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Mark Breckels, Chris Jenkins and Dave Sheahan
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Executive summary

Within the framework of a shadow Habitats Regulations Assessment (HRA), this document provides an assessment of the potential for likely significant effects (LSE) from the proposed Hinkley Point C construction discharges from the temporary jetty on the designated features within the Severn Estuary SAC, SPA, and Ramsar site. Although not part of a Habitats Assessment, the potential effects on species and habitats notified as part of the Bridgwater Bay SSSI are also considered within this report at the request of the Environment Agency.

Construction phase discharges of sewage, dewatered groundwater and tunnelling waste-water from the drilling of cooling water intakes and outfalls will be discharged into the receiving waterbody from a subtidal discharge point near the seaward end of the jetty. The chemical composition of the discharge, and the discharges volumes change throughout the construction period. The assessment focuses on two worst case phases; Case C and Case D. Case C is a short-term (8-week) period of maximum groundwater discharges, which is followed by longer term discharges of groundwater at a reduced rate, Case D. In both cases sewage discharges are expected to be constant, whereas discharges of Tunnel Boring Machine (TBM) ground conditioning chemicals are greatest during Case D.

The assessments made here are based on the outcome of discharge modelling presented in BEEMS Technical Report TR428 Ed. 3, and supported by available evidence.

Discharges of Metals from groundwater and DIN from treated sewage

Groundwater contaminants; cadmium, chromium, lead, copper, zinc, mercury, dissolved in-organic nitrogen (DIN) and un-ionised ammonia were screened for compliance with Environmental Quality Standards (EQS). Following initial screening, groundwater metals zinc and copper were identified as having exceeded the EQS, chromium also exceeded the EQS by a small margin. Zinc was the groundwater metal with the greatest exceedance of the EQS by some margin and was investigated further through modelling of its discharge profile. Discharges of un-ionised ammonia and DIN were predicted to have very localised surface exceedances of the EQS and passed the initial screening test.

The discharge plume of zinc exceeded the EQS (expressed as an annual average) at the surface for an area of 0.625 ha in Case C and 0.125 ha in Case D. Seabed concentrations of zinc did not exceed the average EQS. Designated features including Sabellaria reefs and Corallina waterfalls were never exposed to concentrations of zinc, or copper, in excess of EQS levels during Case C discharges at any point throughout the model run (100%ile). Based on the evidence available, it is concluded that discharges of zinc and associated groundwater constituents, have no LSE on designated estuary features.

Discharges of TBM soil conditioning chemicals.

TBMs will be used to excavate the two cooling water intake tunnels and the cooling water discharge tunnel. The greatest discharge produced during tunnelling is groundwater. Groundwater, generated from digging the galleries allowing access to the tunnels, is considered to be of similar chemical composition to the main dewatering and is assessed in-combination with the main dewatering discharge (Case C).

In addition to groundwater, smaller quantities of water containing chemicals emanating from tunnelling operations will be produced. Chemical use in tunnelling is associated with three broad functions including:

- Fuelling and lubrication of the TBM
- Sealing the tunnel walls against water/soil ingress
- Ground conditioning

Management protocols will be implemented to minimise losses of fuelling and TBM lubricants and oil/chemical spills will be contained by appropriate treatment and disposal. Sealants and greases are, by their nature, impervious to water and will remain associated with the tunnel walls or be removed with the spoil and will be reused onsite in accordance with the site material management plan.
Ground conditioning chemicals are used at the cutter head to optimise TBM efficiency and include anti-clogging agents, anti-wear components and soil-conditioning compounds. The exact chemical constituents of the ground conditioning chemicals will depend upon the ground conditions encountered on site and therefore cannot be precisely specified in advance of drilling trials by the tunnelling contractor in 2018. To enable the discharge to be assessed, several potential drilling compounds were reviewed for toxicity and percentage concentration in the drilling fluids; representative products that would represent a worst case discharge were then selected for assessment. Chemical constituents of TBM ground conditioning products BASF Rheosoil 143 and CLB F5 M failed the initial EQS screening and were investigated further using modelling approaches (BEEMS Technical Report TR428).

Discharges of TBM ground conditioning chemicals, during Case D resulted in average sea surface concentrations above the EQS for an area of 0.96 ha and 0.44 ha for CLB F5 M and BASF Rheosoil 143, respectively. Fish are the only designated feature with a reasonable potential impact pathway resulting from sea surface exceedance of contaminant EQS concentrations due to the restricted spatial extent in the vicinity of the offshore jetty discharge. However, the small area of exceedance combined with low fish densities and predicted brief exposure times of fish indicates that the probability of LSE is negligible.

Average seabed concentrations are not predicted to exceed EQS levels. Designated intertidal and subtidal features were not exposed to applied EQS levels (PNEC) throughout the time-course of the simulation. To account for the strong tidal forcing at the site, 95%ile concentrations were considered, particularly in regard to the Sabellaria features to the east of the site which are exposed to the greatest concentrations due to downward mixing. Even when 95%ile concentrations were considered, the highest concentration any Sabellaria feature was exposed to was 3.62 µg l⁻¹ for CLB F5 M, which is 27% of the EQS/PNEC threshold. Only transitory concentration peaks above EQS levels for TBM compounds occurred when maximum concentrations were investigated (100%ile), however the concentration peak and duration of these events is deemed insufficient to cause acute toxicity. Accordingly, benthic invertebrates are not considered to be susceptible to chronic (or acute) toxicity from TBM discharges.
## Summary of Conclusions

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No LSE means likely significant effects are considered improbable.
1 Background

The construction phase of the Hinkley Point C (HPC) nuclear power station requires the discharge of groundwater, sewage, and tunnelling waste-waters. Cefas was commissioned by NNB Generation Company (HPC) Ltd (NNB GenCo) to assess the priority substances and specific pollutants present in these various discharges on the designated features in the Severn Estuary. The assessment will be made under a proposed construction Water Discharge Activity (cWDA) permit application for the temporary jetty at HPC. Installation of the pipelines along the HPC temporary jetty also requires a non-material amendment to the Development Consent Order (DCO) which, to be non-material, requires that the amendment does not have impacts not already assessed under the DCO Habitats Regulations Assessment (HRA).

In England and Wales, the Directive on the conservation of wild birds (Birds Directive) and the Directive on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) are implemented under the Conservation of Habitats and Species (Amendment) Regulations 2012 (the Habitats Regulations). Under the directives a network of protected areas, the Natura 2000 network, has been implemented and includes Special Areas of Conservation (SAC), designated for habitats and species, and Special Protection Areas (SPA) designated for wild birds. These protected areas are described as European Marine Sites when they incorporate areas lying below highest astronomical tide (i.e. subtidal and/or intertidal areas).

The Habitats Regulations require that, where the possibility of a likely significant effect on a Natura 2000 site cannot be excluded (either alone or in-combination with another plan or project), a competent authority must undertake an Appropriate Assessment (AA) as part of the Habitats Regulations Assessment (HRA) process. The Habitats Regulations state that it is the developer’s responsibility to provide sufficient information to the competent authority to enable them to assess whether there are Likely Significant Effects (LSE) and to enable them to carry out the AA, where necessary.

The HPC New Nuclear Build site is located within the Severn Estuary SPA and the Severn Estuary/ Môr Hafren SAC. The area is also designated as a Ramsar site for its internationally important wetland habitats. The site also falls within the Bridgwater Bay Site of Special Scientific Interest (SSSI).

The purpose of this document is to assess the LSE of the construction discharges on the habitats and species designated as part of the Severn Estuary marine protected areas by way of a shadow Habitats Regulations Assessment (HRA). The assessment of LSE draws upon the results of model predictions of the dilution and dispersion of priority substances within the various discharges (BEEMS Technical Report TR428, Ed. 3) and relevant available evidence of the potential impacts of known chemical discharges on designated receptors.
2 Shadow HRA Designated Features

This shadow HRA determines the LSE of the planned activities on the designated species and habitats listed within the Severn Estuary European Marine Site (EMS), comprising of the Severn Estuary SPA and Severn Estuary Ramsar Site, and the Severn Estuary/ Môr Hafren SAC.

Although not part of a HRA the potential effects on species and habitats notified as part of the Bridgwater Bay SSSI are also considered this report at the request of the Environment Agency.

2.1 Severn Estuary SPA

The Severn Estuary SPA is designated for the following features (c.f. the Natura 2000 Standard Data Form version 25/01/2016):

- Internationally important populations of regularly occurring species Bewick's swan (*Cygnus columbianus bewickii*) (Natural England/Countryside Council for Wales, 2009).
- Internationally important populations of regularly occurring migratory species; greater white-fronted goose (*Anser albifrons albifrons*), dunlin (*Calidris alpina alpina*), redshank (*Tringa totanus*), shelduck (*Tadorna tadorna*) and gadwall (*Anas strepera*).
- Species of national importance are also included in the wider waterfowl assemblage.
- Supporting habitats for the over-wintering and migratory bird assemblages (saltmarshes, intertidal mud and sand, hard substrate habitats).

The Conservation Objectives of the 24,487.91 ha (marine area = 22 112.58 ha) SPA site is to maintain each of the regularly occurring migratory bird species and supporting habitats in favourable condition.

Favourable condition is achieved if, subject to natural processes, conditions relating to 5-year peak mean population size for each species and habitat extent are met and that aggregations of individual bird species may not be subject to significant disturbance. Species specific guidance is available in Natural England/Countryside Council for Wales (2009).

2.2 Severn Estuary / Môr Hafren SAC

The Severn Estuary / Môr Hafren SAC is designated for the following features (c.f. NE, 2009 and Natura 2000 Standard Data Form version 25/01/2016):

- **Annex I Habitats** – ‘Estuaries’ (73,677.25 ha), ‘Mudflats and sandflats not covered by seawater at low tide’ (20,271.38 ha), ‘Atlantic salt meadows (*Glaucio-Puccinellietalia maritimae*)’ (656.06 ha), ‘Sandbanks which are slightly covered by sea water all the time’ (11 779.51 ha) and ‘Reefs’ (1,474.28), ‘Hard substrate habitats’ (approx. 1 500 ha) and notable estuarine assemblages (fish, waterfowl and vascular plants).
- **Annex II species** – designated for 3 migratory fish species: sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), and twaite shad (*Alosa fallax*).

The Conservation Objectives of the SAC are to maintain the Annex I and Annex II features in favourable condition.

---

1. From the Natura 2000 Standard Data Form version 25/01/2016
2. The extents of each feature are taken from the Natura 2000 Standard Data Form version 25/01/2016, with the exception of hard substrate habitats. The Standard Data Form does not provide information on hard substrate habitat, so the extent of this feature is taken from the Natural England/Countryside Council for Wales (2009) Regulation Advice.
3. The notable estuarine assemblages and hard substrate habitats are protected as a sub-feature of the estuary feature.
2.3 Severn Estuary Ramsar Site

The Severn Estuary Ramsar Site is designated for the following features (c.f. NE, 2009):

- Estuaries including intertidal mud and sand habitats, Atlantic salt meadows/ marshes as a supporting feature for birds, *Sabellaria* and hard substrates are sub-features of the estuary.
- The estuarine fish assemblage, which is one of the most diverse in Britain with over 110 species recorded.
- Run of migratory fish between sea and river via the estuary. Species include salmon (*Salmo salar*), sea trout (*Salmo trutta*), sea lamprey (*Petromyzon marinus*), river lamprey (*L. fluviatilis*), allis shad (*A. alosa*), twaite shad (*A. fallax*), and European eel (*Anguilla Anguilla*).
- Designated bird species include the species also afforded protection under the SPA designation: Bewick’s swan (*Cygnus columbianus bewickii*), greater white-fronted goose (*A. albifrons albifrons*), dunlin (*C. alpina alpina*), redshank (*T. totanus*), shelduck (*T. tadorna*) and gadwall (*A. strepera*).
- The wider waterfowl assemblage is also included.

The Conservation Objectives of the Severn Estuary Ramsar site mirror those of the SPA and SAC for features in common. In summary, the conservation objectives for migratory fish species requires that:

- alternations in water quality, water flows or physical barriers to not restrict migratory passage of adult or juvenile stages of fish species,
- no decline in the population size of fish in rivers in the catchment area and returning adults occurs,
- the abundance of prey resources in the estuary is maintained.

Details on the conservation objectives for the SAC, SPA and Ramsar sites are provided in Natural England/Countryside Council for Wales (2009).

2.4 Bridgwater Bay SSSI

The Bridgwater Bay SSSI has a total area of 6237.47 ha (including non-marine components), the notified features with a marine component within include (c.f. Natural England, website accessed 11/08/2017):

- Notified bird features include aggregations of non-breeding dunlin (*C. alpina alpina*), shelduck (*T. tadorna*), gadwall (*A. strepera*), black-tailed godwit (*Limosa limosa islandica*), whimbrel (*Numenius phaeopus*), and wigeon (*Anas penelope*).
- The marine habitats notified for management include intertidal mud and sand flats, which support a wide variety of marine invertebrates and represent an important food source for many fish and bird species. Coastal saltmarshes, which provide habitat for invertebrates and act as important nursery sites for several fish species, as well as refuge, feeding and breeding grounds for wading birds and wildfowl (English Nature, 2005).

The Conservation Objectives of the Bridgwater Bay SSSI, relevant to this report, are to maintain the sediment and water quality of the intertidal mud and sand flats and prevent disturbance to birds (English Nature, 2005).
3 Description of Activities and Discharge Screening Process

Groundwater, containing metals and dissolved inorganic nitrogen (DIN), is currently being released under an Environment Agency permit (Permit: EPR/JP3122GM), into the Severn Estuary via a cross shore discharge at the location of the former dry dock (known as Outlet 1). NNB Genco has proposed a system whereby future construction related discharges will be released subtidally, 1 m above the seabed, near the seaward end of the HPC temporary jetty. The point of discharge will be situated beyond 50 m from MLWS in a minimum of 3 m water depth at low water (8.9 m ODN).

The permit application for the proposed construction Water Discharge Activities (CWDA) requires assessment of the following discharges:

1. Dewatering discharges of groundwater from deep excavations from a network of boreholes to prevent excavations becoming inundated with water. Discharges of 20 l s⁻¹ are anticipated throughout the construction phase and contain metals and DIN.

2. Discharges of secondary treated sewage from the main construction plant containing DIN will be released at a rate of 1150 m³/d (13.3 l s⁻¹).

3. Waste water from tunnel excavations during the construction of the cooling water intake and outfalls. This discharge is primarily groundwater, however, small amounts of soil conditioning chemicals associated with TBM tunnelling operations will also be discharged.

Details of the specific chemical discharges and screening process are provided in BEEMS Technical Report TR428 and are summarised below.

The indicative time-line for construction activities (as at August 2017) and associated discharges is presented in Table 1 and illustrated in Figure 1. The construction time-line is multi-phasic with discharge constituents and volumes changing during the course of the construction period and therefore a number of cases have been considered (BEEMS Technical Report TR428). The two worst case discharge profiles are:

i. Case C (April to June 2019 on the current plan) which includes discharges of 20 l s⁻¹ of groundwater, 13.3 l s⁻¹ of treated sewage and up to 30 l s⁻¹ tunnelling discharge (which consists mostly of groundwater with soil conditioning chemicals from 1 TBM). This discharge has the maximum heavy metal discharge. The DIN discharge is at the predicted maximum loading and is the same as for Case D.

ii. Case D (June 2019 onwards) which includes 20 l s⁻¹ of groundwater, 13.3 l s⁻¹ of sewage and 6 - 7 l s⁻¹ tunnelling discharge from 2 TBMs. This discharge has the maximum concentration of TBM soil conditioning chemicals.

The changes in flow rate and approximate duration of each construction phase is illustrated in Figure 1.
Table 1 Indicative time line of the relevant discharges from BEEMS Technical Report TR428 based upon August 2017 construction plans. The approximate duration of each construction phase is provided in Figure 1.

<table>
<thead>
<tr>
<th>Construction Phase</th>
<th>Approximate Date</th>
<th>Sewage</th>
<th>Dewatering Groundwater</th>
<th>Tunnelling groundwater and associated compounds</th>
<th>Total jetty discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case A</td>
<td>February 2018 Jetty discharge pipeline available.</td>
<td>Sewage discharged at Outlet 1 (dry dock) at a rate of 6.48 l s⁻¹</td>
<td>Dewatering discharge at Jetty 20 l s⁻¹</td>
<td>None</td>
<td>20 l s⁻¹</td>
</tr>
<tr>
<td>Interim-Phase</td>
<td>April 2018 Tunnelling starts.</td>
<td>Outlet 1 at 6.48 l s⁻¹</td>
<td>20 l s⁻¹</td>
<td>Approx. 7 l s⁻¹ until ~ September 2018</td>
<td>Ramp-up</td>
</tr>
<tr>
<td>Case B</td>
<td>September 2018</td>
<td>New treatment plant discharges 13.3 l s⁻¹ from the jetty - temporary plant continues discharging 6.48 l s⁻¹ from Outlet 1</td>
<td>20 l s⁻¹</td>
<td>12 l s⁻¹ ramping up to nearly 30 l s⁻¹. Mostly groundwater but includes soil conditioning chemicals from 1 TBM working on intake 1)</td>
<td>Ramp-up Up to 63 l s⁻¹</td>
</tr>
<tr>
<td>Case C</td>
<td>April 2019 Max combined flow</td>
<td>Sewage discharges from the jetty only at 13.3 l s⁻¹</td>
<td>20 l s⁻¹</td>
<td>Up to 30 l s⁻¹ at the Jetty (mostly groundwater but includes soil conditioning chemicals from 1 TBM working on intake 1).</td>
<td>63 l s⁻¹</td>
</tr>
<tr>
<td>Case D.</td>
<td>June 2019 onwards</td>
<td>Sewage discharges from the jetty at 13.3 l s⁻¹</td>
<td>20 l s⁻¹</td>
<td>SCL works complete, Tunnelling continues on HPC outfall and intake 2. The maximum use of TBM soil conditioning chemicals will correspond to the output from 2 TBMs working simultaneously. 6 l s⁻¹</td>
<td>40 l s⁻¹</td>
</tr>
</tbody>
</table>

At the onset of construction, in Case A, groundwater dewatering discharges commence at 20 l s⁻¹ and remain at this level throughout construction. Once tunnelling begins (approximately April 2018) the discharge from the SCL (Spray Concrete Lined) tunnelling works begin to ramp up and contribute to an increase in total groundwater discharges for approximately 50 weeks. At their maximum point, during Case C, discharges peak at up to 63 l s⁻¹ (Figure 1), with a typical groundwater component constituting 46 l s⁻¹ (dewatering groundwater + groundwater associated with tunnelling waste). During the final construction phase, Case D, discharges from the SCL decrease to low levels resulting in a reduction in the total groundwater discharges to approximately 25 l s⁻¹. During Case D, the waste from the TBM soil conditioning chemicals is at its highest at approximately 40 l s⁻¹.

Sewage discharges from the temporary plant at Outlet 1 and the new treatment plant discharged at the jetty may overlap initially (Case B), however, the total discharge of DIN is capped by the number of people on site. Maximum discharges of metal and ammoniacal nitrogen at the jetty will occur during Case C.
Figure 1. Estimated discharge flow volumes and duration from the proposed jetty discharge point at each construction phase (Cases A-D, detailed in Table 1). Discharge flow from ‘yard’ (wash-water) and TBM tunnelling for intake 1, outfall and intake 2 are shown on the right-hand axis. Indicative construction dates are provided in Table 1. Timing is according to the August 2017 construction scheduling and is subject to change.
3.1 Summary of H1 Screening Assessment for Groundwater and Sewage Discharges

The concentration of groundwater contaminants was assessed by initial screening tests, referred to previously as H1 screening. The screening provides a preliminary assessment to determine conformity to specified Environmental Quality Standards (EQS) in accordance with the surface water risk assessment (Environment Agency and Department for Environment Food and Rural Affairs, 2016). Potential EQS exceedance was tested for the following compounds relative to their baseline concentrations in the receiving waters (BEEMS Technical Report TR428):

- Un-ionised ammonia
- DIN
- Cyanide
- Total cadmium
- Total chromium
- Total lead
- Total copper
- Total zinc
- Total mercury

The 95th percentile concentrations of groundwater contaminants based on data from groundwater measurements (Atkins, 2016) were applied in the screening for discharges to Transitional and Coastal waters (TraC). This approach enabled a reasonable worst-case scenario for determining the magnitude of discharge contaminants during construction activities whilst accounting for the different geology in the area, and hence contaminant concentrations.

Screening assessments were completed for Case C (maximum groundwater flow) and also for Cases A and D. For Case A and D, only zinc and copper failed the initial screening of the groundwater discharge. During the 8-week period of maximal discharges (Case C), in addition to zinc and copper, chromium also marginally failed the initial screening test.

It should be noted that during the initial assessment (and subsequent modelling), the total concentration of the substances was considered. This is a precautionary approach, mitigating for uncertainty regarding the partitioning of substances into the dissolved phase when the freshwater discharge mixes with the receiving seawater. For groundwater metals, solubility may decrease as salinity increases as neutral hydrophobic chemicals and some metals have been shown to decrease in solubility under saline conditions (Turner, 2003).

Mercury and cadmium have assigned annual load limits, of 1 kg and 5 kg, respectively. Neither substance exceeded annual load limits throughout the construction time-line.

A summary of the screening process is provided in Table 2, further details are provided in BEEMS Technical Report TR428.
Table 2 Groundwater contaminants and concentrations likely to be present in the construction dewatering discharge and comparison to EQS for Cases A & D and Case C. AA refers to annual average concentration and MAC refers to the maximum allowable concentration. Effective Volume Flux (EVF) has been derived using 95%ile discharge concentrations and the AA EQS (except for mercury where the MAC EQS has been used). The shaded values indicate those used in the H1 screening assessment. The initial screening result for subtidal discharges in Transitional and Coastal waters (TraC), “Test 5” is provided. (See BEEMS Technical Report TR428).

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Mean</th>
<th>95%ile (used in H1)</th>
<th>Saltwater AA EQS&lt;sup&gt;1&lt;/sup&gt; µg l&lt;sup&gt;-1&lt;/sup&gt;</th>
<th>Saltwater MAC&lt;sup&gt;2&lt;/sup&gt; EQS (as 95%ile) (µg l&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Background&lt;sup&gt;3&lt;/sup&gt; concentration (µg l&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>EVF: Case A &amp; Case D</th>
<th>EVF: Case C</th>
<th>TraC Water Test 5 EVF&lt; 3.0 Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Un-ionised ammonia (N)&lt;sup&gt;3&lt;/sup&gt;</td>
<td>123.5</td>
<td>21</td>
<td>4.6&lt;sup&gt;4&lt;/sup&gt;</td>
<td>0.3</td>
<td>0.77</td>
<td>Pass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIN</td>
<td>2951</td>
<td>7685</td>
<td>2520&lt;sup&gt;5&lt;/sup&gt;</td>
<td>1050</td>
<td>0.2</td>
<td>0.32</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Cyanide</td>
<td>0.025</td>
<td>50</td>
<td>1</td>
<td>0.04</td>
<td>1</td>
<td>2.3</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Total cadmium</td>
<td>0.122</td>
<td>0.374</td>
<td>0.2</td>
<td>0.04</td>
<td>0.1</td>
<td>Pass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total chromium</td>
<td>0.06</td>
<td>39.4</td>
<td>0.6&lt;sup&gt;1&lt;/sup&gt;</td>
<td>32</td>
<td>0.02</td>
<td>1.36</td>
<td>Fail</td>
<td></td>
</tr>
<tr>
<td>Total lead</td>
<td>1</td>
<td>3</td>
<td>1.3</td>
<td>14</td>
<td>0.02</td>
<td>0.016</td>
<td>0.11</td>
<td>Pass</td>
</tr>
<tr>
<td>Total copper</td>
<td>31.7</td>
<td>199.5</td>
<td>4.76</td>
<td>3.95</td>
<td>4.926</td>
<td>11.5</td>
<td>Fail</td>
<td></td>
</tr>
<tr>
<td>Total zinc</td>
<td>429</td>
<td>1620</td>
<td>6.8</td>
<td>2.62</td>
<td>15.5</td>
<td>25.19</td>
<td>Fail</td>
<td></td>
</tr>
<tr>
<td>Total mercury</td>
<td>0.3</td>
<td>1</td>
<td>-</td>
<td>0.07&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.02</td>
<td>0.4</td>
<td>0.9</td>
<td>Pass</td>
</tr>
</tbody>
</table>

1 The EQS in seawater is set for dissolved hexavalent chromium only but this is dissolved total chromium. 2 The EQS for mercury is only set as a 95 percentile. 3 Except for zinc the background concentrations are derived from monitoring data. Amec, 2009. Zinc value derived from EA data in Appendix B. 4 Unionised ammonia data derived using total ammonium data (Amec, 2009) and using the EA unionised ammonia calculator and average conditions of pH, temperature, and salinity for Hinkley Point. 5 99% standard for period 1<sup>st</sup> November – 28<sup>th</sup> February for dissolved inorganic nitrogen for Good status.

3.1.1 Zinc discharge plume modelling

Zinc exceeded the initial EQS screening by the greatest margin (Table 2) and was therefore selected for further assessment of the discharge plume dynamics using modelling approaches, and used as a proxy for copper to determine the worst-case scenario. All other groundwater contaminants are screened out at this stage.

Discharges of zinc were modelled using a 25 m by 25 m resolution, 3D hydrodynamic GETM model with an inbuilt passive tracer to representing zinc (BEEMS Technical Report TR428). Briefly, the passive nature of the tracer assumes that there is no loss of zinc due to sediment absorption or biological uptake, furthermore, the effects of waves, which enhance vertical mixing and increase dilution are not incorporated into the model. Thus, the estimated plume dynamics are conservative, based only on dilution by hydrodynamic forces.

Meteorological conditions, primarily wind speed and direction, can influence the plume trajectory and were modelled based on a worst-case scenario for specific designated features. The model inputs and results are discussed in relation to the individual receptors, principally Sabellaria and Corallina waterfalls, in the relevant sections below.

The background concentration of dissolved zinc in the environment is 2.62 µg l<sup>-1</sup> (Appendix B, BEEMS Technical Report TR428) while the Environmental Quality Standard is 6.8 µg l<sup>-1</sup>. When comparing the model...
results against the EQS, an adjusted threshold value of 4.18 g µl$^{-1}$ was used to account for the background concentration of zinc. The EQS for zinc is an annual average value.

### 3.2 Summary of Screening Assessment for Tunnelling Discharges

Tunnel boring machines (TBMs) will be used to excavate the two cooling water intake tunnels and the cooling water discharge tunnel. The tunnels are constructed in sections with a ring added for each 1.5 m of drilling. At the maximum drilling rate 24-rings per day can be installed by each TBM for the intake tunnels and 16-rings per day for the outfall tunnel. For operational reasons including power availability, all three TBMs will not be operating at full capacity simultaneously and a realistic maximum construction estimate is 40 rings per day.

The greatest discharge produced during tunnelling is groundwater. Ground water, generated from digging the galleries allowing access to the tunnels, is considered in the assessment in combination with dewatering discharges of similar chemical composition (Case C).

In addition to groundwater, smaller quantities of water containing chemicals emanating from tunnelling operations will be produced. Chemical use in tunnelling are associated with three broad functions including:

- Fueling and lubrication of the TBM
- Sealing the tunnel walls against water/soil ingress
- Ground conditioning

Management protocols will be implemented to minimise losses of fuelling and TBM lubricants and oil/chemical spills will be contained by appropriate treatment and disposal. Sealants and greases are, by their nature, impervious to water and will remain associated with the tunnel walls or be retained within the spoil (with the remainder to be disposed of through an appropriate licensed disposal route).

Ground conditioning chemicals are used at the cutter head to optimise TBM efficiency. Spoil from the cutting face is initially removed by a screw conveyor, then transported by conveyor belt to the muck bay. During the transport of spoil material, ground conditioning fluids can leach from the conveyor belts and fall to the tunnel floor. Waste-water and associated chemicals on the tunnel floor will be pumped out with natural groundwater to be discharged at the jetty. The screening assessment is based on a tunnelling rate of 40 rings per day producing 48 litres of ground conditioning product per intake ring and 64 litres for the outfall tunnel rings. It is assumed that 10 % of the active conditioning substance from the tunnel floor and muck bay will be discharged, whilst the remaining 90 % adsorbed to the soil.

Ground conditioning chemicals include anti-clogging agents, anti-wear components and other soil-conditioning compounds. The exact chemical constituents of the ground conditioning chemicals will depend upon the ground conditions encountered on site and therefore cannot be precisely specified in advance of drilling trials by the tunnelling contractor in 2018. In order to enable the discharge to be assessed a list of potential drilling compounds was reviewed for toxicity and percentage concentration in the drilling fluids and representative products that would represent a worst-case discharge were selected for assessment (BEEMS Technical Report TR428).

The active substances in the TBM chemical products were identified from respective material safety datasheets. The substances identified are surfactants from chemical groups commonly found in household detergent products for which there are a range of toxicity studies available. Based upon common elements of their chemical composition, Predicted No Effect Concentrations (PNEC) have been established for representative surfactants and these have been applied here (Table 3).

The PNEC values shown in Table 3 for each active substance are either taken directly from relevant risk assessment reports i.e. for 2-methyl-2-4 pentanediol (SIDS initial assessment report, 2001), or use the lowest PNEC from a substance group assessment i.e. PNEC values calculated for other alcohol ethoxylate sulphates are derived for representative carbon chain length substance or worst case if not known (Table 15 in HERA, 2004,) and for mono-C10-16-alkyl sodium sulphate (Table 13 HERA 2002). The discharge assessment is based on the component within the product that is present in the highest quantities and has the lowest PNEC. In the case of the anti-clogging agent BASF Rheosoil 143, the active substance is sodium...
lauryl ether sulphate and for soil conditioning-additive, CLB F5 M the active substances with the lowest PNEC is are from the mono-C10-16-alkyl sodium sulphate group (Table 3).

Table 3. ‘H1’ assessment of example of ground conditioning chemicals and the active substances. The initial screening result for subtidal discharges in Transitional and Coastal waters (TraC) Test 5 is provided. Chemicals failing the TraC Test are assessed in greater detail.

<table>
<thead>
<tr>
<th>Conditioning product</th>
<th>Main active substance</th>
<th>Estimated Discharge concentration mg l⁻¹ of active substance³</th>
<th>Saltwater AA EQS µg l⁻¹</th>
<th>Background concentration µg l⁻¹</th>
<th>Effective volume flux (Case D) (m³ s⁻¹)</th>
<th>TraC Water test 5 EVF&lt; 3.0 (Pass/Fail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-clogging agent.</td>
<td>Sodium lauryl ether sulphate. (&lt;30%)</td>
<td>19.8</td>
<td>40¹</td>
<td>0</td>
<td>32.3</td>
<td>Fail</td>
</tr>
<tr>
<td>BASF Rheosoil 143</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil conditioning additive.</td>
<td>Ethoxylated, sulphates. (≤10%)</td>
<td>6.6</td>
<td>35¹</td>
<td>0</td>
<td>12.3</td>
<td>Fail</td>
</tr>
<tr>
<td>CLB F5 M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLB F5 M</td>
<td>Mono-alkyl sodium sulphate. (≤10%)</td>
<td>6.6</td>
<td>4.5²</td>
<td>0</td>
<td>107.4</td>
<td>Fail</td>
</tr>
</tbody>
</table>

¹These EQS values were derived from HERA 2004 for both BASF Rheosoil 143 (sodium lauryl ether sulphate).

2. A group of compounds known as alkyl sulphates (AS) are found in CLB F5 M. Toxicity of AS compounds increases with increasing alkyl chain length (C12-C18), whilst solubility is inversely related to chain length. As such, C14 has the lowest reported NOEC values of the AS group. PNEC values for each AS chain-length have been established by applying a factor of 10 to the lowest chronic NOEC; the PNEC for C14 is 4.5 µg l⁻¹ (HERA, 2002). The C14 PNEC is over 4-fold lower than the next most toxic chain-length AS, however, it has been applied as the EQS value as a precautionary measure. The PNEC values are conservative and values derived from micro- and mesocosm studies have identified PNECs in the range of 7.5 – 224 µg l⁻1, and 110 µg l⁻1, respectively (HERA, 2002; and references therein).

4 Assessment of Construction Discharges on Designated Features

The screening process, summarised above, provides the initial stage in the assessment of potential effects on marine receptors within the estuary. Screening was used to identify which discharge compounds required further assessment to determine likely significant effects (LSE). Here, the pathways for eliciting effects on marine receptors are identified and the significance of those effects are assessed.

LSE are “any effect that may reasonably be predicted as a consequence of a plan or project that may affect the conservation objectives of the features for which the site was designated, but excluding trivial or inconsequential effects” (English Nature, 1999).

An activity is considered to generate a LSE when there is credible evidence to suggest risk. Conversely, if an effect pathway is possible but evidence suggests the overall effect is unlikely due to lack of vulnerability (sensitivity or exposure) of the receptor, or if the pathway is considered trivial or inconsequential no LSE exists. This is most likely to be the case when the scale of the activity is very small or short-lived in comparison to the receptor concerned. The receptors tested here are those designated under the relevant legislation with respect to the Severn Estuary SPA, SAC, Ramsar site and Bridgwater Bay SSSI.

In accordance with the EU Habitats Regulations, the LSE of the activities are determined through an initial screening exercise; any identified LSE is then subject to an Appropriate Assessment by a competent authority. As such, testing for significant effects is a coarse filter intended to identify the proposed plans and projects which have the potential to significantly effect a designated feature or conservation objective and therefore require further investigation.

The proposed jetty discharge activities were assessed in relation to the effect categories stated by Natural England/Countryside Council for Wales in their Regulation 33(2a) advice for the Severn Estuary EMS (Natural England/Countryside Council for Wales, 2009).

Effect categories:

1. **Physical loss of feature through substratum loss or smothering** - No physical removal of habitat or species is proposed. Neither is deposition of material proposed, which lead to smothering of habitats and species. No effect pathway exists and the effect category is not considered further.

2. **Physical damage to habitat, for example flow rates or changes to wave exposure suspended sediment levels or abrasion of habitats** - No physical damage to estuarine habitats is predicted. No effect pathway exists and the effect category is not considered further.

3. **Non-physical disturbance through noise or visual disturbance** - No noise or visual disturbance is predicted from the jetty discharge. No effect pathway exists and the effect category is not considered further.

4. **Toxic contamination by introduction of synthetic and/or non-synthetic compounds or radionuclides** – Potentially toxic levels of zinc and copper from groundwater discharges and TBM chemicals may occur and are considered in detail in relation to the designated features in Section 5.2.

5. **Non-toxic contamination including nutrients, thermal regime, turbidity, salinity or oxygenation** – Non-toxic inputs of DIN occur and are assessed in Section 5.1.

6. **Biological disturbance by selective extraction (e.g. selective extraction of species, introduction of pathogens or non-native species)** - No biological disturbance is predicted. No effect pathway exists and the effect category is not considered further.
5 Sewage and groundwater assessment

Sewage and total groundwater (i.e. the combined product of dewatering groundwater and groundwater produced during the construction of cooling water tunnels) (Table 1, Figure 1), is assessed below in relation to potential LSE pathways for ‘non-toxic’ and ‘toxic’ contamination. An LSE assessment of the toxic contaminants in TBM ground conditioning chemicals is provided in Section 6. Modelling results presented below are taken from BEEMS Technical Report TR428, unless otherwise stated, and are specifically based on the assumptions and parameterisation of the model.

5.1 Evidence base supporting LSE assessment for ‘Non-Toxic Contamination’

The jetty discharge will release dissolved inorganic nitrogen (DIN) into the estuary. Under the Water Framework Directive Standards, the Bridgwater Bay waterbody has ‘Good’ status for DIN. Discharges result in a very localised elevation in DIN in the receiving waterbody and the initial screening test was passed (Table 2).

The average annual uplift from the jetty discharge during year 1 was estimated at 0.36 µmol l⁻¹ relative to mean annual concentration of 75 µmol l⁻¹ within Bridgwater Bay and so ‘Good’ status is maintained. Due to the high turbidity environment, productivity in the Severn is light-limited (Underwood, 2010) and the effects of minor DIN loading on the designated Severn Estuary features are deemed insignificant and not assessed further. In-combination effects of discharges from HPB and Outlet 1 are considered in Section 7.

5.2 Evidence base supporting LSE assessment for ‘Toxic Contamination’

5.2.1.1 Un-ionised ammonia

Using the EA calculator, the EQS for un-ionised ammonia (21 µg l⁻¹) was marginally exceeded in Case C only, by 0.2 µg l⁻¹ in the immediate vicinity of the discharge (diameter 10 m). Rapid dilution rates mean that the EQS is only exceeded during Case C when groundwater discharges and sewage discharges are at their maximum. The total area of EQS exceedance is 0.005 ha and even during maximum discharges the initial screening test was passed (Table 2). No likely significant effects are predicted from the discharge of un-ionised ammonia. An additional assessment of the in-combination effects of concurrent sewage discharges from the temporary jetty and Outlet 1 further concluded no significant effects (Section 7).

5.2.1.2 Contaminant metals and the behaviour of the discharge plume

The discharge contaminants considered in greater detail following the initial screening assessment were zinc and copper. Zinc failed the initial screening EQS by the largest margin, accordingly subsequent modelling was based on zinc discharges. Chromium also failed the initial screening marginally during Case C, however the area of exceedance relative to zinc was minimal and not assessed further. The results of the discharge model for zinc are summarised below and discussed in relation to each of the designated features.

The behaviour of the discharge plume in relation to the tidal cycle is key to establishing potential interactions of the contaminants in solution with designated features. The low salinity plume is initially buoyant. During the flood tide the plume begins to elongate and at maximum tidal velocities advection causes a narrow surface streak to form, which is mixed down through the water column. As mixing occurs the concentration within the streak rapidly drops. The plume has a west-east orientation running parallel to the shore with limited north south dispersion. At high water slack tide, the buoyant discharge water pools at the surface. The tidal range in the Severn is such that at high slack water the buoyant surface pool will be separated vertically from the seabed with little interaction with the benthos.

As the tide begins to ebb the pooled plume becomes advected westwards. As the ebb tide increases in velocity, the strong tidal flows and rough topography of the Severn Estuary generates strong vertical mixing resulting in a large reduction in the concentrations of contaminants in the discharged water.
The discharge plume has the greatest potential for interactions with benthic features and communities during low water slack tide, as the pooled discharge water sits closest proximity to the seabed. However, CORMIX modelling indicated that the buoyant plume rapidly comes to the surface, and little downward mixing occurs. Rapid dilution results in a very small foot print (radius < 5 m or 78 m²) on the seabed (BEEMS Technical Report TR428).

Modelling was completed to establish the area of EQS exceedance of zinc for Cases C and D. The results from the zinc discharge model were used as a proxy for copper, enabling a conservative estimate for the latter contaminant.

The total sea surface area exceeding the EQS for zinc during the 8-week period (ca. April to June 2019) of maximum discharges during Case C is **0.625 ha**.

Longer-term discharge rates, expected during construction operations described under Case D, results in a sea surface area of **0.125 ha** in exceedance of the EQS.

### 5.2.2 Estuaries

The total area defined as Annex I Estuary habitat within the Severn Estuary / Môr Hafren SAC is 73,677.25 ha and dominates the habitat type of the site. Estuary features are also included within the SPA as a supporting habitat for designated birds and under the Ramsar and SSSI notifications.

In the case of zinc, the total sea surface area exceeding the average EQS for the short-term period of maximum discharges during Case C equates to **< 0.001 %** of the estuary SAC feature (Table 4; Figure 3).

Longer-term discharges during Case D cause a sea surface area corresponding to **< 0.0002 %** of the SAC estuary area to exceed the zinc EQS (0.125 ha).

Average concentrations of zinc and other contaminants in the buoyant discharge plume are not predicted to exceed the EQS at the seabed.

Due to the small spatial extent of the discharge plume no LSE is predicted for the conservation objectives of the estuary feature.

The spatial distribution of the average sea surface and seabed concentrations of zinc in the discharge plume can be viewed in Figure 2 and Figure 3, respectively.

Table 4. Total area (ha) of the discharge plume in exceedance of the zinc EQS, and the percentage of the designated estuary feature (73,677.25 ha). The EQS is an average annual concentration threshold, at the discharge site the threshold is set at 4.18 µg l⁻¹ above background concentrations.

<table>
<thead>
<tr>
<th>Construction Phase</th>
<th>Area of sea surface exceeding the EQS</th>
<th>% of the SAC estuary feature above the surface EQS threshold</th>
<th>Area of seabed exceeding the EQS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case C</td>
<td>0.625 ha</td>
<td>0.00085 %</td>
<td>0 ha</td>
</tr>
<tr>
<td>Case D</td>
<td>0.125 ha</td>
<td>0.00017 %</td>
<td>0 ha</td>
</tr>
</tbody>
</table>

### 5.2.3 Mudflats and Sandflats not covered by seawater at low tide

The area of ‘mudflats and sandflats not covered by seawater at low tide’ is located to the east of Hinkley Point, several kilometres away from the jetty discharge site. This designated habitat feature is greatly beyond the extent of the discharge plume, accordingly there is no effect pathway and the receptor is not considered for further assessment.
5.2.4 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

The area of ‘Atlantic salt meadows’ (*Glauco-Puccinellietalia maritimae*) and the area of ‘mudflats and sandflats not covered by seawater at low tide’ are located to the east of Hinkley Point, several km from the jetty discharge site. The discharge plume does not intersect this habitat and no further assessment is made.

5.2.5 Sandbanks which are slightly covered by sea water all the time

The area of ‘sandbanks which are slightly covered by sea water all the time’ is located in the subtidal area, at the mouth of the River Parrett well beyond the extent of the discharge plume. The discharge plume does not intersect this habitat and no further assessment is made.

5.2.6 Reefs

Intertidal and subtidal biogenic reefs formed by the honeycomb worm *Sabellaria alveolata* and subtidal *S. spinulosa* reefs have been identified in the area of the jetty discharge. Data collected from a number of surveys on the distribution of intertidal and subtidal *Sabellaria* is provided in (BEEMS Technical Report TR414).

5.2.6.1 Sabellaria and zinc discharges

Subtidal *Sabellaria* reef features are not predicted to come into contact with zinc concentrations exceeding the EQS during the long-term construction phase (Case D), or during the maximum construction discharges in Case C (BEEMS Technical Report TR428).

Intertidal *S. alveolata* located at position G (Figure 2) will be exposed to the highest concentrations of zinc. The mean seabed concentration at this position is predicted to be < 0.12 µg l⁻¹ above background concentrations for Case C during the period of highest groundwater discharge. Even accounting for the 95%ile seabed concentration experienced during the model run for Case C, zinc concentrations are predicted to peak at 0.33 µg l⁻¹ above the background well within the EQS threshold (BEEMS Technical Report TR428).

95%ile zinc concentrations experienced at Position G (to the east of the jetty) during the longer-term construction phase (Case D) are predicted to be less than 0.14 µg l⁻¹ above the background concentration, approximating 3 % of the EQS threshold, whilst mean concentration increases are 0.05 µg l⁻¹ (Table 5).
Table 5 Mean and 95%ile zinc concentrations at subtidal Sabellaria patches A and E, and intertidal patches B, C, D, F, and G for month-long model simulations for long-term operations during Case D and maximum discharges during Case C.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Mean seabed µg l⁻¹</th>
<th>Seabed µg l⁻¹ (95%ile)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case D</td>
<td>Case C</td>
</tr>
<tr>
<td>Subtidal Sabellaria A</td>
<td>0.014</td>
<td>0.032</td>
</tr>
<tr>
<td>(Easting 321350 Northing 147040)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal Sabellaria B</td>
<td>0.037</td>
<td>0.086</td>
</tr>
<tr>
<td>(Easting 320800 Northing 146694)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal Sabellaria C</td>
<td>0.023</td>
<td>0.054</td>
</tr>
<tr>
<td>(Easting 320300 Northing146351)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal Sabellaria D</td>
<td>0.019</td>
<td>0.044</td>
</tr>
<tr>
<td>(Easting 319118 Northing 16309)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtidal Sabellaria E</td>
<td>0.033</td>
<td>0.078</td>
</tr>
<tr>
<td>(Easting 320800 Northing 146800)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal Sabellaria F</td>
<td>0.037</td>
<td>0.0887</td>
</tr>
<tr>
<td>(Easting 321824 Northing146800)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal Sabellaria G</td>
<td>0.050</td>
<td>0.1182</td>
</tr>
<tr>
<td>(Easting 321529 Northing146793)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Potential for bioaccumulation effects

Similar to many polychaetes, Sabellaria has been shown to be resilient to high zinc concentrations. Rubal et al., (2014) recorded the presence of S. alveolata as an important contributing taxon at two impacted sites, where zinc concentrations of ≤10 µg l⁻¹ and over 40 µg l⁻¹ were measured. Copper is present at lower concentrations than zinc in the groundwater and failed the initial screening by a smaller margin (Table 2), accordingly elevated concentrations of copper that Sabellaria will be exposed to will be considerably lower than that of zinc. Polychaetes have been shown to be relatively tolerant to copper contamination with NOEC > 10 µg l⁻¹ reported from several studies (WFD-UKTAG, 2012b). See Section 5.2.8 for further details on invertebrate tolerance to copper and zinc.

The modelling assesses the potential for the Sabellaria feature to interact with zinc in solution within the plume. However, zinc, and other contaminants, may also enter benthic communities through adsorption of dissolved metals onto particulate material within the water column. Subsequent deposition during periods of low energy may result in contaminants becoming available for benthic biota, including Sabellaria. Zinc is known to accumulate in UK estuarine sediments including the Severn and deposition of particulate metals forms an important part of sediment loading. However, the strong hydrodynamic nature of the Severn Estuary and high levels of turbidity mean that contaminated sediments are mixed and dispersed over large areas rather than concentrating near point source discharges (Langston et al., 2003). Furthermore, the mean concentration of zinc in the discharge plume interacting with the seabed (Figure 2) and the overlying surface waters (BEEMS Technical Report TR428) at the position of the Sabellaria patches is orders of magnitude below the EQS. Polychaete species are relatively tolerant to sediment-bound zinc, with tissue concentrations either independent or weakly related to sediment concentrations, suggesting a regulatory ability (Bryan & Langston, 1992). As such, no LSE is predicted in relation to discharges of zinc or copper.
Figure 2. The spatial distribution of the discharge plume showing the mean seabed concentration of zinc (µg l⁻¹) during the maximum construction phase discharges, Case C (worst-case). The distribution of *Sabellaria* is delineated and the location of subtidal *Sabellaria* patch A and E, and intertidal *Sabellaria* patches B, C, and D, F and G are marked. The EQS for zinc is 4.18 µg l⁻¹ above background concentrations.

### 5.2.7 Hard Substrate Habitats

Modelling was completed to identify the potential for the discharge plume to interact with the hard substrate habitats on the rock platform where *Corallina officinalis* waterfalls and *Sabellaria alveolata* reefs occur.

Whilst the tide is the primary mode of transport and dilution of the plume, wind forcing from the north has the potential to push the plume in a southerly direction where it may have a greater probability of interacting with the hard substrate features. To account for this, modelling incorporated wind scenarios from the month of November 2008. The selected month had both the highest proportion of northerly winds, and the highest percentage of days with average wind speeds in exceedance of 5-15 m s⁻¹ from N and NW directions. Therefore, results can be considered a worst-case scenario of real weather conditions.

#### 5.2.7.1 Corallina waterfalls

*Corallina* waterfalls have been identified as features of interest on the rocky intertidal platform (BEEMS Technical Report TR256). Tidal transport results in the spatial extent of the plume extending further in a along-shore, east-west direction with limited north-south dispersion (Figure 3).

None of the *Corallina* waterfalls is predicted to be exposed to areas of the discharge plume that exceed the EQS. Indeed, during Case C, the mean seabed concentration is estimated to increase by only approximately
1 % of the EQS at each of the eight Corallina positions. Figure 3 illustrates the mean sea surface zinc concentration relative to the Corallina positions, mean seabed concentrations are illustrated in Figure 2 (Corallina features not shown).

When the maximum seabed zinc concentration modelled (100%ile) is considered, the highest concentration of zinc is 1.03 µg l⁻¹ at position 5, four times lower than the EQS threshold (see Table 8; BEEMS Technical Report TR428). Therefore, no LSE are anticipated on the Corallina waterfalls.

Figure 3. The spatial distribution of the discharge plume showing average surface concentrations of zinc for Case C in relation to the Corallina features. The plot shows concentrations above background levels, as such the EQS is 4.18 µg l⁻¹ and is exceed in a small area by the discharge itself. Corallina waterfalls are labelled 1-8, the two waterfall locations identified as being at risk from the jetty construction are boxed as Waterfall A and Waterfall B.

5.2.8 Marine Invertebrate Assemblages (as a food source for fish and birds)

Marine invertebrates form an important part of the diet of estuary fish and designated species of birds. Food web-effects have the potential to be mediated through reductions in prey availability resulting from toxicity or through bioaccumulation of contaminants within invertebrate prey tissues, which is subsequently biomagnified up the food web. Both impact pathways are considered in relation to fish and designated bird species.

5.2.8.1 Benthic Invertebrates

The effect of the plume on benthic invertebrates is the primary consideration for food-web effects for two reasons; firstly area-restricted benthic invertebrates are most likely to have the greatest exposure time to the discharges and, secondly, intertidal benthic invertebrates make up a major contributory component of the diet of designated bird species (Table 6). Designated fish species have the potential to be susceptible to
indirect food-web effects should subtidal invertebrate prey be exposed to toxicological effects. Designated bird species, however, feed intertidally and not subtidally, meaning there is no impact pathway between birds and subtidal invertebrates.

**Direct Toxic Effects**

The discharge plume is buoyant and the EQS for zinc is not predicted to be exceeded at the seabed. As such, there is no pathway for direct toxicological effects on benthic marine invertebrates and no predicted food-web LSE.

**Bioaccumulation of Contaminants**

There is the potential for contaminant-bound particles to settle out of suspension and enter benthic foodwebs. Indeed, important bioavailable sources of zinc for benthic organisms include sediment-bound phases, zinc dissolved in interstitial water and in the overlying waterbody (Bryan and Langston, 1992). The extreme tidal range in the Severn Estuary results in dynamic mixing of contaminant-bound sediment particles (Langston et al., 2003).

Intertidal feeding habitats are not predicted to come into contact with waterborne concentrations of zinc, or indeed copper, above the EQS (Sections 5.2.6 and 5.2.7) at any point during construction. Furthermore, many benthic invertebrates are able to regulate tissue zinc concentrations (Bryan and Langston, 1992), and bioaccumulation and biomagnification of zinc up the food chain is considered to be low level (WFD-UKTAG, 2012a). Given that discharge metal concentrations do not exceed the EQS on the seabed it is predicted that effects from metal discharges on benthic invertebrates will be negligible.

Fish feeding on benthic invertebrates along with intertidal feeding waterfowl are not predicted to incur significant food-web effects from accumulation of metal contaminants originating from the jetty discharge plume.

5.2.8.2 **Epi-benthic crustaceans**

Total annual impingement of crustaceans at HPB between 2009-2010 was estimated to be 10,000 kg. Shrimp species, particularly *Crangon crangon*, accounted for both the greatest biomass and greatest number of impinged individuals. Epi-benthic species of shrimp such as *C. crangon*, *Pasiphaea sivado* and *Pandalus montagui* contributed over 85% of the impinged crustacean biomass (BEEMS Technical Report TR129) and are important prey items for many species of fish and designated birds such as redshank (Table 6).

**Direct Toxic Effects**

*Crangon crangon* feeds on the intertidal mudflats at Bridgwater Bay at high water (Henderson et al., 2006). The discharge plume does not exceed the EQS on the seabed and the epi-benthic feeding mode of *C. crangon* and other shrimp species, coupled with very high biomass suggests that it is highly unlikely that the population of this important prey species will be directly affected by jetty discharges.

**Bioaccumulation of Contaminants**

As discussed above, important intertidal feeding habitats are not predicted to come into contact with metal concentrations above the EQS. Thus, the pathway for bioaccumulation resulting from metal discharges in mobile epi-benthic crustaceans is lacking.

5.2.8.3 **Summary of food-web effects**

The concentrations of metal contaminants coming into contact with important intertidal feeding areas is predicted to be low relative to background conditions and well within the EQS. No chronic toxicity is predicted preventing negative impacts on invertebrate populations. In addition, the dynamic sediment environment, coupled with the ability of many species to regulate zinc, and the lack of biomagnification up the food-chain, indicates that food-web effects will be minimal. It is therefore highly unlikely that the predicted
discharges of copper and zinc will have significant food-web effects on designated fish species or the assemblages as a whole or intertidal feeding birds within the estuary.

5.2.9 Migratory Fish and Wider Fish Assemblage

Small areas of the sea surface are predicted to exceed the EQS for zinc during constructions phases Case C and longer-term Case D (Table 4). The likelihood of the protected fishes (allis and twaite shad, river and sea lamprey, eel, salmon and sea trout) being exposed to the toxic contaminants in the discharge plume is considered to be extremely low. The worst-case discharge zone above the zinc EQS of 0.625ha or 0.00085% of the SAC at the surface, forms either a narrow ribbon or a localised fan on the surface of the flood or ebb tide. Given that these migratory fishes are highly mobile animals, any individuals swimming locally to the discharge plume are unlikely to remain in the plume for any length of time and so potential exposure times are likely to be small.

Small numbers of adult eels migrate seawards past Hinkley in January and February and juveniles are present in low numbers in the vicinity of the Hinkley Point B cooling water inlets to the east of the discharge site for virtually all of the year. Given the extreme tidal range and the high tidal velocities in the Severn, it is considered likely that the migratory adults and glass eels and the small number of resident juveniles would all transit past the discharge zone with the tide in a matter of minutes. Neither river nor sea lamprey appears to have a significant presence in the Hinkley Point area, being absent from the BEEAMS fish characterisation surveys (BEEAMS Technical Report TR-S200) and impinged only intermittently at Hinkley Point B. Adult lampreys migrate up-estuary to spawn and juveniles down-estuary to feed. However, both species are parasitic, so their dispersion is controlled by the movements of their hosts, which are likely to be distributed widely through the estuary.

Of the designated species, twaite shad are relatively abundant in the Severn catchment area and were the 22nd most abundant species impinged during the 2009-2010 HPB Comprehensive Impingement Monitoring Programme (BEEAMS Technical Report TR129). Much as they are in the UK as a whole, allis shad are rare in the local area. Juveniles do use estuaries as nursery grounds, but (i) allis shad are extremely rare, (ii) there is no reason to suspect that either species would be concentrated in the area around the discharge zone, and, in any case, (iii) they are sufficiently mobile that they would not remain in the plume for any length of time.

Salmon are relatively rare in the Hinkley Point area and sea trout considered very rare in the locality. Moreover, both species use the estuary for migration only and, if they were to swim close to the shore, are likely to pass by the discharge zone in a very short period of time.

Of the wider fish assemblage, 63 species were impinged at HPB between February and December 2009. Numerically the most abundant were sprat, whiting, Dover sole, cod and flounder. In terms of biomass the top five species were whiting, sprat, flounder, conger eel, and Dover sole (BEEAMS Technical Report TR128). The small spatial extent of the buoyant plume, coupled with the motility of the fish species indicates the proportion of the population exposed to areas in excess of the EQS is likely to minimal, and exposure times extremely brief. It is therefore considered highly unlikely that discharges of metal contaminants will have a significant effect on the wider fish assemblage.

Potential for bioaccumulation

The chronic zinc NOEC for fish, used in combination with values for other species to determination of the saltwater EQS, is 25 µg l⁻¹ indicating that fish are less susceptible to zinc than other species used in the assessment (WFD-UKTAG, 2012a). The situation is the same for copper, with normalised species mean NOEC concentrations for fish (~55 µg l⁻¹) higher than many invertebrate or algae values (WFD-UKTAG, 2012b). Both zinc and copper NOEC concentrations for fish are higher than those predicted at the point of discharge from the jetty and potential exposure times to fish migrating within the estuary are predicted to be very brief (Figure 3).
Chronic accumulation of metals in the organs of yellow perch transplanted from a reference site to a mining impacted lake (7.85 µg l⁻¹ of bioavailable Zn²⁺) showed zinc marginally increased in the gills and kidneys but not in the gut or liver despite 100-fold increases in background concentrations (Kraemer et al., 2005). Noël-Lambot (1981) showed that eels presented with high metals concentrations had the capability of excreting mucus corpuscles enriched with cadmium, zinc and copper and proposed the findings as a potential mechanism for protection against hazardous levels of contamination.

The limited spatial extent of the discharge plume means that fish using the estuary as a migratory pathway will have limited exposure probabilities. Should individual fish encounter the plume, exposure times are likely to be brief. Furthermore, fish have homeostatic capabilities to regulate essential metal concentrations, thus even in the worst-case scenario of some fish species being attracted by the jetty structure, significant toxicological effects are not anticipated. As such, no LSE are predicted.

5.2.10 Bird Assemblages

This section of the report builds on the assessment made in Section 5.2.8 and considers the indirect effects of discharges on specific bird assemblages in the Severn Estuary, mediated through food-web interactions. Direct toxicological effects of exposure to contaminant metals are not predicted to have an impact pathway and are therefore not further assessed.

To establish the potential for discharges to affect the prey species of foraging birds, an understanding of their feeding modes, diet and distribution in relation to the discharge is a prerequisite. Table 6, provides a summary of the dietary composition of species included in the SPA, Ramsar and SSSI designations and identifies the species that rely on intertidal feeding areas.

Analysis of winter Wetland Bird Survey (WeBS) data (November 2002 to February 2003) by the Environment Agency showed that the intertidal foreshore on the HPC frontage is visited by wigeon, curlew and redshank. Whilst these species are observed at the HPC foreshore, densities were higher on intertidal habitats to the east of HPC (Environment Agency, 2012). An intertidal bird survey commissioned at the foreshore at Hinkley Point and to the mudflat habitats to the east also indicated that the most important local foraging resources are located on the Steart mudflats to the east of Hinkley Point B (Entec, 2011). Shelduck have been recorded on the foreshore in very low numbers, whilst large numbers of moulting birds have been observed in July rafting, typically 500 m offshore near the proposed temporary jetty site (Amec, 2011). The potential for disturbance of the jetty construction and operational phases on shelduck has been considered through the HRA process elsewhere (please see MMO, 2010).

Accordingly, of the designated species that feed on intertidal invertebrates and algae only shelduck, wigeon, and redshank may be susceptible to food-web effects arising from discharge contamination as low densities of these species occur in the intertidal areas close to the discharge. However, discharge modelling showed that intertidal areas are subject to only marginal increases in zinc concentration, and copper discharges are considerably smaller (Table 2; Figure 2). Indeed, average seabed increases in zinc concentration at the eight Corallina locations on the HPC foreshore were very minor (1 % of EQS). Accumulation of metal contaminants from the jetty discharge plume is likely to be negligible across the important Steart mudflat areas foraging areas to the east. Furthermore, bioaccumulation and biomagnification of zinc up the food chain is considered to be low level (WFD-UKTAG, 2012a).

No LSE are predicted on the food sources of designated bird assemblages in Bridgwater Bay.
Table 6 Dietary composition and foraging areas for the designated bird species in the Severn Estuary. Data from BEEMS Technical Report TR184 and Environment Agency (2012). Species in bold feed on intertidal prey and therefore are susceptible to potential indirect food-web effect pathways. Underlined species have been observed near the temporary jetty. Please refer to text for further details.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Species</th>
<th>Potential prey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gadwall</td>
<td><em>Anas strepera</em></td>
<td>Gadwall feed predominantly away from intertidal areas, their diet comprises seeds, leaves, roots and stems of aquatic plants grasses and stoneworts.</td>
</tr>
<tr>
<td>Greater white-fronted goose</td>
<td><em>Anser albi</em>frons albi<em>frons</em></td>
<td>Greater white-fronted goose feed on grass, clover, grain, winter wheat and potatoes</td>
</tr>
<tr>
<td>Dunlin</td>
<td><em>Calidris alpina alpina</em></td>
<td>Dunlin feed on benthic invertebrates at low tide and on fields adjacent to the Severn Estuary. Dietary items include small <em>Scrobicularia plana</em>, small <em>Macoma balthica</em>, <em>Hydrobia ulvae</em>, <em>Corophium volutator</em>, <em>Hediste diversicolor</em>, <em>Talitrus spp</em>, <em>Carcinus spp</em></td>
</tr>
<tr>
<td>Bewick’s swan</td>
<td><em>Cygnus columbianus bewickii</em></td>
<td>Bewick’s swans feed on seed, fruits, leaves, roots, rhizomes and stems of aquatic plants grasses sedges, reeds.</td>
</tr>
<tr>
<td>Redshank</td>
<td><em>Tringa totanus</em></td>
<td>Redshank feed in intertidal and freshwater wetland habitats. Overwinter redshank feed predominantly on benthic invertebrates when exposed by the tide and in fields adjacent to the Severn Estuary. Dietary items include <em>Mya spp</em>, <em>Scrobicularia plana</em>, <em>Macoma balthica</em>, <em>Hydrobia ulvae</em>, <em>Corophium volutator</em>, <em>Hediste diversicolor</em>, <em>Nephtys spp</em>, small <em>Carcinus maenas</em>, <em>Crangon crangon</em>, <em>Talitrus spp</em></td>
</tr>
<tr>
<td>Shelduck</td>
<td><em>Tadorna tadorna</em></td>
<td>Shelduck feed on benthic exposed at low tide and in shallow water. Their diet includes: <em>Hydrobia ulvae</em>, <em>Corophium volutator</em>, young <em>Macoma balthica</em>, young <em>Mytilus edulis</em>, young <em>Cerastoderma edule</em>, <em>Hediste diversicolor</em>, <em>Nematoda</em>, <em>Polychaeta</em>, <em>Nereididae</em>, <em>Copepoda</em>, <em>Ostracoda</em>, <em>Amphipoda</em>, <em>Mollusca</em>, <em>Tellinacea</em>, <em>Platyhelminthes</em>, <em>Coleoptera</em>, <em>Tipulidae</em></td>
</tr>
<tr>
<td>Whimbrel</td>
<td><em>Numenius phaeopus</em></td>
<td>During their spring passage, whimbrel congregate on the Somerset and Gwent Levels where they feed on a terrestrial diet consisting mainly of wireworms and caterpillars</td>
</tr>
<tr>
<td>Wigeon</td>
<td><em>Anas penelope</em></td>
<td>Wigeon feed on algae and grasses gathered on mudflats and on land.</td>
</tr>
<tr>
<td>Black-tailed godwit</td>
<td><em>Limosa limosa islandica</em></td>
<td>Black-tailed godwit feed intertidally on <em>Scrobicularia plana</em>, <em>Macoma balthica</em>, <em>Hediste diversicolor</em>. Potential food items also include <em>Skenea spp</em>, <em>Corophium spp</em>, <em>Nematoda</em>, <em>Hydrobia ulvae</em>.</td>
</tr>
<tr>
<td>Curlew*</td>
<td><em>Numenius arquata</em></td>
<td>Curlew feed on a range of intertidal prey including: <em>Mya spp</em>, <em>Cerastoderma edule</em>, <em>Scrobicularia plana</em>, <em>Macoma balthica</em>, <em>Hediste diversicolor</em>, <em>Arenicola marina</em>, <em>Carcinus maenas</em>, <em>Skenea spp</em>, <em>Corophium volutator</em>, <em>Nematoda</em>, <em>Hydrobia ulvae</em>. Earthworms also form a significant part of their diet.</td>
</tr>
</tbody>
</table>

*Curlew are not a designated species; however, foraging has been observed on the Hinkley Point foreshore (Environment Agency, 2012) and are included in the assessment.*
5.3 LSE Assessment of Effect Categories on Designated Features

The evidence presented in the sections above has been synthesised to produce an LSE assessment (Table 7) for the sewage and groundwater discharges from the temporary jetty. The assessment accounts for each of the effect categories outlined in Natural England/Countryside Council for Wales (2009) in relation to the designated features in the Severn Estuary.

Table 7: LSE screening: effect pathways for the local Severn Estuary SAC/SPA/Ramsar site and Bridgwater Bay SSSI. No effect pathway/no effect; weak effect pathway/inconsequential effect (no LSE).

<table>
<thead>
<tr>
<th>Designated feature</th>
<th>Physical loss of habitat</th>
<th>Physical damage to habitat</th>
<th>Non-physical disturbance</th>
<th>Toxic contamination</th>
<th>Non-toxic contamination</th>
<th>Biological disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAC Annex I Habitats and supporting habitats for species listed under SPA, Ramsar and SSSI designations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estuaries</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE. Effects unlikely or inconsequential</td>
<td>No LSE. Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Mudflats and Sandflats not covered by seawater at low tide</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Atlantic salt meadows (<em>Glaucoc-Puccinellietalia maritima</em>)</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Sandbanks which are slightly covered by seawater all the time</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Reefs (including <em>Sabellaria</em>)</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE. Effects unlikely or inconsequential</td>
<td>No LSE. Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Hard Substrate Habitats (including <em>Corallina</em>)</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE. Effects unlikely or inconsequential</td>
<td>No LSE. Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
</tr>
</tbody>
</table>
## Designated feature

<table>
<thead>
<tr>
<th>Physical loss of habitat</th>
<th>Physical damage to habitat</th>
<th>Non-physical disturbance</th>
<th>Toxic contamination</th>
<th>Non-toxic contamination</th>
<th>Biological disturbance</th>
</tr>
</thead>
</table>

### Migratory Fish and Fish Assemblage

- **Sea lamprey** (*Petromyzon marinus*)
- **River lamprey** (*Lampetra fluviatilis*)
- **Twaite shad** (*Alosa fallax*)
- **Allis shad** (*A. alosa*)
- **Salmon** (*Salmo salar*)
- **Sea trout** (*S. trutta*)
- **European eel** (*Anguilla anguilla*)

Wider fish assemblage

- **No effect pathway**
- **No effect pathway**
- **No effect pathway**
- **No LSE. Effects unlikely or inconsequential**
- **No LSE. Effects unlikely or inconsequential**
- **No effect pathway**

### Bird Assemblages (indirect food-web effects):

- **Bewick's swan** (*Cygnus columbianus bewickii*)
- **Greater white-fronted goose** (*Anser albirostris albirostris*)
- **Dunlin** (*Calidris alpina alpina*)
- **Redshank** (*Tringa totanus*)
- **Shelduck** (*Tadorna tadorna*)
- **Gadwall** (*Anas strepera*)
- **Black-tailed godwit** (*Limosa limosa islandica*)
- **Whimbrel** (*Numenius phaeopus*)
- **Wigeon** (*Anas penelope*)

- **No effect pathway**
- **No effect pathway**
- **No effect pathway**
- **No LSE. Effects unlikely or inconsequential**
- **No LSE. Effects unlikely or inconsequential**
- **No effect pathway**

### Marine Invertebrate Assemblages as a food source for birds and fish (SSSI notification)

- **No effect pathway**
- **No effect pathway**
- **No effect pathway**
- **No LSE. Effects unlikely or inconsequential**
- **No LSE. Effects unlikely or inconsequential**
- **No effect pathway**
6 TBM ground conditioning chemicals assessment

6.1 Evidence base supporting LSE assessment for ‘Toxic Contamination’

The exact composition of the ground conditioning chemicals has not been confirmed at this stage and will be
decided by the tunnelling machine employed, and substrate encountered. Consequently, the evaluation
below and the modelling that forms the basis for the assessment is an indicative representation of the types
of chemicals that may be utilised during TBM operations. The assessment follows a precautionary approach
and has been applied to assess representative chemicals from the substance groups with the most
conservative PNEC. The intention of this precautionary assessment is to provide a reference for identifying
potential impact pathways. This assessment has used relevant examples of typical soil conditioning
chemicals (primarily different types of surfactants), which have particularly low (most conservative) PNEC
values. Providing the chemical components of any other products selected for soil conditioning during
tunnelling have an Effective Volume Flux value at, or below 107.4 (Table 3 and see TR428 Appendix E),
then areas of exceedance will be the same or less than those shown for CLB F5 M (mono- alkyl sodium
sulphate), the component substance with the lowest PNEC.

The discharge contaminants considered in greater detail following the initial screening assessment were
tunnelling chemicals BASF Rheosoil 143 and CLB F5 M. Having failed the H1 screening test, these
compounds were modelled in an identical way to the zinc. As the modelling of zinc does not assume any
substance decay, and predicted concentrations come only from dilution, these results have been scaled from
the model simulations undertaken for zinc, by using a multiplier to correctly simulate the mass of discharged
chemical. The chemical components of BASF Rheosoil 143 and CLB F5 M with the lowest PNEC values
were applied as the EQS threshold as background concentrations of these chemical in the Severn Estuary
were expected to be 0 µg l⁻¹.

BASF Rheosoil 143 had an established PNEC (EQS) of 40 µg l⁻¹, whilst the applied PNEC for CLB F5 M is
4.5 µg l⁻¹. Unlike groundwater contaminants, the greatest discharge of TBM ground conditioning chemicals is
expected during the longer-term construction phase, Case D. The predicted spatial extent of the discharges
of BASF Rheosoil 143 and CLB F5 M was modelled. In the case of CLB F5 M, assessments focus on the
most toxic chemical constituents, the alkyl sulphates (AS) group of compounds, whilst toxicological evidence
for alkyl ethoxylate sulphate (AES) is also considered.

6.1.1 Estuaries

The discharge plume for BASF Rheosoil 143 and CLB F5 M has the same buoyant, tidally forced behaviour
as for zinc, described in Section 5.2.

Sea surface concentration:

- In Case D, modelling predicted that the mean concentration of BASF Rheosoil 143 at the sea
  surface will exceed the EQS (40 µg l⁻¹) for an area of 0.44 ha. This equates to 0.0006 % of the
  estuary SAC feature.

- Average sea surface concentrations of CLB F5 M exceeded the EQS threshold (4.5 µg l⁻¹) for an
  area of 0.96 ha, or 0.0013 % of the estuary SAC feature.

Seabed concentration:

The average concentration of BASF Rheosoil 143 and CLB F5 M is not predicted to exceed the EQS at the
seabed.
Table 8. Total area of the discharge plume in exceedance of the EQS, and the percentage of the designated estuary feature (73,677.25 ha). The EQS is an average annual concentration threshold, at the discharge site the threshold is 40 µg l\(^{-1}\) for BASF Rheosoil 143 and 4.5 µg l\(^{-1}\) for CLB F5 M.

<table>
<thead>
<tr>
<th>Discharged chemical</th>
<th>Area of exceedance at surface</th>
<th>Area of exceedance at bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASF Rheosoil 143</td>
<td>4400 m(^2) (0.44 ha)</td>
<td>0</td>
</tr>
<tr>
<td>CLB 5</td>
<td>9600 m(^2) (0.96 ha)</td>
<td>0</td>
</tr>
</tbody>
</table>

6.1.2 Mudflats and Sandflats not covered by seawater at low tide
This designated habitat feature is beyond the extent of the discharge plume, accordingly there is no effect pathway and the receptor is not considered for further assessment.

6.1.3 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
The discharge plume does not intersect this habitat, there is therefore no pathway and no further assessment is made.

6.1.4 Sandbanks which are slightly covered by sea water all the time
The area of ‘sandbanks which are slightly covered by sea water all the time’ is located in the subtidal area, at the mouth of the River Parrett beyond the extent of the discharge plume.

6.1.5 Reefs
Intertidal and subtidal biogenic reefs formed by the honeycomb worm *Sabellaria alveolata* and subtidal *S. spinulosa* reefs have been identified in the area of the jetty discharge.

6.1.5.1 *Sabellaria* and TBM discharges
The model simulation predicts the mean concentration of BASF Rheosoil 143 and CLB F5 M to be well below the average EQS concentration at the seabed for all *Sabellaria* reef features (Table 9). Of the labelled features, intertidal *S. alveolata* located at position G will be exposed to the highest mean seabed concentrations of both CLB F5 M (0.43 µg l\(^{-1}\)) and BASF Rheosoil 143 (1.29 µg l\(^{-1}\)), equating to 10 % and 3 % of the EQS thresholds respectively. Figure 4 shows the average seabed concentration of the CLB F5 M plume as it is closer to the EQS value than BASF Rheosoil 143.
Figure 4. The spatial distribution of the discharge plume showing average (mean) seabed concentration of of CLB F5 M (µg l⁻¹) for Case D. The location of *Sabellaria* features are delineated. Subtidal *Sabellaria* patches A and E and intertidal *Sabellaria* patch B, C, and D, F, and G are marked. The maximum scale of the plot is 0.7 µg l⁻¹ whilst the EQS for CLB F5 M is 4.5 µg l⁻¹.
Table 9. Mean and 95%ile seabed concentrations of TBM ground conditioning chemicals, BASF Rheosoil 143 and CLB F5 M, at subtidal *Sabellaria* patches A, E and intertidal *Sabellaria* patches B, C and D, F, and G. The position of the *Corallina* feature with the greatest exposure is also displayed.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Mean seabed concentration (µg l⁻¹)</th>
<th>95%ile seabed concentration (µg l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLB F5 M (PNEC/EQS 4.5 µg l⁻¹)</td>
<td>BASF Rheosoil 143 (PNEC/EQS 40 µg l⁻¹)</td>
</tr>
<tr>
<td>Subtidal <em>Sabellaria</em> A</td>
<td>0.12</td>
<td>0.35</td>
</tr>
<tr>
<td>Easting 321350 Northing 147040</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> B</td>
<td>0.31</td>
<td>0.94</td>
</tr>
<tr>
<td>Easting 320800 Northing 146694</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> C</td>
<td>0.20</td>
<td>0.59</td>
</tr>
<tr>
<td>Easting 320300 Northing 146351</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> D</td>
<td>0.16</td>
<td>0.48</td>
</tr>
<tr>
<td>Easting 319118 Northing 16309</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtidal <em>Sabellaria</em> E</td>
<td>0.28</td>
<td>0.85</td>
</tr>
<tr>
<td>Easting 320800 Northing 146800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> F</td>
<td>0.32</td>
<td>0.97</td>
</tr>
<tr>
<td>Easting 321824 Northing 146800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> G</td>
<td>0.43</td>
<td>1.29</td>
</tr>
<tr>
<td>Easting 321529 Northing 146793</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Corallina</em> Position 5</td>
<td>0.17</td>
<td>0.51</td>
</tr>
<tr>
<td>Easting 320010 Northing 146285</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Due to the strong tidal forcing at the site, transient concentration peaks were also investigated using model simulations to determine the potential for acute toxic effects. The 95%ile concentrations of the month-long simulation were within the EQS for both chemicals, at all the positions investigated (Figure 6 and Figure 5). Again, *Sabellaria* patch G is exposed to the greatest concentrations of both CLB F5 M (1.21 µg l⁻¹) and BASF Rheosoil 143 (3.62 µg l⁻¹), equating to < 27 % and 9 % of the EQS thresholds respectively (Table 9). This indicates that the frequency of exposure to concentrations peaks is low.
Figure 5. The 95th percentile for seabed concentrations of BASF Rheosoil 143 (µg l⁻¹). The location of *Sabellaria* features are delineated. Subtidal *Sabellaria* patches A and E and intertidal *Sabellaria* patch B, C, and D, F, and G are marked. The EQS for BASF Rheosoil 143 is 40 µg l⁻¹.
Figure 6. The 95%ile for seabed concentrations of CLB F5 M (µg l⁻¹). The location of *Sabellaria* features are delineated. Subtidal *Sabellaria* patches A and E and intertidal *Sabellaria* patch B, C, and D, F, and G are marked. The EQS for CLB F5 M is 4.5 µg l⁻¹.

As a further precautionary approach, the maximum (100%ile) concentration was considered for *Sabellaria* patch G, the location of the highest exposure concentrations. A time-series of the data at patch G reveals that a short-lived spike up to 21.5 µg l⁻¹ for CLB F5 M occurs and lasts for 5-hours during the month-long simulation. In this scenario, *Sabellaria* may be exposed to transient concentrations above EQS thresholds. However, it should be noted that the maximum seabed exceedance represents a transient, worst-case scenario during the month-long model simulation, whereas EQS values are based on average concentrations during periods of chronic exposure. Indeed, the maximum concentration predicted at *Sabellaria* patch G, is within the NOEC for chronic exposure to the most toxic chain length alkyl sulphate (Table 3), and several orders of magnitude below recorded LC50 values for acute toxicity of alkyl sulphate group surfactants to marine species (Table 10). Accordingly, no chronic or acute toxicity to the *Sabellaria* features are predicted as a result of discharges of tunnelling compounds, therefore no LSE are considered to occur.
Figure 7. Concentration time series of CLB F5 M at location G (µg l⁻¹) showing the surrogate EQS of 4.5 µg l⁻¹ (PNEC) and the chronic NOEC (45 µg l⁻¹) for the most toxic chain length (C14) alkyl sulphate (AS) as the active substance within CLB F5 M, values come from HERA (2002) Risk Assessment.
Table 10. Acute toxicity of example chemicals within the Alkyl Sulphate (AS) group. Alkyl sulphates are a group of compounds with the lowest PNEC which occur in the tunnelling product CLB F5 M. Example chemicals from the AS group are selected from the list of compounds in Appendix 2 of the HERA (2002) Environmental Risk Assessment. Of the 39 listed chemicals, seven have registered dossiers with ecotoxicological data and 1 chemical has marine data. Marine examples are available for sodium dodecyl sulphate (SDS), where marine examples are not available the worst-case freshwater data for all the chemicals with toxicological data is provided.

<table>
<thead>
<tr>
<th>Chemical (CAS number)</th>
<th>Species (Taxonomic group)</th>
<th>Freshwater / Marine</th>
<th>Duration</th>
<th>LC50 concentration</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium dodecyl sulphate (SDS) (151-21-3)</td>
<td><em>Cyprinodon variegatus</em> (Fish)</td>
<td>Marine</td>
<td>96 h</td>
<td>4.1 mg l⁻¹</td>
<td>Roberts et al., (1982)</td>
</tr>
<tr>
<td>SDS (151-21-3)</td>
<td><em>Artemia salina</em> (Crustacean)</td>
<td>Marine</td>
<td>48 h</td>
<td>3.15 mg l⁻¹</td>
<td>ECHA* Dyer et al., (1997)</td>
</tr>
<tr>
<td>SDS (151-21-3)</td>
<td><em>Tetraselmis chuii</em> (Algae)</td>
<td>Marine</td>
<td>48 h</td>
<td>30.2 mg l⁻¹</td>
<td>Nunes et al. (2005)</td>
</tr>
<tr>
<td>Sulfuric acid, mono-C12-18-alkyl esters, sodium salts (68955-19-1)</td>
<td>Zebrafish (fish)</td>
<td>Freshwater</td>
<td>96 h</td>
<td>1.3 mg l⁻¹</td>
<td>ECHA*</td>
</tr>
<tr>
<td></td>
<td><em>Daphnia magna</em> (Crustacean)</td>
<td></td>
<td>48 h</td>
<td>2.8 mg l⁻¹</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Desmodesmus subspicatus</em> (Algae)</td>
<td></td>
<td>72 h</td>
<td>20 mg l⁻¹</td>
<td></td>
</tr>
</tbody>
</table>


6.1.6 Hard Substrate Habitats

6.1.6.1 Corallina waterfalls

Similar to the *Sabellaria* results, modelling predicted no exceedance of the EQS value for average concentrations of either BASF Rheosoil 143 or CLB F5 M at the *Corallina* features. The along-shore profile of the plume results in *Corallina* experiencing lower seabed concentrations of contaminants than *Sabellaria* patches to the east of the discharge. *Corallina* features at Position 5 are exposed to the highest mean concentrations of both CLB F5 M (0.17 µg l⁻¹) and BASF Rheosoil 143 (0.51 µg l⁻¹), equating to < 4 % and 1.3 % of the EQS thresholds respectively (Table 9).

No LSE are predicted as a result of discharges of tunnelling compounds under the proposed discharge scenarios.
6.1.7 Marine Invertebrate Assemblages (as a food source)

6.1.7.1 Benthic Invertebrates

The buoyant plume is mixed downwards on the flood tide resulting in higher average seabed concentration areas occurring to the east of the jetty in intertidal areas above MLWS (Figure 6). Average concentrations are not predicted to exceed the EQS for BASF Rheosoil 143 and CLB F5 M at the seabed, however, as stated above transient peaks exceeding the EQS can occur temporarily.

Belanger et al., (1995) tested the effects of anionic surfactants alkyl ethoxylate sulphate (AES) and alkyl sulphate (AS), used in CLB F5 M, on periphyton, protozoa and invertebrates using stream mesocosm experiments. The authors reported a NOEC of 251 µg l\(^{-1}\) during 8-week exposures for AES and 224 µg l\(^{-1}\) for AS. At higher concentrations food-web perturbations were observed, whereby increases in heterotrophic biofilms lead to increases in oligochaete and gastropod abundance. At the highest concentrations tested (582-1586 µg l\(^{-1}\)), significant reduction in mayfly and clam populations occurred (Belanger et al., 1995). Lizotte et al., (2002) found that following 30-day exposures to AES, control stream invertebrate communities and those treated with concentrations of 0.7, 1.27, 2.2, and 4.31 mg l\(^{-1}\) were between 85-95 % similar throughout the course of the experiment, whereas the maximum 10.18 mg l\(^{-1}\) treatment only shared 70 % similarity with controls. Two weeks after exposure to AES ended communities treated with 10.18 mg l\(^{-1}\) showed recovery with the ordinated trajectory returning towards control.

These examples draw on literature from freshwater communities and the physico-chemical properties of the aqueous solution are important considerations determining solubility and toxicity of contaminants. However, they indicate that higher concentrations than those observed during transitory exposure are required to cause toxicity or community effects. Literature values for acute toxicity of alkyl ether sulphates, the active substance in BASF Rheosoil 143, on freshwater invertebrates report EC50 values ranging from 0.37 to 50 mg l\(^{-1}\), with toxicity is likely to be both highly species-dependent, and reliant on the alkyl chain length and number of ethoxylate groups. (Madsen et al., 2001; and references therein). Acute toxicity of AS, occurring in CLB F5 M is provided in Table 10. The model is considered to be precautionary and does not take into account biodegradation of surfactants. Indeed, Madsen et al., (2001) note that extrapolation of laboratory toxicity assays to ecologically representative situations can be challenging due to fast degradation of surfactants resulting in changes to the composition of isomers and homologues. Biodegradation of AS and AES surfactants is rapid for all chain lengths. AS has a half-life in surface waters of 0.75 d, resulting in a degradation rate of 0.92 d\(^{-1}\) (HERA, 2002), whilst AES degradation rates are 0.48 d\(^{-1}\) (HERA, 2004).

Given that the model predicts that the 100%ile concentration experienced during infrequent, brief exposures is below the observed chronic NOEC concentrations, and orders of magnitude lower than acute toxicity levels, no impacts on marine invertebrates are predicted. Therefore, no LSE on invertebrate food as a prey source for designated birds and fish are predicted in relation to the tunnelling discharges.

6.1.8 Migratory Fish Assemblages

The area of sea surface that exceeds the EQS is 0.96 ha and 0.44 ha for CLB F5 M and BASF Rheosoil 143, respectively. As discussed in Section 5.2.9 above, twaite shad is the most numerically abundant designated migratory fish species in the area (BEEMS Technical Report TR129). Assuming impingement rates are a true representation of the population abundance of the species in the local area a conservative estimate, based on the volume of water below the area of sea surface in exceedance of the EQS, predicts that 0.057 individuals are exposed to the plume at any given time (CLB F5 M: 0.96 ha extending to the seabed 8.9 m OD, rather than a buoyant plume and 0.00000067 individuals m\(^{-3}\)).

The low density of the designated species coupled with the small spatial area of the plume in exceedance of the EQS indicates very few designated fish would be exposed to toxic levels of contamination. Furthermore, the motility of migratory fish means exposure time, should the plume be encountered, is likely to be very brief and exposure concentrations at source are below levels where acute toxicity occurs (Figure 8; Table 10). As such, LSE due to direct toxicity is deemed highly unlikely.

The most numerically abundant species in the wider fish assemblage are sprat, whiting, Dover sole, cod and flounder (BEEMS Technical Report TR128). The spatial extent of the buoyant plume is small and any
potential exposure time is likely to be brief. It is therefore considered highly unlikely that discharges of TBM contaminants will have a significant effect on the wider fish assemblage.

Figure 8. The spatial distribution of the discharge plume showing average sea surface concentration of CLB F5 M (µg l⁻¹) during Case D. The EQS for CLB F5 M is 4.5 µg l⁻¹.

As discussed in Section 6.1.7, no toxicological effects on invertebrate taxa inhabiting the important intertidal feeding areas are predicted. Accumulation of surfactants in the tissue of invertebrate prey has the potential to affect fish foraging in the exposed intertidal areas. However, bioaccumulation data for surfactants is sparse. Surfactant bioconcentration is influenced by water physico-chemistry and the structure of the compound, waterborne surfactants can be taken up across the gills and may be biotransformed or excreted (Tolls et al., 1994). Alkyl ether sulphates are readily taken up by fish, however metabolism and elimination are also rapid, leading Madsen et al., (2001) to conclude that bioconcentration does not occur.

As such, no LSE are predicted to occur in response to tunnelling discharges on the designated fish species in the estuary.

6.1.9 Bird Assemblages

Intertidal feeding bird species are not predicted to be exposed to direct toxicological impacts from surfactants as no effect pathway exists. Shelduck, present a potential exception, as moulting birds have been observed in July rafting 500 m offshore near the proposed temporary jetty site (Amec, 2011). The occurrence of birds near the discharge presents a potential impact pathway as surfactants may impede the natural water repelling properties of their feathers. Evidence of the impact of surfactants on the waterproofing properties of feathers is primarily derived from studies of detergent use on oiled birds for which the effective concentrations of surfactant for oil removal are typically mg l⁻¹. For example, Duerr et al., 2009 demonstrated that a concentration of 12 mg l⁻¹ of dispersant containing anionic surfactants caused disruption of feather structure. Such concentrations are well above the model predictions at the immediate vicinity of the jetty.
discharge (Figure 8, Figure 9). Surface concentrations rapidly reduce falling to below the 4.5 µg l⁻¹ EQS for CLB F5 M within 0.96 ha and the 40 µg l⁻¹ EQS for BASF Rheosoil within 0.44 ha. Accordingly, the concentration of surfactants present in the jetty discharge are considered insufficient for effective surfactant properties to operate and hence for significant removal of natural oil from feathers. Therefore, no direct effects on shelduck are predicted.

Figure 9. The spatial distribution of the discharge plume showing the average (mean) sea surface concentration of BASF Rheosoil 143 (µg l⁻¹) during Case D. The EQS for BASF Rheosoil 143 is 40 µg l⁻¹.

The primary intertidal foraging areas for designated birds are located to the east of HPB on the Steart mudflats. These important foraging areas may be exposed to temporary concentrations of surfactants in close exceedance of the EQS during construction discharges but only if maximum concentrations are considered. As discussed previously, average concentrations and 95%ile concentrations do not exceed EQS values.

The potential for bioaccumulation of surfactants in invertebrates and subsequent biomagnification in birds is unknown. However, given the surfactants are not predicted to have an effect on invertebrate prey and LSE are considered to be unlikely.

6.2 LSE Assessment of Effect Categories on Designated Features

The evidence above has been synthesised to produce an LSE assessment for the ground conditioning surfactants. The assessment accounts for each of the effect categories outlined by Natural England/Countryside Council for Wales (2009) in relation to the designated features in the Severn Estuary (Table 11).

It should be noted that exact chemical constituents being used at the cutting face have not be confirmed and the assessment is based on example chemicals with associated PNEC values. This assessment has used
some worst-case examples of typical soil conditioning chemicals (primarily different types of surfactants), which have particularly low (therefore most conservative) PNEC values. Providing the chemical components of other products selected for soil conditioning during tunnelling have an Effective Volume Flux value at, or below 107.4 (Table 3), then areas of exceedance will be the same or less than those shown for CLB F5 M (mono-alkyl sodium sulphate, the component substance with the lowest PNEC.)
Table 11: LSE screening: effect pathways for the local Severn Estuary SAC/SPA/Ramsar site and Bridgwater Bay SSSI for TBM ground conditioning chemicals. No effect pathway/no effect; weak effect pathway/inconsequential effect (no LSE). DIN and groundwater chemicals released during tunnelling are assessed in Section 5, Table 7.

<table>
<thead>
<tr>
<th>Designated feature</th>
<th>Physical loss of habitat</th>
<th>Physical damage to habitat</th>
<th>Non-physical disturbance</th>
<th>Toxic contamination</th>
<th>Toxic contamination</th>
<th>Biological disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estuaries</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Mudflats and Sandflats not covered by seawater at low tide</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Atlantic salt meadows <em>(Glauco-Puccinellietalia maritimae)</em></td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Sandbanks which are slightly covered by seawater all the time</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Reefs (including <em>Sabellaria</em>)</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Hard Substrate Habitats <em>(including Corallina)</em></td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Migratory Fish Assemblages</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Bird Assemblages (indirect food-web effects):</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
<tr>
<td>Marine Invertebrate Assemblages as a food source for birds and fish (SSSI notification)</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
<td>No LSE Effects unlikely or inconsequential</td>
<td>No effect pathway</td>
<td>No effect pathway</td>
</tr>
</tbody>
</table>
7 In-Combination Effects

This section considers the in-combination effects of TBM surfactants, groundwater and sewage discharges in relation to the plans, projects and permissions (PPP) outlined in the original HPC HRA (Environment Agency, 2013), which include:

- HPC temporary jetty
- HPA discharge
- HPB discharge
- Environment Agency Steart coastal management project
- Bristol Port container terminal
- Compensation habitat creation for Bristol Port container terminal
- Swansea Bay Tidal Lagoon (planning succeeded to the original HRA but was considered in BEEMS Technical Report TR414)

The construction discharges from the temporary jetty has also been assessed in relation to the concurrent discharges at Outlet 1. Finally, the toxicity of contaminants is further considered in relation to thermal discharges from HPB and seasonal temperature variations.

The temporary jetty discharges will only persist during the construction phase. Therefore, there are no in-combination effects with operational phases of HPC.

BEEMS Technical Report TR414 completed an assessment of the in-combination effects of the cross-shore construction dewatering discharge for Hinkley Point C (Outlet 1) with the PPP outlined in the original HPC HRA (Environment Agency, 2013), and the Swansea Bay Tidal Lagoon. In support of the original HRA, it was concluded that no in-combination effects of the discharges at Outlet 1 with these PPP on the estuary features was anticipated due to the restricted extent of the discharge plume and the short duration of exposure. These conclusions remain unchanged. No in-combination effects of the proposed construction discharges from the temporary jetty and the aforementioned PPP on designated features are predicted.

7.1 In-combination effects with Outlet 1 and HPB and HPA waste discharges

Outlet 1 is situated 1050 m east, and 300 m south of the jetty discharge location. Once dewatering discharges commence at the jetty location there will be no groundwater discharges at Outlet 1. Surface water run-off from the main site is permitted at Outlet 1 but it should not contain chemicals above EQS and there should be no interaction with the jetty discharge.

There is the potential for sewage to be discharge at Outlet 1 concurrently with discharges at the temporary jetty. Accordingly, the potential contaminants to be considered in-combination are un-ionised ammonia and DIN. The area of EQS exceedance for both un-ionised ammonia and DIN is restricted to a small area near the discharges, no interaction between the discharge plumes is predicted (BEEMS Technical Report TR428; BEEMS Technical Report TR412). This combined uplift in the annual loading of DIN to Bridgwater Bay is estimated to be 0.435 µmol l⁻¹.

Discharges from HPB and HPC enter two waterbodies, the River Parrett waterbody and the Bridgewater Bay waterbody, the combined effects of the two discharges with the temporary jetty and Outlet 1 is expected to uplift DIN by 2.52 µmol l⁻¹ and 0.58 µmol l⁻¹, respectively. The combined discharges do not impact on the ‘Good’ status of either waterbody.

7.2 In-combination thermal effects with HPB

Temperature is considered one of the most important factors influencing chemical toxicity (Heugens et al., 2001). Most aquatic organisms are ectothermic, leading to changes in the metabolic rates following changes in environmental temperature. This metabolic change, also known as Q10, can be two-fold change with a 10°C temperature variation. Thus, an aquatic organism is generally more susceptible to contamination due to increased diffusion and uptake rates (Cairns, 1975). However, such effects are not universal and Lee et al.
(1997) showed no correlation between seasonal temperatures (0 – 28 °C) and periphyton sensitivity to AES and AS surfactants.

Temperatures at the site range from 6.6 °C in February to 19.4 °C in August, with typical inter annual variation in monthly mean temperatures of 1.1 °C (BEEMS Technical Report 187). Thermal discharges from HPB are predicted to cause an average annual increase in sea surface temperature at the jetty site of 1.02 °C, within the range of interannually monthly variation.

Average EQS values are only exceeded in the immediate vicinity of the jetty location with CLB F5 M having the greatest exceedance area of 0.96 ha at the sea surface. None of the chemicals assessed exceed the EQS at the seabed. Seasonality will be the driving factor responsible for temperature dependent-toxicity with toxicity greatest during the warm summer months. However, the in-combination effects of a small temperature uplift from the HPB thermal discharges at the jetty site and the restricted spatial area of EQS exceedance for contaminant metals and TBM surfactants is not considered to have a LSE on the designated estuarine features. As such, no in-combination effects between construction discharges and the HPB thermal plume are predicted at the point of discharge.

Mixing down of the discharge plume results in the highest seabed concentration of chemicals, relevant to the designated features, occurring to the east of the jetty in the intertidal areas adjacent to HPB. To estimate the temperature uplift from HPB in relation to the Sabellaria features results from high resolution thermal modelling (BEEMS Technical Report TR267) were applied (Figure 10; Table 12). Sabellaria patches A-F experience modest annual average temperature uplifts of < 1.3 °C from HPB thermal discharges. Sabellaria patch G is exposed to the highest concentrations of contaminants, and experiences the largest average annual temperature uplift (4.17 °C). However, as discussed in Sections 5.2.6 and 6.1.5, neither average concentrations of construction contaminants, nor 95%ile concentrations exceed the applied EQS/PNEC concentrations at any of the Sabellaria features. Only transitory concentration peaks occur above EQS levels for TBM compounds. Accordingly, no LSE are predicted resulting from the in-combination effects of increased temperature-dependent toxicity of construction contaminants due to thermal discharges from HPB.

Figure 10. Mean excess temperature at the seabed due to HPB discharges from high resolution 25 m model, BEEMS Technical Report TR267.
Table 12. Mean temperature uplift due to HPB at *Sabellaria* locations at the seabed.

<table>
<thead>
<tr>
<th>Sabellaria Patch</th>
<th>Mean temperature uplift (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtidal <em>Sabellaria</em> A</td>
<td>0.41</td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> B</td>
<td>1.18</td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> C</td>
<td>0.78</td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> D</td>
<td>0.68</td>
</tr>
<tr>
<td>Subtidal <em>Sabellaria</em> E</td>
<td>0.94</td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> F</td>
<td>1.27</td>
</tr>
<tr>
<td>Intertidal <em>Sabellaria</em> G</td>
<td>4.17</td>
</tr>
</tbody>
</table>
8 Conclusions

The shadow HRA assessment made in this report, considers the potential for LSE of the proposed Hinkley Point C construction discharges from the temporary jetty on the designated features within the Severn Estuary SAC, SPA, Ramsar site and Bridgwater Bay SSSI. Construction phase discharges include sewage, dewatered groundwater and Tunnel Boring Machinery (TBM) ground conditioning chemicals.

Construction phase discharges change in chemical composition and volume throughout the construction operations. The assessment focused on two specific phases; Case C and Case D. Case C is a short-term (8-week) period of maximum groundwater discharges, followed by longer term discharges of groundwater at a reduced rate, Case D. In both cases sewage discharges are anticipated to be constant, whereas TBM ground conditioning chemicals have the greatest discharges during Case D.

Following initial EQS screening tests discharge modelling focussed on the groundwater contaminants zinc and copper as both metals failed. TBM chemicals BASF Rheosoil 143 and CLB F5 M also failed and were subject to further modelling. Zinc was the groundwater contaminant with by far the greatest exceedance of EQS and was used as a proxy for copper. The results of discharge modelling inform the assessment, which are reliant on the parameters and assumptions presented in BEEMS Technical Report TR428.

The discharge plume was strongly influenced by tidal conditions and clear differences in the concentration profile of the plume could be seen between the sea surface and seabed. The behaviour of the plume had important consequences for the potential interaction with designated features.

Zinc exceeded the average EQS over a small sea surface area of 0.625 ha in Case C and 0.125 ha in Case D. Seabed concentrations of zinc did not exceed the average EQS. Designated features including Sabellaria reefs, Corallina waterfalls and invertebrate assemblages inhabiting supporting habitats for bird and fish were never predicted to experience concentrations of zinc, or copper, in excess of EQS levels at any point throughout the model run (100%ile). Based on the evidence available, it is concluded that discharges of groundwater would have no LSE on designated estuary features whether in solution or following potential deposition of suspended material with bound contaminants. Discharges of DIN and un-ionised ammonia were predicted to be very localised and present a negligible effect. No in-combination effects of the temporary jetty discharge with other plans, projects and permissions are considered likely for discharges of sewage and groundwater metals.

Indicative, worst-case TBM ground conditioning chemicals were used in the assessment. Discharges of TBM chemicals, during Case D resulted in average sea surface concentrations above the EQS for an area of 0.96 ha and 0.44 ha for CLB F5 M and BASF Rheosoil 143, respectively. Average seabed concentrations were not predicted to exceed the EQS. The spatial extent of the buoyant plume in exceedence of the EQS indicated that fish are the only designated feature with a potential impact pathway. However, the small area of exceedance combined with low fish densities and predicted brief exposure times of migratory fish indicate that the probability of LSE is negligible.

Benthic subtidal and intertidal designated features were not exposed to average concentrations of TBM chemicals in exceedence of the applied EQS levels. Downward mixing of the discharge plume results in Sabellaria features to the east of the jetty being exposed to the greatest concentrations of contaminants but even when 95%ile concentrations were considered the highest concentration any Sabellaria feature was exposed to was 27 % of the EQS/PNEC threshold (3.62 µg l⁻¹ for CLB F5 M at patch G). Only transitory concentration peaks above EQS levels for TBM compounds occurred, however the concentration and duration of these events was deemed insufficient to cause acute toxicity. Therefore, no direct LSE are predicted to designated features and any food-web effects on designated birds and fish are considered to be unlikely.
9 References


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Kraemer, L.D., Campbell, P.G.C., and Hare, L. (2005). Dynamics of Cd, Cu and Zn accumulation in organs and sub-cellular fractions in field transplanted juvenile yellow perch (Perca flavescens). Environmental Pollution. 138: 324-337.


