CEFAS REPORT TR581 ASSESSMENT OF AMMONIA DISCHARGES ASSOCIATED WITH TREATED SEWAGE AND COMMISSIONING OF HPC

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BEEMS Technical Report TR581

Assessment of Ammonia Discharges Associated with Treated Sewage and Commissioning of HPC

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Executive summary

The Hinkley Point C (HPC) Development Consent Order (DCO) was granted by the UK Secretary of State for Energy and Climate Change in March 2013. HPC environmental permit for the Construction Sewage Treatment System (Environment Agency's Permit number EPR/XP3321GD/V004) permits NNB GenCo to discharge a maximum of 20 mg/l of ammoniacal nitrogen from the sewage treatment system. The cold commissioning discharge permit (EPR/JP3122GM/V009&010) also allows for additional discharges of ammonia associated with the commissioning phase, tunnelling, and groundwater. Notably these two discharges will overlap during commissioning and therefore need to be considered together for assessment purposes. To support the delivery of HPC, NNB GenCo is considering varying the Construction Sewage Treatment System environmental permit (EPR/XP3321GD/V004) to allow an increased concentration of ammoniacal nitrogen within the permitted discharge. The aim of this assessment is to provide the evidence to support the decision to vary the discharge.

Presently, the discharge of ammoniacal nitrogen from the sewage treatment works was assessed, as 20 mg/l at an average flow rate of 13.3 l/s. To investigate the impact of varying the sewage treatment discharge, three different concentrations have been considered: 40, 60 and 80 mg/l of sewage. Additionally, an alternative flow rate mix has been considered, based on the current dewatering during construction, whereby the sewage flow rate is increased by 10 l/s and the groundwater decreased by 10 l/s, maintaining the overall average 38.3 l/s flow.

The assessments considered the release from the sewage treatment works as both a construction only discharge, plus a combined construction and commissioning discharge.

Applying the Environment Agency's Screening tests, the results of 'test 5' (allowable effective volume flux) showed that when considering construction alone, each scenario tested was within permissible limits. However, the partitioning of un-ionised ammonia is influenced by the physical conditions and this partitioning is not factored into the basic screening tests. Therefore, while the screening test was passed, further assessment of the discharges in terms of mixing calculations and nearfield modelling was conducted. When considering the combined construction and commissioning discharges, due to the considerable increase in ammonia from the commissioning phase, the screening tests were not passed. However, this is consistent with previous assessments (BEEMS Technical Report TR428) which required modelling to fully assess the potential implications of the commissioning discharges.

For the construction discharge alone, nearfield modelling using CORMIX showed that concentrations of un-ionised ammonia fall below the environmental quality standard (EQS) (21 µg/l) within <7.19 m of the discharge point for the original scenario (i.e., 20 mg/l total ammonia). This distance required to mix the discharge down to the EQS increased to a maximum of 45.82 m for the 80 mg/l discharge scenario, with the original flows, and to 82.12 m for 80 mg/l discharge with the alternative flow rates. While the estimated mixing zone was considerably larger under the new scenarios compared to the baseline scenario (increasing from ~7m to over 80 m), the mixing zone was still very small in respect to the scale of the receiving environment and therefore would not be expected to cause any significant environmental effects.

Reanalysis of the General Estuarine Transport Model (GETM) modelling results showed that during the period where the construction and commissioning discharges overlap, the discharge scenarios led to an estimated additional 0.11 to 0.31 µg/l of un-ionised ammonia with the original flow rates and 0.06 to 0.61 µg/l of un-ionised ammonia with the alternative flow rates at the locations of the sensitive biological receptors. From the time series of instantaneous un-ionised ammonia concentrations at the eight *Corallina* locations and seven *Sabellaria* locations, the maximum instantaneous value (10.4 µg/l) was below the EQS of 21 µg/l. For all scenarios, the area of exceedance of un-ionised ammonia, as a 95th percentile, had a maximum value of 0.2 ha at the surface and was not exceeded at the bed. For context the receiving water body (Bridgwater Bay) has a surface area of 9,224.5 ha, and therefore the area of exceedance would represent 0.002% of the water body.

For construction and commissioning the maximum allowable concentration for total ammonia, (8 mg/l as a 95th percentile) was not exceeded at the surface or bed in any scenario, but the PNEC (1.1 mg/l as a mean) was exceeded at the surface only, however only for a maximum of 0.04 ha (equivalent to 1 grid cell in the model and the point of immediate discharge).

The overall conclusion was that all of the scenarios considered would not lead to significant environmental effects.

1 Background

The Hinkley Point C (HPC) Development Consent Order (DCO) was granted by the UK Secretary of State for Energy and Climate Change in March 2013. The DCO and associated Licences and Permits detail NNB Gen Co's (HPC) environmental monitoring requirements with respect to the construction and operation of the new station.

HPC environmental permit (Environment Agency's Permit number EPR/XP3321GD/V004) for the Construction Sewage Treatment System consents NNB GenCo to discharge a maximum of 20 mg/l of ammoniacal nitrogen from the HPC Sewage Treatment plant during construction. Additionally, during commissioning, NNB GenCo are permitted to release 271 mg/l of ammoniacal nitrogen (EPR/JP3122GM/V009&010) and to discharge groundwater during the construction period. To support the delivery of HPC, NNB GenCo is considering varying the site's Construction Sewage Treatment System environmental permit (EPR/XP3321GD/V004) to allow an increased concentration of ammoniacal nitrogen within the permitted discharge. NNB GenCo has commissioned Cefas under the BEEMS programme to undertake appropriate additional modelling studies to support the discharge control strategy.

1.1 Scenarios

The currently permitted discharge of ammoniacal nitrogen from the sewage treatment works was assessed as 20 mg/l at a flow rate of 13.3 l/s, see Case D of BEEMS TR428. The flow from the sewage treatment works represents only a partial flow of the total contribution of ammoniacal nitrogen to the total 38.3 l/s flow of Case D. During the construction period the total flow of Case D is comprised of 13.3 l/s coming from the sewage treatment works and 25 l/s from general groundwater and tunnelling effluent flow.

To investigate the impact of varying the sewage treatment discharge, three different concentrations of ammoniacal nitrogen in the treated sewage flow were considered; 40, 60 and 80 mg/l. Additionally, an alternative flow rate mix has been considered, based on the current dewatering during construction, whereby the treated sewage flow rate is increased by 10 l/s and the groundwater decreased by 10 l/s, maintaining the overall 38.3 l/s flow. Table 1 summaries the different scenarios being tested and their respective ammonia concentrations.

As discussed further in Section 2.3 ammoniacal nitrogen will be discharged during commissioning as well as during the construction phase and while the commissioning discharge will not be varied the implications of altered construction discharges when combined with the commissioning discharges must be considered and are therefore factored into the assessment.

Table 1: Summary of the discharge scenarios and their ammoniacal nitrogen concentrations.

Flow	Scenario (ammoniacal nitrogen in treated sewage)	Total flow (m^3/s)[1]	Total ammonia (µg/l)[2]	Un-ionised ammonia (µg/l)[3]
Original	20 mg/l	0.038	10,034	44.8
	40 mg/l	0.038	16,979	75.7
	60 mg/l	0.038	23,924	106.7
	80 mg/l	0.038	30,869	137.7
Alternative	20 mg/l	0.038	14,020	62.5
	40 mg/l	0.038	26,187	116.8
	60 mg/l	0.038	38,355	171.1
	80 mg/l	0.038	50,522	225.3

[1]: Comprised of 25 l/s groundwater and tunnelling effluent plus 13.3 l/s treated sewage or the original case, or 15 l/s groundwater plus 23.3 l/s treated sewage for the alternative case.
[2]: Derived from the mixing of the sewage ammonia scenario plus groundwater at 4,732 µg/l total ammonia (refer to BEEMS Technical Report TR428).
[3]: Derived using the Environment Agency un-ionised ammonia calculator based on discharge with salinity of 1, pH of 7.3 and temperature of 12.5°C (refer to BEEMS Technical Report TR428).

2 Assessment Methodology

2.1 Screening and un-ionised ammonia mixing

The first step in assessing the alternative treated sewage discharges was to apply the Environment Agency screening tests (Environment Agency and Department for Environment Food and Rural Affairs, 2022). The concentration of substances present in the discharge were assessed against lists of specific pollutants and priority hazardous substances and compared to environmental quality standards (EQS). There are several different 'tests' depending on the nature of the discharge and surrounding conditions. For the construction and commissioning discharges, and in line with previous assessments in BEEMS Technical Report TR428, test 1 and test 5 for 'estuaries and coastal waters' are applicable.

Test 1 is a comparison of the concentration of each assessment substance to the representative EQS. If concentrations of substances are below their EQS levels in the discharges the test is passed and the substance is screened out of further assessment.

Test 5 compares the discharge to calculated Effective Volume Flux (EVF) levels. The EVF is determined based on the discharge rate, the concentration of the substance and the EQS of that substance. The calculation applied is as follows:

EVF = (Discharge Rate (m^3/s) * Concentration (µg/l)) / (EQS – background concentration)

The result is compared to the Allowable EVF (AEVF), which is determined by the water depth at the point of discharge. The water depth at the discharge point is at least 3 m. Consistent with previous assessments (BEEMS Technical Report TR428) an AEVF of 3 has been applied. Background concentrations applied are consistent with BEEMS Technical Report TR428 and follow either baseline measurements from the area (Amec, 2009) or concentrations recommended by the environment Agency.

Ammonia is a key consideration in treated sewage discharges and is considered as both total ammonia (ammoniacal nitrogen NH_3 + NH_4^+) and un-ionised ammonia (NH_3) alone. Un-ionised ammonia is a specific pollutant with a EQS (at 21 µg/l annual average). All measures of ammonia are expressed 'as N' referring to the mass of nitrogen in the compound.

In general, the un-ionised form of ammonia is more toxic than the ionised form. The partitioning between ammonium (NH_4^+) and un-ionised ammonia is controlled by environmental variables, principally, pH, temperature and salinity. At higher pH values, un-ionised ammonia represents a greater proportion of the total ammonia concentration. Temperature increase also raises the relative proportion of un-ionised ammonia, but this effect is much less marked than for pH change. A greater percentage of ammonia will also be in the un-ionised form when the salinity is lower. Un-ionised ammonia concentrations have been calculated using the Environment Agency calculator (following the formulas in Clegg & Whitfield,1995).

The discharged source will be primarily freshwater with different properties to the seawater it will mix with. Therefore, the proportion of un-ionised ammonia will change as the discharge mixes with the surrounding seawater. Mixing curves have been calculated to determine the proportion of un-ionised ammonia at different levels of mixing. Interpolation of these curves at the EQS level provides to amount of mixing required to reach the EQS. Parameters used in the mixing calculations are given in Section 4.

2.2 Construction only discharges

The seven additional discharge scenarios described in Section 1.1 were assessed alone to consider the period of construction discharges before the commissioning discharges are added.

Initial screening was based on the characteristics of the discharge, with a salinity of 1, pH of 7.3 and background temperature of 12.5°C (BEEMS Technical Report TR428). While initial screening showed that construction only discharges are below the AEVF (see Section 3) the partitioning of ammonium and un-ionised ammonia varies with significantly with pH. The ground water pH (7.3) is lower than the background seawater pH (7.86) so as the discharge mixes the proportion of un-ionised ammonia will increase (although notably while being diluted). Therefore, mixing calculations and nearfield modelling were applied to determine the range at which the EQS level would be reached. Whilst the total flow rate considered during the construction only scenario is 38.3 l/s, the flow rate modelled in CORMIX was conservatively increased to 45 l/s, mirroring what was previously modelled using CORMIX in BEEMS Technical Report TR428.

Mixing calculations are described in Section 4 and were used to determine the extent of mixing required to reach the EQS for un-ionised ammonia. Notably these calculations are independent of the volumes of the discharge. Initial mixing was therefore further investigated with the nearfield CORMIX model to determine the range at which the EQS would be met under the different scenarios. The construction discharge was modelled using CORMIX US EPA supported mixing zone model (CORMIX Version 12.0GT HYDRO1 Version 12.0.1.0 January 2023), using the same hydrodynamic model parameters as used in BEEMS Technical Report TR428 which has been previously agreed with the Environment Agency.

To investigate how the discharge evolves over the state of the tide, multiple stages of the tide were considered: peak flood, peak ebb, high water, and low water. Whilst the plume is buoyant[1], the water depth at the discharge is only 3 m at low water, there is a risk of slack water pooling at low water, where the depths and low velocities will inhibit mixing. Therefore, an additional scenario was also modelled in BEEMS Technical Report TR428 and replicated here, of low tide +1 hour.

2.3 Construction and commissioning discharges

High levels of ammonia will be discharge during commissioning overlapping with the construction discharge. Previous modelling of ammonia discharges during construction and commissioning were presented in BEEMS Technical Report TR428. The release and mixing of ammonia was modelled using the validated Hinkley Point 25 m resolution GETM model. This is a 3D hydrodynamic model with an inbuilt passive tracer to represent ammonia. The model setup, calibration and validation are described in BEEMS Technical Report TR267 Edition 2. As with the 100 m resolution Hinkley Point GETM model (BEEMS Technical Report TR177) the surface is forced with reanalysed data from a meteorological model (ERA40 interim from ECMWF). The boundary conditions were forced by a broader 3D GETM domain, described in BEEMS Technical Report TR177.

The discharge outfall is attached to a jetty pile and located approximately 1 m above the seabed (approximately 2 m below lowest astronomical tide (LAT)). CORMIX modelling (shown in Appendix D of TR428) indicates that the plume will be buoyant and form a surface pool (or pond) at slack water which will become increasingly elongated as the tidal flow increases, forming a long thin streak at peak tidal flow. CORMIX is unable to replicate many of the features simulated by the GETM model, and GETM is therefore a better model to use away from the near field (further than 10s of metres from the outfall). Specifically, GETM can replicate wind driven behaviour and has precise bathymetry so that interactions with the tidal flow (e.g. eddies) are well replicated. Whilst CORMIX can include winds, they are applied omnidirectionally and are

[1] The plume is buoyant because it is a freshwater discharge into a saline environment. The discharge is not considered to be heated and has been modelled at ambient temperature, 12.5°C (i.e. there is no thermal uplift).

used for determining heat loss fluxes at the surface. As the discharges considered in this report are released at ambient sea temperature and are not considered to be heated, wind has not been included in the CORMIX model. Neither the CORMIX nor the GETM model includes the effects of waves which enhance vertical mixing and increase dilution. The modelling predictions of plume areas above the EQS are therefore conservative: the actual discharge will be subject to more mixing and dilution (caused by wave action) than the models are able to replicate and so the actual concentrations in the environment will be lower than those predicted.

As the scenarios considered here maintain the same total flow rate as previously modelled, no new GETM modelling was undertaken, but instead the results were scaled according to the change in the concentrations. BEEMS Technical Report TR428 considered two discharge scenarios during the construction + commissioning assessment: 38.3 l/s construction discharge at 10 mg/l ammoniacal nitrogen plus commissioning discharge at either 37 l/s or 70 /ls discharge at 271 mg/l ammoniacal nitrogen, depending on the release from one or two treatment tanks. For the assessment here, the worst case scenario of two treatment tanks has been assessed, due to the higher total ammonia content in the combined discharges. To determine the predicted effect of the treated sewage variation, the previous GETM results are scaled by determining the percentage increase in total mass of ammonia from the various waste streams. This percentage increase was then also applied to un-ionised ammonia results.

To assess the impact of varying the treated sewage discharge, the spatial extent of the total ammonia was assessed at the surface and bed against the (non-statutory) Predicted No Effect Concentration (PNEC) of 1.1 mg/l as a mean and the Maximum Allowable Concentration (MAC) of 8 mg/l as a 95th percentile. Likewise, for the un-ionised ammonia, the spatial extent was assessed against the (statutory) EQS of 21 µg/l at the surface and bed as a mean and 95th percentile.

In addition to the spatial extents, the exposure of un-ionised ammonia to sensitive biological receptors was also considered, specifically *Sabellaria* and *Corallina* (see Section 2.4 for more details on the biological receptors). Figure 1 shows a time series of un-ionised ammonia at the locations of *Corallina*[2] for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428. Individual plots of each time series are shown in Appendix A. From the time series, the average concentration of un-ionised ammonia at the eight stations of *Corallina* is approximately 2 µg/l with periodic spikes in concentration. This is due to the discharge strategy during construction and commissioning. The construction discharge is a small continuous discharge, whereas the commissioning discharge is a pulsed discharge with a higher flow rate and concentration. The spikes in concentration, seen in Figure 1, at the locations of the *Corallina* previously assessed in BEEMS TR428 (see Figure 2) correspond to the time of the pulse discharge, whereas the 2 µg/l mean baseline is made up of both the construction discharge and the dispersion of the commissioning discharges. Therefore, when applying the percentage increase to the un-ionised ammonia, due to the variation in the treated sewage discharge, it was applied to the 2 µg/l mean baseline, rather than applied as a constant to the whole time series.

[2] Note: location C4 was omitted in the original version of this figure in TR428. As such, the figure was reproduced for this report. However, the baseline for C4 was similar to other locations as seen in the results for C4 shown on Figure 1. The omission from the original figure does not influence the illustration of the 2µg/l baseline, which is the purpose of this figure.

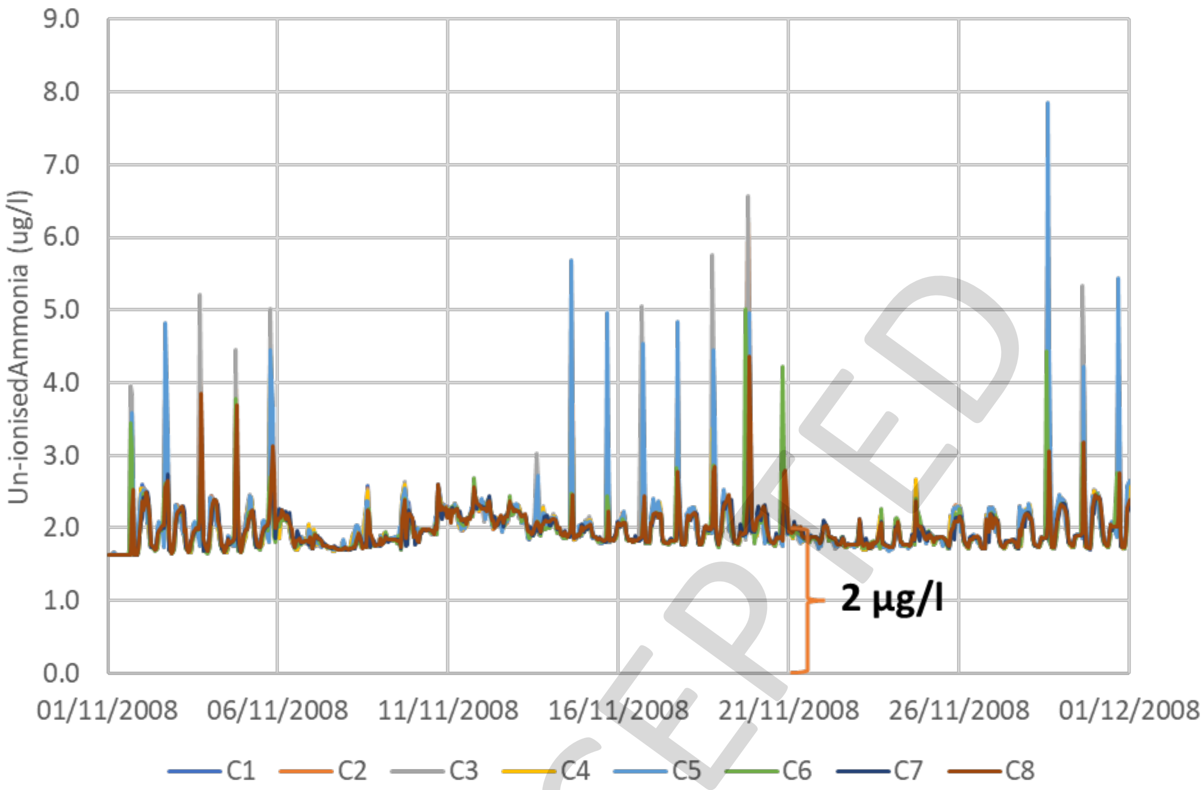

Figure 1: The original time series of un-ionised ammonia at the locations of Corallina (C1 to C8, see Figure 2) for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

2.4 Biological receptors

There are two biological receptors that the un-ionised ammonia was assessed against to determine the acceptable discharge concentration. These are; *Corallina* spp. and *Sabellaria* spp. This report has investigated the potential exposure of these species to un-ionised ammonia with respect to the EQS (21 µg/l annual average).

2.4.1 Corallina spp.

Corallina spp. or coral weed is a calcareous, branching red seaweed (Rhodophyta). Fronds can be up to 4 – 20 cm in length rising from a calcareous crustose holdfast. *Corallina* spp. is an intertidal species typically found inhabiting littoral wave-exposed rocky shores and shallow sublittoral habitats forming turfs in pools and gullies, sometimes extending into the sublittoral fringe (Tyler-Walters, 2008). Dense, sometimes monospecific, swards of *Corallina* are a characteristic feature of the mid to low shore rocky ledges to the west of Hinkley Point (Bamber & Irving, 1992). It is found all around the UK extending its range north to Norway and Greenland and south to Morocco and Argentina (Tyler-Walters, 2008). *Corallina* spp. are of national importance although official conservation status is uncertain (BEEMS Technical Report TR029).

An unusual geological formation at Hinkley Point has caused conditions which favour the development of lush red algal turfs composed mainly of *Corallina* spp. The topography is such that a series of scarps and slopes run parallel to the shore and retain water as the tide retreats, creating a series of narrow pools or streams along the shore. In places where the scarps are breached, water can spill down to the lower shore, thus creating a permanently wet environment suitable for growth of algal species which would otherwise exist only fully submerged in rock pools (BEEMS Technical Report TR029).

Until recently two species of *Corallina* were recognised for the British flora: *Corallina elongata* and *Corallina officinalis* (Irvine and Johansen, 1994). The *Corallina* species found at Hinkley Point has provisionally been described as '*officinalis'*, but the taxonomy of the Corallinales has recently been revised (Walker *et al*., 2009) and a new species *Corallina caespitosa* sp. nov. has been added. Hence, there are three possible species which may exist at Hinkley Point (BEEMS Technical Report TR068B).

Figure 2 shows the location of *Corallina* spp. habitat in relation to the Hinkley Point site. There are eight patches of *Corallina* spp. indicated on the map, as defined in BEEMS Technical Report TR428. Concentrations of un-ionised ammonia were assessed at these locations. As the *Corallina* is intertidal the un-ionised ammonia concentrations at the eight stations will be assessed using the surface concentrations, as in BEEMS Technical Report TR428.

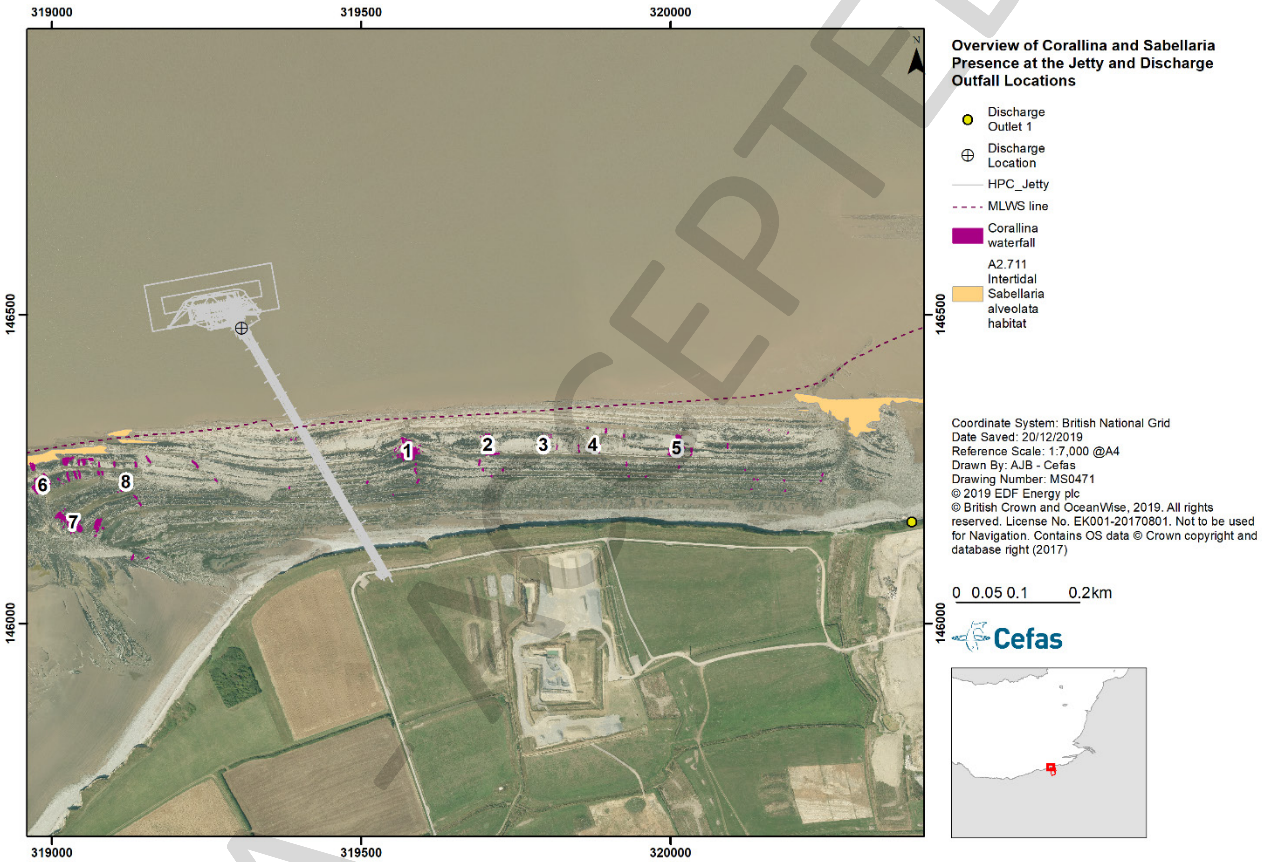

Figure 2: Location of the intertidal *Corallina* spp. around Hinkley Point.

2.4.2 Sabellaria spp.

As part of the Severn Estuary Special Area of Conservation (SAC), *Sabellaria* spp. reefs are a key ecological feature of the site and are included, as biogenic reef habitat, under the SAC designation. The two species of *Sabellaria* spp. that are of interest are *Sabellaria spinulosa* and *Sabellaria alveolata.* As well as a qualifying interest feature of the Severn Estuary SAC, both *S. alveolata* and *S. spinulosa* also have their own UK Biodiversity Action Plans and reef structures are listed under Annex I of the EC Habitats Directive (see BEEMS Technical Report TR068 Version 2).

Both species are sabellariid polychaetes which form reef structures through the aggregation of growth tubes. *S. spinulosa* is a predominantly subtidal species that is relatively widespread around the UK and is found either individually or as crusts or reefs; settling directly on the seabed, on tubes of the same species or on

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hard body parts of other benthic species (such as large bivalves). *S. alveolata* is a predominantly intertidal species that is found mainly around the west and south-west of the UK, settling on exposed bedrock and hard substrates from boulders to pebbles (BEEMS Technical Report TR039). *Sabellaria* reefs are common around Hinkley Point and elsewhere in the Severn Estuary and Bristol Channel but is unusual in that *S. alveolata* occurs in the subtidal, as well as the intertidal which is not commonly observed in other areas.

Figure 3 shows the location of *S. alveolata* habitat in relation to the Hinkley Point site. There are seven patches of *S. alveolata* indicated on the map, as defined in BEEMS Technical Report TR428. Concentrations of un-ionised ammonia will be assessed at these locations. For stations A and E, the *Sabellaria* is subtidal. For stations B, C, D, F and G, the *Sabellaria* is intertidal. As such, for the subtidal *Sabellaria* the un-ionised ammonia concentrations haven been assessed against the EQS using the seabed concentrations, whereas the intertidal have been assessed using the surface concentrations. This is as done in BEEMS Technical Report TR428.

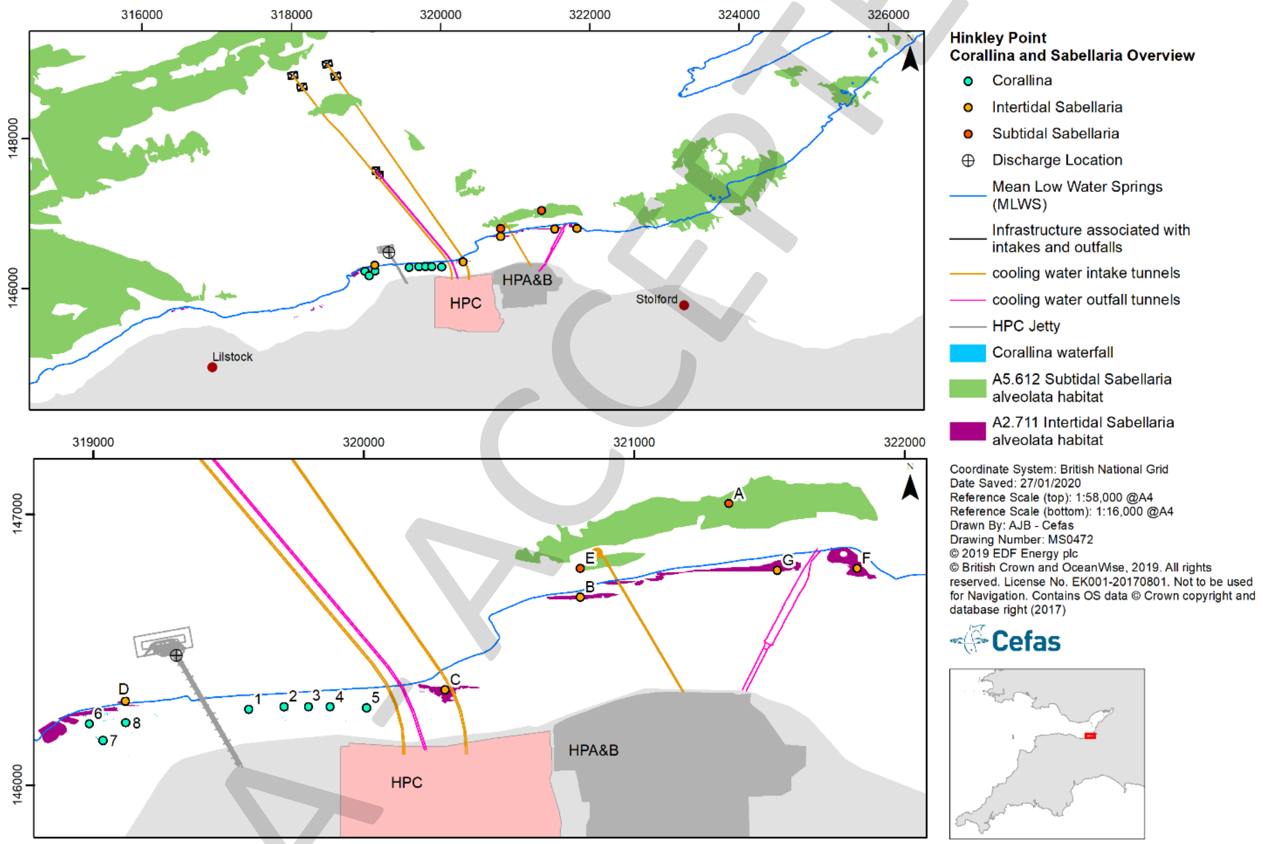

Figure 3: Location of subtidal and intertidal *Sabellaria alveolata* around Hinkley Point.

3 Screening Results

Screening of the seven possible discharge scenarios considering the construction discharge alone showed that all, including the current permitted 20 mg/l ammonia scenario failed test 1 (i.e. are above EQS at the point of discharge). Comparison against the AEVF (test 5) showed that all scenarios were below the threshold. The results of test 5 suggest that when considering construction alone each scenario tested is within permissible limits. The results of the screening tests are shown in Table 2.

As described in Section 2.2, the partitioning of un-ionised ammonia is influenced by the physical conditions and this partitioning is not factored into the basic screening tests. Therefore, while the screening test was passed, further assessment of the discharges in terms of mixing calculations and nearfield modelling is provided in Section 4 and Section 5.1.

Screening of the construction plus commissioning discharges is shown in Table 3. An additional 271,206 µg/l of ammoniacal nitrogen from commissioning was added to construction discharges for these scenarios with the discharge concentration calculated based on a commissioning discharge rate of 70 l/s (refer BEEMS Technical Report TR428, Appendix C for detail of commissioning discharges). Due to the considerable increase in ammonia from the commissioning phase, the screening tests were not passed, however this is consistent with previous assessments (BEEMS Technical Report TR428) which required modelling to fully assess the potential implications of the commissioning discharges. Detailed assessment of the alternative scenarios including the commissioning phase discharges is provided in Section 5.

Table 2: Screening tests for construction phase alternative treated sewage discharge scenarios.

Scenario (ammoniacal nitrogen in treated sewage)	Flow m^3/s	Total ammonia µg/l	Un-ionised ammonia µg/l	Saltwater AA EQS µg/l	Background concentration µg/l	Test 1	Test 5 Effective volume flux	TraC Water test 5 EVF < 3.0 (Pass/Fail)
BASELINE (20 mg/l)	0.038	10,034	44.8	21	4.6	2.1	0.1	Pass
40 mg/l	0.038	16,979	75.7	21	4.6	3.6	0.2	Pass
60 mg/l	0.038	23,924	106.7	21	4.6	5.1	0.2	Pass
80 mg/l	0.038	30,869	137.7	21	4.6	6.6	0.3	Pass
BASELINE (20 mg/l) - alt. flow	0.038	14,020	62.5	21	4.6	3.0	0.1	Pass
40 mg/l - alt. flow	0.038	26,187	116.8	21	4.6	5.6	0.3	Pass
60 mg/l - alt. flow	0.038	38,355	171.1	21	4.6	8.1	0.4	Pass
80 mg/l . alt flow	0.038	50,522	225.3	21	4.6	10.7	0.5	Pass

Notes: Un-ionised ammonia calculated based on discharge with salinity of 1, pH of 7.3 and temperature of 12.5°C.

Table 3: Screening tests for construction and commissioning phase alternative sewage discharge scenarios.

Scenario (ammoniacal nitrogen in treated sewage)	Flow m^3/s	Total ammonia µg/l	Un-ionised ammonia µg/l	Saltwater AA EQS µg/l	Background concentration µg/l	Test 1	Test 5 Effective volume flux	TraC Water test 5 EVF < 3.0 (Pass/Fail)
BASELINE (20 mg/l) + commissioning	0.108	178,878	32,799	21.00	4.60	1,562	216.6	Fail
40 mg/l + commissioning	0.108	181,334	33,249	21.00	4.60	1,583	219.6	Fail
60 mg/l + commissioning	0.108	183,790	33,700	21.00	4.60	1,605	222.5	Fail
80 mg/l + commissioning	0.108	186,247	34,150	21.00	4.60	1,626	225.5	Fail
BASELINE (20 mg/l) - alt. flow + commissioning	0.108	180,288	33,058	21.00	4.60	1,574	218.3	Fail
40 mg/l - alt flow + commissioning	0.108	184,591	33,847	21.00	4.60	1,612	223.5	Fail
60 mg/l - alt. flow + commissioning	0.108	188,894	34,636	21.00	4.60	1,649	228.7	Fail
80 mg/l alt. flow + commissioning	0.108	193,196	35,425	21.00	4.60	1,687	233.9	Fail

Notes: Un-ionised ammonia calculated based on discharge with salinity of 1, pH of 9 (pH 9 represents the expected pH of the commissioning wastewater as per permit EPR/JP3122GM/V009&010) and temperature of 12.5°C. Commissioning flow of 70 l/s added with a concentration of ammoniacal nitrogen of 271,260 µg/l (see Section 1.1 for volume and concentration calculations).

4 Un-ionised Ammonia Mixing Calculations

The mixing of the construction discharges with seawater influences the partitioning of un-ionised ammonia as described in Section 2. Mixing of the discharge was calculated based on the progressive dilution from the source concentration of ammoniacal nitrogen with the discharge characteristics of pH 7.3 and salinity of 1, through to complete mixing down to background ammoniacal nitrogen levels and average ambient seawater conditions (salinity of 31.5 and pH of 7.86). The components of the mixing calculations are consistent with the previous assessment in BEEMS Technical Report TR428. Mixing curves are shown in Figure 4 and Figure 5 and the level of mixing and dilution required to reach the EQS for un-ionised ammonia is summarised in Table 4. These calculations are independent of the volume of the discharge and therefore must be considered in combination with modelling dilution rates from CORMIX modelling (Section 5.1).

Table 4: Nearfield mixing of un-ionised ammonia under the construction phase alternative scenarios.

Scenario (ammoniacal nitrogen in treated sewage)	Un-ionised ammonia (µg/l)	Mixing % required to EQS (21 µg/l)	Dilution factor required to EQS (21 µg/l)
BASELINE (20 mg/l)	44.8	81	4.4
40 mg/l	75.7	90	9.1
60 mg/l	106.7	93	13.3
80 mg/l	137.7	95	17.6
BASELINE (20 mg/l) - alt. flow	62.5	86	7.0
40 mg/l – alt. flow	116.8	94	14.7
60 mg/l - alt. flow	171.1	96	22.1
80 mg/l – alt. flow	225.3	97	29.5

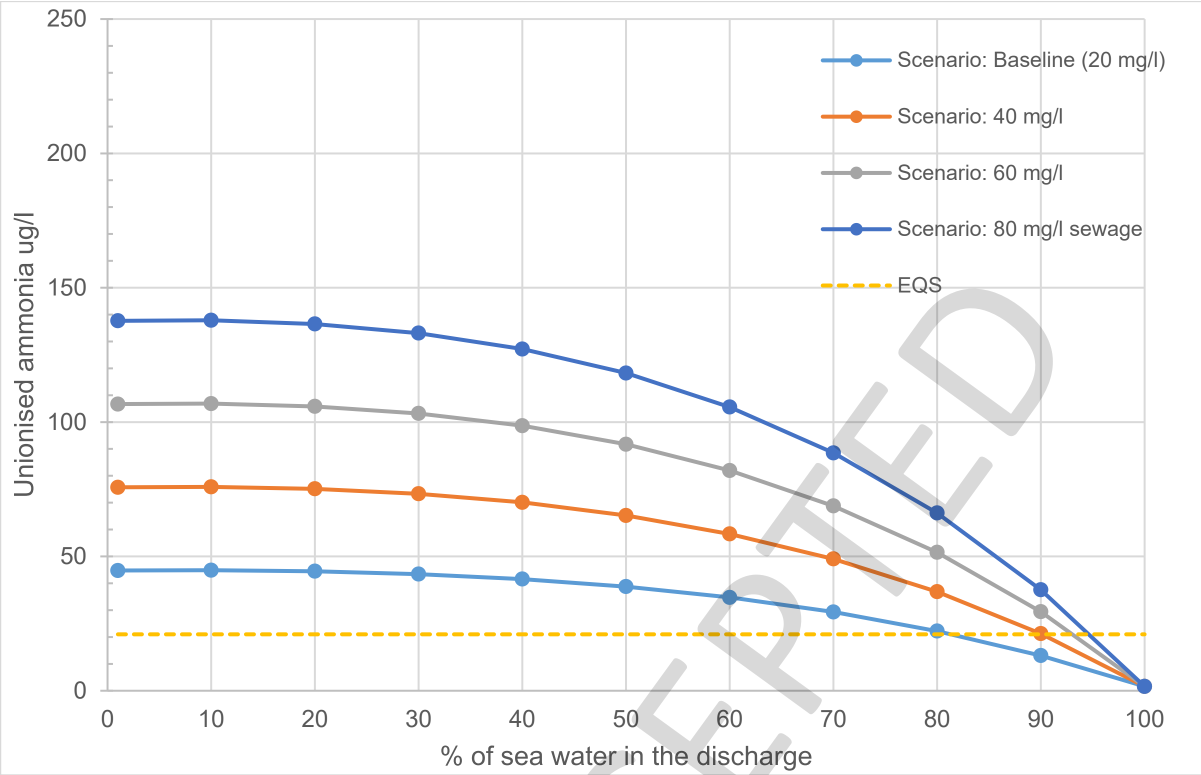

Figure 4: Mixing of the construction discharge and un-ionised ammonia partitioning with baseline flows (treated sewage at 13.3 l/s and groundwater at 25 l/s).

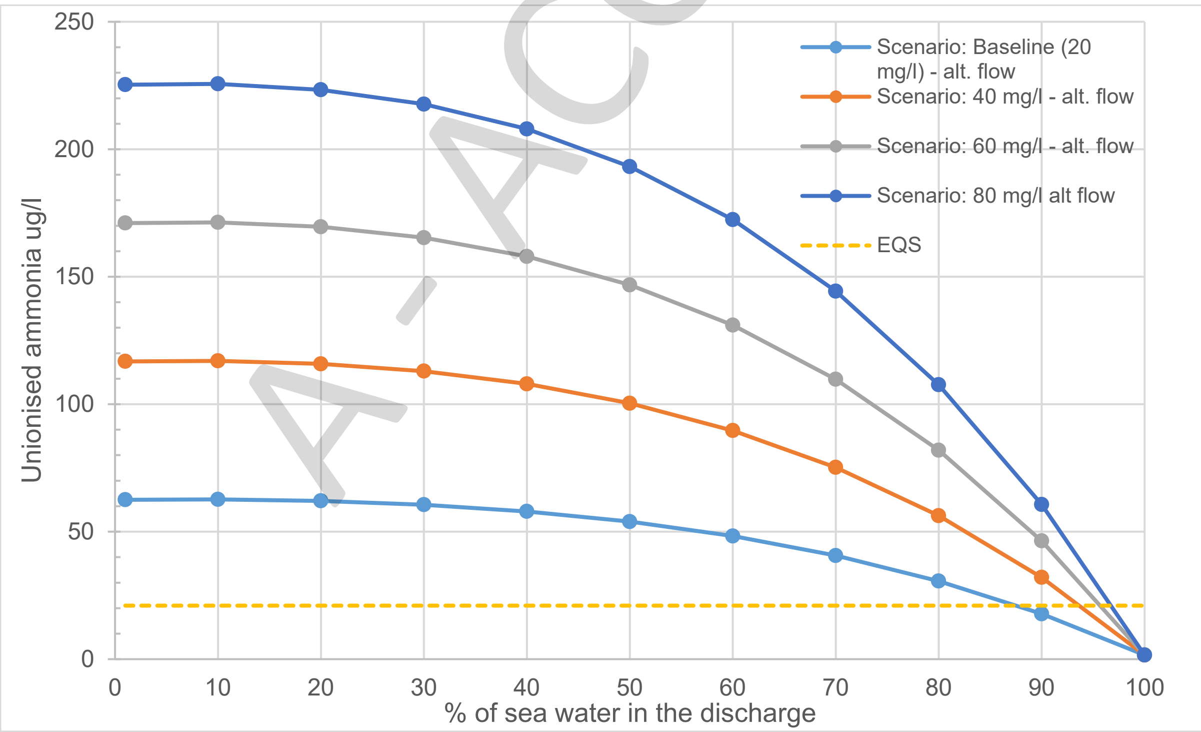

Figure 5: Mixing of the construction discharge and un-ionised ammonia partitioning with alternative flows (treated sewage at 23.3 l/s and groundwater at 15 l/s).

5 Modelling Results

5.1 CORMIX

Figure 6 and Figure 7 show the shape of the plume, from the CORMIX results with a 45 l/s discharge, for the rising tide and low water, respectively. As was seen in BEEMS Technical Report TR428, due to the strong tidal currents, the resulting plume from the construction discharge forms a long elongated shore parallel shape. At low water, this elongated plume expands and pools at slack water. Due to the freshwater nature of the plume, the plume remains buoyant and rises to the surface at all states of the tide. Figure 8 to Figure 12 show the dilution curves for the five states of the tide investigated for the 45 l/s discharge. From these curves, the distance the plume extends before mixing to the required level of dilution can be determined, as summarised in Table 4, in order to fall below the EQS.

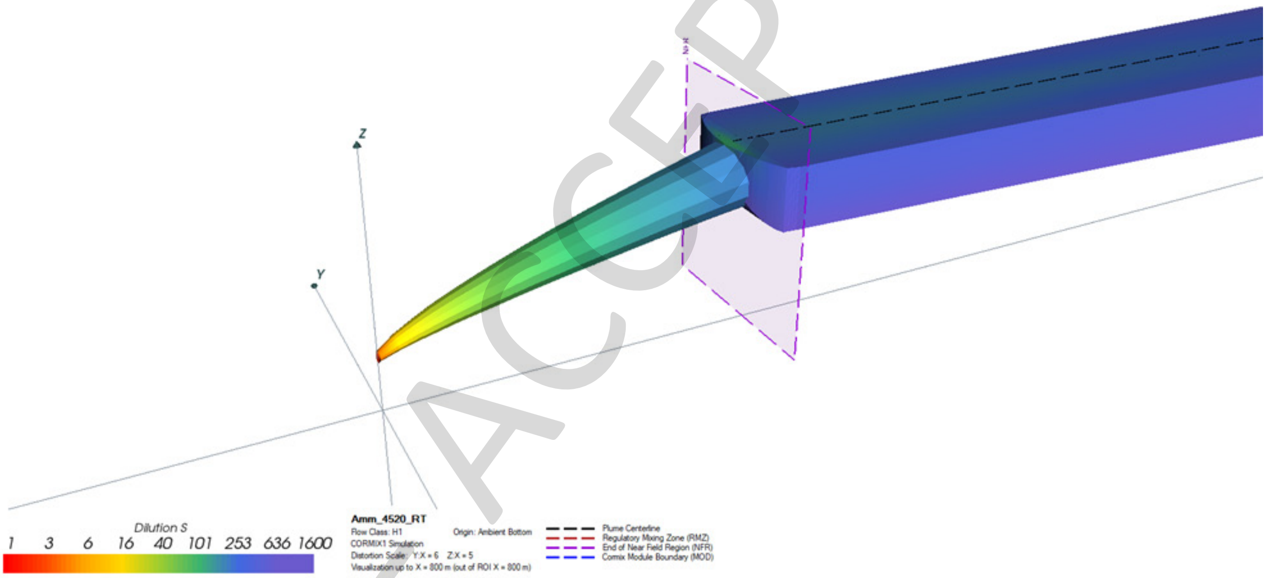

Figure 6: CORMIX output at rising mid tide, showing the long elongated plume due to peak tidal currents.

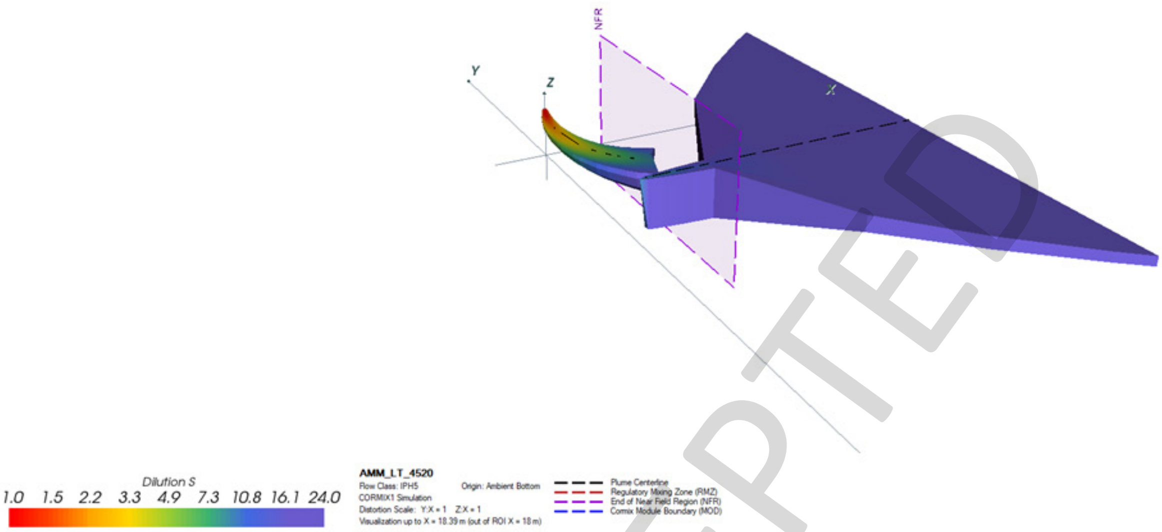

Figure 7: CORMIX output at low tide, showing the buoyant slack water plume.

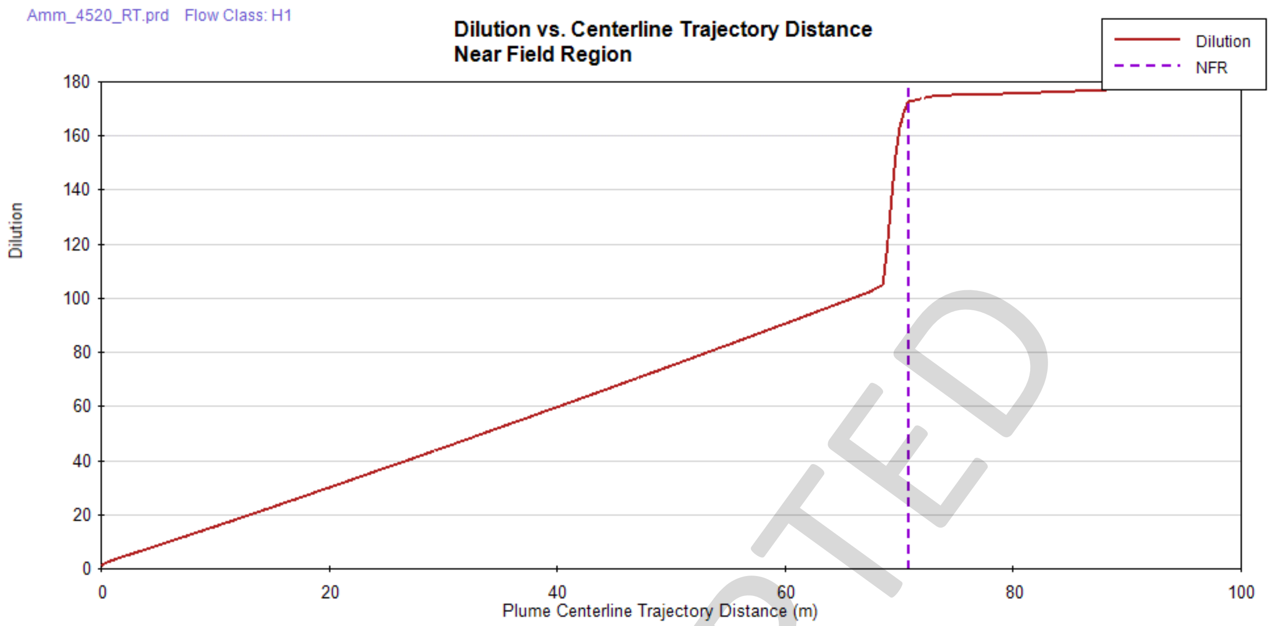

Figure 8: CORMIX outputs showing the dilution of the plume along the centreline for the 45 l/s simulation at rising mid tide.

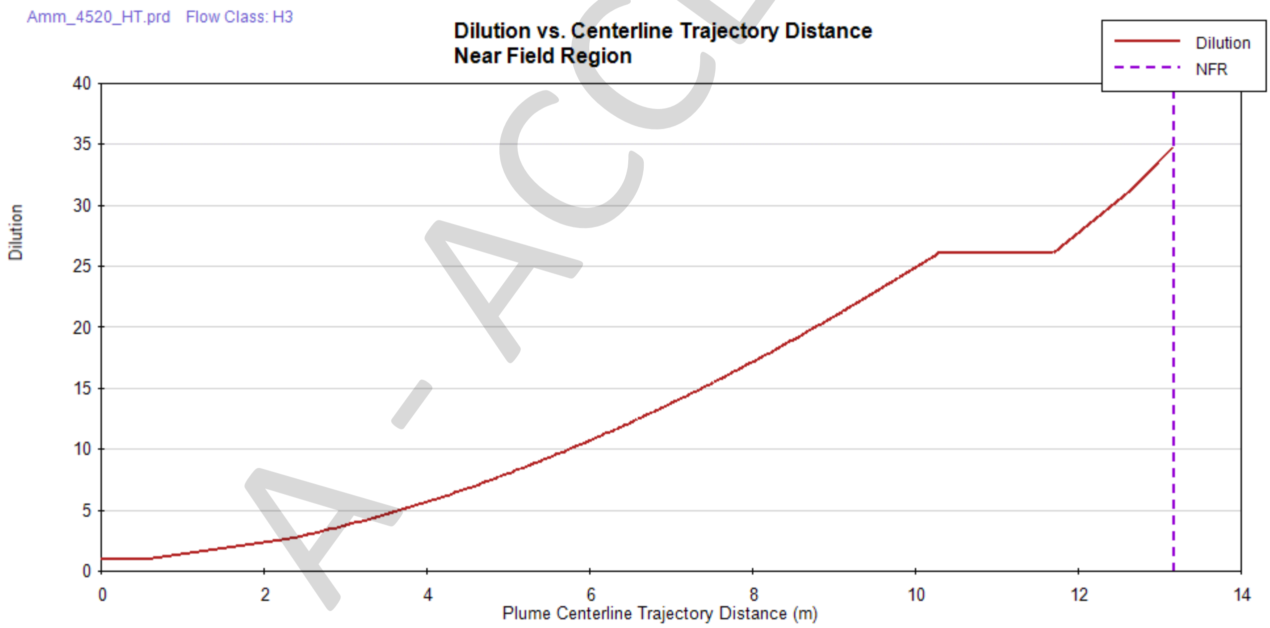

Figure 9: CORMIX outputs showing the dilution of the plume along the centreline for the 45 l/s simulation at high tide.

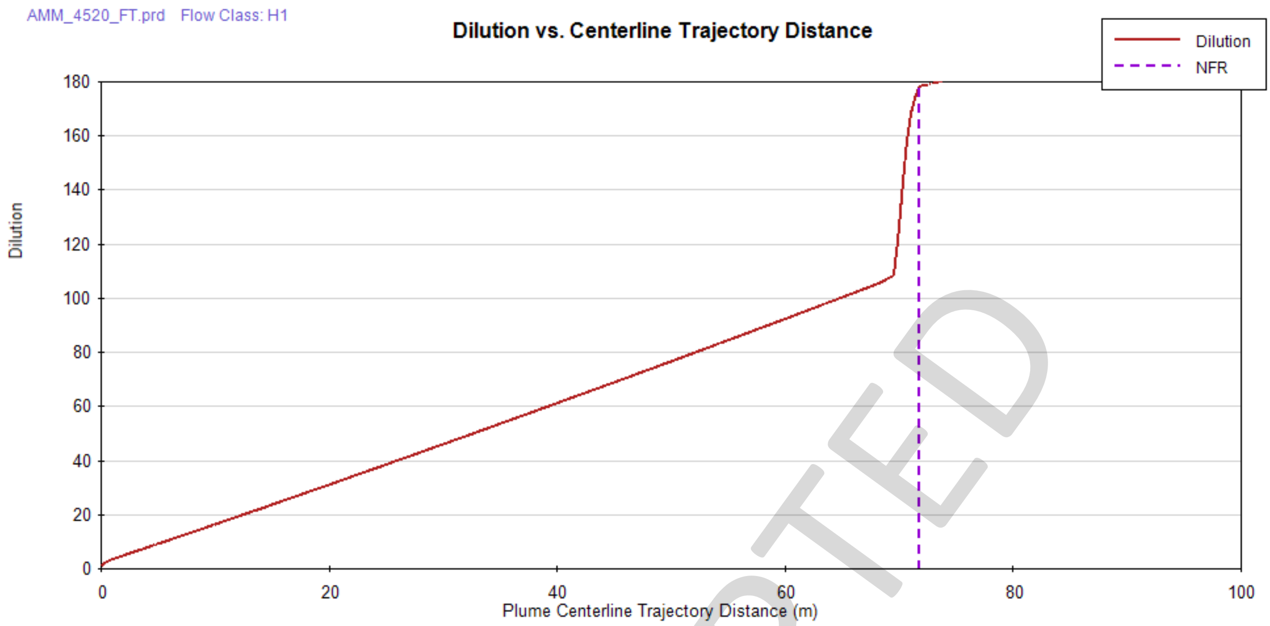

Figure 10: CORMIX outputs showing the dilution of the plume along the centreline for the 45 l/s simulation at falling mid tide.

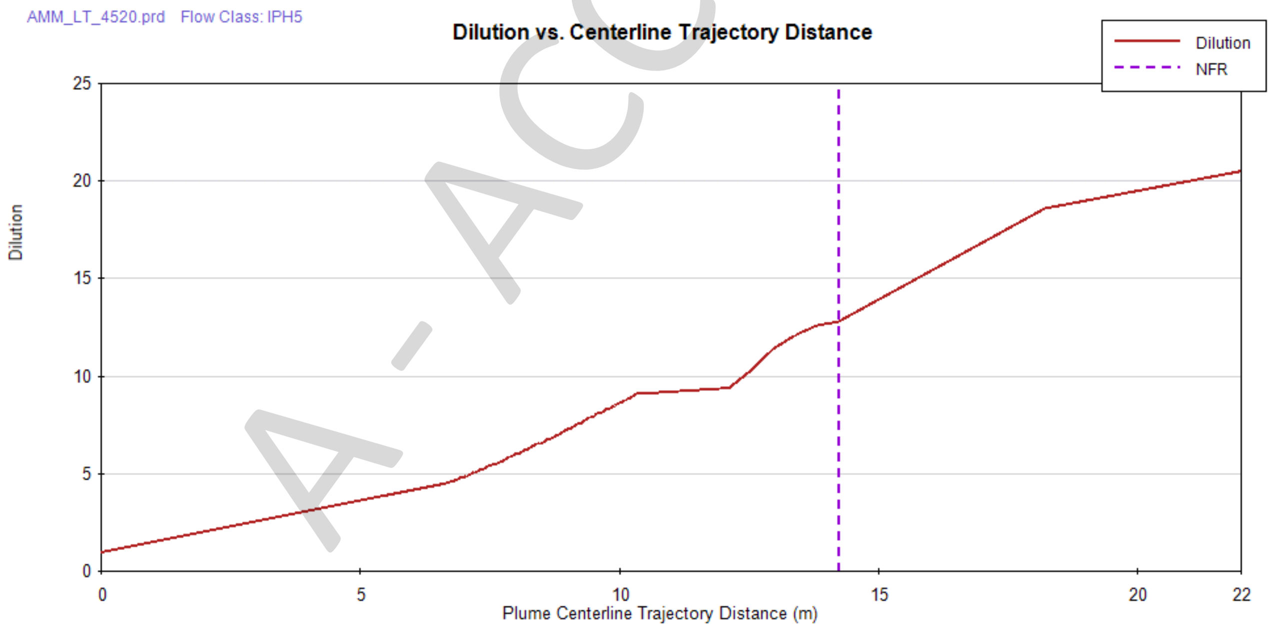

Figure 11: CORMIX outputs showing the dilution of the plume along the centreline for the 45 l/s simulation at low tide.

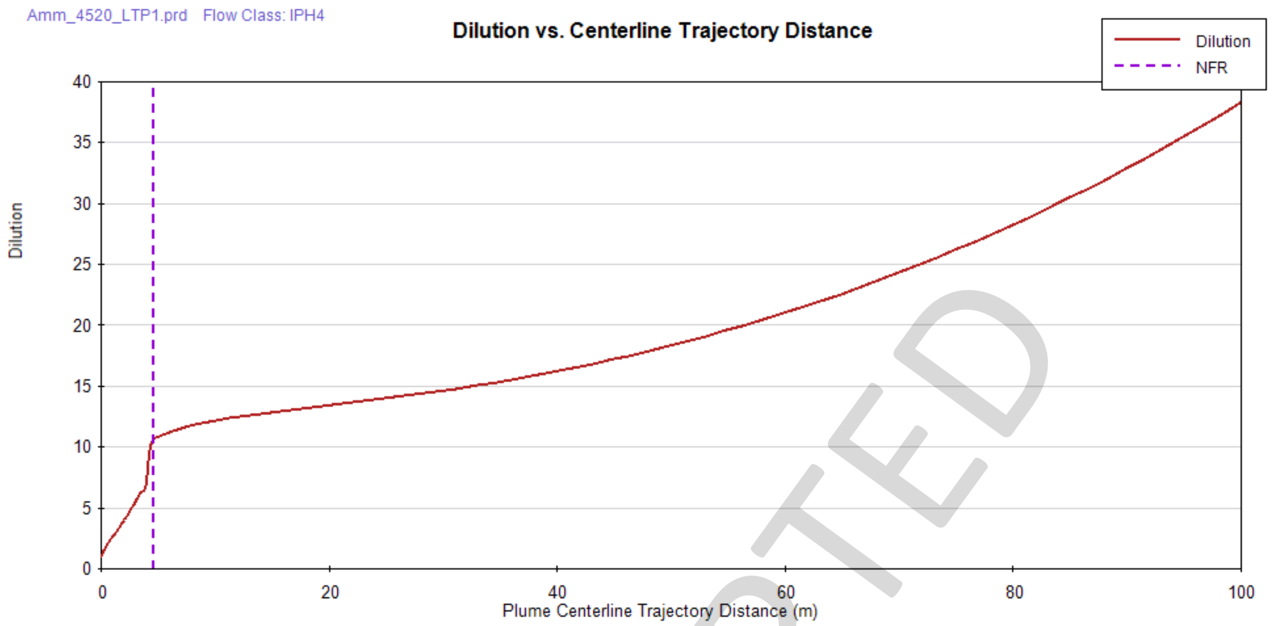

Figure 12: CORMIX outputs showing the dilution of the plume along the centreline for the 45 l/s simulation at low tide +1 hour.

Using the mixing calculations and required dilution to reach the EQS, summarised in Table 4, the CORMIX modelling shows the concentrations of un-ionised ammonia fell below the EQS (21 µg/l) within <7.19 m for the original scenario (i.e. 20 mg/l total ammonia). This distance to the EQS increased to a maximum of 45.82 m for the 80 mg/l discharge scenario, with the original flows, and to 82.12 m for 80 mg/l discharge with the alternative flow rates. The results are summarised in Table 5.

Initial screening of the construction only discharge scenarios shows that while discharges failed test 1 (they are above the EQS), they passed test 5 (the effective volume flux is below 3). This suggests that the construction only discharge should be acceptable at the higher concentrations tested. While the estimated mixing zone is considerably larger under the new scenarios compared to the baseline scenario (increasing from ~7m to over 80m), the mixing zone was still very small in respect to the scale of the receiving environment and therefore is not expected to cause any significant impacts.

Table 5: Summary of CORMIX results showing the distances whereby the discharge of un-ionised ammonia falls below the EQS.

Ammonia Scenario	EQS (µg/l)	Required mixing %	Dilution	Distance to required mixing (m)				
				Rising tide	High tide	Falling tide	Low tide	Low tide +1 hr
Baseline flows – 45 l/s (treated sewage 13 l/s)								
20 mg/l	21	81.3	4.36	2.75	4.58	2.57	7.19	3.51
40 mg/l	21	90.1	9.13	5.78	6.47	5.34	11.73	4.97
60 mg/l	21	93.0	13.34	8.69	7.76	8.19	12.69	18.46
80 mg/l	21	94.6	17.55	11.61	8.88	10.99	14.14	45.82
Alternate flows – 45 l/s (treated sewage 23 l/s)								
20 mg/l	21	87.5	7.00	4.36	5.72	4.02	8.97	4.81
40 mg/l	21	93.6	14.72	9.61	8.14	9.09	13.17	29.86
60 mg/l	21	95.7	22.09	14.74	9.96	14.11	20.98	62.97
80 mg/l	21	96.7	29.47	19.79	12.44	19.02	21.68	82.12
				Limiting distance (lmax) due to TIDAL REVERSAL has been reached[1].				

1. lmax is the maximum distance CORMIX can determine in one direction before the direction of the tidal currents reverses due to the state of the tide and the plume travels back on itself.

5.2 GETM reanalysis

5.2.1 Un-ionised ammonia

High levels of ammonia will be discharge during commissioning overlapping with the construction discharge (38 l/s at 10 mg/l + 70 l/s at 271 mg/l). These discharges have been modelled based on the original flows and concentrations in BEEMS Technical Report TR428. This modelling was then extrapolated to determine the mixing zones for un-ionised ammonia (and total ammonia) by determining the additional total mass as a percentage of the original flows. Table 6 and Table 7 summarise the total mass of each source of ammonia and their contribution to the total mass of ammonia, for the baseline flows and the alternative flows (treated sewage is increased by 10 l/s and groundwater decreased by 10 l/s). From the additional percentage increases for the different flow scenarios, the additional un-ionised ammonia concentration at the location of the *Corallina* and *Sabellaria*, has been calculated and is summarised in Table 8.

During the period where the construction and commissioning discharges overlap, the discharge scenarios led to an estimated additional 0.11 to 0.31 µg/l of un-ionised ammonia with the original flow rates and 0.06 to 0.61 µg/l of un-ionised ammonia with the alternative flow rates at the locations of the sensitive biological receptors (*Sabellaria* and *Corallina*). These values are based on the original un-ionised ammonia time series, shown in BEEMS Technical Report TR428[3], and apply the additional percentage increase based on the total ammonia which, under the original (baseline) scenario, had an average exposure of 2 µg/l over the length of the combined construction and commissioning discharges.

[3] The calculation of un-ionised ammonia from total ammonia used the conditions of the receiving ambient seawater with a salinity of 31.5, pH of 7.86 and temperature of 12.5°C (refer to BEEMS Technical Report TR428)

Table 6: Summary of the contributions to the total mass of ammonia from the different sources, for the different treated sewage scenarios using the baseline flows.

Scenario	Source	Flow	Concentration	Duration	Mass
		(l/s)	(mg/l)	(hrs)	(kg/day)
Baseline - 20 mg/l	Treated sewage	13.3	20	24	22.982
	Groundwater	25	4.732	24	10.221
	Commissioning	70	271	5.95	406.34
				Total mass	**439.54**
Baseline - 40 mg/l	Treated sewage	13.3	40	24	45.965
	Groundwater	25	4.732	24	10.221
	Commissioning	70	271	5.95	406.34
				Total mass (percentage increase)	**462.52 (4.97%)**
Baseline - 60 mg/l	Treated sewage	13.3	60	24	68.947
	Groundwater	25	4.732	24	10.221
	Commissioning	70	271	5.95	406.34
				Total mass (percentage increase)	**485.51 (9.47%)**
Baseline - 80 mg/l	Treated sewage	13.3	80	24	91.930
	Groundwater	25	4.732	24	10.221
	Commissioning	70	271	5.95	406.34
				Total mass (percentage increase)	**508.49 (13.56%)**

Table 7: Summary of the contributions to the total mass of ammonia from the different sources, for the different sewage scenarios using the alternative flows.

Scenario	Source	Flow	Concentration	Duration	Mass
		(l/s)	(mg/l)	(hrs)	(kg/day)
Alternative - 20 mg/l	Treated sewage	23.3	20	24	40.262
	Groundwater	15	4.732	24	6.133
	Commissioning	70	271	5.95	406.34
				Total mass (percentage increase)	**452.73 (2.91%)**
Alternative - 40 mg/l	Treated sewage	23.3	40	24	80.525
	Groundwater	15	4.732	24	6.133
	Commissioning	70	271	5.95	406.34
				Total mass (percentage increase)	**492.99 (10.84%)**
Alternative - 60 mg/l	Treated sewage	23.3	60	24	120.787
	Groundwater	15	4.732	24	6.133
	Commissioning	70	271	5.95	406.34
				Total mass (percentage increase)	**533.26 (17.57%)**
Alternative - 80 mg/l	Treated sewage	23.3	80	24	161.050
	Groundwater	15	4.732	24	6.133
	Commissioning	70	271	5.95	406.34
				Total mass (percentage increase)	**573.52 (23.36%)**

Table 8: Summary of the additional un-ionised ammonia concentration at the location of the *Corallina* and *Sabellaria*, with the baseline construction and commissioning discharges.

Flow	Source	Un-ionised ammonia (ug/l)	Difference from baseline (ug/l)	Un-ionised ammonia (ug/l)	Difference from baseline (ug/l)	Un-ionised ammonia (ug/l)	Difference from baseline (ug/l)	Un-ionised ammonia (ug/l)	Difference from baseline (ug/l)
		20 mg/l		40 mg/l		60 mg/l		80 mg/l	
Baseline	Treated sewage	0.105	0.000	0.209	0.105	0.314	0.209	0.418	0.314
	Groundwater	0.047	0.000	0.047	0.000	0.047	0.000	0.047	0.000
	Commissioning	1.849	0.000	1.849	0.000	1.849	0.000	1.849	0.000
	Total	2.000	0.000	2.105	0.105	2.209	0.209	2.314	0.314
Alternative	Treated sewage	0.183	0.079	0.366	0.262	0.550	0.445	0.733	0.628
	Groundwater	0.028	-0.019	0.028	-0.019	0.028	-0.019	0.028	-0.019
	Commissioning	1.849	0.000	1.849	0.000	1.849	0.000	1.849	0.000
	Total	2.060	0.060	2.243	0.243	2.426	0.426	2.610	0.610

To assess the exposure of un-ionised ammonia at the locations of the *Corallina* and *Sabellaria*, the additional un-ionised ammonia, summarised in Table 8, have been added to the instantaneous time series of un-ionised ammonia concentrations at the eight *Corallina* locations (Figure 13) and seven *Sabellaria* locations (Figure 14). Figure 14 shows that for the 80 mg/l scenario with the alternative flow rates, the maximum instantaneous value (10.4 µg/l) was below the EQS of 21 µg/l. Plots of the individual time series for each *Corallina* and *Sabellaria* stations are shown in Appendix A. The mean and 95th percentile concentrations of un-ionised ammonia at the *Corallina* and *Sabellaria* features for the 20, 40, 60 and 80 mg/l scenarios with the baseline and alternative flows are summarised in Table 9 to Table 12.

Figure 15 show the spatial plots of the surface 95th percentile un-ionised ammonia for the construction and commissioning discharges for the 80 mg/l scenario with alternative flows. Table 13 summarises the area of exceedance above the EQS for un-ionised ammonia for all scenarios.

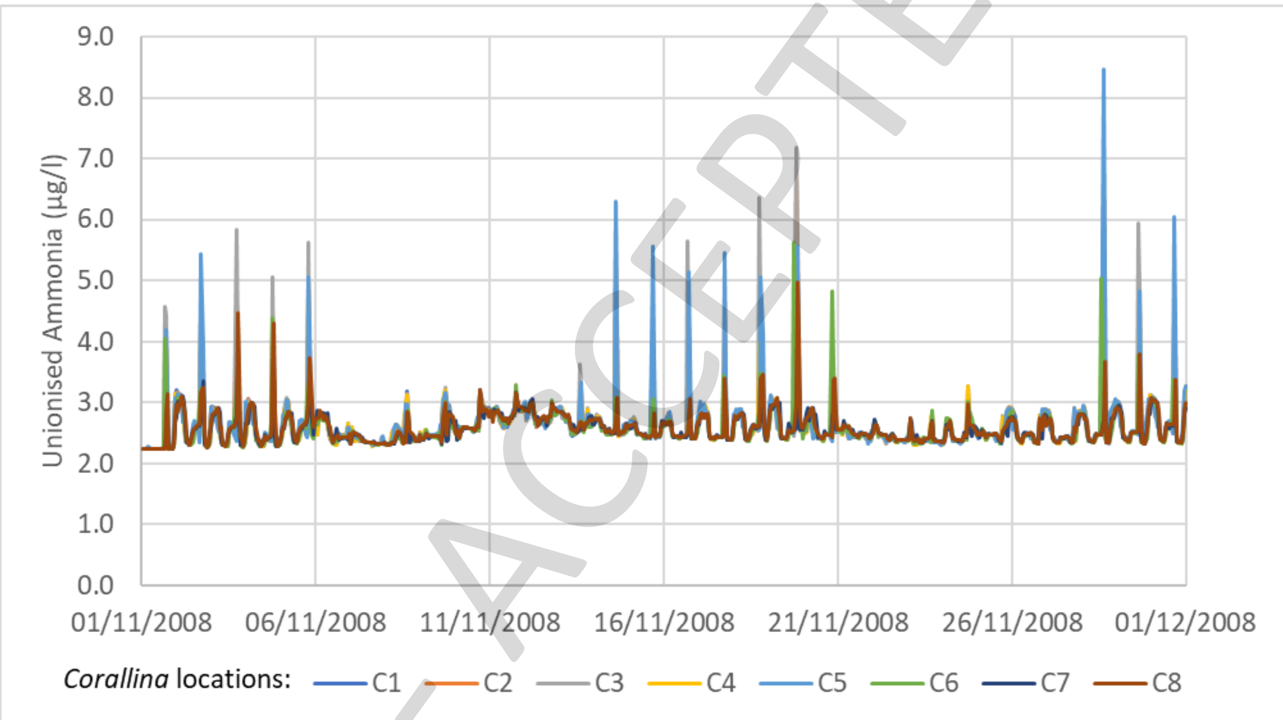

Figure 13: Time series of un-ionised ammonia at the locations of Corallina for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

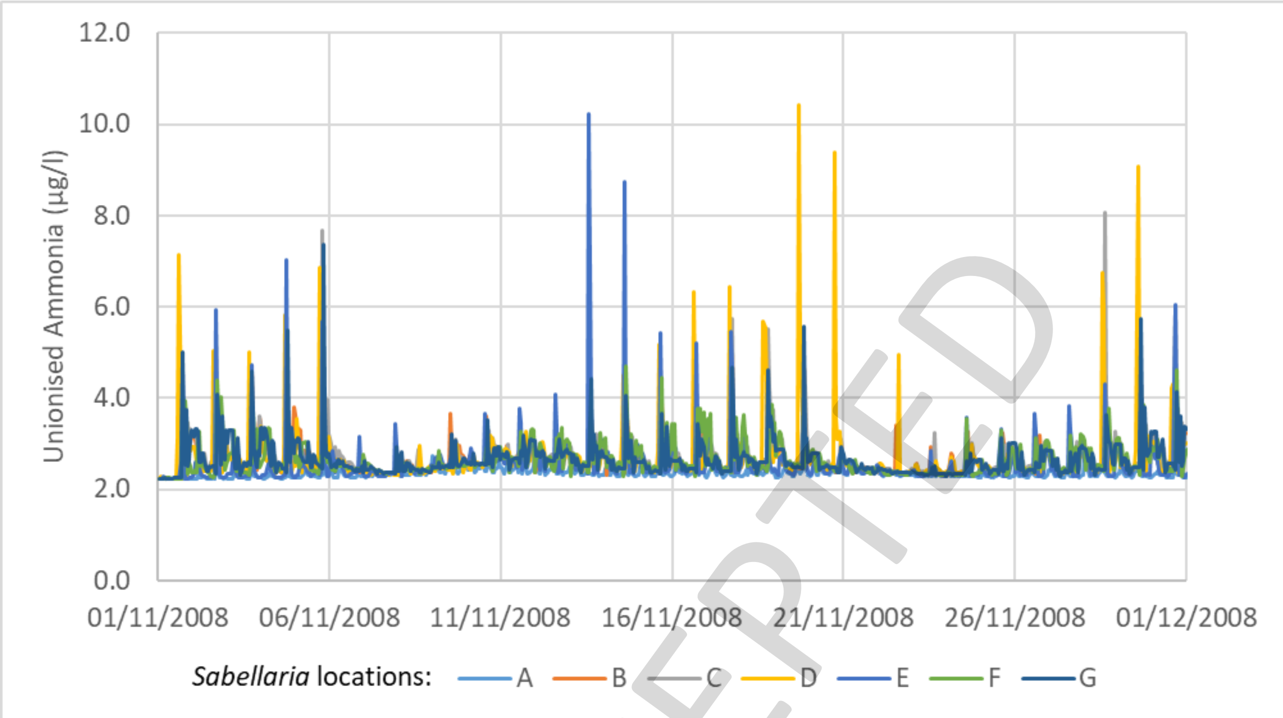

Figure 14: Time series of un-ionised ammonia at the locations of Sabellaria for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

Table 9: Summary of un-ionised ammonia (µg/l) at *Sabellaria* features (A – G) for mean temperatures, with the baseline flows.

Scenario	**20 mg/l**		**40 mg/l**		**60 mg/l**		**80 mg/l**	
Location	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile
A	1.74	1.90	1.84	2.01	1.95	2.11	2.05	2.22
B	2.01	2.60	2.11	2.71	2.22	2.81	2.32	2.91
C	2.08	2.68	2.19	2.79	2.29	2.89	2.40	3.00
D	2.07	2.56	2.18	2.67	2.28	2.77	2.38	2.88
E	1.95	2.54	2.06	2.65	2.16	2.75	2.27	2.86
F	2.03	2.72	2.13	2.82	2.24	2.93	2.34	3.03
G	2.05	2.71	2.15	2.82	2.26	2.92	2.36	3.03

Table 10: Summary of un-ionised ammonia (µg/l) at *Sabellaria* features (A – G) for mean temperatures, with the alternative flows.

Scenario	**20 mg/l**		**40 mg/l**		**60 mg/l**		**80 mg/l**	
Location	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile
A	1.80	1.96	1.98	2.15	2.16	2.33	2.35	2.51
B	2.07	2.66	2.25	2.84	2.43	3.03	2.62	3.21
C	2.14	2.74	2.33	2.92	2.51	3.11	2.69	3.29
D	2.13	2.62	2.31	2.81	2.50	2.99	2.68	3.17
E	2.01	2.60	2.19	2.79	2.38	2.97	2.56	3.15
F	2.09	2.78	2.27	2.96	2.45	3.15	2.64	3.33
G	2.11	2.77	2.29	2.96	2.47	3.14	2.66	3.32

Table 11: Summary of un-ionised ammonia (µg/l) at *Corallina* features (1 – 8) for mean temperatures, with the baseline flows.

Scenario	20 mg/l		40 mg/l		60 mg/l		80 mg/l	
Location	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile
C1	1.97	2.41	2.07	2.52	2.18	2.62	2.28	2.73
C2	2.01	2.50	2.12	2.60	2.22	2.71	2.33	2.81
C3	2.01	2.48	2.12	2.58	2.22	2.69	2.33	2.79
C4	1.98	2.44	2.09	2.54	2.19	2.65	2.30	2.75
C5	2.03	2.48	2.13	2.58	2.24	2.69	2.34	2.79
C6	1.97	2.43	2.08	2.54	2.18	2.64	2.29	2.75
C7	1.96	2.32	2.06	2.43	2.17	2.53	2.27	2.64
C8	1.98	2.39	2.09	2.49	2.19	2.60	2.30	2.70

Table 12: Summary of un-ionised ammonia (µg/l) at *Corallina* features (1 – 8) for mean temperatures, with the alternative flows.

Scenario	20 mg/l		40 mg/l		60 mg/l		80 mg/l	
Location	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile	Mean	95th percentile
C1	2.03	2.47	2.21	2.66	2.40	2.84	2.58	3.02
C2	2.07	2.56	2.26	2.74	2.44	2.93	2.62	3.11
C3	2.07	2.54	2.26	2.72	2.44	2.90	2.62	3.09
C4	2.04	2.50	2.23	2.68	2.41	2.86	2.59	3.05
C5	2.09	2.54	2.27	2.72	2.46	2.91	2.64	3.09
C6	2.03	2.49	2.22	2.68	2.40	2.86	2.58	3.04
C7	2.02	2.38	2.20	2.57	2.38	2.75	2.57	2.93
C8	2.04	2.45	2.23	2.63	2.41	2.81	2.59	3.00

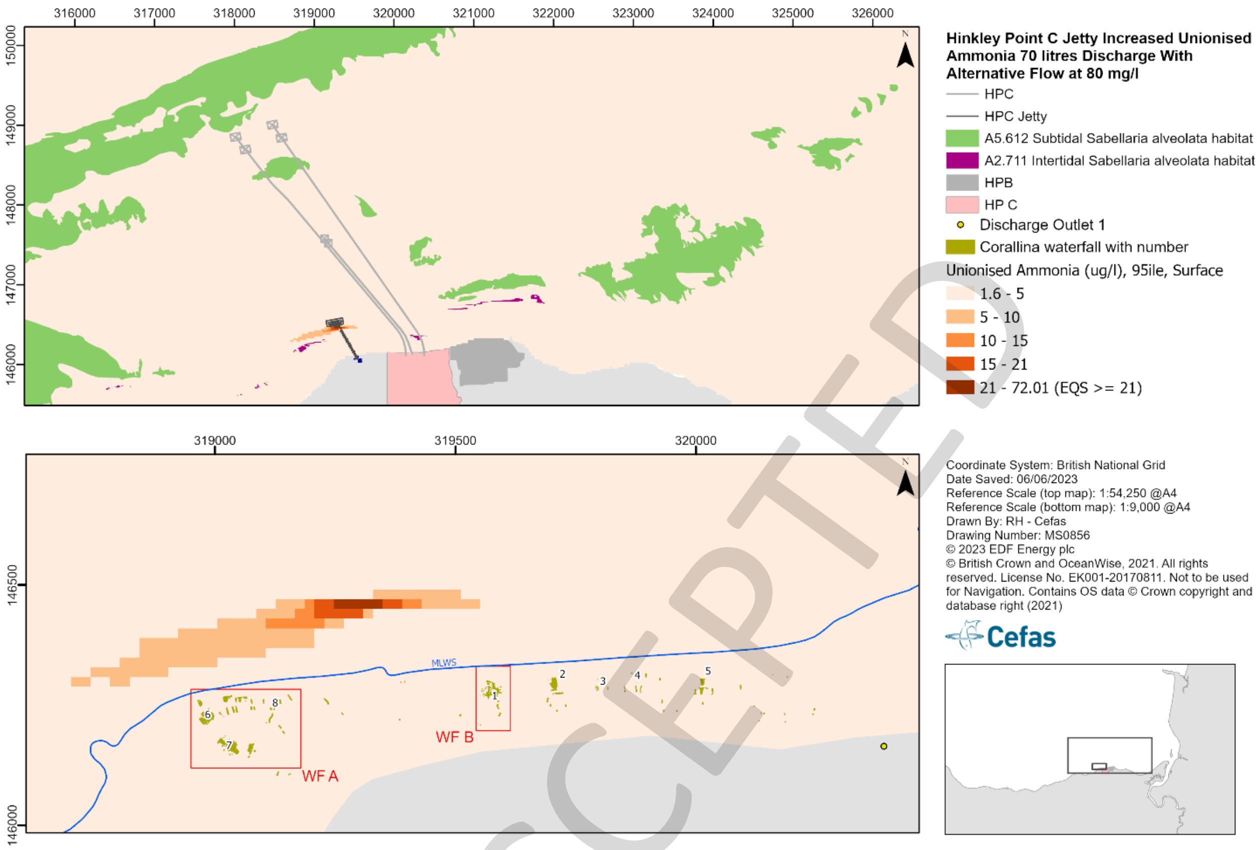

Figure 15: Surface 95th percentile un-ionised ammonia (38 l/s at 80 mg/l+ 70 l/s at 271 mg/l). The upper panel includes the intertidal and subtidal *Sabellaria*. The closest *Sabellaria* to the discharge is in the intertidal near station 8.The lower panel includes *Corallina* waterfalls.

Table 13: Area of exceedance for un-ionised ammonia from GETM model.

Flows	Scenario	20 mg/l		40 mg/l		60 mg/l		80 mg/l	
		Area > 21 µg/l Bed	Area > 21 µg/l Surface	Area > 21 µg/l Bed	Area > 21 µg/l Surface	Area > 21 µg/l Bed	Area > 21 µg/l Surface	Area > 21 µg/l Bed	Area > 21 µg/l Surface
Baseline	Construction (38 l/s) + Commissioning (70 l/s) Mean	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
	Construction (38 l/s) + Commissioning (70 l/s) 95th percentile	No exceedance	0.20 ha	No exceedance	0.20 ha	No exceedance	0.20 ha	No exceedance	0.20 ha
Alternative	Construction (38 l/s) + Commissioning (70 l/s) Mean	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
	Construction (38 l/s) + Commissioning (70 l/s) 95th percentile	No exceedance	0.20 ha	No exceedance	0.20 ha	No exceedance	0.20 ha	No exceedance	0.20 ha

5.2.2 Total ammonia

For total ammonia, the PNEC based on the mean value is 1.1 mg/l, whilst the MAC based on the 95th percentile is 8 mg/l. The MAC was not exceeded at the surface or bed in any scenario, but the PNEC was exceeded at the surface but only for a maximum of 0.04 ha (equivalent to 1 grid cell in the model and the point of immediate discharge). In reality both the PNEC and MAC will be exceeded immediately at the point of discharge, but as the mixing would occur at a sub grid cell level, this is not seen in the GETM model. Figure 16 and Figure 17 show the spatial plots of the surface mean and 95th percentile total ammonia for the construction and commissioning discharges for the 80 mg/l scenario with alternative flows. Table 14 summarises the area of exceedance above the PNEC and MAC for total ammonia for all scenarios.

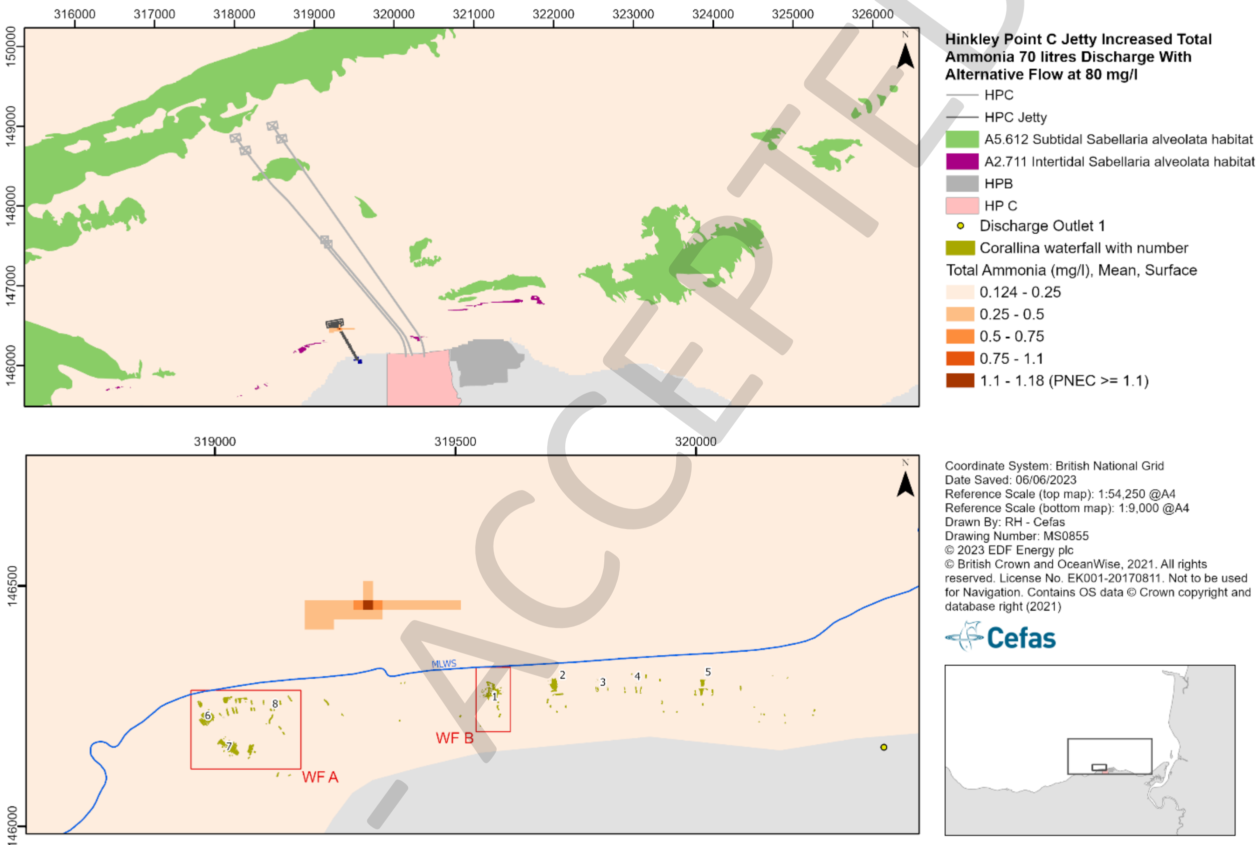

Figure 16: Surface mean ammonia concentration (mg/l) for the 80 mg/l at 70 l/s discharge simulation. The upper panel includes the intertidal and subtidal *Sabellaria*. The closest *Sabellaria* to the discharge is in the intertidal near station 8.The lower panel includes *Corallina* waterfalls.

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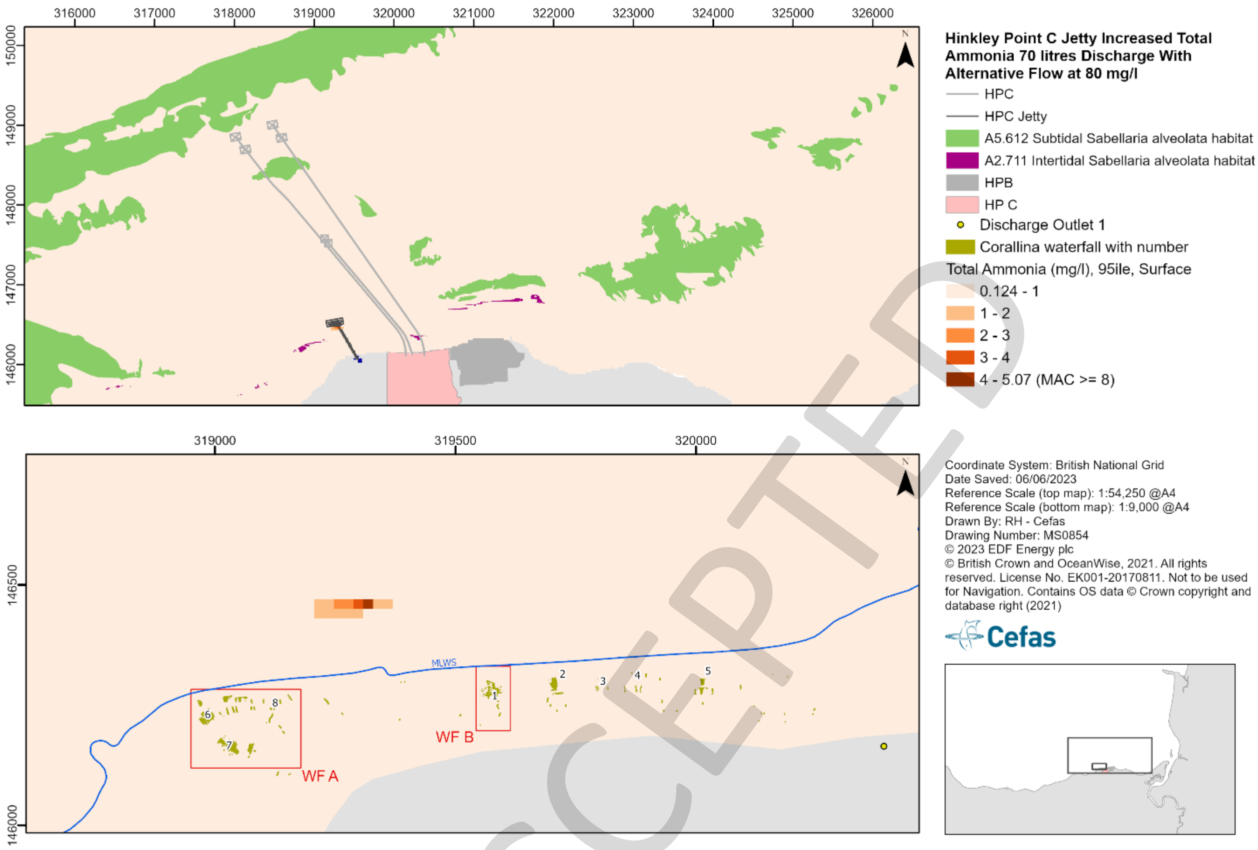

Figure 17: 95th percentile surface concentration (mg/l) of ammonia for 80 mg/l at 70 l/s. No value exceeds > 8000 µg/l MAC. The upper panel includes the intertidal and subtidal *Sabellaria*. The closest *Sabellaria* to the discharge is in the intertidal near station 8.The lower panel includes *Corallina* waterfalls.

Table 14: Area of exceedance for total ammonia, above the PNEC (1.1 mg/l) and MAC (8 mg/l) from GETM model.

Flows	Scenario	20 mg/l		40 mg/l		60 mg/l		80 mg/l	
		Area > 1.1 mg/l Bed	Area > 1.1 mg/l Surface	Area > 1.1 mg/l Bed	Area > 1.1 mg/l Surface	Area > 1.1 mg/l Bed	Area > 1.1 mg/l Surface	Area > 1.1 mg/l Bed	Area > 1.1 mg/l Surface
Baseline	Construction (38 l/s) + Commissioning (70 l/s) Mean	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	0.04 ha	No exceedance	0.04 ha
Alternative	Construction (38 l/s) + Commissioning (70 l/s) Mean	No exceedance	No exceedance	No exceedance	0.04 ha	No exceedance	0.04 ha	No exceedance	0.04 ha
Flows	**Scenario**	**20 mg/l**		**40 mg/l**		**60 mg/l**		**80 mg/l**	
		Area > 8 mg/l Bed	**Area > 8 mg/l Surface**	**Area > 8 mg/l Bed**	**Area > 8 mg/l Surface**	**Area > 8 mg/l Bed**	**Area > 8 mg/l Surface**	**Area > 8 mg/l Bed**	**Area > 8 mg/l Surface**
Baseline	Construction (38 l/s) + Commissioning (70 l/s) 95th percentile	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance
Alternative	Construction (38 l/s) + Commissioning (70 l/s) 95th percentile	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance	No exceedance

6 Conclusion

Seven alternative discharge scenarios, from the HPC sewage treatment works, have been tested and compared to the original construction discharge scenario (treated sewage ammoniacal nitrogen at 20 mg/l at 13.3 l/s + ground water 4.7 mg/l at 25 l/s). The additional scenarios included increasing the treated sewage ammoniacal nitrogen concentration to 40, 60 and 80 mg/l, plus alternative flows by increasing the treated sewage flowrate by 10 l/s and decreasing the groundwater flow by 10 l/s. The assessments considered both the construction only discharge, plus the combined construction and commissioning discharges.

Applying the Environment Agency's Screening tests, the results of 'test 5' shows that when considering construction alone each scenario tested was within permissible limits. However, the partitioning of un-ionised ammonia is influenced by the physical conditions and this partitioning is not factored into the basic screening tests. Therefore, while the screening test was passed, further assessment of the discharges in terms of mixing calculations and nearfield modelling was conducted. When considering the combined construction and commissioning discharges, due to the considerable increase in ammonia from the commissioning phase, the screening tests were not passed. However, this is consistent with previous assessments (BEEMS Technical Report TR428) which required modelling to fully assess the potential implications of the commissioning discharges.

For the construction only discharge, nearfield modelling using CORMIX shows the concentrations of un-ionised ammonia fall below the EQS (21 µg/l) within <7.19 m for the original scenario (i.e. treated sewage at 20 mg/l ammoniacal nitrogen). This distance to the EQS increased to a maximum of 45.82 m for the 80 mg/l discharge scenario, with the original flows, and to 82.12 m for 80 mg/l discharge with the alternative flow rates. While the estimated mixing zone was considerably larger under the new scenarios compared to the baseline scenario (increasing from ~7m to over 80m), the mixing zone was still very small in respect to the scale of the receiving environment and therefore is not expected to cause any significant environmental effects.

Reanalysis of the GETM modelling results show that during the period where the construction and commissioning discharges overlap, the discharge scenarios will lead to an estimated additional 0.11 to 0.31 µg/l of un-ionised ammonia with the original flow rates and 0.06 to 0.61 µg/l of un-ionised ammonia with the alternative flow rates at the locations of the sensitive biological receptors. From the time series of instantaneous un-ionised ammonia concentrations at the eight *Corallina* locations and seven *Sabellaria* locations, the maximum instantaneous value (10.4 µg/l) was below the EQS of 21 µg/l. For all scenarios, the area of exceedance of un-ionised ammonia as a 95th percentile has a maximum value of 0.2 ha at the surface and was not exceeded at the bed. For context the receiving water body (Bridgwater Bay) has a surface area of 9,224.5 ha, and therefore the area of exceedance represents 0.002% of the water body.

For total ammonia, the MAC (8 mg/l as a 95th percentile) was not exceeded at the surface or bed in any scenario, but the PNEC (1.1 mg/l as a mean) was exceeded at the surface only, however only for a maximum of 0.04 ha (equivalent to 1 grid cell in the model and the point of immediate discharge).

The overall conclusion was that all of the scenarios considered would not lead to significant environmental effects.

References

Amec. 2009. Summary of Marine Surface Water Quality Non-Radiochemical Analysis Results (Campaigns 1-4) 15011/TN/00081.

Bamber, R.N. and Irving, P.W. 1992. Littoral studies at Hinkley Point 1: Corallina run-offs. Fawley.

BEEMS Technical Report TR029. 2011. Ecological Characterisation of the Intertidal Region of Hinkley Point, Severn Estuary: Results from the 2008 Field Survey and Assessment of Risk, Cefas, Lowestoft.

BEEMS Technical Report TR039 Edition 4. 2011. Hinkley Point seabed habitat mapping. Interpretation of swath bathymetry, side-scan sonar and ground-truthing results. Cefas, Lowestoft.

BEEMS Technical Report TR068 Version 2. 2011. An initial review of the effects of new nuclear build on the marine ecology of Hinkley Point and Bridgwater Bay. Cefas, Lowestoft.

BEEMS Technical Report TR068B. 2011. Distribution of coralline turfs at Hinkley Point with respect to nuclear new build. Cefas, Lowestoft.

BEEMS Technical Report TR177. 2011. Hinkley Point Thermal Plume Modelling: GETM Stage 3a results with the final cooling water configuration. Cefas, Lowestoft.

BEEMS Technical Report TR267 Edition 2. 2017. HP GETM Plume Model- V2- Model Setup, Validation and annual runs. Cefas, Lowestoft.

BEEMS Technical Report TR428. 2021. Hinkley Point C construction discharge modelling assessment at the temporary jetty location. Cefas, Lowestoft.

Clegg, S.L., and Whitfield, M. 1995. A chemical model of seawater including dissolved ammonia and the stoichiometric dissociation constant of ammonia in estuarine water and seawater from -2 to 40°C. Geochimica et Cosmochimica Acta, Vol. 59, No. 12. pp. 2403-2421.

Environment Agency, and Department for Environment Food and Rural affairs. 2022. Guidance - Surface water pollution risk assessment for your environmental permit. Accessed 07/03/20123 https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit.

Irvine, L.M., Johansen, H.W. 1994. Corallinoideae. In Irvine L. M. & Chamberlain Y. M.(eds.) Seaweeds of the British Isles Vol.1 Rhodophyta Pt. 2B. Corallinales, Hildenbrandiales. London: HMSO, 276 p.

Tyler-Walters, H. 2008. Corallina officinalis. Coral weed. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 07/07/2009]. Available from: http://www.marlin.ac.uk/speciesfullreview.php?speciesID=3039.

Walker, R.H., Brodie, J., Russell, S., Irvine, L.M., Orfanidis. S. 2009. Biodiversity of coralline algae in the northeastern Atlantic including *Corallina caespitosa sp. nov*. (corallinoideae, rhodophyta). Journal of Phycology 45:287 – 297.

Appendix A Additional Plots

A.1 Time series of ammonia discharge – baseline

Figure 18 to Figure 25 show the individual time series of un-ionised ammonia at the *Corallina* locations C1-C8, for the original baseline conditions from BEEMS Technical Report TR428 as originally shown grouped in Figure 1. Figure 26 to Figure 32 show the individual time series of un-ionised ammonia at the *Sabellaria* locations A – G.

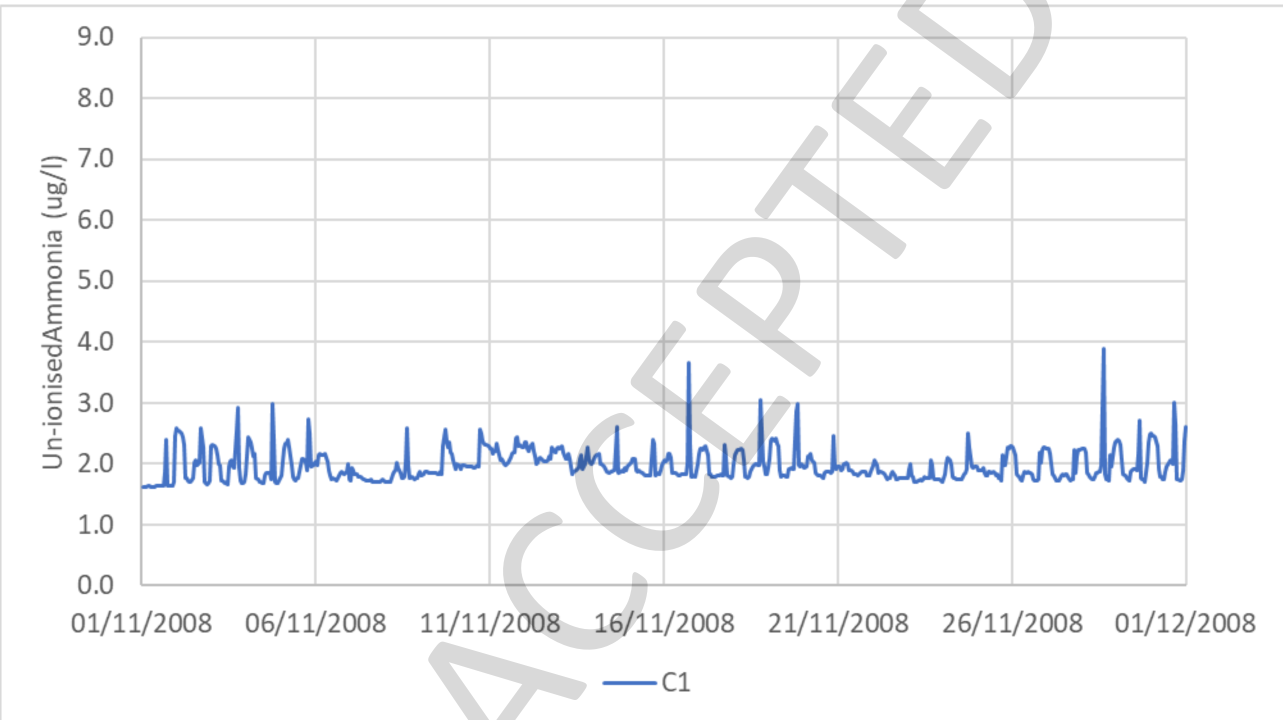

Figure 18: The original time series of un-ionised ammonia at the *Corallina* location C1 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

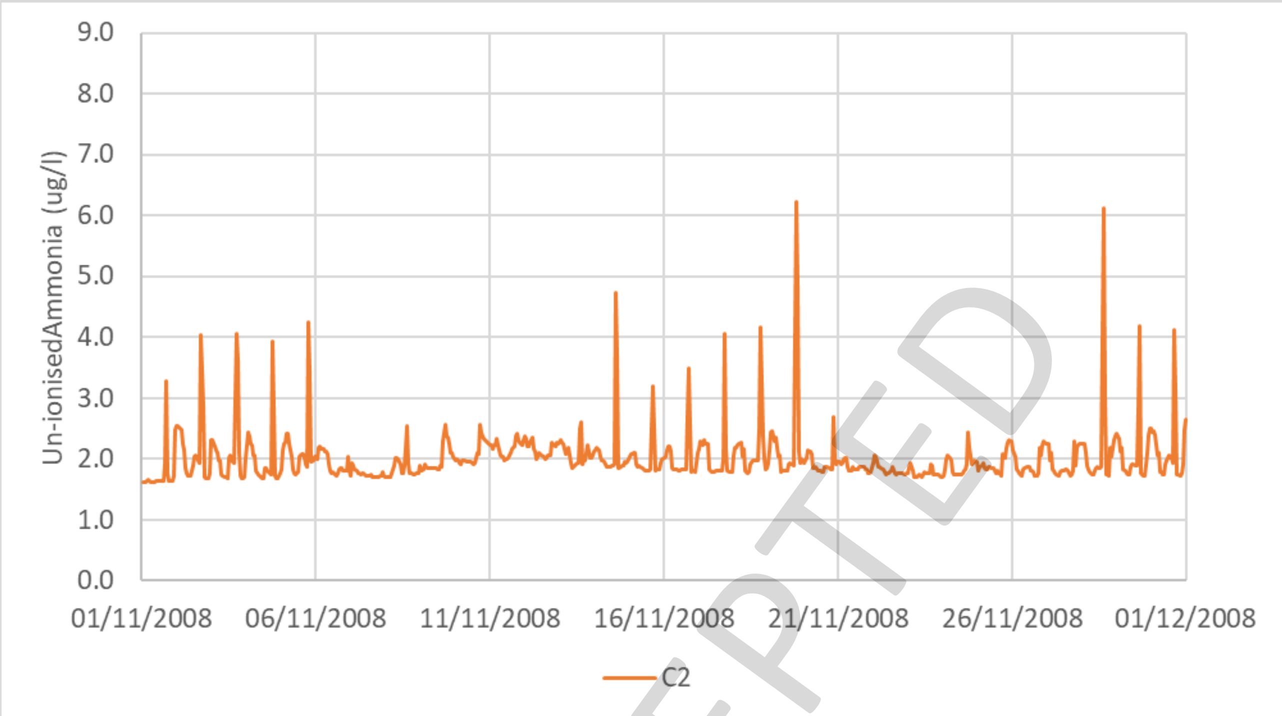

Figure 19: The original time series of un-ionised ammonia at the *Corallina* location C2 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

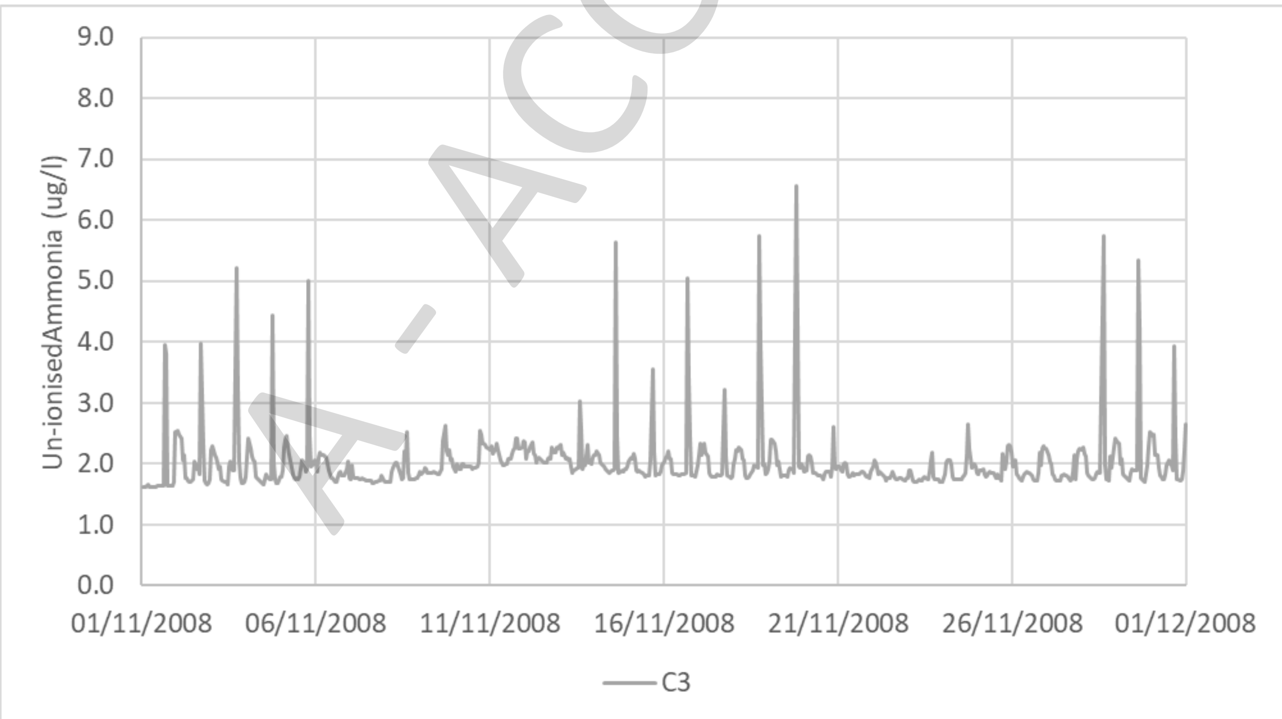

Figure 20: The original time series of un-ionised ammonia at the *Corallina* location C3 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

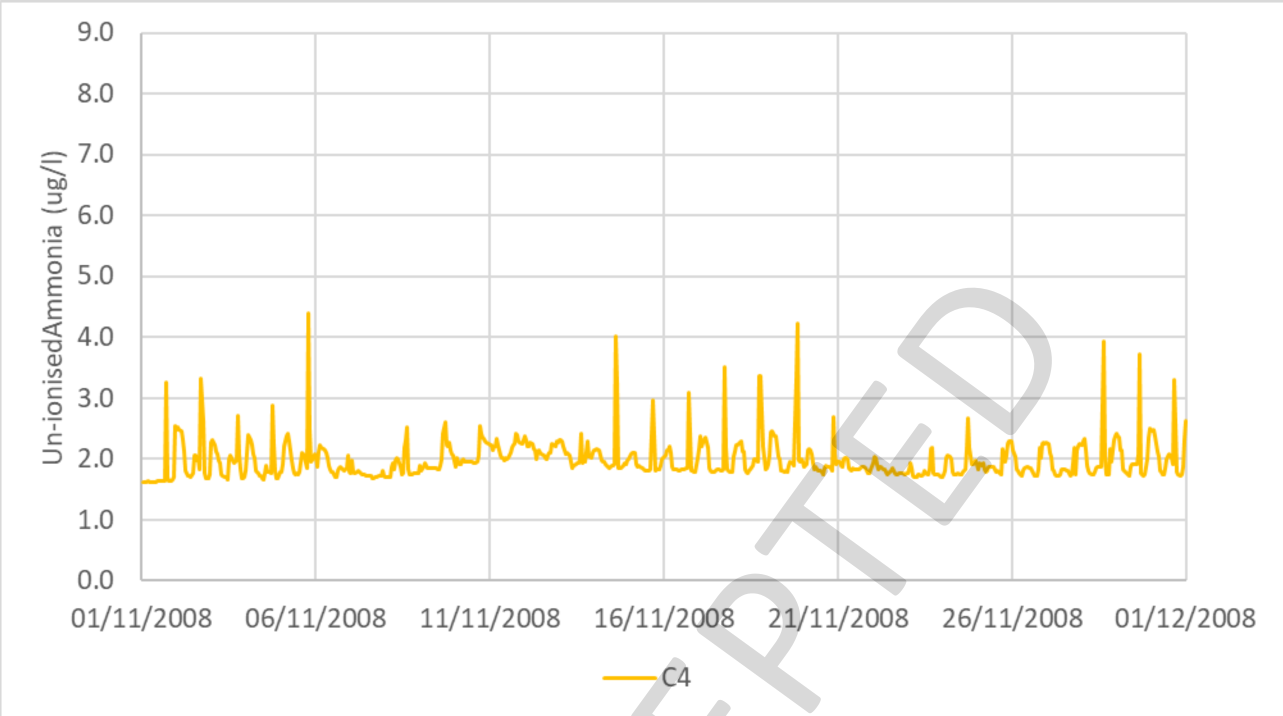

Figure 21: The original time series of un-ionised ammonia at the *Corallina* location C4 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

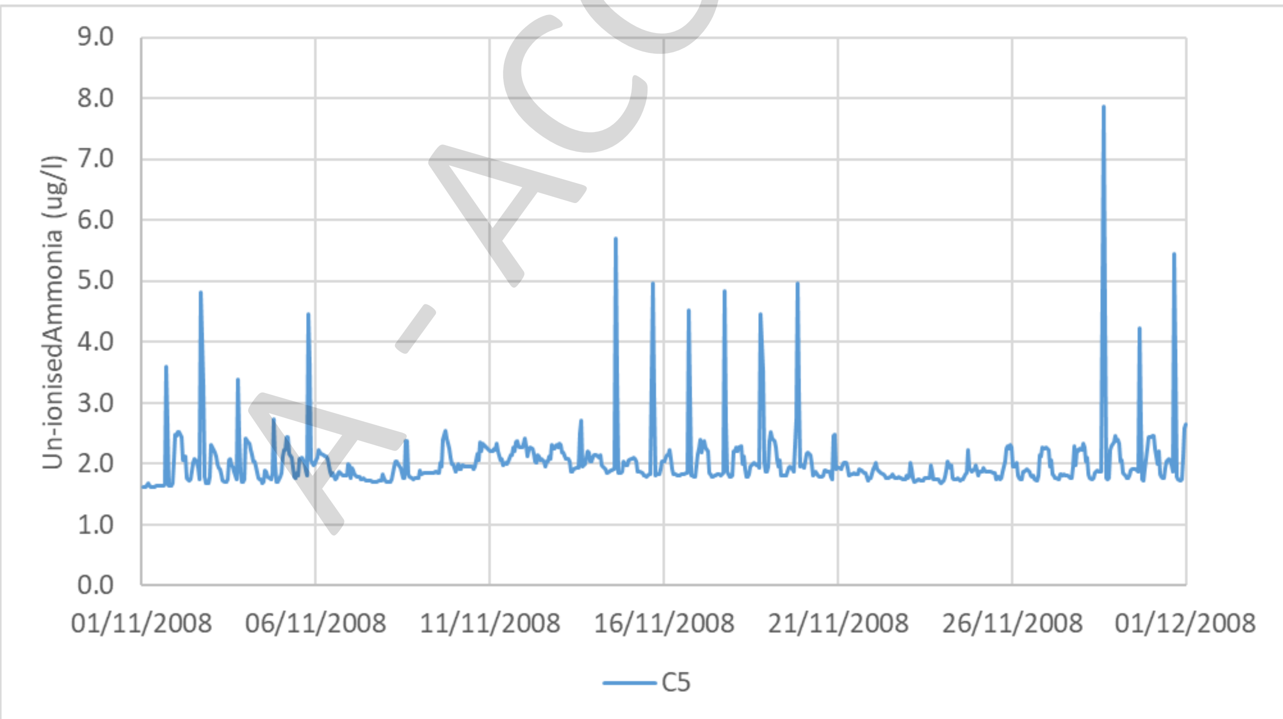

Figure 22: The original time series of un-ionised ammonia at the *Corallina* location C5 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

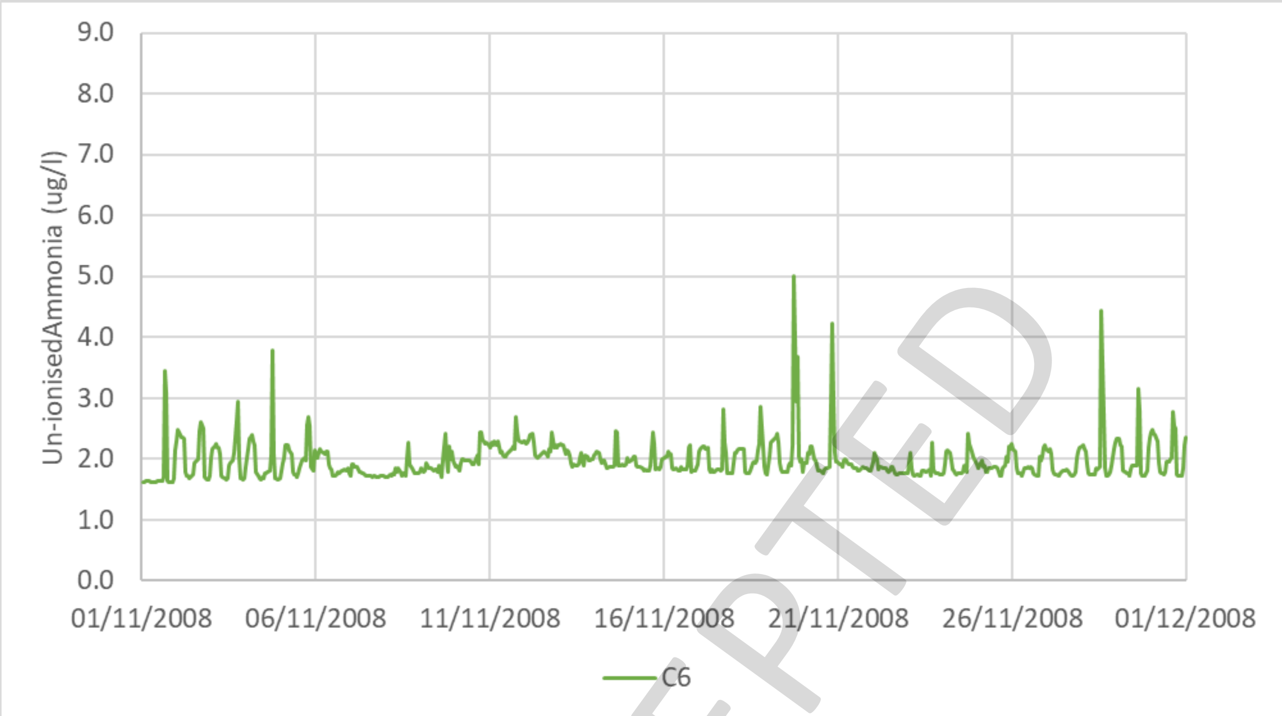

Figure 23: The original time series of un-ionised ammonia at the *Corallina* location C6 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

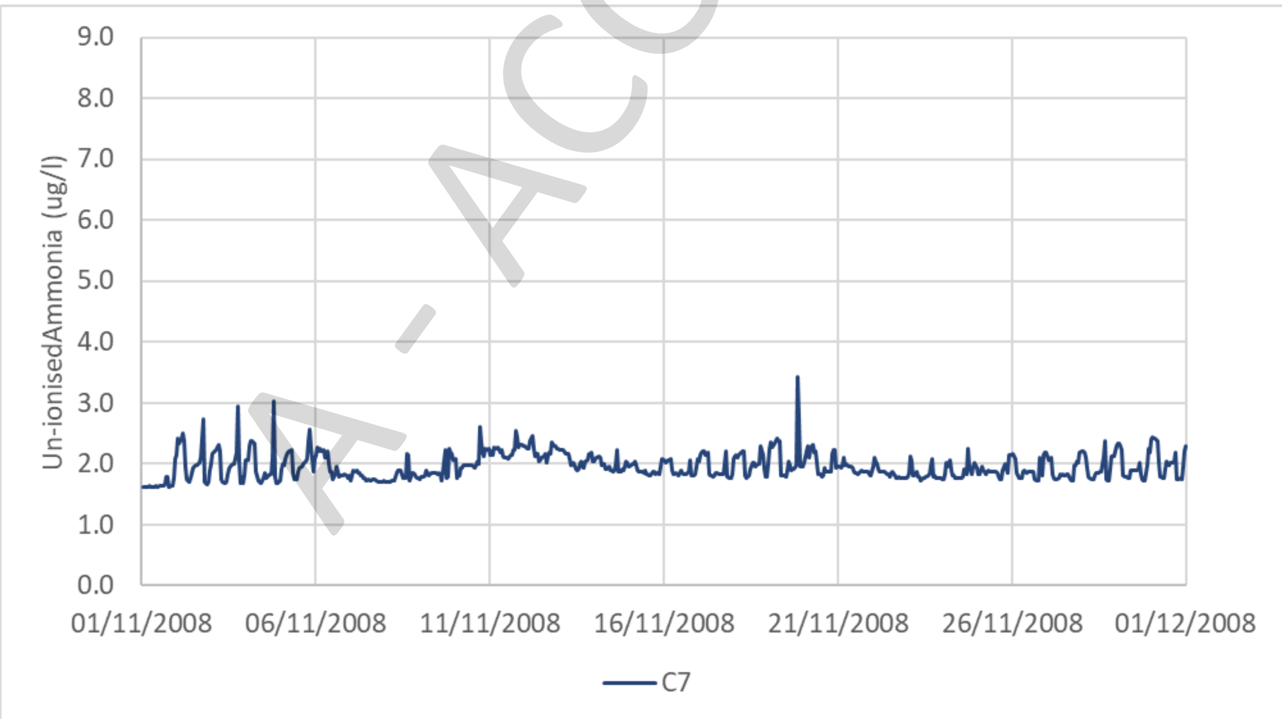

Figure 24: The original time series of un-ionised ammonia at the *Corallina* location C7 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

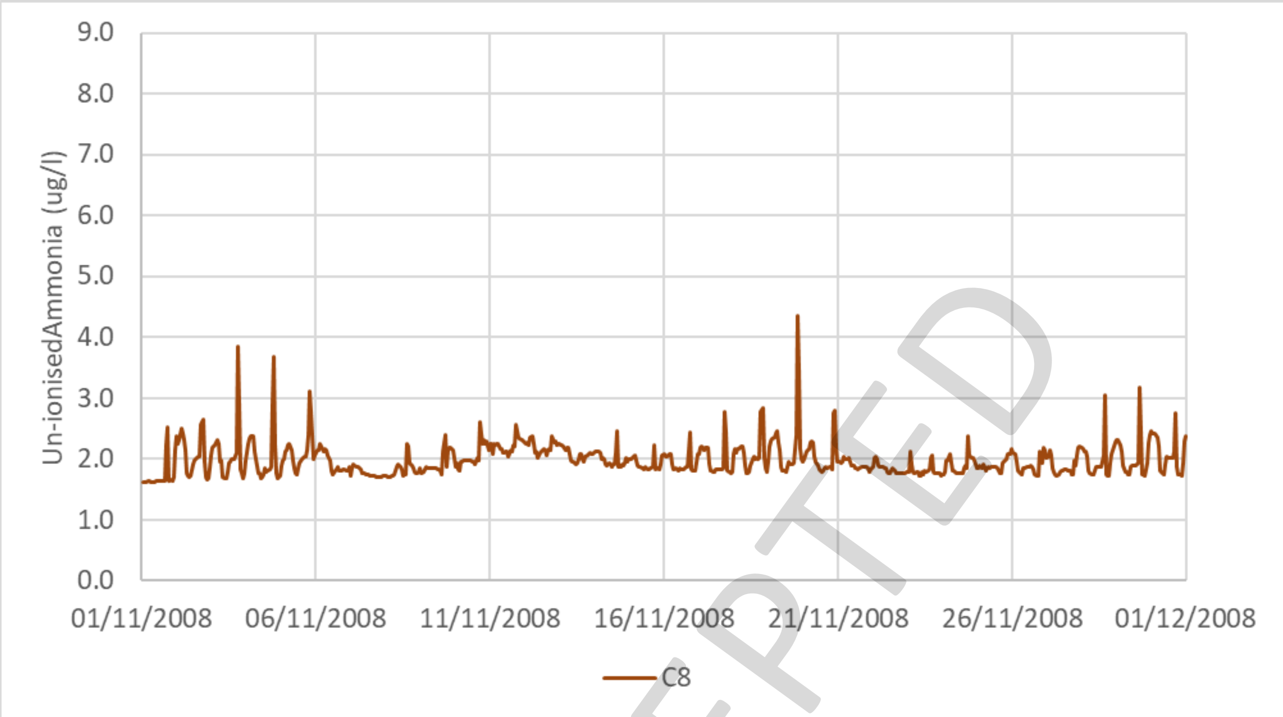

Figure 25: The original time series of un-ionised ammonia at the *Corallina* location C8 for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

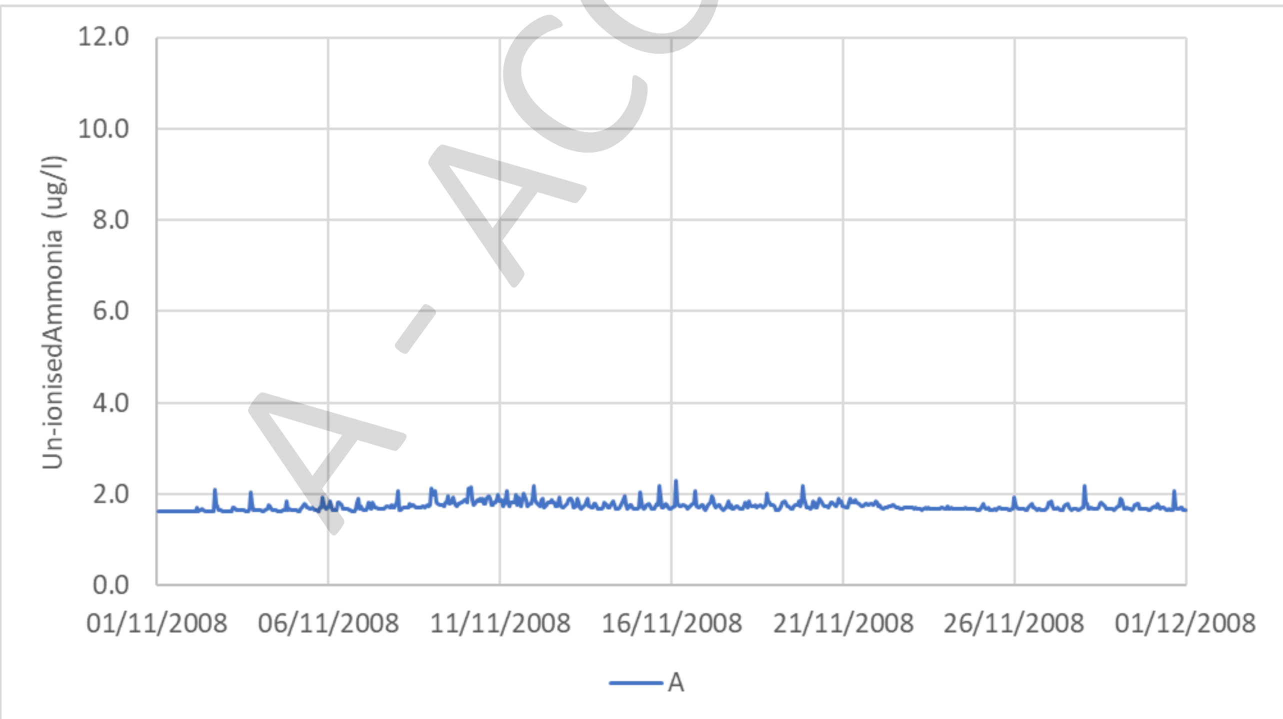

Figure 26: The original time series of un-ionised ammonia at the *Sabellaria* location A for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

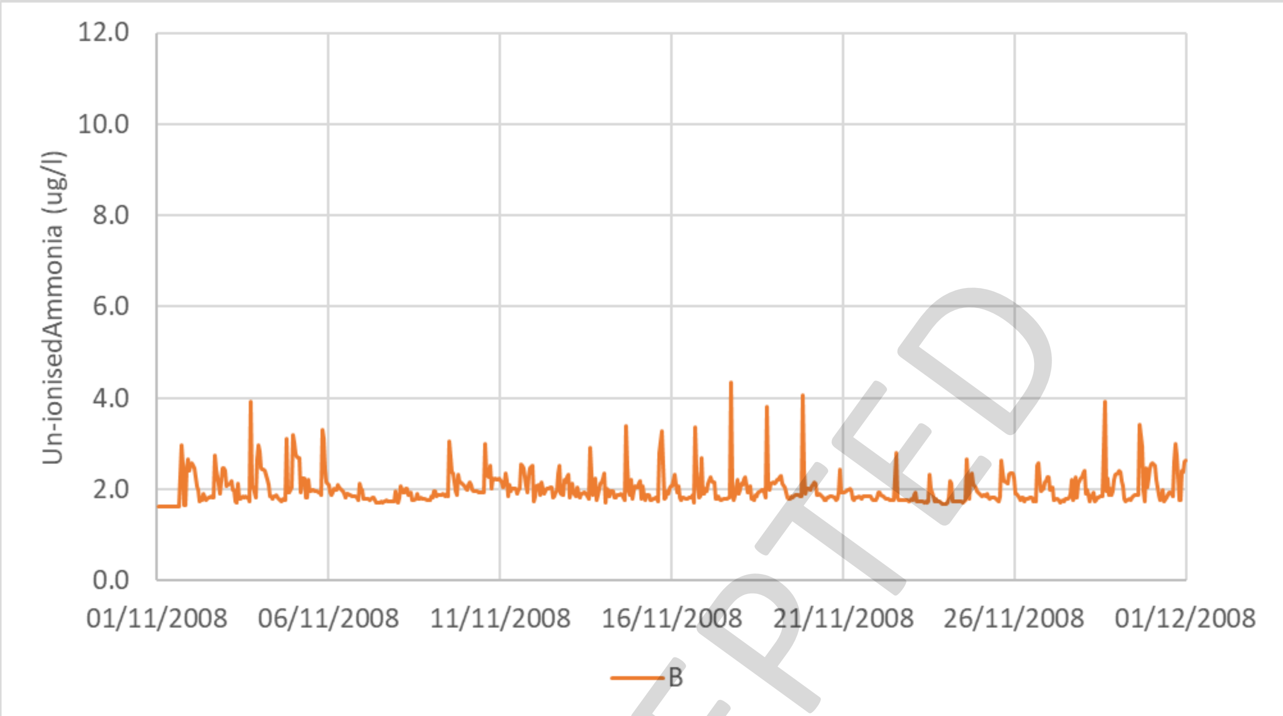

Figure 27: The original time series of un-ionised ammonia at the *Sabellaria* location B for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

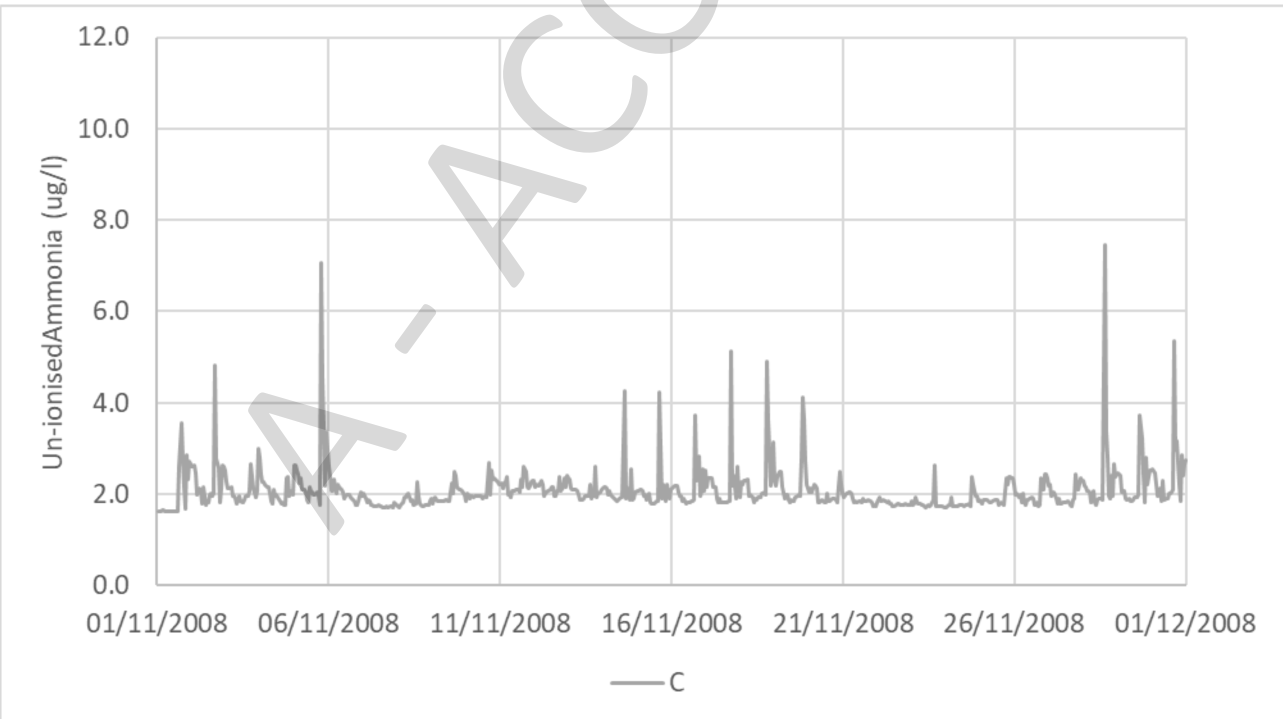

Figure 28: The original time series of un-ionised ammonia at the *Sabellaria* location C for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

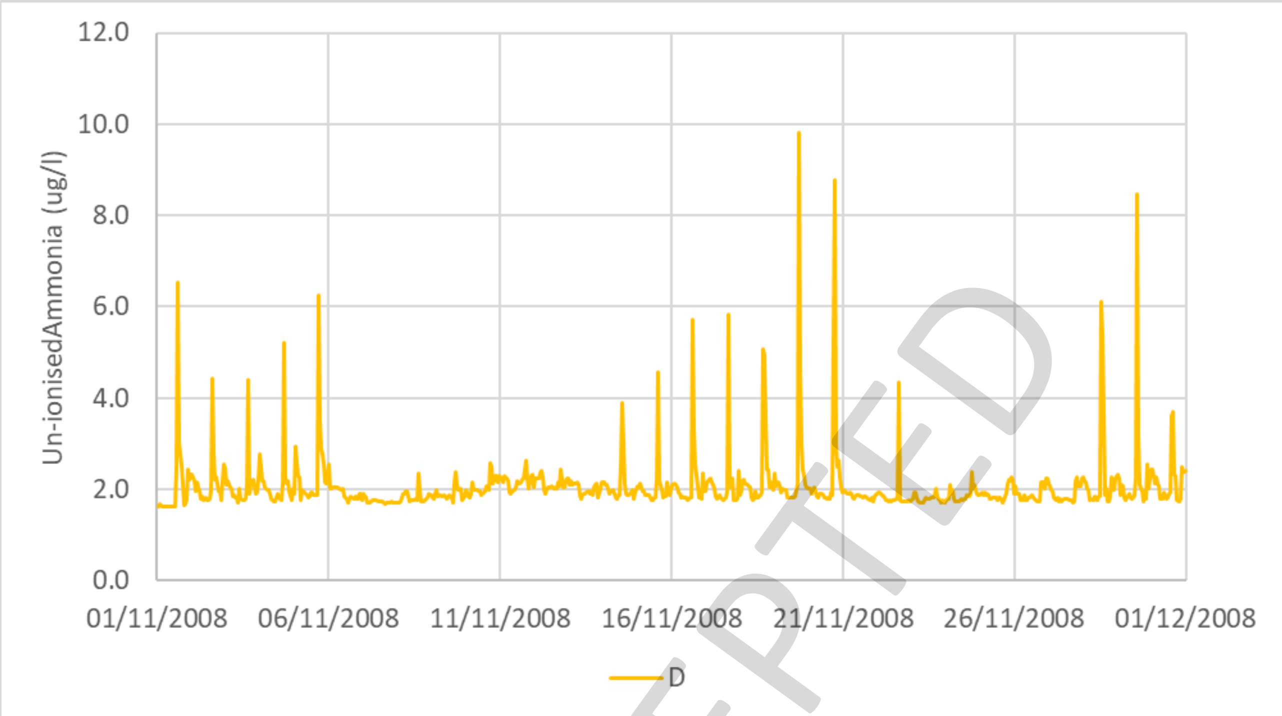

Figure 29: The original time series of un-ionised ammonia at the *Sabellaria* location D for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

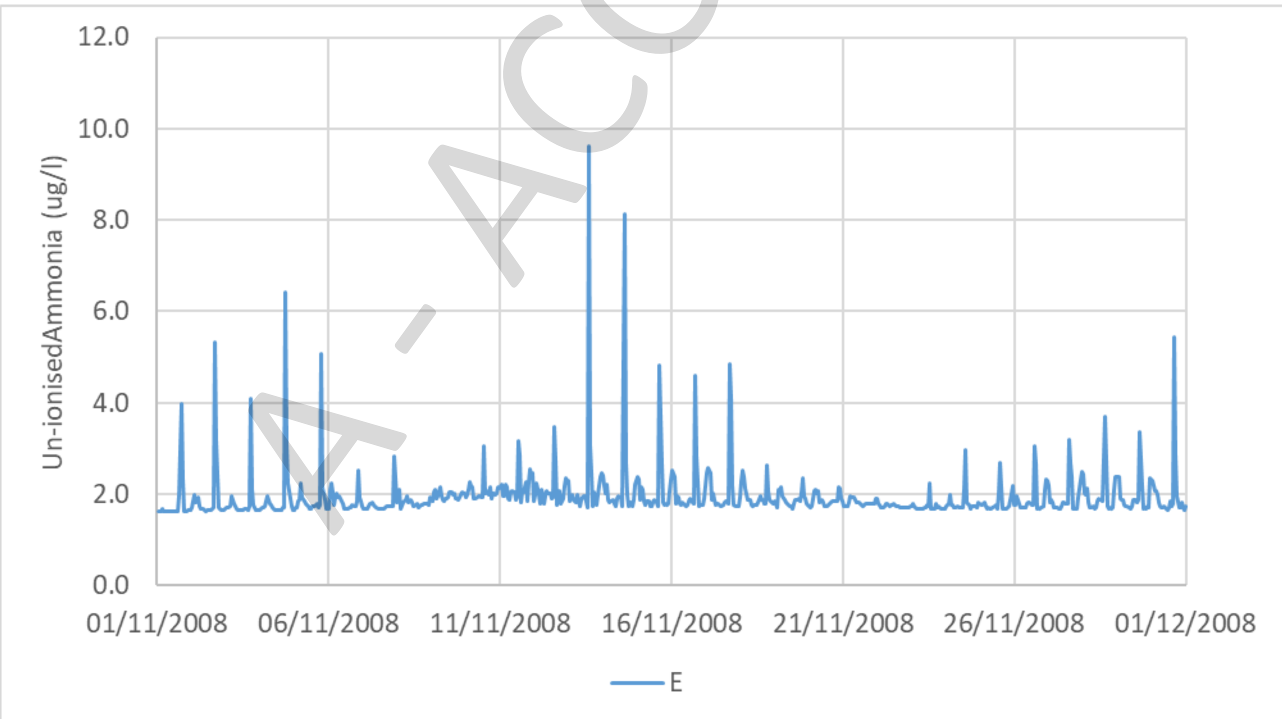

Figure 30: The original time series of un-ionised ammonia at the *Sabellaria* location E for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

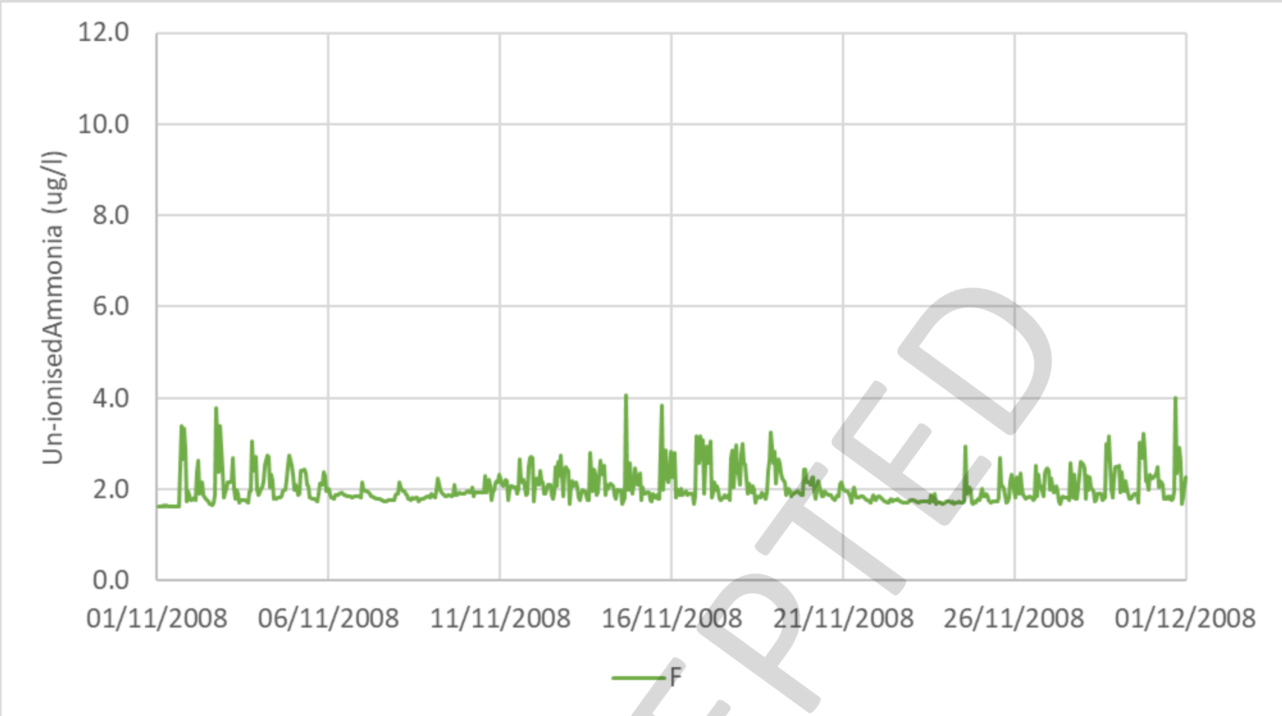

Figure 31: The original time series of un-ionised ammonia at the *Sabellaria* location F for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

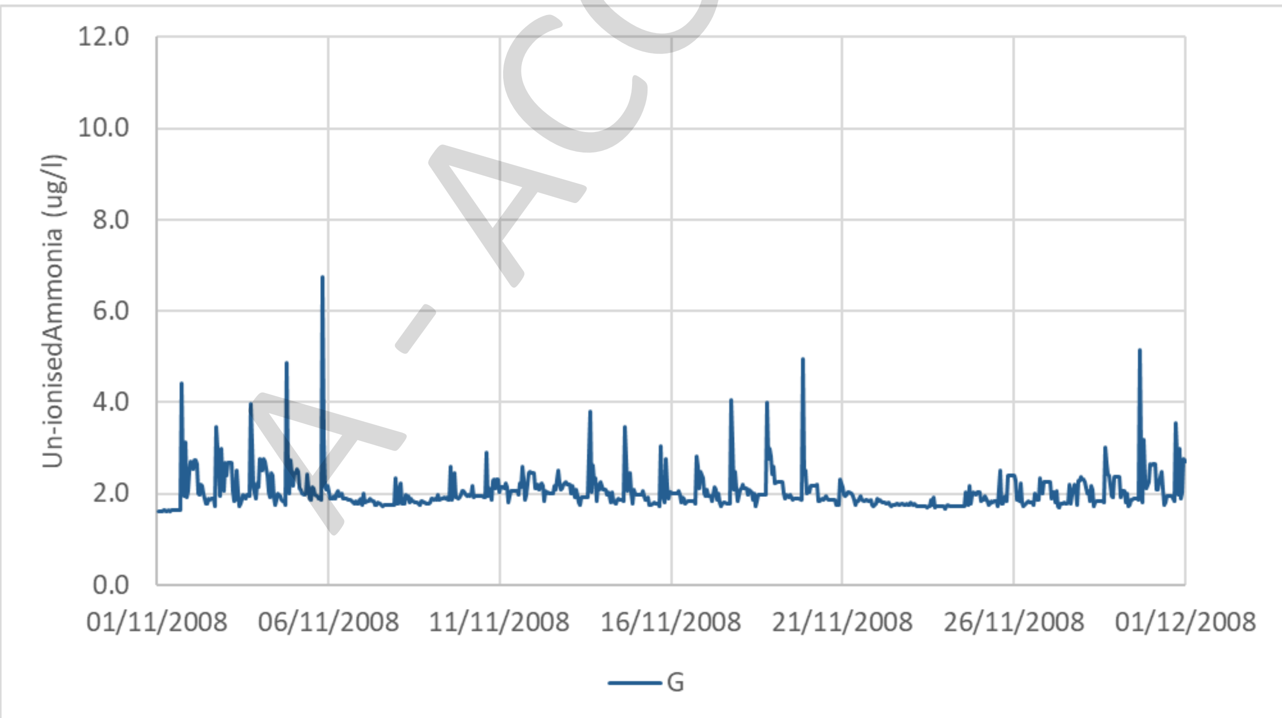

Figure 32: The original time series of un-ionised ammonia at the *Sabellaria* location G for the 38 l/s at 10 mg/l +70 l/s at 271 mg/l scenario, as shown in BEEMS Technical Report TR428.

A.2 Time series of ammonia discharge – 80 mg/l sewage

Figure 33 to Figure 40 show the individual time series of un-ionised ammonia at the *Corallina* locations C1-C8, as originally shown grouped in Figure 13. Figure 41 to Figure 47 show the individual time series of un-ionised ammonia at the *Sabellaria* locations A – G, as originally shown grouped in Figure 14.

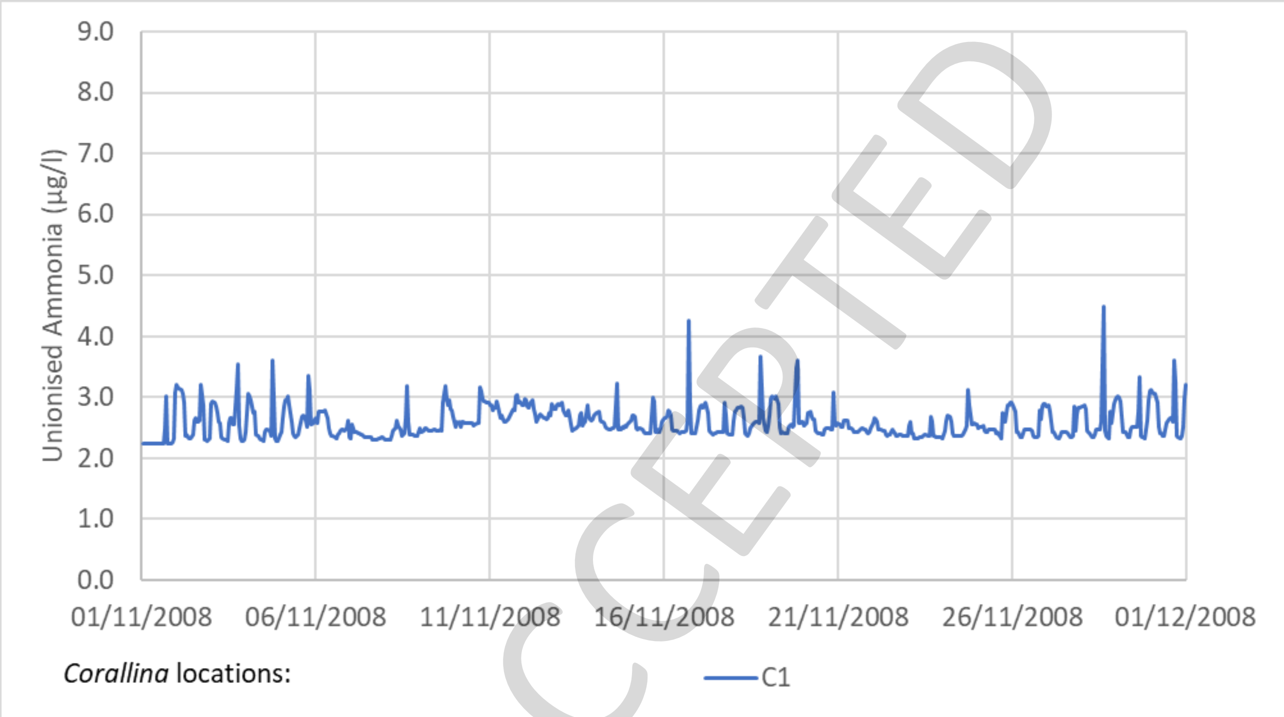

Figure 33: Time series of un-ionised ammonia at the *Corallina* location C1 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

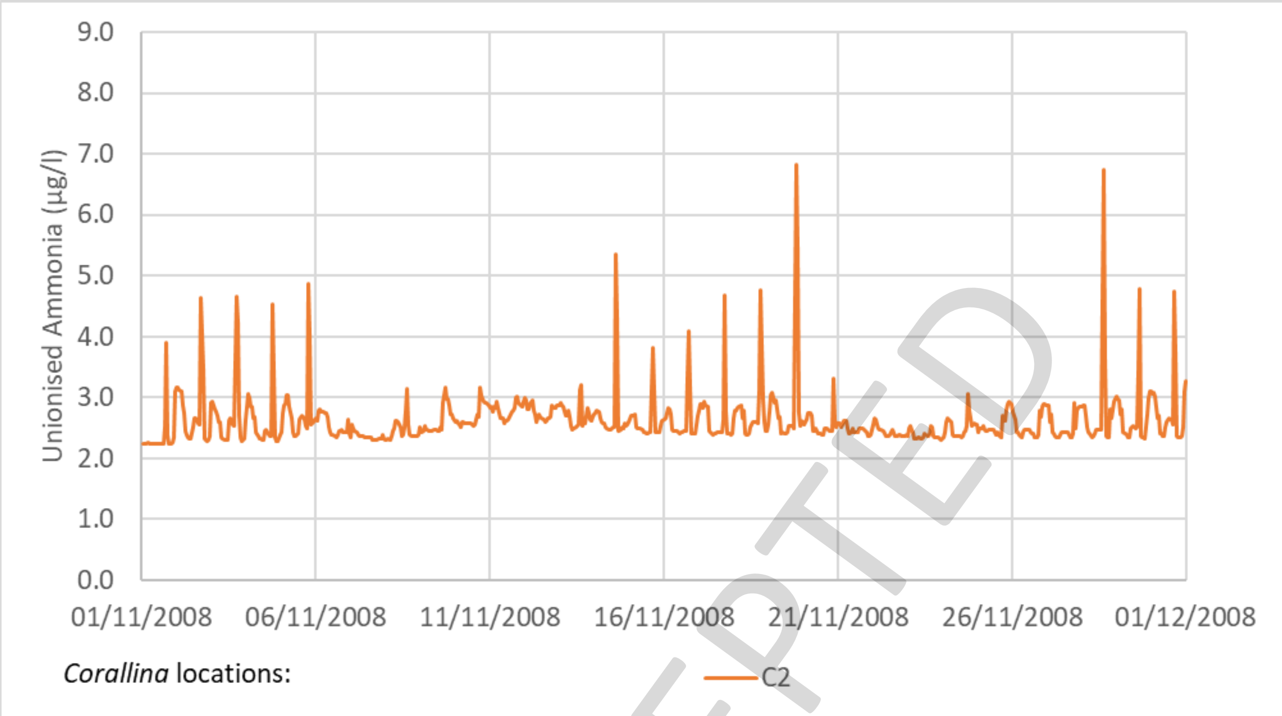

Figure 34: Time series of un-ionised ammonia at the *Corallina* location C2 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

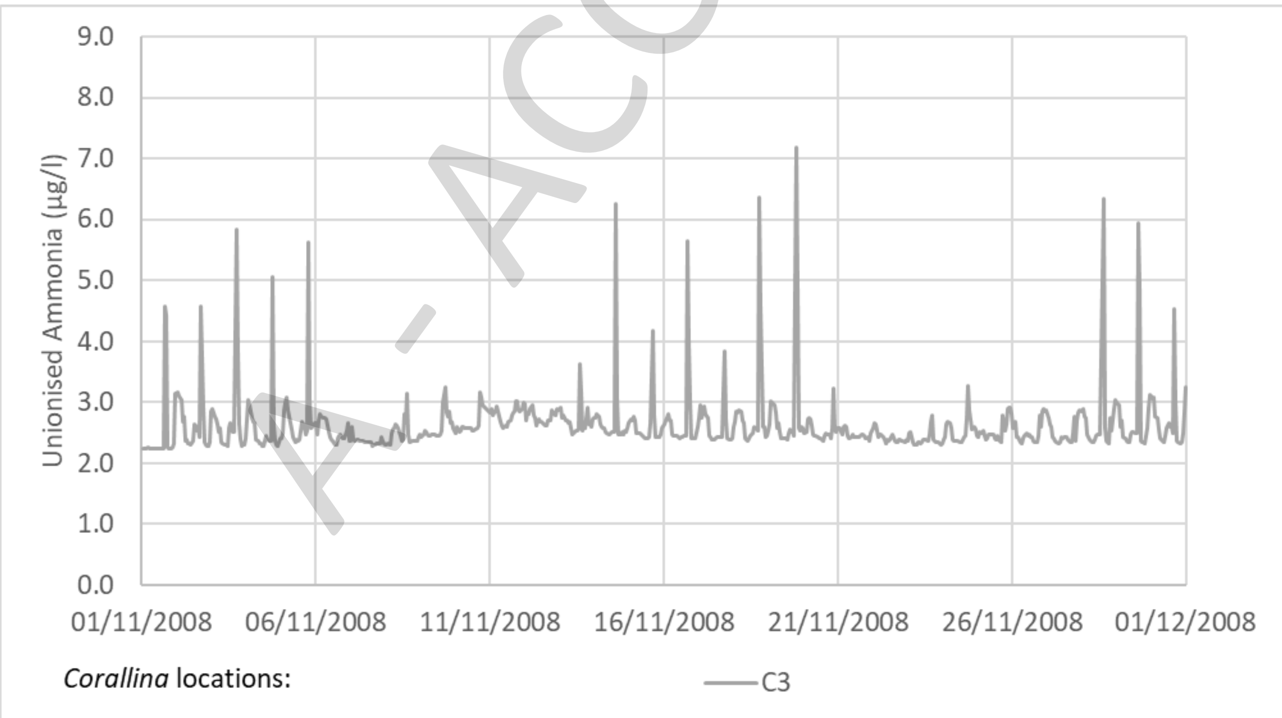

Figure 35: Time series of un-ionised ammonia at the *Corallina* location C3 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

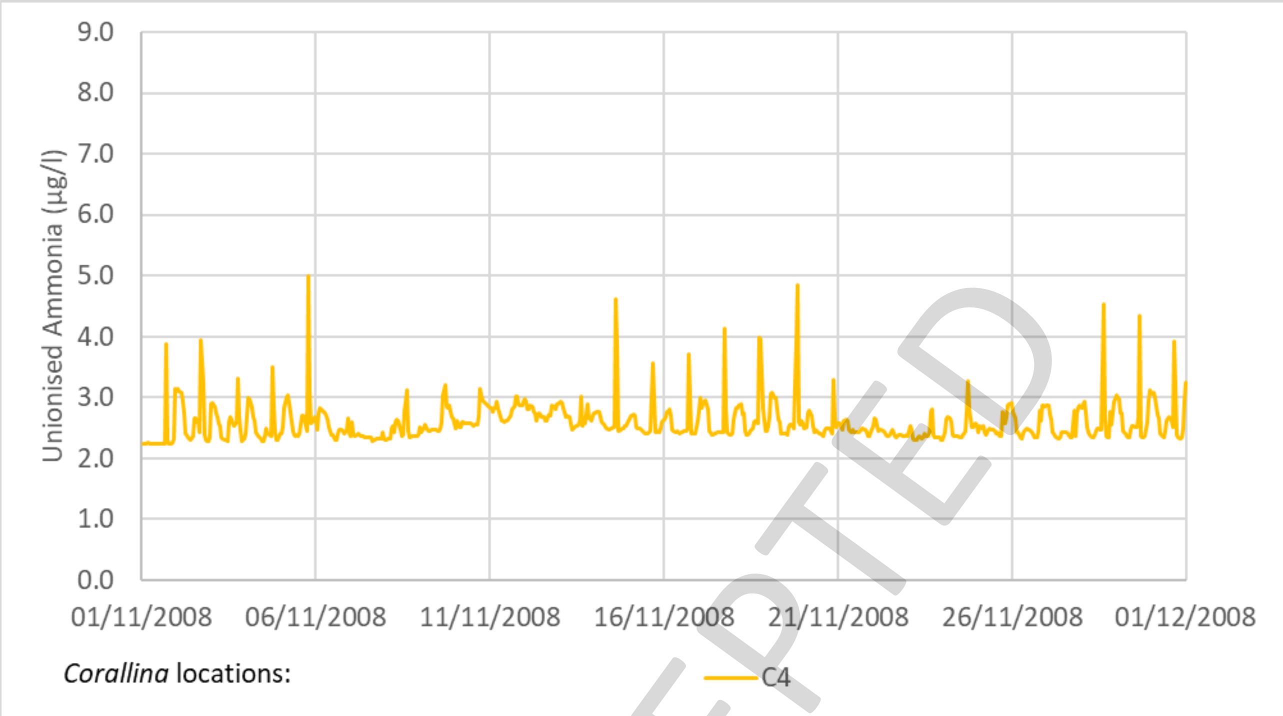

Figure 36: Time series of un-ionised ammonia at the *Corallina* location C4 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

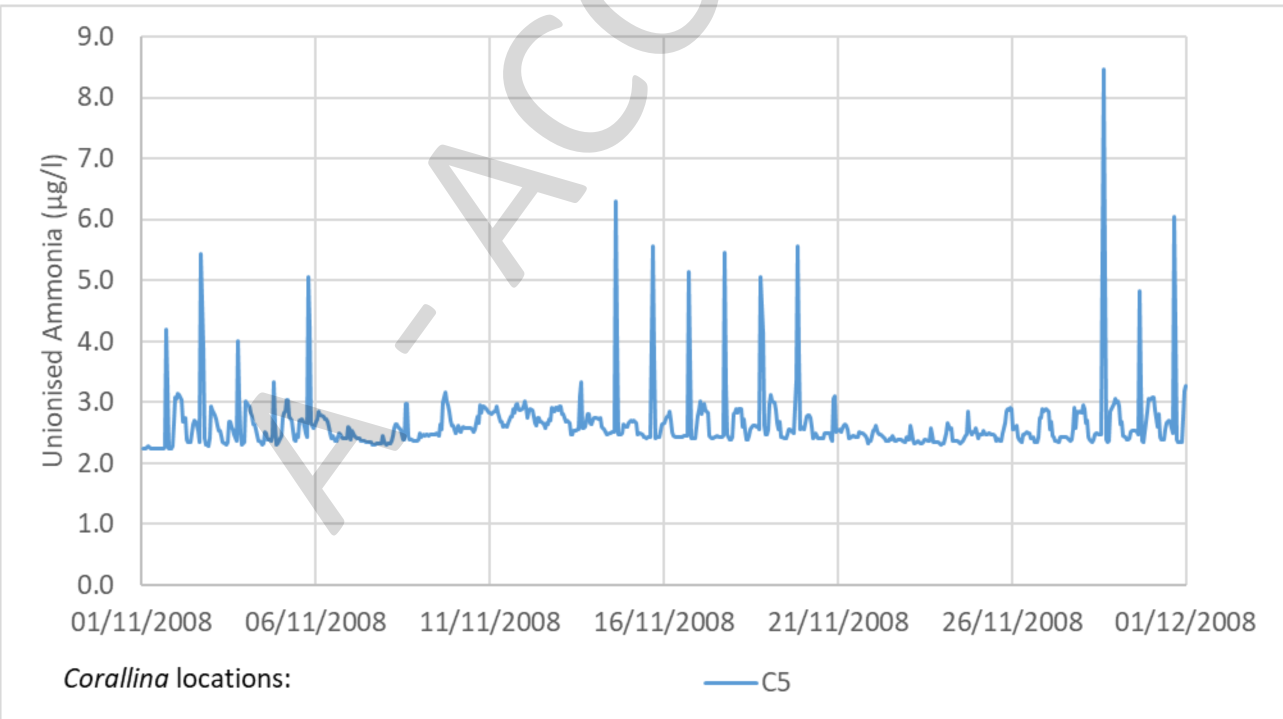

Figure 37: Time series of un-ionised ammonia at the *Corallina* location C5 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

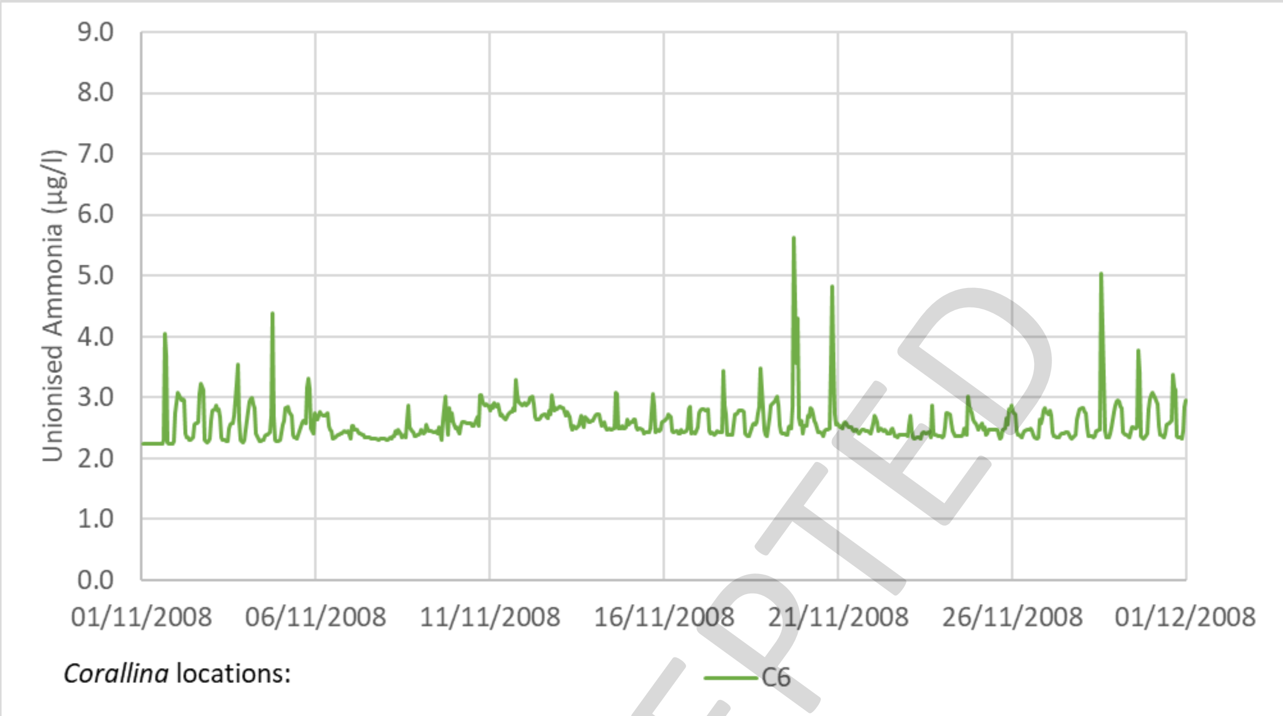

Figure 38: Time series of un-ionised ammonia at the *Corallina* location C6 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

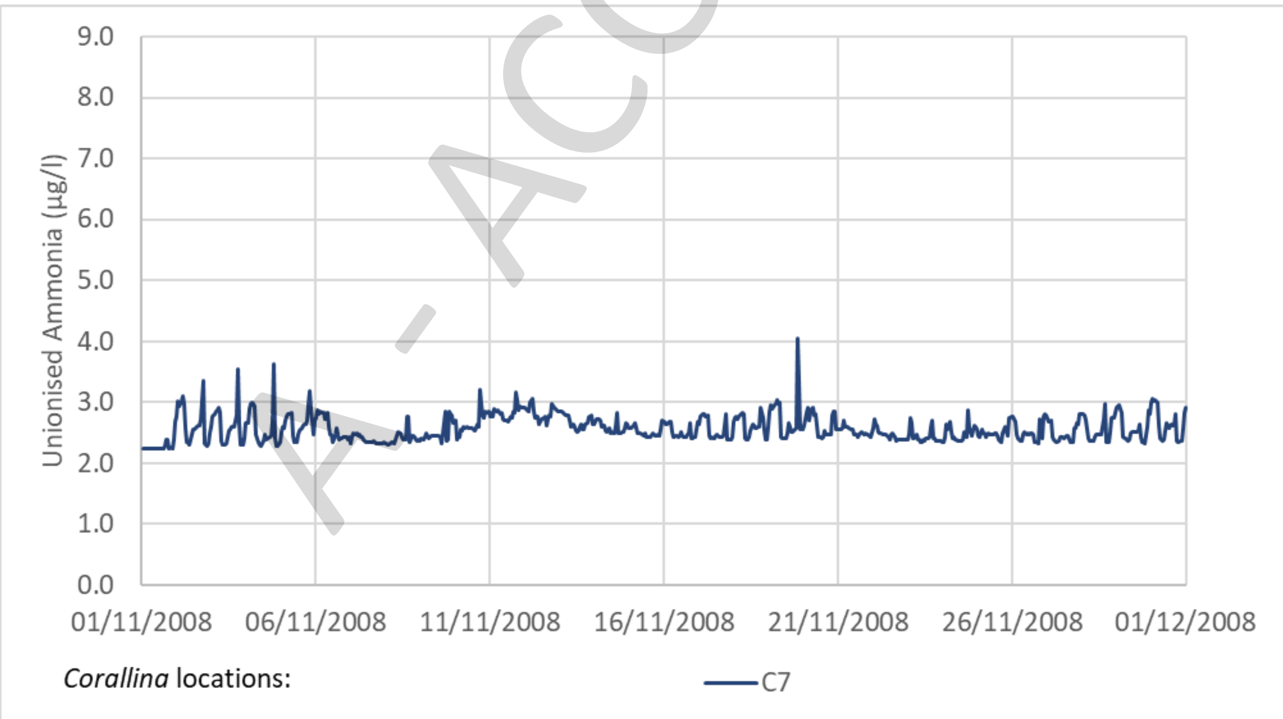

Figure 39: Time series of un-ionised ammonia at the *Corallina* location C7 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

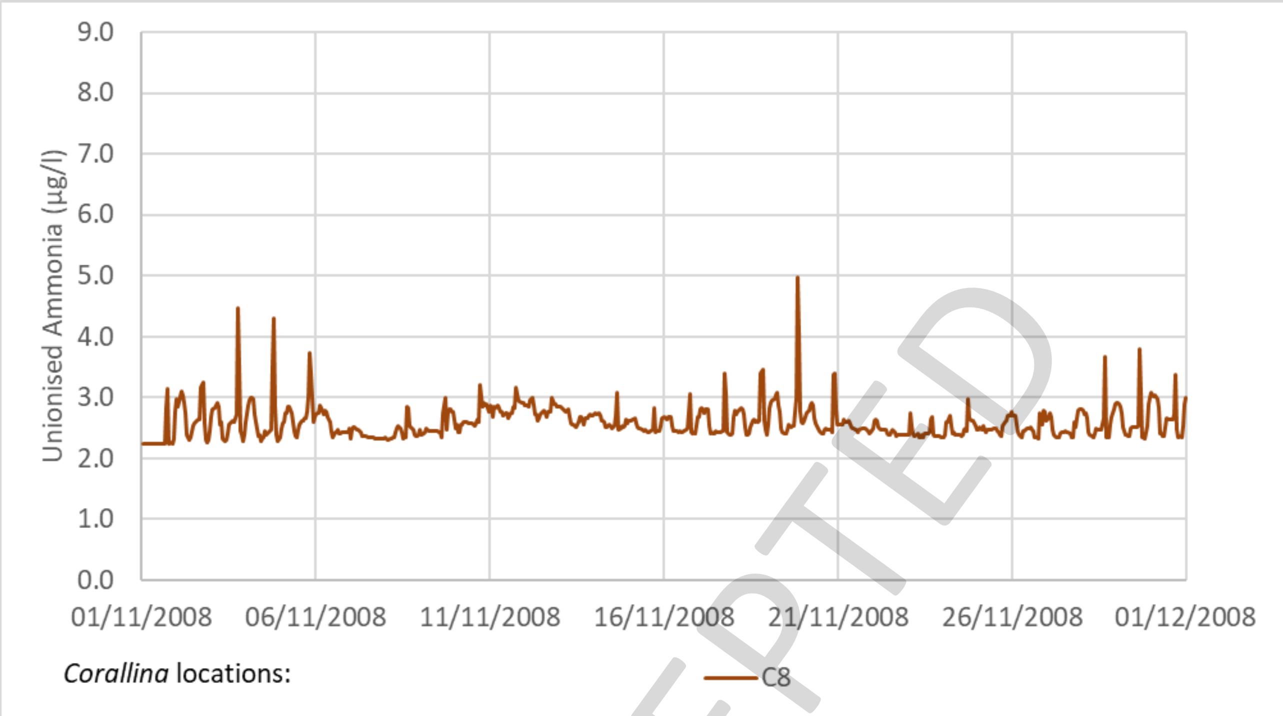

Figure 40: Time series of un-ionised ammonia at the *Corallina* location C8 for the alternative 38 l/s at 80 mg/l+70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

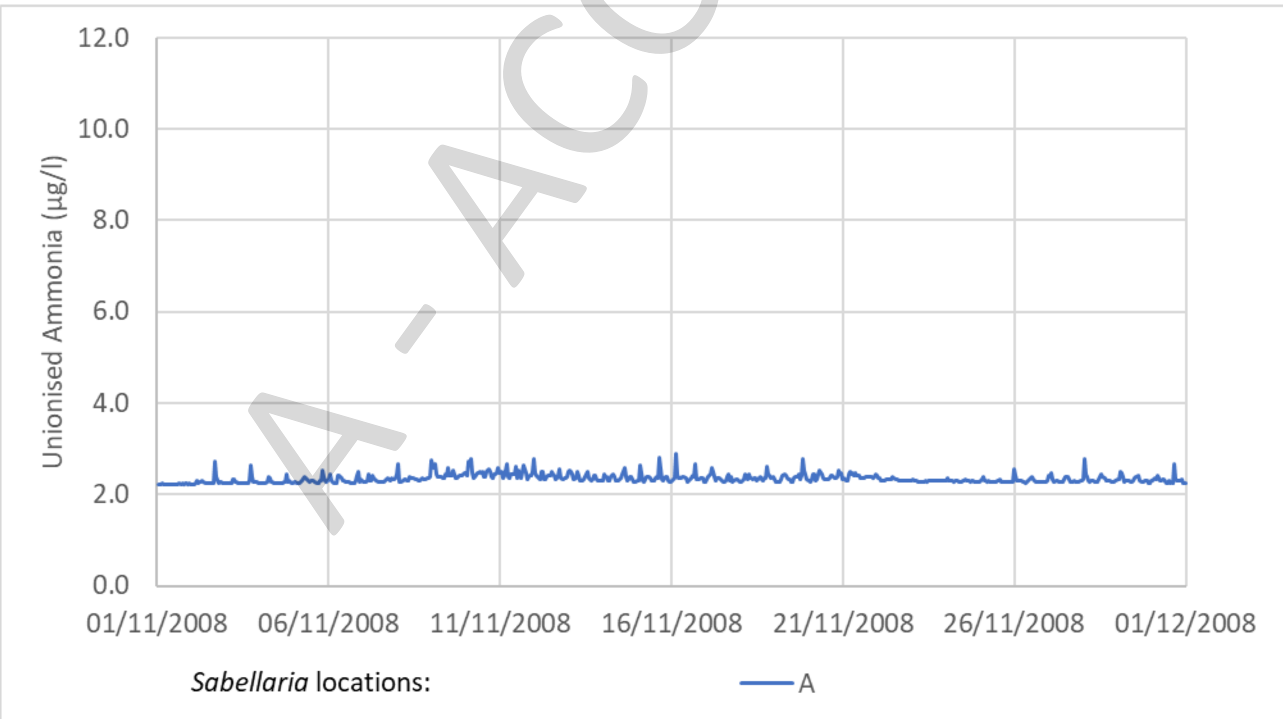

Figure 41: Time series of un-ionised ammonia at the *Sabellaria* location A for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

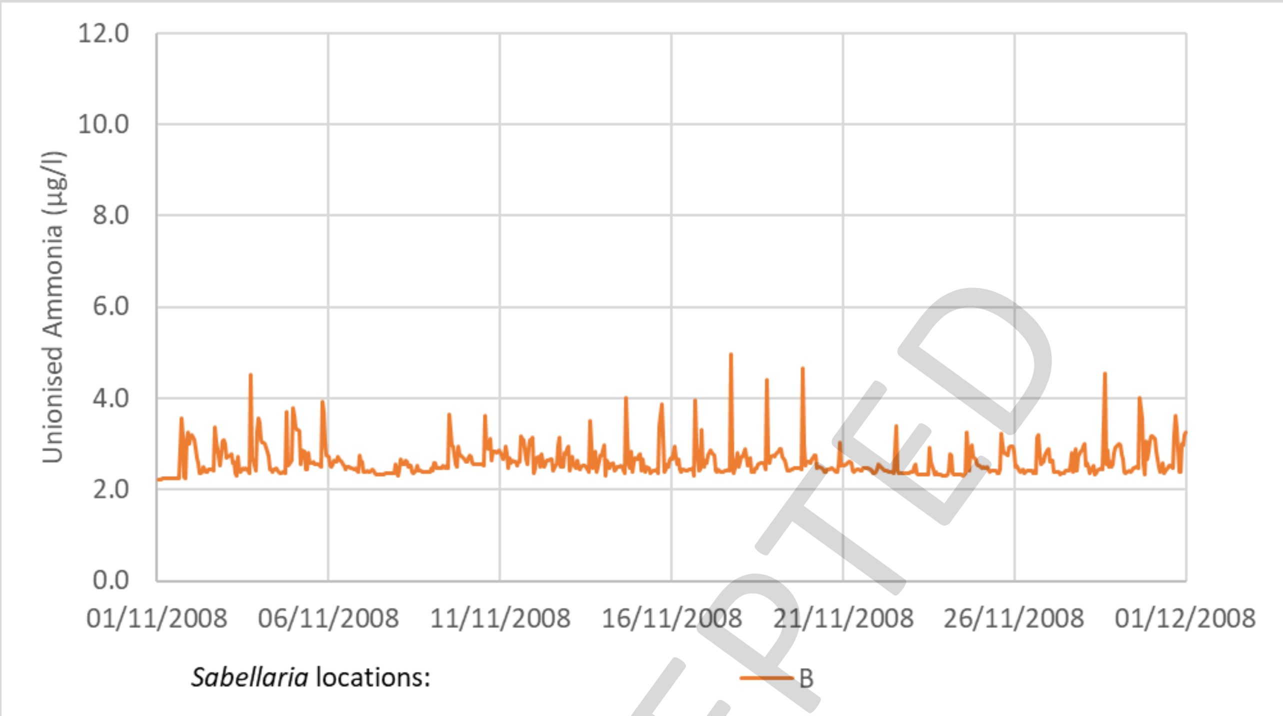

Figure 42: Time series of un-ionised ammonia at the *Sabellaria* location B for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

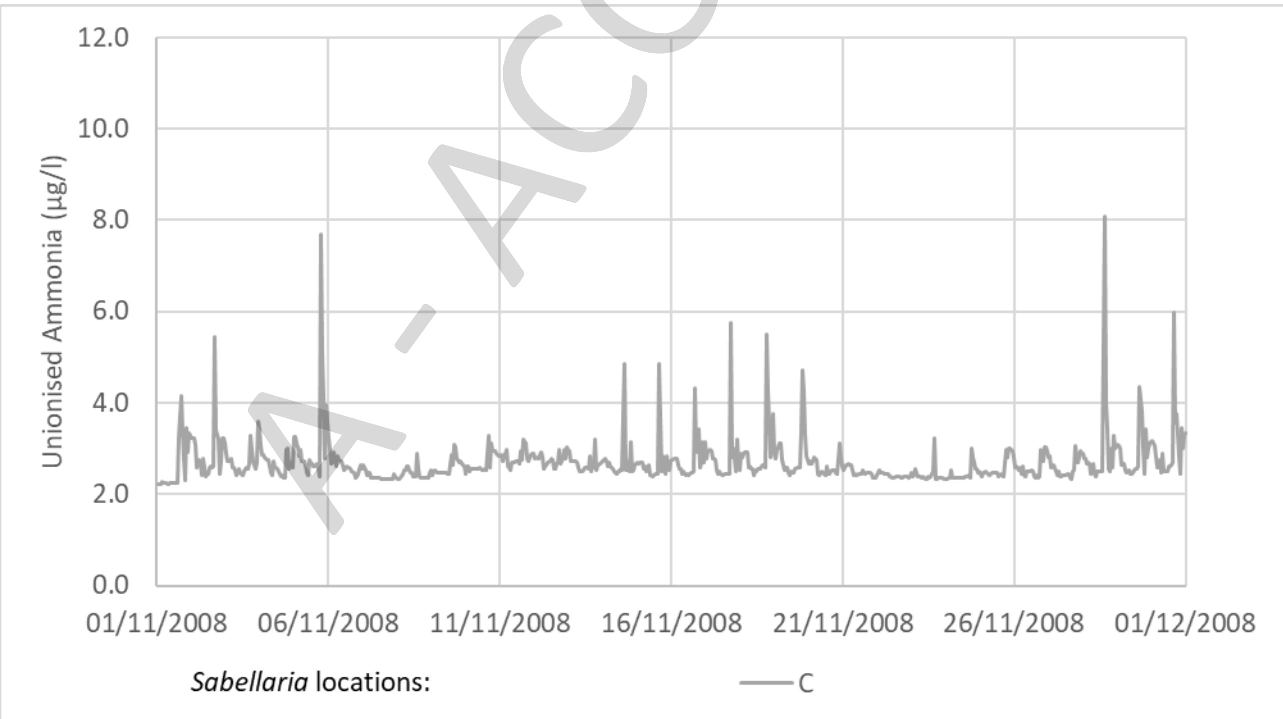

Figure 43: Time series of un-ionised ammonia at the *Sabellaria* location C for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

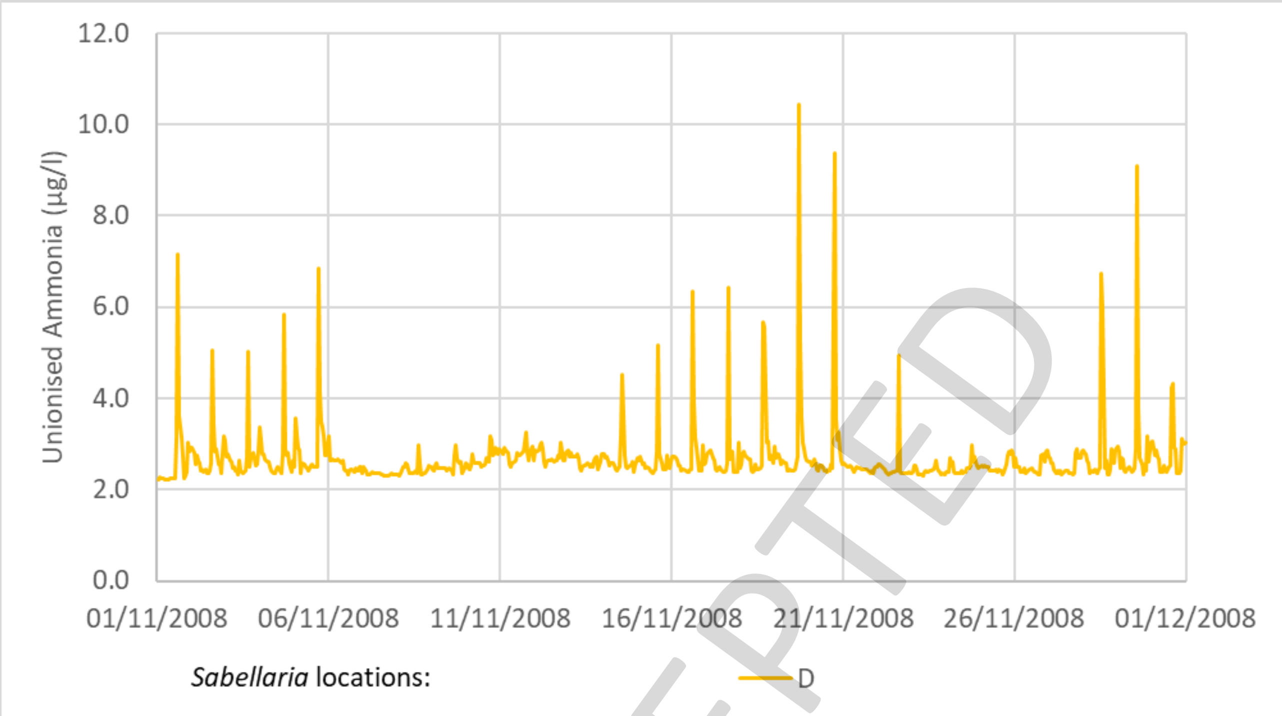

Figure 44: Time series of un-ionised ammonia at the *Sabellaria* location D for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

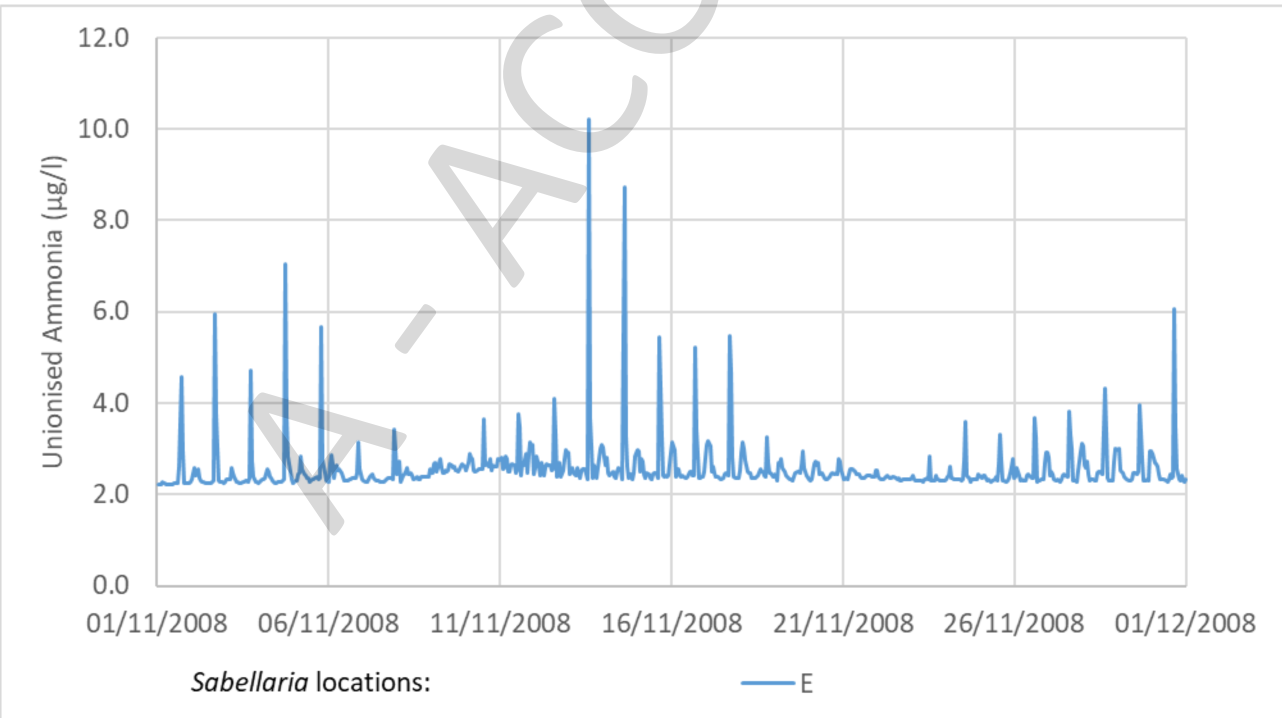

Figure 45: Time series of un-ionised ammonia at the *Sabellaria* location E for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

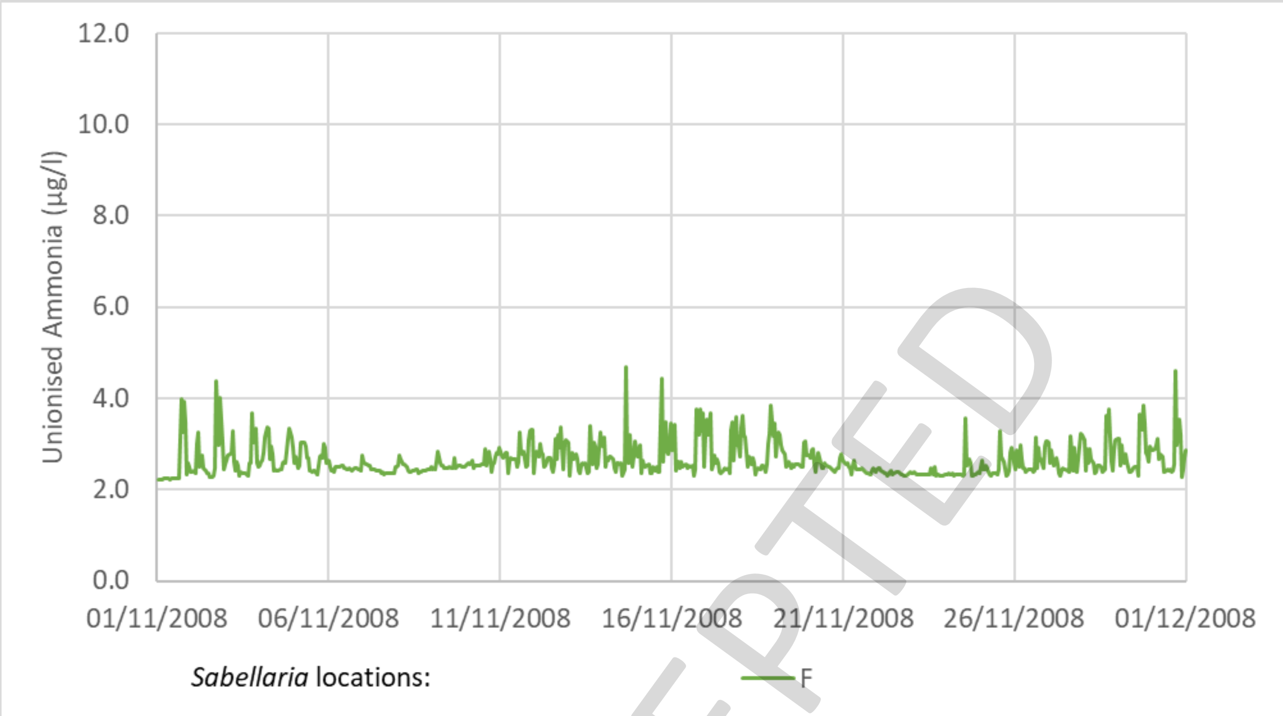

Figure 46: Time series of un-ionised ammonia at the *Sabellaria* location F for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

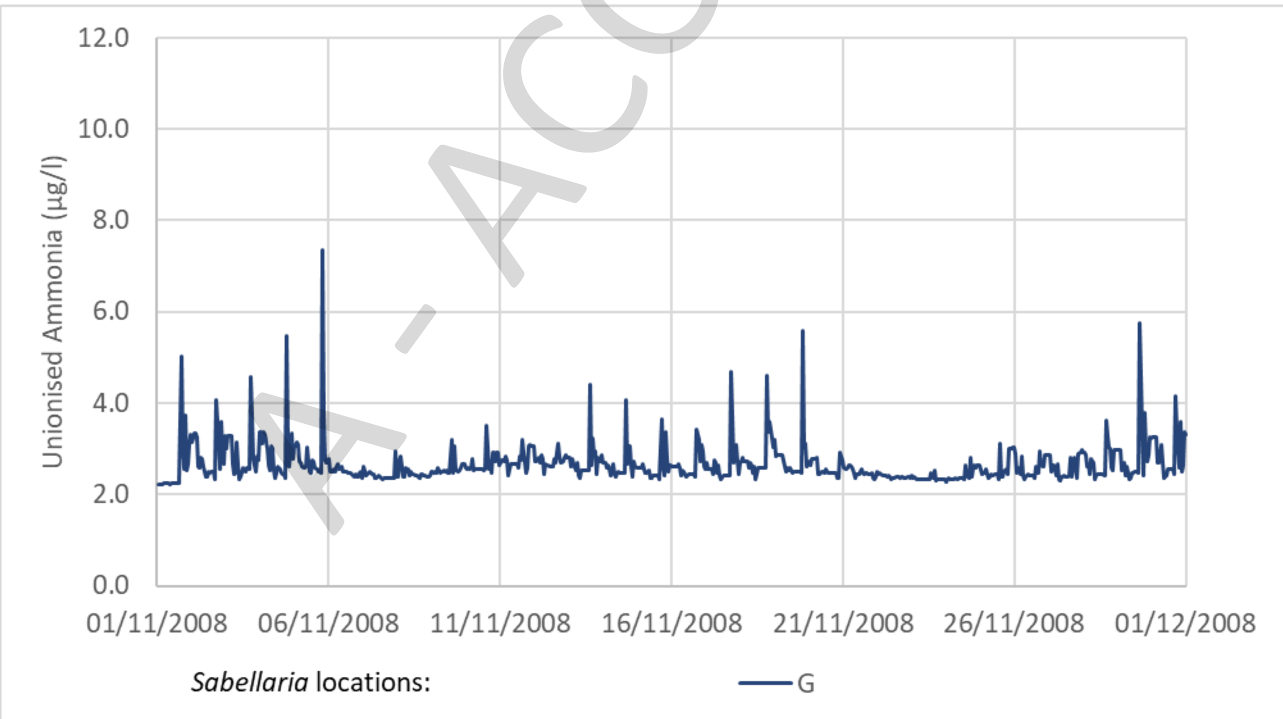

Figure 47: Time series of un-ionised ammonia at the *Sabellaria* location G for the alternative 38 l/s at 80 mg/l +70 l/s at 271 mg/l scenario using mean conditions of temperature, salinity, and pH.

Glossary

Term / acronym	Definition
AEVF	Allowable Effective Volume Flux
DCO	Development Consent Order
EQS	Environmental Quality Standard
EVF	Effective Volume Flux
HPC	Hinkley Point C
MAC	Maximum Allowable Concentration
PNEC	Predicted No Effect Concentration
WDA	Water Discharge Activity