



The Sizewell C Project

6.18 Fourth ES Addendum, Volume 3: Appendix 3A - Sizewell C Desalination Plant Construction Discharge H1 Type Assessment

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**Cefas BEEMS Technical Report TR552
Sizewell C Desalination Discharge
Assessment**

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**BEEMS Technical Report TR552 Cefas
Sizewell C Desalination Plant
Construction Discharge Assessment**

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Executive Summary

NNB Generation Company (Sizewell C) Ltd (SZC Co.) is planning to build a new nuclear power station at Sizewell, Suffolk (SZC). Any development at Sizewell that includes discharges to, or operations in the adjacent marine environment must be considered in relation to their potential effect on coastal water quality. A temporary desalination plant and associated infrastructure is required to produce potable water for the construction period but would cease operating prior to commencement of Cold Functional Testing at Sizewell C. This report provides a H1 type assessment of the expected discharges from the desalination process.

The outfall is located close to the outfall of the proposed Fish Recovery and Return Tunnel, beyond the inner bank. To prevent ingress of glass eels and other early life-stages of fish and invertebrates the seawater intake would consist of a Passive Wedge-Wire Cylinder (PWWC) screen with a mesh size of approximately 2mm. As a result, screening at the intake will be of sufficient size to prevent entrainment of fish and debris. No fish recovery or return infrastructure is required. The outfall will discharge beyond the inner bank. Brine is available for discharge without further treatment and will be discharged over 24 hours/day.

In Revision 2 of this report, following ISH15 and comments from the MMO a further set of analyses has been undertaken to determine the:

- ▶ evolution of the plume throughout the full spring-neap cycle from high to low water;
- ▶ sensitivity of the plume extent to potential temperature changes during the desalination process;
- ▶ implications for the brine plume on dissolved oxygen; and
- ▶ the potential for further in-combination effects between CDO and desalination discharges.

Although the discharge will be highly saline the results within the mixing zone model CORMIX indicate that excess salinity falls to within 1 Practical Salinity Unit of background levels within ca., 6.8-21.5 m and well within the natural variation at the site (conditions at the discharge site are well mixed and would also facilitate mixing but are not included in this more precautionary assessment). The time taken for a passive particle to traverse through the saline plume would also be short at between approximately 28 to 215 seconds for all tidal velocities above a slack threshold of 0.1 m/s at the location of the desalination outfall. Therefore, except for the influence of the high salinity of the concentrate at the point of discharge, the elevated salinity is expected to have negligible effects upon marine species beyond a few metres from the point of discharge. A sensitivity analysis was conducted by applying a temperature differential between the ambient sea conditions and the desalination discharge to inhibit mixing. Due to the small flows considered, the effect of the temperature uplift is minimal. Using a thermal uplift of 10°C (which is not anticipated), the extent of the salinity plume, to the 1 PSU above background threshold, is only extended by 11 cm.

Salinity can alter the dissolved oxygen content of water. As noted above the salinity plume is dispersed rapidly, within 6.8-21.5m. Changes in salinity and chemical treatment for dechlorination are unlikely to cause dissolved oxygen levels to reduce below the WFD 'high' threshold even in the immediate vicinity of the discharge location, and any effects would be rapidly dispersed as the saline plume mixes with the surrounding seawater. Therefore, the level of change to dissolved oxygen from changes in salinity is assessed as negligible.

Various activities during the construction period of the Project can add nitrogen and phosphorus to discharges to the marine environment, including the desalination concentrate discharge, and this can influence algal growth. The total loading of these nutrients was evaluated as part of an annual assessment using a combined phytoplankton and macroalgal model. The nutrient inputs from treated sewage and groundwater during construction and including the desalination inputs, is predicted to lead to a 0.39% increase in annual production indicated by modelling. However, this would have only a small influence on the ca., 4% reduction in production that results from entrainment of phytoplankton at Sizewell B. Overall, these

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small changes would not be detectable against a natural background of inter annual variation in production within Sizewell Bay.

The desalination concentrate also contains elevated levels of various metals and other substances resulting from the concentration in the desalination process. Three metals, chromium, lead, and zinc exceeded an initial screening assessment, indicating they might exceed their respective Environmental Quality Standards (EQS) beyond the immediate discharge. Therefore, more detailed modelling was undertaken for these metals using a mixing model, CORMIX. In all cases, the plume area above the respective EQS for each metal was relatively small, with a maximum estimated area of exceedance of 0.17 ha for chromium with the other metals EQS exceedances being less than this area. A precautionary assessment was undertaken which derived an area above EQS for any discharge that is not >1.0 ha at the seabed (this assumes the maximum extent of any discharge, based on chromium represents the radius of a circle around the discharge point, which is a highly precautionary approach as it ignores the tidal influenced elongated shape of the plume). This modelling provides a precautionary assessment as it does not take account of natural mixing processes and the relatively shallow waters at this location would be expected to be well mixed.

Notably the Fourth ES addendum¹ assessed the precautionary area of EQS exceedance based on an earlier modelled estimate of 0.5 ha [\[REP7-030\]](#). The change to 1.0 ha does not materially change the assessment of magnitude which would remain low when considering an area of 1.0 ha. Therefore there are no changes to the conclusions in the Fourth ES addendum based on the updates in this report.

As part of the surface water pollution risk assessment there are specific requirements for the minimisation of the annual loads of selected hazardous substances such as cadmium and mercury which require further consideration. Neither metal was shown to exceed threshold loadings following a cumulative annual assessment which incorporated all input sources of these metals during the construction period.

The discharge rate and the magnitude of the chromium, zinc and lead concentrations for the desalination concentrate are similar to those for assessments made for other construction discharges which were assessed as not significant.

The potential interaction of discharges from the CDO during the main construction period with both the desalination plant intake and outfall was also considered. Discharges from the CDO that have been considered were metals from groundwater and chemicals used during tunnelling. As the predicted concentration of chemicals from the CDO at the intake and discharge of the desalination plant were at least tens of times below relevant annual average EQSs they were considered to have negligible additional influence on the area affected by the desalination discharge.

¹ Document 6.18 Fourth Environmental Statement Addendum - Volume 1: Main Text - Revision 1.0 [\[REP7-030\]](#)

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1 Introduction

1.1 Background to site

SZC Co is planning to build a new nuclear power station at Sizewell, Suffolk (SZC). The new power station will be located on the Suffolk coast, northeast of Ipswich and south of Lowestoft. The approximate National Grid reference for the centre of the proposed development is TM 4730 6410. The new power station will be built near and to the north of the Sizewell B station which will continue to operate after the commissioning of SZC. Sizewell A, which is located to the south of Sizewell B, ceased operation in 2006.

Any development at Sizewell that includes discharges to, or operations in the adjacent marine environment must be considered in relation to their potential effect on coastal water quality.

A temporary desalination plant and associated infrastructure is required to produce potable water for the construction period up to Cold Functional Testing at Sizewell C. The outfall pipe headwork is located close to the outfall of the proposed Fish recovery and Return Tunnel, beyond the inner bank. The intake is ca., 100 m northeast of the outfall location. Screening at the intake will be of sufficient size to prevent entrainment of fish and debris. No fish recovery or return infrastructure is required. The outfall will discharge beyond the outer longshore bar. The location of intake and outfall pipes are shown on Figure 2-1. The outfall structure for discharge of waste concentrate is in a maximum depth of water of ca., 5.8 m. Water discharge will be between 1 m and 1.8 m above the seabed. Minimum discharge depth is therefore ca., 4.8 m. The Seawater Reverse Osmosis (SWRO) desalination plant will operate for 20 hours/day with some activities, such as sludge dewatering restricted to shorter operating periods. Brine is available for discharge without further treatment and will be discharged over 24 hours/day.

Approximately 60% of the abstracted seawater would be discharged back into the sea. The discharge would consist of concentrated saline water, increased concentrations of naturally occurring metals as well as added phosphorus.

1.2 Objectives

At each phase of the development (construction, commissioning, and operation) the potential and extent of any effects on water quality will be assessed. Assessment will take account of temporary and permanent discharges from the site. This report provides supporting information for screening assessment of potential discharges of concentrate wastewater from the desalination plant during the construction period only.

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2 Assessing potential concerns for marine water quality

2.1 Background

A detailed list of the currently available EQS values that have been assigned as reference values for water quality for both the freshwater and marine environments and are described for other surface waters (Transitional and coastal waters, TraC Waters) for priority hazardous substances and other pollutants under Directive 2013/39/EU (implemented by the Water Framework Directive (Standards and Classification) Directions (England and Wales, 2015). The Water Framework Directive increased the list of chemicals for consideration as priority substances to 45 of which 29 are classed as specific pollutants (Defra, 2014). Following assessment, chemical status is recorded as 'good' or 'fail'. The chemical status classification for the water body is determined by the worst scoring chemical.

The water quality monitoring campaigns (defined periods of monitoring) for marine water quality are described in detail within BEEMS Technical Report TR189 and in BEEMS Technical Report TR314 (an update of monitoring reported in BEEMS Technical Report TR189 that includes data on selected determinands from monitoring conducted in 2014/15). A Sizewell Water quality literature review in BEEMS Technical Report TR131 provides historic information on background water quality for the Suffolk coastal waterbody. This document also provides details of all the relevant Screening EQS values for saltwater and the legislation and guidance documents from which they are derived.

2.2 Contaminants of concern for the desalination concentrate discharge

Various chemical and physical standards for the protection of marine water may be affected by the discharges from SZC.

During construction and commissioning a construction discharge outfall (CDO) will be in place to collect and allow discharge of various wastewater streams to the marine environment. However, the desalination plant will have a separate intake and discharge as shown in Figure 2-1. The discharge flow rates for the desalination plant are shown in Table 2-1. The desalination process generates a wastewater concentrate with elevated concentrations of salts and trace metals and these are shown in Table 2-2.

The saline plume also has the potential to influence the physical properties of the receiving water. Characteristics of the saline plume are described in section 5.2.4. Changes in salinity can also affect dissolved oxygen (DO) concentrations as the solubility of oxygen is dependent on salinity, temperature and pressure (see BEEMS Technical report TR131). An increase in salinity will lead to a decrease in oxygen saturation and this is further considered in section 5.2.3.

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Table 2-1 Maximum flow rate of the desalination concentrate discharge.

Flow Characteristics	Desalination Wastewater Concentrate Trade Effluent
Maximum volume of effluent discharged per day (m ³ /day)	6000
Maximum rate of discharge (l/s)	69

Table 2-2 Maximum concentrations of substances (based on measured dissolved concentration except where indicated) likely to be present in the desalination wastewater concentrate and relevant EQS values and marine background concentrations. (The nutrients nitrogen and phosphorus are considered in section 4.0)

Substance	Maximum concentration µg l ⁻¹	Maximum (total) concentration µg l ⁻¹	Saltwater EQS AA µg l ⁻¹	Saltwater EQS MAC µg l ⁻¹	Marine Background concentration µg l ⁻¹
Aluminium	19.6	21.52	24 ⁱ	-	12
Arsenic	1.71	4.17	25	-	1.07
Cadmium	0.08	0.08 ²	0.2	1.5	0.05
Chromium	0.93	2.94	0.6	32	0.57
Copper	3.55	4.80	3.76	-	2.15
Iron	165	2352	1000	-	<100
Lead	-	3.38	1.3	14	2.07
Mercury	0.03	0.03 ²	-	0.07	0.02
Nickel	1.3	2.70	8.6	-	0.79
Zinc	24.95	31.66	6.8	-	15.12
Ammoniacal nitrogen	18.02 (NH ₄ -N)	NA	21 (NH ₃ -N)	-	11.38
Boron	4929	4956	7000	-	4225

¹ Annual average EQS value (Golding et al., 2015); ² total value the same as dissolved due to influence of values below detection.

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3 Screening assessment of desalination concentrate discharge

3.1 Background

As part of a surface water risk assessment to comply with Environment Agency and the Department for Environment Food and Rural Affairs guidance (Defra, 2016), the concentration of substances present in the discharge must be assessed against a list of specific pollutants and compared with their EQS. Initial screening tests (historically referred to as H1 tests) were conducted to determine if the concentrations of priority substances and specific pollutants in the discharge exceeded their respective EQS. For any substances that breach the EQS in the initial screening tests (Test 1), a further screening test was applied to take account of initial dilution upon discharge (Test 5). The brine discharge from the desalination process would contain higher concentrations of naturally occurring metals and trace elements present in natural seawater. As the discharge concentrate from the desalination plant is saline and has an approximate salinity of 53 and so is much more dense than natural seawater it would sink to the seabed. The high salinity would invalidate further stages of screening assessment and require more detailed modelling to be applied. However, as the discharge is to the subtidal, and seawater at this location is well mixed and a diffuser will be employed to further facilitate mixing, the screening test 5 is considered appropriate here (Table 3-1) to identify the higher priority discharges for modelling.

3.2 Screening assessment

The maximum concentrations discharged in the desalination concentrate (Table 2-2) are used for assessment of Test 5 as shown in Table 3-1. The maximum concentration values are based on the total daily loading for each chemical divided by the total volume of concentrate produced and discharged over a 24 hour period. The assessment includes the screening of the source terms against the saltwater EQS values presented in the Water Framework Directive (Standards and Classification) Directions (England and Wales) (Defra, 2015).

The updated guidance for surface water pollution (Defra, 2016) recommends the application of an initial test (Test 1) for discharges to Transitional and Coastal (TraC) waters in which the discharge concentration is compared to the relevant quality standard or equivalent for that substance. Where the discharge concentration exceeds the standard concentration, further assessment is required. For the purposes of this assessment, a more precautionary assessment was undertaken whereby any discharge concentration when divided by the EQS in Test 1 which produces a value of ≥ 0.5 was considered for further screening. As this construction discharge will be subtidal and is over 50 metres offshore, a further test ("Test 5") was considered appropriate. Test 5 is normally not advocated in the case of high salinity discharges but is applied here to provide an indication of the priority order of substances for modelling. The modelling outputs for the worst-case substances modelled then provides an envelope for the extent of effects of the lower concentration discharges. With reference to values shown in Table 3-1, Test 5 divides the concentration of a substance and volume discharged in litres/second (the discharge specific Effective Volume Flux, EVF) by its EQS minus background concentration in micrograms/per litre (the location specific Allowable Effective Volume Flux, AEFV). If the EVF is not greater than the AEFV, then the discharge is considered insignificant and is screened out. The AEFV references the discharge depth, and this value can be up to a maximum of 3.5 metres. For Sizewell, the water depth at the desalination outfall concentrate headworks discharge relative to chart datum is ca., 5.8 metres therefore a maximum value of 3.5 is used as the AEFV for comparison in Table 3-1.

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Table 3-1 Determination of whether after discharge and initial mixing the calculated contribution to substances of concern from the site desalination concentrate (using maximum concentrate values based on total measured concentrations) during the main construction period is likely to exceed the acceptable threshold above which significant impacts may occur. (values in test 1 ≥ 0.5 were then taken forward to Test 5; Text in bold indicates test failed.)

Parameter value	Calculated total substance discharge concentration $\mu\text{g l}^{-1}$	TraC Water test 1 <100%EQS	Pass/Fail	TraC Water test 5 EVF<AEVF	Pass/Fail
Aluminium	21.52	0.9 (21.52/24 ⁱ)	≤ 1.0 (Pass)	0.12 (21.52x0.069 ⁱⁱ)/(24-12 ⁱⁱⁱ)	0.12<3.5 ^{iv} (Pass)
Arsenic	4.17	0.17 (4.17/25)	≤ 1.0 (Pass)		
Cadmium	0.08	0.41 (0.08/0.2 ^v)	≤ 1.0 (Pass)		
Chromium	2.94	4.9 (2.94/0.6)	≥ 1.0 (Fail)	6.76 (2.94x0.069 ⁱⁱ)/(0.6-0.57 ⁱⁱⁱ)	6.76>3.5^{iv} (Fail)
Copper	4.8	1.28 (4.8/3.76)	≤ 1.0 (Pass)	0.21 (4.8x0.069 ⁱⁱ)/(3.76-2.15 ⁱⁱⁱ)	0.21<3.5 ^{iv} (Pass)
Iron	2352	2.35 (2352/1000)	≤ 1.0 (Pass)	0.18 (2352x0.069 ⁱⁱ)/(1000-100 ⁱⁱⁱ)	0.18<3.5 ^{iv} (Pass)
Lead	3.38	2.60 (3.38/1.3)	≥ 1.0 (Fail)	N/A ^{vi}	N/A
Mercury (MAC)	0.03	0.48 (0.03/0.07)	≤ 1.0 (Pass)	0.05 (0.03x0.069 ⁱⁱ)/(0.07-0.02 ⁱⁱⁱ)	0.05<3.5 ^{iv} (Pass)
Nickel	2.7	0.31 (2.7/8.6)	≤ 1.0 (Pass)		
Zinc	31.66	4.65 (31.66/6.8 ⁱⁱ)	≥ 1.0 (Fail)	N/A ^{vi}	N/A
Ammoniacal nitrogen	18.02	0.014 (0.3 ^{vii} /21)	≤ 1.0 (Pass)		
Boron	4956	0.71 (4956/7000)	≤ 1.0 (Pass)	0.12 (4956x0.069 ⁱⁱ)/(7000-4225)	0.12<3.5 ^{iv} (Pass)

ⁱ Annual average EQS value (Golding et al., 2015); ⁱⁱ maximum desalination concentrate discharge m^3/sec ⁱⁱⁱ mean background concentration Sizewell TR189; ^{iv} Allowable effective volume flux is taken as a value of 3.5, ^v cadmium is assessed against annual average mean but would pass as 95th percentile standard of 1.5 $\mu\text{g/l}$ also; ^{vi} The background concentration for Sizewell from monitoring

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data in BEEMS Technical Report TR314 was higher (zinc 15.12 µg/l, lead 2.07) than the seawater EQS; ^{vii} This figure is the maximum proportion of un-ionised ammonia calculated with the un-ionised ammonia calculator for total ammonia and starting conditions for the concentrate (salinity 53.8, temperature 19.4C and pH 7.8 as described below).

From the results shown in Table 3-1, just over half of the substances screened would fail the initial test or produce a screening value close to a failure value of '1'. Therefore, a precautionary assessment was undertaken which involved a second screening test for values from test 1 of ≥ 0.5 . The second screening test (test 5) is not robust for assessment of highly saline discharges (although here improved mixing is facilitated by use of a diffuser) and is used here to indicate substances that are considered to have priority for assessment. Chromium would clearly fail screening test 5 and zinc and lead were also further investigated by undertaking more detailed modelling assessment, as the high background values for both these metals were already shown to exceed EQS levels based upon reported monitoring data in BEEMS Technical Report TR314.

For ammonia (NH₄) the changing physicochemical conditions influence the proportion of un-ionised ammonia (NH₃, considered the most toxic form) relative to ionised ammonia present, and this can be calculated using the Environment Agency calculator (Clegg and Whitfield, 1995). However, the starting concentration of NH₄ is only equivalent to 0.3 µg l⁻¹ un-ionised ammonia (average concentrate pH 7.8 and salinity 53.8 and 95th percentile temperature 19.4). Subsequent mixing of the concentrate discharge to reach the background salinity of seawater would only marginally increase the un-ionised ammonia to 0.4 µg l⁻¹ un-ionised ammonia (average Sizewell seawater pH 8.05 and salinity 33.3 and 95th percentile temperature 19.4). During mixing the concentrate contribution to un-ionised ammonia would therefore remain considerably below the EQS 21 µg l⁻¹ NH₃-N (as an annual average).

3.3 Significant load assessment

As part of the surface water pollution risk assessment there are specific requirements for the minimisation of the annual loads of selected hazardous substances discharged to the environment and cadmium and mercury are included in this category and therefore require further assessment. Total annual loads in desalination concentrate discharges are 0.07 kg for mercury and 0.18 kg for cadmium. Based on estimates of annual construction discharges including these trace metals a total cumulative load for cadmium over 3.5 years of the construction period was 0.45 kg and for mercury was 0.05 kg (BEEMS Technical Report TR193). The combined source loadings for cadmium (0.63 kg) and mercury (0.12 kg) do not exceed significant annual loads (in discharges) of 5kg/year for cadmium and 1 kg/year for mercury.

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4 Assessment of nitrogen and phosphorus discharges during construction

4.1 Background

During construction, discharges that overlap with the desalination discharge include relatively small quantities of nitrate and phosphate; primarily from groundwater and treated sewage. During the construction period the exact mass of the discharges has considerable variation, depending on which activity is occurring and varies considerably with the workforce on site. The details of this variation are described in BEEMS Technical Report TR193, where worst case examples have been used.

Table 4-1 shows a summary of the nitrogen and phosphorus loading from different sources during the construction period which include groundwater and treated sewage. The only conditioning chemical expected in the discharge concentrate is phosphorus, derived from use of a membrane descaling chemical.

Descaling chemical use is expected to add 3.3 g per cubic metre of concentrate. In 6000 m³ of concentrate this represents a total of 19.8 kg/day. The phosphorus discharge loading for desalination is a composite of chemical addition in the membrane cleaning process added to the natural phosphorus background in the seawater. Most phosphorus in the seawater used for desalination (99%) is expected to be rejected by the reverse osmosis membranes used in desalination and would be increased in concentration relative to the natural background in the reject concentrate. The average phosphorus background concentration is 33 µg l⁻¹ (BEEMS Technical Report TR314) and an additional load to the concentrate (above that naturally present as background) would be 33 x 4000 (m³) = 0.132 kg. The total loading from antiscaling chemical input and added natural phosphate background therefore = 19.9 kg (19.8 + 0.132)/day.

For nitrogen with just the added background concentration in the brine and no other additions the total addition is small and represents ca., 0.56 kg/day.

Typically, in offshore waters of the UK, nutrient concentrations are reduced to very low levels due to phytoplankton uptake, but in the near shore coastal waters (3-5 km from the coast) off Sizewell due to the turbid nature of the coastal environment and continual freshwater input from the south of the area (River Orwell and River Deben), there are background summertime inputs of nutrients. Observations (BEEMS Technical Report TR314) show these to be around 10 µMol l⁻³ for nitrate and 0.65 µMol l⁻³ for phosphate. As the daily exchange of water is around 10%, the total additional mass of nitrate per day in summer is the volume x 10% x concentration of the nutrient. This gives a daily exchange of 16.9 tonnes of nitrate and 2.4 tonnes of phosphate. During construction (Table 4-1) maximum daily inputs are less than 0.2% for nitrogen and just under 2% for phosphate relative to the normal daily exchange of nutrients at the boundary (based on the summer period when background nutrient concentrations are low) and therefore these would be indistinguishable from the modelled situation without the SZC discharges.

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Table 4-1 Summary of nitrogen and phosphorus construction discharges including desalination. Figures are shown relative to the daily exchange with the wider environment

Substance	Peak loading in construction (groundwater+ sewage + desalination) kg per year and (per day)	Daily exchange with wider environment based on summer period (i.e. minimum background for nutrients), kg	Fraction of maximum possible daily loading in construction and desalination
Nitrogen (as N)	6278 (17.20) ¹	16900 (as N)	0.10%
Phosphates (as P)	16724 (45.82) ²	2440 (as P)	1.88%

¹ The nitrogen loading during construction are derived from groundwater and sewage as described in BEEMS Technical Report TR193 section 5.4 (16.64 kg/day) and 0.56 kg/day from desalination concentrate inputs. ² The total phosphorus loading of 45.82 kg/day is made up of a loading during construction derived from groundwater and sewage as described in BEEMS Technical Report TR193 section 5.5 (25.92 kg/day) and 19.9 kg/day from desalination concentrate inputs and background.

During the summer period, nitrogen can be limiting in the marine environment in Sizewell Bay. Therefore, to confirm that expected nutrient loadings from construction do not significantly influence conditions in Sizewell Bay a combined phytoplankton and macroalgal model (CPM) has been deployed. The CPM used is as detailed in BEEMS Technical Report TR385. Four runs have been considered as follows:

1. Productivity with no Sizewell B (SZB) operating,
2. A scenario which incorporates the effect of SZB together with the construction discharges from SZC,
3. A scenario which includes the SZB operation combined with desalination discharges associated with SZC
4. and a scenario that includes desalination and construction discharges associated with SZC only.

It should be noted that a factor to account for mortality of phytoplankton through power station entrainment is also included in the modelling. The effect of a power station can be simulated by increasing the daily natural mortality by the fraction of the box model volume that the power station filters each day. In the baseline situation with just SZB operating the entrainment and chlorination at SZB is predicted to reduce phytoplankton production by 4.4% (Table 4-2). The additional nutrient input from the desalination plant overlaid on the background entrainment mortality, increases annual production in the Sizewell Bay region by 0.17% over the existing SZB situation, so there is still an overall reduction in production due to the entrainment impact of SZB, but this is slightly reduced (Table 4-2).). When construction and desalination nutrient inputs are combined the entrainment impact of SZB is further reduced (a production increase of 0.39%), but overall, there is still a reduction in production of 3.92% relative to the natural production of Sizewell Bay without the influence of SZB entrainment.

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Table 4-2 Summary of nitrogen and phosphorus construction discharges and from the desalination plant. Figures are shown relative to the daily exchange with the wider environment.

Scenario	Phytoplankton Annual Gross Production (g C m ⁻² y ⁻¹)	Percentage difference from SZB
Sizewell Bay	56.53 ¹	+4.40%
SZB operation only (included mortality due to SZB but no additional nutrients)	54.04	0
SZB operation + Desalination	54.13	+0.17%
SZB operation + SZC Construction discharge	54.33	+0.49%

¹ BEEMS Technical reports assessed the production of Sizewell Bay as 56.8 g C m⁻² y⁻¹, the value here uses the same conditions but is run on updated software which has resulted in a non-significant difference in the estimated carbon value.

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5 Summary of screening assessment and further modelling

5.1 Screening results

Except for zinc and lead, the discharge concentrations of all substances listed in Table 3-1 as present in the desalination concentrate passed the TraC waters test 5 assessments. Chromium would pass the screening assessment based on the dissolved concentration of $0.57 \mu\text{g l}^{-1}$ however, for an assessment using the total concentration, $1.8 \mu\text{g l}^{-1}$, it would fail, and so is also assessed with more detailed modelling.

Zinc, monitoring data (BEEMS Technical Report TR314) indicates a zinc background concentration of $15.12 \mu\text{g l}^{-1}$ which exceeds the annual EQS of $6.8 \mu\text{g l}^{-1}$ (dissolved concentration). For the desalination concentrate the discharge concentration is assessed to be $24.95 \mu\text{g l}^{-1}$ dissolved zinc (total zinc $31.66 \mu\text{g l}^{-1}$) and would fail screening. For lead, there is no dissolved concentration data and a total concentration in the background seawater $2.07 \mu\text{g l}^{-1}$ (increasing to $3.38 \mu\text{g l}^{-1}$ in the discharge) already exceeds the annual EQS of $1.3 \mu\text{g l}^{-1}$ (dissolved lead concentration).

5.2 CORMIX modelling

5.2.1 Discharge assessment methodology

The release and mixing of chemicals and trace metals in the desalination discharge was modelled using CORMIX US EPA supported mixing zone model (CORMIX Version 12.0GT HYDRO1 Version 12.0.0.0 2021). The proposed discharge is a low volume of dense brine, with concentrations of some contaminants exceeding EQS levels.

The proposed design of the desalination outfall consists of a single riser with two duckbill diffusers discharging between 1-1.8 m above the seabed. CORMIX can be used to either model a single riser with a single discharge outlet or a diffuser with a minimum of 3 risers. As such, a conservative approach is taken to model the desalination outfall as a single riser discharge 1 m off the seabed as this represents the worst-case discharge conditions. A contraction ratio of 0.65 is used on the end of the outfall pipe (i.e., a nozzle) to increase the jet velocities and enhance the mixing of the plume. However, the full diffuser proposed will result in a smaller plume than those modelled herein.

The location and basic properties of the proposed discharge are shown in Table 5-1.

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Table 5-1 Desalination discharge conditions.

Discharge Characteristics	Value
Location OSBG	647980 E 264030 N
Charted water depth (surface to bed) at discharge location	5.8 m
Discharge flow	69 $\mu\text{g l}^{-1}$
Discharge salinity	53.8 PSU ¹
Depth of discharge (above seabed)	1.00 m
Pipe diameter	0.25 m

¹ Practical salinity units. Ambient salinity conditions were based on 31.5 PSU as the lower range of measured values in BEEMS Technical Report TR189. Discharge salinity was based on the maximum calculated discharged chloride (derived from measured values in BEEMS Technical Report TR189 and multiplied by the discharge volumes) converted to salinity. These values were used to give the maximum differential in salinity conditions to model a worst case for mixing.

Three substances from Table 3-1 have been modelled using CORMIX: these are the trace metals, lead, zinc, and chromium.

For lead, the mean background total concentration is $2.07 \mu\text{g l}^{-1}$ whilst the EQS is $1.3 \mu\text{g l}^{-1}$ (based on the dissolved concentration). The background total lead levels are in exceedance of the EQS. The EQS for lead therefore cannot be used as the threshold value for the CORMIX modelling. The detection limit for lead in seawater samples (BEEMS Technical Report TR314) is $0.04 \mu\text{g l}^{-1}$. Therefore, the threshold value for lead was set at $2.07+0.04 = 2.11 \mu\text{g l}^{-1}$, which represents the limit at which lead would no longer be detected above the background concentration.

The mean background concentration of zinc in the environment is $15.12 \mu\text{g l}^{-1}$ whilst the EQS is $6.8 \mu\text{g l}^{-1}$. Since the natural background levels exceed the EQS level, the EQS cannot be used as the threshold value for the CORMIX modelling. The detection limit for zinc in seawater samples (BEEMS Technical Report TR314) is $0.4 \mu\text{g l}^{-1}$. Therefore, the threshold value for zinc was set at $15.12+0.4 = 15.52 \mu\text{g l}^{-1}$, which represents the limit at which zinc would no longer be detected above the background concentration.

The mean background concentration of chromium in the environment is $0.57 \mu\text{g l}^{-1}$ whilst the EQS is $0.6 \mu\text{g l}^{-1}$ so the modelling assessment was considered against the natural background.

The CORMIX modelling provides a conservative estimate, as it does not include additional mixing and dilution due to waves.

5.2.2 Modelling a dense saline plume

It should be noted that with a dense saline plume with a discharge in an offshore location, unless mixing occurs, there may be an impact on seabed features in the local area. Consideration of the tidal cycle is useful in understanding the likely modes of impact. When the flood tide is at its strongest (with flow to the south), the discharge plume will be initially denser than the background salinity meaning it will sink to the seabed and will then be advected in a long narrow streak that eventually mixes up into the water column. As

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mixing occurs, the concentration within the streak will rapidly drop. At low water, near slack tide, a pool of the discharged water will form at the seabed which will be advected northwards as the ebb tide increases.

To investigate how the plume evolves over the state of the tide, multiple stages of the tide have been considered: peak flood, peak ebb, high water, and low water. As the water depth at the discharge is only 5.8 m, there is a risk of seabed impacts from slack water pooling at low water, where the depths and low velocities will inhibit mixing. Therefore, a sensitivity analysis around low water was conducted, with tidal flows conducted at 0.5, 1 and 2 hours either side of low water. The hydrodynamic conditions for this study have been extracted at the location of the desalination intake from the high resolution 2D hydrodynamic model of Sizewell as detailed in BEEMS Technical Report TR543. Table 5-2 and Table 5-3 show the hydrodynamic conditions at the different tidal states tested with CORMIX, which represent a spring and neap tidal range.

As the discharge is very dense compared to background, more than 20 PSU above background, the discharge pipe will employ a diffuser. The basic shape of the diffuser used in the CORMIX modelling is shown in Appendix Figure 9-1.

Table 5-2 States of the tide under spring conditions tested with CORMIX.

Stage of Tidal Cycle	Water Depth (m)	Velocity (m/s)	Time wrt Slack (hours)
Peak Flood	5.983	0.737	-2.08
High Water	6.829	0.324	-0.75
Peak Ebb	5.818	0.688	2.92
Low Water -2 hours	5.057	0.566	-2.08
Low Water -1 hour	4.663	0.434	-1.08
Low Water -0.5 hours	4.492	0.294	-0.58
Low Water	4.352	0.120	-0.08
Low Water+0.5 hours	4.530	0.160	0.42
Low Water +1 hour	4.849	0.411	0.92
Low Water +2 hours	5.655	0.477	1.92

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Table 5-3 States of the tide under neap conditions tested with CORMIX.

Stage of Tidal Cycle	Water Depth (m)	Velocity (m/s)	Time wrt Slack (hours)
Peak Flood	5.305	0.487	-3.00
High Water	6.174	0.197	0.50
Peak Ebb	5.809	0.422	2.00
Low Water -2 hours	5.417	0.266	-2.00
Low Water -1 hour	5.199	0.227	-1.00
Low Water -0.5 hours	5.073	0.126	-0.50
Low Water	5.000	0.020	0.00
Low Water+0.5 hours	5.040	0.168	0.50
Low Water +1 hour	5.124	0.311	1.00
Low Water +2 hours	5.395	0.437	2.00

5.2.3 Dissolved oxygen interaction with salinity

The solubility of oxygen is dependent on salinity, temperature and pressure. Measurements of dissolved oxygen saturation at Sizewell (BEEMS Technical Report TR314 and TR189) demonstrate that the coastal water is fully saturated (i.e., at or close to 100%), as would be expected in a well-mixed shallow coastal environment. The lowest measured dissolved oxygen was 6.96 mg/l which is well above the WFD threshold for 'high' (5.7mg/l) (BEEMS Technical Report 131). The relationship of DO with salinity is described in Benson and Krause (1984), based on the warmest (98th percentile) seawater temperatures of 19.4°C (BEEMS Technical Report 131) and background salinity of 33.3 PSU, the maximum DO at 100% saturation would be 7.55mg/l, increasing salinity to the maximum of 53.8 PSU (Table 5-1) reduces the maximum saturation to 6.69mg/l, still well above the WFD threshold for 'high' assuming maximum saturation. Sensitivity testing for temperature also showed that even with a speculative 10°C rise the saturation would remain at 5.7mg/l.

Chemical dechlorination of the seawater before passage through the Reverse Osmosis membranes has the potential also to reduce dissolved oxygen. However, monitoring to avoid chemical overdosing for dechlorination would be in place to minimise any potential for oxygen reduction. It should also be noted that the seawater is well oxygenated and would pass through a diffuser which would further minimise any influence on background dissolved oxygen levels.

5.2.4 Results of CORMIX modelling

For Revision 2 (this revision) an improved method to account for the 2D plume shape was used to calculate the distances to relevant thresholds as predicted by CORMIX. The improved method resulted in minor changes to the results.

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As the plume is dense, it will sink to the seabed and travel along the seabed. As a diffuser is used on the discharge outlet, mixing is enhanced, and the seabed impact is minimised. Although the discharge has a higher density than the receiving seawater the diffuser heads facilitate more rapid mixing and will limit the area at the seabed that is influenced by the discharged plume. For excess salinity to fall to within 1 PSU above background, it would require 95% mixing or a 19-fold dilution. The results from CORMIX modelling show that this would be achieved within 6.76 m - 21.51 m, for all tidal states, see Table 5-4.

To be precautionary and assuming the size of the saline plume to 1 PSU above background is constant, using the maximum distance of 21.51 m, from Table 5-4, the time taken for a passive particle to traverse through the saline plume would be between approximately 28 to 215 seconds for all tidal velocities above a slack threshold of 0.1 m/s at the location of the desalination outfall. For the threshold of 38.5 PSU, this travel time is reduced to 42 seconds for all tidal velocities above a slack threshold of 0.1 m/s.

Table 5-4 Distances to which discharge salinity would fall to within 1 PSU above background.

Salinity	Distance to Threshold (m)									
	Rising Tide	High Tide	Falling Tide	Low Tide -2 hrs	Low Tide -1 hr	Low Tide -0.5 hrs	Low Tide	Low Tide +0.5 hrs	Low Tide +1 hr	Low Tide +2 hrs
+ 1 PSU (spring)	10.67	7.03	10.21	8.93	7.78	6.91	11.50	10.29	7.69	8.18
38.5 PSU (spring)	0.98	1.65	1.02	1.19	1.40	1.73	3.73	3.40	1.44	1.32
+ 1 PSU (neap)	8.23	6.84	7.80	6.83	6.76	11.24	21.51	6.98	7.09	7.91
38.5 PSU (neap)	1.32	2.09	1.40	1.81	1.97	3.69	4.22	2.24	1.68	1.39

The dispersion of the brine plume is driven by density which is a function of both salinity and temperature. The brine plumes modelled in CORMIX are tested against ambient sea water temperature (12.5°C) and no thermal uplift associated with the desalination process has been assumed. In response to queries raised by Interested Parties at the Sizewell Examination Issue Specific Hearing 15, a sensitivity analysis was conducted by applying a temperature differential between the ambient sea conditions and the desalination discharge to inhibit mixing. However, due to the small flows considered, the effect of the temperature uplift is minimal. Using a thermal uplift of 10°C, the extent of the salinity plume, to the 1 PSU above background threshold, extended the distance by 11 cm. 10°C was used solely to test the sensitivity of the CORMIX model and temperature rises due to warming following exposure to air are likely to be limited. Therefore, the implications of the plume extent due to moderate warming of abstracted water from depth being treated at sea level are minimal. A 10°C thermal uplift is not anticipated. The 10°C thermal uplift was also tested against the 98th percentile background temperature (19.4°C) but made little change (12 cm plume extension vs 11 cm at 12.5°C) as it is the density gradient (the difference between the discharge and background) that

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drives dispersion and not solely the background conditions. Therefore, these refined assessments of the saline plume do not materially change the overall outcome.

For lead, the EQS is reached at ca.10 - 30 m, depending on the tidal state. For zinc, the limit of detection is reached within ca. 11-25 m, although, the EQS is not reached at low water neaps, with concentrations of 15.60 $\mu\text{g l}^{-1}$ extending ca 34.87 m, compared to background of 15.12 $\mu\text{g l}^{-1}$. For chromium, the EQS is not reached at low water and the following half an hour, with concentrations of 0.602 $\mu\text{g l}^{-1}$ extending ca. 56.7 m, compared to an EQS of 0.6 $\mu\text{g l}^{-1}$.

Appendix Table 9-1 and Table 9-2 summarises for lead, zinc, and chromium the distance the discharge plume travels at different states of the tide under spring and neap conditions before reaching the relevant EQS. The maximum extent of the plume is for chromium ca., 56.8 m in length with an estimated peak area of exceedance of 0.17 ha (maximum areas of exceedance are derived from a calculated tidal ellipse assuming maximum plume extent is 5.9 times its width based on plume modelling with particle release reported in BEEMS Technical Report TR333). For lead the maximum extent for the discharge plume in exceedance of the EQS is 32.8 m, with an estimated peak area of exceedance of 0.06 ha. For zinc the maximum plume extent in exceedance is 34.8 m with an estimated peak area of exceedance of 0.06 ha. Based on the assumption that the maximum plume extent 56.8m (for chromium) represents the radius of a circle around the discharge point, the maximum bounding area affected by substances in the desalination discharge would be precautionarily estimated as not >1.0 ha. However, this is very conservative as this an unrealistic representation of a narrow long plume and is much larger than the largest instantaneous area of 0.17 ha (for chromium).

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6 Interaction with CDO discharge

The chosen easting of the desalination outfall places it directly in line with the CDO but approximately 300 m to the south meaning the discharges of both follow the same hydrodynamic streamline. The desalination intake is offset from the CDO by approximately 100 m east meaning the risk of recirculation from the CDO discharges into the desalination plant are minimal. The following discharges from the CDO have been considered: metals and tunnelling effluent.

6.1 Metals

Consideration has been given the combined discharges of both the CDO and the desalination plant, as both are discharging some of the same chemicals assessed in the CORMIX modelling: zinc, chromium, and lead.

Previous CORMIX modelling of chromium and zinc discharges from the CDO, presented in BEEMS Technical Report TR306, highlight that chromium would fall below the EQS within 25 m and zinc within 3 m of the discharge point. CORMIX modelling of the desalination plant has shown that chromium would fall below the EQS within 56.7 m and zinc would fall below the limit of detection with 34.9 m from the point of discharge. As such, the likelihood of the two plumes combining at levels above the EQS is very low given the two outfalls are separated by 300 m.

The General Estuarine Transport Model (GETM) was also used to model the CDO discharges for comparison, which showed slightly larger plume extents. These were due to GETM underpredicting the initial dilution, as discussed in BEEMS Technical Report TR306. Plume concentrations from the CDO at the location of the desalination intake were extracted to assess the recirculation potential. Figure 2-1 shows the excess concentration above background for zinc, chromium, and lead at the desalination intake.

The maximum recirculation concentration at the desalination intake was $0.002 \mu\text{g l}^{-1}$ for zinc, $0.016 \mu\text{g l}^{-1}$ for chromium and $0.001 \mu\text{g l}^{-1}$ for lead. Both zinc and lead were shown to have lower values than their respective limits of detection. The addition of a further $0.016 \mu\text{g l}^{-1}$ of chromium, to the source concentration, at the desalination intake was investigated with CORMIX. Under the worst hydrodynamic condition, the plume only extended a further 2 m. As this does not affect the conclusions of the H1 assessment, the combined discharges of the CDO and desalination were not considered further.

At the location of the desalination outfall (Figure 6-2), the maximum concentration from the CDO was $0.006 \mu\text{g l}^{-1}$ for zinc (well below the annual EQS of $6.8 \mu\text{g l}^{-1}$ and the higher seawater background). For lead, the maximum concentration was $0.003 \mu\text{g l}^{-1}$ (this is considerably below the annual EQs of $1.3 \mu\text{g l}^{-1}$ and the measured lead background of $2.07 \mu\text{g l}^{-1}$). For chromium the maximum concentration was $0.058 \mu\text{g l}^{-1}$, which is ten times lower than the background concentration and the annual EQS for chromium VI of $0.6 \mu\text{g l}^{-1}$.

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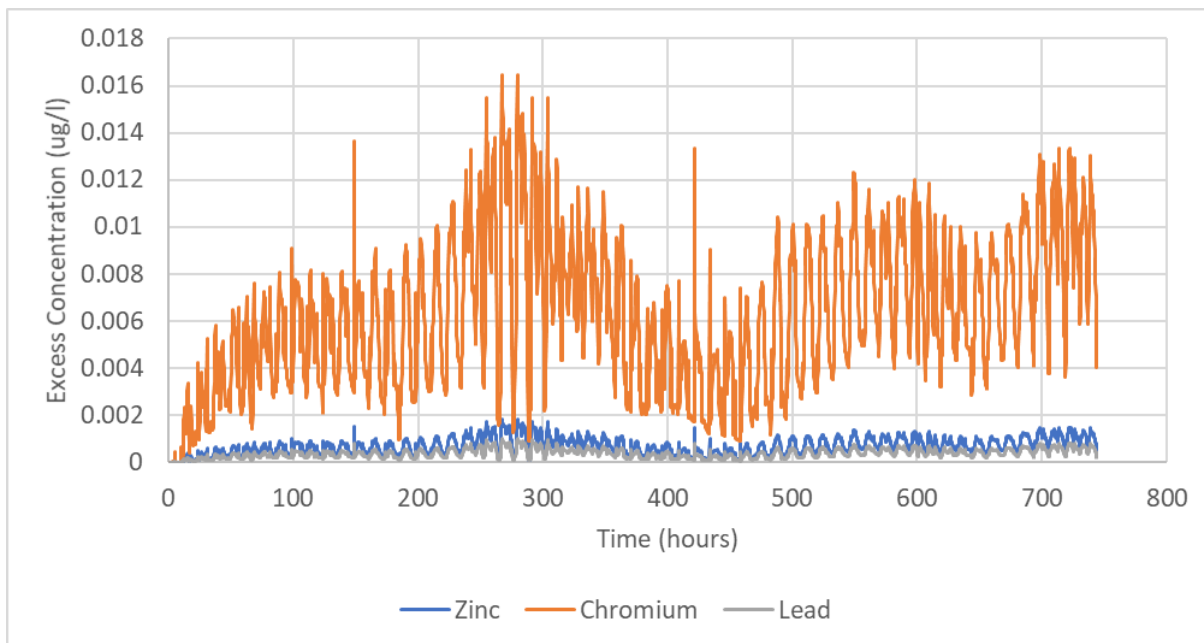


Figure 6-1 Excess concentration extracted of metals from GETM at the location of the desalination intake.

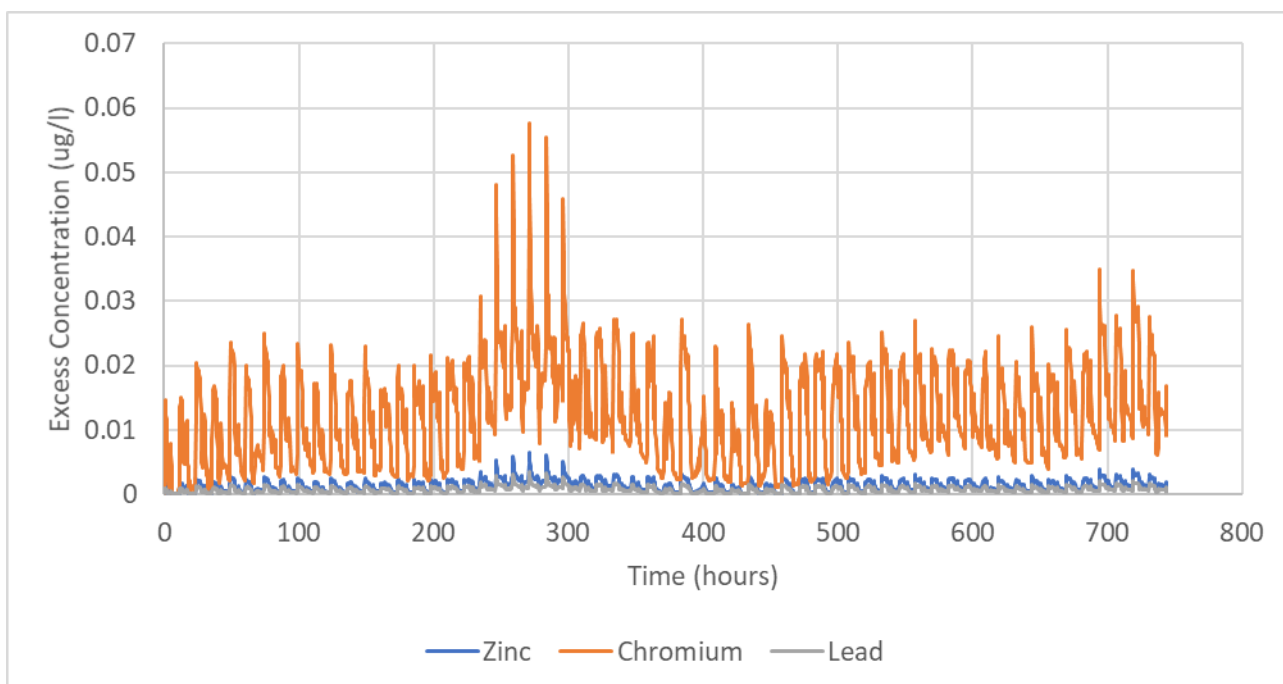


Figure 6-2 Excess concentration extracted of metals from GETM at the location of the desalination outfall.

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6.2 Tunnelling Effluent

Tunnel boring machines (TBM), possibly with slurry method, will be used to construct the cooling water tunnels. Ground conditioning chemicals (such as anti-clogging agents, anti-wear components and other soil-conditioning compounds) are used at the cutter head to optimise TBM efficiency. The exact chemical constituents of the ground conditioning chemicals will depend upon the ground conditions encountered on site and therefore cannot be precisely specified. To enable the discharge to be assessed wastewater volumes are based on those used for Hinkley Point C (HPC), namely BASF Rheosoil 143 (sodium lauryl ether sulphate) and CLB F5 M (Ethoxylated, sulphates).

BASF Rheosoil 143 (sodium lauryl ether sulphate) and CLB F5 M (Ethoxylated, sulphates) failed the initial H1 screening. Rheosoil is assessed against the EQS value of $40 \mu\text{g l}^{-1}$ as a mean. There are two EQS values for CLB F5 M, as such, concentrations are compared against the lowest EQS value of $4.5 \mu\text{g l}^{-1}$ as a mean. In addition to the two conditioning chemicals, bentonite was also investigated. As bentonite is a PLONOR (Pose Little or No Risk) chemical, there is no EQS value to assess against. Instead, it is considered in this report with respect to discharge concentrations.

The maximum instantaneous recirculation concentration of tunnelling effluent at the desalination intake (see Figure 6-3) was $0.006 \mu\text{g l}^{-1}$ for Rheosoil and $0.002 \mu\text{g l}^{-1}$ for both CLB F5 M and Bentonite. As the concentrations of Rheosoil and CLB F5 M are well below their EQS levels, (on the order of thousand times less) they have not been considered further. For Bentonite, at such low levels of concentration at the intake, Bentonite has also not been considered further.

At the outfall, the maximum instantaneous concentration of tunnelling effluent from the CDO discharge, and not the desalination discharge (see Figure 6-4) was $0.025 \mu\text{g l}^{-1}$ for Rheosoil, $0.008 \mu\text{g l}^{-1}$ for CLB F5 M and $0.01 \mu\text{g l}^{-1}$ for Bentonite. As the concentrations of Rheosoil and CLB F5 M are well below their EQS levels, (on the order of hundred to a thousand times less for Rheosoil and CLB FM 5, respectively) they have not been considered further. For Bentonite, at such low levels of concentration at the intake, Bentonite has also not been considered further.

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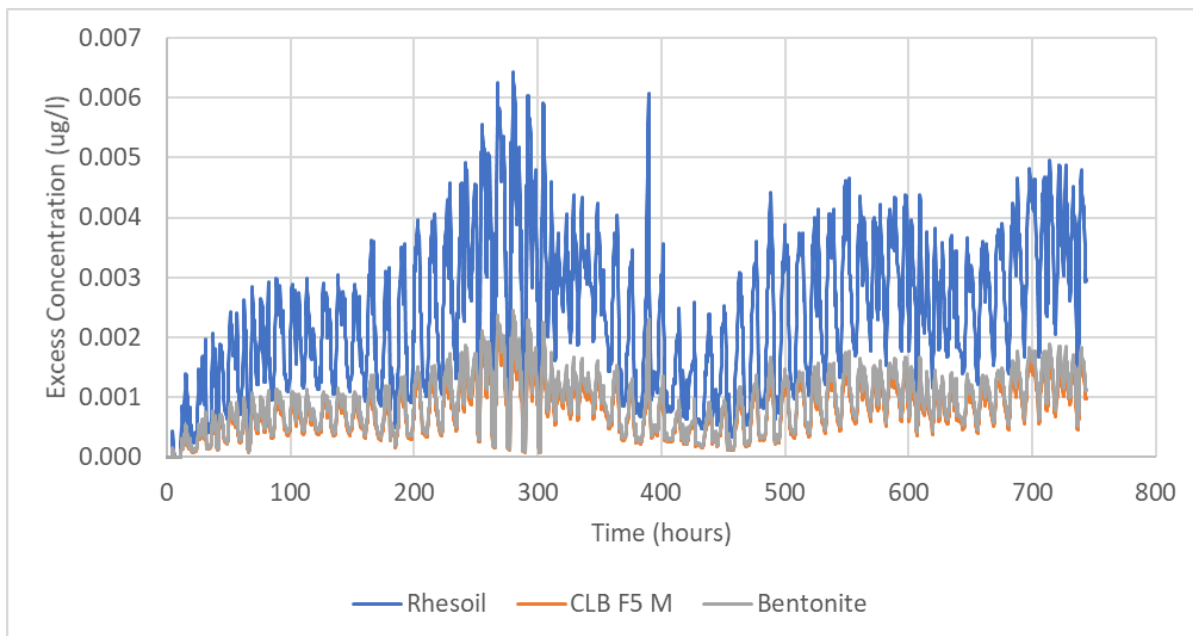


Figure 6-3 Excess concentration extracted of tunnelling effluent from GETM at the location of the desalination intake.

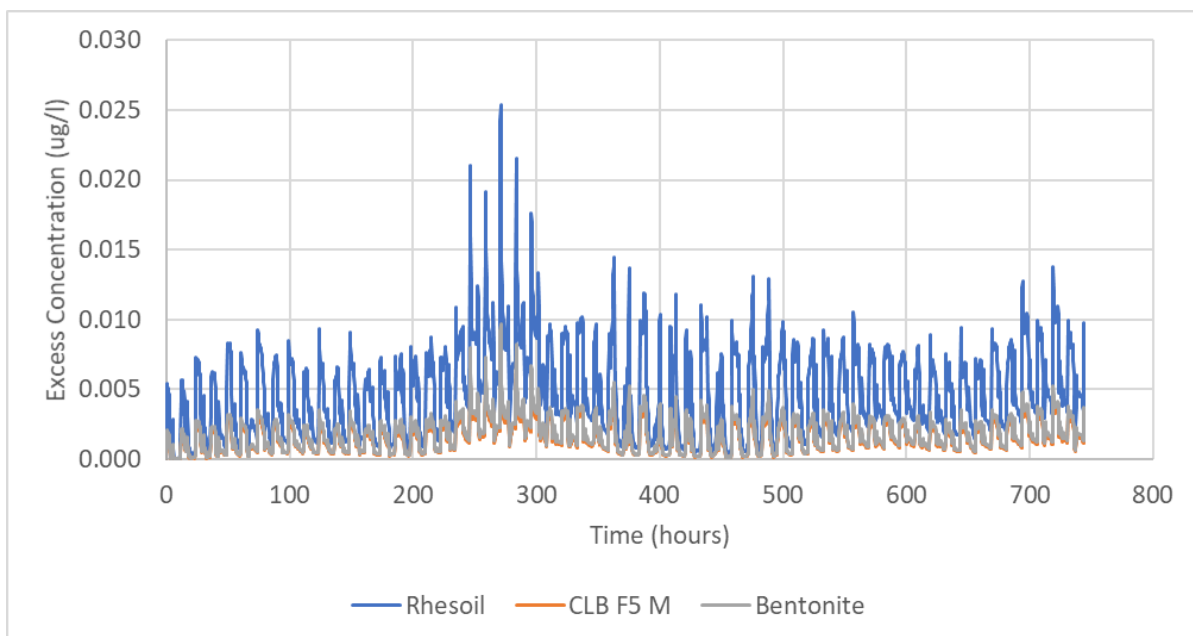


Figure 6-4 Excess concentration extracted of tunnelling effluent from GETM at the location of the desalination outfall.

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7 Conclusion

A temporary desalination plant and associated infrastructure is required to produce potable water for the construction period but will cease to operate prior to commencement of Cold Functional Testing at Sizewell C. An assessment was undertaken for the discharge of substances present in the planned desalination concentrate discharge during the construction period. The concentrate would be highly saline ca., 20 PSU above the seawater background. Although the discharge has a higher density than the receiving seawater, the diffuser head facilitates more rapid mixing and limits the area at the seabed that is influenced by the discharge plume. The results of CORMIX modelling indicate that excess salinity falls to within 1 PSU of that at background within ca., 6.8-21.5 m which is well within the natural variation at the site (conditions at the discharge site are well mixed and would also facilitate mixing but are not included in this more precautionary assessment). The time taken for a passive particle to traverse through the saline plume would also be short at between approximately 28 to 215 seconds for all tidal velocities above a slack threshold of 0.1 m/s at the location of the desalination outfall. Therefore except for the influence of the high salinity of the concentrate at the point of discharge upon initial plume behaviour, the elevated salinity is expected to have negligible effects upon marine species beyond a few metres from the point of discharge. A sensitivity analysis was conducted by applying a temperature differential between the ambient sea conditions and the desalination discharge to inhibit mixing. Due to the small flows considered, the effect of the temperature uplift is minimal. Using a thermal uplift of 10°C (which is not anticipated), the extent of the salinity plume, to the 1 PSU above background threshold, is only extended by a distance of 11 cm.

As noted above the salinity plume is dispersed rapidly, within 6.8-21.5 m. Changes in salinity and chemical treatment for dechlorination are unlikely to cause DO levels to reduce below the WFD 'high' threshold even in the immediate vicinity of the discharge location, and any effects would be rapidly dispersed as the saline plume mixes with the surrounding seawater. Therefore, the level of change to dissolved oxygen from changes in salinity is assessed as negligible.

The potential interaction of discharges from the CDO during the main construction period with both the desalination plant intake and outfall was also considered. Discharges from the CDO that have been considered were metals from groundwater and chemicals used during tunnelling.

Chemicals present in the CDO discharge plume that overlap with the desalination intake have the potential to become concentrated through the RO process and be discharged from the desalination plant. The maximum recirculation concentrations of metals from the CDO were very low for metals with values of 0.002 $\mu\text{g l}^{-1}$ for zinc, 0.016 $\mu\text{g l}^{-1}$ for chromium and 0.001 $\mu\text{g l}^{-1}$ for lead. Both zinc and lead were shown to have lower values than their respective limits of detection. The addition of a further 0.016 $\mu\text{g l}^{-1}$ of chromium, to the source concentration, at the desalination intake was investigated with CORMIX. Under the worst hydrodynamic condition, the plume only extended a further 2 m. This does not affect the conclusions of the H1 assessment.

At the location of the desalination outfall, the maximum concentration from the CDO was 0.006 $\mu\text{g l}^{-1}$ for zinc. For lead, the maximum concentration was 0.003 $\mu\text{g l}^{-1}$. For chromium the maximum concentration was 0.058 $\mu\text{g l}^{-1}$. These values are many times below the respective EQS values and do not change the H1 assessment for the desalination plant discharge.

An assessment of the interaction between possible surfactant chemicals potentially discharged from the CDO during tunnelling with the desalination plant intake shows that all chemicals considered are an order of one thousand times below their respective EQS values. Therefore discharge of tunnelling chemicals from the CDO is expected to have a negligible influence of the desalination intake. Tunnelling chemicals discharged

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from the CDO are also at very low concentrations (one hundred to one thousand times below relevant chemical EQS values) where they overlap with the desalination plant discharge. Therefore it is considered the interaction of the CDO discharge of tunnelling chemicals has negligible influence on the potential area influenced by the desalination plant discharge.

Various activities during the construction period can add nitrogen and phosphorus to discharges to the marine environment and this can influence algal growth. Descaling chemicals used for cleaning the Reverse Osmosis (RO) membranes used for desalination contain phosphorus so this together with the phosphorus background in the seawater is also rejected in the desalination concentrate. Background phosphorus and descaling chemicals together contribute ca., 20 kg/d phosphorus. Based on the seawater natural nitrogen background levels, the RO process also results in increased nitrogen concentration of ca., 0.6 kg/d in the desalination discharge. The nitrogen and phosphorus inputs from the desalination process were considered together with other construction activity inputs (treated sewage and groundwater) and the total loading was evaluated in an annual assessment using a combined phytoplankton and macroalgal model. The additional nutrient loading of the desalination discharge during the construction period is predicted to result in a 0.17% increase in annual production in Sizewell Bay relative to the baseline situation including SZB. The combination of construction period nutrient inputs from treated sewage and groundwater with those for desalination, result in an increase of 0.49% in production relative to the current baseline with SZB. However, despite these additional nutrient inputs there is still an overall reduction in production in Sizewell Bay due to the influence of SZB. The influence of SZB in reducing production in Sizewell Bay and the small positive additions to production that would occur due to nutrient inputs from construction and desalination would not be detectable against a natural background of inter annual variation in production within Sizewell Bay (Appendix 22H of the Marine Ecology and Fisheries ES, BEEMS Technical Report TR385). This level of change is therefore evaluated to have a negligible impact.

The desalination concentrate also contains elevated levels of various trace metals and other substances resulting from the concentration process.

As part of the surface water pollution risk assessment there are specific requirements for the minimisation of the annual loads of cadmium and mercury discharged to the aquatic environment which require assessment. Neither metal was shown to exceed threshold loadings for a cumulative annual assessment incorporating all input sources which include these trace metals during the construction period.

There was shown to be insufficient ammonia present in the discharge to present a risk from the proportion of un-ionised ammonia (the more toxic form) exceeding its EQS under the expected discharge physicochemical conditions, so no further modelling assessment was required.

A screening assessment of substances present in the desalination discharge identified three metals: zinc, lead and chromium which would fail the assessment and would need more detailed modelling to be conducted. Using the US EPA mixing zone model CORMIX the maximum discharges of lead, zinc and chromium were evaluated to determine the extent of any areas of EQS exceedance. Modelling was conducted using a simple diffuser. For the three metals assessed using CORMIX the plume area above the EQS was between 0.02 to 0.17 ha. Other substances that just exceeded their respective EQS in Test 1 (Table 3) but were not taken forward for modelling are likely to act in combination within the lower plume area of 0.02 ha where zinc, chromium, and lead would all exceed their respective EQS. The diffuser would facilitate more rapid mixing of the saline discharge, but the plume would still sink and influence areas of the seabed close to the discharge point. A precautionary assessment derives an area above EQS for any discharge that is not >1.0 ha at the seabed (this assumes the maximum extent of any discharge, based on chromium represents the radius of a circle around the discharge point). The modelling provides a precautionary assessment as it does not take account of natural mixing processes and the relatively shallow

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waters at this location would be expected to be well mixed (BEEMS Technical Report TR189). Based on this assessment the desalination concentrate discharge would be expected to have negligible effects on background water quality beyond the immediate small, localised area influenced by the discharge.

An assessment of potential interaction of the CDO discharge with both the intake and discharge of the desalination plant showed that chemical concentrations would be tens to thousands of times below respective EQS values. They therefore would have negligible influence on the areas affected by the desalination plant discharge and do not change the overall H1 assessment.

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- BEEMS Technical Report TR193 Ed.5. Sizewell C H1 assessment - supporting data report. Cefas, Lowestoft. (ES Appendix 21F)
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9 Appendix

9.1 Cormix modelling supplementary data

The results presented here are indicative of the performance of a basic diffuser. The outfall used for the CORMIX modelling is a single port riser discharging 1 m off the seabed, with a single nozzle with a contraction ratio of 0.65 (i.e., there is a narrow nozzle on the end of each to enhance discharge momentum and increase mixing) and a pipe diameter of 0.25 m. As the discharge is denser than the background water, the outfall pipe is discharged upwards at an angle of 45°, to project the flow up into the water before sinking to the seabed, to enhance mixing.

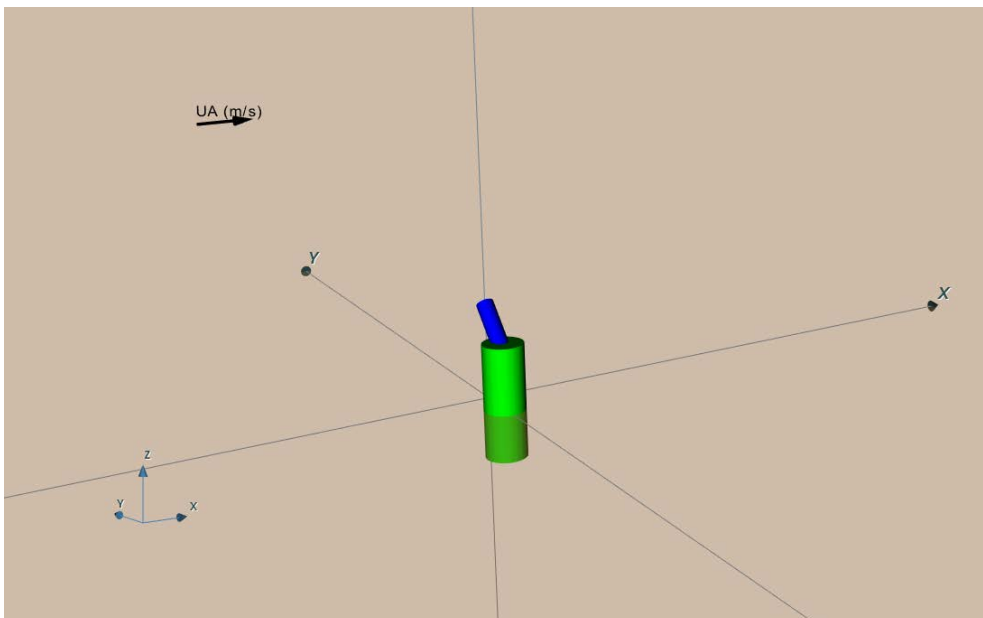


Figure 9-1 Basic shape of the diffuser used in CORMIX.

Figure 9-2 and Figure 9-3 show the plume geometry under peak flood and low water conditions, respectively. Whilst the plots show the concentrations specifically for chromium, the plume geometry is the same for zinc and lead, but the concentrations within the plume would be different.

Figure 9-4 and Figure 9-5 show the centreline plume concentration and dilution, respectively, for lead under peak flood conditions.

Figure 9-6 and Figure 9-7 show the centreline plume concentration and dilution, respectively, for chromium under peak flood conditions.

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Figure 9-8 and Figure 9-9 show the centreline plume concentration and dilution, respectively, for zinc under peak flood conditions.

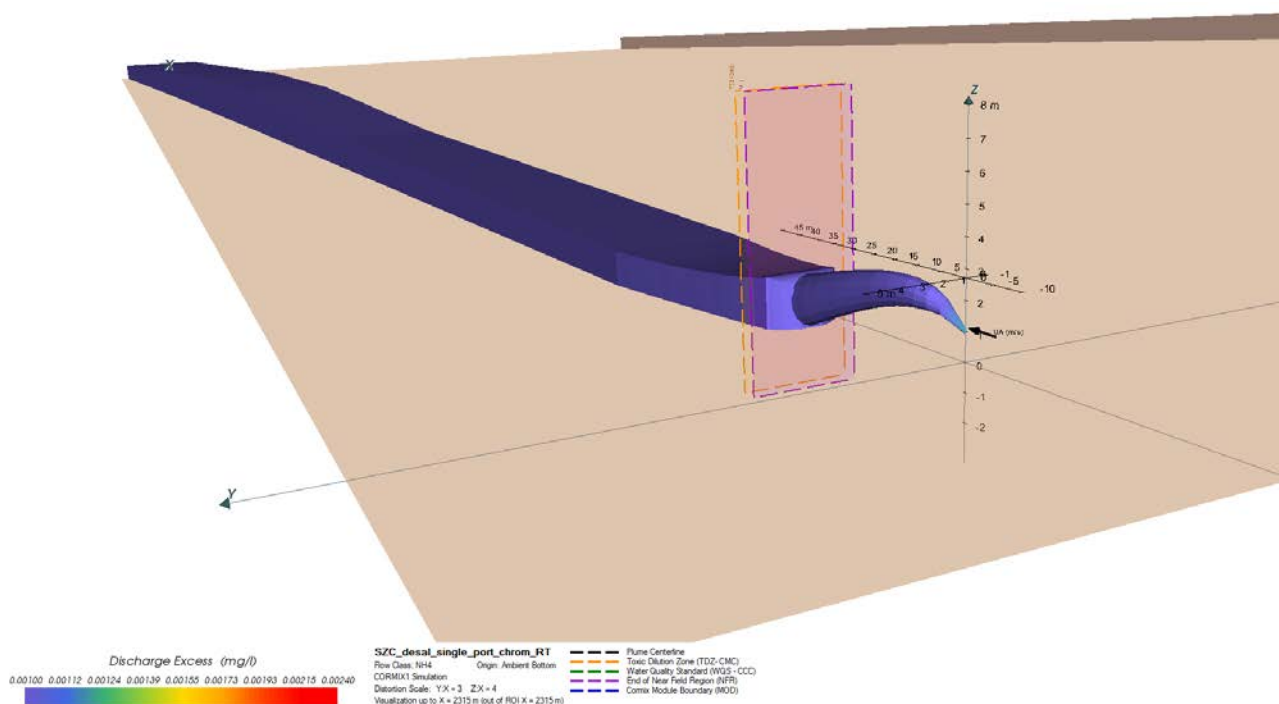


Figure 9-2 Plume geometry under peak flood conditions with a single port riser

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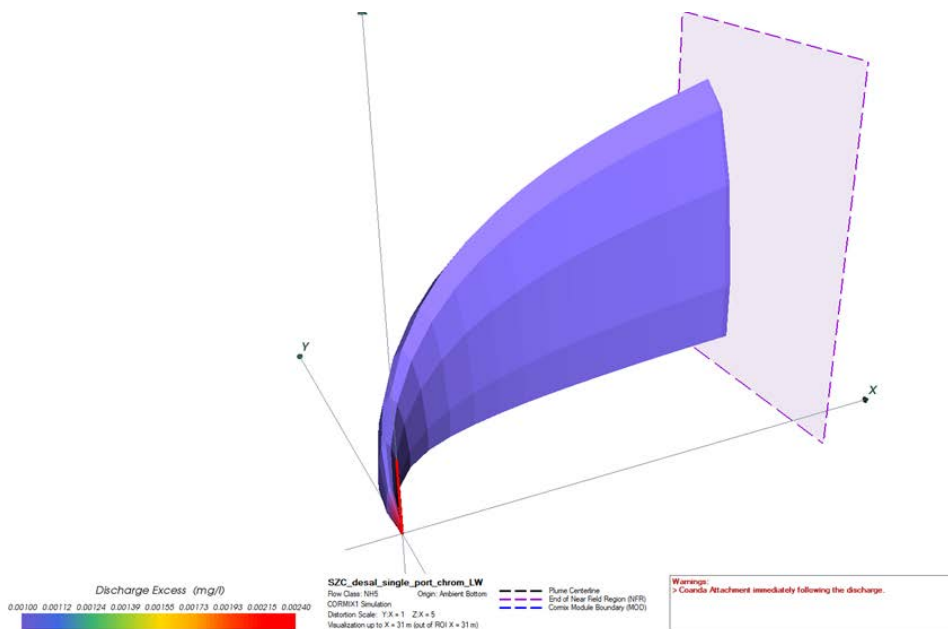


Figure 9-3 Plume geometry under low water conditions with a single port riser.

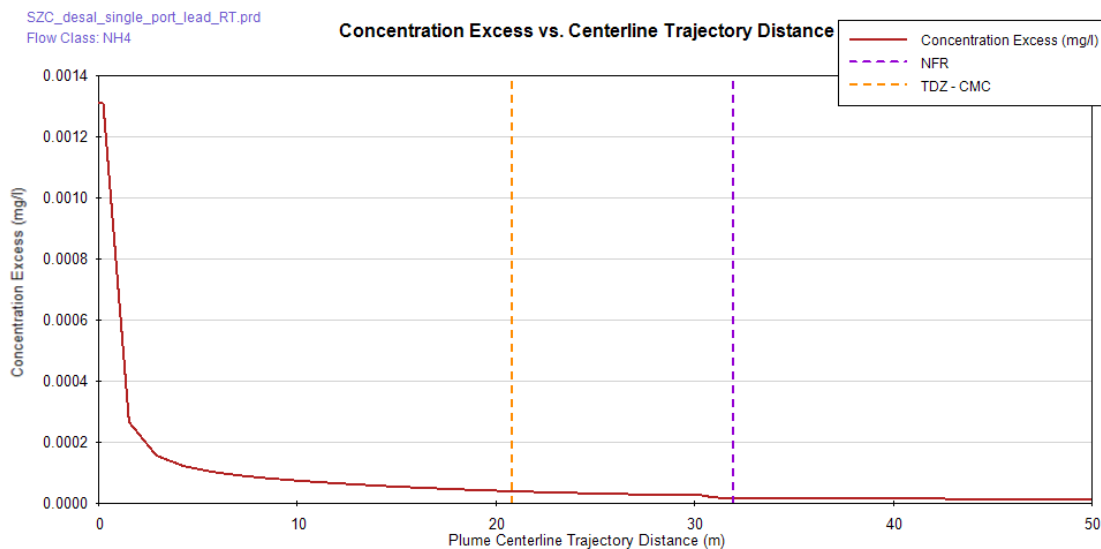


Figure 9-4 Centreline plume concentration for lead under peak flood conditions with diffuser. (CMC represents EQS value).

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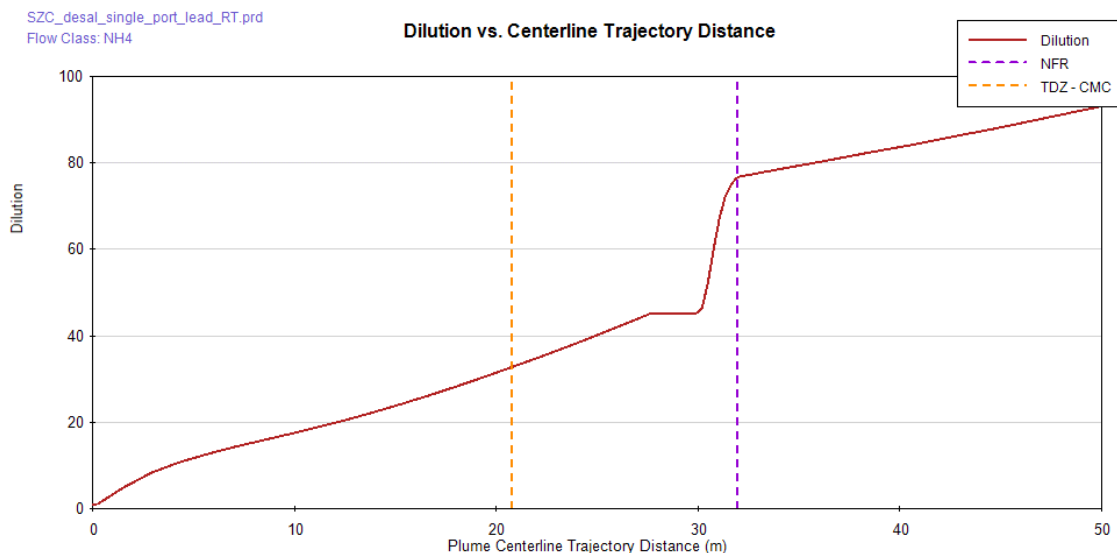


Figure 9-5 Centreline plume dilution for lead under peak flood conditions with diffuser. (CMC represents EQS value).

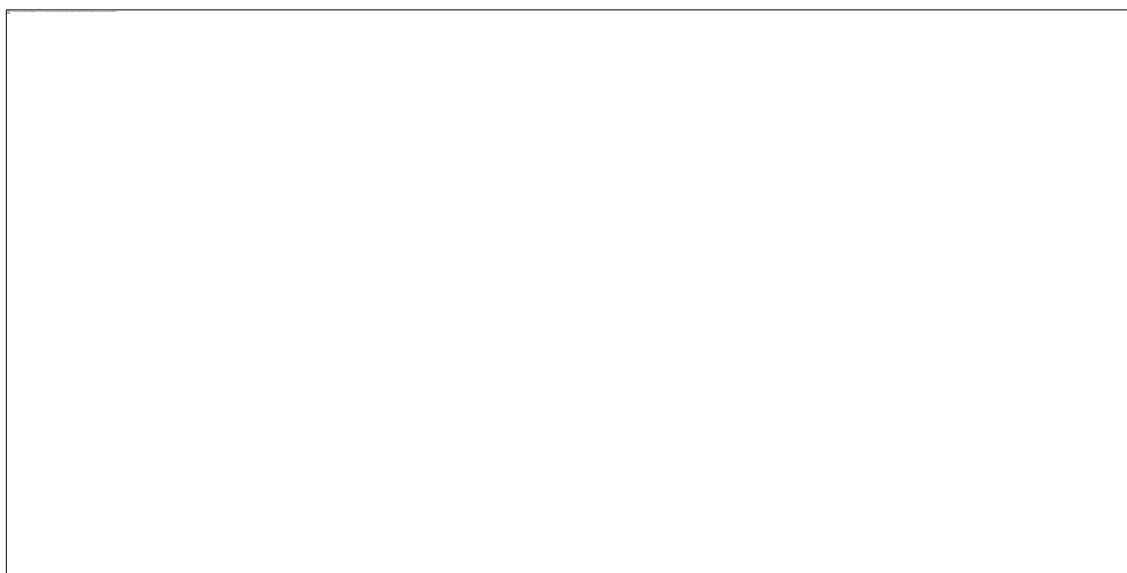


Figure 9-6 Centreline plume concentration for chromium under peak flood conditions with single port riser (CMC represents EQS value).

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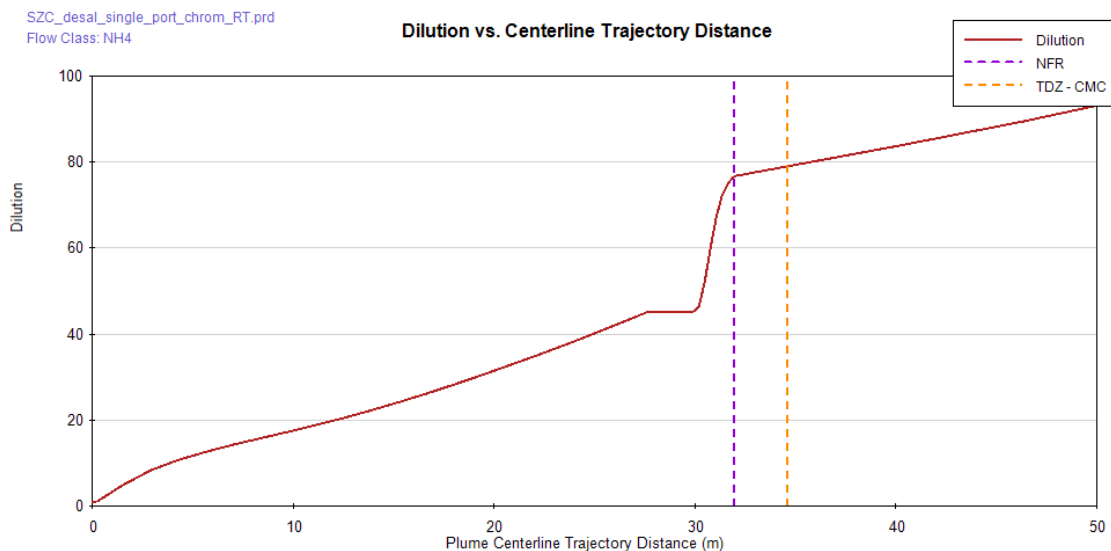


Figure 9-7 Centreline plume dilution for chromium under peak flood conditions with single port riser. (CMC represents EQS value).

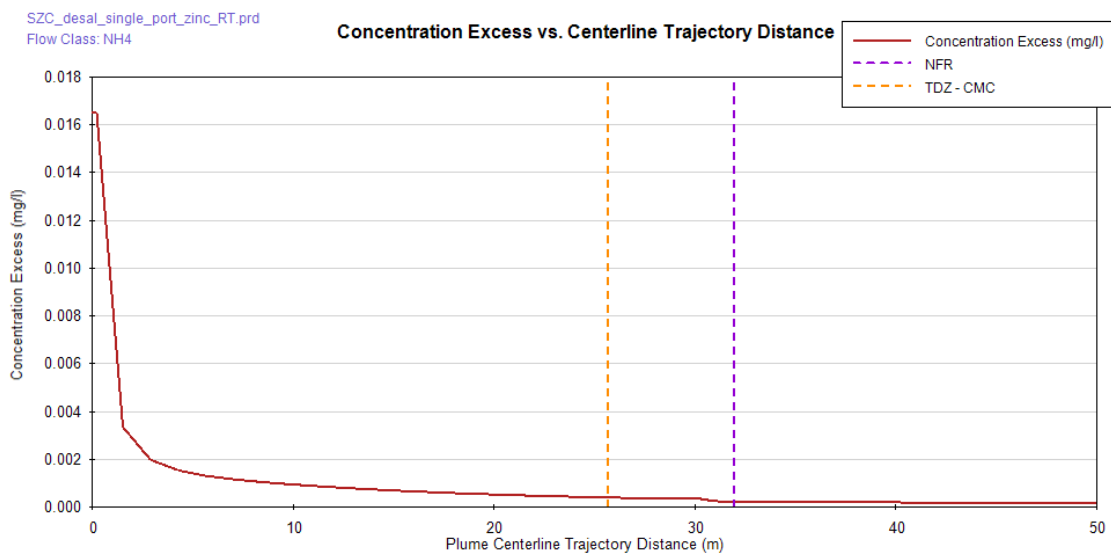


Figure 9-8 Centreline plume concentration for zinc under peak flood conditions with single port riser. (CMC represents EQS value).

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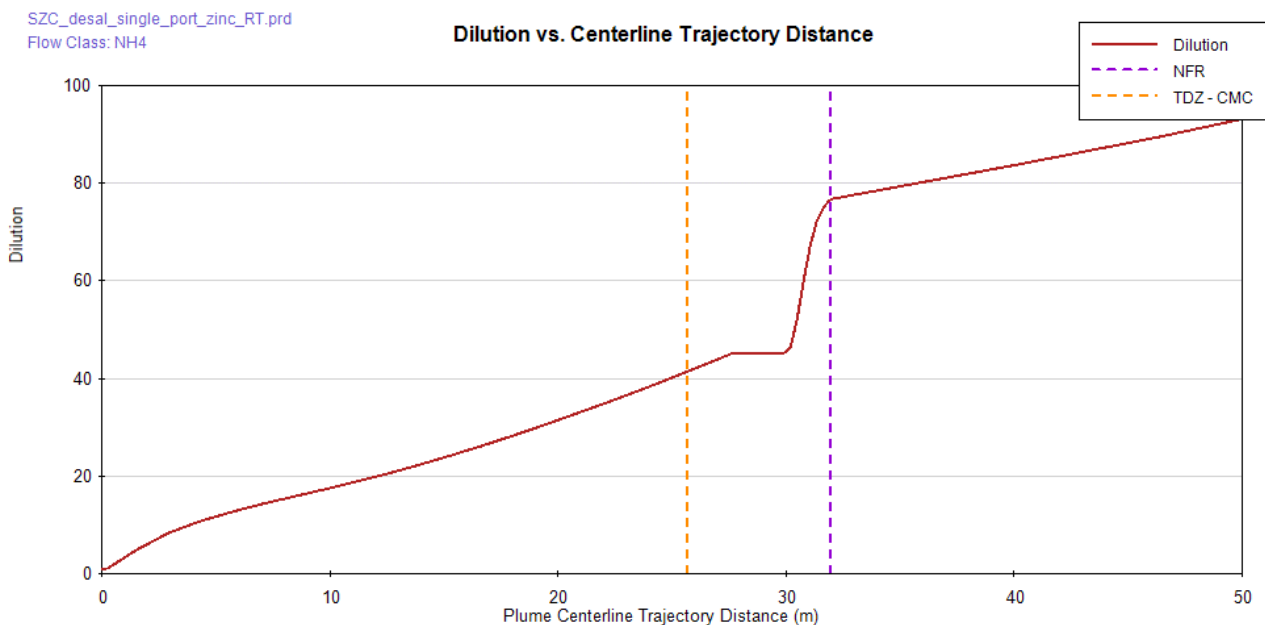


Figure 9-9 Centreline plume dilution for zinc under peak flood conditions with single port riser. (CMC represents EQS value).

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Table 9-1 and Table 9-2 summarises the distances the plume travels before falling below the threshold of detection (for lead and zinc) or below the EQS using the diffuser, under spring and neap conditions, respectively. Note, for some conditions the EQS may not be reached, as denoted by NA (Not Achieved) as the CORMIX simulation reaches a condition of tidal state reversal and the plume cannot propagate any further.

Table 9-1 Summary of distances to EQS threshold under spring conditions.

Chemical	Distance to Threshold (m)									
	Rising Tide	High Tide	Falling Tide	Low Tide -2 hrs	Low Tide -1 hr	Low Tide -0.5 hrs	Low Tide	Low Tide +0.5 hrs	Low Tide +1 hr	Low Tide +2 hrs
Lead	20.14	12.10	19.30	16.73	14.21	11.57	16.75	16.34	13.94	15.14
Zinc	24.99	14.66	24.04	20.68	17.37	13.96	20.42	21.00	17.13	18.66
Chromium	31.58	25.01	31.18	25.1	22.03	26.68	NA	NA	25.63	24.41

Table Note:

- i) NA means threshold 'Not Achieved' before tidal state reversal. NA* For chromium, the EQS is not reached at low water and the following half an hour, with concentrations of $0.61 \mu\text{g l}^{-1}$ extending ca. 41.0 m, compared to an EQS of $0.6 \mu\text{g l}^{-1}$

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Table 9-2 Summary of distances to EQS threshold under neap conditions.

Chemical	Distance to Threshold (m)									
	Rising Tide	High Tide	Falling Tide	Low Tide -2 hrs	Low Tide -1 hr	Low Tide -0.5 hrs	Low Tide	Low Tide +0.5 hrs	Low Tide +1 hr	Low Tide +2 hrs
Lead	15.25	10.28	14.12	11.13	10.53	16.53	32.80	9.99	12.08	14.44
Zinc	18.77	11.85	17.36	13.37	12.55	20.34	NA	11.12	14.64	17.77
Chromium	23.44	NA*	25.24	31.98	40.33	43.66	NA	NA	31.99	25.27

Table Note:

- i) NA means threshold 'Not Achieved' before tidal state reversal. NA* For chromium, the EQS is not reached at low water and the following half an hour, with concentrations of $0.61 \mu\text{g l}^{-1}$ extending ca. 56.7 m, compared to an EQS of $0.6 \mu\text{g l}^{-1}$