other than the same chemicals used during normal operations. The HFT discharge would, therefore, be similar and subject to the same permit limits as those that would apply during normal day-to-day operation.

We have not, therefore, been able to specifically assess discharges from the HFT process. What this means in practice is that the same permit limits we have proposed for various contaminants during normal operations will also apply to discharges arising during HFT. NNB GenCo (SZC) is aware of this requirement.

NNB GenCo (SZC) has made a commitment in its permit application to submit a detailed commissioning discharges management plan before any commissioning activities begin. Given the lengthy time frames involved with the construction process, we consider this to be acceptable. From a regulatory viewpoint, the commissioning discharges management plan is an important requirement and, as such, is reinforced through a pre-operational measure attached to the draft permit. Our pre-operational measures are detailed in section 4.17.

4.7. Operation of the UK EPR™ units

NNB GenCo (SZC) has outlined several scenarios that describe the operation of SZC. An appreciation of the configuration of the plant during these scenarios, which are described in the following sections, is important in understanding how we have approached determining the application. A theoretical scenario (maintenance test RF2) has also been described, which although it should not occur in practice, has been proposed by NNB GenCo (SZC), in order to define the limits of its impact assessment.

4.7.1 Standard operation

This refers to the situation when both units are operating normally at their full capacity, that is 100% load, with all 4 main cooling water (CRF) pumps operational. The UK EPR™ reactor units may be subject to power changes within this scenario from time to time in line with operational requirements, but the default is for operation at full capacity.

4.7.2 Outage

This refers to the situation when one of the UK EPR™ reactor units is shut down for planned routine maintenance and/or refuelling. Typically, maintenance would be to a CRF pump or to an element of the filter train. During an outage, neither CRF pump on the shutdown unit is operational. The smaller pumps continue to feed cooling water to the auxiliary systems. The other EPR™ reactor unit would continue to operate as per standard operation. Typically, outages will last for about 2 weeks, and are expected to occur every 18 to 22 months. It is currently anticipated that EPR™ unit 1 will not have a refuelling outage until commissioning of EPR™ unit 2 is completed.

4.7.3 Maintenance test (RF3)

This refers to the situation when both EPR™ reactor units are operational, one on 100% load with 2 CRF pumps running, and the other unit on 90% load with only a single CRF pump in operation. The plant could be operated under this configuration as a result of both planned and unplanned situations. The remaining CRF pump would be subject to maintenance during this period. Therefore, 3 of 4 CRF pumps would be operational in this scenario.

Normally, this type of pump maintenance would be planned to coincide with an outage as described. However, NNB GenCo (SZC) reports that it is not unknown for unexpected failures to occur while the unit is operating at full power, for example, pump or drum screen failure. If this unplanned situation were to occur, the load on the unit would be reduced to a maximum of around 90% rated thermal power (RTP) to compensate for the loss. It would remain in this configuration until the fault is rectified, which would be expected to take no longer than one month.

NNB GenCo (SZC) has stated that even when routine pump maintenance is scheduled to coincide with an outage, it may be necessary to operate the plant in the RF3 configuration for up to a month. This is because the time to complete the required maintenance work is going to take longer than the critical tasks normally associated with an outage, for example, refuelling of the UK EPR™ unit. In this planned situation, the CRF pump would either be taken offline before the outage proper begins or it could remain offline after the critical outage tasks have been completed and the EPR™ unit has been brought back up to power.

4.7.4 Maintenance test (RF2)

This refers to a theoretical situation where both UK EPR™ units are operating at 100% load, with only a single CRF pump serving each unit, that is with only 50% cooling water capacity (as only 2 of the 4 CRF pumps would be operational). NNB GenCo (SZC) states that if this situation occurred in practice, this would likely result in the plant being shut down, as having more than one CRF pump out of operation at any one time would not be considered to be part of normal operations. However, because this situation represents a useful worst case in terms of cooling water flow, it has used it within its assessment to characterise short-term (24 hour) discharges.

4.8 Main issues of the proposed decision

4.8.1 Emissions to surface waters (water quality assessment)

While the draft permit relates to the water discharge activities, the main focus of our assessment relates to the quality of the effluents and the proper operation of the equipment provided. The main issue for us, therefore, was to carefully consider the emissions to surface waters, particularly the discharge of (a) heat, in the thermal plume, (b) biocide, (c) hazardous chemicals and elements used in the various waste process streams A to G, as well as the discharge (d) of polluting matter in waste stream H.

4.8.2 Habitats Regulations assessment

We are required under Regulation 63 of the Conservation of Habitats and Species Regulations 2017 (as amended) (Habitats Regulations), to carry out an appropriate assessment of any applications for permissions that could have a likely significant effect on the designated conservation sites (European sites).

The purpose of this assessment is to establish whether we can conclude that our permissions, on their own or together with other relevant permissions, plans or projects will not adversely affect the integrity of the designated sites in question.

We have carried out an appropriate assessment (Habitats Regulations assessment report (HRAR)), which covers all relevant Environment Agency permissions, plans or projects in-combination, as well as those of other bodies. A summary of our appropriate assessment for the water discharge activities is discussed in section 4.12.

4.8.3 Generic design assessment

Generic design assessment (GDA) is a joint programme between the Environment Agency and the Office for Nuclear Regulation (ONR), which is part of the Health and Safety Executive. Under GDA, we assess generic design matters for new nuclear reactor designs to determine whether they are suitable for future authorisation, subject to various site-specific licensing and permitting regimes. ONR is responsible for assessing the nuclear safety and security aspects of the new reactor designs, while we consider the environmental aspects.

As mentioned in section 1.3, we carried out a detailed assessment of the UK EPR™, which included considering the abstraction and discharge of cooling water and liquid effluent to surface water. In considering non-radiological discharges to surface water, our main objective based on the generic information submitted, was to decide 'in principle' whether we would be able to grant a WDA permit for the UK EPR™ at the subsequent, site-specific permitting phase.

From our assessment of the UK EPR™, we concluded that we should be able to permit the discharge of non-radiological substances to surface water. However, we recognised that this would depend on our consideration of various site-specific issues, and knowing that any application for a WDA permit would need to include an environmental impact assessment based on detailed dispersion modelling of the receiving waters within the Greater Sizewell Bay.

It was particularly important to our assessment to identify matters that were outside the scope of the GDA which applicants would need to address during site-specific permitting. We consider that all of the site-specific issues arising from our GDA assessment, which are relevant to the WDAs, have been satisfactorily addressed by NNB GenCo (SZC) during the course of our determination of the application, as listed here:

1) The impact of the thermal plume (heat) on the receiving environment. This has been addressed by NNB GenCo (SZC) within its detailed assessment using 3-dimensional hydrodynamic modelling of excess temperature from the thermal plume in the Greater Sizewell Bay.
2) The impact of biocide residues on the receiving environment. This has been addressed by NNB GenCo (SZC) within its detailed assessment using 3-dimensional hydrodynamic modelling of total residual oxidant (TRO) and CBPs (bromoform) into the Greater Sizewell Bay.
3) The consideration of the ecological impacts of the discharge(s), including assessment under the Habitats Regulations, where applicable. This has been addressed by NNB GenCo (SZC) within its information for the Habitats Regulations assessment report (Appendix C of NNB GenCo (SZC)'s WDA application, document reference 100232391) with respect to the designated European sites of the Greater Sizewell Bay, (for example,

SACs/SPAs/Ramsars), and consideration of impacts on relevant non-European designated sites (for example, SSSIs).

4) The impact assessment of those substances and metals currently without an environmental quality standard (EQS), in particular circuit conditioning chemicals. This has been addressed by NNB GenCo (SZC) within its H1 screening assessment carried out in accordance with our guidance, as well as detailed assessment using hydrodynamic modelling of hydrazine discharges into the Greater Sizewell Bay.

5) The full consideration of trace metal contained within bulk raw materials. This has been addressed by NNB GenCo (SZC) within its H1 screening assessment carried out for the priority hazardous substances (PHSs) cadmium and mercury, which are present as trace elements in the raw materials used in certain on-site water treatment processes.

6) The discharge arrangements for non-radioactive effluent streams. This has been addressed by NNB GenCo (SZC) within its description of discharge arrangements and provision of a site plan sufficient to determine the application. Some elements are still to be confirmed on completion of final design, and are subject to a pre-operational measure in the proposed permit.

7) The design of the on-site sewage treatment system. This has been addressed by NNB GenCo (SZC) as sufficient information on the discharge of treated sewage has been provided, including expected emissions data and effluent quality standards. Final design of the sewage treatment plant (STP) will be confirmed in accordance with a pre-operational measure in the proposed permit.

8) The exact nature of the effluent monitoring system. This has been addressed by NNB GenCo (SZC) as in-depth descriptions of the procedures and techniques that could be used for monitoring the various waste streams have been provided. Confirmation of final details will be subject to a pre-operational measure in our proposed permit, as will confirmation of the exact locations of the monitoring points on each waste stream, following completion of detailed design.

The information provided in the GDA was previously used to inform the operational WDA permit application for HPC in 2012. As part of the replication strategy between HPC and Sizewell C (SZC), this WDA permit application reflects, where possible, developments in design and information available from the HPC project.

In the proposed draft permit, we believe it is necessary to include a pre-operational measure with respect to issue numbers 6 (PO13) and 7 (PO2), and 2 pre-operational measures with respect to issue number 8 (PO14 and PO15). They relate to issues of detail and not principle that NNB GenCo (SZC) cannot reasonably deal with until further detailed design work has been completed. These issues will be fully addressed following satisfactory assessment and completion of the pre-operational measures.

NNB GenCo (SZC) has highlighted areas within its permit application where the information presented is different from that it submitted under GDA. The most obvious difference is the fact that the GDA submission was based on a single UK EPR™ unit, while at SZC there would be 2 UK EPR™ units.

The other main differences relate to the production of demineralised water. The permit application states that at SZC the demineralised water required to feed the primary and secondary circuits would be produced from the treatment of mains water in a demineralisation plant. The GDA submission was based on a combination of demineralisation and desalination technology. Desalination is not proposed for SZC during commissioning and operation.

4.8.4 Cooling water abstraction

We have decided that an abstraction licence for direct cooling is not required for SZC, as we consider that the abstraction is from the open sea. An abstraction licence is only required if the location or method of abstraction leads to the water being abstracted from an inland water.

The proposed cooling water system for SZC includes 2 fish recovery and return (FRR) systems. The FRR systems will form an integral part of the design to sensitively recover (capture) and return impinged species back to the Greater Sizewell Bay via 2 dedicated FRR system outfall tunnels (one tunnel serving each of the 2 FRR systems).

4.8.5 Control of biological fouling

Biological fouling (or biofouling) refers to the growth or colonisation by bacteria, fungi, biofilms or other species (such as mussels) within the cooling water system. Without appropriate control measures the abstraction of seawater for cooling would present considerable operational risks due to biofouling, particularly in the condensers, where significant colonisation of organisms entrained with the cooling water would reduce the overall efficiency of the power station. The potential for biofouling increases as the sea temperature rises.

A sea water temperature of 10°C is typically regarded as the point at which operators would begin dosing the incoming cooling water with biocide to control the growth of undesirable organisms. The operational requirement to achieve and then maintain a level of control over biological growth in the cooling water system tends to focus on techniques involving (a) the intrinsic design of the system where specialised materials, paints and coatings can be used, and (b) chemical dosing of the incoming cooling water with an appropriate biocide, for example, sodium hypochlorite. The most appropriate strategy for any given location depends on site-specific factors, with careful consideration needed to determine the best system of control.

The proposals for controlling biofouling at SZC involve intrinsic design measures together with risk-based intermittent chemical dosing. Based on the known risk of biofouling at Sizewell (due to operations of SZB and SZA), it would be necessary to dose critical plant at Sizewell C (the condensers and essential cooling water systems) during the growing season when seawater temperatures exceed 10°C, and also to have the flexibility to dose those systems at other times of the year based on operational need.

Within its application, NNB GenCo (SZC) has provided outline details of its proposed strategy for chlorination of the incoming cooling water and an associated risk assessment, looking at the potential impact of total residual oxidant (TRO) and chlorination by-products in the receiving waters of the Greater Sizewell Bay.

NNB GenCo (SZC) has stated that the information contained within the permit application presents a worst-case scenario in terms of the contaminants associated with chlorination. It proposes to finalise its biofouling control strategy for SZC, based on the lessons learnt through commissioning and early operation of the UK EPR™ being built at HPC in Somerset, England, and those EPR™ units at Flamanville in France. We consider this to be acceptable and have included a pre-operational measure in the draft permit which requires NNB GenCo (SZC) to confirm and justify its final control strategy for SZC.

4.9 The water discharge activities

Given that a water discharge activity is "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", in making an environmental permit application NNB GenCo (SZC) has a duty to describe such matter or effluents in its application.

NNB GenCo (SZC) has described the various waste streams (A to H) that would make up the water discharge activities at SZC, and these are summarised in the executive summary.

Various treatment systems will be applied to waste streams B to G to reduce the contaminant concentrations, and to enable the recycling of boron and water in the primary circuit. The proposed treatment techniques include filtration, membrane filtration, ion exchange, degassing, evaporation and oil/water separation. The type of treatment is specific to both the origin and nature of the waste stream and the required treatment objectives.

NNB GenCo (SZC) describes a procedure for each waste stream where the effluent will be received in monitoring tanks and then sampled before being discharged. If the sample exceeds environmental permit limits, then the effluent can be recirculated through the treatment system again and either discharged when within environmental permit specification, or tankered off site for disposal.

Following treatment, all of the individual waste streams will be combined with the returned cooling water in an outfall pond before being discharged to the Greater Sizewell Bay. The outfall pond (sometimes also referred to as a ‘seal pit’ or ‘surge chamber’) is a large concrete basin structure set into the ground, which allows the operator to regulate the water level and control the pressure head on the discharge side of the system. It is part of the cooling water system infrastructure and will be located within the nuclear licensed site boundary. The SZC design incorporates 2 outfall ponds, one for each UK EPR™ unit.

Figure 6 is a conceptual view of the waste streams and the treatment facilities that make up the water discharge activity during standard operation.

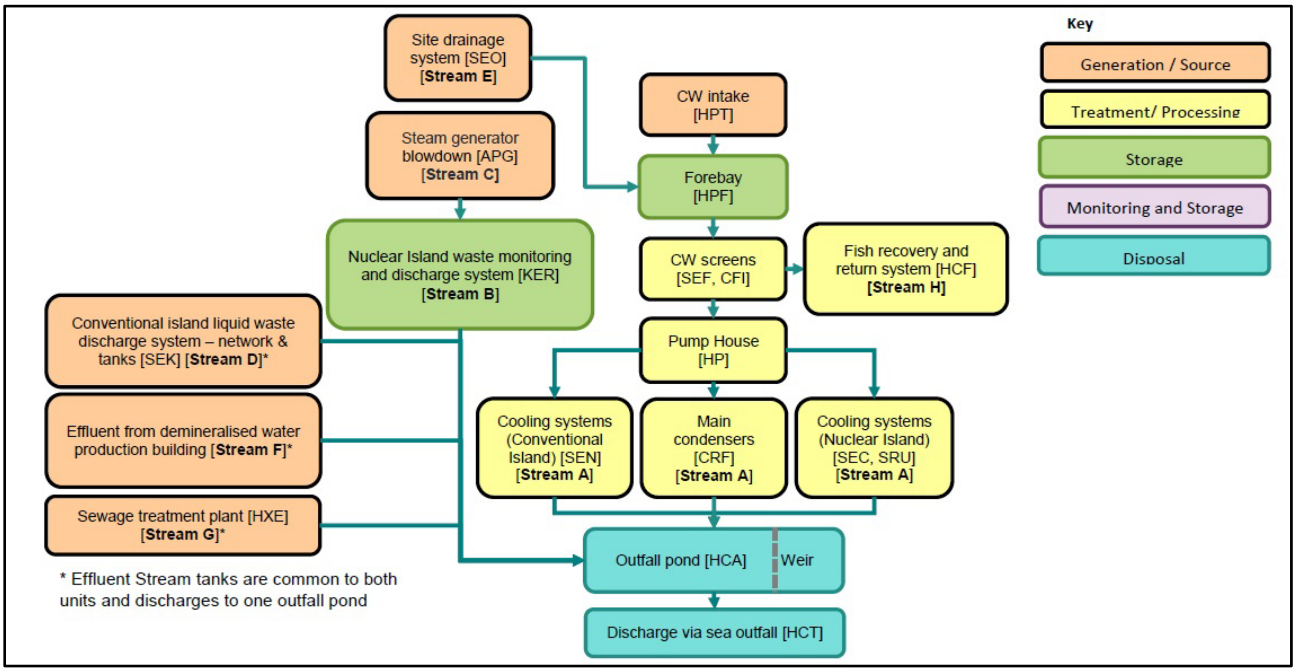

Figure 6. Simplified overview diagram of effluents contributing to the surface water discharge. Reproduced from figure 2.2.2 in NNB GenCo (2020g, SZC project – Water discharge activity permit application submission Sizewell C and Appendix A - 100232385SZC)

In order to characterise each waste stream, NNB GenCo (SZC) has provided estimated emissions data, comprising maximum daily and annual loadings and maximum concentrations for each substance. The loading data refers to the maximum amount of the substance (in kilograms) resulting from the waste stream, while the substance concentration refers to the value in the waste stream before it is combined (diluted) with the flow of returned cooling water via waste stream A (which forms over 99% of the volume of SZC’s operational water discharge activities combined).

In tables 2 to 5, the substance concentration is the maximum concentration that could occur on any one day. Although not true for all substances, it typically represents the maximum short-term concentration associated with periods outside of standard operation when the plant is not running at full load on both units, for example, during a planned refuelling and/or maintenance outage. Maximum concentrations arising during the day-to-day running of SZC will, for most substances, be considerably less than those stated here.

NNB GenCo (SZC) states that the estimated emissions from SZC are derived from operational experience and feedback from nuclear power plants operated by EDF in France, as well as the information used for the operational WDA permit application for HPC. NNB GenCo (SZC) has stated that the information contained within the permit application presents a worst-case scenario in terms of emissions. Nevertheless, it proposes to confirm proposed emissions from SZC based on further design evolution and lessons learnt through commissioning and early operation of the UK EPR™ units being built at HPC in Somerset, and those at Flamanville in France. We consider this to be an important and necessary step and have therefore included the requirement for NNB GenCo (SZC) to confirm the proposed emissions via a pre-operational measure in our permit.

We have also included 2 further pre-operational measures (PO4 and PO5) to the draft permit which concern preparing (for our assessment and written approval) an emissions management plan (EMP). This is a standard permitting requirement and will set out how the operator plans to prevent, or where that is not practicable, minimise, any emissions not covered by limits in our permit.

4.9.1 Waste stream A

Waste stream A comprises seawater abstracted from the Greater Sizewell Bay for direct cooling of the condensers and various auxiliary systems. The cooling water is passed once through the cooling water system and discharged via the outfall tunnel with the addition of waste heat and possibly total residual oxidant (TRO) as a consequence of biofouling control (chlorination). Chlorination would also result in CBPs being produced due to the interaction of chlorine with seawater. Bromoform is one of the most dominant CBPs in BEEMS (2011), and was found to be the most dominant of those CBPs detected in laboratory simulations using Sizewell seawater (NNB GenCo 2021a; TR193 and 2020b; TR306).

Flow and temperature

The cooling water discharge (waste stream A) is characterised predominantly by the heat load or excess temperature, that is the temperature rise above ambient in the sea water as it passes through the cooling water system. The temperature rise above ambient (ΔT) largely depends on the instantaneous cooling water flow rate together with the load on the UK EPR™ units. The amount of cooling water available is influenced by the state of the tide, with higher flow rates at high tide and lower flows rates at low tide, due to the variation in pressure head above the intakes. The number of main cooling water pumps in operation will also influence the flow rate. While the nature of the cooling water discharge is influenced both by environmental and operating factors, on average (over the tidal cycle) with both reactors at maximum load, the cooling water flow rate will be in the order of 132m³/second (tidal mean).

NNB GenCo (SZC) has used the scenarios described in section 4.7 to define the main discharge parameters for waste stream A, as discussed in additional detail here.

The proposed maximum daily discharge volume of cooling water is 11,404,800 cubic metres per day (m³/day), based on a discharge rate of 132m³/second (as a tidal mean). Due to tidal influences, the minimum discharge rate at low tide will be 116m³/second (instantaneous).

Waste stream A will be characterised by its thermal content due to being used as cooling water for the power station's condensers and associated plant systems, as well as its chlorine (as total residual oxidant) content due to bio fouling control.

The proposed temperature/thermal characteristics of the operational cooling water discharge via waste stream A are summarised below:

- maximum temperature of effluent waste stream A: 35°C (as a 95th percentile)
- maximum temperature increase between sea water inlet (forebay) and outfall pond during normal/standard power operation (including outage of one EPR™ reactor unit) is 11.6°C (as a tidal mean)
- maximum temperature increase between sea water inlet (forebay) and outfall pond during exceptional/maintenance circumstances is 23.2°C (as a tidal mean)

Normal/standard operation refers to the situation where both UK EPR™ reactor units are operating normally at their full capacity (100% load), with all 4 CRF pumps operational (as 2 CRF pumps serve each EPR™ reactor unit). The EPR™ units may be subject to power changes within this scenario from time to time in line with operational requirements, but the default is for operation at full capacity.

Outage refers to the situation when one UK EPR™ unit is shut down for planned routine maintenance and/or refuelling. Typically, maintenance would be made to a CRF pump or to an element of the filter train. During an outage, neither CRF pump on the shutdown UK EPR™ unit is operational, although the smaller pumps continue to feed cooling water to the auxiliary systems. The other UK EPR™ unit would continue to operate as per standard operation, with 2 operational circulating water system (CRF) pumps. An outage would be expected to take place every 18 to 22 months and typically last for about 2 weeks.

Reduced dilution overall arises as a result of operating only 2 out of 4 main cooling water (CRF) pumps. Given the reduced dilution available, additional discharges arising from the outage (for example, treatments applied to primary and secondary circuits during shutdown and start-up, as well as drain-down after lay-up or cleaning during maintenance) will be managed to ensure compliance with permitted limits during the short periods of planned outages by:

- treatment of the effluent where facilities exist (for example, for hydrazine destruction)
- recycling within the effluent systems (where appropriate)
- retention of effluents in the appropriate available tanks (until the CRF system has been returned to normal (full) flow rate)
- discharge from the effluent tanks at a restricted rate (which would be calculated so as to remain within the permitted limits)

The details of how outage discharges will be managed will be confirmed following the completion of the detailed design of the relevant systems. It is proposed that NNB GenCo (SZC) will provide this in its forward action plan, for which requirements will be specified within this WDA draft permit via pre-operational measures. Once we have assessed the measures, and if approved, they will be incorporated into the permit as operating techniques.

During an outage, neither of the 2 CRF pumps on the shutdown UK EPR™ unit are operational, although the smaller pumps continue to feed cooling water to the auxiliary and essential systems. These smaller cooling water pumps serve the conventional island and the nuclear island, which include the auxiliary cooling system (SEN), essential service water system (SEC), ultimate cooling water system (SRU) and drum screen and band screen (CFI) pumps.

The worst-case exceptional/maintenance scenario (known as ‘RF2’) refers to a theoretical situation where both UK EPR™ units are operating at 100% load, with only a single operational main cooling water (CRF) pump serving each reactor unit (that is, only 50% cooling water capacity). This is the worst-case temperature scenario, as when 2 out of the 4 CRF pumps are under maintenance, the flow of cooling water would be halved, but the heat content of 2 full power UK EPR™ units would remain approximately the same (raising the excess temperature at the 2 cooling water outfalls from 11.6°C to 23.2°C above ambient temperature). Under these circumstances, the load (condenser heat load) would be reduced across the UK EPR™ generating units to ensure that the temperature is brought back down to around 11.6°C above ambient within a short timescale.

It should be noted that the hotter plume near to the discharge point transfers heat to the atmosphere much more efficiently than the normal, cooler plume. This means that there is less heat to mix down into the water column, resulting in a smaller plume at both the surface and at the bed.

The RF2 scenario represents a useful worst case in terms of cooling water and provides a useful reference short-term or 24-hour discharge assessment scenario, as the scenario is not considered to be part of normal (typical day-to-day) operations at SZC. If this scenario occurred in reality, it would likely result in the power station being shut down until the main cooling water (CRF) pumps were brought back into operation.

An alternative, more typical maintenance scenario (RF3) refers to the situation when both UK EPR™ units are operational, one on 100% load (with 2 CRF pumps in operation), and the other unit on 90% load (with only a single CRF pump in operation). The plant could be operated under this configuration as a result of both planned and unplanned situations. The remaining CRF pump would be subject to maintenance during this period.

Normally, pump maintenance of this type would be planned to coincide with an outage as described. It is not unknown for unexpected failures to occur while the UK EPR™ unit is operating at full power, for example, pump or drum screen failure. If this unplanned situation were to occur, the load on the relevant UK EPR™ unit would be reduced to a maximum of around 90% rated thermal power to compensate for the loss, and would remain in this configuration until the fault is rectified, which would be expected to take no longer than one month.

Even when routine pump maintenance is scheduled to coincide with an outage, it may be necessary to operate the plant in the RF3 configuration for up to a month. This is because the time to complete the required maintenance work is going to take longer than the critical tasks normally associated with an outage, for example, refuelling of an UK EPR™ unit. In this planned situation, the CRF pump would either be taken offline before the outage begins, or it could remain offline after the critical outage tasks have been completed (and the UK EPR™ unit has been brought back up to power).

Cooling water outlet temperature and concentration of discharged contaminants during normal power operation increases due to reduction in dilution before discharge by CRF flows with one pump on outage.

Given the reduced dilution available, effluents will be managed to ensure compliance with permitted limits during the short periods of planned outages by:

- treatment of the effluent where facilities exist (for example, for hydrazine)
- recycling within the effluent systems (where appropriate)

- retention of effluents in the appropriate available tanks (until the CRF system has been returned to normal flow rate)
- discharge from the effluent tanks at a restricted rate, which would be calculated so as to remain within the permitted limits

The specific details of how outage and maintenance discharges will be managed will be confirmed following the completion of the detailed design of the relevant systems. NNB GenCo (SZC) therefore proposes to provide this through the SZC WDA permit application forward action plan. We have, therefore, included the requirement to submit a detailed method statement and impact assessment as a pre-operational measure in our permit.

Chlorination

Chlorine is commonly applied to prevent biofouling of cooling water infrastructure. Based on the known risk of biofouling at Sizewell from historic operation of the power stations at Sizewell A and B, chlorination of the SZC cooling water system will be required to maintain control of biofouling risks to its cooling water infrastructure and other critical plant equipment. An initial biocide dose of 0.5 milligrams per litre (mg/l) of sodium hypochlorite (chlorine) will be injected into the cooling water after the removal of fish into the FRR systems, but before the condensers (Figure 4) to protect the very fine heat exchanger tubes within the condensers from biological growth taking hold.

Once mixed with the cooling water, the sodium hypochlorite will form a number of oxidants, which typically include hypobromous acid/hypobromite as the dominant species. These biocidal oxidants are unstable and rapidly degrade in the presence of the organic matter in the cooling water. Nevertheless, there will be a degree of residual contamination in the cooling water discharge. The level of contamination is measured as total residual oxidant (TRO). In addition to TRO, other non-oxidising agents are formed by chlorine interacting with seawater. These are collectively known as chlorinated by-products (CBPs). The most prevalent species include bromoform and trihalomethanes. Bromoform was found to be the most dominant of those CBPs detected in laboratory simulations using Sizewell seawater (NNB GenCo 2021a; TR193 and 2020b; TR306).

The NNB GenCo (SZC)'s operational policy is to continuously dose (every 30 minutes) with chlorine at 0.5mg/l during the growing season (when seawater temperature exceeds 10ºC) to achieve a minimum TRO dose (within the required cooling water infrastructure and condenser inlets) of 0.2mg/. The resulting TRO concentration discharged to the Greater Sizewell Bay via the 2 cooling water outlets would therefore be 0.15mg/l.

NNB GenCo (SZC) has confirmed that chlorination of the required cooling water infrastructure will not be applied before the removal of fish into the FRR systems, and that the flushing water used to improve flow in the 2 FRR systems' fish gutters (located after the drum screens) will not be chlorinated. Therefore, waste stream H will not be chlorinated.

Suspended solids

The marine waters of the Greater Sizewell Bay are characterised by high concentrations of suspended solids due to sediment mobilisation from the seabed caused by the highly dynamic tidal regime. Sediment suspended in sea water is the result of both natural processes and human activities. The suspended sediment concentration (SSC) is depth dependent, highly seasonal, and varies throughout the tidal cycle due to processes of deposition and resuspension.

Results from NNB GenCo (SZC)'s marine water quality monitoring campaign during 2014/2015 showed the mean suspended solids concentration at the proposed SZC intake and outfall location within the Greater Sizewell Bay (approximately 3.5km offshore) to be 55.5mg/l, with a maximum recorded value of 137mg/l.

Suspended sediment concentrations from sampling 500 metres off the coast adjacent to SZC (inshore of the Sizewell-Dunwich Bank) recorded the daily minimum, mean and maximum SSCs (Table 1) between 2008 and 2009. High levels of SSC are driven by both high wave energy events and peak spring tidal currents. Minimum observations were observed when neap tides coincide with low wave energy. The difference between daily maximum and minimum suspended load is approximately 300mg/l at 1.0m above the seabed, and 500mg/l at 0.3m above the seabed.

Table 1. Suspended sediment concentration 500m from SZC (reproduced from table 5.5.1 in NNB GenCo 2020g; SZC project – Water discharge activity permit application submission Sizewell C and Appendix A)

Statistic	SSC at 0.3 m above the bed (mg/l)	SSC at 1 m above the bed (mg/l)
Daily minimum	24-28	15-19
Daily mean	103 – 161	72 – 105
Daily maximum	357 – 609	266 – 459

Abstracting seawater for direct cooling will cause the suspended solids (silt) naturally present in the water column to be drawn through the cooling water system and discharged back to source. The passage of silt through the system offers certain benefits in terms of biofouling control, acting as a mild abrasive to limit scope for biological growth. Nothing more than sodium hypochlorite is potentially added to the cooling water, therefore under normal operations its subsequent discharge does not present any environmental concerns.

Over time silt will accumulate within the cooling water forebays, as the incoming flow velocity is reduced, and the finer material settles out. While intrinsic design measures are used to minimise the potential for silt accumulation, it will need to be periodically removed from the forebays. NNB GenCo (SZC) suggests that, when necessary, it is likely to simply re-suspend the accumulated silt within the forebays for discharge within the normal flow of cooling water.

NNB GenCo (SZC) has made a commitment in its permit application to submit a detailed method statement for de-silting the forebays (incorporating an impact assessment) when the design of the cooling water system is further advanced, and before commissioning commences. Given the lengthy time frames involved until the system would be operational, we consider this to be acceptable. From a regulatory viewpoint, de-silting the forebays does not present any concerns, in principle. However, it is important that the activity is considered as part of the overall water discharge activities. We have, therefore, included the requirement to submit a detailed method statement (and impact assessment) as a pre-operational measure in our permit.

Waste stream A will be the main, continuous discharge in terms of flow from SZC during operation, and will be discharged (in admixture with the effluents generated via waste stream B to G) back to the Greater Sizewell Bay via a single dedicated cooling water tunnel and 2 diffuser outfalls.

4.9.2 Waste streams B and C

Waste stream B is mainly associated with let-down (draining) from the primary circuit, which is required to maintain correct circuit chemistry. The let-down water is treated and recycled, where possible, with any non-recyclable (spent) effluent being processed further before final discharge. A number of additional, smaller sources also contribute effluent to waste stream B, including the hot laundry, hot workshops, facilities for decontamination, the interim storage facility for spent fuel, and the segregated drains of the nuclear vent and drain system.

Waste stream B comprises demineralised water and residual dosing chemicals. The dosing chemicals are required to condition the circuit, that is to control pH levels and eliminate oxygen, reducing the potential for corrosion. These chemicals include lithium hydroxide, ammonia, hydrazine, morpholine and ethanolamine. However, chemical conditioning will not totally eliminate corrosion, and the effluent will contain metals used in the fabrication process such as aluminium, copper, chromium, iron, manganese, nickel, lead and zinc. Additionally, boric acid is used as a neutron absorber within the primary circuit to control the reactivity of the fission process.

Waste stream C results from the need to continually ‘bleed’ water from the steam generators to maintain the correct chemistry within the secondary circuit. It comprises largely demineralised water, residual dosing chemicals and dissolved salts. To counteract the effect of losing water due to blowdown, there is a corresponding top up with fresh demineralised water. The steam generator blowdown system also treats and recycles the blowdown water back into the secondary circuit. Any non-recyclable, spent effluent is processed further before it is finally discharged.

In determining the application, we have considered waste streams B and C as a single, combined effluent. This is because NNB GenCo (SZC) was unable to separate out waste streams B and C in order to characterise them individually. It says this is because the chemical loadings submitted in the application have been derived from measurements on existing French nuclear power plants and the capability to monitor the waste streams on these plants only exists after the point where waste streams B and C merge. Therefore, the data it submitted represented the combined contribution of waste streams B and C (this approach is consistent with that taken for the determination of the HPC operational WDA permit).

Given that the effluents from these waste streams are similar in composition, with both arising on the nuclear island, and the fact that at SZC they would share a common treatment facility and discharge tanks, considering them together is sensible and practical. Effluent will be held and monitored in the nuclear island waste monitoring and discharge system tanks, of which there are 3,750m³ capacity KER (Liquid radwaste monitoring and discharge system) tanks. NNB GenCo (SZC) proposes to empty each tank intermittently on a batch basis if monitoring confirms compliance with permitted limits.

The effluents generated by waste streams B and C will be discharged together. The proposed maximum daily discharge volume is 1,500m³/day, which will be discharged on an intermittent, batched basis at a rate of up to 83.3 litres/second (rate based on a maximum pump capacity of 300m³/hour) if monitoring confirms compliance with permitted limits. The discharge will occur in admixture with the continuous flow of cooling water generated by waste stream A.

Table 2 shows the maximum daily and annual loads and the maximum concentration for each substance present in waste streams B and C as provided by NNB GenCo (SZC).

Table 2. Substance daily and annual loadings, and concentration data for the combined waste streams B & C for 2 EPR™ units (reproduced from table 4.1.9 in NNB

GenCo 2020g; SZC project – Water discharge activity permit application submission Sizewell C and Appendix A)

Substance	Daily load kg/d	Annual load kg/yr	Concentration mg/l
Boron	984	2,448	656
Lithium hydroxide	4.40	8.8	2.93
Hydrazine	1	3	0.67
Morpholine	75	210	50
Ethanolamine	15	65	10
Nitrogen (as N)	8.2	253.25	5.33
Nitrogen (as NH_4^+)	1.83	325.2	0.95
Phosphate	150	602.5	100
Suspended solids	20.24	135	13.50
COD	39.27	601	26.2
Aluminium	0.09	0.41	0.06
Copper	0.01	0.03	<0.01
Chromium	0.14	0.65	0.09
Iron	0.6	2.7	0.4
Manganese	0.06	0.26	0.04
Nickel	0.01	0.03	0.01
Lead	0.01	0.02	<0.01

Zinc	0.1	0.46	0.07

In addition to these substances, the effluent will contain small quantities of cadmium and mercury which are present in trace amounts within the raw materials used in the treatment process.

NNB GenCo (SZC) has demonstrated via a H1 screening risk assessment (NNB GenCo, 2021a; TR193) that the amount of cadmium and mercury present in the discharge would not be environmentally significant. Nevertheless, cadmium and mercury are defined as priority hazardous substances (PHSs) under the Water Framework Directive (WFD).

We have therefore included a pre-operational measure (PO12) in the draft permit requiring NNB GenCo (SZC) to submit, for our assessment and approval, a plan that describes how it intends to manage the use of chemicals so as to gradually cease or phase out discharging PHSs, in accordance with the objectives set out under WFD.

4.9.3 Waste stream D

Waste stream D results from leakage and/or drainage (not blowdown) from the secondary circuit within the turbine hall and its floor drains. It comprises largely demineralised water with residual dosing chemicals, dissolved salts, oils, greases and lubricants. The maximum daily discharge volume of waste stream D is 1,500m³/d, from the 2, 750m³ SEK (conventional island liquid waste discharge system) tanks that serve this waste stream. NNB GenCo (SZC) proposes to empty each tank intermittently on a batched basis, at a maximum rate of discharge of 83.3l/s over a period of time ranging between 2 and 3 hours. This is based on a maximum pump capacity of 300m³/hour from each tank.

Table 3 shows the maximum daily and annual loads and the maximum concentration for each substance present in waste stream D as provided by NNB GenCo (SZC).

Table 3. Substance daily and annual loadings, and concentration data for waste stream D for 2 EPR™ units combined (reproduced from table 4.1.13 in NNB GenCo 2020g; SZC project – Water discharge activity permit application submission Sizewell C and Appendix A)

Substance	Daily load (kg/d)	Annual load (kg/year)	Concentration (mg/l)
Hydrazine	3	24.3	2
Morpholine	17.25	1,464	11.5

Ethanolamine	9.75	854	6.5
Nitrogen (as N)	319.8	9,876.7	8
Nitrogen (as NH_4^+)	71.3	12,683.7	47.53
Phosphate	202.5	187.5	135
Suspended solids	399.8	2,665	267
Chemical oxygen demand (COD)	290.7	4,449	194
Aluminium	1.01	4.85	0.67
Copper	0.074	0.39	0.05
Chromium	1.56	7.72	1.04
Iron	6.55	32.27	4.37
Manganese	0.61	3.07	0.41
Nickel	0.083	0.41	0.06
Lead	0.055	0.28	0.04
Zinc	1.1	5.54	0.73

4.9.4 Waste stream E

Waste stream E is generated from the site drainage system, including drainage from the SZC's road and roof drainage network, drainage from the oily water network and atmospheric condensate from chillers.

The proposed maximum daily discharge volume is 35,000m³/day. It comprises effluent generated following rainfall (system designed for up to a 30-year storm event and incorporates a 40% allowance for climate change) from the site's road and roof drainage network. This volume is based on the SZC site area of approximately 40ha (hectares) or 400,000m², and a rainfall depth of approximately 3.57mm/hour over a

24-hour period. The discharge rate will be determined and confirmed during the design process (PO2) and will be subject to a pre-operational condition within the permit.

The oily water drainage network serves those areas on site where oils and hydrocarbons are stored and used, and which therefore, present a risk of contamination from surface water run-off rather than a planned introduction of hydrocarbons into the waste stream. These areas include the backup diesel generators, transformer compounds, electrical substations, electrical equipment areas, diesel fuel and chemical storage areas, oil and grease storage areas, oil and hydrocarbon offloading areas and various workshops.

The drains also serve other areas containing chillers, which represents a potential source of contamination due to the condensates produced from the chilling process (which although is essentially generated as distilled water, may contain low concentrations of metals from corrosion of metal equipment).

The drainage system will incorporate oil and water separators, specified to meet the requirements of the BS-EN-858 Class 1 standard to provide treatment for hydrocarbons (reducing hydrocarbon concentrations to 5.0mg/l), with resultant sludges disposed of off-site to an appropriately licensed waste management facility.

Waste stream E will be discharged on an intermittent basis, with the continuous flow of cooling water generated by waste stream A via the forebay.

4.9.5 Waste stream F

Waste stream F results from the process of producing high quality demineralised water to supply the primary and secondary circuits. At SZC this would be carried out using a combination of membrane technology and ion exchange processes within a demineralisation plant. However, the final design of the SZC demineralisation plant has not yet been completed, so NNB GenCo (SZC) has not been able to provide accurate data for emissions arising from the proposed process.

The data submitted in the application is based on the discharge loadings extrapolated information from the Flamanville 3 site, which is a combined desalination and demineralisation plant) and local sea water quality, rather than just treatment of mains (potable) water supply as is proposed for SZC. This means that the emissions data submitted, which is reproduced in Table 4 is conservative and bounding, that is, it represents a worst case, upper limit, which the actual emissions will not exceed (as there is no discharge loading data currently available for only demineralisation of mains supply water). The emissions of several substances from the SZC demineralisation plant would be considerably less than those below, for example, chloride, iron and suspended solids, due to the fact that desalination technology will not be used.

The demineralisation plant effluent will also contain sequestering agents, which are used to prevent mineral deposits from forming and blocking the reverse osmosis membranes.

For SZC, one of two sequestering agents will be used in the demineralisation plant, either amino tri-methylene phosphonic acid (ATMP) or a sodium polymer sequestering agent. ATMP is the active ingredient in the commercial ATMP based sequestering agent. For the sodium polymer based sequestering agent, the commercial product comprises 10% alky-phosphonic acid which degrades into HEDP (X), acetic acid and phosphoric acid, and 90% sodium polyacrylate, formed of sodium polyacrylate (polymer) and acrylic acid (residual monomer). The type of sequestering agent used will depend on the final design of the SZC demineralisation plant.

The maximum daily discharge volume is 4,000m3/d and the maximum rate of discharge is 46l/s. Table 4 shows the maximum daily and annual loads and the maximum concentration for each substance present in waste stream F, as provided by NNB GenCo (SZC). The values presented are based on the production of the water required for 2 UK EPR™ units, which represent maximum discharge values and that demineralisation unit runs for several hours each day, with a regeneration cycle occurring every 30 days (and assume that desalination units also run continuously).

Table 4. Substance daily and annual loadings, and concentration data for waste stream F (based on data from table 4.1.20 in NNB GenCo 2020g; SZC project – Water discharge activity permit application submission Sizewell C and Appendix A)

Substance	Daily load kg/d	Annual load kg/yr	Concentration mg/l
Detergents	-	624	0.43
Suspended solids	450	88,000	112.5
Iron	250	46,000	62.5
Chloride	450	87,100	112.5
Sulphates	2,000	98,400	500
Sodium	855	52,400	213.75

Amino tri-methylene phosphonic acid (ATMP)	45	9,100	11.25
Hydroxy ethylidene-diphosphonic acid (HEDP)	4.5	890	1.13
Acetic acid	0.1	14	0.03
Phosphoric acid	0.1	12	0.03
Sodium polyacrylate	40	8,030	10
Acrylic acid	1	165	0.25

4.9.6 Waste stream G

Waste stream G comprises treated domestic sewage effluent generated by personnel working on site at both of SZC's UK EPR™ units. A single sewage treatment plant (STP) will be installed to treat this effluent to secondary standard. The treated sewage effluent will be characterised by its concentrations of biochemical oxygen demand (BOD), suspended solids and ammonia.

The proposed maximum daily discharge volume is 190m^3/day, and the STP will operate with a continuous discharge. However, this maximum volume is based on 1,900 people being on site during outage/maintenance, which represents a peak/worst-case scenario as it is not a frequent occurrence. The typical discharge volume during normal (typical day-to-day) operation will be 90m^3/day, based on 900 people being on site.

These 2 volumes are calculated based on 100 litres per person per day at industrial/factory sites with office and canteen facilities for their staff/workers, as stated in the British Water's Code and Practice document 'Flows and Loads 4: Sizing Criteria, Treatment Capacity for Sewage Treatment Systems' (ISBN: 978-1-903481-10-3).

The STP will be appropriately designed and sized to accommodate both the peak and normal operation site populations. The STP is required as the site is unable to connect to the main foul sewer.

The waste stream G treated sewage effluent will be discharged via one of the site's 2 outfall ponds (one per UK EPR™ unit) and into the main cooling water flow (waste stream A).

Table 5 shows the maximum daily and annual loads and the maximum concentration for each substance present in waste stream G as provided by NNB GenCo (SZC).

Table 5. Substance daily and annual loadings, and concentration data for waste streams G from SZC's STP (based on data from table 4.1.26 in NNB GenCo 2020g; SZC project – Water discharge activity permit application submission Sizewell C and Appendix A)

Substance	Daily load kg/d	Annual load kg/yr	Concentration mg/l
Biochemical oxygen demand (BOD)	3.8	1,387	20
Suspended solids	5.7	2,080.5	30
Total ammonia	3.8	1,387	20
Total nitrogen (as N)	4.37	1,595.05	23

4.9.7 Waste stream H

Waste stream H is trade effluent composed of returned abstracted seawater via the 2 fish recovery and return (FRR) systems.

SZC will have 2 fish recovery and return (FRR) systems (FRR system 1 and FRR system 2), with one FRR system serving each UK EPR™ reactor unit. Each FRR system will discharge a maximum volume of 25,920m³/day, and will operate on a continuous basis (at a discharge rate of 0.3m³/second or 300 litres/second).

The 2 FRR systems are proposed to protect SZC's cooling water system, as the abstracted water will be passed through a series of screens (drum and band screens) to reduce the risks of blockage and biofouling. Any debris and biota larger than the screen mesh size will be trapped and removed (impinged).

Some of this biota will still be alive, and therefore the 2 SZC FRR systems are proposed to return this biota back to the receiving water body via 2 dedicated outfalls (at suitable locations where they are not likely to be returned to the cooling water intakes).

However, a proportion of this biota will not survive transit onto the screens and through the FRR systems, and so dead or moribund (close to, or at the point of death) biota will also be returned to the Greater Sizewell Bay via each FRR system outfall. It is the discharge of this moribund biota that constitutes a potential source of polluting matter. The potential impacts on water quality and designated features have therefore been assessed as part of this permit application.

Our assessment considered the contribution of nutrients, unionised ammonia, organic enrichment, biochemical oxygen demand (BOD) and deoxygenation caused by the decay of the moribund biota from the 2 SZC FRR system discharges.

Although supplied via the same source of abstracted water for the main cooling water system (waste stream A), an appropriate chlorination dosing point will be implemented to prevent contamination of the 2 FRR system flows with chlorine (TRO). Therefore, the 2 FRR systems will not be a source of chlorine (TRO) into the Greater Sizewell Bay via the 2 FRR system outfalls.

4.10 General issues

4.10.1 Administrative issues

NNB GenCo (SZC) is the sole operator of the regulated facility.

We are satisfied that the applicant, (NNB GenCo (SZC)), and proposed operator is the company that will have control over the operation of the facility if the permit is granted, and would be able to operate the regulated facility so as to comply with the conditions included in the permit. The proposed decision was taken in accordance with our guidance on legal operator for environmental permits.

4.10.2 Management

NNB GenCo (SZC) has stated in its application (via bespoke WDA permit application form B2) that it will implement an environmental management system (EMS) that will be certified under ISO14001. We have included a pre-operational measure in the draft permit that requires the operator to provide a summary of the EMS before the plant is commissioned, and to make all EMS documentation available for inspection. We recognise that the EMS cannot be certified until the regulated facility is operational. Therefore, we have also included an improvement condition in the draft permit requiring the operator to report progress towards gaining accreditation of its EMS after commissioning of the SZC power station has begun.

We have no evidence to suggest that the operator will not have the management systems to allow it to comply with the permit conditions. We took this decision in accordance with our guidance for legal operator and competence requirements for environmental permits.

4.10.3 Accident and incident management

NNB GenCo (SZC) has submitted an initial environmental risk assessment of potential accidents and incidents at SZC relevant to the water discharge activities. The assessment identifies a range of accidents that could occur, their potential environmental consequences, and comments on the control measures that would be applied. At this stage, a quantitative assessment of the risk associated with each accident or hazard has not been made. NNB GenCo (SZC) has stated that it will provide this when detailed design data is available.

Having considered NNB GenCo (SZC)'s outline approach to developing an accident and incident management plan and other information submitted in its application regarding preventing and controlling pollution, we are satisfied that appropriate measures will be in place to make sure that accidents that may pollute the water environment are prevented and that, if they should occur, their consequences are minimised. The plan will address how environmental risks will be prevented and mitigated during operation, and, in particular, will address the storage and handling of hazardous materials during operation of the site. The plan will also include a quantified hazard risk assessment that incorporates the engineering and procedural mitigation measures that will be in place before operation commences, and how environmental risks will be prevented and mitigated during operation.

NNB GenCo (SZC) has made a commitment in its permit application to provide a detailed accident and incident management plan for the water discharge activities before commissioning, as for example, the full drainage system (waste stream E) for SZC has not yet been designed. This plan should form part of the EMS and, as such, this requirement is covered in a pre-operational measure referred to under section 4.17.

4.10.4 Consideration of foul sewer

Providing several kilometres of pipeline and the associated pumping infrastructure to enable process effluent and/or treated sewage effluent to be discharged to the public foul sewer is environmentally unsustainable. Furthermore, it does not offer significant environmental benefits over a discharge out into the Greater Sizewell Bay, where there is much greater capacity to dilute and disperse effluent, rather than for example, into the fresh surface watercourses of Leiston Beck (water body ID GB105035046271) or a tributary of the Minsmere River (water body ID GB105035046270), where most of the local public sewage treatment works ultimately discharge (for example, under WDA permits at Leiston Valley Road Water Recycling (WRC) Centre (WDA permit reference ASENF1122), and Westleton WRC (WDA permit reference AW4NF582X), both operated by Anglian Water Services Limited).

This approach regarding foul sewer connection is consistent with that taken for the Sizewell A and Sizewell B power stations, as well as other similar power station development sites across England (for example, HPC). We therefore agree with NNB GenCo (SZC)'s justification for not connecting to the foul sewer.

4.10.5 Operating techniques

We have specified that NNB GenCo (SZC) must operate the regulated facility in accordance with the documents contained in its permit application:

- sections 2.3.1 to 2.3.8 of the main application document (NNB GenCo, 2020g. SZC project – Water discharge activity permit application submission Sizewell C and Appendix A - 100232385) for the descriptions of the treatment systems used to remove contaminants before discharge. This is required to ensure that the underlying principles and the techniques are adopted by NNB GenCo (SZC) for treating effluent from each waste stream before discharging
- section 2.6.2 of the main application document for the description of the prevention of unplanned emissions of oils from heat exchangers. This is required to ensure that environment oil coolers are not used.
- Section 2.7.2 of the main application document for the description of hot functional testing (HFT). This is required to ensure that HFT does not involve dosing anything other than the chemicals that will be used during normal operation of the SZC power station, and which have been included under this WDA permit application.
- Section 3.1.3 of the main application document for minimisation of impingement of marine life to reduce potential for generation of polluting matter (arising through the death of impinged marine organisms) to ensure the multi-staged approach is adopted as stated, with respect to LVSE intake design, and exclusion systems, including FRR system 1 and 2 designs.
- Section 3.5 of the main application document for the oily water treatment description, to ensure that the installation and operation of oily water interceptors follows GOV.uk guidance which includes:
    - https://www.gov.uk/guidance/storing-oil-at-a-home-or-business
    - https://www.gov.uk/guidance/pollution-prevention-for-businesses
    - https://www.gov.uk/oil-storage-regulations-and-safety/business

- Section 3.5 of the main application document for the oily water treatment description, to ensure that the installation and operation of oily water interceptors follows GOV.uk guidance:
- Section 3.7.3 of the main application document and additional information provide in response to Schedule 5 Notice No.2 for strategy for minimising chlorination. This is required to ensure that the in-principle strategy is developed based on risk-based dosing.
- Section 3.8 of the main application document for the sanitary effluent (treated sewage effluent) discharge description. This is to ensure that an appropriately sized and designed sewage treatment plant (STP) is provided to accommodate peak flows during outage, and the waste hierarchy is applied (to include the separation of uncontaminated surface water run-off from the site’s foul flows).
- Section 3.9 of the main application document for the segregation of surface water drainage description. This includes the pollution prevention measures that will be applied to prevent polluting materials entering the surface water drainage system, why uncontaminated surface water runoff from the system will not require treatment prior to discharge, and the system design which allows plant to be isolated in the event that surface water runoff does become contaminated (to prevent discharge to the Greater Sizewell Bay and allow storage for appropriate offsite disposal).

We have also specified that NNB GenCo (SZC) must operate the regulated facility in accordance with the following plans.

- Emissions management plan, as approved in accordance with pre-operational measure PO5 in Table S1.4
- Commissioning discharges management plan, as approved in accordance with pre-operational measure PO6 in Table S1.4
- Commissioning discharges management plans, as approved in accordance with pre-operational measure PO6 in Table S1.4
- Operational strategy for the control of biofouling, as approved in accordance with pre-operational measure PO7 in Table S1.4.
- Commissioning plan for the 2 FRR system discharges, in accordance with pre-operational measure PO8
- Forebay de-silting plan, as approved in accordance with pre-operational measure PO9 in Table S1.4.
- Hydrazine management plan, as approved in accordance with pre-operational measure PO10 in Table S1.4.
- Environmental monitoring plan, as approved in accordance with pre-operational measure PO11 in Table S1.4
- Priority hazardous substances management plan, as approved in accordance with pre-operational measure PO12 in Table S1.4.

- Effluent monitoring plan, as approved in accordance with pre-operational measure PO15 in Table S1.4.
- Hydrodynamic modelling review plan, as approved in accordance with preoperational measure PO16 in Table S1.4

NNB GenCo (SZC) must submit these plans to us for approval as part of a package of pre-operational measures included in our permit. Our approvals must be provided before the hot functional testing (HTF) phase of the commissioning process begins.

Due to the lengthy design process and construction period associated with SZC, certain aspects of the detailed design are ongoing and evolving. We are, therefore, using these pre-operational measures in many instances to require the operator to confirm that the details and procedures proposed in the application have been adopted or implemented before commissioning begins. If designs change after the application is made, then the conditions require the operator to validate the original application data and, if necessary, demonstrate how any changes will prevent or minimise impacts on the environment and ensure compliance with our permit.

The details set out here would form part of the permit through permit condition 2.3.1 (operating techniques) and Table S1.2 in the Schedule 1.

4.11 The environmental impact of the water discharge activities

We can set limits on environmental permits for the substances listed within 2008/105/EC, (as amended by 2013/39/EU), the Environmental Quality Standards Directive (EQSD) and for specific pollutants covered by Annex 8 of 2000/60/EC the Water Framework Directive (WFD).

The standards for these substances were transposed into UK legislation through The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Environment Agency (2019), and our GOV.UK guidance lists environmental quality standard (EQS) thresholds for ‘hazardous chemicals and elements’. An EQS is the concentration below which a substance is not believed to be detrimental to aquatic life, based on the results of toxicity tests on organisms covering a range of levels within food chains. Each substance has its own EQS, which can differ depending on whether the receiving environment is fresh, transitional, or coastal water.

Hazardous chemicals and elements in Environment Agency (2019) comprise:

- pollutants classed as either priority hazardous substances, priority substances or ‘other pollutants’ by the EQSD

- specific pollutants listed in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- substances which have an operational (non-statutory) environmental quality standard (EQS)

Environment Agency (2019) can also be applied to assess the environmental risk of substances with ecotoxic properties which are not within these categories, but that are present in discharges at sufficient concentrations to be of potential environmental concern. Rather than an EQS, these substances may have an equivalent environmental/ecotoxic threshold such as a predicted no effect concentration (PNEC) value.

Our ecotoxicology advisory service (ETAS) typically reviews any PNECs or other alternative threshold values that are proposed by an applicant for substances without an EQS, to confirm that the PNEC has been appropriately derived.

Substances with EQSs will have either a maximum allowable concentration (MAC) or an annual average (AA) concentration standard or both, and so the risk assessment will take into consideration mixing zones (Section 4.11.1), short-term (Section 4.11.2) and long-term effects (Section 4.11.3).

4.11.1 Mixing zones

The mixing zone is defined as the predicted area of the receiving water body that is expected to contain concentrations of these substances above the relevant EQS or PNEC value as a result of the discharge activity.

Computer modelling was used to determine the extent of the substance’s mixing zone created by the cooling water discharge to determine the environmental impact and pollution risk of these relevant substances. The extent of the predicted mixing zone, with reference to the underlying toxicity data, was then be used to determine whether there would be an adverse effect on designated features or sites.

Based on the modelling and outcomes from our HRAR and WFD assessments for the operational SZC WDAs, numeric compliance conditions and limits will be applied for a substance to ensure the modelled mixing zone is not exceeded (as any exceedance of a modelled mixing zone may result in an adverse effect on site integrity). This may be achieved by setting a concentration limit (for example, mg/l or µg/l) and/or a loading limit (for example, kg/day or kg/year) for the substance assessed via the modelling.

If a modelled mixing zone is not acceptable, then we may have to set permit limits which will deliver an acceptable mixing zone. However, we may potentially have to refuse the permit application if the impact of the proposed discharge on the receiving environment is determined to be unacceptable.

4.11.2 Short-term effects

The maximum allowable (MAC) EQS of the proposed substance will be considered in order to evaluate the short-term environmental impact that the proposed discharge of the substance may cause. For substances with PNEC values, the short-term environmental impact is assessed via an appropriately derived acute PNEC value (calculated as a maximum allowable concentration, or maximum as a 95th percentile).

4.11.3 Long-term effects

The annual average EQS concentration of the proposed substance will be considered in order to evaluate the long-term environmental impact that the proposed discharge may cause. For substances with PNEC values, the long-term environmental impact is assessment via an appropriately derived chronic (calculated as a mean/average) PNEC value.

4.11.4 Application to assessing the SZC cooling water systems

For power stations with direct (or partial direct) cooling water systems, a specific allowance and H1 screening methodology has been developed for the assessment of hazardous chemicals and elements (Environment Agency, 2019), as detailed within guidance on GOV.UK. This is to assess the substances within any continuous or batched process waste streams that are then discharged into the main cooling water stream (which provides an effective ‘initial dilution’ of these process waste streams) before they are discharged in admixture into the receiving environment.

Circumstances where this allowance can be made for dilution by the cooling water stream are those power stations discharging to lower estuaries or to coastal waters. This is the case with the proposed operational WDAs from Sizewell C that are the subject of this environmental permit determination.

As part of the H1 screening assessment, the applicant for the permit must take into account the existing background concentrations of the hazardous chemicals and elements within the abstracted cooling water from the coastal water body. This provides the prevailing environmental conditions that must be considered when concluding our assessments.

The aim of the H1 screening risk assessment process is to identify those hazardous chemicals and elements within the process waste streams that may contribute to the deterioration of the receiving water body’s water quality. This includes preventing target standards such as status objectives under the WFD or requirements under the Habitats Directive being achieved. The permit applicant will need to complete appropriate modelling to determine the environmental significance of relevant substances. The screening risk assessment process also enables those hazardous chemicals and elements which are environmentally insignificant and not of concern to be identified within the proposed WDAs.

For any hazardous chemicals and elements that fail the screening risk assessment process, further assessment and investigation by completing appropriate modelling will be needed. The permit applicant completes this modelling as part of its supporting information, and we review/audit it when determining the permit application.

The modelling is required to assess the potential environmental impact of these relevant substances. If the concentration of a hazardous chemical or element exceeds the relevant EQS (AA and/or MAC, or percentile standard) or PNEC (chronic and/or acute) within the cooling water flow, then a mixing zone will be created at the point of discharge.

Calculation method for predicted average and maximum concentrations in cooling water

The method of calculation is essentially mass balance, and needs to cover predicted average concentrations of a hazardous pollutant in the cooling water to assess against annual average (AA) EQS, and predicted maximum concentrations of a hazardous pollutant in the cooling water to compare against a maximum allowable concentration (MAC) EQS or a 95th percentile EQS.

Predicted average concentrations in the cooling water

Predicted average concentrations of a hazardous substance in the cooling water should be based on the average load of the hazardous pollutant in a process waste stream, and the average operational cooling water flow rate with an average background concentration in the abstracted cooling water.

This is calculated as follows:

1. Multiply the average background concentration by the average cooling water flow (to determine background load).
2. Add the average load of the chemical and element in the waste stream to the result from step 1.
3. Add the average process waste stream flow to the average cooling water flow.
4. Divide the result of step 2 by the result of step 4 (and compare the result to the AA EQS or PNEC)

Predicted maximum concentrations in the cooling water

Predicted maximum concentrations of a hazardous substance in the cooling water should be based on the maximum load of the hazardous pollutant in a process waste stream, and the minimum operational cooling water flow rate with the maximum background concentration in the abstracted cooling water. Where the EQS is a 95th percentile, the maximum background concentration can also be a 95th percentile.

This is calculated as follows:

1. Multiply the maximum background concentration by the minimum cooling water flow (to determine background load).
2. Add the maximum load of the pollutant in the waste stream to the result from step 1.
3. Add the average process waste stream flow to the minimum cooling water flow.
4. Divide the result of step 2 by the result of step 4 (and compare the result to the MAC EQS or PNEC).

Outcome of NNB GenCo (SZC)'s H1 screening risk assessment

If the concentration of a hazardous chemical or element exceeds the relevant EQS (AA and/or MAC or percentile standard) or PNEC (chronic and/or acute) in the cooling water discharge flow, then there will be a mixing zone created at the point of discharge. This will need to be modelled in an appropriate way to help determine the extent of the plume, its potential to cause pollution (and also potential environmental impacts to designated conservation sites and their listed features), as well as interactions with other discharge plumes and the mixing zones they created by discharges from the same site or neighbouring sites. For example, nuclear new build power stations are typically located alongside existing power stations that discharge operational and/or decommissioning/legacy water discharge activities (WDAs).

If the relevant EQS/PNEC is not exceeded for the relevant hazardous chemical or element in the cooling water discharge, then no further assessment is required. This is because the substance is considered to be environmentally insignificant and not liable to cause pollution within the receiving water body.

NNB GenCo (SZC) submitted a discharge H1 type assessment report (NNB GenCo, 2021a: TR193) as part of its operational WDA permit application. This is to determine the environmental significance of the relevant hazardous chemical or elements within SZC's operational waste streams A to G, in order to screen out those that could be considered insignificant and for which detailed modelling is not necessary (in line with our guidance (LIT13134, Environment Agency 2019) for surface water pollution risk assessment and modelling).

Many of the hazardous chemicals and elements in the proposed SZC operational waste stream discharges do not have an established EQS. NNB GenCo (SZC) has therefore used appropriate substitute benchmarks to define the threshold for potential environmental harm. This includes using background (ambient) data from its marine water quality surveys, predicted no effect concentration (PNECs) and no observable effect concentration (NOECs) values, which are based on ecotoxicological studies.

We consider using these substitute environmental benchmarks is a valid and practical approach to the risk assessment. This approach is also consistent with that taken for other WDA permit applications containing potentially hazardous chemicals and elements.

NNB GenCo (SZC) made several assumptions in its calculations for the EQS AA and EQS MAC H1 screening risk assessment for the operational waste streams released into the cooling water discharge (NNB GenCo, 2021a: TR193):

1) The SZC operational discharge loading are based on those shown in Table 6.
2) The maximum daily and annual loading values have been adopted to provide a worst-case scenario in terms of contaminant loadings in the SZC cooling water discharge. The use of daily chemical loading values needs to be treated with caution, as the H1 screening risk assessment methodology is developed for the assessment of long-term discharges. These discharge values are compared to EQS values which are normally based on annual average (AA) concentrations.
3) For chemicals in the discharge that do not have an EQS, PNECs are derived if enough toxicity data are available. Comparisons are made to any acute toxicity values where ecotoxicological data are limited and where no toxicity data are available comparisons are made to site background levels for the relevant chemical.
4) For substances subject to intermittent (batched) release which is considered appropriate for 24-hour discharge assessments, a factor of 100 would normally be applied to the lowest L(E)C50 of at least 3 short-term tests for species from 3 taxonomic groups to derive a short-term PNEC.
5) For annual discharge assessments where 2 long-term test NOECs are available, the lowest has a factor of 500 applied to derive a chronic NOEC for marine data and where 3 are available a factor of 100 is appropriate.
6) The maximum annual loadings are assumed to be discharged at a constant rate over the course of a year and to be mixed in the cooling water flows prior to discharge to the environment. It is assumed within the presented H1 calculations that for average annual concentrations the cooling water discharge flow, into which all discharges are mixed, is 116m³/second as a worst case under normal operational flow.
7) For 24 hour discharges, the assessment has been made for a discharge flow of 66m³/second to provide a worst-case ‘incidental’ dilution scenario. This discharge volume assumes that only a single cooling water (CRF) pump is operating for each UK EPR™ unit during a low water period. However, it should be noted that 24-hour discharges are unlikely to occur exclusively

under low tide conditions and when only one cooling water pump is functioning normally (it is therefore particularly conservative).

8) For metals, it is assumed that annual loading figures relate entirely to metals in the dissolved phase. As dissolved metals are in a biologically available form, this assumption allows for assessment of a worst-case potential impact scenario.

9) The chemical discharge values consider any initial dilution or degradation of chemicals within holding tanks.

10) Mean background concentrations are used in place of EQS values for those substances which have no EQS and for which there is no or insufficient toxicity data to derive a predicted no effect concentration. Mean background concentrations are based on the results for the monitoring programme conducted in 2010 (as reported in NNB GenCo, 2019a; TR314)

11) Discharge loadings have been used for both desalination and demineralisation processes as these combined sources represent a worst-case scenario (even though desalination will not be carried out at SZC during operation).

Table 6. The operational phase substance maximum 24 hour and annual loadings for 2 EPR™ units at SZC (reproduced from table 30 in NNB GenCo, 2021a; TR193)

Substance	Circuit conditioning (kg/yr)	Sanitary waste discharge (kg/yr)	Producing demineralised water (kg/yr)[1]	Maximum annual loading (kg/yr)	Maximum 24-hour loading (kg/d)
Boric acid (H3BO3)	14,000	-	-	14,000	5,625
Boron	2,448	-	-	2,448	984
Lithium hydroxide	8.8	-	-	8.73	4.4
Hydrazine	24.3	-	-	24.3	3.0
Morpholine	1,680	-	-	1,674	92.3
Ethanolamine	920	-	-	919	24.75
Nitrogen as N	10,130	1595	-	11,725	332

Un-ionised ammonia (NH3)	-	-	-	958[2]	27[2]
Phosphates (PO43)	800	-	-	790	352.5
Detergents		-	624	624	-
Suspended solids	2,800	2,080	88,000	92,879	870
BOD	-	1,387	-	1,387	3.8
COD	5,050	-	-	5,050	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	-	46,000	66,035	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	-	-	87,100[3]	87,100	450
Sulphates	-	-	98,400[3]	98,400	2,000
Sodium	-	-	52,400[3]	52,400	855
ATMP	-	-	9,100	9,100	45

HEDP	-	-	890	890	4.5
Acetic acid	-	-	14	14	0.1
Phosphoric acid	-	-	12	12	0.1
Sodium polyacrylate	-	-	8,030	8,030	40
Acrylic acid	-	-	165	165	1
Chlorine (TRO) and bromoform[3]	-	-	-	-	150µg/l, 190µg/l

[1] Figures represent combined demineralisation and desalination and therefore bounding.
[2]These figures are back calculated from the un-ionised ammonia concentration derived from the un-ionised ammonia calculator using the NH_4 concentration that results from the combined sanitary and conditioning inputs.
[3] Based on the expected chlorine dose required to achieve a target concentration of 200µg/l at the condensers of the power station and taking account of subsequent decay of TRO a precautionary discharge source term of 150µg/l is proposed in TR316 (NNB GenCo, 2021c) and for bromoform 180µg/l (NNB GenCo, 2019b; TR303).

Calculations for the maximum (24 hour) SZC discharge loadings

NNB GenCo (SZC) completed the H1 screening risk assessment for maximum, 24 hour predicted operational phase chemical discharge loadings based on a cooling water discharge rate of 66m³/second under maintenance conditions (that is, with a single operational UK EPR™ unit). The screening outcomes are provided within Table 7.

Table 7. Screening MAC for large cooling water discharges for the maximum 24-hour loadings predicted for operational phase chemical discharges at SZC for 2 UK EPR™ units (bold underlined values indicate failure of the relevant H1 risk assessment screening test), which replicates Table 32 within NNB GenCo (SZC)'s H1 risk assessment (2021a: TR193).

Substance	EQS or surrogate value (µg/l)	Derivation of surrogate	Discharge + background (µg/l)	Max discharge /EQS <1

Boron[1]	7,000	Pre WFD EQS	4,656	0.67
Lithium hydroxide	65[2]	Mean background	90.2[2]	**1.39**[3]
Hydrazine	0.004	Acute PNEC	0.53[4,5]	**131.5**
Morpholine	28	Acute PNEC	16.18	0.58
Ethanolamine	160	Acute PNEC	4.34[5]	0.03
Nitrogen as N	980[6]	WFD 99th percentile	484.3[7]	0.49
Unionised ammonia (NH_3-N)	21	WFD AA-EQS	7.34[8]	0.35
Phosphates (PO_4-P)	33.5	Mean background	127	**3.79**
Suspended solids	74,000[3]	Mean background	154[5]	0.002
BOD	2,000	Mean background	0.675[5,9]	0.0003
COD	239,000	Mean background	57.87[5]	0.00024
Aluminium	12	Mean background	20.19	**1.68**
Copper	3.76	WFD AA-EQS	4.76	**1.27**
Cadmium	1.5	WFD MAC-EQS	0.13	0.09

Chromium	32	WFD MAC-EQS	2.48	0.08
Iron	1,000	WFD AA-EQS	302	0.3
Manganese	2	Mean background	-	-
Mercury	0.07	WFD MAC-EQS	0.02[10]	0.29
Nickel	34	WFD MAC-EQS	1.17	0.03
Lead	14	WFD MAC-EQS	3.94	0.28
Zinc	6.8	WFD AA-EQS	46	**6.77**
Chloride	14,128,000	Mean background	78.9[5]	0.00
Sulphates	2,778,000	Mean background	350.7[5]	0.00
Sodium	10,400,000	Mean background	150[5]	0.00
ATMP	74	NOEC	7.89[5]	0.11
HEDP	13	EC50	0.79[5]	0.06
Acetic acid	301	LC50 (48h fw crust)	0.02[5]	0.00006
Phosphoric acid	200	LC50 (72h fw algae)	0.02[5]	0.0001

Sodium polyacrylate	180	LC50	7.01[5]	0.04
96h fw algae;	7.015	0.04		
Acrylic acid	1.7	EC50 (96 h fw algae)	0.18[5]	0.1
Chlorine (TRO) bromoform	(10) [5]	MAC-EQS	(150), 190	(15)38

[1] Variable dissociation products of boric acid and other boron compounds in seawater so assessment focuses on equivalent boron concentration.
[2] Expressed as lithium.
[3] Figures in bold exceed the EQS or reference value.
[4] This loading does not include hydrazine from streams B and C because this would not be discharged except during start up and shutdown when hydrazine from stream D would not be discharged.
[5] Discharge only does not include background or no background either measured or detected.
[6] It should be noted that a more specific methodology for deriving 99th percentile values based on a relationship between SPM and DIN is recommended in draft Environment Agency guidance and for an annual average SPM of 55.2mg/l would give a slightly lower value of 952µg/l as a 99th percentile but the screening here would only slightly change.
[7] This figure includes a calculated 4.4kg day from sanitary effluent derived by calculation from permitted 23mg/l N from STP discharge – stream G.
[8] These figures are back calculated from the unionised ammonia concentration derived from the unionised ammonia calculator using the NH4 concentration that results from the combined sanitary and conditioning inputs.
[9] The BOD value is derived from stream G based on a BOD5-atu concentration of 20mg/l and the derived concentration due to the discharge (0.67µg/l) is negligible relative to the site background (2.0mg/l) and not significant in terms of impact on dissolved oxygen when oxygen flux for vertically well mixed water column at site is considered.
[10] The mean is used in place of the 95th percentile as values below detection result in lower.
[11] fw represents freshwater species toxicity test data which determines PNEC.

Results of screening for SZC operational discharges for the maximum 24-hour loadings

Table 7 shows that for the 24-hour SZC operational discharge assessment, hydrazine, chlorine produced residual oxidants (TRO) and bromoform concentrations in the operational discharge will exceed the acute EQS/PNEC values and were therefore taken forward for assessment via more detailed modelling.

Other substances also appeared to fail the H1 screening risk assessment. However, they were not considered further for the following reasons.

The operational 24-hour discharge concentrations for copper and zinc also exceed EQS assessment criteria. However, in each case, the estimated discharge concentrations are at least 30 times below the relevant annual average (AA) EQS (and are also below their respective detection limits for analysis). It is therefore the high, derived 95th percentile background loadings that are responsible for these exceedances. Therefore, no measurable exceedance resulting from the SZC cooling water discharge itself would be detectable, and so NNB GenCo (SZC) decided not to conduct additional assessment via modelling.

Lithium hydroxide, phosphate and aluminium do not have EQS or PNEC values, but instead reference site mean backgrounds, and so the 95th percentile load calculations which use site background 95th percentile values will invariably result in an exceedance of the relevant assessment values.

In the case of aluminium, the actual SZC discharge contributes a sixtieth of the background, and for lithium hydroxide the equivalent lithium input from the proposed operational discharge is almost 300 times below the background. In neither case are these inputs considered of significance, and so NNB GenCo (SZC) did not carry these through for additional assessment via modelling.

The phosphate input is several times above background, and as phosphate can contribute to nutrient status, it was considered further via detailed modelling.

While not part of the H1 screening risk assessment, concentrations of other substances for which the 24-hour loading discharge concentration are present in the operational SZC discharge at >40% of their EQS (or equivalent reference value via PNEC or background) are also considered here. These are boron (boric acid), morpholine, DIN, and unionised ammonia.

The boron background concentration in Sizewell seawater as a 95th percentile (as used in the 24-hour discharge calculation) is around 4,564µg/l. As the estimated discharge concentration of boron represents around one twentieth of this value, it is the background concentration that has the most influence on the scale of the cooling water discharge concentration relative to the EQS.

As the elevation of boron above the seawater background is relatively small, any influence will be localised to the area around the immediate discharge. As an essential element for many marine algal species, the low elevation of boron concentration expected in short-term discharges is likely to have negligible effects.

Morpholine was 58% of its derived PNEC for 24 hour discharges, but is a readily degradable chemical and has a low likelihood of bioconcentration (EDF, 2021a;

TR193,). This coupled with its low toxicity indicates it would have negligible effects on marine species under this discharge scenario.

Unionised ammonia was 35% of its EQS. As temperature may influence the relative amount of unionised ammonia, the operational discharge has been further assessed considering temperature elevation and this was given further consideration in the via detailed modelling.

The 24-hour discharge concentration of dissolved inorganic nitrogen was 49% of the site 99th percentile winter standard for water bodies of intermediate turbidity. As the loading of dissolved inorganic nitrogen (DIN) may influence algal growth, this was considered further via detailed modelling.

Average annual loadings

NNB GenCo (SZC) completed the H1 screening risk assessment for average annual (AA) concentrations. For this assessment, the cooling water discharge flow into which all discharges are mixed, is 116m³/second as a worst case under normal operational flow.

The cooling water flow of 116m³/second is based on each UK EPR™ unit having a minimal operational cooling water flow of 58m³/s under low tide conditions (the worst-case scenario within 'standard operation'). The screening outcomes are provided within Table 8.

Table 8. Screening for large cooling water discharges for AA loadings predicted for operational phase chemical discharges for 2 UK EPR™ units at SZC (bold underlined values indicate failure of the relevant H1 risk assessment screening test), which replicates Table 33 within NNB GenCo (SZC)'s H1 risk assessment (2021a: TR193).

Substance	EQS/surrogate value (µg/l)	Derivation of surrogate	Discharge concentration including background (µg/l)	Annual Discharge/EQS <1
Boron[1]	7,000	Pre WFD EQS	4,145.67	0.59
Lithium hydroxide	65[2]	Mean background	65[2]	**<u>1.00</u>**
Hydrazine	0.0004	Chronic PNEC	0.01[4]	**<u>16.6</u>**

Morpholine	17	Chronic PNEC	0.46[5]	0.03
Ethanolamine	160	Acute PNEC	0.25[5]	0.001
Nitrogen as N	980[6]	WFD 99th percentile	360.127	0.37
Unionised ammonia (NH_3-N)	21	WFD AA-EQS	0.96[8]	0.05
Phosphates	33	Mean background	33.57	**<u>1.00</u>**
Detergents	-	-	0.17[5,9]	0.2
Suspended solids	74,000[3]	Mean background	25.4[5]	0.0003
BOD	2,000	Mean background	0.38[5,10]	0.0002
COD	239,000	Mean background	1.38[5]	0.00001
Aluminium	12	Mean background	12	**<u>1.00</u>**
Cadmium	0.2	WFD AA-EQS	0.05	0.25
Copper	3.76	WFD AA-EQS	2.15	0.57
Chromium	0.6	WFD AA-EQS	0.57	0.95

Iron	1,000	WFD AA-EQS	132.58	0.13
Manganese	2	Mean background	-	0.00
Mercury	0.07	WFD MAC-EQS	0.02	0.29
Nickel	8.6	WFD AA-EQS	0.79	0.09
Lead	1.3	WFD AA-EQS	1.0	**0.76**
Zinc	6.8	WFD AA-EQS	14.7	**2.16**
Chloride	14,128,000	Mean background	23.81[5,6]	-
Sulphates	2,778,000	Mean background	26.90[5]	-
Sodium	10,400,000	Mean background	14.32[5]	-
ATMP	74	NOEC 96h fw11 algae	2.49[5]	0.03
HEDP	13	NOEC 96h algae	0.24[5]	0.02
Acetic acid	62.8	NOEC 21d fw crust	0.004[5]	0.0001
Phosphoric acid	20	LC50 72h algae	0.003[5]	0.0002

Sodium polyacrylate	11.2	NOEC 72h fw crust	2.20[5]	0.20
Acrylic acid	0.34	NOEC 72 h fw algae	0.05[5]	0.13

[1] Variable dissociation products of boric acid and other boron compounds in seawater so assessment focuses on equivalent boron concentration.
[2] Expressed as lithium.
[3] Figures in bold exceed the EQS or reference value.
[4] This loading does not include hydrazine from streams B and C because this would not be discharged except during start up and shutdown when hydrazine from stream D would not be discharged.
[5] Discharge only does not include background or no background either measured or detected.
[6] It should be noted that a more specific methodology for deriving 99th percentile values based on a relationship between SPM and DIN is recommended in draft Environment Agency guidance and for an annual average SPM of 55.2mg/l would give a slightly lower value of 952µg/l as a 99th percentile but the screening here would only slightly change.
[7] This figure includes a calculated 1,595kg/y from sanitary effluent derived by calculation from permitted 23mg/l N from STP discharge – stream G.
[8] These figures are back calculated from the unionised ammonia concentration derived from the unionised ammonia calculator using the NH4 concentration that results from the combined sanitary and conditioning inputs.
[9] Detergents are assumed to be non-ionic for cleaning reverse osmosis membranes (Beyer and others, 2017) and the PNEC is derived from Belanger and others, 2006 cited in Table 4.37 HERA, 2009 for most toxic alcohol ethoxylates with chain length C18 and added application factor of 10 is applied to this value as it is based on freshwater data.
[10] The BOD value is derived from stream G based on a BOD5-atu concentration of 20mg/l and the derived concentration due to the discharge (0.38µg/l) is negligible relative to the site background (2.0mg/l) and not significant in terms of impact on dissolved oxygen when oxygen flux for vertically well mixed water column at site is considered.
[11] fw represents freshwater species toxicity test data which determines PNEC.

Results of screening for discharges for the average annual loadings

As shown in Table 8, for annual loadings in the SZC operational cooling water discharge hydrazine, chlorine and bromoform again exceed relevant PNEC or EQS values in the screening assessment and so will be considered further by detailed modelling in the appropriate assessment.

Discharges during the operational phase would also just exceed or equal the relevant annual average EQS/PNEC or background concentration for lithium hydroxide, phosphates, aluminium, and zinc (Table 8).

Lithium hydroxide, phosphate and aluminium do not have EQS or PNEC values, so instead reference site mean backgrounds. Therefore, the mean load calculations which use site background water quality mean values will invariably result in an exceedance.

In the case of aluminium and lithium hydroxide, the actual operational discharge concentrations are below the method detection limit (LOD) and are several orders of magnitude below the site background, so the discharge contributions would have negligible effects and do not warrant further assessment.

The phosphate discharge concentration is also below the method detection limit and although the discharge concentration is very low the input can contribute to nutrient status and increased primary production so will be taken through to appropriate assessment.

Zinc fails the annual loading discharge assessment. However, it is the high background loading that is responsible for this exceedance and the actual discharge concentration would be below detection. Therefore, this input is considered to have negligible effects and was not considered via modelling.

In screening, copper and chromium were 57% and 95% of their respective annual average EQS values. However, for both, the predicted operational discharge concentrations are below method detection limits and are several orders of magnitude below their respective EQS (that is, site backgrounds are not included) therefore negligible likely effects are predicted.

As was the case for the 24-hour screening assessment, elevation of boron above the seawater background is relatively small and so any influence will be localised to the area around the immediate discharge. As an essential element for many marine algal species the low elevation of boron concentration is likely to have negligible effects and therefore this is screened out of further assessment.

For the annual discharge screening assessment, with DIN at 37% of its background reference, additional DIN can contribute to the nutrient status and increased primary production and will be considered within the appropriate assessment.

Un-ionised ammonia concentration was low at 0.05% of its EQS, but was considered further in relation to the influence of temperature elevation on the percentage of unionised ammonia and will be considered within the appropriate assessment.

Review of substances with PNECs

We reviewed all of the substances within Table 7 and Table 8 with PNECs to ensure that we were satisfied with the derivation process for each PNEC. Following review by our ecotoxicology advisory service (ETAS), we agreed with the derivation process apart from for the following 4 substances, for which our ETAS team advised alternative PNECs to be considered within the H1 screening risk assessment:

Ethanolamine: NNB GenCo (SZC) derived PNEC of 160µg/l (TR193) replaced with ETAS derived PNEC of 7.0µg/l based on the use of a lower effect endpoint and an additional assessment factor (AF).

Acetic acid: NNB GenCo (SZC) derived PNECs of 62.8µg/l (chronic) and 301µg/l (acute) replaced with ETAS derived PNEC of 32µg/l for both chronic and acute. ETAS was able to identify additional, lower effect concentrations from EU review data in relation to use of acetic acid as a pesticide. The chronic PNEC is based on an endpoint of 16mg/l (noted for the species Lemna minor) and application of an AF of 500, producing a chronic PNEC of 62.8µg/l. A lower short-term endpoint of 19mg/l was identified from an acute study on the species Daphnia magna. Application of an AF of 1,000 would provide an acute value of 19µg/l, which is lower than the proposed chronic PNEC of 32µg/l. Therefore, ETAS advised that a PNEC of 32µg/l should be applied for consideration of both acute and chronic exposure.

Phosphoric acid: NNB GenCo (SZC) derived PNECs of 20µg/l (chronic) and 200µg/l (acute) replaced with ETAS derived PNECs of 3.2 (chronic) and 32µg/l (acute). These PNECs are derived based on identification of a lower toxicity endpoint of 32mg/l for an algal species, but with the same AFs as applied by EDF (an AF of 10,000 for the chronic concentration and an AF of 1,000 for the acute concentration).

Acrylic acid: NNB GenCo (SZC) derived PNECs of 0.34µg/l (chronic) and 1.7µg/l (acute) replaced with ETAS derived PNECs of 0.3µg/l (chronic) and 1.3µg/l (acute). These PNECs are derived based on a slightly lower end point also for an algal species, which is the most sensitive data available when compared to available data for invertebrates and fish. The derivation of the chronic PNEC is based on a 3d EC10 for Selenastrium capricorunutum (green algae) of 0.03mg/l, with the application of an AF of 100. The derivation of the acute PNEC is based on a 3d EC50 for Selenastrium capricorunutum of 0.13mg/l.

As part of our permit determination, we re-ran the H1 risk screening process for the 24-hour and annual scenarios within Table 7 and Table 8 for these 4 substances, using the revised PNECs as advised by ETAS.

We concluded that the 4 substances still pass the H1 screening risk assessment process using the revised PNEC values, and they are therefore considered to be insignificant (and so do not require any additional assessment via modelling).

Annual significant load test for priority hazardous substances (PHSs)

Our guidance also requires that the annual significant load for all priority hazardous substances (PHSs) is assessed, even if the substance has already been screened out by the H1 screening risk assessment process above.

For the operational SZC discharges, the only identified PHSs are cadmium and mercury. Therefore, the annual significant load test only applies to cadmium and mercury from the list of 15 priority hazards substances (PHSs) by the Water Framework Directive (WFD).

Cadmium and mercury are potentially present within the operational SZC cooling water discharge as trace concentrations within the raw materials of process chemicals.

These process chemicals are used within the water treatment processes that generate effluent waste streams B, C and D, F. For example, hydrochloric acid, sulphuric acid and sodium hydroxide all contain trace concentrations of cadmium and mercury. Cadmium and mercury are not dosed directly into any of the SZC on-site water treatment processes.

Significant loads are annual loads which have been set for PHSs. These loads are derived from mass thresholds for similar substances in the European Pollutant Release and Transfer Register (EPRTR).

The annual significant load in a discharge is calculated as follows:

1) Mean discharge quality (μg/l) x mean flow (litres/day) = μg/day (micrograms per day)
2) Result divided by 1,000 = mg/day (milligrams per day)
3) Result then divided by 1,000,000 = kg/day (kilograms per day)
4) Result then multiplied by 365 = kg/year

If the calculated load exceeds the significant load for that substance, the substance has failed the significant load test and is potentially significant. It will then need to be modelled and require a numeric emission limit within any granted permit. If the substance passes the significant load test, the discharge of that substance is not liable to cause pollution, and as stated within our guidance (Environment Agency, 2019), there is no further assessment required via water quality modelling.

The estimated annual and 24-hour load contributions of cadmium and mercury from the raw material chemical use in the operational water treatment systems for SZC are summarised here (based on data and operational experience from EDF's French fleet of nuclear power stations):

- **cadmium:** Annual discharge loading of 0.37kg/year and 24 hour loading 0.005kg/day
- **mercury:** Annual discharge loading of 0.099kg/year and 24 hour loading of 0.0011kg/day

The annual significant load requirements for cadmium and mercury are 5.0kg and 1.0kg respectively. Therefore, the annual (and daily worst case if scaled over a year) meet the annual significant load requirements, and so no additional assessment via detailed water quality modelling is required for cadmium and mercury (as per Table 9 and Table 10). This is based on the data within Table 3.6.5 and Table 3.6.6 of NNB GenCo (SZC)'s Appendix A main SZC operational WDA supporting information report.

Table 9. H1 assessment of cadmium discharges (reproduced from table 3.6.5 in NNB GenCo 2020g; SZC project – Water discharge activity permit application submission Sizewell C and Appendix A)

Discharge scenario	Cadmium discharge loading (kg)	Cooling water flow (m^3/sec)	DC[1] (µg/l)	BC[2] (µg/l)	Discharge load (µg/sec) mean or 95%	DC (µg/l) mean or 95%+ BC	Mean or 95% DC+BC over EQS (%)
Annual	0.37	116	1.0E-04	0.05	11.73	0.05	0.25
24-hour	0.005	66	9.0E-04	0.13	57.87	0.13	0.09

1 DC - Discharge concentration.
2 BC - Background concentration (NNB GenCo, 2019a; TR314).

Table 10. H1 assessment of mercury discharges (reproduced from table 3.6.6 in NNB GenCo 2020g; SZC project – Water discharge activity permit application submission Sizewell C and Appendix A)

Discharge scenario	Mercury discharge loading (kg)	Cooling water flow (m^3/s)	DC (µg/l)	BC[1] (µg/l)	Discharge load (µg/sec) mean or 95%	DC (µg/l) mean or 95%+ BC	Mean or 95% DC+BC over EQS (%)
Annual	0.099	116	2.7E-05	0.02	3.14	0.02[2]	0.29
24-hour	0.0011	66	2.0E-04	0.02	12.73	0.02	0.29

1 BC - background concentration.
2 The mean and 95% background for mercury is same value due to large number of less than detection values in the dataset (these were set to face value detection limit).

Outcome of the H1 risk assessment process

We agree with the chemical H1 risk assessment screening approach NNB GenCo (SZC) completed, and the majority of the EQS/PNEC values applied. Where there is no EQS, PNECs have been applied. Following our review, we did not agree with 4 of the PNECS applied, which are for ethanolamine, acetic acid, phosphoric acid and acrylic acid. We therefore proposed and assessed alternative PNEC values as advised by ETAS.

However, using these revised PNECs, these 4 substances all still screen out from requiring further modelling, following the process specified in TR193 section 10.1 to 10.4 (NNB GenCo, 2021a).

Following on from the H1 screening risk assessment process, the following 3 chemicals require further consideration via modelling to determine the environmental acceptability of the mixing zones created by their discharge:

- chlorine as total residual oxidant(TRO) present within waste stream A
- bromoform present within waste stream A due to use of chlorine
- hydrazine present within waste streams B/C and D

TRO originates from the combination of chlorine and organic material during chlorination of the cooling water system. Chlorination deters settling of biofouling organisms and is only anticipated to be needed continuously when temperatures are 10°C or higher, although spot chlorination (short-duration chlorination) may occur outside of this temperature range (NNB GenCo, 2021b; information report for the HRA, see also Table 11 for monthly mean sea temperatures). For protection of the marine environment, chlorine has a maximum allowable concentration (MAC) EQS expressed as a 95th percentile (as TRO) of 10 micrograms per litre (µg/l) for discharges to transitional and coastal (TRaC) waters (Environment Agency, 2019).

NNB GenCo (SZC) has modelled the TRO resulting from the combination of chlorine and organic material in the abstracted seawater, based on laboratory testing of seawater at Sizewell (NNB GenCo, 2019b; TR303; section 6.2.2).

Due to the site-specific water chemistry at Sizewell, bromoform is the predominant chlorinated by-product (CBP). Since bromoform is a product of chlorination, the same modelling scenarios were considered as those used for TRO.

There is no published EQS for bromoform, so NNB GenCo (SZC) proposed a calculated PNEC of 5.0µg/l as a 95th percentile. The amount of bromoform that is discharged mainly depends on the amount of chlorine that is added, but also on the amount of mixing at the cooling water outlets. NNB GenCo (SZC)’s modelling of bromoform discharges is described further in sections 4.11.7 and 4.11.9.

Hydrazine is an oxygen scavenger used in power plants to inhibit corrosion in steam generation circuits, and NNB GenCo (SZC) proposes to use hydrazine at SZC. Liquid effluent containing residual hydrazine concentrations will be generated from the site’s boiler cooling water circuits to control pH and prevent corrosion (present within SZC’s waste streams B and C combined, and D). This effluent will be released periodically (also known as a ‘batched’ discharge) to the environment via the main cooling water stream (waste stream A) and its 2 long sea outlets.

There is evidence that hydrazine is harmful to aquatic organisms at low concentrations, with a low to moderate persistence within the marine environment, depending on its concentration and the receiving water quality. There is no established EQS for hydrazine, so NNB GenCo (SZC) proposed a chronic PNEC of 0.4 nanograms per litre (ng/l) for long-term effects (calculated as the mean of the concentration values), and an acute PNEC of 4.0ng/l for short-term effects (represented by the 95th percentile) (NNB GenCo, 2021b; information report for the HRA). NNB GenCo (SZC)’s modelling of hydrazine discharges is described further in section 4.11.10.

These water quality impacts are covered in additional detail in NNB GenCo (SZC)’s ‘Marine water quality and sediment synthesis report’ (NNB GenCo, 2020b; TR306).

4.11.5 Thermal plume modelling

SZC’s 2 cooling water system (CWS) outlets will create a thermal plume due to the abstracted seawater being discharged back to the Greater Sizewell Bay at a higher temperature from the power station than the surrounding receiving seawater.

NNB GenCo (SZC) modelled the thermal plume from SZC using the validated Sizewell General Estuarine Transport Model (GETM); full details of the model and detailed thermal plume maps are presented in TR302 (NNB GenCo, 2020a), with a summary of the model provided within TR306 (NNB GenCo, 2020b).

In the Sizewell Stage 1 modelling (TR132 and TR229), the setup of 2 different plume models (GETM and Delft 3D) was described, and the simulated SZB cooling water discharge was validated against observations (NNB GenCo, 2020a; TR302).

Stage 2 modelling within TR133 and TR230 used the validated models to test initial cooling water discharge configurations for the proposed SZC power station. The Stage 2a review (NNB GenCo, 2014a; TR301) critically reviewed the performance of these models, and selected the GETM model as the primary tool for assessing thermal plume effects, as it was shown to produce the most accurate predictions and also to be the most conservative.

An extended set of options for selecting the SZC cooling water outfall locations were then analysed, and a preferred location identified on the basis of recirculation and environmental concerns.

Location O9 offshore of the Sizewell-Dunwich Bank (the furthest west that a SZC CW outfall could be built) was identified for 2 cooling water outfalls (O9a and O9b), with offshore cooling water intakes (2 intakes required per UK EPR™ unit) at locations I3 and I4 (Figure 2).

At I3 and I4, 3 location options were then identified (I3a, b and c, and I4a, b and c), with I3a and I3b, and I4a and I4b selected as the preferred options for the cooling water intakes (NNB GenCo, 2020a; TR302), with I3c and I4c as reserve location options (NNB GenCo, 2014a; TR301). The locations of O9a, O9b, I3a to I3c, and I4a to I4c (Figure 2).

The GETM is a 3-dimensional hydrodynamic model used for simulating water movement in the marine environment. Within the model, the sea is divided into a 3-dimensional grid, with cells extending across the surface, and vertically down to the seabed.

This model uses parameters to simulate the physical, chemical, and biological properties of water, and the interactions between these, within each cell over a period of time, with the sum of these results describing patterns throughout the whole of the coastal zone that is modelled. Calculations are performed for very small time steps (less than one minute) with the models' output summarised for each hour, or for longer periods of time such as a season, or a full year.

The GETM model has been calibrated and validated for the zone of influence (ZoI) of the proposed SZC power station. The model was set up and run for a year following our modelling guidelines. The year was selected by examining the inshore temperature network data managed by Cefas for Sizewell. 2009 was chosen to be modelled because, in relation to temperature, it was an average year (NNB GenCo, 2020a; TR302), with the mean annual temperature in 2009 the same as the mean annual temperature from 2003 to 2012. This is in line with our guidance which suggests that the modelling year should be representative of the last 10 years.

Additionally, the availability of boundary forcing elevation data and meteorological forcing data were also primary considerations for selecting 2009; these data were available for 2009 by mid-2010 (NNB GenCo, 2020a; TR302). An oceanography field programme to collect calibration data for currents and tides was undertaken at Sizewell in September 2008 and a further thermal plume validation exercise in 2009, with these separate calibration and validation studies enabling estimates of the accuracy of the model to be determined (NNB GenCo, 2020a; TR302).

We have accepted the SZC GETM model as fit for purpose for its intended use in calculating both the thermal and chemical plumes (TRO, bromoform and hydrazine) from the SZC power station. In the SZC Marine Technical Forum, Environment Agency BEEMS Review (Period 1), our comments of 18 September 2014 note that we consider both the Delft 3D and GETM models fit for purpose for their intended use.

4.11.6 Assessment of thermal plume

There are 2 thermal changes that need considering in terms of the Habitats Directive and Water Framework Directive requirements. These are absolute water temperature and thermal uplift. For consideration and assessment under Water Framework Directive (WFD) requirements, UKTAG (2008) recommends that the maximum temperatures at the edge of the mixing zone should not exceed 23°C, and that outside of the mixing zone, temperature rises above ambient should be limited to 3°C uplift.

Our full assessment of these standards is provided in greater detail for Habitats Directive requirements within our SZC operational WDA's habitats regulations assessment report (HRAR), and for Water Framework Directive (WFD) compliance within our SZC operational WDA's WFD assessment report. These are available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space

Absolute water temperature refers to the temperature of the sea as it could be measured with a thermometer. Thermal uplift is the degree to which the sea temperature has been increased above what it would otherwise be as a result of the discharge of heated water from the power station's cooling water system (CWS).

For example, when SZC is operational, temperature at the sea surface near to the CWS discharge point might be measured as 15°C; this would be the absolute temperature. Without the influence of the cooling water discharge, the surface temperature might otherwise have been 13°C, in which case the surface water would be experiencing a 2°C thermal uplift.

Absolute water temperature

While the Habitats Directive has no specific temperature requirements, the UK Technical Advisory Group (UKTAG) on Water Quality for the Water Framework Directive (WFD) recommended temperature thresholds as trigger values for assessing the impact of thermal discharges on SPAs and SACs (WQTAG sub-group, 2006).

For SPAs, WQTAG sub-group (2006) includes a maximum temperature of 28°C as a 98th percentile at the edge of the mixing zone. The threshold of 28°C as a 98th percentile means that, within the mixing zone, sea surface temperatures will exceed 28°C for 2% or more of a year. The mixing zone is the area around a discharge within which a regulator can permit a quality standard to be exceeded.

For SACs, WQTAG sub-group (2006) includes a maximum temperature threshold of 21.5°C as a 98^{th} percentile at the edge of the mixing zone. However, this threshold is set to protect salmonid fish, considered the most sensitive organisms to thermal impacts (WQTAG sub-group, 2006) and is therefore not appropriate for use in examining impacts on sites in the Greater Sizewell Bay (GSB).

The WFD also has no formal, specific temperature requirements for the assessment of thermal impacts, including barriers to fish movement (known as occlusion).

We can implement the freshwater UKTAG (WFD) standards for ‘good’ status for cold water to define the extent of the mixing zones for thermal discharges into TraC waters in relation to WFD requirements. UKTAG (2008) recommends interim thermal standards that maximum (absolute) temperatures at the edge of the mixing zone should not exceed 23°C as an annual 98th percentile (that is, they should not be exceeded for more than 2% of the time) allowed at the edge of the mixing zone, and that outside of the mixing zone, temperature rises above ambient should be limited to 3°C uplift.

WQTAG160 states that where a site is designated as both an SPA and SAC, then the most stringent temperature threshold should be applied for any assessment in relation to Habitats Regulations requirements.

However, for consideration of the operational SZC cooling water discharge’s thermal plume, the SAC absolute water temperature criteria were not applied for consideration of the southern North Sea SAC (designated for harbour porpoise). Instead, the SPA threshold of 28ºC (as a 98th percentile) was applied for marine mammal sensitivity assessments (NNB GenCo, 2020b; TR306).

This is because salmonid fish species are not designed features of the European marine site (EMS) within the zone of influence (ZoI) of the SZC thermal plume, and because the Southern North Sea SAC (located directly adjacent to the proposed operational SZC site) is designated for harbour porpoise; these are a highly mobile species and are not predicted to be adversely affected by thermal discharges (NNB GenCo, 2020h; TR483).

As the abstracted seawater passes through the SZC operational CWS, it will experience a thermal uplift of 11.15°C (EDF, 2020b; TR306). Sea temperatures at Sizewell B (SZB) peak in August at around 19.0°C, with the monthly mean sea temperature for 2009 being 19.8°C (2009 was the year for which the GETM model was run) (Table 11). With a sea temperature of 19.8°C, the cooling water would reach a maximum temperature of 30.95°C as it passed through the system.

Table 11. Monthly mean sea temperatures (°C) at SZB power station. Source: Cefas Inshore Temperature Network (data reproduced from Table 8 in NNB GenCo, 2020a; TR302).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2009	4.9	4.4	6.3	9.4	12.7	16.2	18.6	19.8	17.4	13.8	11.6	7.9	11.9
1967-2012 mean	5.9	5.4	6.1	8.4	11.5	15.1	18.0	19.0	17.7	14.8	11.3	7.8	11.8
2002-2012 mean	6.8	6.3	6.1	8.5	11.5	15.1	18.0	19.0	17.7	14.8	11.3	7.8	11.9

Under baseline conditions (when SZB is operating alone), the sea surface will not be exposed to temperatures in excess of 28°C as a 98th percentile (NNB GenCo, 2020b; TR306). Similarly, when SZC is operating alone, the sea surface will not be exposed to temperatures in excess of 28°C as a 98th percentile (Table 21 in EDF, 2020b; TR306).

When SZC and SZB are operating in combination, 0.11ha (0.0011km²) of the sea surface will be exposed to temperatures in excess of 28°C as a 98th percentile (Table 21 in NNB GenCo, 2020b; TR306). However, at the immediate point of discharge, the maximum predicted temperatures at the surface will not exceed 8°C above ambient (NNB GenCo, 2021j, via response to Schedule 5 No.5).

During SZC power station maintenance scenarios, 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. However, the warmer plume loses heat faster to the atmosphere, which reduces the size of the excess temperature plume compared to that arising during normal operation. 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, as referenced within NNB GenCo (SZC)'s main WDA application supporting information document (NNB GenCo, 2020g) and our Water Framework Directive compliance assessment review report.

Thermal uplift

The Habitats Directive/Regulations have no specific water temperature requirements. However, WQTAG sub-group (2006) recommended temperature thresholds for assessing the impact of thermal discharges on SPAs and SACs, which included a 2°C deviation from ambient as a maximum allowable concentration (MAC) at the edge of the mixing zone, as a 100th percentile. The annual 100th percentile plume describes the area within which thermal uplift greater than the specified value is exceeded at any point during the year. Thermal uplift of 2°C is not considered to have any link to specific ecological effects, but serves as a precautionary threshold to trigger further investigation (NNB GenCo, 2021b).

NNB GenCo (SZC)'s GETM model predicts that the surface area of the annual 2°C (100th percentile) thermal uplift plume from SZC alone would be 16,775ha (167.75km²) at the surface and 12,244ha (122.44km²) at the seabed (NNB GenCo, 2021b; information report for the HRA).

The surface extent of this plume is equivalent to 4.27% of the 392,450ha (3,924.5km²) total surface area of the Outer Thames Estuary SPA and 0.45% of the 3,695,100ha (36,951km²) Southern North Sea SAC, into both of which it directly discharges.

The area within the annual ≥2°C thermal uplift (100th percentile) plume includes any model cell in the GETM for which ≥2°C thermal uplift is experienced at any point during the year, regardless of the duration of the exceedance.

For example, a cell experiencing ≥2°C thermal uplift for one hour out of the whole year would be within the plume. Having established that there would be exceedance of the annual ≥2°C thermal uplift (as a 100th percentile) threshold as a result of the cooling water system discharge of SZC alone, NNB GenCo (SZC) investigated further by using its GETM to predict annual thermal uplift plumes, as 98th percentiles (Figure 7). The annual 98th percentile plume describes the area within which thermal uplift, greater than the specified value, is exceeded for at least 2% of the time steps modelled. Outside of the annual 98th percentile plume, thermal uplift is less than the specified value for 98%, or more, of the time steps modelled.

The area of the annual ≥2°C thermal uplift plume (as a 98th percentile) is 1,551ha (15.5km²) at the sea surface for SZC alone, as compared to the 16,775ha (167.75km²) of the equivalent 100th percentile plume (Figure 7) (data from Tables 21 and 23 in NNB GenCo, 2020b; TR306). 1,551ha is equivalent to 0.40% of the Outer Thames Estuary SPA, and 0.04% of the Southern North Sea SAC for SZC alone.

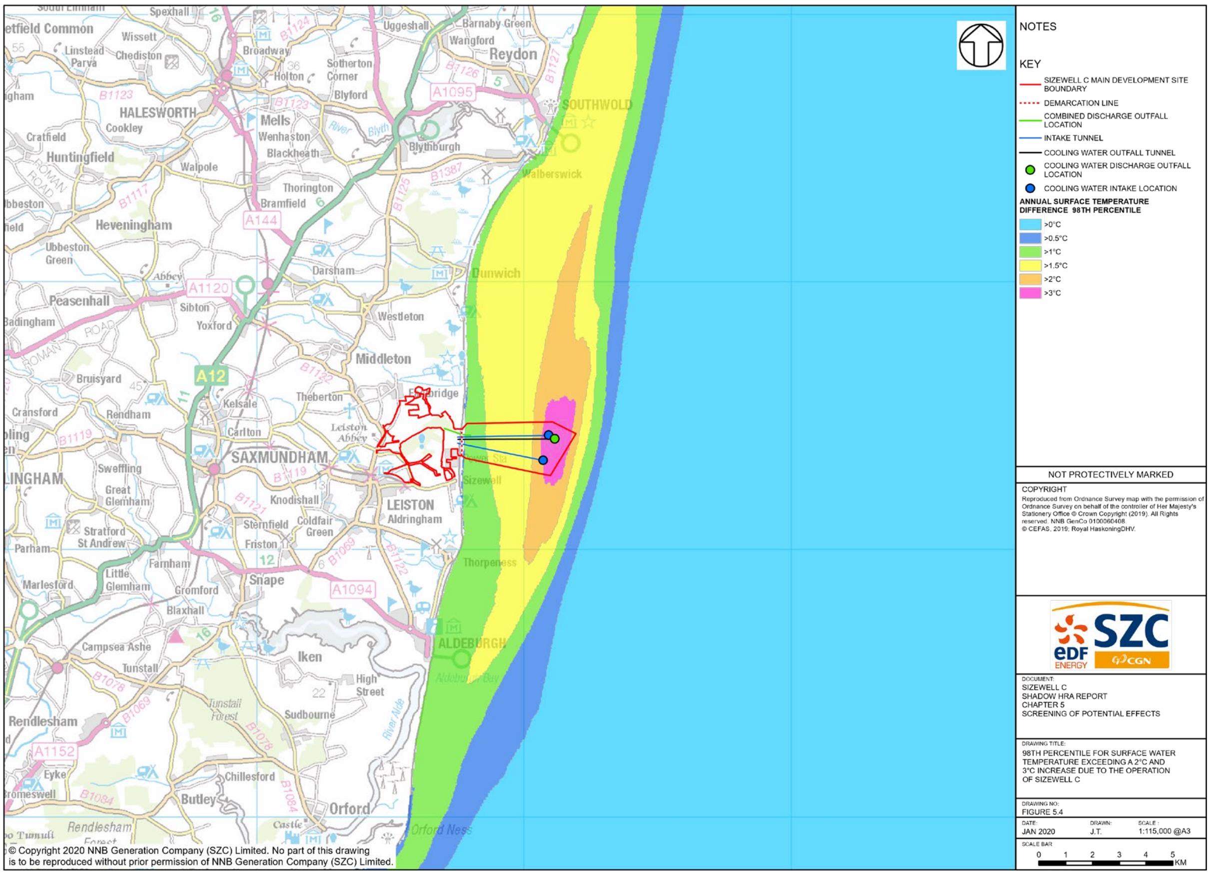

Figure 7. Annual thermal uplift (98th percentile) plumes for SZC. Reproduced from Figure 5.4 in NNB GenCo, 2021b; information report for the HRA.

Although this application is for an operational discharge from SZC, there is an existing thermal plume from SZB (operational since 1995) the assessment of effects from the thermal plume has also been undertaken with SZC and SZB; the water temperature increase caused by the SZB thermal plume forms part of the baseline. However, there is a synergistic effect at the interface between the SZB and SZC plume, meaning that the area of thermal uplift plumes for SZC and SZB in combination may be greater than the sum of the areas of the SZC alone and SZB alone thermal uplift plumes (Figure 8).

The area of the annual ≥2°C thermal uplift plume (as a 98th percentile) at the sea surface is 7,899ha (79.0km²) for SZC and SZB in combination (data from Table 23 in NNB GenCo, 2020b; TR306). This is equivalent to 2.01% of the Outer Thames Estuary SPA and 0.21% of the Southern North Sea SAC for SZC and SZB in combination.

Under the baseline condition of SZB alone, the area of the annual ≥2°C thermal uplift plume (as a 98th percentile) at the sea surface is 2,433ha (24.3km²) (data from Table 23 in NNB GenCo, 2020b; TR306), which is equivalent to 0.62% of the Outer Thames Estuary SPA and 0.07% of the Southern North Sea SAC.

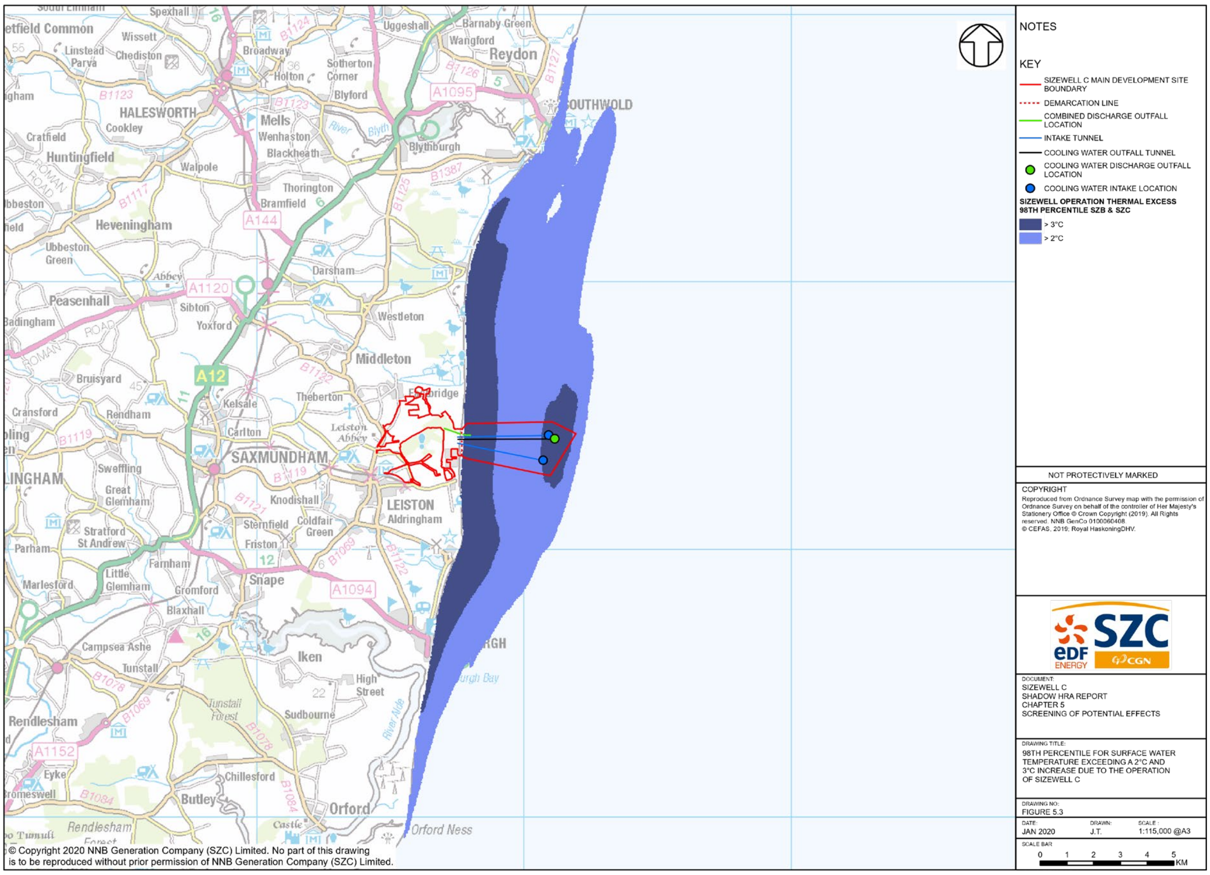

Figure 8. Annual thermal uplift (98th percentile) plumes for SZB+SZC in combination. Reproduced from figure 5.3 in NNB GenCo (2021b; information report for the HRA)

The Water Framework Directive/Regulations also have no formal, specific temperature requirements for the assessment of thermal impacts, including barriers to fish movement (known as occlusion). UKTAG (2008) recommends interim thermal standards that annual maximum uplift (as a 98%ile) for ‘good’ status of 2ºC < Uplift ≤ 3ºC.

During normal operation, these thermal standards are not predicted to be exceeded at either the seabed (Figure 9) or surface (Figure 10) when the discharge from SZC alone is modelled, as there is no interaction between the SZC thermal plume and the Suffolk coastal WFD water body).

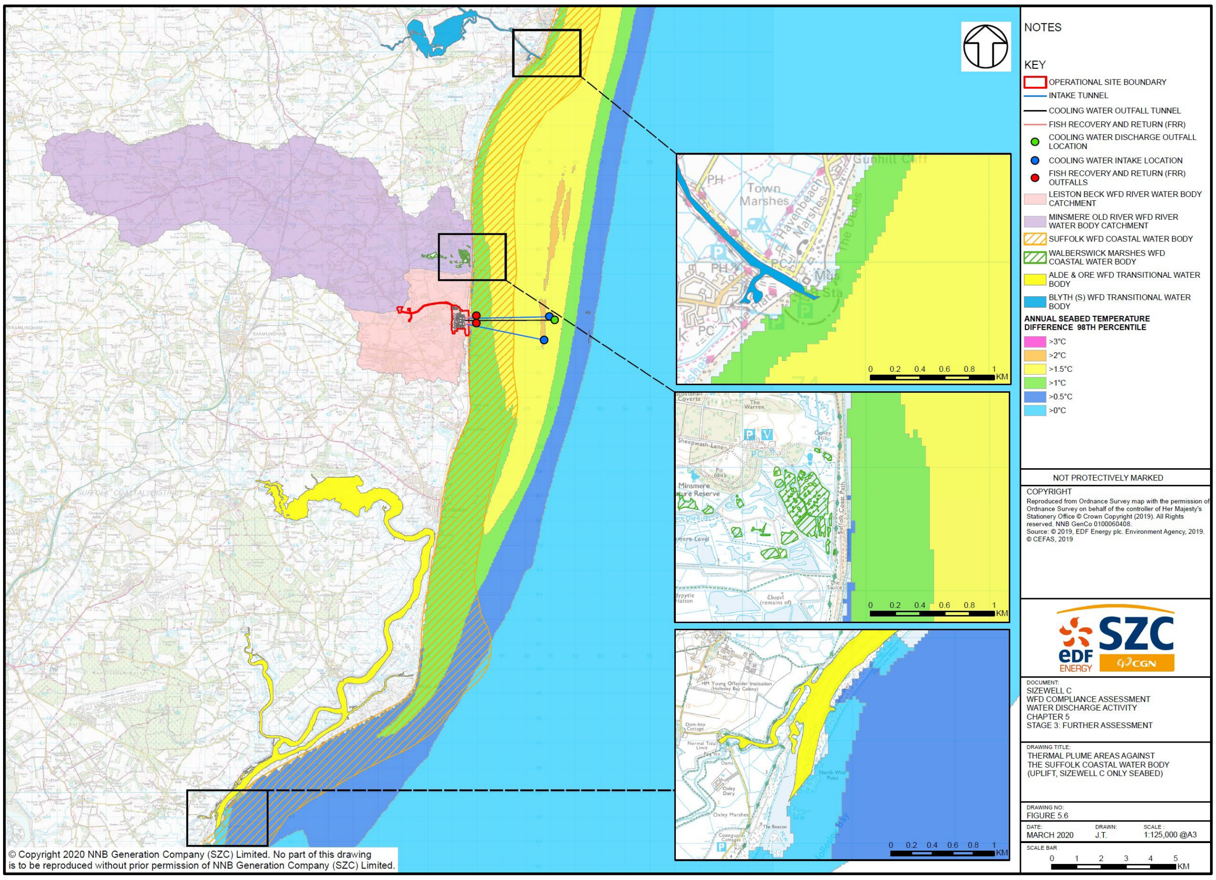

Figure 9. Thermal plume uplift areas at the seabed from SZC alone against the Suffolk coastal water body. Reproduced from figure 5.6 in NNB GenCo, 2021k; Appendix D – WFD compliance assessment report.

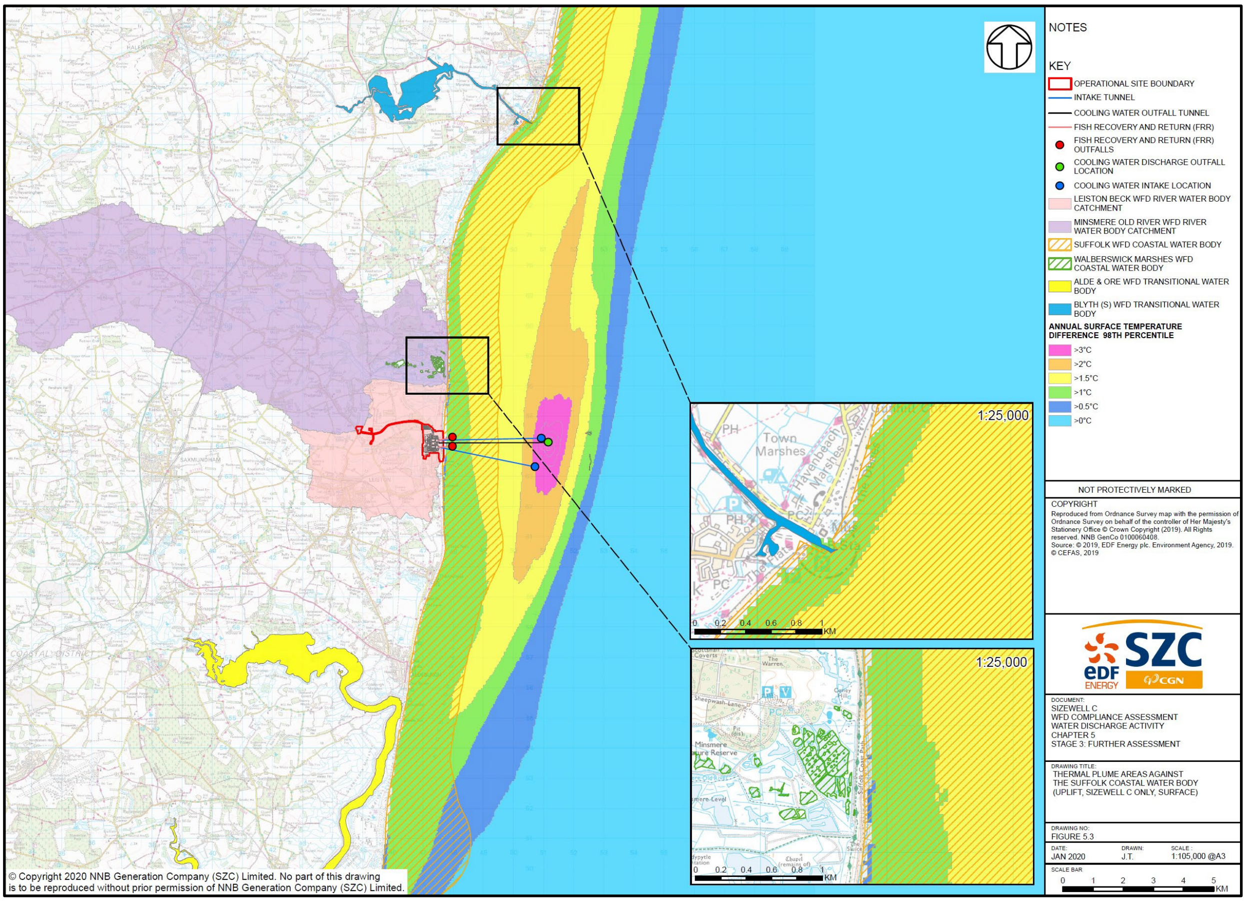

Figure 10. Thermal plume uplift areas at the surface from SZC alone against the Suffolk coastal water body. Reproduced from figure 5.3 in NNB GenCo, 2021k; Appendix D – WFD compliance assessment report.

However, the uplift thermal standards are predicted to be exceeded while SZB and SZC are both operating, as the modelled mixing zone is 26% (an area of 3,758 hectares) of the Suffolk coastal WFD water body at the seabed (Figure 11) and 28% (an area of 4,123 hectares) of the Suffolk coastal WFD water body at the surface (Figure 12).

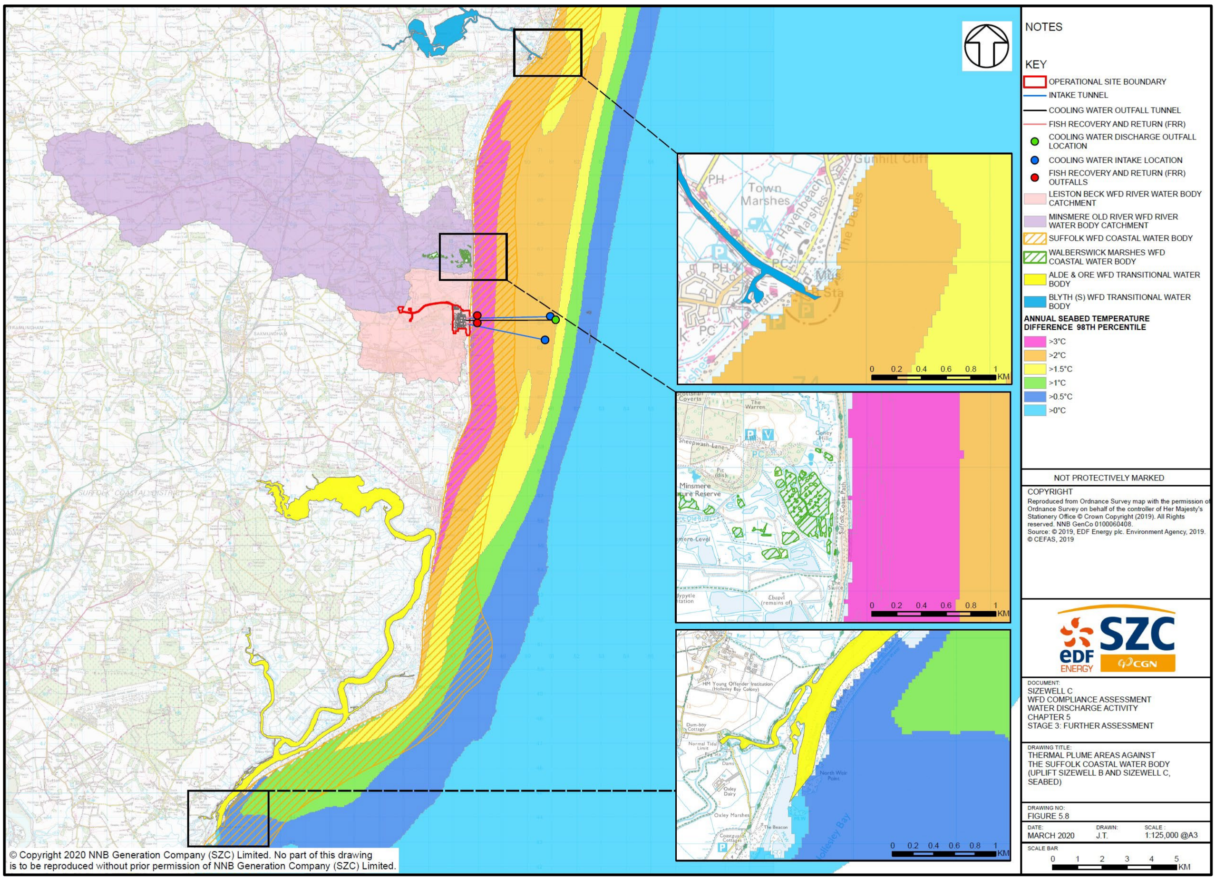

Figure 11. Thermal plume uplift areas at the seabed for operation of SZC and SZB against the Suffolk coastal water body. Reproduced from figure 5.8 in NNB GenCo, 2021k; Appendix D – WFD compliance assessment report.

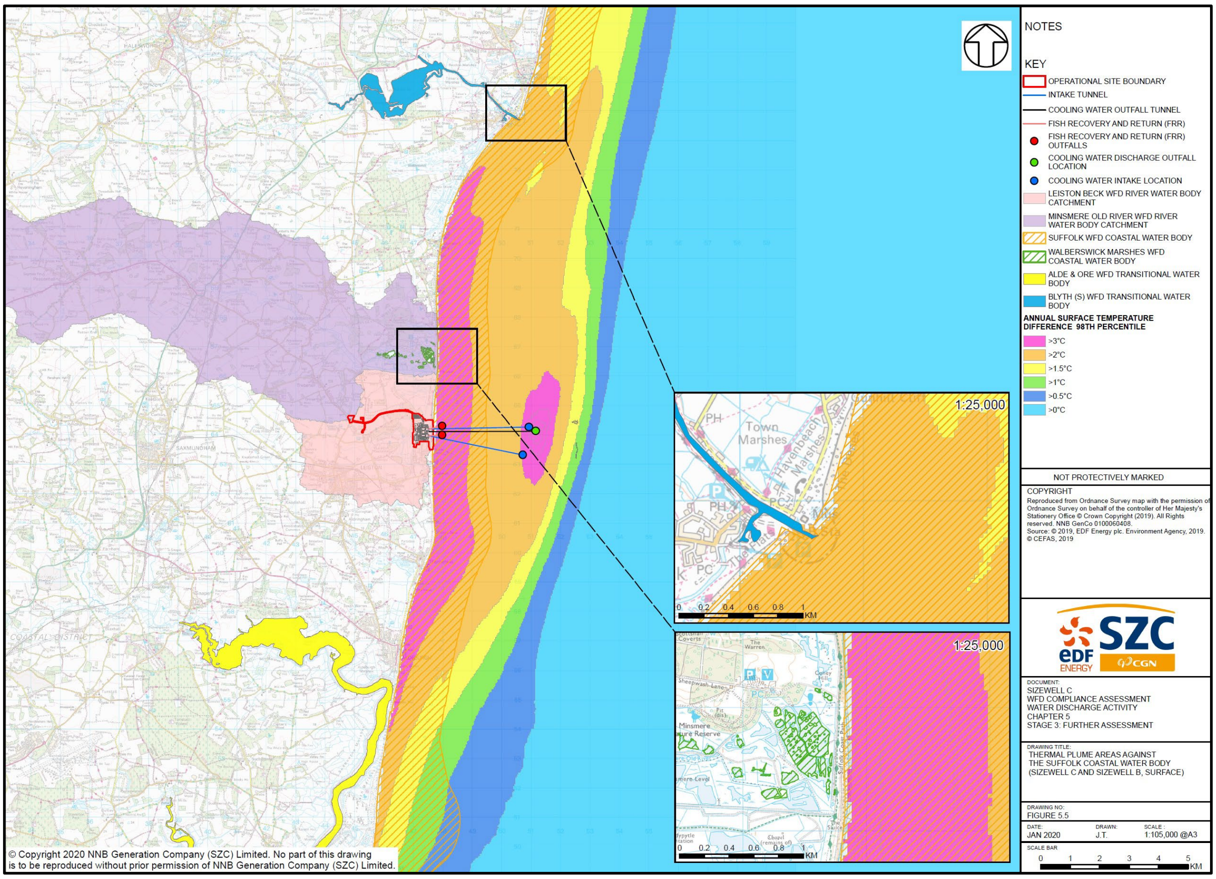

Figure 12. Thermal plume uplift areas at the surface for operation of SZC and SZB against the Suffolk coastal water body. Reproduced from figure 5.5 in NNB GenCo, 2021k; Appendix D – WFD compliance assessment report.

The significance of the seabed and sea surface area mixing zone/plumes for temperature are fully assessed in specific detail in relation to the Habitats Directive and Water Framework Directive requirements via our WDA HRA report (HRAR) book 3 and our review of the WFD compliance assessment report, available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space

4.11.7 Chemical plume modelling - Setup

Bespoke computer modelling is required to assess the potential environmental impact of the operational SZC discharges of TRO, bromoform and hydrazine. If the concentration of a hazardous chemical or hazardous substance exceeds the relevant EQS (annual average and/or MAC or percentile standard) or PNEC (chronic and/or acute) once diluted within the cooling water flow, then a mixing zone will be created at the point of discharge; this being the area within which the environmental standard is exceeded.

NNB GenCo (SZC) has (2019b; TR303) defined mixing zones for TRO, bromoform and hydrazine using the same GETM model as for the thermal plume studies (NNB GenCo, 2014a; TR301 and, 2020a; TR302).

The GETM is a 3-dimensional hydrodynamic model used for simulating water moments in the marine environment. Within the model, the sea is divided into a 3-dimensional grid, with cells extending across the surface, and vertically down to the seabed. The model uses parameters to simulate the physical, chemical and biological properties of water, and the interactions between these, within each cell over a period of time, with the sum of these results describing patterns throughout the whole of the coastal zone that is modelled. Calculations are performed for very small time steps (less than one minute), with the models' output summarised for longer periods of time.

The potential effects of the chemical plume are on the local biology, and so NNB GenCo (SZC)'s modelling studies have focused on the period of the year of highest biological productivity. Chemical discharges were modelled for one month only because the dispersion of chemical discharges is related to the hydrodynamics of the spring neap tidal cycle, which does not change significantly with each month.

May was chosen as it has the highest phytoplankton growth, which drives the whole marine ecosystem. One of the effects investigated was chlorination of the cooling water system (CWS) to deter settling of biofouling organisms. Control measures will need to be applied during May as it coincides with mussel spawning and larval dispersion (NNB GenCo, 2019b; TR303).

4.11.8 Assessment of chlorine as total residual oxidant (TRO)

Chlorine is commonly applied to prevent biofouling of cooling water infrastructure. Due to the known biofouling risk from historic operation of the existing power stations at Sizewell A (SZA) and Sizewell B (SZB), chlorination of the SZC cooling water system (waste stream A) will be required to maintain control of biofouling risks to its cooling water infrastructure and other critical plant.

NNB GenCo (SZC)'s operational policy is to continuously dose with chlorine during the growing season (when seawater temperature exceeds 10ºC) to achieve a minimum TRO dose (within the required cooling water infrastructure and condenser inlets) of 0.2 milligrams per litre (mg/l) (NNB GenCo, 2021c; TR316). This TRO concentration will be achieved by injecting 0.5mg/l of active chlorine (sodium hypochlorite), applied sequentially once every 30 minutes per cooling water channel. The resulting TRO concentration discharged to the seawater of the Greater Sizewell Bay via the 2 cooling water outlets would therefore be 0.15mg/l.

NNB GenCo (SZC) has confirmed that chlorination of the required cooling water infrastructure will not be applied before the SZC drum or band screens, and that the flushing water used to improve flow in the 2 fish recovery and return (FRR) systems' fish gutters (located after the drum screens) will not be chlorinated. Therefore, waste stream H will not be chlorinated, and so the 2 FRR outlets will not discharge sources of TRO into the Greater Sizewell Bay.

The TRO predicted to result from the combination of chlorine and organic material in the seawater at SZC were modelled using an empirical demand/decay formulation derived from experiments with Sizewell seawater coupled into the GETM Sizewell model (NNB GenCo, 2014b; TR143).

For TRO, the area exceeding the EQS of 10µg/l TRO (as a 95th percentile) is approximately 2.0ha (0.02km²) at the seabed and 337ha (3.37km²) at the sea surface (Table 12).

The cooling water discharge from SZC will be directly into 2 European sites via the 2 cooling water outlets, the Outer Thames Estuary SPA (covering an area of 3,924km²) and the Southern North Sea SAC (covering an area of 36,951km²).

Although this application is for an operational discharge from SZC, there is an existing TRO plume from SZB (operational since 1995) and so, where appropriate, our HRA and WFD review assessments of effects will also consider the area of TRO exceedance when SZC and SZB are both operating. There are no sources of TRO from SZA as this power station is no longer operational and is undergoing decommissioning.

For SZC, TRO exceedances are located offshore due to the location of the CW outlets, and do not come into contact with either the Suffolk coast, or the TRO exceedance plume for the operational discharges at SZB (Figure 13). Unlike the situation for thermal uplift, there is no synergistic effect between the TRO exceedance plumes of SZC and SZB (Figure 14).

For SZC alone, the offshore 337ha (3.37km²) surface TRO exceedance plume corresponds to 0.09% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 12 and Figure 13)

When SZC and SZB are both operating, 726ha (7.3km²) of the sea surface exceeds the TRO EQS, corresponding to 0.10% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 12). However, the total area of exceedance will comprise of two separate plumes (Figure 14).

For SZB alone, the nearshore 388ha (3.9km²) surface TRO exceedance plume corresponds to 0.10% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 12).

Table 12. The total surface area of TRO exceedance for SZC alone, SZB alone, and SZC+SZB in combination. Data from Table 25 in NNB GenCo (2020b; TR306) and Table 9 of NNB GenCo (2019b; TR303).

Scenario	Area TRO ≥ EQS 10µg/l (95th percentile) plume on the seabed	Area of TRO ≥ EQS 10µg/l (95th percentile) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924km²)	Area of surface plume as a % of Southern North Sea SAC (36,951km²)
SZC alone	2.13ha (0.02km²)	337.56ha (3.4km²)	0.09%	0.01%

SZB alone	164.95 (1.64km²)	388.56ha (3.9km²)	0.10%	0.01%
SZC+SZB in combination	167.08 (1.76km²)	726.21ha (7.3km²)	0.19%	0.02%

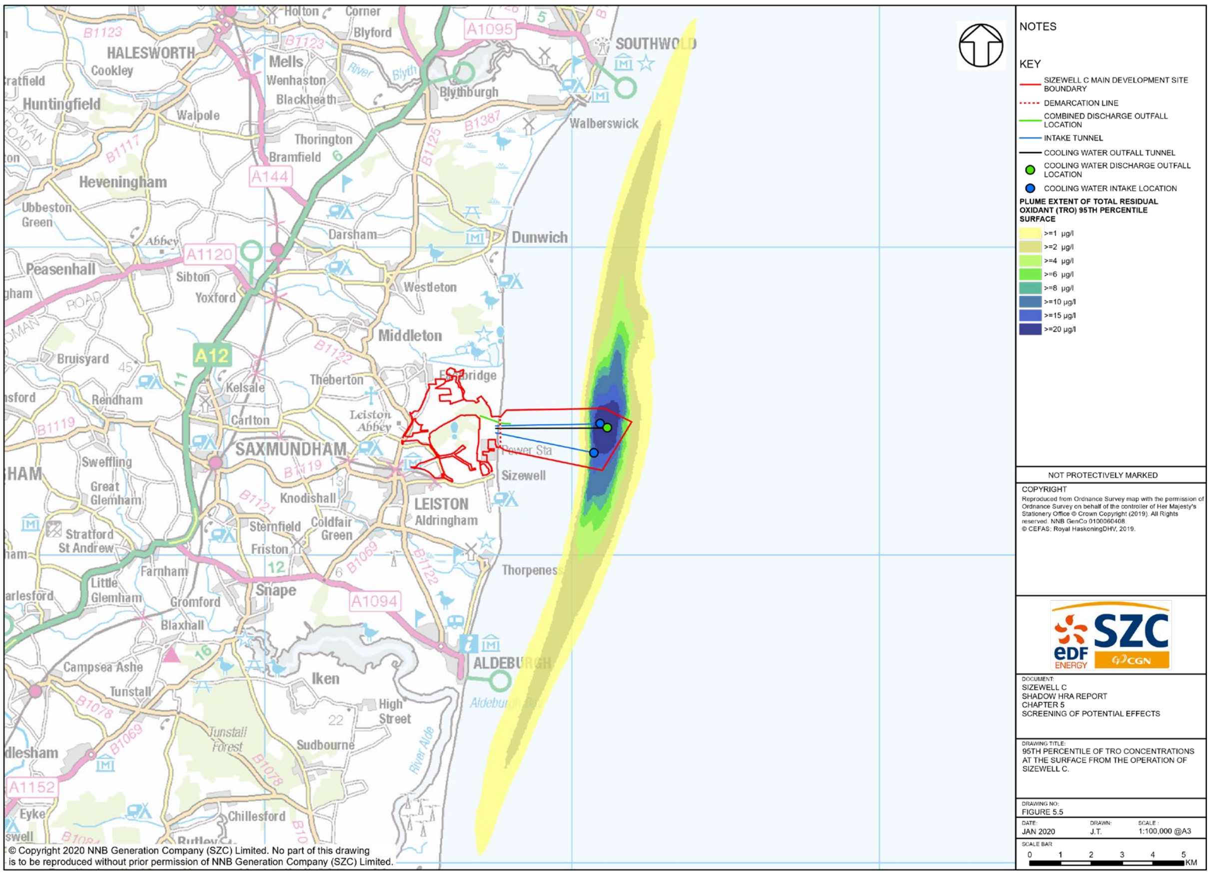

Figure 13. NNB GenCo (SZC)'s modelling of surface TRO concentrations (as 95th percentiles) for SZC alone. Map reproduced from Figure 5.5 of NNB GenCo (2021b; information report for the HRA)

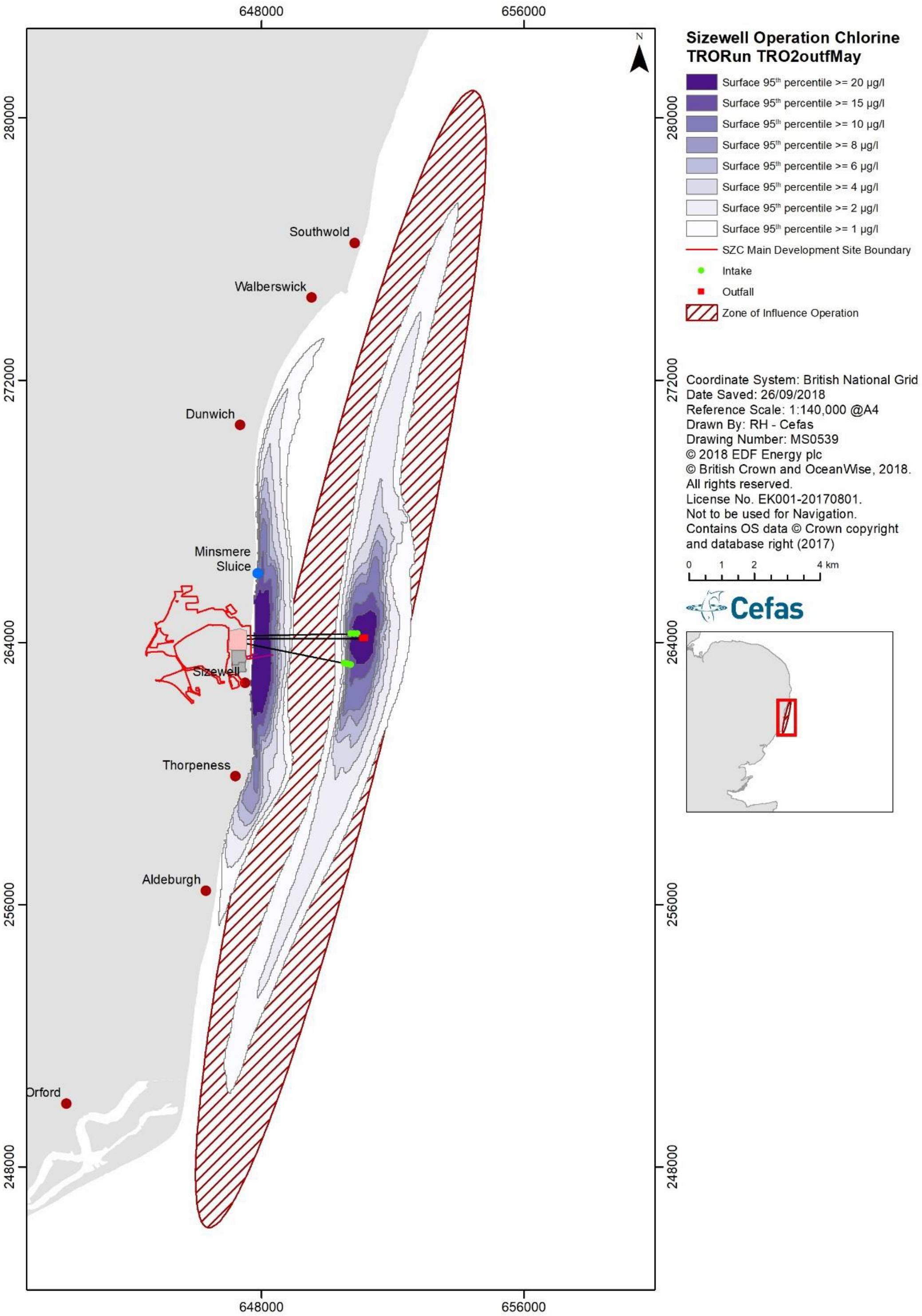

Figure 14. NNB GenCo (SZC)'s modelling of surface TRO concentrations (as 95th percentiles) when SZC and SZB are both operating. The hatched area shows the outer tidal excursion. Map reproduced from Figure 10 in EDF (2021a; TR193).

From a Water Framework Directive perspective, the results of the TRO modelling show that there would be no interaction between the TRO plume and the Suffolk coastal water body, as demonstrated in Figure 15.

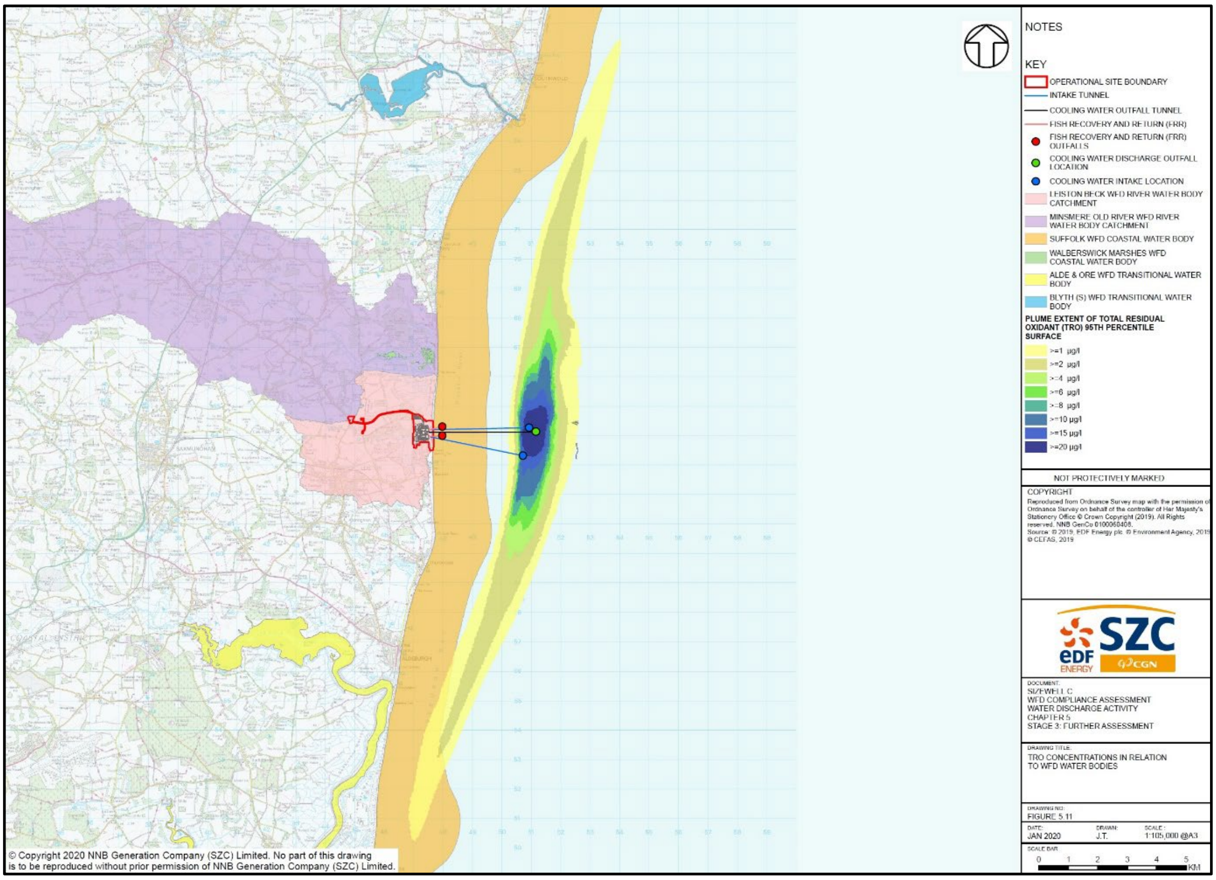

Figure 15. TRO concentrations in relation to WFD water bodies. The TRO plume areas at the EQS (10µgl/1 as a 95th percentile) in the Suffolk coastal water body have been calculated and show that there is no interaction between the Sizewell C TRO plume (above the EQS) and the Suffolk coastal water body. Reproduced from Figure 5.11 in NNB GenCo, 2021k (Appendix D - WFD compliance assessment report)

The significance of the seabed and sea surface area mixing zone/plumes for TRO are fully assessed in specific detail in relation to the Habitats Directive and Water Framework Directive via our WDA HRA report (HRAR) Book 3 and our review of the WFD compliance assessment report (and as summarised within sections 4.12 and 4.14 of this consultation document).

4.11.9 Chlorinated by-products (CBP): Bromoform

In addition to TRO, chlorination of seawater results in chlorination by-products (CBPs), due to the result of complex chemical reactions in seawater. The number and type of CBPs formed are site-specific, being dependent on the composition and physical parameters of the seawater, with losses from the marine environment occurring largely via volatilisation to the atmosphere.

Bromoform was found to be the most dominant of those CBPs detected in laboratory simulations using seawater from Sizewell, as the amount of bromoform discharged is mainly dependent on the amount of chlorine added, as well as the amount of mixing that occurs (NNB GenCo, 2020b; TR306).

As there is no EQS for bromoform, NNB GenCo (SZC) used a derived PNEC of 5.0µg/l (calculated as a 95th percentile) for its modelling assessment.

The PNEC for bromoform was considered by our ecotoxicology advisory service (ETAS) who confirmed that the derivation of the PNEC was in line with the available ecotoxicology data, and that the assessment factors (AFs) used to derive the PNEC were also appropriate.

The PNEC value is also consistent with that used in determining the HPC operational WDA permit application (reference EPR/HP3228XT, granted on 13/03/2013).

NNB GenCo (SZC)'s modelling shows that like the TRO plume, the bromoform plume from SZC is a long, narrow feature parallel to the Suffolk coast (Figure 16).

As with the TRO exceedance plumes, there is no interaction between the bromoform plumes of SZC and SZB when both stations are operating, with the SZB plume remaining inshore of the Sizewell-Dunwich Bank and the SZC plume being outside of the Bank (Figure 17).

Both SZC and SZB plumes are strongly stratified with larger areas at the surface than at the seabed. The SZC plume, as modelled, is generally smaller and narrower than that resulting from SZB, which is due to the lower initial discharge concentration and greater water depth at the 2 SZC outlet locations (17m water depth vs. 5.1m water depth for SZB's single outlet).

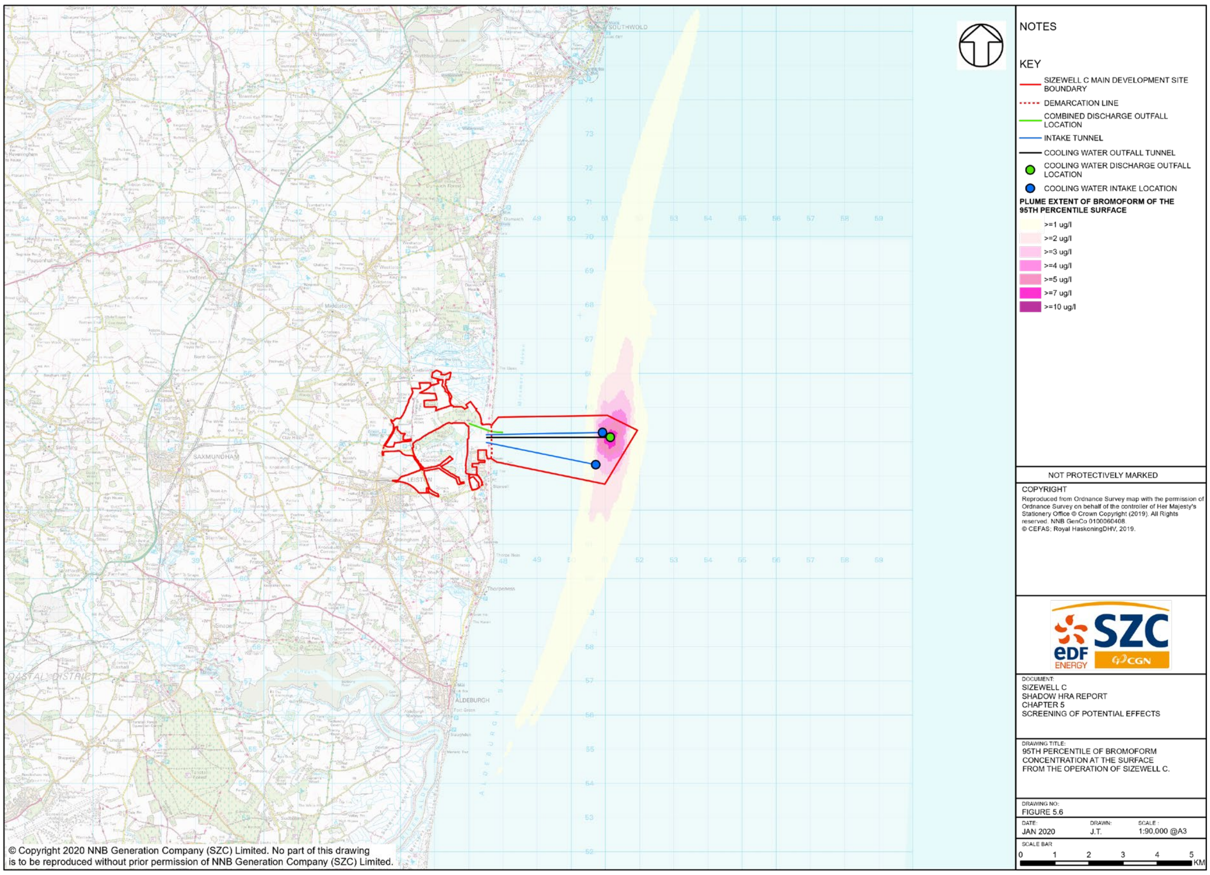

Figure 16. **NNB GenCo (SZC)'s modelling of surface bromoform concentrations (as 95th percentiles) for SZC alone. Map reproduced from Figure 5.6 of NNB GenCo (2021b; information report for the HRA)**

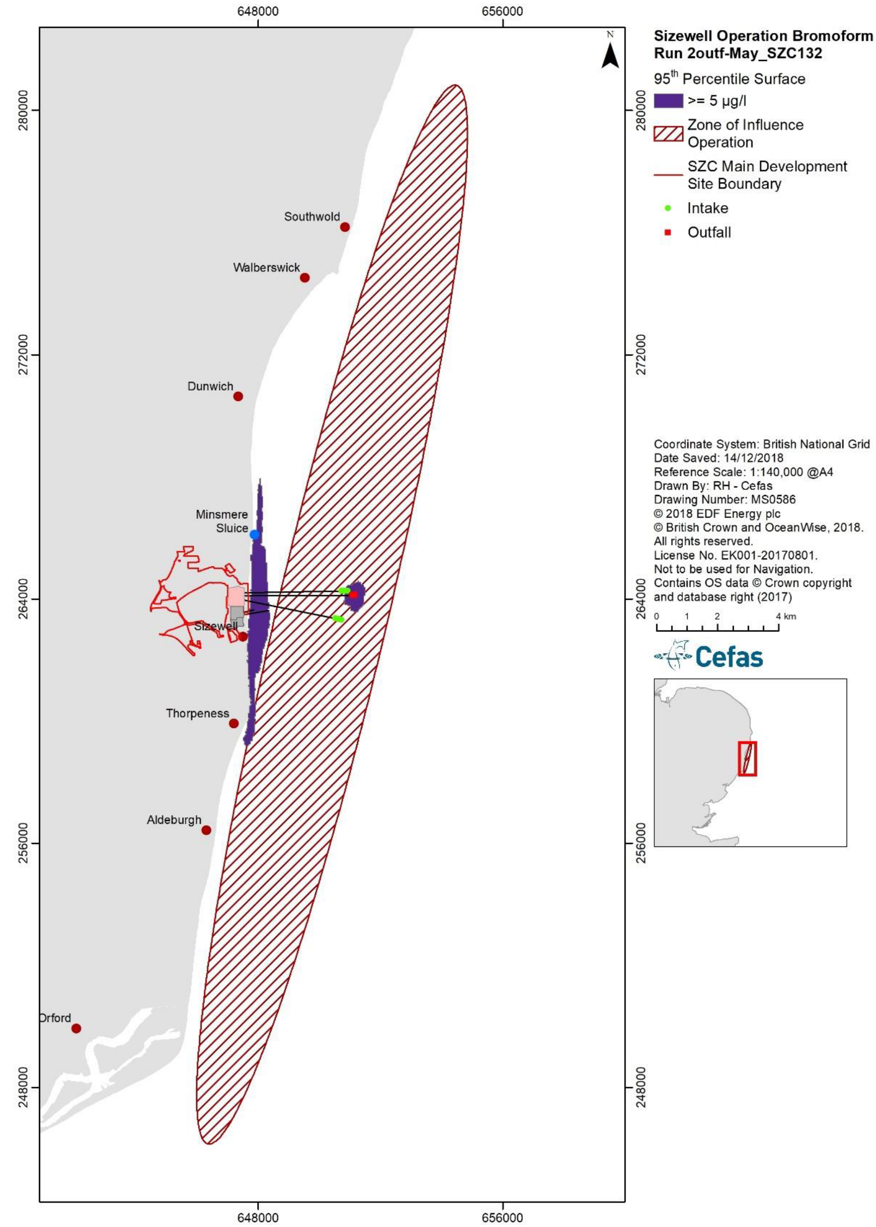

Figure 17. 95th percentile of the bromoform concentration at the surface for chlorination from SZB and SZC. Purple line delineates the PNEC of 5.0 µg/l. The hatched area shows the outer tidal excursion. Reproduced from Figure 14 in NNB GenCo (2020b; TR306).

NNB GenCo (SZC) has calculated the areas of bromoform exceedance, where bromoform is greater than or equal to the PNEC value of 5.0µg/l as a 95th percentile.

For SZC alone, the offshore 52ha (0.5km²) surface bromoform exceedance plume corresponds to 0.01% of the total surface area of the Outer Thames Estuary SAC, and <0.01% of the area of the Southern North Sea SAC (Table 13 and Figure 16).

When SZC and SZB are both operating, 358ha (3.6km²) of the sea surface exceeds the bromoform PNEC, corresponding to 0.09% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 13), with the total area of exceedance is comprised of 2 separate plumes (Figure 17).

For SZB alone, the nearshore 306ha (3.1km²) surface bromoform exceedance plume corresponds to 0.08% of the total surface area of the Outer Thames Estuary SAC, and 0.01% of the area of the Southern North Sea SAC (Table 13).

Table 13. The total area of bromoform exceedance for SZC alone, SZB alone, and SZC and SZB in combination. Data from Table 27 in NNB GenCo (2020b; TR306) and Table 12 in NNB GenCo (2019b; TR303)

Scenario	Area bromoform ≥ PNEC 5µg/l (95th percentile) plume on the seabed	Area of bromoform ≥ PNEC 5µg/l (95th percentile) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924km²)	Area of surface plume as a % of Southern North Sea SAC (36,951km²)
SZC alone	0.67ha (0.007km²)	52.14ha (0.5km²)	0.01%	< 0.01%
SZB alone	129.52	305.80ha (3.1km²)	0.08%	0.01%
SZC+SZB in combination	130.19	357.94ha (3.6km²)	0.09%	0.01%

From a Water Framework Directive perspective, the results of the bromoform modelling show that there would be no interaction between the bromoform plume and the Suffolk coastal water body, as demonstrated in Figure 18.

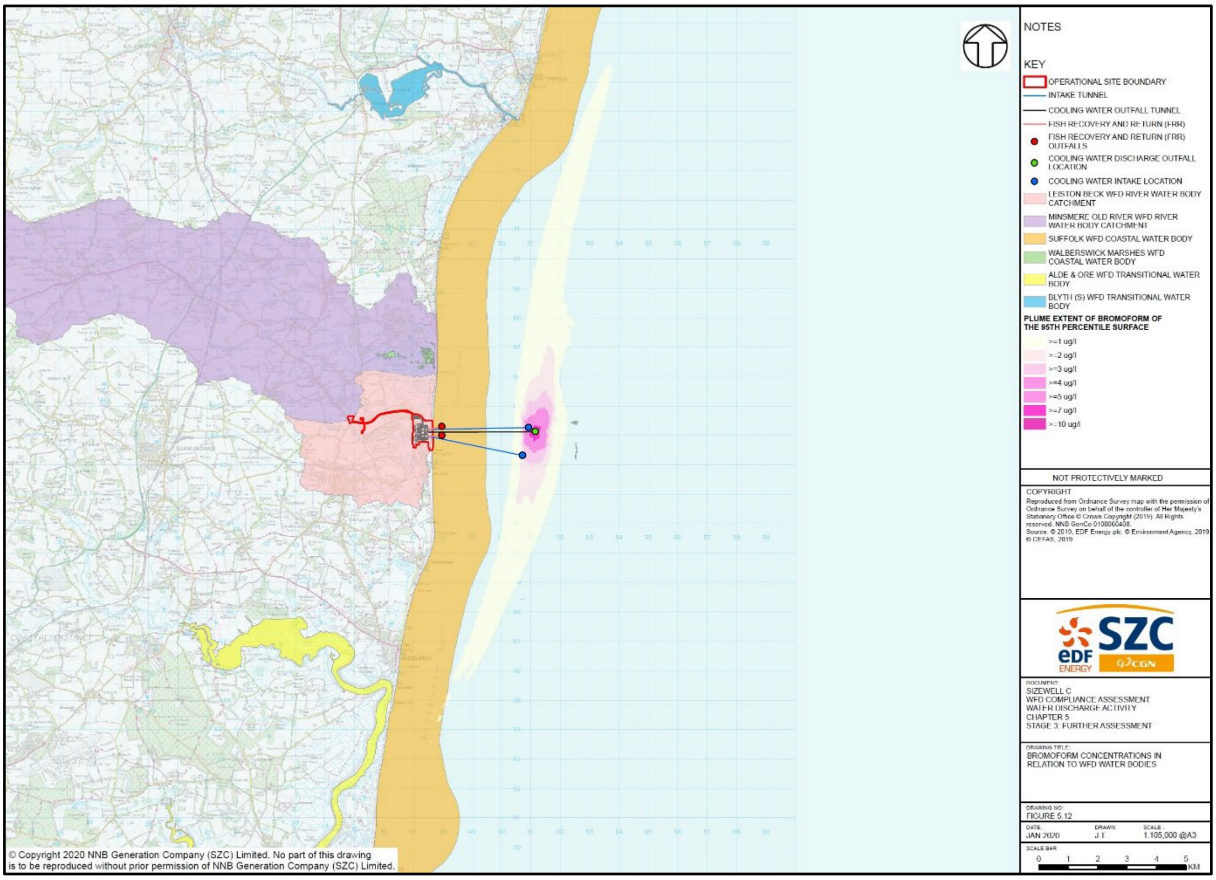

Figure 18. Bromoform concentrations in relation to WFD water bodies. Reproduced from Figure 5.12 in NNB GenCo (2021k; WFD compliance assessment report)

The significance of the seabed and sea surface area mixing zone/plumes for bromoform are fully assessed in specific detail in relation to the Habitats Directive and Water Framework Directive via our WDA HRA report (HRAR) Book 3 and our review of the WFD compliance assessment report (and as summarised within sections 4.12 and 4.14 of this consultation document).

4.11.10 Hydrazine

There is no environmental quality standard (EQS) for hydrazine. Due to use of hydrazine at several of its operational power station sites, NNB GenCo (SZC) EDF Energy (NNB Generation Company (SZC) Limited) conducted multiple research projects (reported in NNB GenCo, 2008; TR352) to analyse the available ecotoxicology data, proposing 2 predicted no-effect concentrations (PNECs) for use as thresholds in environmental risk assessments:

- a chronic PNEC value of 0.4ng/l (calculated as a mean) for assessing long-term effects
- an acute PNEC value of 4.0ng/l (calculated as a 95^{th} percentile) for assessing short-term effects

Since this earlier research, more recent assessments used in support of Canadian Federal Water Quality Guidelines (FWQGs) for hydrazine indicate concentrations below 200ng/l have a low probability of adverse effects/impacts for marine life, while a freshwater threshold of 2.6μg/l has been applied based on a greater availability of data in the freshwater environment (Environment Canada, 2013).

Although these standards have not been adopted within the UK, they will be considered here against any extreme acute exposure (for example, maximum concentrations experienced) where appropriate.

The fate of hydrazine in the aquatic environment is dependent on several variables, including dilution and dispersion, chemical and biological degradation, and processes such as volatilisation and sedimentation (Kuch, 1996).

Our ecotoxicology advisory service (ETAS) team has reviewed NNB GenCo (SZC)'s supporting documentation and justification for the 2 derived PNECs, and agreed that in the absence of an established EQS, the derived PNECs can be used as an effect threshold for purposes of surface water, WFD and Habitats Regulations assessments (Appendix 2).

The hydrazine PNEC values are consistent with those previously considered for determining the HPC operational WDA permit application (EPR/HP3228XT, granted on 13/03/2013), as well as the recently varied (EPR/JP3122GM/V009 and V010) HPC construction and cold commissioning WDAs permit (EPR/JP3122GM granted on 25/03/2022).

It should be noted that the EU Technical Guidance for Deriving Environmental Quality Standards (EC 2018) advises that an assessment factor of 10,000 is applied to derive a quality standard for short-term effects for saltwater environments, and that an assessment factor of 1,000 is applied for long-term effects.

Instead, NNB GenCo (SZC) has applied assessment factors of 1,000 and 100 respectively. However, in this instance we agree this is reasonable, as a range of species (principally marine species) have been investigated, including algae, invertebrates and fish. The data selected to derive the PNECs was for the most sensitive species within the studies (a marine algal species; Dunaliella tertiolecta).

NNB GenCo (SZC) has assessed the daily discharges from SZC in relation to an annual hydrazine discharge of 24.3 kilograms per year (kg/y) into the cooling water flow (waste stream A) via waste stream D (as this waste stream contains daily sources of hydrazine).

There is also a potential for hydrazine to be discharged into the cooling water flow via the combined waste streams B and C. However, the discharge of hydrazine from these combined waste streams is not a daily occurrence, and will only occur during start up or shut down periods (under which the worst case hydrazine discharge would be after wet-lay up of steam generators, which is not expected to occur during a normal refuelling outage and is unlikely to occur for many years).

Therefore the assessment is of Hydrazine is based on the daily loads from the secondary circuit via waste stream D (as this assessment will also encompass the lower discharge loading of hydrazine via the combined waste streams B and C that will only occur infrequently and not at the same time as the hydrazine discharge from waste stream D).

For the assessment, it is assumed that a daily mean hydrazine loading of 66.6 grams (g) from waste stream D is discharged into a 116m³/second cooling water flow, with the concentration in the SEK treatment tank being 0.089mg/l or 0.044mg/l depending on whether one or 2 conventional island waste discharge system (SEK) tanks are used (with each tank having a storage volume capacity of 750m³).

To understand the impact of different discharge rates from the treatment tanks and assuming no treatment, NNB GenCo (SZC) studied 2 scenarios for the operational SZC discharges of hydrazine (NNB GenCo, 2020b; TR306):

1) a hydrazine discharge of 69ng/l in daily pulses of 2.32 hours (2 hours 18 minutes) starting at 12pm
2) a hydrazine discharge of 34.5ng/l in daily pulses of 4.63 hours (4 hours 38 minutes) duration starting at 12pm

The 2 scenarios simulate hydrazine being discharged by either one or 2 SEK treatment tanks. The daily discharge concentration in the cooling water flow would be 69ng/l over a 2.32 hour period if one tank were used, or 34ng/l over a 4.63 hour period if 2 tanks were used.

The modelling simulations for these 2 scenarios show that both resulted in similar plume sizes; the calculated concentration of the hydrazine plume is higher at the surface than at the seabed, as was the case for the TRO and bromoform modelling results (Table 14 and Table 15).

No hydrazine is permitted to be released by SZB's operational WDAs, and so the area of exceedance plumes when both SZC and SZB are operating will be the same as for SZC alone.

Table 14. The total area of chronic hydrazine exceedance for SZC alone. Data from Table 29 in NNB GenCo (2020b; TR306).

Scenario	Concentration released (ng/l)	Area of chronic hydrazine ≥ PNEC 0.4ng/l (as a mean) plume on the seabed	Area of chronic hydrazine ≥ PNEC 0.4 ng/l (as a mean) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924 km²)	Area of surface plume as a % of Southern North Sea SAC (36,951 km²)
SZC alone over 2.32 hours	69ng/l	0.56ha (<0.01km²)	158.11ha (1.58km²)	0.04%	<0.01%
SZC alone over 4.63 hours	34ng/l	0.34ha (<0.01km²)	156.88ha (1.56km²)	0.04%	<0.01%

Table 15. The total area of acute hydrazine exceedance for SZC alone. Data reproduced from Table 29 in NNB GenCo (2020b; TR306)

Scenario	Concentration released (ng/l)	Area of acute hydrazine ≥ PNEC 4ng/l (95th percentile) plume on the seabed	Area of acute hydrazine ≥ PNEC 4ng/l (95th percentile) plume at the sea surface	Area of surface plume as a % of Outer Thames Estuary SPA (3,924km²)	Area of surface plume as a % of Southern North Sea SAC (36,951km²)
SZC alone over 2.32 hours	69ng/l release	0.22ha (<0.01km²)	13.79ha (0.14km²)	<0.01%	<0.01%
SZC alone over 4.63 hours	34ng/l release	0.0ha (<0.01km²)	17.38ha (0.17km²)	<0.01%	<0.01%

For SZC alone, the offshore 158ha (1.58km²) surface chronic hydrazine exceedance plume under the 69ng/l release scenario corresponds to 0.04% of the total surface area of the Outer Thames Estuary SAC, and <0.01% of the area of the Southern North Sea SAC (Table 14, Figure 19).

Under the 34ng/l release scenario, the surface chronic PNEC exceedance is very similar at 157ha (1.57km²), representing essentially the same proportion of the protected areas (Table 14).

For SZC alone, the offshore 14ha (0.14km²) surface acute hydrazine exceedance plume under the 34ng/l release scenario corresponds to <0.01% of the total surface area of the Outer Thames Estuary SAC, and <0.01% of the area of the Southern North Sea SAC (Table 15 and Figure 20).

Under the 34ng/l release scenario, the surface acute PNEC exceedance is larger than under the 69ng/l scenario, being around 17ha (0.17km²), although this still represents less than 0.01% of the protected areas (Table 15).

From a WFD perspective, the results of the hydrazine modelling show that the narrow, elongated plume running up the coast with no interaction between the hydrazine plume and the Suffolk coastal water body in the 69ng/l discharge scenario (a sea surface area of 13.79ha). The second hydrazine discharge scenario of 34.5ng/l will impact a larger sea surface area of 17.38ha, an increase of 3.58ha (Table 15).

Given the spread of the plume it is unlikely that this additional area of cover would interact with the Suffolk Coast water body (area of 14,653.3ha or 146.53km²) to any measurable extent. Figure 21 demonstrates the surface 95th percentile hydrazine concentrations in relation to WFD water bodies for the SZC hydrazine discharge scenario of 69ng/l in pulses of 2.32 hours.

Due to the offshore location of the 2 SZC cooling water outlets, neither the chronic nor the acute hydrazine exceedance plumes come into contact with the Suffolk coastline (Figure 19 and Figure 20).

The impacts of the discharge of hydrazine are fully considered within our HRAR Book 3 and our WFD assessment report (and as summarised within sections 4.12 and 4.14 of this consultation document).

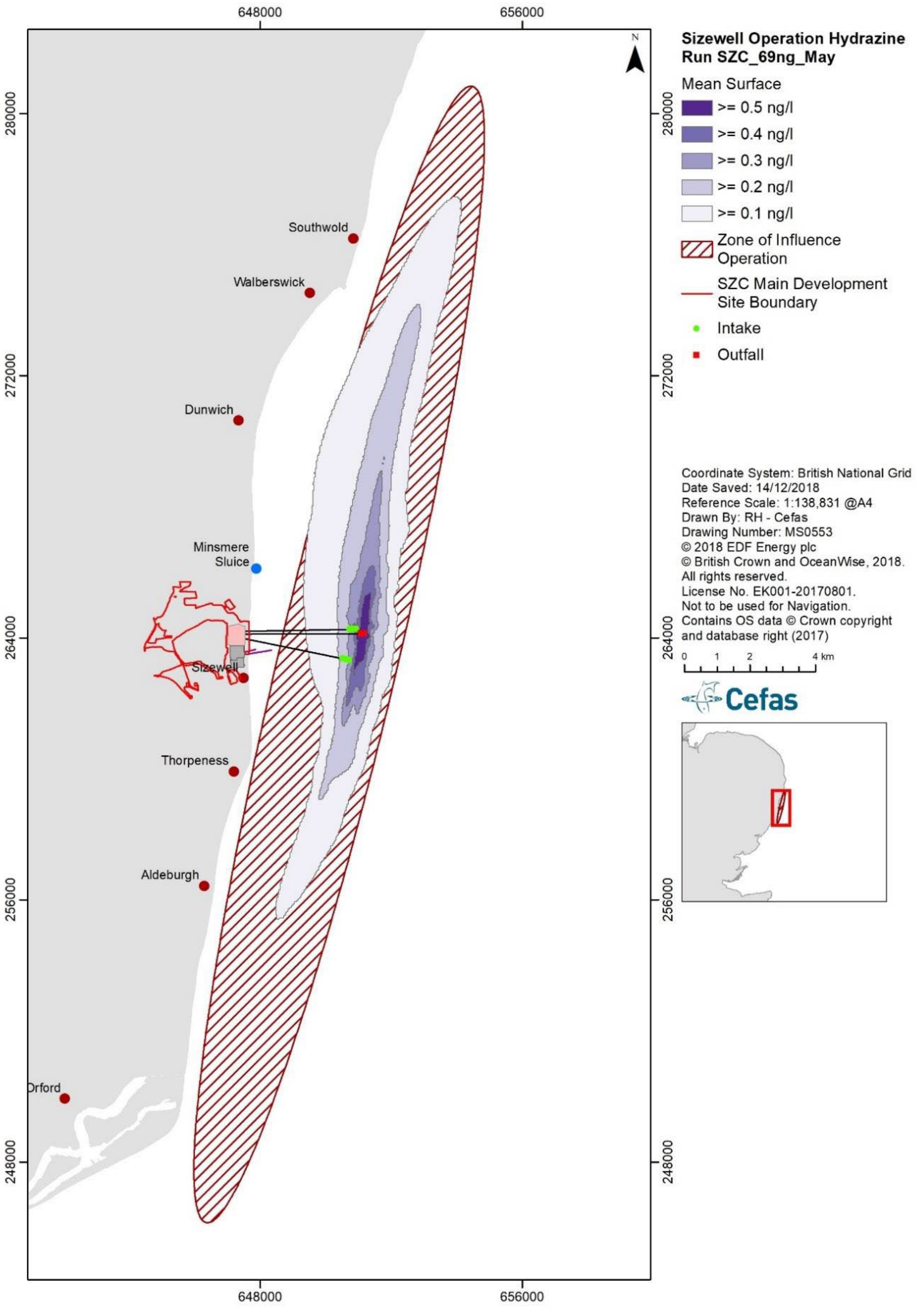

Figure 19. Mean hydrazine concentrations at the surface after release of 69ng/l in pulses of 2.32h from SZC. The ≥0.4ng/l contour represents the chronic PNEC value. Map reproduced from NNB GenCo (2021a; TR193)

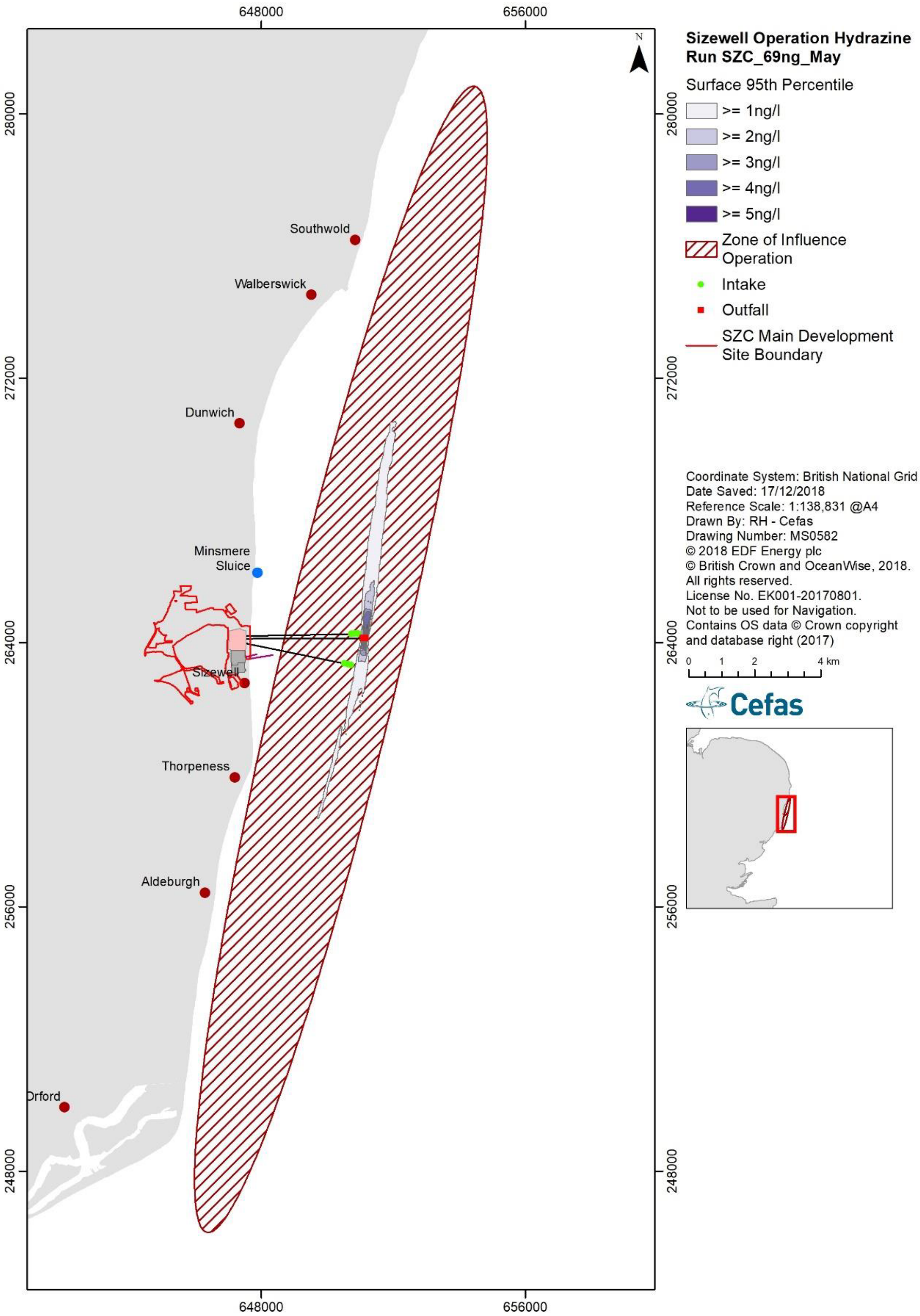

Figure 20. 95th percentile of hydrazine concentrations at the surface after release of 69 ng/l in pulses of 2.32h from SZC. The ≥ 4.0 ng/l contour represents the acute PNEC value. Map reproduced from NNB GenCo (2020b; TR306)

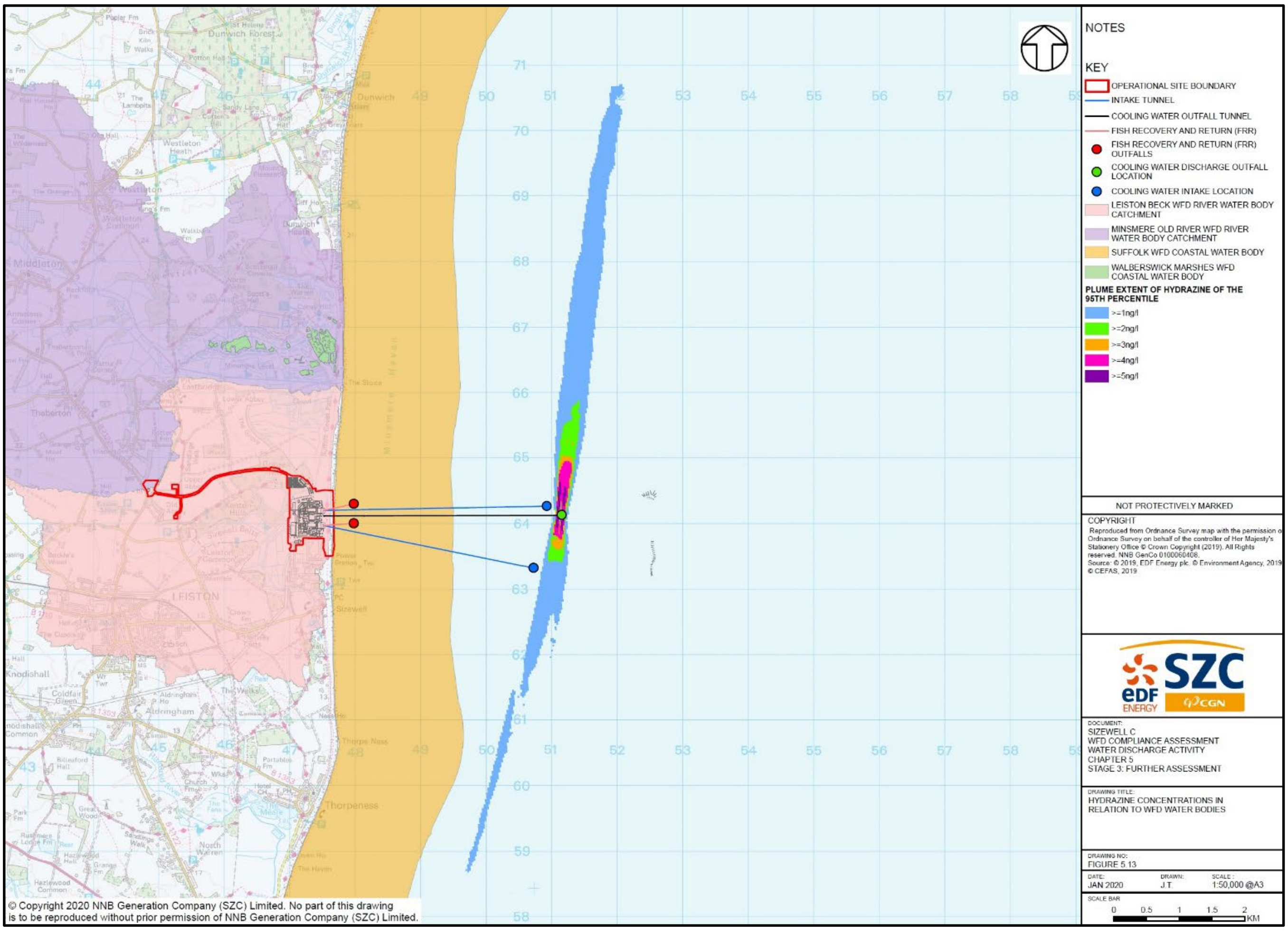

Figure 21.Surface 95th percentile hydrazine concentrations in relation to WFD water bodies after SZC release of 69ngl-1 in pulses of 2.32h. Map reproduced from Figure 5.13 in NNB GenCo, 2021k (WFD compliance assessment report).

The significance of the seabed and sea surface area mixing zone/plumes for hydrazine are fully assessed in specific detail in relation to the Habitats Directive and Water Framework Directive via our WDA HRA report (HRAR) Book 3 and WFD report, as summarised within sections 4.12 and 4.14 of this consultation document. They are also available at [Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space]

4.11.11 Assessment of sanitary/treated sewage effluent and bacterial load (Waste stream G)

The operational Sizewell C (SZC) power station site will generate black and grey wastewater generated from the site's lavatories and welfare/kitchen and office facilities, which will be treated by an appropriately sized sewage treatment plant (STP). This will discharge treated sanitary effluent to the site's main cooling water stream, which will discharge to the Greater Sizewell Bay via the 2 cooling water discharge outfalls.

The STP will be designed to deal with a varying site staff/worker population that considers both day-to-day operations (typical, normal operations) and site outage operations. For example, infrequent occurrences when the site requires maintenance and refuelling which will require additional workers, which represents a maximum/worst-case scenario for the demand placed on the STP:

1) normal 24 hour/daily flow: based on a site staff/worker population equivalent of 900 people using 100 litres per person per day (l/p/d) equates to a treated effluent volume of 90,000 litres per day (l/d) or 90 cubic metres per day (m^3/d)
2) maximum 24 hour/daily flow: based on a site staff/worker and contractor population equivalent of 1,900 people using 100l/p/d equates to a treated effluent volume of 190,000l/d or 190m^3/d

The above normal and maximum volumes are based on the combined flows from personnel serving the whole site (for 2 operational UK EPR™ units), and is based on the operational HPC WDA permit application (reference EPR/HP3228XT, granted on 13/03/2013) estimates used to determine maximum discharge concentrations of inputs into the sewage treatment plant serving HPC.

The flow of 100l/p/d is based on guidance from British Water's Code and Practice document 'Flows and Loads 4: Sizing Criteria, Treatment Capacity for Sewage Treatment Systems' (ISBN: 978-1-903481-10-3) for industrial/factory sites with office and canteen facilities for their staff/workers. A copy of Flows and Loads 4 can be accessed online via the British Water website:

- https://www.britishwater.co.uk/page/Publications

The sewage treatment plant will be designed to treat the influent to the following standard as a minimum before it is discharged as treated effluent into the cooling water stream:

- biochemical oxygen demand (BOD5-atu) concentration of 20 milligrams per litre (mg/l)
- suspended solids concentration of 30mg/l
- ammoniacal nitrogen (as N) concentration of 20mg/l

Based on the above maximum site population and treated effluent standards, the following annual loads can be calculated based on the maximum (worst case) volume of 190m^3/day:

- biochemical oxygen demand (BOD5-atu) loading of 1,387 kilograms per year (kg/y)
- suspended solids loading of 2,080kg/y
- total ammonia loading of 1,387kg/y
- total nitrogen (as N) loading of 1,595kg/y (based on 23mg/l)

For the assessment of the microbiological parameters of the worst case (190m^3/day) treated sewage effluent discharge, secondary treatment implies a 100 factor (2.0 log) reduction in coliforms and intestinal enterococci (the bacteria present in sewage effluent). If tertiary treatment was to be applied via UV treatment (disinfection of sewage effluent via the use of ultraviolet (UV) light to destroy bacteria/pathogens), then a 5.4 log reduction is assumed.

When discharged with the cooling water flow from one operational UK EPR™ unit (flow rate of 66m³/second, or 66,000l/s), the 190m³/day discharge (rate of 2.19l/s) of treated sewage will receive an initial dilution of approximately 31,000 before reaching the Greater Sizewell Bay via the 2 cooling water outfalls. Based on this initial cooling water dilution, the application of secondary treatment alone will achieve compliance with bathing water standards at the 2 points of discharge via the cooling water outfalls.

The assessment of dilution with a cooling water flow rate of 66m³/second provides a worst-case incidental dilution scenario, as this discharge volume assumes that only a single cooling water (CRF) pump is operating for each UK EPR™ unit during a low water period.

However, it should be noted that 24-hour discharges are unlikely to occur exclusively under low tide conditions and when only one cooling water pump is functioning normally, and is therefore a particularly conservative assessment (TR193).

NNB GenCo (SZC)'s assessment (TR193) is based on the Bathing Water Regulations (2013) for coastal and transitional waters, for which good status requires that the colony forming unit (cfu) counts for intestinal enterococci are ≤200cfu/100ml, and for escherichia coliforms (commonly known as E.coli, the major species in the fecal coliform group) are ≤500cfu/100ml.

The nearest designated bathing waters in proximity to Sizewell C are Southwold The Denes (UK10850) and Felixstowe North (UK10900), which are approximately 10km and 35km away respectively. To ensure that there is no impact on compliance at these locations it is necessary to confirm that treatment and dilution of the sewage effluents produced during the operation meets the required standard.

Based on data in support of the HPC operational WDA permit (which can be applied to SZC as it has the same site design), estimates were provided for maximum levels of faecal indicator organisms for the raw sewage input to the treatment plant:

- secondary treatment implies a 100 factor (2.0 log) reduction in coliforms and enterococci
- if tertiary treatment is also applied, a 5.4 log reduction is assumed

Following application of these different levels of treatment, the dilution factor required to reduce the coliforms to levels that would comply with bathing water standards (and the distance from the point of discharge at which this would be achieved) has been derived.

Assuming treatment reductions of 2.0 log for secondary treatment, and 5.4 log if tertiary treatment was also included, then compliance with the bathing water standards would be achieved at the point of discharge via the cooling water outfalls with secondary treatment only (as well as with tertiary treatment).

Our guidance for the disinfection of wastewater (Environment Agency, 2011; LIT12163) confirms that a discharger can achieve the required reduction of coliforms for compliance with bathing water standards through a combination of conventional secondary treatment, disinfection and dilution/dispersion (all dependent on the site specifics at the proposed discharge location). So, for the operational SZC discharge of treated sewage effluent, secondary treatment is considered acceptable for ensuring compliance with bathing water standards for good status via the 2 cooling water discharge outfalls.

There will be no risk of sewage discharged in a storm event as the SZC STP will receive no surface water inputs (the SZC site drainage will be kept separate from the foul site drainage, which forms waste stream G). Additionally, we would not permit a discharge of storm sewage from this type of system even if it had been applied for.

4.11.12 Assessment of unionised ammonia

As temperature may influence the relative amount of unionised ammonia, the operational SZC discharge has been further assessed by Cefas by considering temperature elevation via modelling.

During operation, sources of ammonia will be discharged from SZC from the combined circuit/plant conditioning chemicals via waste streams B, C and D, and the sewage treatment plant (STP) via waste stream G (via the cooling water outfalls). As discussed in section 4.11.11, the site's proposed STP will discharge a minimum treated sewage effluent quality of 20mg/l ammoniacal nitrogen (as N).

The worst-case annual ammonia discharge from SZC is calculated as 14,396kg/year, which results in a calculated mean ammonia discharge concentration of 3.9µg/l (3.06µg/l NH4-N). These values are based on data from table 26 in NNB GenCo TR193 (2021a).

- the worst-case annual loading for ammonia from the STP of 1,387kg/year
- the worst-case annual discharge of nitrogen (as NH_4) resulting from the combined circuit/plant conditioning chemicals used for the 2 UK EPR™ units of 13,009kg/year
- a worst-case cooling water discharge of 116m^3/second

As a conservative assumption, this value has been added to the site-specific background mean and 95th percentile values to derive the unionised ammonia calculation.

NNB GenCo (SZC) calculated the SZC unionised ammonia concentrations using our (Environment Agency) calculator (Clegg and others, 1995) and the GETM output for temperature elevation to account for operation of SZB and SZC in combination, and SZB alone, observed values for background water quality parameters (temperature, salinity and pH), and background ammonia concentrations.

This is to allow consideration of the cooling water discharge with the annual average EQS of 21µg/l for unionised ammonia, with the model run to replicate an annual cycle.

Table 39 of TR193 displays the results of the derived unionised ammonia concentrations, for which the results were derived using both average temperature and ammonia values.

The outcome shows that the derived unionised ammonia concentrations result in unionised ammonia values that are low in comparison to the annual average EQS of

21µg/l; for example, a maximum concentration of 0.52µg/l based on the thermal input for SZB and SZC in combination, and 0.5µg/l for that from SZB alone.

The 24-hour discharge figure for unionised ammonia is just over a third of the EQS at 7.92µg/l, but the site background concentration is also low (maximum concentration of 5.2µg/l). In all cases (including worst case) for unionised ammonia, no areas at the surface within the receiving water body exceed the annual average EQS of 21µg/l in the modelled scenarios.

NNB GenCo (SZC) has also considered additional potential contributions of ammonia from the operation of SZC via the operational use of hydrazine, morpholine and/or ethanolamine:

- hydrazine breakdown during operation (or subsequently during holding and potentially treatment on site) may result in nitrogen loss to the atmosphere
- ethanolamine/morpholine may not readily breakdown to directly release ammonia

However, estimated maximum ammonia inputs from the combined loadings of these 3 substances could contribute a 4.0% increase to the annual loading. This additional potential loading is considered to be sufficiently small in addition to the terms of the assessment results (summarised in Table 39 of NNB GenCo, 2021a; TR193) so as not to be of significance to background elevation. We confirm our agreement with this conclusion.

4.11.13 Assessment of dissolved inorganic nitrogen (DIN)

The 24-hour discharge concentration of dissolved inorganic nitrogen (DIN) from the SZC STP (waste stream G) was 49% of the site's 99th percentile winter standard for water bodies of intermediate turbidity (TR193, Table 32). As the loading of DIN may influence algal growth, NNB GenCo (SZC) completed further assessment using a combined macroalgal and phytoplankton (CMP) model (NNB GenCo, 2020d; TR385), which incorporated the influence of chlorination on phytoplankton survival.

During operation of SZC, the maximum number of personnel on site occurs during outages for refuelling/maintenance, during which nitrate and phosphate loads are increased above background concentrations (with outages lasting between 4 and 6 weeks, occurring at any time of the year). The use of conditioning chemicals via waste streams B and C also contribute as sources of nitrate and phosphate.

NNB GenCo (SZC) states that it is only in the summer that the discharge of additional nutrients needs to be assessed, as during winter there is no effect resulting from the additional supply of nutrient (as light is the limiting factor for phytoplankton growth). The maximum operational 24-hour loading of nitrogen from all sources is 332kg, and the maximum operational annual loading is 11,725kg/year, which equates to 32.1kg/d. During operation, the maximum daily loading of nitrogen therefore reaches approximately 2.0% of the daily exchange for the Greater Sizewell Bay, but the average daily value is low at 0.2%

of this daily exchange (indistinguishable from background concentrations) (NNB GenCo, 2020d; TR385).

During operation of SZC, the use of hydrazine, morpholine and/or ethanolamine via waste streams B and C (used as conditioning chemicals to inhibit corrosion in circuits in contact with air, where volatile inhibitors cannot be used) could potentially contribute to the nitrogen input to the marine environment via the 2 cooling water discharge outfalls.

Hydrazine breakdown during operation or subsequently during holding and, potentially, treatment before discharge may result in nitrogen loss to the atmosphere. However, estimated maximum nitrogen inputs from the combined loadings of hydrazine, ethanolamine and morpholine could only contribute a loading of 1.3kg/day. This additional potential loading is small relative to the 32kg/day from other sources. It would be insignificant relative to the daily exchange and would not be expected to influence phytoplankton growth above that predicted for other operational inputs of nitrogen (NNB GenCo, 2021a; TR193).

The conclusion within the NNB GenCo (SZC) CPM modelling report (NNB GenCo, 2020d; TR385) is that total phytoplankton production in the modelled abstraction area is predicted to be reduced by approximately 5.0% due to phytoplankton entrainment mortality from operations at SZB and SZC. This is well within the natural variability of phytoplankton in the area:

- There is greater daily exchange of water between Sizewell Bay and the greater Southern North Sea than there is daily extraction of water due to the power stations. Due to this exchange, the apparent concentration of phytoplankton will not be reduced in Sizewell Bay when considered against the high natural variability. In particular, the predicted effect of either the present SZB or the proposed SZC would not be observable in any monitoring programme.

When additional sources of nitrogen are added from the 2 fish recovery and return (FRR) system discharges (Table 5 in NNB GenCo, 2020d; TR385), the small additional nitrogen from operational use of hydrazine (and morpholine and ethanolamine) is even more inconsequential.

4.11.14 Assessment methodology for the fish recovery and return (FRR) system discharges (Waste Stream H)

Introduction

The proposed design for the cooling water system at Sizewell C (SZC) includes 4 low velocity side entry (LVSE) intake heads, and 2 fish recovery and return (FRR) systems.

The FRR systems are proposed to protect the power station’s cooling water system by reducing risks of blockage/biofouling. Within each FRR system, the abstracted water will pass through a series of screens, any debris and biota larger than the screen mesh size will be trapped and removed (impinged).

Some of this biota will still be alive, and therefore the 2 FRR systems are proposed to return these individuals back to the Greater Sizewell Bay via 2 outlets (one outlet per FRR system). However, a proportion of this biota will not survive, and this dead or moribund biota will also be returned to the Greater Sizewell Bay. It is the discharge of this moribund biota via the 2 FRR systems that are constituted as WDAs (via waste stream H of the permit), as they are considered as discharges of polluting matter under Schedule 21 of EPR 2016.

This section describes the methodology used to estimate the amount of polluting matter predicted to be discharged, and what potential impacts this may have on relevant water quality elements. These quantitative results can then be considered qualitatively within our review of our WFD compliance assessment report, assessment, HRAR Book 3 WDA report and Wildlife and Countryside Act (CRoW Act) assessment.

NNB GenCo (SZC) provided its analysis of potential water quality effects of the FRR system discharge within TR520 'Sizewell C Influence on the fish recovery and return system on water quality and ecological receptors' (NNB GenCo, 2020f).

Our review of this analysis is provided our technical brief (TBS) TBS011 (Environment Agency, 2022f) 'Potential Water Quality and Ecological Impacts'. In summary, the assessment process we conducted, as part of the operational WDA application determination, was identical to NNB GenCo (SZC)'s.

However, the calculations were updated using several different evaluations of the potential biomass discharged. The difference between NNB GenCo (SZC)'s and our figures was largely due to differing estimates of the impingement predicted at SZC. Our impingement methodology was informed by 4 technical briefs (TBS) we completed to help our WDA permit determination:

- TBS002 (Environment Agency, 2022b): Vertical Audit and Raw Data Quality Assurance summary report
- TBS004 (Environment Agency, 2022c): SZC Fish Recovery and Return system mortality rates
- TBS006 (Environment Agency, 2022d): Biomass weight and mortality report
- TBS007 (Environment Agency, 2022e): SZC Entrapment predictions – uncertainty analysis report

NNB GenCo (SZC) estimated SZC impingement based on surveys of Sizewell B (SZB) impingement. However, a significant proportion of the SZB surveys failed to measure night time impingement rates. This resulted from the overnight sample overflowing, and either being abandoned with no result reported, or if completed, reported with a 'greater than' result. For the affected surveys, NNB GenCo (SZC) did not use the result of the night time sample and instead extrapolated 24-hour impingement from measured daytime rates alone. NNB GenCo (SZC) was unable to show, to our satisfaction, that day and night time impingement rates were, for a given survey, the same.

As a consequence, we considered NNB GenCo (SZC)'s estimate of SZC impingement to possibly be an underestimate of the true figure. To address the uncertainty in SZC's estimated impingement, we therefore re-analysed the SZB data applying a factor to measured daytime impingement rate, for overflowing surveys, to account for the possibility that night time rate is greater than daytime. We have presented our figure for SZC impingement as a 'reasonable worst case' on the basis that the true figure, while unknown, is likely to be below ours.

Assessment process

The general steps involved in the assessment process are as follows:

1. Estimate the number of individuals that will be impinged within the SZC cooling water system (CWS).

This will use impingement sampling data collected from SZB and apply scaling factors to take account of the differing volumes and intake designs.

2. Calculate the biomass of these impinged individuals.

3. Calculate the biomass of the individuals that will not survive the journey through the abstraction and FRR systems by applying appropriate 'FRR system mortality rates'.

These will differ between the types of species impinged.

4. Conduct a literature review to understand the decay products of moribund organisms.

5. The daily loading of those breakdown products (nitrogen, phosphorus, unionised ammonia, biochemical oxygen demand (BOD), and organic carbon) is then calculated using the biomass from Step 3 and the literature values in Step 4.

6. These loadings can then be compared against a relevant standard (for example, EQS or equivalent) to estimate a 'mixing zone' for each element and plume footprint for organic enrichment.

Estimating Sizewell C impingement (Step 1)

To support the operational WDA application, NNB GenCo (SZC) submitted various reports to present their data analysis process to predict the number, weight, and size distribution of individuals by species that will be impinged at SZC, using impingement sample data from the Comprehensive Impingement Monitoring Programme (CIMP) at SZB:

- NNB GenCo, 2021f. TR339 Sizewell Comprehensive Impingement Monitoring Programme 2009 – 2017. NNB Generation Company (SZC) Limited
- NNB GenCo, 2021g. SPP111 Sizewell C impingement predictions corrected for Sizewell B raising factors and cooling water flow rates. Revision 2
- NNB GenCo, 2020c. TR406 Sizewell C – Impingement predictions based upon specific cooling water system design. Revision 7. NNB Generation Company (SZC) Limited

Vertical audit

We carried out a vertical audit on NNB GenCo (SZC)'s data processing as detailed within these reports. This audit is detailed in Environment Agency (2022b; TBS002) and involved correcting errors identified in the NNB GenCo (SZC) data processing. This audit also includes our derivation of amended predictions of SZB impingement.

It should be noted that the results NNB GenCo (SZC) presented in support of its operational WDA permit application have changed between it submitting the application in June 2020 and submitting further information in August 2021. This is partly a result of the QA process we have undertaken, reporting our findings to NNB GenCo (SZC), and it then correcting its analysis as a result. It is also due to the change to the total cooling water flow to account for auxiliary cooling water (ACW) and essential cooling water (ECWA) systems.

We have compared our results to those NNB GenCo (SZC) presented in NNB GenCo (2021f; TR339) and NNB GenCo (2021g; SPP111). Table 16 summarises how issues identified with NNB GenCo (SZC)'s data processing has been addressed between our technical brief, and NNB GenCo (2021f; TR339) and NNB GenCo (2021g; SPP111) calculations.

Table 16. Summary of corrections made for identified data processing errors

Data issue	TR339 v3	SPP111 v2	EA TBS002
Error in individual Pisces raw data files	Present	Corrected	Corrected
Factor up on number of screens or number of pumps	Screens	Pumps	Pumps
Account for ACW and ECW[1]	No	Yes	Yes
Treatment of overflowing bulk samples	Pisces included, Cefas excluded	All excluded	Pisces included, Cefas excluded[3]
Account for missing survey samples	No	Yes	Yes
Double counting of combined species	No	Yes	?[2]

[1]Auxiliary cooling water (ACW) and essential cooling water (ECW).
[2]We have not received the data. Need to allow this check to be made.
[3]We have treated Pisces and Cefas overflowing samples differently to reflect how they were treated in TR339 v3, as the dataset the QA is based on is from TR339 v3. To work from the raw data from SPP111 v2 would have meant repeating many parts of the QA.

A number of errors in data processing, made in EDF (2021f; TR339), have been identified, where the calculation method followed differs from that described in the report. These have been corrected in EDF (2021g; SPP111). Therefore, the results presented in EDF (2021g; SPP111) are in line with the methodology set out in EDF (2021f; TR339).

Differences between our calculations and results in EDF (2021f; TR339) and EDF (2021g; SPP111) are relatively small and reflect the relative insignificance of the errors identified.

Uncertainty analysis

No attempt was made to address the uncertainty in the Comprehensive Impingement Monitoring Programme (CIMP) results due to overflowing bulk samples in either NNB GenCo (2021f; TR339), NNB GenCo (2021g; SPP111), or our QA. As a high proportion of bulk samples collected overflowed, there is a significant source of uncertainty in the estimates of SZB and SZC impingement NNB GenCo (SZC) presented. For each overflowing bulk sample, the result obtained is less than the true value, and the degree by which the true value is underestimated is unknown.

Consequently, as part of our role in the SZC DCO consultation, we requested a sensitivity analysis accounting for overflowing bulk samples. The response to the request is set out in NNB GenCo (2021h; SPP116). NNB GenCo (2021h; SPP116) only examined data from surveys when the bulk sample did not overflow. Therefore, the conclusion of no significant differences between hourly and bulk impingement rates that was drawn applies to surveys when the bulk sample did not overflow, and does not necessarily apply to surveys when the bulk sample did overflow. Therefore, we have carried out an uncertainty analysis on our impingement estimates, documented in Environment Agency (2022e; TBS007).

The uncertainty analysis in Environment Agency (2022e; TBS007) sets out work aimed at quantifying the potential impact of the overflowing bulk samples on impingement predictions and allowed us to calculate a 'reasonable worst-case estimate' of impingement at SZC. The presence of the overflowing bulk samples means we do not know the true impingement at SZB, which contributes to the uncertainty in the predicted impingement at SZC. We have therefore arrived at an estimate of SZC impingement that we consider the true value is unlikely to exceed, therefore we have termed it a 'reasonable worst case'.

Potential sources of uncertainty in the impingement estimate for SZC that we have not included in this uncertainty analysis include the different spatial locations of the SZB and SZC abstraction intakes. Fishing surveys found no significant spatial differences in the fish community, nor the fish length distributions for species other than sea bass, between the locations of the SZC and SZB intakes (NNB GenCo, 2020c; TR406). For sea bass, NNB GenCo (SZC)'s SZC impingement prediction was reduced by 90% based on these findings (NNB GenCo, 2020c; TR406). We have not applied a similar adjustment in our analysis.

LVSE factor

As sample data from SZB is used to predict the impingement at SZC, a factor needs to be applied to account for the low velocity side entry (LVSE) cooling water intake designs at SZC (termed the LVSE factor). We have reviewed the work contained in NNB GenCo (SZC)'s report, NNB GenCo (2021i; SPP099) 'Predicted performance of the SZC LVSE intake heads', compared with the SZB intakes.

In summary, we consider it unlikely that the true LVSE factor would be less than 1.0, but there is also evidence that the LVSE intake heads could act as an artificial reef and, therefore, be greater than 1.0. However, without any evidence or basis for a calculation otherwise, we have assumed an LVSE factor of 1.0 in our estimates of SZC impingement.

It is true that our guidance (Environment Agency, 2010) is in favour of LVSE designs as their configuration gives fish a chance to swim away from the intake if they wish to do so. However, in the present case, there is no reason to assume that they will wish to avoid the intake, without a form of behavioural cue.

Calculate the biomass of impinged individuals (Step 2)

The Comprehensive Impingement Monitoring Programme (CIMP) provided fish and invertebrate numbers caught over 204 separate days during the period of 03/2009 to 10/2017 at SZB. This data was collected through a hybrid sampling method, with a bulk sample collected in the trash basket for 18-hours (overnight), followed by 6, one-hour samples collected from the drum screen channels in baskets. This data allowed biomass estimates to be calculated for 87 species, for each day of sampling, to give the impinged mass for one day (kg/24h).

This biomass data from SZB was then scaled up to estimate biomass impingement at SZC, following the methodology described in NNB GenCo (2020c; TR406). The SZC 'volume scale' estimate directly raises the SZB impingement weights by the ratio of cooling water flows. An additional scaling factor is also applied to account for the overflowing bulk samples. This scaling determines the SZC worst-case scenario.

These scaling factors are summarised in Table 17.

Table 17. Environment Agency revised method of predicting SZC impingement estimates from SZB CIMP data, as defined in Environment Agency (2022g; TBS007)

Factor	SZC volume scale	Additional scaling SZC worst-case volume scale
Environment Agency factors	2.56 (132/51.5)	5
TR406 factors	2.56 (132/51.5)	N/A

To derive annual biomass estimates, the daily impingement estimates were bootstrapped to 5,000 iterations for each species and scaled up to an annual amount (multiplied by 365.25). Bootstrapping is a statistical method for resampling a single dataset to create many simulated samples.

Results from our annual biomass estimates indicate that 11 species groups contribute to around 95% of the impinged baseline scenario at SZC, and 94% of the worst-case scenario (Table 18). Herring (Clupea harengus) and whiting (Merlangius merlangus) have the highest weight impinged. Our annual biomass impingement for SZC baseline and SZC worst case is estimated as 498,009kg and 1,051,455kg respectively.

The EDF impingement surveys at SZB were affected by a significant number of overflowing samples. In NNB GenCo (SZC)'s operational WDA permit application documents, no factor was applied to account for the impact of the overflowing samples.

Our baseline estimate replicates the method NNB GenCo (SZC) followed for figures reported in NNB GenCo (2021f; TR339) corrected for a number of errors in NNB GenCo (SZC)'s work, but treating bulk samples in the same way.

Table 18. Species with the highest annual mass (kg) of impingement

Fish – Latin name	Fish - common name	SZC baseline	SZC worst case
Clupea harengus	Herring	256,353	487,414
Merlangius merlangus	Whiting	81,211	185,321
Sprattus sprattus	Sprat	49,076	124,604
Dicentrarchus labrax	European seabass	48,988	101,552
Crangon crangon	Common (brown) shrimp	10,150	23,858
Gadus morhua	Atlantic cod	7,177	10,578
Limanda limanda	Dab	4,861	12,798
Solea solea	Sole (Dover sole)	4,633	9,932
-	Epibenthic mix unidentified	4,280	9,757
Palaemon serratus	Common prawn	4,276	11,361
Liza ramada	Thin lipped mullet	3,907	12,150
Overall total for all species:		498,009	1,051,455

Calculation of the biomass of moribund organisms from the FRR system (Step 3)

To calculate the biomass of individuals that will not survive the journey through the cooling water abstraction and FRR systems, we apply FRR system mortality rates to the biomass impingent estimates from Step 2.

Environment Agency (2022c; TBS004) provides the FRR system mortality rates we used during the HPC operational WDA permit variation determination (following our extensive review). It details our review of the FRR system mortality rates used by the SZC project, and considers the differences in the FRR systems as provided by NNB GenCo (SZC).

It then recommends a final set of FRR system mortality rates for each species in the impingement record at SZB (the basis for the SZC analysis), which are used in the process of calculating the predicted moribund biomass and any resulting water quality issues.

The FRR system mortality rates for the most common fish species captured in the SZB impingement data are provided in Table 19.

Table 19. Selected mortality rates to use in the EA's estimate of impact from the FRR system. EA values are from Environment Agency (2022c; TBS004)

Species	FRR system mortality factor used by NNB GenCo (SZC) in Table 4 of NNB GenCo (2021h; SPP116)	FRR system mortality factor used by the Environment Agency for the HPC permit variation	FRR system mortality factor used by the Environment Agency in Environment Agency for SZC
European sprat	1.000	1.000	1.000
Atlantic herring	1.000	1.000	1.000
Whiting	0.551	0.552	0.552
European seabass	0.551	0.608	0.608
Sand goby	0.206	0.200	0.206
Dover sole	0.206	0.200	0.206
European anchovy	1.000	NA	1.000
Dab	0.535	NA	0.535
Thin-lipped grey mullet	0.551	NA	1.00
Flounder	0.231	0.200	0.231
Smelt (cucumber)	1.000	NA	1.000
European plaice	0.206	0.200	0.206
Atlantic cod	0.553	0.563	0.563

Thornback ray	0.206	0.545	0.545
Twaite shad	1.000	1.000	1.000
River lamprey	0.206	0.200	0.206
European eel	0.206	0.200	0.206
Horse mackerel	1.000	NA	1.000
Mackerel	1.000	NA	1.000
Tope	0.206	NA	1.000
Sea trout	1.000	1.000	1.000
Sea lamprey	0.206	0.200	0.206
Allis shad	1.000	1.000	1.000

Six biomass scenarios were run to determine the quarterly and annual average of all dead fish and invertebrates. Table 20 defines the 6 biomass scenarios we have assessed.

As a precautionary measure, the quarter 1 mean daily loading of moribund impinged fish was calculated along with the annual mean. The highest daily loadings of impinged fish and invertebrates occurred in Q1 at 6,063kg of dead biota per day. Upper 95% confidence limit values (u 95% c.l) were used for assessments where comparison is to an acute standard (for example, unionised ammonia). For nutrients' assessment, the annual average load is relevant as short-term acute events are not of concern.

Table 20. EA biomass scenarios, including both baseline and worst-case calculations for SZC

	Environment Agency baseline[1]		Environment Agency reasonable worst case[2]			
	Baseline no Invert u95	Baseline with Invert u95	Worst case no Invert	Worst case with Invert	Worst case no Invert u 95% c.l.	Worst case with Invert u 95% c.l.
Daily loading of impinged fish - annual mean (kg)	1,661	1,773	2,257	2,505	3,835	4,083

Daily loading of impinged fish - Q1 mean (kg)	3,700	3,812	5,917	6,063	7,900	8,046

[1]Baseline: Our estimate of SZC impingement following the same calculation method as that NNB GenCo (SZC) used, with no factor applied to overflowing samples.
[2]Worst case: Our estimate of SZC impingement, arrived at after applying a factor to account for overflowing samples that we consider the true value is unlikely to exceed.

Conduct a literature review (Step 4)

In support of the operational SZC WDA permit application, NNB GenCo (SZC) provided NNB GenCo (2020f; TR520), a 'Technical Report (TR) on the influence of the Fish Recovery and Return (FRR) system on water quality and ecological receptors'. This documents NNB GenCo (SZC)'s review of the current relevant literature. We have reviewed the literature cited and have found no more relevant sources, so the values provided in NNB GenCo (2020f; TR520) are accepted and used within our own analysis.

Calculate the daily loading of breakdown products and estimate mixing zones for each element (Steps 5 and 6)

We reviewed further the evidence provided in NNB GenCo (2020f; TR520) to determine whether the FRR system discharge would cause a deterioration of water quality to inform this HRAR.

To determine any deterioration or impacts, the assessment considered the potential effects on:

- nutrient concentrations
- unionised ammonia
- biochemical oxygen demand (BOD)
- organic enrichment

Following our review, we replicated the same analysis as NNB GenCo (SZC) provided in NNB GenCo (2020f; TR520). However, our calculations were updated using several different evaluations of the potential biomass discharged from the FRR system outlet (as shown in Table 24). This analysis is detailed in Environment Agency (2022f; TBS011) 'Potential water quality and ecological impact from the SZC FRR system discharge', but a summary for each element is provided here.

Calculation of nutrient inputs

The nutrient loads were predicted using published estimates in fish tissue (Gende and others, 2004; Walker and others, 2011). The average daily biomass was multiplied by the maximum estimates of phosphorus and nitrogen (for example, daily load x (0.5/100)) = kg P). It is estimated that the discharge of dead fish and invertebrates from the FRR system will result in an average of 142.9kg of dissolved inorganic nitrogen (DIN) and 20.4kg of phosphate per day.

Table 21 compares the nutrient input estimates using the ‘reasonable worst-case with invertebrates’ annual mean and Q1 mean. The third column in this table shows the range of nutrient concentrations in fish tissue (as %) in the literature. In each case, the maximum concentration was applied, shown in bold.

Table 21. Phosphorus and nitrogen inputs based on estimates of nutrient tissue concentrations (Gende and others, 2004; Walker and others, 2011).

Scenario	Nutrient	% Wet Weight	Kg
4,083 (annual average)	Phosphorus	0.45 - 0.5	20.4
	Nitrogen	3.2 - 3.5	142.9
8,046 (Q1 average)	Phosphorus	0.45 - 0.5	40.2
	Nitrogen	3.2 - 3.5	281.6

Calculation of unionised ammonia

As applied in NNB GenCo (2020f; TR520), Timm and Jorgenson’s (2002) study of cod tissue was used to derive an equation of ammonium ions (125mg/kg of NH_4 from cod tissue).

The calculated value of total ammonia was then used in the unionised ammonia calculator (NH3SEA) with background conditions as described in NNB GenCo (2020f; TR520): pH 8.23, salinity 31.7, temperature 11.73°C) to derive a corresponding unionised ammonia discharge (NH_3 as N per day).

The volume of seawater required to dilute this mass of unionised ammonia to the environmental quality standard (EQS) was then calculated using the unionised ammonia EQS of 21µg/l and assumed background level of 1.6µg/l. Assuming this is equally mixed through the full depth of the water column (4.0m), this volume can then be converted to an area that would be needed to dilute the unionised ammonia concentrations down to the EQS.

For example, using the reasonable worst-case with invertebrates quarter 1 95^{th} daily biomass value of 8,046kg:

- 8,046kg/day x 125mg/kg of NH_4 from cod tissue = 1,005,688mg NH_4-N per day
- this converts to a corresponding unionised ammonia discharge of 28,534mg NH_3-N per day
- 28,534mg NH_3-N x 1,000µg/mg = 28,533,644µg NH_3-N
- 28,533,644µg NH_3-N/(21µg/l – 1.6µg/l) = 1,470,806 litres
- 1,470,806l/1,000l/m^3 = 1,470.81m^3
- 1,470.81m^3/4m = 367.7m^2

Figure 22 presents the full range of results from each of the scenarios assessed, including with a temperature uplift to allow for the power station thermal discharge.

Calculation of biochemical oxygen demand (BOD)

To assess the BOD, the influence on the dissolved oxygen is calculated in terms of the amount of water required to meet the corresponding oxygen demand from that biological demand.

Stigebrandt (2001) concluded that there are 3.5kg of oxygen per kg of carbon. The dry/wet weight conversion is assumed to be 0.36 (Wang and others, 2013). Therefore, the estimate of BOD input (each day) was calculated by:

- kg of biota/day x 3.5kg/kg C x 0.36 = kg BOD per day

OSPAR (1997) reports that a BOD of 1.5mg/l effectively produces 0.5mg/l O_2 reduction. Using this information, oxygen reduction in the receiving water can be calculated:

- (kg BOD/1.5mg/l) x 0.5mg/l = O2 reduction kg/day

As defined in NNB GenCo (2020f; TR520), the background dissolved oxygen concentration level is 6.96mg/l O_2, therefore the amount of water containing this equivalent amount of O_2 can be calculated. Assuming this is equally mixed through the full depth of the water column (4.0m), this volume can be converted to the corresponding area.

This volume is also compared to the daily tidal exchange for the Suffolk Coastal water body to calculate the percentage of the total daily tidal exchange required to meet that oxygen demand. As defined by Dyer (1979), a daily volume exchange of 10% would be equivalent to 36,400,000m^3.

In addition to daily exchange, daily re-aeration at the sea surface contributes 3.2g/m^2/d (Hull and others, 2016). Therefore, the area required to replenish that oxygen demand can also be calculated.

For example, using the reasonable worst case with invertebrates quarter 1 95th daily biomass value, of 8,046kg:

- 8,046kg/day x 3.5kg/kg C x 0.36 = 10,137.3kg BOD
- (10,137.3kg BOD/1.5mg/l) x 0.5mg/l = 3,379.1kg/day O_2 reduction
- 3,379.1kg/day O_2 reduction x 1,000g/kg x 1,000mg/g = 3,379,113,322mg/day O_2 reduction
- 3,379,113,322mg/day O_2 reduction/6.96mg/l background O_2 = 485,504,787.6l
- 485,504,787.6l/1,000l/m^3 = 485,504.8m^3
- 485,504.8m^3/4m = 121,376.2m^2

Corresponding to:

- 485,504.8m^3/36,400,000m^3 = 1.33% of daily exchange

Or

- 3,379.1kg/day O2 reduction/0.0032kg/m^2/day = 1,055,973m^2

Figure 22 presents the full range of results from each of the scenarios assessed.

Calculation of organic enrichment

Organic enrichment refers to carbon released by the decomposition of dead species. As proxy for an EQS, 100g organic carbon/m^2/year is an acceptable benchmark to assess the negative impacts of organic enrichment (Tyler-Waters and others, 2018). From Alves and others, (2019) it is assumed that the carbon content of fish process waste is 64.7% of the dry weight and the carbon dry/wet weight conversion factor applied within this study is 0.48.

The daily carbon load is divided by the daily benchmark of carbon and converted to a daily value. If the daily carbon input were evenly spread, so that the release of carbon/m^2 occurred at the proxy EQS rate, the corresponding area can be considered the 'mixing zone' where a potential effect from this organic enrichment might be experienced.

Given that the Suffolk Coastal water body has an area of 146.53km^2, this 'mixing zone' can be compared with the area of the water body to consider the percentage of the water body that could see effects of organic enrichment.

For example, using the reasonable worst case with invertebrates quarter 1 95th daily biomass value, of 8,046kg:

- 8,045.5kg wet weight x 0.48 dry weight/wet weight x 0.65 carbon kg/kg = 2,510.2kg carbon/day
- 2,510.2kg carbon/day/(100g organic carbon/m2/year x (1kg /1,000g)/(365 days/1 year)) = 9,162,224.4m2 affected
- 9,162,224.4m2/146,530,000 X 100 = 6.25 % of water body affected

Figure 22 presents the full range of results from each of the scenarios assessed.

Results

Figure 22 presents a summary of the predicted water quality effects of SZC's FRR system discharge. This table also compares the results provided in NNB GenCo (2020f; TR520) to those we produced. The process in which these figures were calculated is identical to the analysis in NNB GenCo (2020f; TR520). However, the loadings of dead biota discharged from the FRR system have been revised and several scenarios have been considered (Table 24) including:

- baseline scenario - daily loading, not including invertebrates, upper 95th percentile, annual mean and quarter 1 mean
- baseline scenario - daily loading, including invertebrates, upper 95th percentile, annual mean and quarter 1 mean
- worst-case scenario - daily loading, not including invertebrates, annual mean and quarter 1 mean

- worst-case scenario - daily loading, including invertebrates, annual mean and quarter 1 mean
- worst-case scenario - daily loading, not including invertebrates, upper 95th percentile, annual mean and quarter 1 mean
- worst-case scenario - daily loading, including invertebrates, upper 95th percentile, annual mean and quarter 1 mean

There are a number of uncertainties in all of these calculations. The factors used to calculate the breakdown products are specific to one or a limited number of species or studies; they do not strictly apply to all fish/invertebrate species. In the absence of more or better data, it was considered acceptable to apply the factors universally.

The approach taken here can be considered precautionary, as it assumes 100% of the biomass discharged will sink immediately and not be re-suspended or advected over a larger area. This is contrary to the particle tracking study in NNB GenCo (2021d; TR511), which predicted 12% of dead sprat would be transported away from the FRR discharge point by tidal currents.

The approach also does not take account of accumulation, or consumption by detritivores. Our figures are thought to provide a worst-case acute impact. Given the location of the two SZC FRR system outlets, dispersal could be significant.

Our calculations for organic enrichment, using the reasonable ‘worst-case with invertebrates’ scenario, resulted in the largest potential area that could be affected by the FRR system discharge. This area is also called the ‘maximum potential area of organic exceedance’ to reflect the precautionary assumptions used in this analysis.

		TR520	TR520	EA calculations					
		Cefas		EA Baseline		EA Worst Case			
		w/o LVSE u95	with LVSE u95	Baseline no Invert u95	Baseline with Invert u95	Worst case no Invert	Worst case with Invert	Worst case no Invert u 95% c.l.	Worst case with Invert u 95% c.l.
Daily loading of impinged fish - Annual mean		1498	535	1,661	1,773	2,257	2,505	3,835	4,083
Daily loading of impinged fish - Q1 mean		3326	1187	3,700	3,812	5,917	6,063	7,900	8,046
Nutrient input	Max Daily P content (kg)	7.5	2.7	8.3	8.9	11.3	12.5	19.2	20.4
	Max Daily N content (kg)	52.4	18.7	58.1	62.1	79.0	87.7	134.2	142.9
Un-ionised ammonia	Total NH_4 (mg)	415,780	148,434	462,478	476,515	739,685	757,842	987,531	1,005,688
	Unionised ammonia from calculator (mg)	11,797	4,211	13,122	13,520	20,998	21,502	28,018	28,534
	Volume required to dilute to the EQS (l)	608,073	217,082	676,368	696,898	1,082,379	1,108,335	1,444,251	1,470,806
	Area required (m^2 area)	**152.02**	**54.27**	**169.09**	**174.22**	**270.59**	**277.08**	**361.06**	**367.70**
	Unionised ammonia from calculator with temperature uplift (mg)	13,741	4,906	15,284	15,748	24,459	25,046	32,637	33,237
	Volume litres required to dilute to the EQS with temperature uplift (l)	708,303	252,864	787,855	811,768	1,260,790	1,291,023	1,682,309	1,713,242
	Area required with temperature uplift (m^2 area)	**177.1**	**63.2**	**197.0**	**202.9**	**315.2**	**322.8**	**420.6**	**428.3**
Influence on dissolved oxygen	kg of BOD	4,191	1,496	4,662	4,803	7,456	7,639	9,954	10,137
	kg/day O_2 reduction	1,397	499	1,554	1,601	2,485	2,546	3,318	3,379
	Area needed to meet oxygen demand through reaeration (m^2 area)	436,569	155,855	485,602	500,341	776,669	795,735	1,036,907	1,055,973
	Area needed to meet oxygen demand through reaeration (km^2 area)	**0.437**	**0.156**	**0.486**	**0.500**	**0.777**	**0.796**	**1.037**	**1.056**
Organic enrichment	kg of carbon/day	3,326	1,187	3,700	3,812	5,917	6,063	7,900	8,046
	Area affected (m^2 area)	3,787,922	1,352,291	4,213,358	4,341,246	6,738,825	6,904,248	8,996,802	9,162,224
	Area affected (km^2 area)	**3.79**	**1.35**	**4.21**	**4.34**	**6.74**	**6.90**	**9.00**	**9.16**
	Area affected (% WB)	**3%**	**1%**	**3%**	**3%**	**5%**	**5%**	**6%**	**6%**
	Ellipse length (m)	**5,334**	**3,187**	**5,626**	**5,710**	**7,115**	**7,201**	**8,220**	**8,296**
	Ellipse width (m)	**904**	**540**	**953**	**968**	**1,206**	**1,221**	**1,393**	**1,406**

Figure 22. Summary of the predicted water quality effects of SZC's FRR system discharge.

Conclusion of FRR systems

The quantitative results from Figure 22 for 'worst-case with invertebrates upper 95th confidence level' scenario (termed 'Environment Agency reasonable worst-case scenario') were taken forward for consideration within our review of the WFD compliance assessment, our HRA report (HRAR) and Wildlife and Countryside (CRoW) Act assessment to consider the potential effects on water quality and protected species. The conclusion outcomes are summarised here.

Our WDA HRAR (Book 3) report concluded that the release and/or decay of biota discharged by the FRR systems will not lead to a deterioration in water quality that will affect designated features, resulting in a conclusion that there will be no adverse effect on integrity of sites alone or in combination. A summary is provided in section 4.12.

Our WFD compliance assessment report review concluded that the biota discharged out of the FRR systems does not give rise to any impacts that could compromise Water Environment (Water Framework Directive) Regulations 2017 (WER) objectives for water quality, habitats or fish. A summary is provided in section 4.14.

Our Wildlife and Countryside Act (CRoW) assessment concluded that the FRR system WDAs are not operations that are likely to damage the SSSIs as the biota discharged from the FRR systems will not result in the condition of the sites deteriorating, nor will it prevent them from improving or recovering where necessary. A summary is provided in section 4.13.

In coming to these conclusions, we consider that we have taken into account all relevant considerations and legal requirements, to ensure that the draft permit will provide the appropriate level of environmental protection, and that appropriate emission limits and monitoring requirements will be set in accordance with the assessment methodology.

Our assessment is precautionary, being based on the upper 95% confidence level of either the annual, or the Q1 (quarter 1 - January, February, March) mean daily loading of fish and invertebrates. These are 4,083kg biota impinged per day (annual mean daily loading) and 8,046kg biota impinged per day (Q1 mean daily loading).

4.11.15 Assessment of siltation

There will be a discharge of suspended solids as a part of the STP discharge (waste stream G). This will therefore be considered further to see if it could cause siltation (any potential to cause nutrient enrichment will be considered under the changes in nutrients/organic enrichment section).

WDA permits are typically given a standard limit regarding the concentration of suspended solids that can be discharged. This standard limit for an STP discharge is 30mg/l. This is less than the mean observed suspended solid concentration at the SZC outlet locations of 55.5mg/l (NNB GenCo, 2019a; TR314).

However, in addition to considering is the concentration of suspended solids being discharged, we should also consider the dilution. As a worst-case scenario when discharging 190m³/day for refuelling or outages due to maintenance, the STP discharge will receive around 60,000 times dilution via the 132m³/s cooling water flow before it reaches the Greater Sizewell Bay via the two cooling water outfalls. For typical day-to-day operation, a 90m³/day quantity will receive 126,270 times dilution via the cooling water flow before it discharges into the Greater Sizewell Bay.

It is therefore considered that the suspended solids ultimately discharged into the Greater Sizewell Bay as part of the STP discharge (waste stream G) will be low impact and too small to result in a conceivable effect.

4.11.16 Assessment of physical damage

The discharge of 132m^3/s of water from the two cooling water outlets has the potential to cause physical damage through scouring of the seabed.

The outlet heads will be located a few hundred metres away from the two northerly intakes and around a kilometre from the two southerly cooling intakes, with the two cooling water outlets being up to 8.0m deeper than the intakes (Figure 23). The natural turbidity of the North Sea within the Greater Sizewell Bay would therefore not be expected to differ between these intake and outlet locations, as reported in section 4.9.1. As the abstracted seawater passes through the cooling water system, the turbidity of the water being discharged will effectively be equal to that being abstracted.

NNB GenCo (SZC) has described how scour is likely to occur around both of the submerged cooling water outlets as a result of the disruption in local hydrodynamic flow patterns and how jet scour from the discharges will add to this (NNB GenCo, 2018; TR310). Worst-case scour depths of 4.67m (due to the structure) and 6.75m (jet scour) are predicted around the cooling water outlets, leading to an area of habitat change of around 0.5ha (5,000m^2) within the Outer Thames Estuary SPA. However, this is a conservative estimate as it assumed that the jet will be discharged at bed level, when it will in fact be offset above the bed.

The cooling water outlets will be of the same design as those used at HPC, with these being 3.2m high, with water discharging horizontally from the top of the structure (NNB Generation Company (HPC) Limited, 2016) (Figure 22). Also, cooling water forms a buoyant plume and so will quickly raise above bed level, further reducing the effect. While scouring may well take place in the short-term, in the longer term, an equilibrium would be expected such that over the lifetime of the project, the effects of jet scour or scour resulting from the structures themselves, will not significantly alter the turbidity of the surrounding water body.

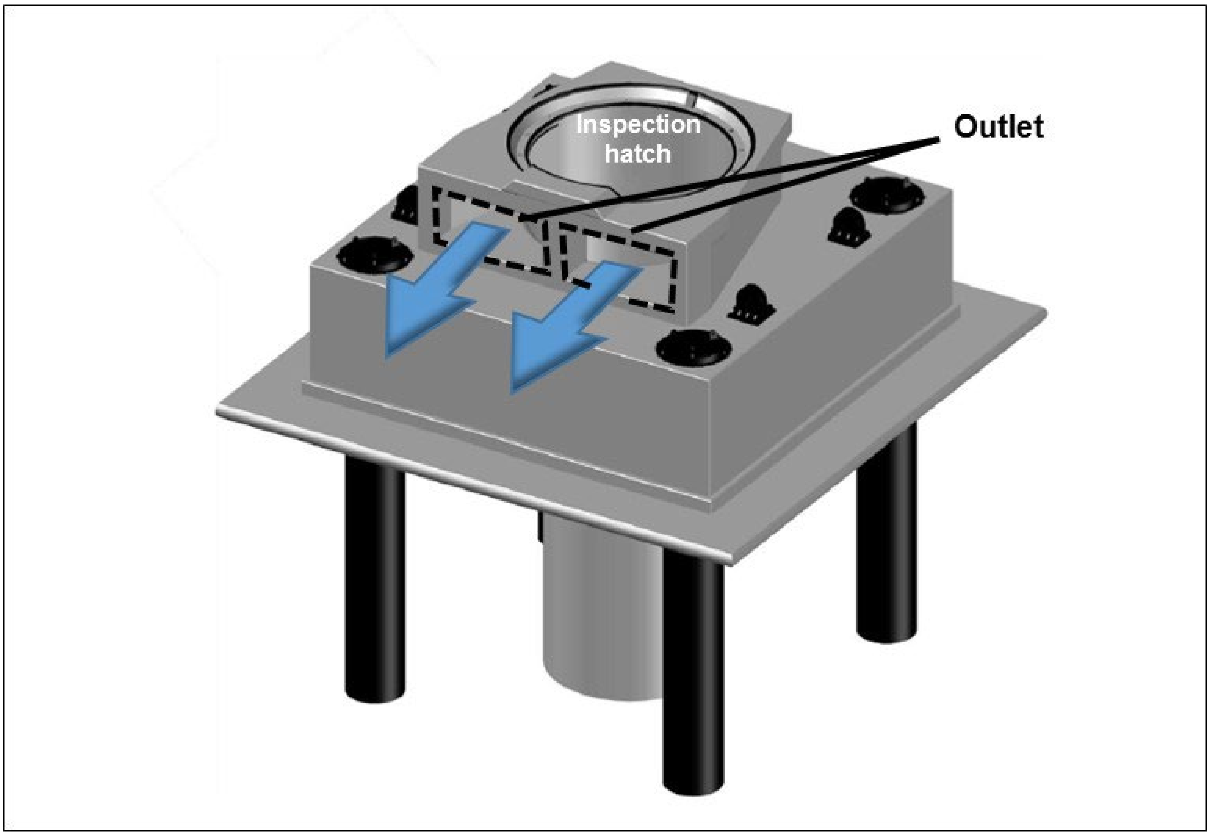

Figure 23. Three-dimensional view of the cooling water outlet structure showing how water is discharged parallel to, but raised above, the seabed (NNB Generation Company (HPC) Limited, 2016)

At 25,920m³/day, equivalent to 0.3m³/s, discharge from the 2 FRR system outlets is of a much lower volume than discharge from the two cooling water outlets, but will discharge further inshore than the cooling water abstraction point (Figure X).

As it will not have passed through the cooling water system, the two FRR system discharges will not form a buoyant plume. There will be no additional suspended solids added to the two FRR system discharges. NNB GenCo (2018; TR310) predicts worst case jet scour depths around the two FRR system outlets as being up to 0.74m, again noting this is a conservative assessment assuming the jet is discharged at bed level rather than being elevated above bed level as is planned.

Jet scour from the two FRR systems would not exceed the scour depth of up to 2.07m resulting from the effect of the outlet structure itself. As with the two cooling water outlets, scouring may take place in the short-term, but an equilibrium will be reached such that over the lifetime of the project, the effects of jet scour or scour resulting from the structures themselves will not significantly alter the turbidity of the surrounding water body.

The discharge of water from the CWS outlets and the FRR system outlets will not result in an increase in erosion or siltation of sufficient magnitude to result in a conceivable effect on the conservation objectives, so the discharges are considered to be low impact in terms of risk of physical damage.

4.12 Habitats Regulations assessment

In this section, we summarise how we have considered the potential impacts of the WDAs in relation to our duties under The Conservation of Habitats and Species Regulations 2017 (as amended), which are known as the Habitats Regulations.

Under Regulation 63 of the Habitats Regulations, before deciding to undertake or give a permit which:

(a) is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects)

(b) is not directly connected with or necessary to the management of that site

We must make an appropriate assessment of the implications for that site in view of that site's conservation objectives, and we must consult Natural England on the findings of this assessment.

We have therefore considered the potential effects of discharges to water from the operational SZC site on plant and animal life at the relevant designated European sites; Special Areas of Conservation (SAC), which are designated for important high quality habitat sites and rare species, Special Protection Areas (SPA) for the protection of rare and vulnerable birds, and Ramsar sites. Ramsar sites are wetlands of international importance designated under the Ramsar Convention, but it is government policy that they are given the same protection as SACs and SPAs. The habitats and species protected by these European sites are known as 'designated' habitats and species, or collectively as 'designated features'.

We have assessed NNB GenCo (SZC)'s WDA permit application in accordance with our guidance and concluded that for the purposes of the Habitats Regulations there was the potential for significant effects on several European sites, and so we undertook an appropriate assessment (Habitats Regulations assessment Stage 2) of those effects. We have made this available as part of our consultation on our proposed decision.

The conclusions in this section have been taken from our wider Habitats Regulations assessment report (HRAR), which for consideration of the operational SZC WDAs are assessed within Book 3.

We have consulted Natural England on the draft HRAR. They raised some minor points that we have addressed in our final HRAR for public consultation.

Due to the level of detail in our HRAR Book 3, it is not appropriate to reproduce entire sections in this decision document. The full HRAR document is available to review as part of our draft decision consultation available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space.

4.12.1 Screening for likely significant effects

Regulation 63(1) of the Habitats Regulations 2017 requires us, the competent authority, to carry out a screening exercise to identify those permissions, plans or projects (PPP) that are likely to have a significant effect on the features of a European site. These effects are then subject to appropriate assessment.

For our assessment, a very high level and precautionary likely significant effect (LSE) stage was carried out considering a simple source receptor pathway linkage (that is, is there a potential link between the discharge and designated species and/or habitat that are sensitive to the pollutant).

We took this approach due to the bespoke, complex and detailed modelling NNB GenCo (SZC) submitted with its application, and we determined that this should be used for an appropriate assessment and not an LSE screen. We also completed additional detailed assessment work to support our HRAR.

Our determination on likely significant effect is in line with case law which requires that where a project is 'likely to have a significant effect' if there is a real risk of a likely significant effect occurring that is, the risk of it occurring cannot be excluded on the basis of objective information.

If the absence of risk in the plan can only be demonstrated after a detailed investigation, or expert opinion, that is an indicator that a risk exists and the competent authority must move from preliminary examination to appropriate assessment.

For the WDAs LSE screening, the simple source receptor pathway approach can be summarised as follows:

1. Is there a pathway such that the potential hazard could affect the interest features alone? If it is considered there is no connectivity, or any connectivity or effect would be of low impact and too small to result in a conceivable effect on the feature or site, then no in-combination assessment is required.

2. What is the exposure of the feature to this hazard?

3. For each hazard, is the potential scale or magnitude of any effect likely to be significant? The aim of the screening process is to identify those hazardous chemicals and elements within the process waste streams that may contribute to the deterioration of the receiving water body. This may be through preventing the achievement of the conservation objectives for a European site.

The following are the reasonably foreseeable risks for this type of project, as generated via our internal habitats regulations assessment system (HRAS) database for WDAs:

1. changes in thermal regime
2. toxic contamination
3. nutrient enrichment

4. pH
5. change in salinity regime
6. physical damage
7. siltation
8. turbidity

However, we concluded that some of these risks are not relevant to the proposed operational WDAs at SZC, and so did not require further assessment within our HRAR. Following consideration of the above risks with the proposed WDAs, we took the decision to focus on, and complete a detailed assessment of, the following risks within our HRA assessment:

- changes in thermal regime (due to the increased temperature of the discharged cooling water)
- toxic contamination (from any chemicals discharged within the cooling water, such as TRO, bromoform and hydrazine)
- nutrient enrichment or eutrophication, including potential for turbidity from nutrient increases arising from the treated sewage effluent and other nutrient sources within the cooling water, and from the dead and moribund biota within the 2 FRR system discharges

The sources brought forward in our HRAR have been determined using our H1 screening methodology (Risk assessments for specific activities: environmental permits - GOV.UK). As previously discussed, our H1 methodology is used to identify any proposed hazardous chemical or other elements of discharges that represent a possible risk to the environment (as is required under the EPR 2016).

For marine discharges, the standard approach for determining the potential impacts to water quality from industrial aqueous discharges is to apply the screening of contaminant contributions from surface drainage sources, as per our H1 environmental risk screening assessment. Any substances identified as a potential risk in the H1 process are then subject to further analysis and potentially detailed modelling, which we then use as part of our decision-making within our HRA.

In addition to the above risks for the sites that the WDA discharges directly into (Southern North Sea SAC and Outer Thames Estuary SPA), our assessment also considered the potential for:

- siltation
- physical damage

The risks of siltation and physical damage were assessed for LSE for the Outer Thames Estuary SPA only. Based on the assessments within sections 4.11.15 and 4.11.16, we concluded no LSE (and no requirement for in-combination assessments) for both the risks of siltation and physical damage as a result of the WDAs from the two cooling water and two FRR system outfalls.

Within our WDA HRAR, the following European sites were considered for the potential for LSE from the remaining identified risks.

This is because these sites are either in direct connectivity with the proposed WDAs (via the 2 cooling water outfalls, and/or the 2 fish recovery and return system outfalls), or the sites are within the potential zone of influence (ZoI) and/or the Greater Sizewell Bay (GSB) area:

- Alde-Ore and Butley Estuaries SAC: located to the south of the main development site and there is therefore potential for water discharges to reach the site
- Alde-Ore Estuary SPA and Ramsar: located to the south of the main development site and there is therefore potential for marine water discharges to reach the site
- Benacre to Easton Bavents SPA: located approximately 15km from the main development site
- Minsmere to Walberswick Heaths and Marshes SAC: adjacent to the main development site so there is potential for the WDAs to interact with the site
- Minsmere-Walberswick SPA and Ramsar: adjacent to the main development site so there is potential for marine discharges to enter the freshwater element via the Minsmere Sluice
- Orfordness-Shingle Street SAC: located to the south of the main development site and there is therefore potential for marine water discharges to reach the site
- Outer Thames SPA: adjacent to the main development site and the operational outlet goes directly into the site
- Southern North Sea SAC: adjacent to the main development site and the operational outlet goes directly into the site

We have also considered and assessed the potential for LSE on the migratory and highly mobile features of more distant designated European sites (to establish whether they are ecologically functionally linked to the Greater Sizewell Bay area). The features of these more distance sites include seabirds, marine mammals and Annex II fish species:

- Coquet Island SPA and Flamborough and Filey Coast SPA, designated for seabirds
- Humber Estuary SAC and Ramsar, designated for grey seal, sea lamprey and river lamprey
- The Wash and North Norfolk Coast SAC, designated for harbour seals
- Plymouth Sound and Estuaries SAC, designated for the fish species, allis shad
- Ten continental sites which are Sites of Community Importance (SCI) designated for the fish species sea lamprey, river lamprey and twaite shad. These 10 continental sites are listed in our LSE screening table, which forms part of our HRAR

Within our HRAR, we have concluded no LSE effect alone and in combination from the SZC operational WDAs for the following designated features of certain sites:

- annual vegetation of drift lines, perennial vegetation of stony banks, European dry heath designated features of the Minsmere to Walberswick Heaths and Marshes SAC
- nightjar designated feature of the Minsmere to Walberswick SPA
- grey seal designated feature of the Humber Estuary SAC and Ramsar
- sea lamprey and river lamprey designated features of the Humber Estuary SAC and Ramsar and 10 continental SCI protected sites

- allis shad designated feature of the Plymouth Sound SAC
- twaite shad designated features of the 10 continental SCI protected sites

Using the LSE screening process, we therefore identified the following 10 European sites and their features to include within our appropriate assessment:

- Alde-Ore and Butley Estuaries SAC
- Alde-Ore Estuary SPA and Ramsar
- Benacre to Easton Bavents SPA
- Minsmere-Walberswick SPA and Ramsar
- Orfordness to Shingle Street SAC
- Outer Thames Estuary SPA
- Southern North Seas SAC
- The Wash and North Norfolk Coast SAC

Our appropriate assessment looked at whether changes in thermal regime (seawater temperature), toxic effects from chemicals, or nutrient enrichment could lead to an adverse effect on the features of these European sites.

The 2 cooling water discharge outlets, and 2 FRR system discharge outlets go directly into 2 European sites; the Outer Thames Estuary SPA designated for little tern, common tern and red throated diver, and the Southern North Sea SAC designated for harbour porpoise. Little tern, common tern, Sandwich tern and lesser black backed gull from nearby sites could also feed in the area.

We examined the modelling of the changes in temperature, toxic effects from chemicals, and nutrient enrichment and considered if they could affect these populations. The distances that these designated features travel to feed could mean that they are likely to come into contact with, and potentially be affected by, the area of discharge within the sea.

We also used the detailed computer modelling to see if the potentially hazardous chemicals and elements could reach other sites, or if mobile features from more distant sites could come into contact with the discharges.

In our appropriate assessment, we have fully considered each site in terms of their site-specific targets and pressures provided in the supplementary advice on conservation objectives (SACOs) relating to water quality (where these are available for each designated site, as they can also be of relevance to their coastal and freshwater supporting habitats):

- https://www.gov.uk/guidance/conservation-advice-for-marine-protected-areas-how-to-use-site-advice-packages
- https://www.gov.uk/guidance/conservation-objectives-for-land-based-protected-sites-in-england-how-to-use-the-site-advice

4.12.2 In-combination assessment for WDA operational permit

Regulation 63 of The Conservation of Habitats and Species Regulations 2017 requires the competent authority to consider within the HRAR, any permission, plans or projects (including Environment Agency permissions and plans/projects) that are likely to have a significant effect on a European site, either alone or in combination with other permissions, plans or projects (PPP).

Where permissions indicate a likely significant effect, these will be assessed in combination with each other and with other relevant plans and projects. The alone and in combination test is also carried out at the appropriate assessment stage.

4.12.3 In-combination assessment summary screening for likely significant effects

Our in-combination assessment has considered the potential for in-combination effects between other relevant PPP for the WDA draft permit risks of change in thermal regime, toxic contamination (chemicals) and nutrient/organic enrichment.

This included considering the effect between the 3 SZC operational EPR permits being applied for (WDA, RSR and CA) and between the different waste streams of the operational WDAs (waste streams A to H).

Construction of the SZC power station will require additional EPR permits, which NNB GenCo (SZC) has yet to apply for. There is insufficient information at this stage to include effect of construction permits as part of the in-combination assessment although we have taken into consideration the construction discharges NNB GenCo (SZC) provided in its H1 screening risk assessment (NNB GenCo, 2021a: TR193), but we have not reviewed these in detail. Defra guidance (February 2021) states in-combination assessment should be undertaken with applications that have been submitted which is not the case here. When the SZC construction EPR permits are applied for, they will be subject to HRAs.

From the information currently available, we concluded that there are no in-combination effects between the operational and construction WDAs.

Change in thermal regime

The only PPP where there is potential for an in combination change in thermal regime is SZB, for the relevant sites and features (seabirds and marine mammals). We assessed this in detail in the seabird and harbour porpoise features chapter (section 8) of Book 3 of our HRAR. We concluded that there was no adverse effect on the relevant features of the European sites.

Toxic contamination (chemical)

Our in-combination assessment considered other PPP that might contribute to in-combination effects. Of these, the only risk was with the potential for re-suspension of contaminants from construction of offshore windfarms. However, we were able to discount these effects as any changes to water quality would be very localised, temporary and for a short duration, with normal conditions returning rapidly once activity stops. While this is a risk, we considered there is no potential for an in-combination effect with the operational WDAs of SZC.

Nutrient and organic enrichment

The only PPP that requires an in-combination assessment for nutrient or organic enrichment is the Sizewell A and B sewage treatment plant (STP) discharge outlet (as SZA and SZB share a STP).

The operational WDA alone assessment was carried out in the context of the prevailing environmental conditions with current water quality, including SZA and SZB, considered within this baseline. The supplementary advice on conservation objectives (SACO) for the Outer Thames Estuary SPA provides a target for the supporting habitat of the designated marine birds to “maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgae and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing.”

There are no indicators of eutrophication within the Outer Thames Estuary SPA, and NNB GenCo (SZC)’s modelling has shown that there will be no deterioration in water quality from the operational WDAs, in the context of the prevailing environmental conditions. We concluded there is no potential for an in-combination effect with SZC.

4.12.4 In-combination assessment conclusion

We therefore considered that there is no adverse effect in-combination between the SZC operational WDA draft permit and other PPPs on the features of the following designated sites:

- Alde-Ore Estuary SPA
- Alde-Ore Estuary Ramsar
- Benacre to Easton Bavents SPA
- Minsmere-Walberswick SPA
- Orfordness to Shingle Street SAC
- Outer Thames Estuary SPA
- Southern North Sea SAC
- The Wash and North Norfolk Coast SAC

4.12.5 Appropriate assessment conclusion

Our appropriate assessment determined whether the risks associated with the operational WDAs via toxic contamination, change in thermal regime or nutrient enrichment could lead to an adverse effect on the features of the sites where a likely significant effect (LSE) was identified.

We were able to conclude no adverse effect on the features of the European sites where a likely significant effect had been identified alone or in combination, in view of the sites’ conservation objectives.

Integrity test

Regulation 63(5) of the Habitats Regulations requires that a competent authority "shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned."

The European Union's Managing Natura 2000 guidance (Commission Notice C(2018)) explains the concept of the 'integrity of the site' at section 4.6.4 as the "coherent sum of the site's ecological structure, function and ecological processes, across its whole area, which enables it to sustain the habitats, complex of habitats and/or populations of species for which the site is designated."

We do not consider that, for those European sites requiring appropriate assessment, the operational WDAs from SZC will impact on their ecological structure, function and ecological processes across their whole area, as identified in the Managing Natura 2000 guidance.

We were able to reach this conclusion due to the bespoke modelling results which confirmed that the effects identified would be low impact and too small to undermine the achievement of the conservation objectives or would have no connectivity with the more distant sites. Site integrity cannot be considered to be adversely affected if the conclusions of an appropriate assessment demonstrate that the conservation objectives will not be undermined alone or in combination with other PPP.

Conclusion details for each site included in our appropriate assessment

We have completed an appropriate assessment and concluded that the operational WDAs at SZC can be ascertained to have no adverse effect on the integrity of the following sites, either alone or in combination with other plans and projects:

- Alde-Ore and Butley Estuaries SAC
- Alde-Ore Estuary SPA and Ramsar
- Benacre to Easton Bavents SPA
- Minsmere-Walberswick SPA and Ramsar
- Orfordness to Shingle Street SAC
- Outer Thames Estuary SPA
- Southern North Sea SAC
- The Wash and North Norfolk Coast SAC

These conclusions are not dependent on any specific mitigation measures or conditions within the WDA permit.

Our conclusions of no adverse effect in combination for the above sites are also based on the best available information from NNB GenCo (SZC) for within project effects from the operation and construction of SZC. Full in-combination assessments will be carried out when NNB GenCo (SZC) makes environmental permit applications for WDAs into the marine environment associated with the construction of SZC and the conclusions of this appropriate assessment do not prejudge the outcome of those future assessments or preclude a different outcome.

Alde, Ore and Butley Estuaries SAC

For the Alde, Ore and Butley Estuaries SAC, we have concluded no adverse effect alone and in combination for the designated features of the Alde, Ore and Butley Estuaries SAC. We also considered impacts on the freshwater features of the SAC due to potential connectivity between them and the operational WDAs. These designated features are Atlantic salt meadows, estuaries, mudflats and sandflats (not covered by seawater at low tide).

For changes in thermal regime, we concluded that the extent of the SZC thermal plume would not reach the SAC, as is the plume will be located over 12km to the north of the SAC.

For toxic contamination, the modelled plumes for TRO, bromoform and hydrazine are offshore, so there will be no connectivity with the SAC or its estuary features.

For nutrient enrichment, our assessment showed that there is no predicted increase in organic or nutrient enrichment in the Greater Sizewell Bay area, and therefore there will be no effect on the SAC or its estuary features.

We also do not believe that the operational WDA permit will impact on the Alde, Ore and Butley Estuaries SAC ecological structure, function and ecological processes across its whole area. We were able to reach this conclusion due to the modelling results confirming that the effects identified would not reach the SAC and would therefore be unable to undermine the achievement of the site's conservation objectives.

Alde-Ore Estuary SPA and Ramsar

For the Alde-Ore Estuary SPA and Ramsar, we have made a conclusion of no adverse effect alone and in combination for the following features, as bespoke modelling showed there will be no connectivity between the discharges and the site.

For the estuary's SPA features this conclusion applies to avocet, marsh harrier, ruff avocet, marsh harrier, ruff and redshank. For the estuary's Ramsar features this conclusion applies to avocet, redshank, waterbird assemblage (wintering), wetland bird assemblage (breeding), wetland invertebrate assemblage and wetland plant assemblage.

We have also considered functional linkage between the marine bird species of the Alde-Ore Estuary SPA and Ramsar, and the area of the Outer Thames Estuary SPA into which the operational SZC discharges. A conclusion of no adverse effect was also made alone and in combination for little tern, Sandwich tern and lesser black-backed gull, as these are functionally linked designated features of the SPA and Ramsar which forage offshore.

For aqueous contaminants, we concluded that there will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding Sandwich tern and little tern feature or reach the SPA and Ramsar site itself.

The decay of biota discharged by the 2 FRR systems will not lead to the release of unionised ammonia to the extent that there will be a deterioration in water quality that will affect the breeding little tern, lesser black-backed gull and Sandwich tern features or affect the water quality in the SPA and Ramsar itself.

For dissolved oxygen (DO), we concluded that the decay of dead and moribund biota discharged by the 2 FRR systems will not lead to a deterioration of existing levels of DO concentration in the offshore marine environment or within the SPA and Ramsar.

For dissolved inorganic nitrogen (DIN), we concluded that discharges from the cooling water and FRR systems will not lead to increases in DIN levels to the extent that indicators of eutrophication affect in the offshore marine environment or within the SPA and Ramsar.

For turbidity, we concluded that discharges of nutrients from the cooling water and FRR systems will not lead to significant increases in turbidity in the offshore marine environment or within the SPA and Ramsar.

We also reached these conclusions when considering the overlapping operation of SZC and SZB for the offshore foraging birds.

Despite the decline in numbers of breeding pairs of little tern since the site was designated (from 48 pairs to no longer being regularly occupied), the scale of impacts from the discharges from the cooling water and FRR systems, compared to the foraging area of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the little tern feature of the SPA.

Despite the considerable decline in numbers of breeding pairs of Sandwich tern, from 100 to 300 breeding pairs (1993 to 1996) to less than 10, and often no, breeding pairs per year (1997 to 2009), the scale of impacts from the discharges from the cooling water and FRR systems, together with the flexibility in foraging behaviour of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the Sandwich tern feature of the SPA.

Despite the considerable decline in numbers of breeding pairs of lesser black-backed gulls since the site was designated (from >14,000 to <2,000 breeding pairs), the scale of impacts from the discharges from the cooling water and FRR systems, compared to the foraging range and generalist diet of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the lesser black-backed gull feature of the SPA and Ramsar.

We are of the opinion that the operational WDA permit will not impact the Alde-Ore Estuary SPA's ecological structure, function and ecological processes across its whole area due to impacts on the foraging birds functionally linked to the SPA or Ramsar. We were able to reach this conclusion due to the modelling results confirming that the effects identified above would be low impact and too small to undermine the achievement of the conservation objectives.

Benacre to Easton Bavents SPA

Consideration was given to functional linkage between the little tern of the Benacre to Easton Bavents SPA and the area of the Outer Thames Estuary SPA into which the operational SZC WDAs discharge.

We do not believe that the operational WDA permit will impact on the Benacre to Easton Bavents SPA's ecological structure, function and ecological processes across its whole area. We were able to reach this conclusion due to the modelling results confirming that the effects identified would not reach the SPA and would therefore be unable to undermine the achievement of the site's conservation objectives.

Minsmere-Walberswick SPA and Ramsar

For the Minsmere-Walberswick SPA and Ramsar, our conclusion of no adverse effect was made alone and in combination for the SPA designated features, which are the hen harrier, teal, greater white-fronted goose fronted goose, avocet, marsh harrier, shoveler and gadwall.

We have considered the functional linkage between the little tern of the Minsmere-Walberswick SPA and the area of the Outer Thames Estuary SPA into which the operational SZC discharges, for which we made a conclusion of no adverse effect alone and in combination.

We considered impacts on the freshwater SPA features due to a potential connectivity between the operational WDAs via the Minsmere sluice. However, we concluded that although there is connectivity between the sites and the point of discharge via the Minsmere Sluice, the thermal and chemical plumes (for TRO, bromoform and hydrazine) are located so far offshore that they will not reach the sluice intake.

The nutrient and organic enrichment risks from the treated sewage effluent from SZC's STP and the 2 FRR system discharges will not cause a deterioration in water quality in the marine environment and will therefore not alter the water quality of the freshwater environment or have indirect effects on eels as prey items of bittern. We therefore made a conclusion of no adverse effect alone and in combination.

We also concluded no adverse effect alone and in combination for the Ramsar designated features, which are the mosaic of marine, freshwater, marshland and associated habitats, the wetland bird assemblage (breeding) and wetland invertebrate assemblage.

For the areas offshore that are considered functionally linked for little tern, we concluded that there will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded. However, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding little tern feature.

The decay of biota discharged by the FRR systems will not lead to the release of unionised ammonia to the extent that there will be a deterioration in water quality that will affect the breeding little tern feature.

For dissolved oxygen (DO), we concluded that the decay of dead and moribund biota discharged by the FRR systems will not lead to a deterioration of existing levels of DO concentration within the offshore foraging areas functionally linked to the Minsmere-Walberswick SPA.

For dissolved inorganic nitrogen (DIN), we concluded that the discharges from the cooling water and FRR systems will not lead to increases in DIN levels to the extent that indicators of eutrophication affect the offshore foraging areas functionally linked to the SPA.

For turbidity, we concluded that the discharges from the cooling water and FRR systems will not lead to significant increases in turbidity associated with potential nutrient increase within the offshore foraging areas functionally linked to the SPA.

Similarly, we determined that there is minimal interaction with the discharges from the cooling water systems and the FRR systems of SZC and SZB combined.

Despite the decline in numbers of breeding pairs of little tern since the site was designated, from 32 breeding pairs at the time of classification (1991) to 1.6 breeding pairs (5 year mean peak count 2014 to 2018), from the scale and location of impacts from the discharges from the cooling water and FRR systems, compared to the potential foraging area of the little tern and areas of its concentrated foraging activity, coupled with the transitory nesting behaviour and meta-population structure of the little tern, we were able to conclude that there will be no adverse effect alone or in combination on the SPA.

We are of the opinion that the operational WDA permit will not impact on the SPA or Ramsar's ecological structure, function and ecological processes across its whole area. We were able to reach this conclusion due to the modelling results confirming that the effects identified would be low impact and too small to undermine the achievement of the conservation objectives.

Outer Thames Estuary SPA

For the Outer Thames Estuary SPA, our conclusion of no adverse effect was made alone and in combination for the SPA's designated bird species features, which includes the little tern, common tern and red throated diver. Our conclusions are based on the best available information from NNB GenCo (SZC) for within project effects from the operation and construction of SZC.

For aqueous contaminants, we concluded that although there will be mixing zones in which the EQS/PNEC values for TRO, bromoform and hydrazine will be exceeded, these will not be large enough to result in deterioration in water quality at a scale which will affect the breeding little tern feature.

The decay of biota discharged by the FRR systems will not lead to the release of unionised ammonia to the extent that there will be a deterioration in water quality that will affect the designated features of the SPA.

For dissolved oxygen, we have concluded that the decay of dead and moribund biota discharged by the FRR systems will not lead to a deterioration from existing levels of DO concentration within the SPA.

For dissolved inorganic nitrogen (DIN), we have concluded that the discharges from the cooling water and FRR systems will not lead to increases in DIN levels to the extent that indicators of eutrophication affect the SPA.

For turbidity, we have concluded that the discharges from the cooling water and FRR systems will not lead to significant increases in turbidity within the SPA.

Similarly, we have determined that there is minimal interaction with the discharges from the cooling water systems and the FRR systems of SZC and SZB combined.

Despite an overall decrease in numbers of breeding pairs of little tern since the site was designated, from 451 breeding pairs at, or near, the time of the constituent breeding colony's classification to 373 breeding pairs (2011 to 2015), the scale and location of impacts from the discharges from the cooling water and the FRR systems, compared to the potential foraging area and areas of concentrated foraging activity of all constituent colonies, coupled with the transitory nesting behaviour and meta-population structure of the feature, allows us to conclude that there will be no adverse effect alone or in combination on the little tern feature of the SPA.

Due to its relatively recent designation, population trends for the common tern (breeding) feature of the Outer Thames Estuary SPA are not available (Marine site detail (naturalengland.org.uk)). However, the scale and location of impacts from the discharges from the cooling water and FRR systems, compared to the potential foraging areas of all common tern colonies supported by the Outer Thames Estuary SPA, coupled with the relatively generalist diet and variety of foraging methods available to common terns, allows us to conclude that there will be no adverse effect on the comment tern feature of the SPA.

The operational WDAs from SZC will take place within the north-western section of the Outer Thames Estuary SPA. Although the density of red-throated divers has been observed to be lower in the southern section than in the north-western section, the north-western section is used by, and is of importance to, the non-breeding red-throated diver feature. The scale of impacts from the discharges from the cooling water and FRR systems, compared to the extensive home range and opportunistic diet of the non-breeding red-throated diver feature, allows us to conclude that there will be no adverse effect on the red throated diver feature of the SPA.

Additionally, we do not believe that the operational WDA permit will impact on the SPA's ecological structure, function and ecological processes across its whole area. We were able to reach this conclusion due to the modelling results confirming that the effects would be low impact, and too small to undermine the achievement of the SPA's conservation objectives.

Southern North Sea SAC

For the Southern North Sea SAC, our conclusion of no adverse effect was made alone and in combination for the SAC's relevant designated feature, the harbour porpoise. Our conclusions are based on the best available information from NNB GenCo (SZC) for within project effects from the operation and construction of SZC.

For water and prey quality, we have concluded that due to the small proportion of the Southern North Sea SAC experiencing thermal uplift or chemical exceedance (for TRO, bromoform and hydrazine), and the low level of organic input relative to the size of the SAC, the water discharge activities of SZC alone, will not have an effect on water quality of sufficient magnitude to affect the harbour porpoise feature or its supporting habitats. Prey quality will also not be affected.

We have concluded that there is no risk of bioaccumulation of TRO, chlorinated by-products, or hydrazine discharged by SZC alone. Similarly, we have determined that there is minimal interaction with the discharges from the cooling water and FRR systems of SZB and SZC combined.

We are of the opinion that the operational WDA permit will not impact on the Southern North Sea SAC's ecological structure, function and ecological processes across its whole area. We were able to reach this conclusion due to the modelling results confirming that the effects identified be low impact and too small to undermine the achievement of the SAC's conservation objectives.

The Wash and North Norfolk Coast SAC

For the Wash and North Norfolk Coast SAC, our conclusion of no adverse effect was made alone and in combination for the SAC's relevant functionally linked designated feature, the harbour seal, which forages offshore.

Thermal uplift and discharges of polluting chemicals (TRO, bromoform and hydrazine) will occur off the Sizewell coast. However, the areas affected via the thermal and chemical plumes are small compared to the foraging area of harbour seals from The Wash and North Norfolk Coast SAC as they travel between the site and the Thames Estuary which is considered to be functionally linked.

We have concluded that there is no potential for nutrient enrichment to affect the ability of the water column habitat to support the foraging behaviour of the harbour seal feature.

The scale and location of impacts from the discharges from the cooling water and FRR systems, together with the distance from haul-out sites within the SAC, allows us to conclude that there will be no adverse effect on the harbour seal feature of the Wash and North Norfolk Coast SAC.

We are of the opinion that the operational WDA permit will not impact on the Wash and North Norfolk Coast SAC's ecological structure, function and ecological processes across its whole area. We were able to reach this conclusion due to the modelling results confirming that the effects identified would be low impact and too small to undermine the achievement of the SAC's conservation objectives.

4.12.6 Differences in approach between the Information provided within NNB GenCo (SZC)'s Appendix C (information report for the HRA) and our WDA HRA

NNB GenCo (SZC) provided information about in-combination with other, non SZC, plans and projects. However, NNB GenCo (SZC) did not provide any within project in-combination, such as:

- between differing permits applied for
- between construction and permitting (where information was available), although some information was provided within TR193
- no indication of the temporal overlap between construction, commissioning and operation
- no consideration of the potential for interaction between the different waste streams; for example, the potential for the thermal plumes to interact with the chemical plumes

To address these issues, we required additional information, for which we issued Schedule 5 No.5 and No.6 to NNB GenCo (SZC). NNB GenCo (SZC) provided responses to our requests by allowing these potential in-combination effects to be considered within our HRA's appropriate assessment.

There were other differences we identified too:

At LSE, NNB GenCo (SZC) ruled out sites that we, and Natural England (NE) felt should go through to appropriate assessment and due to the amount of detailed modelling that was used to rule out LSE.

NNB GenCo (SZC) did not consider all the relevant information within the advice packages provided by Natural England (as requested by our Schedule 5 No.5 request notice for additional information).

In some cases, NNB GenCo (SZC) did not clearly assess the effects of SZC alone (the permission being applied for), before considering SZC in combination with SZB.

The foraging ranges of breeding sea birds are a way to ascertain if the designated features could be affected by an activity or permit. NNB Genco (SZC) used the best available information at the time of its WDA permit submission; by using foraging ranges quoted in a scientific paper by Thaxter published in 2012, with additional species-specific information where this was available.

However, in 2019 an updated paper became available (Woodward and others, 2019) which is now considered the best available evidence. We therefore used this within our HRAR.

NE also advised us that to be consistent with windfarm applications, and to reflect the fact that there can be considerable variation in foraging ranges, we should use the Woodward and others 'mean maximum' ranges plus one standard deviation to determine the potential for connectivity with distant sites. The use of ‘mean maximum + 1SD’ is consistent with assessments made for offshore windfarms. This meant that we considered more distant sites than the NNB GenCo (SZC)’s HRA information report.

NNB GenCo (SZC) also used current locations of breeding sea bird colonies such as little tern for its assessment. Acknowledging the fact that these nesting colonies can move over time, we asked for a consideration of the closest coastal point as a worst-case scenario. Information was provided in response to our Schedule 5 notices No.5 and No.6, which we then considered in our HRAR.

NNB GenCo (SZC) screened out waste stream G (the STP discharge of treated sewage) at LSE stage, and the FRR discharge is considered only in relation to seabirds feeding on dead or moribund biota (NNB, 2021, p63, Table 5.4).

Where NNB GenCo (SZC) considers there to be LSE, this is due to:

- seabirds “avoiding the areas of thermal increase, thus possibly reducing feeding opportunities” (Table 5.4, page 63)
- seabirds similarly avoiding areas due to the chemical plume (Table 5.4, page 63)
- ‘there is the possibility that avian prey species will avoid areas of the thermal plume and this may reduce the feeding opportunities for marine birds’ (5.3.26, page 61, Note – there appear to be two 5.3.26s in NNB GenCo (SZC)’s HRA information report)
- “fish may avoid areas with elevated levels of chemicals in the water column, particularly those like chlorine and its’ by-products, which can cause irritation of the skin or other sensitive organs such as gills. This can cause a reduction in feeding opportunities for marine birds” (5.3.27, page 62)

In its relevant representations advice, provided through the SZC DCO process, NE has stated that it is not satisfied with NNB GenCo (SZC)’s HRA information, due to the potential effects of “direct exposure of foraging birds to changes in marine water quality, temperature and turbidity, arising from the intakes and outfalls, CDO (combined drainage outfall) and drilling chemical discharges” not having been addressed (Relevant reps advice 30/0920).

We considered that, in addition to the direct input of dead and moribund biota, pathways also exist via potential water quality effects, resulting in the breakdown of this matter. Determining the extent of potential water quality effects requires predicting the numbers of impinged fish and modelling the effects on water quality that may result from their decomposition. Consequently, we did not screen out effluents from the FRR system at the LSE stage, but we did consider this pathway in our appropriate assessment.

Consideration of direct effects on sea birds: This was not considered by NNB GenCo (SZC). NE raised this during DCO, but it was not raised during the evidence plan, and so was not investigated by NNB GenCo (SZC). However, we have considered this within our WDA HRA.

We refined the approach to the biomass being discharged from the 2 FRR systems, taking into account some uncertainty in the sampling method SZB used due to overflowing bulk samples, as discussed in section 4.11.14.

4.12.7 Consultation with Natural England

On 15 February 2022, we sent our draft HRAR for the operational WDAs at SZC to Natural England for consultation. We have had regard to the comments raised in accordance with Regulation 63 of the Habitats Regulations 2017.

4.13 Conservation duties (other than Habitats Regulations)

In this section, we have considered the impact of the proposed discharges on the environment in relation to our duties under other statutory conservation provisions. We refer to these as 'conservation duties'.

Section 6(1) of the Environment Act 1995 (conservation duties with regard to water)

We have considered whether we should impose any additional requirements in relation to our duty to promote the conservation and enhancement of the natural beauty and amenity of coastal waters, and the conservation of flora and fauna that depend on the water environment under section 6(1) of the Environment Act 1995. We believe that the conditions of the environmental permit will be sufficient, and, therefore, have not identified any other requirements.

Section 6(6) of the Environment Act 1995 (fisheries duty)

Section 6(6) of the Environment Act 1995 imposes a duty to maintain, improve and develop fisheries. We have taken account of this duty, particularly with respect to the passage of migratory species in terms of potential impacts associated with the thermal and chemical plumes of the cooling water discharge, as well as the discharges from the 2 FRR systems. We are satisfied that the permit conditions are sufficient to make sure we carry out our duties appropriately. For that reason, we do not consider that different or additional measures are needed.

Section 7 of the Environment Act 1995 (pursuit of conservation interests)

Section 7(1)(c) of the Environment Act 1995 places a duty on us when considering any proposal to consider the effect this would have on the economic and social wellbeing of local communities in rural areas, and to take into account any effect the proposal would have on the beauty or amenity of any rural area. We consider that the conditions of the environmental permit are sufficient in this case.

Section 8 Environment Act and Section 28I Wildlife and Countryside Act 1981

Under Section 28I of the Wildlife and Countryside Act 1981, we have a duty to consult the relevant conservation body, Natural England (NE) in relation to any permit that is likely to damage a Site of Special Scientific Interest (SSSI).

We have completed assessments under the Wildlife and Countryside Act (CRoW) for the following 4 Sites of Special Scientific Interest (SSSI) as they have all been identified as being potentially at risk from the operational WDAs from SZC.

- Alde-Ore Estuary SSSI
- Leiston to Aldeburgh SSSI
- Minsmere-Walberswick Heaths and Marshes SSSI
- Pakefield to Easton Bavents SSSI

The operational discharges from SZC will result in the creation of a thermal plume and a chemical plume (for TRO, bromoform and hydrazine), and will also result in areas of nutrient and organic enrichment as a result of waste discharges and discharge from the site's 2 FRR systems.

NNB GenCo (SZC) carried out a detailed assessment looking at the nature of the tidal cycle within the area to help define a potential zone of influence (ZoI) of the operational WDAs (NNB GenCo, 2021a; TR193). The aim of the ZoI was to provide an initial reference point for considering the spatial and temporal area of impacts of discharges from the site.

For SZC, discharges occur both within the Sizewell-Dunwich Bank (via the 2 outlets serving each of the 2 FRR systems as waste stream H) and beyond it (via the 2 cooling water outlets for waste streams A to G) within the Greater Sizewell Bay. NNB GenCo (SZC) used several methods to determine the volume of water that may be influenced by these discharges. We agree with the applicant that SSSIs beyond the geographic extent of the areas defined by these methods can be considered to be outside the ZoI of the discharges.

The normal seaward limit of a SSSI is above mean low water mark (Defining ASSI/SSSIs with 'marine biological components' and setting out a process for determining their contribution to the UK MPA network (jncc.gov.uk)). This means that there is limited direct connectivity of the ZoI with any of the SSSI sites along the Suffolk coast, as the operational WDAs are into the marine environment. Despite this, there is potential for notified features of the sites, especially mobile species such as birds, to forage offshore from the SSSI, so we need to consider any connectivity. The coastal SSSIs within this broad ZoI are from north to south as follows:

- Pakefield to Easton Bavents SSSI
- Minsmere-Walberswick Heaths and Marshes SSSI
- Leiston to Aldeburgh SSSI
- Alde-Ore Estuary SSSI

In line with our statutory duties, we have therefore completed an assessment in which we have fully assessed the risks that the SZC operational discharges pose, to conclude whether or not there will be an impact to the 4 SSSIs and if so, how significant the impact(s) will be.

Our CRoW assessment will determine whether:

1. there is a potential risk from the WDA permit application, which could affect the features of the identified 4 SSSIs, either directly or indirectly, and if the features are sensitive to the relevant risks
2. there is a pathway such that the potential risk could affect the interest features of the identified SSSIs, and the exposure of the feature to this risk
3. for each risk, the potential scale or magnitude of any effect could result in an operation likely to damage the features of the SSSIs

NNB GenCo (SZC) has provided information and modelling to inform our assessment, and we have reviewed this information. Using advice from Natural England on 'Operations likely to damage the special interest' for the 4 SSSIs, we consider the relevant operation for all 4 sites to be 'the dumping, spreading or discharge of any materials'.

We consider this the relevant operation under NE's guidance, as the operation of SZC will result in discharges of effluent that could potentially impact on the sites and their notified features. For example, the cooling water discharges will result in a chemical and thermal plume, while the 2 FRR systems will result in a discharge of organic matter, dead and moribund fish. The discharge from the FRR systems may cause an increase in nutrient enrichment and potentially alter the water quality, along with the discharge of treated sewage (waste stream G) that could likewise impact on the water quality.

Our CRoW assessment was made to determine whether there will be any damage to the SSSIs because of these discharges, based on the potential risks of change to thermal regime, toxic contamination and nutrient enrichment.

It is our conclusion that the pathway of potential impact for the 4 SSSI sites is limited. The detail for this is provided within our CRoW assessment, but is summarised here.

For Minsmere-Walberswick Heaths and Marshes SSSI, damage as a result of the SZC operational WDAs can only occur via the Minsmere Sluice, or via indirect effects on European eel, which is a prey species for bittern. The thermal and chemical plumes will not reach the site via this mechanism due to the plumes occurring far offshore, and the organic and nutrient enrichment will not be at a level high enough to result in damage to the site or its notified species. The WDAs of SZC will not affect the ability of eel to migrate into the SSSI, and consequently their availability as a food source for bittern.

For Leiston to Aldeburgh SSSI, all the notified features are located above the mean high watermark, and therefore the thermal plume, chemical plume or the area of organic enrichment will not reach the site for any damage to occur.

For the Alde-Ore Estuary SSSI and Pakefield to Easton Bavents SSSI, the thermal and chemical plumes, and the area of organic enrichment cannot reach the site, and the only potential pathway for damage is for breeding seabird species that venture offshore for feeding. Our assessment concluded no damage to these SSSIs due to the small scale of the temperature, chemical and nutrient/organic matter plumes.

Following our assessment, we have concluded the proposed WDA permission is not likely to damage any of the flora, fauna or geological or physiological features which are of special interest of the 4 SSSIs.

We have therefore concluded that the WDAs of the operational SZC power station are not operations likely to damage the Pakefield to Easton Bavents SSSI, Minsmere-Walberswick Heaths and Marshes SSSI, Leiston to Aldeburgh SSSI or to the Alde-Ore Estuary SSSI.

The 4 SSSIs included in our CRoW assessment also legally underpin several European designated sites:

- Minsmere-Walberswick Heaths and Marshes SSSI underpin the Minsmere to Walberswick Heaths and Marshes SAC, the Minsmere-Walberswick Ramsar and the Minsmere–Walberswick SPA
- Alde-Ore Estuary SSSI underpins the Alde, Ore and Butley Estuaries SAC, the Alde-Ore Estuary Ramsar, the Alde-Ore Estuary SPA and Orfordness to Shingle Street SAC
- Pakefield to Easton Bavents SSSI underpins Benacre to Easton Bavents SPA and SAC

The detailed evidence and reasoning for making the above conclusions is provided within the technical sections of our CRoW assessment.

Some of the features designated under the SSSIs are replicated across these associated European sites. The potential for impact on the European sites has been fully considered separately in our HRAR Book 3.

Our CRoW assessment is available for review as part of our 'minded to' consultation process for our draft SZC WDA permitting decision, available at [Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space]

The methodology and approaches used to assess the potential impact in our CRoW assessment are the same as those used in our HRAR for the equivalent European sites, and where appropriate, information and main arguments presented in the HRAR are replicated within our CRoW assessment.

We have considered the application in the context of the 4 SSSIs, and concluded that the proposed WDAs will not cause damage to any of these SSSIs. We will share our CRoW assessment with NE as part of our public consultation.

Section 28G of the Wildlife and Countryside Act 1981

Under [Section 28G] of the Wildlife and Countryside Act 1981, we have a duty to take reasonable steps to further the conservation and enhancement of the flora, fauna or geological or physiographical features by reason of which a site is of special scientific interest (SSSI). As mentioned, we have formally given notice to NE of our conclusion that the proposed WDAs will not cause damage to Pakefield to Easton Bavents SSSI, Minsmere-Walberswick Heaths and Marshes SSSI, Leiston to Aldeburgh SSSI or Alde-Ore Estuary SSSI.

Section 85 of the Countryside and Rights of Way Act 2000

Section 85 of the Countryside and Rights of Way Act 2000 places a duty on us to consider conserving and enhancing the natural beauty of the Area of Outstanding Natural Beauty (AONB) when carrying out any of our work in relation to, or so as to affect, land in such an area. We have considered the application in the context of the Suffolk Coast and Heaths AONB. We have considered whether we should impose any further requirements, but believe that existing proposed conditions in the proposed draft permit are sufficient.

4.14 Duties arising under legislation

In the following sections, we describe how we have assessed the impact of the proposed SZC operational water discharge activities (WDAs) in relation to our duties under the legislation (or statutory provisions) relevant to this WDA environmental permit application.

Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (Statutory Instrument 2017 No.407) (WER)

Introduction

The Water Framework Directive (WFD) was a European directive (2000/60/EC) which was transposed into UK law in 2003. Its requirements are now encompassed within the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (WER); Regulation 3 of the WER imposes a general duty on us to exercise our functions so as to secure compliance with the requirements of the WFD.

The WER imposes legal requirements to protect and improve the water environment.

Reference is made to the WFD in documents used in this assessment, since they were created prior to enacting the WER.

Under the WER, all designated water bodies are classified based on quality elements which encompass a range of physical, biological, and chemical parameters. Water body elements may be classed as being at (in descending order) high, good, moderate, poor, or bad status, with the lowest scoring element defining the overall status of the water body (under the 'one out, all out' principle). The target is for all water bodies to achieve a minimum of good status (or good potential for heavily modified water bodies).

Following the European Court of Justice 'Weser ruling' deterioration is considered when a WFD quality element falls by one class, even if that fall does not result in a drop in the overall classification of a water body.

An applicant must show that activities will not lead to a deterioration in water body status or prevent water body objectives being achieved. We provide guidance via GOV.UK in 'Clearing the Waters for all' (CtW) on how to undertake a WFD compliant assessment in estuarine (transitional) and coastal waters. It consists of 3 stages – screening, scoping and appropriate assessment. We then review the relevant parts of the applicant's assessment as part of our WDA determination.

WFD assessment

NNB GenCo (SZC) via Appendix D of the WDA permit application considered whether activities that are relevant to the commissioning and operation of the cooling water system, and related process effluents, would affect compliance of the SZC project with WFD.

Potential impacts of SZC were considered for the Suffolk Coastal water body (GB650503520002) which covers an area of 14,738 hectares.

The other water bodies scoped into the assessment were:

- Leiston Beck (water body ID GB105035046271)
- Minsmere Old River (GB105035046270)
- Walberswick Marshes (GB610050076000)
- Blyth(S) (GB510503503700)
- Alde and Ore estuaries (GB520503503800)

The combined discharges from the 2 cooling water outfalls, and the outlets of the 2 fish recovery and return (FRR) systems (one outfall per FRR system) were identified as having the potential to affect ecological, physical and/or chemical aspects of the above water bodies. Associated potential impacts on protected sites were also investigated.

The operational SZC WDAs that were 'scoped in' for further consideration were identified as:

1. The cooling water discharge, which includes returned abstracted seawater at elevated temperature (waste stream A: thermal properties only), process chemicals during commissioning and operation (within the trade effluents of waste streams A to F – chemical parameters only), and sewage effluent during operation (waste stream G only).

2. Two fish recovery and return (FRR) system discharges, which included the discharge of polluting matter (as waste stream H).

Overall, NNB GenCo (SZC) proposes that the proposed WDAs will not cause deterioration, nor result in any water bodies being unable to meet their objectives under the Water Framework Directive (WFD).

Environment Agency compliance review

While we can agree with much of the data and many of the conclusions drawn in NNB GenCo (SZC)'s assessment, there are several points of concerns that we felt needed considering further. These are fully described in our report 'Environment Agency Review of the Water Framework Directive Compliance Assessment', available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space

This report is available for review as part of our 'minded to' consultation regarding our proposed decision for the WDA permit application (as well as the combustion and radioactive substances activity permit applications).

In the following section, we have provided a summary of what we did to address these concerns.

Thermal impacts

There are no formal standards for assessing thermal impacts, including barriers to fish movement (known as occlusion), in estuarine and coastal waters. This is outlined in section 4.11.6. Draft WFD standards were published by the UK Technical Advisory Group for WFD in March 2008 (UKTAG 2008), which includes a guidance of no more than 2°C as a maximum allowable concentration (MAC) at the edge of the mixing zone. The thermal thresholds for marine water bodies under WFD are presented in EDF TR302, 2020a in section 4.2.2 as detailed in Table 22.

Table 22

WFD thermal thresholds	High	Good	Moderate
Annual 98th percentile of absolute temperature	< 20ºC	20ºC < T ≤ 23ºC	23 ºC < T ≤ 28ºC
Annual maximum uplift as a 98%ile	≤ 2ºC	2ºC < Uplift ≤ 3ºC	Uplift > 3ºC

The intention of these mixing zone boundaries is to maintain an open corridor for fish migration. 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.

NNB GenCo (SZC) has proposed that there is no barrier to fish movement in the Alde and Ore Estuary. While we agree with its modelled temperature information, we have reviewed the available scientific information of the impact on migratory fish in the Blyth and the Alde and Ore estuaries. This is because we have concerns about the possibility of occlusion of the estuary mouth (specifically for the Blyth) and the contribution of thermal impacts to fish behaviour along the coast. Our focus has therefore been on the fish entering the Blyth and Alde and Ore estuaries.

We reviewed the supporting evidence referenced in the permit application, including the paper 'Experimental Study on the Preference and Avoidance of Thermal Increments by Estuarine / Freshwater Juvenile Fish' by Jacobs (2008). Looking at the data and the discussion presented in this report, we felt it is not possible to conclude that smelt do not exhibit avoidance at ∆2°C or ∆3°C for the conditions tested, or how using different environmental conditions such as different start temperatures or salinities could affect the results. It is also not possible to conclude what impact absolute temperature has on smelt.

We therefore formally requested further evidence to support the use of the thermal avoidance threshold applied to smelt, including a detailed assessment of the abundance and length of impinged smelt for each month monitored against the range of tidal conditions and thermal plume from the operating Sizewell B (SZB) station.

NNB GenCo (SZC) produced SPP101 (2020i). Looking at the data and discussion presented in SPP101, it is not possible to conclude that smelt do not exhibit avoidance at ∆2°C or ∆3°C or how background or absolute temperatures may affect smelt. Larger smelt may avoid the area with increasing background or absolute temperatures. It is not possible to know if more smelt would have been impinged in the absence of the plume during any period, as no control samples are available for comparison.

We also considered potential effects on bass, herring, sprat, sea lamprey, river lamprey and eel. The impact of SZC on these species is not expected to have to have a detrimental impact on the quality of the fish element in WFD water bodies.

Chemical impacts

Following review by our ETAS team, we did not agree with 4 of the predicted no effect concentrations (PNECs) applied for ethanolamine, acetic acid, phosphoric acid and acrylic acid, and propose different values. However, using revised PNECs, these 4 substances still ‘screen out’ of requiring further chemical plume modelling, following the risk assessment process specified in NNB GenCo (SZC)’s application (NNB GenCo, 2021a, TR193 sections 10.1 to 10.4).

Biota estimates in the FRR system discharges

The permit application assessment was based on the fish loss predictions presented in NNB GenCo (SZC) or EDF (TR406 v7), which we reviewed and considered had underestimated the potential impacts of dead and damaged fish discharged from the FRR systems. We produced our own analysis using revised figures via our FRR systems assessment in section 4.11.14. These demonstrate an increase in the modelled area of impact, but do not give rise to any additional impacts that could compromise WFD objectives for water quality, habitats or fish.

In-combination assessment

We considered the assessment submitted in the application was incomplete and had concerns over its robustness. We reviewed the likely impacts from project-wide activities that could affect water quality in combination with the WDA discharges, including:

- discharges that would occur during the construction and commissioning phases, due to a risk of residual effects overlapping with effects from operational discharges. These may include:
    - groundwater dewatering

  - treated surface water run-off from the wider site, including deep excavation area
  - construction phase sewage treatment effluent
  - cold-flush commissioning of the cooling tunnels
  - water from concrete wash and tunnel construction for intakes and outfalls

- operational combustion activities, due to a risk of airborne contaminants becoming deposited onto water or washed into water once deposited onto land
- dredging activities, due to a risk of effects on water quality adding to the effects from operational discharges

It is important to note that no in-combination assessment that considers the abstraction impacts has been provided in NNB GenCo (SZC)'s assessment or this review, as that is being led through the WER assessment for the SZC DCO.

NNB GenCo (SZC) screened out all other nearby projects with a spatial/temporal link to the operational phase of the SZC project from their WFD assessment. Projects were screened out mainly because the effects from other projects are not predicted to be significant (due to limited spatial scale or temporary nature of effects). We are satisfied with its screening assessment of other projects.

Conclusions

Based on the additional work carried out, we have reached the following conclusions.

Temperature impacts

The potential thermal impacts on smelt (due to the cooling water plume) remain a concern as the available scientific evidence is not sufficient to demonstrate whether smelt will avoid the area of the thermal plume at the 2°C or 3°C uplift, or what effect absolute temperatures will have on this species.

A breeding population is known to exist in the Alde and Ore water body. Smelt have also been recorded in the Blyth water body, but there is insufficient evidence to confirm a breeding population. Avoidance of or delays due to the presence of a thermal plume while undertaking a spawning migration has the potential to affect reproductive success. While their remains some uncertainty in this assessment, it is considered that the risk of deterioration due to significant avoidance as a result of the thermal plume remains low. So no deterioration is expected.

It is useful to note, that suitable agreement on mitigation measures is being secured through the SZC DCO (via its Deed of Obligation and Deed of Covenant) and a robust monitoring programme put in place, which would trigger additional compensation if required, we feel that risks to the transitional fish populations due to the uncertainties in the data could be managed.

This will include the installation of fish passes at Snape Sluice on the Alde and Blyford Bridge Sluice on the Blyth prior to the abstraction of any cooling water from the station.

Should a population deterioration be observed to smelt as a result of the operation of SZC in the Alde and Ore water body, then further funding will be released to undertake additional compensatory improvements in this water body.

Improving fish passage in the barriers in the Alde and Ore and Blyth Estuaries will help smelt breed more successfully in these water bodies; this will help smelt populations in these water bodies be more resilient to human impacts.

NNB GenCo (SZC) has also committed to undertaking entrapment monitoring of all species once the SZC station becomes operational. Should a population deterioration be observed that can be attributed to the operation of SZC, then further funding (which has been secured through the Deed of Obligation and Deed of Covenant) will be released to undertake additional mitigation. Should the increased risk of deterioration to the fish element under the WER be anticipated in the Alde and Ore water body, which can be attributed to the operation of SZC, this would also trigger the release of funds to deliver mitigation through habitat improvements for fish.

Chemical impacts

The 2 cooling water outlets are outside the WER seaward boundary (approximately 1.6 nautical mile offshore compared to the 1nm for the water body boundary) and chemical plumes are not predicted to reach as far as the Suffolk Coast water body. Some localised elevations of total residual oxidants (TRO), bromoform, hydrazine and phosphate concentrations were predicted after initial dilution in the vicinity of the discharge.

The results of NNB GenCo (SZC)'s modelling show that there is a narrow, elongated plume running up the coast with no interaction between the hydrazine plume and the Suffolk coastal water body. We agree that there will be no deterioration in water quality in the Suffolk coastal water body as a result of the hydrazine plume for either of the modelled discharge scenarios. The results of the modelling also show that there is no interaction between the TRO and bromoform plumes, and the Suffolk coastal water body at levels exceeding the EQS. We agree that there will be no deterioration in water quality in the Suffolk coastal water body from either plume.

Free chlorine and chloramine are known to increase in toxicity as a result of increasing temperature. A 5°C increase in temperature more than halved the effect concentration for various marine species. However, the acute effects of this exposure would be expected to diminish rapidly upon discharge, with a 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.

The synergistic effects of chlorination and ammonia discharges were considered as these may result in the formation of additional combined products, primarily the more toxic dibromamine. As total ammonia is only around one-third of the background ammonia, any increase in toxicity is expected to be very small. As a result, additional water quality effects are not predicted.

Polluting matter

Impacts of the 2 FRR system discharges were considered for several water quality parameters. In terms of nutrient loading, our revised estimate of impact from both the FRR system discharges and treated sewage effluent discharge was less than 1% of the normal daily exchange of nutrients with the wider environment.

Given this, and the fact that the assessment approach excludes any removal of fish (and therefore nutrients) through consumption by predators, it is considered that the nutrients discharged from the 2 FRR systems will not result in a failure to meet WFD water quality objectives in the wider Suffolk coastal water body.

Our revised assessment of dissolved oxygen and unionised ammonia resulting from the discharge from the FRR systems showed that it would not result in a water body deterioration or a failure to meet WFD water quality objectives in the Suffolk coastal water body.

In addition, impacts of the organic enrichment of benthic sediments due to smothering and subsequent habitat loss were considered. While we consider the benthic community shows some sensitivity to organic enrichment and the effects of smothering, it has also been shown that the Corallina crag filter feeding community may also show improved growth from the additional food supply (Walker and Rees, 1980). We propose that there will be no overall WFD deterioration in benthic invertebrate community class of the Suffolk coastal water body due to organic enrichment of the seabed.

In relation to the potential impacts on the fish element of the estuaries, we found that no deterioration of the fish element of estuaries is predicted as a result of change to dissolved oxygen, biochemical oxygen demand or unionised ammonia from the two SZC FRR system discharges.

In-combination assessment

Construction of the SZC power station will require additional EPR permits, which NNB GenCo (SZC) has yet to apply for. We have considered the construction discharges NNB GenCo (SZC) provided in its H1 screening risk assessment (EDF, 2021a: TR193), but we have not reviewed these in detail. When the SZC construction EPR permits are applied for, they will be subject to full WFD compliance assessment.

From the information currently available, we concluded that there are no in-combination effects between the operational and construction WDAs. However, the effects of any interaction between construction, commissioning and operational discharges are likely to be only temporary and are unlikely to change the individual assessments of effects.

We are satisfied that any interaction between the cooling water and FRR systems with nitrogen and acid deposition (as a result of the commissioning and operation of diesel generators) is unlikely to change the individual assessment of effects on Minsmere to Walberswick Heath and Marshes. This is due to the minimal predicted effect from the

WDAs on marine water quality at the coastline, and the fact that seawater can only enter the sluice under specific flow conditions.

During the operational life of the project, the navigational channel leading up to the beach landing facility may require dredging each time before the beach landing facility can be used for abnormal indivisible loads. However, the scale of dredging is small in relation to the size of the Suffolk coastal water body, and any impacts after each period of dredging activity would be temporary. Therefore, we are satisfied that any interaction between operational WDAs with dredging is unlikely to change the individual assessment of effects from the cooling water and FRR system outfalls.

Overall WER conclusion

Considering the limited scope of this assessment for in combination and with the measures in place under the Deed of Obligation, our assessment of these impacts concludes that there is minimal risk of these operational SZC WDAs on compliance with WER and compromising achievement of WER environmental objectives.

Bathing Water Regulations 2013 (Statutory Instrument 2013 No.1675)

We have considered the potential impact of the proposed WDAs on the designated bathing waters, including Southwold The Denes (UK10850), located approximately 10.7km north of the discharge points, and Felixstowe North (UK10900), located approximately 36km south of the discharge points. We have concluded the proposed discharge of treated sewage effluent (waste stream G) will make an insignificant contribution to the bacterial levels in the receiving waters of the Greater Sizewell Bay, and so there is no risk of impact to the above designated bathing waters for the following reasons:

- the proposed quality of the treated sewage effluent to be discharged
- the location of the proposed cooling water discharge outfalls into the Greater Sizewell Bay, located approximately 3.0km offshore
- the significant dilution of the discharge within the cooling water flow (waste stream A) and within the receiving waters of the Greater Sizewell Bay

Shellfish protected areas via the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (Statutory Instrument 2017 No.407)

Shellfish protected areas are referred to in Regulation 9 of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. The list of shellfish protected areas is provided here.

The operational SZC WDAs will not impact on any shellfish waters. The nearest designated shellfish water protected areas are:

- Butley River shellfish water (SFW ID: 9), located approximately 32km south from the 2 cooling water (CW) discharge outfalls

- Blakeney shellfish water (SFW ID: 6), located approximately 120km north from the 2 CW discharge outfalls
- River Deben shellfish water (SFW ID: 137), located approximately 32km south from the proposed CW discharge outfalls

The operational SZC WDAs will not impact on any of these shellfish waters, as these are all located outside of the ZoI of the proposed WDAs. Cefas was consulted on the application, and did not identify any additional shellfisheries near the proposed WDA discharges.

Urban Waste Water Treatment (England and Wales) Regulations 1994 (UWWTR) (Statutory Instrument 1994 No.2841)

Regulation 5(7) of UWWTR requires that urban waste water entering collecting systems from agglomerations with a population equivalent of less than 10,000, and thereafter discharging to coastal waters, must be appropriately treated.

We are satisfied that the WDAs generated at SZC will be appropriately treated in this case. Appropriate treatment is that which allows the receiving waters to meet the relevant water quality objectives, and the relevant provisions of EC Directives.

The Eels (England and Wales) Regulations 2009 (Statutory Instrument 2009 No.3344)

The Eels (England and Wales) Regulations 2009 (Statutory Instrument No. 3344) came into force on 15 January 2010. These Regulations implement Council Regulation (EC) No 1100/2007 (OJ No L 248, 22.9.2007), establishing measures for the recovery of the stock of European eel (Anguilla anguilla, and includes elvers and glass eels) in England and Wales. As part of the Regulations we have to consider screening and passage for eels.

Migratory species such as eels can be sensitive to power station operational discharges if avoidance of the discharge plume impacts on their migratory pathways, as thermal and/or chemical plumes may alter water quality properties and cause fish species to avoid an area due to the potential for a reduction in water quality. NNB GenCo (SZC) has considered the potential for the thermal and chemical (TRO, bromoform and hydrazine) plumes from the operational WDAs to provide a barrier to eel passage.

European eels have been recorded in low numbers in the surveys carried out by NNB GenCo (SZC) in the GSB and along the Suffolk Coast (NNB GenCo (SZC), 2020e; Eels Regulations Compliance Assessment). Glass eels generally arrive in the North Sea in January to February and would transit past SZC on their passage to river estuaries from February to April. It is also reasonable to assume that adult silver eels would transit past SZC on their return migration to the Sargasso Sea from November to February (NNB GenCo (SZC), 2020e).

We have assessed the potential impacts of the SZC operational WDA discharges on the European eel through our Habitats Regulations Assessment (HRA), as European eels could be affected by the operational SZC WDAs, and are a prey species of Bittern.

Bittern are notified features of the Minsmere–Walberswick SPA and Ramsar, for which the site's supplementary advice package states that the distribution, abundance and availability of key food and prey items at preferred sizes must be maintained. Of these key items, only eels have a marine lifecycle component. As Minsmere Sluice is fitted with an eel pass (to facilitate migration of eels into and out of the Minsmere marshes), our HRA has considered if the two cooling water and two FRR system outlets for the operational WDAs could act as a barrier to eel migration.

We are satisfied that in carrying out our HRA assessment, and our review of NNB GenCo (SZC)'s WFD compliance assessment report, we have also fulfilled our duty to consider the requirements of the Eels Regulations in this WDA permit determination. Any effects on entrapment of eels are discussed and are being considered through the SZC DCO process, along with any aspects relating to the design of the cooling water intakes and FRR systems.

The two CW outfalls are located approximately 3.0 km offshore in deep water (the two CW outfalls will be covered by about 6.3m of water at lowest astronomical tide). This will allow for initial mixing and minimise intersection with the Suffolk Coast coastline. As demonstrated via the modelling outcomes, there will therefore be no overlap of the chemical plumes above EQS/PNEC (for TRO, bromoform or hydrazine), or thermal plumes with the Minsmere sluice outlet and the freshwater environment.

NNB GenCo (SZC) have also considered if the offshore thermal uplift could prove a barrier along the coast; it concluded there was no barrier based on the available evidence for thermal avoidance of migratory species off Sizewell using thermal uplift thresholds applied for glass eel and silver eel (Table 23).

Thermal modelling results showed that temperatures in excess of potential avoidance thresholds would exceed 25% of the coastal corridor (a 3.0 km transect from the coast to the SZC cooling water outfalls) for less than 5.0% of the time during their migration periods.

Therefore, no occlusion effects were predicted (Table 23, Figure 24). Silver eel are the outward migrating pre-adult life stage, and as such would not be available as food to bitterns once they have left freshwater. The thermal uplift threshold NNB GenCo (SZC) applied to glass eels (>+12°C) is high compared to that used for silver eel (>3°C) (Table 23).

However, Figure 7 shows that it is rare for more than 25% of the cross-sectional area of the 3.0 km coastal corridor to experience thermal uplift in excess of 3°C during the glass eel migration period. As such, no occlusion effect would be predicted for glass eel, even if applying the thermal uplift threshold used for silver eel.

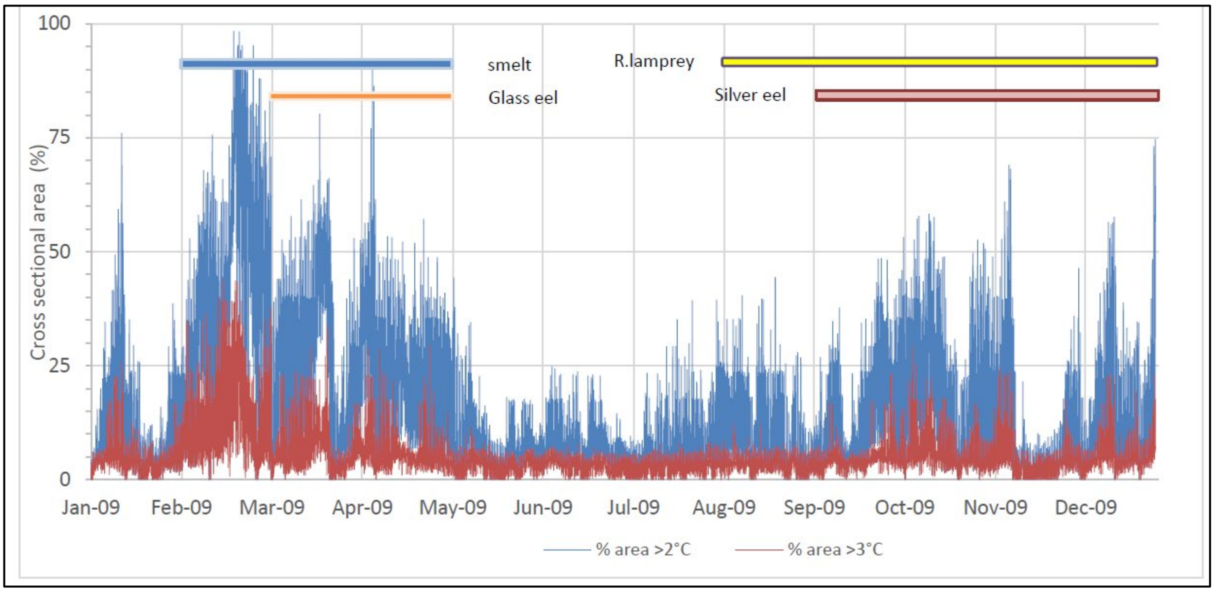

Figure 24: Cross-sectional area of instantaneous plume across the transect with >2°C and >3°C Uplift (reproduced from Figure 16 in NNB GenCo (2020a; TR302).

Table 23: Percentage of Sizewell C transect experiencing >25% exceedance of thermal thresholds for glass eel and silver eel, reproduced from NNB GenCo (2020a; TR302)

Life stage	Assumed thermal threshold	Migration period	Percentage of migration period during which >25% of the 3.0 km migration corridor exceeds the assumed thermal threshold	Conclusion
Glass eel	>+12°C	March – April	0%	Would not experience a barrier to migration in a transect from the coast to the SZC outfalls
Silver eel	3.0°C	September - December	0.07%	Would not experience a barrier to migration in a transect from the coast to the SZC outfalls

We have also considered the potential for nutrient or organic enrichment as a result of the operational discharges from SZC's sewage treatment plant (STP) (via the two CW outfalls), and the two FRR systems (via the two FFR system outfalls, located approximately 0.4 to 0.6 km offshore).

Following NNB GenCo (SZC)'s assessment, and our additional assessment work, it is demonstrated that the potential for nutrient or organic enrichment from the STP and FRR system discharges will be insufficient to lead to increased opportunistic macroalgal or phytoplankton blooms, and therefore it is concluded that there will be no effect on eels from waste streams G and H.

This assessment is discussed in greater detail within our WDA HRAR's section 6.3, via the consideration and assessment of the potential risks of the treated sewage effluent, un-ionized ammonia (UIA), dissolved inorganic nitrogen (DIN), and nutrient and organic enrichment from the two FRR systems. We consider that the discharges from the STP and FRR systems will not result in a change to nutrient and organic enrichment within the wider Greater Sizewell Bay. As these operational discharges will not cause a deterioration in water quality in the marine environment following discharge via the CW and FRR system outfalls, they will also not alter the water quality of the freshwater environment, or have indirect effects on eels as prey items of bittern.

Overall, we are satisfied that we have appropriately considered the requirements of the Eels Regulations.

Section 40 Natural Environment and Rural Communities Act 2006

Section 40 of this Act requires us to have regard, so far as is consistent with the proper exercise of our functions, to the purpose of conserving biodiversity. Conserving biodiversity includes, in relation to a living organism or type of habitat, restoring or enhancing a population or habitat. We have had regard to the conservation of biodiversity when carrying out our permit determination and concluded that no additional measures were required in the draft permit.

4.15 Setting permit limits

This section of the draft decision document describes and explains the permit limits (compliance limits) in the draft permit for the proposed water discharge activity. These will form the legal requirements against which we would regulate the permitted water discharge activities and through which we would monitor operational performance. In deciding to apply these limits and conditions we have considered:

- NNB GenCo (SZC)'s H1 risk screening assessment
- NNB GenCo (SZC)'s detailed modelling and assessment and what it shows to be an acceptable impact on the environment in the context of the relevant environmental standards for temperature, TRO, bromoform and hydrazine
- NNB GenCo (SZC)'s information for the Habitats Regulations assessment report
- NNB GenCo (SZC)'s Water Framework Directive (WFD) compliance assessment report
- NNB GenCo (SZC)'s fish recovery and return system report on water quality and ecological receptors

- NNB GenCo (SZC)'s responses to the Schedule 5 notice requests for additional information
- our own assessments of the proposed waste streams where required
- our Habitats Regulations assessment report (HRAR)
- our Water Framework Directive (WFD) assessment
- the requirements of other applicable legislation

We are satisfied that the limits and conditions as set out in the draft permit will ensure a high level of environmental protection.

4.15.1 Our approach to permitting

The water discharge activity being considered in this application will result in a single, continuous discharge to the Greater Sizewell Bay, comprising returned cooling water and several smaller waste streams. It could be argued, therefore, that only a single discharge to the environment needs to be permitted, with a single compliance point either at the outlet or at a point upstream where it is possible to obtain a reliable, representative sample of the discharge. However, we have decided that the various waste streams will be conditioned separately. This means that the draft permit has:

- 2 permitted outlets to the marine environment (Greater Sizewell Bay) for waste streams A to G, via the cooling water outfall diffusers at the end of the single cooling water outfall tunnel
- 2 permitted outlets to the marine environment (Greater Sizewell Bay) for waste stream H, via the individual outlets for each of the 2 FRR discharge systems, which are each served by an individual outfall tunnel

We have proposed permit limits (compliance limits) on the individual waste streams B to G before they are combined with the returned cooling water (waste stream A) in the outfall pond, as well as on the cooling water itself. We have also proposed permit limits for waste stream H for the 2 FRR systems. Our reasons for this are as follows:

- there is the considerable practical problem of obtaining a representative sample of the discharge. We cannot sample at the end of the outfall tunnel, submerged and approximately 3.0km offshore in the Greater Sizewell Bay. We also consider that the highly turbulent mixing environment within the discharge pond would prevent us from obtaining a truly reliable, representative sample of the combined discharge at that point
- NNB GenCo (SZC) has confirmed that it is not possible to obtain a sample of the combined cooling water flow before it is discharged through the common outfall tunnel. This means that for waste stream A, each UK EPR™ unit will need to be sampled separately in its respective turbine hall
- despite these practical issues, we consider that a single compliance point does not allow enough control of the discharges from the individual processes, or sufficient flexibility in assessing new or varied discharges that may be produced during the operation of the power plant, for example, due to process development

- future changes in environmental legislation may drive changes in the chemicals used in individual processes, or the processes themselves. In this case, we would want to be able to regulate the individual waste streams

Other important reasons for this proposed approach are that it allows the impact of each discharge to be assessed alone and in combination for Habitats Regulations assessment (HRA) purposes, as well as allowing the definition of any treatment measures which are needed to mitigate the potential impact of a particular waste stream to be clearly made.

Permit limits are normally set as concentrations in the final effluent and, if relevant, as loads (based on measured flows and concentrations in the final effluent) over a time period (for example, daily and annual). Other types of permit limit can be used, for example, differential concentrations between cooling water intake and discharge, but these are not considered to provide a simple means of regulating the various process effluent discharges, apart from the cooling water for temperature. We have applied a combination of limits to our proposed WDA permit, that is effluent concentrations, loads (daily and annual), and differentials, depending on the most suitable measures for each waste stream.

In setting permit limits and conditions, we have thought about what is necessary in terms of our main objective to protect the environment, and also what is acceptable from a regulatory viewpoint. At the same time, and where our permitting guidance allows, we have respected the need for the operator to be able to manage the power station to maximise output and feed the National Grid, without being overly constrained by the permit. We have set out here our reasons for the limits in our permit.

4.15.2 Waste stream A

Waste stream A will be specified as activity A1 within Schedule 1 of the permit.

The cooling water discharge will be characterised by flow rate, heat load (both in terms of maximum temperature and the temperature rise above ambient) and total residual oxidant (TRO) if it is necessary to control biofouling by injecting sodium hypochlorite into the cooling water system. For waste stream A, permit limits have been applied to both the combined discharge of cooling water from the 2 UK EPR™ units, and that from each UK EPR™ unit individually.

For the combined discharge of cooling water from the 2 UK EPR™ units, permit limits have been set for the maximum tidally-averaged flow and the maximum cooling water temperature as a 99.5 percentile.

For each individual UK EPR™ unit, permit limits have been set for the maximum temperature increase compared with the inlet water temperature (as a tidal mean), for both normal operation and during specific planned maintenance work, maximum total residual oxidant (TRO), minimum and maximum pH, and no significant trace of visible oil and grease so far as is reasonably practicable.

Our permit limits and conditions for flow rate, temperature, and TRO, are discussed here. The limits for pH and visible oil or grease are in accordance with our standard permitting requirements, and are the same across all the SZC operational waste streams A to G.

Flow rate

The cooling water flow rate at SZC will vary depending on the tidal state at the intake heads, and the number of main cooling water (CRF) pumps in use, which, in turn, is influenced by the operational state of the power station. During standard operation with both UK EPR™ units operating at full load and all 4 CRF pumps running, the power station will abstract between 125m³/s and 140m³/s of cooling water. The higher flows are abstracted at high water spring tides, and the lower flows at low water spring tides. Over the tidal cycle, with both reactors at maximum load, the cooling water flow rate will be in the order of 132m³/s.

NNB GenCo (SZC) has confirmed that it will not be possible to monitor the combined cooling water flow from SZC, that is, the combined flow from both UK EPR™ units. This is due to the physical characteristics of the structures and the engineering difficulties involved. The junction point where the flows from each UK EPR™ unit meet after each unit's outfall pond is at the head of the common outfall tunnel, which will be located below ground level. Cooling water flow monitoring will therefore be undertaken individually on each of the 2 UK EPR™ units. To obtain combined flows from the 2 UK EPR™ units, the individual flows measured for each UK EPR™ unit at a given time will be added together.

In setting limits on flow rate, we have considered the possible need for (a) a maximum daily volume, (b) a maximum flow rate, and (c) a minimum flow rate. We have decided that the only flow control we need relates to the maximum flow rate, and we have therefore proposed a tidally averaged flow (or tidal mean). This instantaneous flow limit is 132m³/s as a tidal mean for the combined cooling water flows from the 2 UK EPR™ units.

We considered the need for a maximum daily discharge volume, but consider that it would not provide any additional benefit over the maximum flow rate already discussed. We are satisfied that this would provide sufficient control during standard operation of SZC.

We also considered the need for a minimum flow rate, particularly relevant when the power station is operating under a non-standard configuration. During an outage for example, the cooling water flow rate could be as low as 71.5m³/s. In this situation, we would want to make sure that the amount of cooling water flowing through the system was sufficient to dilute the contaminants arising in the other waste streams before discharge, so that maximum short-term emissions did not exceed those stated in the permit application (and upon which the NNB GenCo (SZC)'s H1 screening risk assessment outcomes are based).

We are satisfied in this case that a limit on the minimum flow rate will not be necessary. This is because the application states the amount of water needed to serve the UK EPR™ unit on outage would be 5.24m³/s, while, at the same time, the second UK EPR™ unit would be operating normally (a minimum flow of 66.25m³/s). The need for cooling water on the unit on outage is a safety related measure and, therefore, we consider that this flow will always be available. We expect that this control would be written into NNB GenCo (SZC)'s environmental management system and operating techniques. When combined with the cooling water serving the other reactor unit, we are satisfied that the overall dilution will be enough to make sure that short-term emissions will not differ significantly from those stated in the permit application, which underpin the H1 screening risk assessment outcomes and modelling assessments.

Another situation that could occur with each UK EPR™ unit, and which NNB GenCo (SZC) has stated could be a normal operational circumstance, is where one of the two CRF pumps serving a UK EPR™ unit is undergoing routine planned maintenance, referred to as RF3 maintenance in the application. As previously stated, this CRF pump maintenance would generally be scheduled to coincide with a planned outage, but this cannot be guaranteed.

Under this RF3 scenario, there will be only one CRF pump running for a UK EPR™ unit. The resulting average cooling water flow will be 35.74m^3/s. Pump maintenance would not be expected to take longer than one month, and advanced notice would be needed. No change to the permit limits for the combined flows from the 2 EPR™ units is considered necessary for this situation given the combined cooling water flow from both UK EPR™ units will be 102m^3/s.

Temperature

The actual temperature of the cooling water being returned to the Greater Sizewell Bay will depend on the ambient water temperature at the cooling water intake heads, the thermal loading related to the output of the power station, and the cooling water flow, which depends on the tidal height at the intake heads. As the ambient water temperature of the cooling water inflow to a power station at any given time is an unknown, the temperature of the cooling water outflow is usually quoted as a temperature differential (or ΔT), that is the excess temperature of the outflow compared with the inflow.

On average (over the tidal cycle) with both reactors at maximum load, the temperature differential is 11.6ºC, with the cooling water flow rate being in the order of 132m^3/s. Based on these temperature differentials and related cooling water flows (provided by NNB GenCo (SZC)), it has been assumed that the temperature differential is directly proportional to the cooling water flow, which is itself directly proportional to the tidal height at the cooling water intake heads.

In setting limits on cooling water temperature, we have considered the possible need for (a) a maximum cooling water temperature, and (b) a maximum temperature differential.

However, recognising the variation in cooling water flows over the tidal cycle, we have decided to control the cooling water temperature under normal operation for each UK EPR™ unit by using a tidally-averaged cooling water temperature differential. This limit is 11.6ºC as a tidal mean, for each UK EPR™ unit.

A 99.5 percentile cooling water temperature of 35ºC has also been set for the combined cooling water flows from the 2 UK EPR™ units. This 99.5 percentile limit is the cooling water temperature that must not be exceeded for 99.5 per cent of the time. The percentile method does allow the standard to be exceeded on occasions, which would seem reasonable, as the ambient water temperature at the intake heads cannot be controlled. In addition, a percentile value allows time for the operation of the plant to be appropriately managed during a persistent period of exceedance.

In order to provide the necessary information to assess these cooling water temperature limits, the water temperatures in the cooling water inflow prior to the condensers, and the water temperatures in the cooling water outflow downstream of the condensers, before being discharged into the outfall ponds, will need to be continuously monitored. The temperature limits set for the individual UK EPR™ units can be assessed directly from the monitoring data. To assess the maximum temperature limit set for the combined cooling water discharge from the 2 UK EPR™ units, the temperature of the combined cooling water discharge needs to be calculated from the temperature and instantaneous flow data measured for each of the individual UK EPR™ units. A simple mass balance calculation will be used to obtain the cooling water temperature for the combined flows from the 2 EPR™ units, assuming that the water temperature is constant in the 2 cooling water flows until they are fully mixed and discharged from the 2 cooling water outfalls.

As mentioned earlier, another situation that may occur with each UK EPR™ unit, and which NNB GenCo (SZC) has stated could be a normal operational circumstance, is where one of the two CRF pumps serving an UK EPR™ unit is undergoing routine planned maintenance, referred to as 'RF3 maintenance'. This pump maintenance would generally be scheduled to coincide with a planned outage, but this cannot always be guaranteed.

In this situation, there would be only one CRF pump running for a UK EPR™ unit. The maximum tidally-averaged temperature limit in this situation would be 23.2ºC. This higher permitted temperature differential could apply to each UK EPR™ unit, but not simultaneously, depending on which unit is undergoing pump maintenance at the time.

Pump maintenance would not be expected to take longer than one month, and advanced notice would be needed. It is recognised that the maximum cooling water temperatures could potentially exceed the 35ºC 99.5 percentile limit for the combined UK EPR™ unit cooling water flows, if planned pump maintenance was scheduled for the summer months. However, to avoid a prolonged period of cooling water temperatures exceeding 35ºC, no change to the 99.5 percentile is proposed, so that pump maintenance will need to be planned for those months when the ambient water temperatures allow the 35ºC maximum limit to be met.

Total residual oxidant (TRO)

NNB GenCo (SZC) will need to control biofouling based on past operational experiences at the Sizewell A and Sizewell B power stations. As required when seawater temperatures exceed 10°C, the required total residual oxidant (TRO) dosing concentration of 0.2mg/l (200µg/l) will be achieved by injecting 0.5mg/l of active chlorine (sodium hypochlorite), applied sequentially once every 30 minutes per cooling channel, into the abstracted cooling water upstream of the condensers, but at a suitable location so as to not contaminate the 2 FRR systems. TRO is used as the relevant parameter for assessing the level of chlorine in seawater, because of the chemical interactions that occur when chlorine or hypochlorite is added to seawater.

NNB GenCo (SZC) has stated in its permit application that the maximum concentration of TRO in waste stream A (the cooling water) would be 0.2mg/l (200µg/l). This is based on the need to achieve a chlorine residual of 200µg/l downstream of the condensers in order to achieve the required level of control over biological growth within the SZC cooling water system.

At this concentration, TRO exceeds the EQS of 10µg/l within the cooling water and therefore, there will be a mixing zone upon discharge to the Greater Sizewell Bay via the 2 cooling water outfalls. However, we do not consider the mixing zone for TRO, as identified and assessed through hydrodynamic modelling, to be significant. We, therefore, consider it appropriate, having taken into account Habitats Regulations and WFD requirements, to apply TRO limits of 200µg/l for each UK EPR™ unit within our permit.

The chlorine breakdown product (CBP) bromoform exceeds the PNEC of 5.0µg/l within the cooling water and therefore, there will be a mixing zone upon discharge to the Greater Sizewell Bay via the 2 cooling water outfalls.

However, we do not consider the mixing zone for bromoform, as identified and assessed through hydrodynamic modelling, to be significant. We therefore consider it appropriate, having taken into account Habitats Regulations and WFD requirements that bromoform does not require control via numeric limits within our permit, as we will be applying TRO limits of 200µg/l, upon which the modelling assessment for bromoform was determined (the numeric compliance limits for TRO will ensure that bromoform is controlled).

4.15.3 Waste streams B and C combined, D and F

Within Schedule 1 of the permit, waste stream B and C combined will be specified as activity A3, waste stream D will be specified as activity A4, and waste stream F will be specified as activity A5.

As reported in section 4.9, NNB GenCo (SZC) has provided emissions data in relation to waste streams B and C combined (from the nuclear island processes, including steam generator blowdown), waste stream D (mainly turbine hall drainage), and waste stream F (from the demineralisation plant). The information provided includes maximum daily and annual loadings, and maximum concentrations for the range of substances expected to be present in each of these waste streams.

As shown through the H1 risk screening assessment, the majority of the substances within these waste streams screen out of the H1 risk assessment as insignificant upon discharge into the cooling water of waste stream A. Lithium hydroxide, phosphates, aluminium, cadmium, copper and zinc were considered further following the H1 risk assessment screening process and were not considered as requiring further assessment via modelling. Only hydrazine required further assessment via modelling.

We have determined that, at the maximum concentrations stated in the application, none of the substances, other than hydrazine, exceed the relevant EQS or other standard following dilution within the returned cooling water. From a regulatory viewpoint, to make sure that the actual emissions are in accordance with those specified in the application, we have applied the proposed emissions to the permit, as formal numeric limits, both as maximum daily loads and maximum annual loads. We would require NNB GenCo (SZC) to monitor and report against these limits by submitting calculated loads, associated effluent flow and substance concentration data.

In order to do this, NNB GenCo (SZC) would need to monitor flow and take samples of each effluent waste stream before they entered the outfall pond(s).

In order to limit substance concentrations to the maximum levels stated, we have incorporated the pre-dilution concentration tables from the application into the draft permit as an operating technique (OT1).

These are the maximum concentrations before mixing with the cooling water in the outfall pond. Although we do not feel it appropriate to include these concentrations as formal numeric compliance limits, they are nonetheless important in making sure that the SZC plant is operated such that the maximum levels quoted in the permit application are respected, as these form the basis of the H1 risk screening impact assessment work. We expect that these limits would provide a useful benchmark for process control by NNB GenCo (SZC).

For hydrazine, we have specified compliance limits within the draft permit in line with our guidance (Environment Agency, 2014, LIT 10419) for determining the acceptability of mixing zones, which states:

"if a modelled mixing zone is acceptable, then permit limits can reflect the effluent flow and concentrations used in the modelling."

We have therefore set the compliance limits for hydrazine to match the basis of the 2 scenarios modelled for waste stream D, as it is these 2 discharge scenarios we have assessed via our HRA and WFD assessments, and which underpin our conclusions:

- the load of hydrazine exiting the hydrazine treatment system is less than or equal to 66.6g/day
- over the period of daily addition of hydrazine to the CW, the rate of addition shall be constant, and the CW flow shall be greater than or equal to 116m^3/s (the modelled concentrations of 34 and 69ng/l are derived from a load of 66g/day and a flow rate of 116m^3/second)
- period of daily addition of hydrazine waste streams to the cooling water to be no less than 2 hours 18 minutes, and no more than 4 hours and 38 minutes (these limits being the 2 scenarios examined in the modelling)

We have also proposed to apply the above compliance limits to the infrequent potential discharge of hydrazine within the combined waste stream B and C, which will not occur at the same time as the discharge of hydrazine within waste stream D. The modelled hydrazine scenarios for waste stream D encompass the proposed loading and concentrations of hydrazine within the combined waste streams B and C. We have therefore specified an additional compliance control within the proposed permit's limits of specified activity (table S1.1) for the combined waste streams B and C, and D to ensure that any discharges of hydrazine from these two waste streams do not occur within the same 24 hour period.

NNB GenCo (SZC) has also proposed to make available to us (before HFT commissioning) the results of an optioneering exercise on the feasibility of further minimising discharges of hydrazine as far as possible. This will take into account the lessons learned from (a) early operation of the Flamanville 3 EPR™ in France, (b) HPC and (c) further design development.

4.15.4 Waste stream E

Waste stream E will be specified as activity A6 within Schedule 1 of the permit.

Waste stream E comprises oily water from the oily water drainage network, which serves those areas on site where oils and hydrocarbons are used and which, therefore, present a risk of contamination. These areas include the backup diesel generators, transformer compounds, electrical substations, oil and grease store, oil and hydrocarbon offloading areas and various workshops.

NNB GenCo (SZC) proposes to install a class 1 oil interceptor specified to achieve a maximum hydrocarbon concentration of 5mg/l. We have incorporated this proposal as an 'operating technique' in our permit. NNB GenCo (SZC) has estimated that the maximum daily discharge volume would be 35,000m^3/day, and we have applied this figure to the draft permit as a limit. We have also applied a visible oil or grease limit that requires the operator to make a daily visual inspection of the discharge, with the compliance criteria being no significant trace present. This is in accordance with our standard permitting procedures for discharges of site drainage.

4.15.5 Waste stream G

Waste stream G will be specified as activity A6 within Schedule 1 of the permit.

NNB GenCo (SZC) has stated in its permit application an effluent quality from the on-site sewage treatment plant of 20mg/l BOD, 30mg/l suspended solids, and 20mg/l total ammonia (ammoniacal nitrogen, as N) will be achieved. The STP will need to be sized to take into account peak flows arising when maximum numbers of staff are on site, for example, during an outage. The maximum daily discharge volume is calculated as being 190m^3/d.

We are satisfied that the plant has been sized appropriately and that the quoted performance is acceptable in terms of effluent quality. This will ensure that a good quality secondary treated sewage effluent is discharged. We have no environmental concerns with respect to a discharge at the standard quoted being made at the proposed location. We have already concluded that in terms of bacteriological load and the potential for impact on designated bathing waters, the discharge will make an insignificant contribution to the bacterial levels in the receiving waters of the Greater Sizewell Bay. We have therefore applied the STP specification data to our permit, also adding our standard controls for pH and no visible oil or grease. This approach is consistent with other WDA permits at power station sites for discharges of treated sewage effluent.

4.15.6 Waste stream H

Waste stream H will be specified as 2 activities, A7 (FRR system 1) and A8 (FRR system 2), within Schedule 1 of the permit.

To ensure that our reasonable worst-case scenario is not exceeded, a total moribund biomass (kg/day) maximum limit will be set on waste stream H for the 2 FRR system discharges*.

To cover the 2 time periods considered with the assessments (that is, the Q1 mean daily loading for BOD, DO and unionised ammonia; and the annual mean daily loading for nutrient inputs), the point source emissions limits below are set on the permit for the combined waste stream H discharged via FRR systems 1 and 2:

- maximum total daily moribund biomass for 4,083kg, measured as daily mean over a 12-month rolling period (annual average)
- maximum total daily moribund biomass for 8,046kg, measured as a daily mean over a 90-day rolling period

The compliance measurement of these emission limits is not straightforward, as direct measurement of the moribund biomass is not possible. However, as can been seen from our assessment methodology, this can be calculated using appropriate data and evidence.

For each FRR system (1 and 2), we will also specify a maximum daily discharge volume of 25,920m^3/day, and a maximum discharge rate of 300 litres/second.

*These emission limit requirements are consistent with our approach to regulating the proposed FRR system discharge at HPC. However, in regard to HPC, it should be noted that these proposals are currently being considered by the Planning Inspectorate (PINS) within an EPR appeals process (reference APP/EPR/573) of WDA permit variation application reference EPR/HP3228XT/V004 by NNB Generation Company (HPC) Limited.

4.16 Monitoring

4.16.1 Scope of consideration

The monitoring systems associated with the water discharge activities at SZC are still being designed. It has, therefore, not been possible in NNB GenCo (SZC)'s application to specify the exact location of the monitoring points associated with each effluent waste stream.

We have therefore included a pre-operational measure in our permit (PO14), which requires NNB GenCo (SZC) to confirm the locations of the monitoring points for each waste stream, including exact National Grid references (NGRs) and site plans before the HFT phase of commissioning begins.

We have decided that NNB GenCo (SZC) should carry out effluent monitoring of the waste streams for the following parameters as listed below.

Waste stream A

- Flow rate (15-minute instantaneous or integrated flow), temperature (maximum and differential), total residual oxidant (TRO)

Waste streams B and C combined

- Maximum volume, flow rate (15-minute instantaneous or integrated flow), daily and annual loads of Hydrazine, Morpholine, Ethanolamine, Nitrogen (as N), Ammoniacal nitrogen (expressed as NH_4^+), Phosphate (as PO_4^{3-}), COD, Aluminium (total), Chromium (total), Copper (total), Iron (total), Manganese (total), Nickel (total), Lead (total), Zinc (total), Cadmium and Mercury

Waste stream D

- Maximum volume, flow rate (15-minute instantaneous or integrated flow), daily and annual loads of Boron (as B), Lithium (as Lithium Hydroxide), Hydrazine, Morpholine, Ethanolamine, Nitrogen (as N), Ammoniacal nitrogen (expressed as NH4+), Phosphate (as PO43-), COD, Aluminium (total), Chromium (total), Copper (total), Iron (total), Manganese (total), Nickel (total), Lead (total), Zinc (total), Cadmium and Mercury

Waste stream E

- No visible oil or grease, pH

Waste stream F

- Maximum volume, flow rate (15-minute instantaneous or integrated flow), annual loads of Detergents, and daily and annual loads of Sulphates, Amino tri-methylene phosphonic acid (ATMP), Hydoxy Ethylidene Diphosphonic acid (HEDP), Acetic acid, Phosphoric acid, Sodium polyacrylate, Acrylic acid, Cadmium and Mercury

Waste stream G

- Maximum volume, flow rate (15-minute instantaneous or integrated flow), ATU-BOD as O2, Suspended solids (measured after drying at 105°C), Ammoniacal nitrogen (expressed as N) and no visible oil or grease

Waste stream H

- Maximum volume, flow rate (15-minute instantaneous or integrated flow), total combined moribund biomass with daily mean (90 day rolling average) and daily mean daily mean (12 month rolling period (annual average))

We have set these monitoring requirements in the draft permit in order to make sure that the level of emissions does not harm the receiving environment. We will also monitor certain aspects of the discharge as part of our routine compliance work.

Our draft permit includes a pre-operational measure (PO11), which requires NNB GenCo (SZC) to submit for approval an environmental monitoring plan for the purpose of post-scheme validation. NNB GenCo (SZC) will need to agree the scope of this plan with us.

In accordance with our guidance, monitoring equipment, techniques, staff and organisations employed for the emissions monitoring programme and environmental monitoring shall have either MCERTS certification or MCERTS accreditation (as appropriate), where available, unless otherwise agreed in writing by us. MCERTS is our monitoring certification scheme. It provides the framework for businesses to meet our quality requirements. If an operator complies with MCERTS we have confidence in its monitoring of emissions to the environment. NNB GenCo (SZC) will be required via a pre-operational measure (PO11 and PO15) in the draft permit to confirm the proposed monitoring procedures/ techniques to be used, and its MCERTS status, before the HFT phase of commissioning begins.

4.17 Pre-operational conditions

Based on the information in the application, we consider that we need to impose pre-operational conditions ('measures'). These measures are set out here. We have also referred to them throughout this draft decision document, where appropriate. The pre-operational measures must be completed before the hot functional testing phase of plant commissioning begins. Many of the measures require the operator to submit a specific plan for our approval before a particular water discharge activity begins.

Due to the lengthy design process and construction period associated with Sizewell C, certain aspects of the detailed design are ongoing and evolving. Our pre-operational measures in many instances require the operator to confirm that it has adopted or implemented the details and measures proposed in its application before commissioning begins. We note that the UK EPR™ is an evolutionary design based on operational PWR power stations in France and Germany. The most recent French design was the N4, a predecessor of the UK EPR™, brought into commercial operations in 1996 (Chooz B1, located in France). The most recent German design was KONVOI, brought into commercial operation in 1989 (GKN-2, located in Germany). We expect NNB GenCo to learn lessons from the detailed design and construction of the other EPR™ units under construction, in particular at Flamanville in France and HPC in Somerset, and that this experience will inform its responses to our pre-operational measures.

Where design amendments have taken place since the application was made, then the measures require the operator to validate the original application data and, where appropriate, demonstrate how any amendments will prevent or minimise impacts on the environment and ensure compliance with this permit.

Pre-operational measure PO1

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit a summary of the site environment management system (EMS) to the Environment Agency and make available for inspection all documents and procedures which form part of the EMS. The EMS shall be developed in line with our guidance on development of management systems for environmental permits, and shall include an accident management plan for the water discharge activities. The documents and procedures set out in the EMS shall form the written management system referenced in condition 1.1.1 (a) of the permit.

Pre-operational measure PO2

Prior to the hot functional testing (HFT) phase of commissioning, the operator shall submit to the Environment Agency for approval a report which includes a completed, as-built description of the plant and infrastructure relevant to the water discharge activities. Note that the report shall take into account the whole cooling water system, including the design of the two FRR systems.

In addition, the report shall contain an updated site plan clearly showing all relevant buildings and structures and the route of the associated pipework, including all land-based infrastructure associated with the cooling water system.

Should the final design vary from that described in the permit application, the report shall include, as appropriate, a risk assessment to demonstrate how the changes will prevent or minimise impacts on the receiving water environment, and ensure compliance with this permit.

Pre-operational measure PO3

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a report which reviews the proposed substance loadings and emissions to surface water from Sizewell C. The report shall include, but not be restricted to the following:

- a summary of the lessons learnt through design evolution and/or commissioning and operating the EPR™ at Flamanville 3 in France, Hinkley Point C in Somerset, or any other EPR™ site worldwide
- information from designers and suppliers which has influenced the final design with respect to the flow and composition of effluents
- reference to outputs from the demineralisation plant (expected to be based on no desalination technology in variance to the data provided in GDA and the permit application)

The report shall validate the proposed substance loadings and emissions from Sizewell C, fully describing and justifying:

- any expected variances from the substance loadings and emissions proposed in the permit application
- any additional mitigation measures required to ensure compliance with this permit

Pre-operational measure PO4

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a scoping document for development of an emissions management plan, to show how emissions not covered by emission limits in Table S3.1, will be prevented, or where that is not practicable, minimised.

Pre-operational measure PO5

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval an emissions management plan in accordance with the scope agreed under PO4.

Pre-operational measure PO6

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a commissioning discharges management plan. The plan shall describe how the operator intends to undertake hot functional testing (HFT). The plan shall include, but not be restricted to, the following:

- the timetable for HFT of both UK EPR™ units
- a description of the HFT process
- a description of associated effluent treatment measures
- confirmation of the expected substance loadings and emissions to surface water
- confirmation of the expected thermal loading, including the expected temperature of the discharge

- proposals for effluent monitoring during the HFT process.

The plan should also demonstrate how the operator's management and engineering controls will ensure that substance loadings and emissions to surface water do not exceed the levels stated in the permit application, with particular reference to how:

- environment impacts will be prevented or minimised
- compliance with this permit will be achieved.

Pre-operational measure PO7

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a report which confirms and justifies their operational strategy for the control of biofouling of the cooling water system. The report shall include, but not be restricted to, the following:

- an appraisal of the operational conditions and chlorination strategy employed at Sizewell B power station, and a description of how this has been taken into account in defining the proposed strategy for SZC
- the lessons learnt through design evolution and/or commissioning and operating the EPR™ at Flamanville 3 in France, Hinkley Point C in Somerset, or any other EPR™ site worldwide
- details of how the operational strategy has been optimised to reduce the need for chemical dosing and the subsequent discharge of TRO and the formation of chlorinated by-products (CBPs)
- validation of the impacts of the proposed dosing regime, to include reference to numerical modelling and ecotoxicological studies, as appropriate

Pre-operational measure PO8

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a commissioning plan for the 2 FRR (fish recovery and return) systems. The plan shall include, but not be restricted to, the following:

- a description of how the operator intends to optimise the 2 FRR systems to minimise impacts upon fish
- details of the monitoring proposed to facilitate optimisation and meet the above objective
- confirmation of the timetable associated with the commissioning of the 2 FRR systems
- proposals for demonstrating the effectiveness of the optimisation process to the Environment Agency prior to the start of active commissioning of the first SZC UK EPR™ unit

Pre-operational measure PO9

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a forebay desilting plan for the removal of accumulated silt from within the cooling water forebays. The plan shall include:

- verification of the initial impact assessment findings detailed in the permit application
- a method statement for undertaking the desilting activity

Pre-operational measure PO10

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a hydrazine management plan which details how hydrazine shall be managed and treated within the waste stream prior to discharge. The plan shall include, but not be restricted to, the following:

- the methodology to be followed in managing and treating hydrazine prior to discharge to ensure the modelled scenarios are achieved
- proposals for monitoring during commissioning (HFT) to demonstrate that the required treatment of hydrazine is being achieved in (i) waste streams B and C (combined) and (ii) waste stream D
- proposals for ongoing process monitoring to ensure that the hydrazine treatment process maintains its effectiveness
- details to ensure that an appropriate analytical method and limit of detection (LOD) for monitoring of hydrazine is implemented, the use of which shall be approved by the Environment Agency
- details of contingency plans to deal with equipment failure and/or breakdown, or other reasonably foreseeable incidents which may compromise the effectiveness of the hydrazine treatment processes

Pre-operational measure PO11

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval an environmental monitoring plan for the purpose of post-scheme validation.

The plan shall propose monitoring methods to determine the physical, chemical and biological characteristics of the area of the projected plumes along with monitoring locations and frequencies. It shall also include the procedures for assessing any effects and reporting the results of the monitoring and assessment to the Environment Agency. The plan shall include, but not be restricted to, the following aspects:

- thermal plume monitoring
- chemical plume monitoring

- subtidal and intertidal benthic ecology
- water quality monitoring
- sediment quality monitoring
- the quality assurance procedures in place
- discharges of moribund biomass as a potential source of polluting matter
- review of the limit of detection for effluent monitoring techniques
- the progress towards MCERTS certification or MCERTS accreditation, unless otherwise agreed in writing by the Environment Agency, and, if necessary, a timetable for achieving the MCERTS standard

Pre-operational measure PO12

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a priority hazardous substances management plan. The plan shall describe how the operator intends to manage the use of chemicals so as to gradually cease or phase out discharging priority hazardous substances, in accordance with the objectives set out under the Water Framework Directive.

The plan will make reference to, amongst other things, the cadmium and mercury which is present as trace contaminants in bulk raw materials, and will propose a timetable for the gradual phasing out of the use of such chemicals.

Pre-operational measure PO13

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency confirmation of the final National Grid references (NGRs) for the individual diffuser heads on the cooling water outfall tunnel, to refine the NGRs in the permit application which were submitted with a 50m limit of deviation to allow for tunnel drilling contingency.

Following written approval by the Environment Agency, the NGRs shall be deemed to be incorporated under Table S3.2 of this permit.

Pre-operational measure PO14

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency:

- confirmation of the NGRs for the compliance monitoring points associated with each waste stream, as listed in Table S3.3
- confirmation of the monitoring point references, to be prefixed by 'M', for the waste stream compliance monitoring points
- detailed site plan(s) showing the exact location of the waste stream compliance monitoring points.

Following written approval by the Environment Agency, the NGRs and monitoring point references shall be deemed to be incorporated under Table S3.3 of this permit. The site plan(s) shall be deemed to be incorporated under Schedule 7 of this permit.

Pre-operational measure PO15

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval an effluent monitoring plan which specifies the monitoring techniques and assessments to be used for monitoring of effluents under this permit. The plan shall also include, but not be restricted to, the following:

- the quality assurance procedures in place
- the progress towards MCERTS certification or MCERTS accreditation, unless otherwise agreed in writing by the Environment Agency, and, if necessary, a timetable for achieving the MCERTS standard

Pre-operational measure PO16

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a hydrodynamic modelling review plan. The plan shall include a description of the sampling and monitoring regimes that will be put in place to meet the requirement of improvement condition IC2 in Table S1.3 of this permit.

Pre-operational measure PO17

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a site plan detailing the following storage locations of (a) hydrazine and ammonia storage, (b) chemical products storage, and (c) oil and grease storage. Following written approval by the Environment Agency, the site plan shall be deemed to be incorporated under Schedule 7 of this permit.

Pre-operational measure PO18

Prior to the commencement of the hot functional testing phase of commissioning the operator shall submit to the Environment Agency for approval a site plan detailing the location of where the operating techniques specified in table S1.2 will be applied. Following written approval by the Environment Agency, the site plan shall be deemed to be incorporated under Schedule 7 of this permit.

4.18 Improvement conditions

Based on the information in the application, we consider that we need to set what are called ‘improvement conditions’. In the case of a new regulated facility such as SZC, these are, in fact, conditions that require measures to be taken which cannot be carried out before the permit is granted (frequently to obtain operational information or environmental monitoring data for post-scheme appraisal); they are not measures to improve matters at a later stage. We are using these conditions to require NNB GenCo (SZC) as the operator to provide us with details that need to be validated or confirmed during operation. These conditions are set out here, and they have been referred to in the relevant section of this draft decision document.

Improvement condition IC1

The operator shall submit a written report to the Environment Agency on the implementation of its environmental management system and the progress made in the accreditation of the system by an external body, or, if appropriate, submit a schedule by which the EMS will be subject to accreditation. The report shall be submitted within 12 months of the date on which the hot functional testing phase of commissioning commences.

Improvement condition IC2

The operator shall review their hydrodynamic modelling for the purpose of post-scheme appraisal within 5 years of the commencement of commercial operation of UK EPR™ unit 2, to validate their modelling predictions. The review shall include re-calibration and validation of the hydrodynamic model(s) if necessary, as well as a reassessment of the assumptions concerning the near-field behaviour of the discharges.

The operator shall submit a written report to the Environment Agency on the review of their hydrodynamic modelling within one month of completion of the review.

Improvement condition IC3

The operator shall review their hydrodynamic modelling and associated impact assessment in light of the following:

- best available climate change projections
- operational performance of the power station
- the output from post scheme appraisal studies; within 5 years of the commencement of commercial operation of UK EPR™ unit 2, and every 10 years thereafter unless otherwise agreed in writing by the Environment Agency

The review will assess how the climate change projections could influence the operation of the power station in the future. The results of the review must be reported to the Environment Agency in writing within one month of completing of each review.

4.19 Consideration of best available techniques

The use of Best Available Techniques (BAT) is a well-established approach for identifying, assessing and selecting appropriate controls on pollution. Most conventional power stations are covered by the Industrial Emissions Directive (IED), and therefore require the application of BAT by law.

Nuclear power stations are not covered by the IED, although they do fall under EPR 2016 for water discharge activities (WDAs). In carrying out our WDA permitting functions, there is no duty on us (the Environment Agency) to consider Best Available Techniques (BAT). However, the obligations of the OSPAR Convention applies to these discharges.

The OSPAR Convention requires Contracting Parties (as the UK is) to apply BAT and Best Environmental Practice (BEP) including, where appropriate, clean technology, in their efforts to prevent and eliminate marine pollution.

As defined in Appendix 1 of the OSPAR Convention, BAT means "the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste". BEP is defined as "the application of the most appropriate combination of environmental control measures and strategies".

In addition to our obligations under the OSPAR convention, we are also guided by the Government Nuclear National Policy Statement (EN-6) which states that:

3.7.7: Discharges into water sources will be controlled in accordance with permits issued by the EA. Applicants will be expected to demonstrate Best Available Techniques to minimise the impacts of cooling water discharges.

In considering BAT we recognise that a point can be reached where the additional costs of securing further reductions in discharge quantity and / or quality, and of the risks associated with those discharges, would far outweigh the increased protection arising from such improvements to the environment and / or the general public. However, where a statutory obligation, for example, an EQS, requires stricter conditions and quality limits than those achievable by the use of BAT then we would seek to ensure that:

a) the operator investigates whether alternative means exist, for example, a change in process or equipment, or a change in operational regime
b) additional regulatory measures or controls are applied as necessary
c) compliance with said discharge quality limits can be achieved

We assessed the justifications given by NNB GenCo (SZC) in relation to pollution control and Best Available Techniques provided in their assessment.

(a) With respect to the discharge of process chemicals:

For the various effluent streams that contribute towards the operational WDAs from SZC, NNB GenCo (SZC) demonstrates that it has applied BAT principles to the use of raw materials, minimising effluent at source; re-use of water; process design and effluent treatment and preventing the contamination of effluents and surface water.

Consideration of foul sewer connection

As discussed in sections 4.9.6 and 4.11.11, we are satisfied with NNB GenCo (SZC)'s proposal to install and operate a private STP and discharge to the Greater Sizewell Bay via the two cooling water outfalls, as connection to the main foul sewer for the treatment of X effluent is unreasonable. We are satisfied with the effluent quality that the proposed STP will achieve for BOD, ammonia and suspended solids, for which we have applied numeric compliance standards within our permit. The use of a private STP at SZC is consistent with other power station sites, such as SZA and SZB, as well as other proposed power station sites such as HPC.

Although the trade effluent waste streams B to G could theoretically be sent to foul sewer, providing several kilometres of pipeline and the associated pumping infrastructure to enable the process effluent and/or treated sewage effluent to be discharged to the public foul sewer is environmentally unsustainable. Furthermore, it does not offer significant environmental benefits over a discharge out into the Greater Sizewell Bay, where there is much greater capacity to dilute and disperse effluent, rather than for example, to the inland fresh watercourses of Leiston Beck and Minsmere River where the two nearest local public sewage treatment works discharge (as discussed in section 4.10.4)

Consideration of the justification for use of hydrazine

Hydrazine will be used as an oxygen scavenger is required to prevent corrosion associated with oxidation of metals in the steam generator (i.e. rusting). NNB GenCo (SZC) advise/state that although other oxygen scavengers are available, these either reduce the efficiency of the power station, or are more harmful to the environment than hydrazine. These alternatives substances include Carbohydrazide, diethyl hydroxylamine, methy ethyl ketone, hydroquinone and erythorbic acid. Of the alternatives tested, NNB GenCo (SZC) state that none remove oxygen from high temperature and pressure boilers as efficiently as hydrazine. NNB GenCo (SZC) therefore concluded that hydrazine represents the most appropriate oxygen scavenger for use at SZC.

Site specific laboratory studies have been completed by NNB GenCo (SZC) to identify how quickly hydrazine decomposes in the environment to help access potential environmental impacts. Hydrazine degradation in seawater collected at Sizewell was shown to be around 38 minutes for hydrazine concentrations in the range of 30 to 3,000 ng/l. These studies provided the source data in support of the operational discharge modelling undertaken by NNB GenCo (SZC) for the two operational discharge scenarios and the plumes generated. We have assessed these in section 4.11, and have confirmed as acceptable following our HRA and WFD assessments, as summarised in sections 4.12 and 4.14.

Hydrazine will be present within the combined waste streams B and C, via the nuclear island waste monitoring and discharge system and tanks (KER), and waste stream D via the conventional island liquid waste discharge system network and tanks (SEK).

Hydrazine will be monitored by NNB GenCo (SZC) within these systems. If hydrazine is detected above the modelled bounding parameters (that is, the parameter we have accessed as acceptable and set compliance limits), it will be destroyed/reprocessed to an acceptable level by an appropriate treatment method by NNB GenCo (SZC) before any discharges occur. The appropriate method for treatment of hydrazine will be confirmed at a later date, and will be progressed by NNB GenCo (SZC) through its SZC forward action plan (action 3), supported by information from other sites operating EPR™ units in France and at HPC to ensure that discharges of hydrazine are minimised as far as possible.

Prior to commissioning of SZC, NNB GenCo (SZC) will conduct an optioneering study into the feasibility of further minimising hydrazine prior to discharge at levels below those given and modelled in its permit application. This exercise will balance potential environmental benefit, technical feasibility and the costs associated with implementing various engineering or management options. The results of this exercise will be made available to us for review.

The optioneering study will form part of NNB GenCo (SZC) forward action plan (action 3, development of operational management plans), for which we have incorporated a pre-operational measure condition (PO10) in our environmental permit for management of hydrazine.

Before any operational discharges of hydrazine via waste streams B and C or D can commence, NNB GenCo (SZC) will need to submit its hydrazine management plan to us to comply with the pre-operational measure condition. We will review this plan, and if it is acceptable, provide our written approval before any operational discharges can commence. Following our written approval, the hydrazine management plan will be incorporated into the environmental permit as an operating technique.

Consideration regarding the production of demineralised water

We are satisfied that BAT is demonstrated for the approach to producing demineralised water, which will utilise mains water supply as its source and not desalinisation. The demineralised water plant will use a combination of membrane (e.g. reverse osmosis) and ion exchange technology, which is considered to reduce emissions and associated impacts. Several emissions will also be avoided by not utilising desalinisation.

There will be emissions of iron and suspended solids associated with preliminary treatment of raw water. However, because SZC will use mains water only for the production of demineralised water, waste stream F will not contain a significant source of iron or suspended solids. This is because filtration of seawater will not be required for the removal of sediment from abstracted seawater, avoiding the discharge of suspended solids. Additional sources of iron and suspended solids will also be avoided from the waste stream F discharge as there will be no requirement for the backwashing of sand filters, and iron following coagulation and precipitation of substances using ferric chloride will also be avoided.

As SZC will use mains water for the production of demineralised water, waste stream F will not be a significant source of chlorides or concentrated brines. However, sodium will be introduced to the waste stream when the demineralisation resins and membranes are cleaned with sodium hydroxide, and when effluent is treated with sodium hydroxide in the neutralisation pit.

Sulphates will be introduced to waste stream F when the demineralisation resins and membranes are cleaned with sulphuric acid, or when basic effluent is neutralised with sulphuric acid.

Consideration that priority hazardous substance concentrations are trace only

There are no priority hazardous substances (PHSs) dosed directly into any of the SZC operational processes or waste streams, and we are satisfied that the sources of PHSs are trace only in nature, which is reasonable in terms of BAT.

Cadmium and mercury are present within the operational SZC cooling water discharge as trace concentrations within the bulk raw materials of process chemicals used within the water treatment processes that generate waste streams B, C and D, F. For example, waste stream F is generated by membrane and ion exchange treatments, and neutralisation of effluents following the demineralisation of mains water. These processes utilise hydrochloric acid, sulphuric acid and sodium hydroxide, which all contain trace concentrations of cadmium and mercury

NNB GenCo (SZC) has demonstrated in its risk assessment that mercury and cadmium are environmentally insignificant, as the 2 substances pass both the H1 risk assessment screening process, as well as the PHS annual significant loading test (based on the trace concentrations generated by the water treatment processes).

Additionally, NNB GenCo (SZC) will submit for our written approval a PHSs management plan (see pre-operational condition PO12), which will describe how they intend to manage the use of raw materials so as to gradually cease or phase out the discharge of PHSs. This plan will make reference to the cadmium and mercury which are present (as trace contaminants) in bulk raw materials, and will propose a timetable for the gradual phasing out of the use of such chemicals at the operational SZC.

Consideration of chlorination strategy

NNB GenCo (SZC) state that bio-fouling of the cooling water system, in particular the condensers, by bacteria, fungi or macrofauna can reduce the overall efficiency of the power station. NNB GenCo (SZC) state that there are only a limited number of options available to prevent biofouling of the cooling system, including:

- use of anti-fouling paints and coatings
- copper-nickel self-cleaning bar screens
- chemical dosing, usually with sodium hypochlorite

NNB GenCo (SZC) state that the main disadvantage of using paints or coatings is that many of the more effective types contain substances that are hazardous to the environment (such as tributyl tin). The preferred option described in the GDA is therefore to select an approach based on self-cleaning bar screens at the cooling water intakes and chlorination of the cooling water prior to the condensers.

As discussed in section 4.9.1, based upon the known risk of biofouling at Sizewell, it is necessary to dose critical plant at SZC (the condensers and essential cooling water systems) during the growing season when seawater temperatures exceed 10°C, and also to have the flexibility to dose those systems at other times of the year based upon operational need (which NNB GenCo (SZC) will detail via their operating techniques).

The chlorination policy for the other parts of the SZC CW system has to be effective against any biofouling risk that would threaten the operation of SZC whilst minimising toxicological effects on non-target species. As discussed in section X, SZC will be fitted with two FRR systems to reduce the mortality of impinged fish, and as detailed in our best practice screening guidance, chlorination should be avoided before FRR systems so as to minimise any loss of fitness for those fish returned to the marine environment. NNB GenCo (SZC) have stated that the chlorination dosing point will situated at an appropriate location downstream of the FRR systems but before the condensers

The typical options available for supplying chlorine are to:

- produce sodium hypochlorite in an on-site production plant and store it for dosing purposes, as described in the GDA
- undertake in-situ sodium hypochlorite production at the dosing location
- import and store sodium hypochlorite for dosing.

Production of sodium hypochlorite through electrolysis is widely used in EDF's French and UK fleet of operational power stations, including at Flamanville in France and at SZB. The option that will be applied at SZC will be confirmed once the chlorination strategy has been developed as described in the FAP (Action 4: Environmental performance). The assumption is that no additional emissions will be made from any associated, such as cleaning and regeneration.

The proposed chlorination strategy to maintain the required dose of TRO for SZC is discussed in section 4.9.1, and our assessment is provided in section 4.11.8 and 4.11.9. NNB GenCo (SZC) have stated that the following proven approaches will be adopted to minimise the amount of chlorination required at SZC:

- A strategy will be implemented based on 'Cooling Water Management in European Power Stations: Biology and Control of Fouling', and best practice used by EDF Energy Nuclear Generation (formally British Energy) for the existing fleet of nuclear power stations, as set out in its strategy document BEOM 006 (EDF, 2015), which involves developing a site specific risk based protocol to prevent biofouling.
- The strategy based on BEOM 006 (EDF, 2015) involves screening, cleaning and dosing in that order of preference. NNB GenCo (SZC) state that effective screening and cleaning are the first lines of defence from biofouling, so appropriate plant and practices will be put in place at SZC to achieve these. Screening and filtration help prevent cooling water systems becoming fouled, but eventually the systems will need to be cleaned. Chemical dosing is a means of limiting fouling but is only

carried out in conjunction with screening and cleaning and will not be relied on as the sole means of preventing fouling.
- Identifying the need for chlorination will also be closely linked to monitoring protocols for fouling, including monitoring of the condenser efficiency, examination of growth in circuits and monitoring populations of organisms in the surrounding sea.

Ultimately, the strategy to be developed by NNB GenCo (SZC) will be a risk based intermittent dosing regime, that will respect the operational needs of the SZC plant, the EQSs and PNECs for TRO and bromoform, and the SZC modelling thresholds assessed and considered acceptable as part of this permit determination.

The SZC strategy for control of biofouling will be considered further by NNB GenCo (SZC) via its forward action plan (action 4). We have therefore included a pre-operational measure condition (PO7) within the draft permit, which requires NNB GenCo (SZC) to submit for our written approval, a report which confirms and justifies its operational strategy for the control of bio-fouling of the cooling water system, which shall include, but is not limited to:

- an appraisal of the operational conditions and chlorination strategy employed at Sizewell B power station, and a description of how this has been taken into account in defining the proposed strategy for SZC
- the lessons learnt through design evolution and/or commissioning and operating the EPR™ at Flamanville 3 in France, HPC in Somerset, or any other EPR™ site worldwide
- details of how the operational strategy has been optimised to reduce the need for chemical dosing and the subsequent discharge of TRO and the formation of chlorinated by-products (CBPs)
- validation of the impacts of the proposed dosing regime, to include reference to numerical modelling and ecotoxicological studies, as appropriate

Consideration of management of treated sewage effluent

We have specified numeric compliance limits for the proposed sewage treatment plant (STP) for Biochemical Oxygen Demand (BOD), ammonia and suspended solids. These are standard effluent quality conditions for secondary treated sewage effluent. Although the exact specification of the STP design has yet to be defined by NNB GenCo (SZC), sufficient information on the proposed secondary treated effluent discharge has been provided in terms of its loading/sizing and final discharge effluent quality. This is consistent with other WDA permit determinations for proposed discharges of secondary treated sewage effluent when the exact STP model is yet to be confirmed.

NNB GenCo (SZC) has stated in its permit application an effluent quality from the on-site STP of 20mg/l BOD, 30mg/l suspended solids, and 20mg/l total ammonia (ammoniacal nitrogen, as N) will be achieved. The STP will need to be sized to take into account peak flows arising when maximum numbers of staff are on site, for example during an outage. The maximum daily discharge volume is calculated as being 190m^3/d.

We are satisfied that the sewage treatment plant has been sized appropriately and that the quoted performance is acceptable in terms of effluent quality. This will ensure that a good quality secondary treated sewage effluent is discharged. We have no environmental concerns with respect to a discharge at the standard quoted being made at the two proposed cooling water discharge locations. We have already concluded that in terms of bacteriological load and the potential for impact on designated bathing waters, the discharge will make an insignificant contribution to the bacterial levels in the receiving waters of the Greater Sizewell Bay. We have therefore applied the plant specification data above to our permit, adding also our standard controls for pH and no visible oil or grease.

Consideration of surface water management and oily water

Waste stream E will include sources of oily water from the oily water drainage network (SHE), which serves those areas at SZC where oils and hydrocarbons are used and which, therefore, present a risk of contamination. These areas include the back-up diesel generators, transformer compounds, electrical substations, oil and grease store, oil and hydrocarbon offloading areas and various workshops.

The exact design specification of the site oil-water interceptors has yet to be confirmed by NNB GenCo (SZC), but have confirmed that our guidance on pollution prevention for businesses will be followed. Our guidance (Environment Agency, 2016) which sets out the main principles for oil separators, including the type, class, size and use of oil separators for any sites with a risk of oil contamination including car parks, roads, and fuel off-loading facilities.

The following aspects are considered to reduce emissions and associated impacts from waste stream E:

- SHE drainage from SZC plant areas where there is the potential for contamination with hydrocarbons will be segregated from other drainage, preventing the contamination of other effluents and clean surface water run-off
- segregation of this drainage will be such that it does not pass through the site's STP (waste stream G), ensuring that sewage treatment is not adversely affected during periods of high rainfall (preventing any possibility of the discharge of sewage in rainfall/storm events)
- SHE drainage will flow either to correctly sized, full retention oil/water separators, or bypass separators, which will be Class 1 standard designed to be compliant with BS-EN-858 Separator Systems for Light Liquids, and achieve a discharge concentration of less than 5.0mg/l of oil to the forebay
- The site's oil/water separators will be specified to the meet the requirements of the BS-EN-858 Class 1 standard to provide effective treatment for hydrocarbons and will reduce hydrocarbon concentrations in the effluent discharged to the forebay to less than 5.0mg/l
- Segregation of uncontaminated sources of surface water run-off will not be required to pass through these separator systems

- NNB GenCo (SZC) will maintain the site's oil separators to comply with our guidance, with any collected hydrocarbons/oil, sludge and sediment disposed of to an appropriately permitted offsite waste management facility

(b) With respect to the cooling water method:

This is considered as an effluent stream as it relates to the discharge of heat, therefore as above, BAT principles are also appropriate. This requires a justification as to the choice of direct cooling (also known as open cycle or once-through cooling) as the preferred option. NNB GenCo (SZC) has provided a summary of its options assessment, based on the assessment made for the same UK EPR™ design at HPC. NNB GenCo (SZC)'s application also refers to a 'safety assessment', which we requested to ensure a complete record of their considerations.

Both justifications use our 2010 guidance on cooling water options as a basis for appraising BAT. With regard to cooling, the report concludes that direct cooling "can be the most appropriate environmental option for large power stations sited on the coast or estuaries, subject to current best planning, design and operational practice and best available mitigations being put in place, and meeting conservation objectives of the site in question." Based on this conclusion we accepted at the GDA stage that the selection of direct cooling for the UK EPR™ is consistent with current best practice. An abstraction licence is not required for the intake of water from the sea.

We subsequently commissioned further searches for evidence of how the equivalent of BAT for cooling waters is managed internationally. The evidence is mostly from the United States Environment Protection Agency (USEPA) who require mitigation to reduce the effects of entrapment on fish and biota populations. Our report concludes that a similar approach is not transferrable to the UK given the regulatory paradigm whereby entrapment effects on populations are managed through the DCO process, whereas pollution control is managed through environmental permitting of WDAs.

For the purposes of this WDA environmental permit, we have considered whether direct cooling is the best option given the potential impacts of the thermal discharge and release of dead and damaged fish from the two FRR systems.

As both assessments have returned an unlikely to be significant result, we conclude that in this case, direct cooling is the most appropriate cooling option for a power station at this location. The addition of further mitigation measures at the intakes are not required on the basis of WDA permit requirements and OSPAR BAT. Matters relating to the impact of seawater abstraction on marine life are considered in the planning process for the SZC DCO.

(c) With respect to the discharge of moribund biota from the two FRR systems:

We required NNB GenCo (SZC) to demonstrate that BAT principles are applied to limit the polluting effect of dead fish and biota discharged from SZC's two FRR systems. NNB GenCo (SZC) has proposed the following considerations and mitigation to reduce the quantity of fish and biota abstracted into the cooling water system, the design of the plant and the two fish recovery and return systems.

Cooling water intake siting

NNB GenCo (SZC) demonstrates that the location of cooling water intakes was decided by following our guidance [EA guidance 2010]. A subsequent evidence review [ref] did not bring to light any conclusive evidence to counter this earlier guidance.

Low velocity side-intake (LVSE)

Traditional offshore intakes were vertical shafts with water potentially being drawn from all sides. In our guidance (Environment Agency, 2005), the design for the best practice intake was changed. The new specification was for the intake to be a side-opening design, which when aligned with the tidal current produces a more even intake velocity across the face. We granted a WDA environmental permit for HPC on the basis of this intake design. However, HPC is not yet operational, and there is no large-scale LVSE in operation for which evidence of efficacy can be gained. We note that there is a balance between low velocity of water intake and the risk of biofouling, which would require higher dosing of chemicals to prevent.

A summary is provided in NNB GenCo (SZC)'s application as to why additional measures, such as behavioural deterrents, are not justified under the principles of BAT. Given the conclusions of our own assessment of waste stream H in section 4.11.14 on the impact of dead and damaged fish from the two FRR system outfalls on water quality and the local environment, we do not intend to require any further justification on mitigations at the four cooling water intakes.

Fish Recovery and Return (FRR) systems

The design and operation of the proposed two FRR systems is based on our guidance (Environment Agency, 2005) to reduce the risk of damage and mortality of fish and biota passing through the systems prior to discharge. The passage of biota through the plant with water can be damaging as organisms undergo a range of stresses that often lead to injury or death. The main causes of harm can be classified into (1) mechanical (abrasion, pressure changes and shear stress), (2) thermal (elevated water temperature and rapid changes in temperature) and (3) chemical (addition of biocides and low oxygen).

NNB GenCo (SZC) have stated that the two FRR systems will employ the following features in line with our guidance

- very low-pressure wash sprays (1 bar) shall be used for biota removal from the pumping station's rotating, 10 mm fine-mesh band screens in order to minimise the potential for harm and abrasion of the biota
- the geometry of the collection hoppers is designed to minimise the escape of fish and return into the screen well

- the screen buckets are designed to retain water, with the contents of the bucket channelled via a wash water gully to the sea under gravity flow via a dedicated pipeline, separate to the cooling water outflow channel
- fish gullies will be smooth
- swept bends of radius >3m will be used
- dedicated fish return tunnels will be used
- a wash water supply will be provided to ensure the fish are immersed as they move along the return line
- minimal use of chemicals for intake water pre-treatment
- the two SZC FFR system outfall locations have been chosen to avoid live fish being immediately entrapped in the SZB intake and, therefore, being returned to sea dead and moribund

The application of these measures will help to ensure that as many fish as possible are returned to the Greater Sizewell Bay alive via the two FRR system outfalls, therefore reducing the amount of dead and moribund fish being discharged, which could constitute polluting matter (for which our assessment is detailed within section 4.11.14). It will also reduce the amount of trash being directed to landfill.

4.20 Other statutory considerations

We have considered this application in the context of the government's policy to achieve net zero by 2050 as described in the Energy White Paper: Powering our Net Zero Future. The white paper's 10-point plan states: "Nuclear power provides a reliable source of low-carbon electricity. We are pursuing large-scale nuclear, whilst also looking to the future of nuclear power in the UK through further investment in Small Modular Reactors and Advanced Modular Reactors." As nuclear power generates electricity without the CO2 emissions associated with fossil fuels, SZC is expected to significantly contribute to the government's policy to achieve net zero.

Environment Act 1995, Section 4: Principal aim of the Environment Agency ('sustainable development')

Under Section 4 of the Environment Act 1995 (EA 1995), we are required to contribute towards achieving sustainable development, as considered appropriate by the Secretary of State and set out in guidance issued to us. 'The Environment Agency's Objectives and Contribution to Sustainable Development: Statutory Guidance' (issued by Defra in December 2002) provides guidance to us on matters such as formulating approaches that we should take to our work, decisions about our priorities and our allocation of resources. It is not directly applicable to our individual regulatory decisions.

The statutory guidance states that our main contribution to sustainable development will be to deliver our various objectives in a way that takes account (subject to and in accordance with EA 1995 and any other enactment) of economic and social considerations. In respect of EPR 2016, the guidance refers to the objective of regulating water discharge activities in accordance with statutory duties, statutory guidance and UK government policy.

We consider that the overall approach described in this document, which takes into consideration social and economic factors, and the assessment of the impact of the discharges on the environment, contribute appropriately to the aim of achieving sustainable development, having regard to the statutory guidance.

Environment Act 1995, Section 5: Pollution control powers

Section 5 of EA 1995 sets out the purpose for which our pollution control powers, including our powers under EPR 2016, must be used. This is for “preventing or minimising, or remedying or mitigating the effects of, pollution of the environment.” We consider that we have proposed proper use of our pollution control powers for that purpose, in that:

- we have proposed draft limits and conditions, as specified in the statutory guidance, and having regard to government policy
- the environment would be protected

Environment Act 1995, Section 7(1)(c)(ii): Amenity issues

Under Section 7(1)(c)(ii) of EA 1995, we must take into account any effect which our proposals would have on the amenity of any rural or urban area. Following our assessment of the proposed WDAs, we do not consider that any additional or different limits or conditions are required in the draft permit, in relation to this duty.

We are satisfied that our proposed decision to permit the WDAs, in accordance with legal and policy requirements, will not lead to any harmful effects on local amenities.

Environment Act 1995, Section 7(1)(c)(iii): Wellbeing of local communities

Under Section 7(1)(c)(iii) of EA 1995, we must have regard to the effect our proposals would have on the economic and social wellbeing of local communities in rural areas.

We have had regard, as appropriate, the potential effect on the economic and social wellbeing of the local community as part of:

- our assessment of NNB GenCo (SZC)’s proposals in relation to the use of BAT
- our considerations in relation to the principal aim of the Environment Agency (sustainable development)
- our assessment of the impact of the proposed WDAs

Following our assessments of the impacts of the proposed WDAs, we do not consider that any additional or different limits or conditions are required in the draft permit, in relation to this duty.

Environment Act 1995, Section 39: Likely costs and benefits

Under Section 39, we have a duty to take into account the likely costs and benefits of whether and how we exercise our powers ('costs' being defined as including costs to the environment as well as to any person). This duty, however, does not affect our obligation to discharge any duties imposed upon us in other legislative provisions.

We have taken into account the likely costs and benefits in our assessment of BAT. We are satisfied that the conditions in the draft permit are proportionate.

Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 and Groundwater Directive (schedule 22 to EPR 2016)

Under the Water Environment (Water Framework Directive) Regulations 2017, we must exercise our functions to secure compliance with the Water Framework Directive (Directive 2000/60/EC), which seeks to protect groundwater and surface water on an integrated river basin basis, and the Environmental Quality Standards Directive (Directive 2008/105/EC).

Schedule 22 to EPR 2016 implements the Groundwater Directive (Directive 2006/118/EC) to require the taking of all necessary measures to prevent the input of any hazardous substances entering groundwater, and to limit non-hazardous pollutants entering groundwater, so they do not cause pollution. No releases to groundwater from the operational WDAs are applied for, or are permitted by the proposed draft permit.

Water Resources Act 1991, Section 15 (particular regard to duties of the sewerage undertaker)

We have a duty under Section 15 of the Water Resources Act 1991 to consider whether granting an environmental permit is likely to affect the duties of any water or sewerage undertaker. We have considered whether we should impose any further requirements in terms of this duty, but we believe that the existing conditions are sufficient.

Marine and Coastal Access Act 2009

We have considered the new duties placed upon us under the Marine and Coastal Access Act 2009, one of the most important of which is set out in Part 3, Chapter 4, Section 58. This requires that any authorisation decision taken by a public authority must be in accordance with the appropriate marine policy documents that is the relevant marine plan or the Marine Policy Statement (MPS), unless relevant considerations indicate otherwise.

The MPS outlines the government's policies for achieving sustainable development in the marine environment around the UK, while at a local level, marine plans have been developed to provide the statutory basis for decision-making on activities within that area. The East Inshore and East Offshore Marine Plan (England) includes the Suffolk Coast, which incorporates the waters of the Greater Sizewell Bay within the East Inshore Area.

The proposed decision we have reached affects the marine waters of the Suffolk Coast (including the Outer Thames Estuary SAC and those assessed within our HRAR), and so it has been made with reference to the Marine Policy Statement and the East Inshore and East Offshore Marine Plan. We believe that our proposed decision is in accordance with the Marine Policy Statement and the East Inshore and East Offshore Marine Plan.

Human Rights Act 1998

We have considered potential interference with rights addressed by the European Convention on Human Rights in reaching our proposed decision. We consider that our decision is compatible with our duties under the Human Rights Act 1998 (UK Parliament, 1998). In particular, we have considered the right to life (Article 2), the right to a fair trial (Article 6) (which here includes the right to a reasoned decision – as provided in draft in this document), the right to respect for private and family life (Article 8) and the right to protection of property (Article 1, First Protocol). We do not believe that Convention rights are engaged in relation to this determination.

Public participation and duty to involve

Regulation 60 of EPR 2016 requires us to prepare and publish a statement of our policies for complying with our public participation duties. We have published our public participation statement (Environment Agency, 2019) and this application is being consulted upon in line with it. This satisfies the requirements of the Public Participation Directive.

Section 23 of the Local Democracy, Economic Development and Construction Act 2009 (UK Parliament, 2009d) requires us, where we consider it appropriate, to take such steps as we consider appropriate to secure the involvement of interested persons in the exercise of our functions by providing them with information, consulting them or involving them in any other way.

We have described our consultation in relation to this application within this draft decision document. We have described the way in which we have taken account of representations we have received in Appendix 1.

Deregulation Act 2015 – Growth duty

We considered our duty to have regard to the desirability of promoting economic growth set out in Section 108(1) of the Deregulation Act 2015 (UK Parliament, 2015b) and the guidance issued under Section 110 of that Act in deciding whether to grant this permit.

Paragraph 1.3 of the guidance says:

"The primary role of regulators, in delivering regulation, is to achieve the regulatory outcomes for which they are responsible. For a number of regulators, these regulatory outcomes include an explicit reference to development or growth. The growth duty establishes economic growth as a factor that all specified regulators should have regard to, alongside the delivery of the protections set out in the relevant legislation."

We have addressed the legislative requirements and environmental standards to be met in sections 4.12 to 4.20, of this consultation document. Paragraph 1.5 of the guidance is clear that encouraging economic growth should not be pursued at the expense of protecting the environment.

We consider the requirements and standards we have set in the proposed permit are reasonable and necessary to protect the environment and people. This also promotes growth among legitimate applicants and operators because the standards applied to the applicant are consistent across businesses in this sector and have been set to achieve the required legislative standards.

Equality Act 2010

We have had regard to the Public Sector Equality Duty and are satisfied that our proposed decision and decision-making process are in accordance with the duty. For example, we undertook an equality analysis to help inform our engagement activities relating to the Sizewell C project.

4.21 Matters which are outside the Environment Agency's permitting remit

Matters such as nuclear safety, the location of the facility, traffic movements and flood risk are generally dealt with under other regimes and/or by other bodies and not as part of our WDA permitting remit.

For example, vehicle access to the facility and traffic movements are relevant considerations when granting planning permission, but do not form part of the WDA environmental permit application decision-making process. There is currently a DCO application process taking place for the proposed new power station at SZC which will take regard of such planning permission aspects.

Where consultees have raised issues relating to such matters, we provide more information in Appendix 1.

5. Our proposed decision

Our proposed decision, subject to careful consideration of any issues that are identified through this consultation, is that we should grant the application and issue a permit for the proposed operational WDAs from SZC.

A draft WDA permit, containing our proposed conditions is available on our SZC proposed decision consultation pages on online consultation hub and available at Information regarding three new environmental permit applications for the proposed Sizewell C power station - Environment Agency - Citizen Space

5.1 Conditions of draft permit

The draft permit contains many conditions taken from our standard environmental permit template, including the relevant annexes. We developed these conditions in consultation with industry, having regard to the legal requirements of the Environmental Permitting Regulations 2016 and other relevant legislation.

We regularly review these conditions to make sure that they are up-to-date and effective, that permits for specific sites properly protect people and the environment, and that they are consistent with the relevant government legislation and policies.

This document does not therefore include an explanation for these standard conditions. Where they are included in the permit, we have considered the permit application and accepted the details are sufficient and satisfactory to make the standard condition appropriate.

The draft permit is based on our standard template permit for WDAs. We have developed the standard template over a number of years and we regularly review it to make sure that it is up-to-date and effective.

As well as the standard template conditions, the draft permit contains 2 bespoke conditions, regarding monitoring and reporting associated with the operation of SZC in RF3 maintenance configuration. We believe these are necessary to make sure that the permit achieves the required level of environmental protection.

The permit template and its conditions are described more fully in How to comply with your environmental permit for trade effluent discharges that are classed as water discharge or groundwater activities.

The standard permit template consists, principally, of:

- an introductory note (this is not part of the permit)
- a certificate page, authorising the permit
- Parts 1 to 4, being standard conditions about management, operations, discharges and monitoring, and provision of information

- Schedule 1, defining the permitted water discharge activities
- Schedule 3, specifying the volume, rate, composition, monitoring and routes of the permitted water discharge activities to the Greater Sizewell Bay
- Schedule 4, specifying reporting requirements
- Schedule 5, notification form
- Schedule 6, interpretation
- Schedule 7, being a site plan showing the geographical extent of the regulated facility

The conditions in Parts 1 to 4 of the draft permit have not been modified from the standard conditions of our template, apart from those relating to monitoring and reporting during operation in RF3 maintenance configuration.

In Schedule 1, we have included 3 improvement conditions, and 18 pre-operational measure conditions for the reasons explained in sections 4.17 and 4.18.

Schedule 3 specifies the proposed point source releases and, as relevant, the proposed limits that apply to specific substances for each of the approved release points.

We are of the view that our proposed decision and draft permit conditions are consistent with the relevant legislation, and that we have reached the proposed decision having regard to the statutory guidance concerning the regulation of WDAs into the environment and relevant government policy.

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A BEEMS Expert Panel produced some of the reports. The reports are based on its members' own expertise, the scientific literature, the BEEMS Data Centre and inputs from named invited scientists with relevant specialist knowledge. An example of such a report is ‘Chlorination by-products in power station cooling waters’, SAR009.

In the case of SAR009, the panel included experts from academia, regulatory authorities and commercial consultants.

Other reports have been produced for EDF by commercial consultants without, to the best of our knowledge, reference to the Expert Panel.

Our reference list distinguishes between both types of reports. We reference only those reports known to have originated from the Expert Panel as having been authored by BEEMS, for example, SAR009 is cited as BEEMS (2011). All other technical reports submitted by the applicant (NNB GenCo (SZC)) as part of its application will be referenced with NNB GenCo as the corporate author.

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Glossary

Term	Meaning
Admixture	The act of mixing or mingling.
Activity	A generic title for the practices or operations which need to be permitted (unless exempted from the need for a permit).
AONB	Area of Outstanding Natural Beauty.
APG	Steam generator blowdown system.
BAT	Best available techniques – see 'Schedule 6 – Interpretation' in the draft permit for a full definition.
Batched discharge	A controlled discharge into the main cooling flow of trade effluent generated from an intermittent process in which a known volume of process/waste effluent is produced, collected, monitored, stored and treated as required to ensure

	environmental standards as determined via the H1 risk screening process or modelling are achieved.
BEIS	Department for Business, Energy & Industrial Strategy.
Biota	In the context of our assessment, biota refers to animals (intact or otherwise) that have passed through the fish recovery and return system (ctenophores and jellyfish are excluded from our impingement mortality calculations).
Blackwater	Waste water contaminated with human faecal material.
Bootstrapping	Statistical method for resampling a single dataset to create many simulated samples
CBP	Chlorinated by-product.
Cefas	Centre for Environment, Fisheries and Aquaculture.
CFI	Drum screen and band screen pumps.
CFT	Cold flush testing.
Chemical plume	An area of water within which concentrations of chemicals are above background levels, as a result of a discharge activity.
CRF	Circulating water system pumps.
CROW	Countryside and Rights of Way Act.
CVCS	Chemical and volume control system.
CW	Cooling water.
CWS	Cooling water system.
DCO	Development Consent Order.
Defra	Department for Environment, Food and Rural Affairs.
DIN	Dissolved inorganic nitrogen.

DO	Dissolved oxygen.
ECHA	European Chemicals Agency
EDF	Électricité de France.
Enterococci	Bacteria; indicators of the presence of faecal material in water.
EPR™	European Pressurised Reactor.
EPR 2016	Environmental Permitting (England and Wales) Regulations 2016.
EQS	Environmental quality standard: The concentration and a corresponding statistic (for example, mean or 95th percentile), below which a substance is not believed to be detrimental to aquatic life, based on the results of toxicity tests on organisms covering a range of levels within food chains. Each substance has its own EQS which can differ depending on whether the receiving environment is fresh, transitional or coastal water.
Eutrophication	The increase in primary productivity and subsequent impacts on an ecosystem that arise as a result of inputs of nutrients (which can be human) raising ambient nutrient concentrations.
Ecotoxicology	The nature, effects and interactions of substances that are harmful to the environment.
FSA	Food Standards Agency.
FRR	Fish recovery and return system (SZC has 2 FRR systems).
FWP	Forward work plan.
GDA	Generic design assessment.
Greywater	Waste water without human faecal contamination.
GSB	Greater Sizewell Bay.

Haul-out site	A location on land that is used by seals – for rest, to moult and to breed. The nature of these sites varies widely and can include rocky islets or shorelines, sandy beaches or sandbanks.
HPA	Health Protection Agency (superseded by Public Health England and then by the UK Health Security Agency).
HPC	Hinkley Point C.
HRA	Habitats Regulations assessment.
HSE	Health and Safety Executive. Regulator with responsibilities under IRR17 (UK Parliament 2017b).
Impingement	This describes organisms (fish and invertebrates) trapped on the various screens which filter seawater to prevent damage occurring within the cooling water system. Impinged organisms are returned to sea via the fish recovery and return system.
IRR17	Ionising Radiations Regulations 2017.
iSoDA	Interim Statement of Design Acceptability.
KER	Liquid radwaste monitoring and discharge system.
LSE	Likely significant effect.
MCERTs	The Environment Agency's Monitoring Certification Scheme.
MCZ	Marine Conservation Zone.
Mg	Milligram (mg): A unit of mass equal to one thousandth of a gram (1.0mg = 0.001g).
Moribund	Where an organism is at the point of death. In our mortality calculation, we have used the term 'moribund biota' to mean biota passing through the FRR system that is dead and acts as a polluting matter.
Mixing zone	The mixing zone is the area around a discharge within which a quality standard is exceeded. The role of the regulator is to

	ensure that the size of the mixing zone is small enough so as to not impact on the function of the wider water body or habitat.
Mwe	Megawatt electrical, a measure of electrical power.
Ng	Nanogram (ng): A unit of mass equal to one thousandth of a microgram, and one billionth of a gram (1.0ng = 0.001µg).
NIA 65	The Nuclear Installations Act 1965.
NE	Natural England.
Nuclear island	The facilities within the reactor and associated buildings.
Nutrient enrichment	The introduction of additional and/or new nutrients into a water body or other environment. This can cause disruption to the existing water quality regime and therefore impact on species and habitats.
ONR	Office for Nuclear Regulation: a statutory public corporation, responsible for regulation of nuclear safety and security across the UK.
OSPAR	Oslo and Paris Convention for the protection of the marine environment in the north-east Atlantic. The UK is a signatory to this Convention, whose strategies aim to prevent pollution of the maritime area by continuously reducing discharges, emissions and losses of chemically hazardous substances and radioactive substances.
PHE	Public Health England (which superseded the Health Protection Agency (HPA) in 2013) and which became part of the UK Health Security Agency in 2021.
PHS	Priority hazardous substance.
PNEC	Predicted no effect concentration: The concentration of a chemical which marks the limit below which no adverse effects of exposure in an ecosystem are measured. The PNEC is used for substances for which an EQS has not been set.
PPP(s)	Permissions, plans or projects.

PWR	Pressurised water reactor.
Ramsar	Ramsar sites are wetlands of international importance that have been designated under the criteria of the Ramsar Convention on Wetlands for containing representative, rare or unique wetland types or for their importance in conserving biological diversity.
Regulated facility	A collective term for the range of activities permitted under EPR 2016.
RSR	Radioactive Substances Regulations.
SAC	Special Area of Conservation: A protected area designated under the Conservation of Habitats and Species Regulations 2017 in England and Wales, or the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) for UK offshore areas. A Special Area of Conservation is part of a network of import high-quality conservation sites that will make a contribution to conserving the habitats and species identified in Annexes I and II, respectively of European Council Directive 92/43/EEC, the Habitats Directive.
SACO	Supplementary advice on conservation objectives.
SEK	Conventional island liquid waste discharge system.
Sedimentation	The process by which suspended particles may settle out over time onto the bed of the water body.
SPA	Special Protection Area: Special Protection Areas are protected areas for birds classified under the Wildlife & Countryside Act 1981 (as amended), the Conservation (Natural Habitats, & c.) Regulations 2010 (as amended) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended).
SoDA	Statement of Design Acceptability.
Source pathway receptor (SPR)	Source pathway receptor: A framework for assessing risk of a proposal on the environment. The source refers to the hazard – something that has the potential to cause harm. The receptor is something that could suffer harm from a hazard. The pathway is

	the way in which a hazard can come into contact with a receptor.
SRU	Ultimate cooling water system pumps.
SSSI	Site of Special Scientific Interest.
STP	Sewage treatment plant.
Synergistic effect	The impact of the interaction of a number of effects is greater than the sum of the individual effects.
SZA	Sizewell A power station.
SZB	Sizewell B power station.
SZC	Sizewell C power station.
Thermal plume	The area of heated water caused by the discharges from a cooling water system.
Thermal regime	Refers to the existing temperature system of an area or water body.
Thermal uplift or thermal excess	The increase in temperature of a body of water as the result of a thermal input.
TraC	Transitional and coastal (water body).
TRO	Total residual oxidant.
µg	Microgram (µg): A unit of mass equal to one thousandth of a milligram, and one millionth of a gram (1µg = 0.001mg).
UIA	Unionised ammonia.
UWWTD	Urban Wastewater Treatment Directive.
Volatilisation	The process of converting a chemical substance from a liquid or solid to a gas or vapour.
WDA	Water discharge activity.

WFD	Water Framework Directive.

Appendix 1 - Consultation on the application

The application was advertised and consulted on in accordance with our public participation statement and government consultation principles. The way in which this has been carried out and how we have carefully considered consultation responses in preparing our proposed decision are summarised in this appendix and section 3.4 of this document. Copies of all consultation responses have been placed on our public register except where the person making the response asked us not to do so. Responses made using our e-consultation tool can also be accessed online via our consultation hub.

How we publicised the consultation on the application

The consultation on the application was advertised by a notice on GOV.UK from 6 July to 2 October 2020 and a press release. The notice provided brief details of the application and told people where they could see a copy of the application and how to make comments. Copies of the application were made available for public inspection using our e-consultation tool via our consultation hub.

We publicised the consultation by issuing press releases, advertising in local newspapers and writing directly to a number of organisations and individuals inviting them to participate. As the application was made at a time when government had placed restrictions on the movements and activities of the public due to the Covid-19 pandemic, we were unable to hold a consultation drop-in session or place copies of the application in local libraries and institutions as we would usually. We held a public question and answer session by phone on 20 July 2020 and put in place processes to enable interested parties to respond to the consultation over the telephone. We asked NNB GenCo (SZC) to make copies of the application available on USB sticks, which it did.

Who we consulted

We wrote to the following bodies informing them of the application and directing them to copies of the application online:

- Food Standards Agency
- Natural England (NE)
- Marine Management Organisation (MMO)
- Centre for Environment, Fisheries and Aquaculture Science (Cefas)
- Eastern Inshore Fisheries and Conservation Authority (IFCA)
- Health and Safety Executive (HSE)

- East Suffolk District Council – Environmental protection/health, local planning authority
- Suffolk County Council
- Public Health England (now the UK Health Security Agency)
- Ipswich and East Suffolk Clinical Commissioning Group
- Anglian Water
- The Norfolk and Suffolk Broads National Park
- Historic England

We also emailed over 800 other interested groups, non-governmental organisations, councils, members of parliament, businesses and individuals informing them of the consultation and inviting them to participate.

Responses to the consultation on the application

We received 28 responses from organisations and individuals. These are summarised here, together with our consideration of them.

Response received from Natural England

Natural England (NE) were consulted and responded that due to resource constraints, it would be their preference to delay comment on the permitting until the formal/statutory consultation phase, as their current focus is on the SCZ Development Consent Order (DCO) application and prioritising their statutory Relevant Representations (prior to looking at non statutory requests). As reported in section 4.12.7, we consulted NE on our draft HRAR on the 15 February 2022, and we have had regard to the comments raised in accordance with Regulation 63 of the Habitats Regulations 2017.

Response received from Marine Management Organisation

Response received from Marine Management Organisation (MMO). This was a generic response with guidance, and did not contain any site specific comments regarding the SZC operational WDAs. The response informed us that any works within the marine area require a licence from the MMO and that it is down to the applicant themselves to take the necessary steps to ascertain whether their works will fall below the mean high water springs mark. The response also provides advice regarding marine licensing, environmental impact assessment, marine planning and minerals, waste plans and local aggregate assessments.

Based on this response there was no further action required from us as part of the WDA permit determination.

Response received from East Suffolk Council Environmental Health

Response stated that East Suffolk Council Environmental Health are consultees to the ongoing SZC DCO application and the situation in terms of noise and amenity is currently under discussion and assessment in terms of the proposed activity prior to examination. If you require specific information from us regarding this then please confirm the nature of that information, currently there are no noise or amenity issues, neither is there any ongoing enforcement as the facility is some way off being consented or built.

Based on this response there was no further action required from us as part of the WDA permit determination.

Response received from Historic England

The response from Historic England informed us that it is a statutory consultee with regards to the ongoing SZC DCO application, and the situation in relation to the historic environment is currently under discussion. Historic England also informed us that it is currently assessing the Environmental Statement in terms of the proposal prior to examination.

Based on this response there was no further action required from us as part of the WDA permit determination.

Responses received from Eastern Inshore Fisheries and Conservation Authority (IFCA), Suffolk Coast Friends of the Earth, Together Against Sizewell, Stop Sizewell C, Suffolk Wildlife Trust, Royal Society for the Protection of Birds (RSPB) and 18 individuals

The responses and representations received from the above group raised similar issues and concerns with the proposed SZC operational WDA permit application. We have therefore decided to combine and summarise the same issues that have been raised within this group of responses, and the way in which we have considered these in the permit determination process. Only one of the 18 individual responses stated no issues or concerns regarding the proposed new nuclear power station at SZC and its WDAs, and that they did not see anything wrong with having SZC as a source of energy generation.

Summary of issues raised - Concerns raised regarding the impact on marine flora, designated European sites (including the Outer Thames Estuary SPA, Minsmere-Walberswick SPA, Southern North Sea SAC) and their designated habitat and species features (including Little Tern, Common Tern, Red Throated Diver, Harbour Porpoise), impacts on species foraging success, and impacts on prey species as a result of the proposed operational WDAs from SZC.

Our consideration of the issue

In response to our duties under The Conservation of Habitats and Species Regulations 2017 (as amended), we have carried out a comprehensive Habitats Regulations assessment report (HRAR), including completion of an appropriate assessment and in-combination assessment (for other plans, permissions and projects) of the potential impacts of the proposed operational WDAs from SZC on the Outer Thames Estuary SPA and the Southern North Sea Severn Estuary SAC, SPA and Ramsar, as well as several other designated European conservation sites.

The main areas of concern were (i) thermal impacts due to the discharge of cooling water at a higher than ambient temperature, (ii) toxic contamination due to process chemicals, including the use of biocide to control biofouling, and (iii) nutrient enrichment to determine if these could lead to an adverse effect on the features of the European sites.

We have consulted Natural England on our draft HRAR, and we have had regard to their comments raised in accordance with Regulation 63 of the Habitats Regulations 2017 (as confirmed in section 4.12.7 of this consultation document).

We have concluded that the operational WDAs at SZC can be ascertained to have no adverse effect on the integrity of the sites assessed (including their designated features, as well as functionally linked land and their features), either alone or in combination with other plans and projects. This is detailed within sections 4.11 and 4.12 of this consultation document.

Summary of issues raised - Concern raised regarding the potential impacts of the proposed SZC operational WDAs on local SSSIs

Our consideration of the issues

We have completed assessments under the Wildlife and Countryside Act (CRoW) for the Alde-Ore Estuary SSSI, Leiston to Aldeburgh SSSI, Minsmere-Walberswick Heaths and Marshes SSSI, Pakefield to Easton Bavents SSSI, as these SSSIs have all been identified as being potentially at risk from the operational WDAs from SZC. The details of our assessment are reported in section 4.13 of this consultation document.

Some of the features designated under the SSSIs are replicated across these associated European sites. The potential for impact on the European sites has been fully considered separately in our HRAR within section 4.12 of this consultation document.

The methodology and approaches we have used to assess the potential impact in our CRoW assessment are the same as those used in our HRAR for the equivalent European sites, and where appropriate, information and main arguments presented in the HRAR are replicated within our CRoW assessment.

We have considered the application for the operational WDAS from SZC in the context of the 4 SSSIs, and concluded that the proposed WDAs will not cause damage to any of these SSSIs. We have shared our CRoW assessment with Natural England as part of our public consultation.

Summary of issues raised - Concerns raised regarding the impact of the fish recovery and return (FRR) system discharges and how these have been considered, and how waste will be disposed of

Our consideration of the issue

We have completed an assessment of the proposed discharges from the two FRR system discharges (waste stream H) and their impact, as reported within section 4.11.14 of this consultation report. Given the proposed conclusions of our assessment of waste stream H on the impact of dead and damaged fish/marine biota (moribund biomass) from the two FRR system outfalls on water quality and the local environment of the Greater Sizewell Bay, we do not intend to require any further justification on mitigations at the four cooling water intakes.

The proposed compliance measures for waste stream H, as reported within section 4.15.6. There are also pre-operational measure conditions regarding the FRR systems, which will require our approval before any discharges can commence. These include PO4 and 5 (Emissions management plan), PO8 (FRR systems commissioning plans) and PO15 (effluent monitoring plan), as reported within section 4.17 of this consultation report.

In terms of safe disposal, NNB GenCo (SZC) has stated in its main WDA application document that only the material that will require disposal is the material impinged on the course screens (at the Debris Recovery Building). The disposal of this material will be made to an appropriately licensed waste disposal facility.

Summary of issues raised - Concern raised regarding the potential for scour and damage of the seabed as a result of the proposed discharges from SZC

Our consideration of the issue

We have assessed the potential risks from the proposed SZC operational WDAs into the Greater Sizewell Bay via the two cooling water (CW) outfalls and two fish recovery and return (FRR) system outfalls via our HRAR.

This includes consideration and assessment of the potential risks from physical damage and scour from the proposed cooling water and FRR system discharge outfalls, as reported in sections 4.11.15 and 4.11.16 of this consultation document. We have concluded that the discharges from the two CW CWS outlets and the FRR system outlets will not result in an increase in erosion or siltation of sufficient magnitude to result in a conceivable effect on the conservation objectives of the Outer Thames SPA, and so the proposed discharges are considered to be low impact with regard to the risks of physical damage and scour.

Summary of issues raised - **Concerns raised regarding the risks and impact of TRO and Bromoform used for biofouling control on the receiving marine environment, designated sites (and their designated habitat and species features) and bathing water and tourist beaches**

Following our review and assessment of the permit application, as reported in sections 4.11, 4.12 and 4.14, we do not consider the potential impact of TRO and Bromoform (CBP), as shown through detailed modelling, to be significant. Additionally, the modelled plumes for TRO and Bromoform (where the EQS for TRO, and PNEC for Bromoform are exceeded) are located offshore and do not interact or come into contact with, the Suffolk coastal water body, the designated bathing water beaches at Southwold and Felixstowe, or other beaches located at Dunwich, Sizewell, Thorpeness and Aldeburgh.

Pre-operational measure PO7 in our draft permit requires NNB GenCo (SZC) to confirm and justify its operational strategy for controlling biofouling. It will need to validate the impacts of the proposed dosing strategy on the marine environment.

Pre-operational measure PO11 in our draft permit requires NNB GenCo (SZC) to agree with us an environmental monitoring plan to be used for post-scheme appraisal. This will need to include provisions for monitoring TRO and Bromoform (CBPs).

Summary of issues raised - Concerns regarding impact on AONBs as a result of the proposed SZC operational WDAs

Our consideration of the issue

As reported in section 4.13 of this consultation document, Section 85 of the Countryside and Rights of Way Act 2000 places a duty on us to consider conserving and enhancing the natural beauty of the Area of Outstanding Natural Beauty (AONB) when carrying out any of our work in relation to, or so as to affect, land in such an area. We have considered this operational WDA application in the context of the Suffolk Coast and Heaths AONB. We have considered whether we should impose any further requirements, but believe that existing proposed conditions in the proposed draft permit are sufficient.

Summary of issues raised - Concerns regarding the discharge of treated sewage effluent and impacts on water quality, bathing waters and tourism

Our consideration of the issue

We have assessed the potential water quality impacts from the proposed STP discharge (waste stream G), as discussed within section 4.11.11 of this consultation document. There will be no discharges of sewage effluent during storm events as the surface water (waste stream E) and foul system (waste stream G) will be segregated. There is no discharge of storm sewage included in the SZC operational WDA permit application, and no discharge of storm sewage is permitted in the proposed permit.

As also reported in Section 4.11.11, we have considered the potential impacts on local designated bathing waters and conclude that the proposed discharge of treated sewage effluent via the offshore cooling water outfalls will make an insignificant contribution to the bacterial levels in the Greater Sizewell Bay at the points and discharge, and so there is no risk of impact to the designated bathing water beaches or other local tourist beaches.

Summary of issues raised - Concerns regarding inadequate risk assessments

Concerns have been raised that some of the risk assessments submitted with the application do not contain adequate levels of information regarding the proposed operational WDAs.

Our consideration of the issue

As part of the permit application review and determination process, where we found a document or report lacking in detail or information, or if this detail or information was missing, we asked NNB GenCo (SZC) for further information to be supplied, along with amendments to the documents or reports submitted with the permit application. This was required to allow us to complete our review and assessments, in order that we could come to our proposed decision on the permit application. We asked for this information by issuing 6 Schedule 5 notices to NNB GenCo (SZC), as reported in section 3.5 of this consultation report. This additional information was used to allow us to complete our assessments, including HRAR (including in-combination assessment), WFD compliance report review and CROW assessment, as reported within this consultation document.

Summary of issue raised - Concerns were raised regarding the number of documents submitted in the SZC WDA permit application

Our consideration of the issue

We are unable to control the number of documents submitted by an applicant with their environmental permit application. It is the applicant's permit application, and it is their responsibility to submit sufficient relevant information and evidence to support the application for their proposal. The supporting information and evidence submitted should also be proportional to the complexity of the proposed WDA and the environmental risk to the proposed receiving environment. The application, supporting information and evidence must also be submitted in the correct form before we are able to confirm if we are able to begin our determination of the permit application.

For this permit determination, we decided to share all of the application and supporting information and evidence in full as part of the application's consultation, and we have demonstrated which parts of the application we have referenced in this consultation document (as well as within our HRAR and in our review of the WFD compliance report). We have guidance available for the requirements of permit application for discharges to surface water, and guidance for the requirements for surface water risk assessment.

Summary of issue raised - Operator competence

Concerns were raised about NNB GenCo (SZC)'s ability to competently run the proposed site.

Our consideration of the issue

The proposed permit requires NNB GenCo (SZC) to have an appropriate management system that we will be ensuring they comply with as part of our ongoing compliance work. We have no reason to believe that they would not be able to comply with this requirement In the proposed permit.

Summary of issue raised - Concerns raised regarding the discharge of boron, ammonia and other chemicals, including heavy metals (such as lead, cadmium and zinc) from the proposed SZC operational WDAs

Our consideration of the issue

We have completed a detailed water quality impact review and assessment of the proposed waste streams (A to H). The proposed discharges of boron via waste streams were reviewed and assessed following our guidance for H1 risk screening assessments for discharges into cooling water which are then discharged to TraC waters. The proposed discharge of these substances within the cooling water (via the corresponding waste streams) are considered to be environmentally insignificant in terms of risk to the Greater Sizewell Bay, as reported in sections 4.9, 4.11, 4.15 to 4.17 of this consultation document.

Summary of issue raised - Concerns raised regarding the proposed SZC operational WDAs and climate change

Our consideration of the issue

We recognise the importance of considering the potential effects of future climate change. We have therefore proposed to include an improvement condition within the draft permit (IC3) requiring NNB GenCo (SZC) to regularly review its hydrodynamic modelling and associated impact assessments for the operational WDAs in light of best available climate change projections, and to consider how these projections could influence the operation of the SZC power station in the future.

Summary of issue raised - Concerns raised regarding the location of the proposed facility

Our consideration of the issue

Decisions about land use are matters for the land-use planning system. There is currently a DCO application process taking place for the proposed new power station at SZC. The location of the facility is a relevant consideration for environmental permitting under EPR 2016 but only in relation to its potential to have an adverse environmental impact on members of the public or sensitive environmental receptors. The impact on members of the public and the environment has been assessed as part of the determination process, and as reported within this draft decision consultation document.

Summary of issue raised – Concerns raised regarding flood risk and natural disasters

A number of consultees, raised concerns about the flood risk of the site, particularly in relation to coastal erosion and sea level rise. Consultees raised concerns about the suitability of the site given the potential impacts of climate change on the Sizewell coastline.

Our consideration of the issue

We have provided advice and guidance on flood risk in our consultation responses relating to the NNB GenCo (SZC)'s application to the planning authority for a Development Consent Order (DCO). Our advice on these matters is normally accepted by both the applicant and the planning authority. There is currently a DCO application process taking place for the proposed new power station at SZC.

The Office for Nuclear Regulation (ONR) considers flood risk as part of its regulation of nuclear site licensed sites. Flood risk and other external hazards would be addressed as part of the safety case for the site developed by NNB GenCo (SZC). NNB GenCo (SZC) has applied to ONR for a nuclear site license.

Summary of issues raised – Issues and concerns raised regarding impact on fish stocks (including livelihoods of local fishermen), intake of marine biota (fish and other creatures) via the cooling water intakes, and use of acoustic and behavioural deterrents on the cooling water intakes to minimise impacts on marine biota

Our consideration of the issue

Impacts on fish stocks, issues relating to the abstraction of cooling water, and use of acoustic/behavioural deterrents to minimise impacts on fish numbers/stocks are not within the remit of this WDA permit determination. These are instead considered under planning and the SZC Development Consent Order (DCO). NNB GenCo (SZC) has made an application for a DCO that, at the time of writing, is being considered by the Planning Inspectorate (PINS). NNB GenCo (SZC) has a dedicated website that provides information on its application and the DCO process, as well as the DCO application documents. The DCO process considers a wide range of environmental issues associated with the SZC site and its related developments, including the types of issues raised by consultees for the operational WDA permit application (that are outside of the remit of the operational WDA permit application). PINS also has its own portal for documents and information related to the SZC DCO process.

Summary of issue raised – Concerns raised regarding the use of nuclear power, stating that it is not an appropriate technology choice for energy generation.

Our consideration of the issues

Energy policy, including the use of nuclear power is a matter for government and does not form part of the remit of this environmental permit application. Government published an Energy White Paper: Powering our Net Zero Future on Energy in 2020 that set out the need for nuclear power, among other measures, to achieve net zero by 2050. In 2022 the Government also published the British Energy Security Strategy that states an aim that by 2050, up to a quarter of the power consumed in Great Britain is from nuclear.

Summary of issues raised - Concerns raised regarding radioactive discharges and releases, and the storage and management of radioactive waste that will be generated from operation of SZC

Our consideration of the issue

In determining this WDA permit application, we have thoroughly assessed the discharges of non-radioactive liquid effluents from SZC (waste streams A to H), as reported in this consultation document. We are satisfied that there will not be a significant impact on the marine environment within the Greater Sizewell Bay as a result of the proposed operational WDAs.

The fate and behaviour of radioactivity in the environment and its potential impact on human health, following release from SZC, is not within the remit of this WDA permit determination. However, it has been considered and assessed within the SZC radioactive substance activities (RSA) environmental permit application (reference EPR/HB3091DJ/A001).

Summary of issues raised - Concerns regarding decommissioning

Our consideration of the issue

This is not a consideration for the determination of the proposed SZC operational WDAs permit application. However, under the proposed SZC operational RSA permit application, NNB GenCo (SZC) has made a commitment (under the Forward Work Plan supplied with the application) to develop its decommissioning arrangements. We will work with ONR and BEIS to consider the Decommissioning and Waste Management Plan when submitted by NNB GenCo to ensure it is capable of being carried out in a way that is consistent with our regulatory requirements and expectations. This finding will be further addressed by draft permit condition 1.1.3 of the RSA permit.

Appendix 2- Hydrazine PNECs

Our ETAS review of hydrazine PNECs proposed by NNB GenCo (SZC) within its SZC operational WDAs permit application.

Background to query:

NNB Generation Company (NNB GenCo) proposes to construct and operate new nuclear power stations within the UK, primarily at Hinkley Point in Somerset, to be known as Hinkley Point C (HPC) and at Sizewell in Suffolk, to be known as Sizewell C (SZC). The construction and operation of these power stations will require various permissions from the Environment Agency.

During the commissioning and operation of these power stations, the operator would like to discharge trade effluent contain concentrations of hydrazine. To assess the environmental implications of these discharges, NNB GenCo has investigated the toxicity of hydrazine in order to propose a suitable predicted no effect concentration (PNEC) as an appropriate environmental impact threshold.

NNB GenCo has proposed the following PNECs:

- a chronic PNEC of 0.4ng/l (calculated as a mean) for assessing long-term effects
- an acute PNEC of 4.0ng/l (calculated as a 95th percentile) for assessing short-term effects

It has also referred to more recent assessments used in support of Canadian Federal Water Quality Guidelines (FWQGs) for hydrazine that indicate concentrations below 200ng/l have a low probability of adverse effects for marine life, while a freshwater threshold of 2.6µg/l has been applied based on a greater availability of data in the freshwater environment (Environment Canada, 2013).

Enquiry:

1. Can we consider that the proposed PNEC concentration values stated by NNB GenCo (and how they have been derived) are appropriate?
2. If not, what alternative PNEC concentration values should be considered as appropriate for use in our audit of the assessments?

ETAS response

An environmental quality standard (EQS) for the protection of aquatic life is not available for hydrazine. An EQS reflects the concentration of a substance above which there is the potential for an adverse effect on aquatic organisms based on consideration of the available toxicity data. Formal EQSs are only available for a relatively small number of substances. In situations where an EQS is not available for a substance of interest, but an indication of a concentration of potential concern in the environment is needed, a review of the available data on the substance can be undertaken to identify other relevant, available thresholds and also data on the aquatic toxicity of a substance. In the absence of a suitable threshold the available toxicity data can be used to derive a predicted no effect concentration (PNEC) value to give an indication of a concentration of potential concern.

In the absence of an EQS for hydrazine NNB GenCo proposed a PNEC value of 4ng/l (acute exposure) and 0.4ng/l (chronic exposure). We have considered the information provided on the toxicity data and approach used to derive the PNEC value proposed. This data (outlined in submitted reports, for example, TR357 and 445) indicated that the PNEC was derived based on consideration of the available aquatic toxicity data and application of an assessment factor to the lowest effect concentration located. The PNEC proposed is based on a toxicity study for the algal species Dunaliella tertiolecta, for which an EC50 of 0.4ug/l was reported. An assessment factor of 100 was applied to derive the acute value of 4ng/l and an AF of 1,000 to derive the chronic value of 0.4ng/l. Data was available for a range of species including algae/macrophytes, invertebrates and fish.

Alongside the toxicity data noted to have been considered by NNB, we also considered the aquatic toxicity data collated in an Environment Canada report (2013) (https://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=D66353C2-1#a8). Toxicity data for a wide range of species was included in this report, including data for algae/macrophytes, invertebrates and fish. The data indicated that algae/macrophytes were the most sensitive species based on the available dataset. None of the endpoints noted in this report were below the lowest effect concentration noted in the data NNB GenCo provided.

We undertook an additional data search to see if there was any additional data for hydrazine. Some additional information was located from an ECHA (European Chemicals Agency) substance dossier, but the data did not include a lower effect concentration than that which had been used to derive the PNEC NNB GenCo proposed.

Assessment factors (AFs) were used to derive the proposed PNEC value. The use of AFs is an approach used to derive EQSs and other environmental thresholds. They are applied to take account of the fact, for example, that toxicity data is not available for all species and endpoints. The size of the AF applied is dependent on the available dataset, for example, the range of species and endpoints for which data is available and whether the short-term and long-term exposure studies are available. The AFs used to derive the PNEC are broadly in line with the assessment factors noted in the guidance for deriving EQS values under the Water Framework Directive (Technical Guidance No 27 (2018) (https://rvs.rivm.nl/sites/default/files/2019-04/Guidance%20No%2027%20-%20Deriving%20Environmental%20Quality%20Standards%20-%20version%202018.pdf)

This is the guidance currently used when deriving EQSs in the UK. NNB GenCo has applied an AF of 100 to derive the acute value for hydrazine and an AF of 1,000 to derive the chronic value. Based on the available data for hydrazine, this is broadly in line with the AFs noted in the guidance. A difference however is that an additional AF of 10 has not been applied for the marine environment. Additional AFs are proposed in deriving EQSs for saltwater where there is limited data for saltwater species and are used to recognise greater species diversity in the marine environment. The additional AF has not been applied, with the argument being that hydrazine is not persistent and bioaccumulative. This is not a specific reason noted in the guidance for not applying an additional AF. There could therefore be an argument that an additional AF should be applied in this case.

Based on considering the above:

- Aquatic toxicity data is available for hydrazine for a range of species, including algae, invertebrates and fish.
- Algae/macrophytes seem to be the most sensitive organisms based on the available toxicity data. The lowest effect concentration reported in the dataset located was for Dunaliella tertiolecta. An EC50 of 0.4ug/l was noted for this species. This was the lowest effect concentration for the dataset overall and the lowest effect concentration for algae/macrophytes.
- As this is the lowest value, it seems appropriate to use this as the basis of deriving a PNEC based on the available data.
- The AFs used in deriving the PNEC are 100 for the acute value and 1,000 for the chronic value. Based on the available toxicity data, this is broadly in line with the guidance for EQS derivation. An additional AF of 10 was not applied. The argument noted, that is, hydrazine is not persistent or bioaccumulative is not a specific reason noted in the guidance for not applying an AF.
- Based on the available dataset however and the approach used, the PNEC NNB GenCo proposed is based on the most sensitive toxicity endpoint available, the data is for saltwater algal species which seem more sensitive than invertebrates and fish. It could therefore be considered a reasonable screening value in the absence of an EQS.
- For information, the Canadian and ECHA values that have been derived differ from the proposed PNECs as different studies have been used as the basis of the threshold derived and different assessment factors have been applied. The PNECs NNB GenCo proposed for hydrazine, that is, 0.4ng/l and 4.0ng/l are based on the

lowest effect concentration available, that is, the Dunaliella species and also uses a larger assessment factor than for the Canadian or ECHA values.

- The lowest effect concentration noted in the available toxicity data set was that for a marine algal species Dunaliella tertiolecta. This was used as the basis of the PNEC proposed. The data from this particular study indicated this was the most sensitive of the range of species studied. The latter included algae and also macroalgae, including a number of species of seaweed, invertebrates such as crustaceans and polychaetes, as well as a number of fish species. Sabellaria is a type of polychaete and Corallina is a type of seaweed. Therefore, although data was not available on the toxicity of hydrazine to these particular species, there was data for other species within these taxa. As the effect concentration for the algal species used to derive the PNEC, that is, Dunaliella spp, was lower than the effect concentrations noted for polychaetes and other types of algae, and in addition a large assessment factor of 1,000 has been applied, this suggests that the approach taken to derive the PNEC would be considered precautionary for Sabellaria and Corallina based on the available data.
- Mobile species such as fish and invertebrates are considered in deriving the PNEC, as data for a number of species within these taxa are available in the dataset for hydrazine. The impact of hydrazine on these species has therefore been considered in deriving the PNEC.
- The PNECs proposed for hydrazine do not take into consideration direct effects on birds. Effects of hydrazine on their prey is likely to be considered as the PNEC derived considered data on the effects on invertebrates and fish for example, but the specific effects on birds are not taken into account in these PNECs.

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