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BRADWELL SITE

ENVIRONMENTAL RISK ASSESSMENT
TO SUPPORT THE EPR PERMIT VARIATION FOR FED DISCHARGES THROUGH THE NEW DISCHARGE LINE

BRAD/EN/REP/130/FED

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BACKGROUND AND INTRODUCTION

Background

Over time the inlet and outfall culverts have been silting up and now present a risk of preventing discharges to the estuary. As mitigation against this, the site has installed four new 180mm diameter polyethylene pipes in the East Outlet Culvert to provide a discharge route to the Blackwater Estuary. Treated Fuel Element Debris (FED) effluent and treated general radioactive effluent will be discharged through one of the lines, with treated non-radioactive effluents and site drainage being discharged through the remaining lines. With this solution, there will no longer be pre-dilution of the carrier water that is part of the existing discharge arrangements authorised under Environmental Permit EPR/DP3127XB. The effluent will be discharged from an hour after High Water to two and half hours after High Water to ensure effective dispersion from the outfall point into the estuary.

The scope of the current permit EPR/DP3127XB under Schedule 1 specifies that FED related effluent discharges take place within a 12 month period. At the time of the original application, it was recognised by the Company that the facility would be required to run for a period of at least 12 months to complete operations for the treatment of Bradwell's Fuel Element Debris (FED). The 12 month period was seen as the best operational case and most constraining environmental case as the total discharge for the entire project (based on the inventory of FED material being retrieved from the Bradwell site vaults) was compared against EQS annual averages. This was stated in the original permit application[1] that discharge from the FED dissolution programme is expected to occur within a 24 month period. During pre-application discussions, the Company was advised to notify the Environment Agency if the duration of operations extended beyond 12 months. Discharges commenced on 23rd June 2014 and within this period, the Company has completed initial commissioning and optimised the process to improve throughput. All of the environmental performance criteria were met. Throughput over the past 12 months has been minimal and the Company requires extension to the existing 12 month discharge duration to allow the project to complete the treatment of Bradwell's FED.

This report supports the application for a variation to the existing permit to extend the current 12 month discharge period under Schedule 1 of permit EPR/DP3127XB for a further 24 months and also authorise discharges through the new line when it is required. Until the existing route completely blocks, discharges will continue to be made through the existing arrangements and in compliance with the permit.

Additionally, improvements have been identified to optimise the NOx scrubber liquor arisings. The intention is to use the liquor as part of the acid charge in the FED dissolution process, rather than having a separate waste effluent. This effluent is referred to as the combined FED effluent in this assessment. Approximately 5 cubic meters of NOx scrubber liquor will be added to FED dissolution batches over a nominial period of 17 days; this equates to approximately 50 litres per batch. There may be slight differences to this amount depending on the type of FED being dissolved; for example, the more corroded FED will require less acid to be added. The improvement has been underpinned by a design review, a hazard and operability (HAZOP) study along with engineering advice, including the Engineering Advice Note (EAN) M/EF/BWA/EAN/0015/14[2].

Although thought unlikely, there may be operational reasons to 'bleed' NOx scrubber towers in addition to the initial acid charge in FED dissolution. This may happen if the acid concentration is outside the range specified. Should this happen, the NOx Scrubber liquor will be discharged into an empty FED reaction vessel and pumped to the Aqueous Discharge Abatement Plant (ADAP) for treatment prior to discharge. The concentration of the constituents would be measured to ensure they meet the Environment Agency's (EA) 'not liable to cause pollution' test before discharge.

The environmental impacts associated with extending the period of discharges for a further 24 months under the current permit will not change, but rather the annual loadings will be less than previously submitted. Therefore, the environmental risk assessment remains unchanged.

For FED discharges through the new line, a thorough assessment has been made of the potential impacts and it is supported by the environmental modelling work undertaken by HR Wallingford (specialists in this field). The scope of this work includes assessment of the load and behaviour of effluent containing heavy metals and nitrates that would be discharged from Bradwell Site. The modelling that underpins the existing permit EPR/DP3127XB provides key information (e.g. in the development of the model and behaviour of the plume of discharges and retention calculations) that remains useful for this risk assessment. This is summarised in Discharge Dispersion EX6399 report by HR Wallingford[3]. It is supported by Environmental Risk Assessment in Support of Fuel Element Debris[4]; as updated by Addendum to Environmental Risk Assessment NOx Scrubber Liquors[5]. The basis for assessing compliance with the EQS-AA was established in a HR Wallingford Report RT011 Annual Average Concentration of FED Constituents[6].

A structured approach has been undertaken in producing this environmental risk assessment using the following guidance:

- H1 Annex D1 Assessment of hazardous pollutants within surface water discharges[7]
- Technical Guidelines for the identification of mixing zones pursuant to Art. 4(4) of the Directive 2008/105/EC[8]

1. PURPOSE

The purpose of this document is to summarise the results of the environmental risk assessment that covers the impacts from heavy metals, nitrates and temperature associated with the discharge of effluent from the FED dissolution process. It supports the Environmental Permit variation application for the discharge of treated FED related effluent through the new discharge line when it is required (i.e. when the existing line silts up).

The configuration of the discharge arrangements will be changing from the existing one in terms of:

- losing the current 75:1 pre-dilution from carrier water;
- making discharges through narrower bore pipes;
- changing the discharge port on the outfall structure to a slightly lower level (which may potentially have an effect on dispersion); and
- changing the discharge sampling point (the common point for all effluents will no longer be available).

Consequently, there could be potential change to the environmental impacts; these require assessment and permitting.

2. SCOPE

The scope of this environmental risk assessment includes:

- updated information gathered from analysis of the NOx scrubber liquor from samples taken on the 24th September 2014;
- updated information from the radioactive FED dissolution commissioning trial batch 6 analysis undertaken between 23rd - 29th May 2014;
- assessment of combined FED effluent (i.e. FED effluent with NOx scrubber liquor added to the dissolution batch);
- the basis for assessing compliance with EQS AA and EQS MAC for short daily discharges (e.g. half an hour);
- Phases 1 and 2 screening assessment of all substances in the effluent liable to cause pollution as defined in EA guidance H1 Annex D1 Guidance;
- an assessment of the nitrate loading against the agreed EA 'no deterioration threshold' of less than 10% of the background; and
- a review of the thermal impacts from the effluent discharged.

3. NEW DISCHARGE LINE

HR Wallingford were commissioned to undertake modelling to inform the outfall design of the new discharge line in order to ensure optimum dispersion. This work is summarised in BRAD/EN/REP/FED/082 FED Discharge Outfall EBR4908-RT008-R01[9]. The recommendations from this report were incorporated into the design; these included:

- attaching an outfall port of diameter 0.065m to the new discharge line;
- discharging effluent horizontally;
- raising the outfall port 5.5 m above the sea bed, but always submerged; and
- angling the outfall port offshore, perpendicular to the tidal current direction.

The new line installed comprises four 180mm diameter polyethylene pipes, with 65mm discharge nozzles housed in the existing East Outlet Culvert. To maximise dispersion, the effluent is discharged through specially designed nozzles to achieve positive initial

dispersion of the effluent as it enters the Blackwater Estuary. Overall the discharge line is estimated to give an exit velocity of 3.3 m/s and a densimetric Froude number of approximately 14, which is associated with rapid turbulent mixing.

Appendix A provides a drawing of new line and discharge ports. Appendix B shows images from the multi-beam survey conducted by Port of London Authority on the changing pattern of silt build up around the outfall structure.

Treated FED effluent and general treated radioactive effluent arisings will be discharged through one of the lines, with the treated non-radioactive effluents and site drainage being discharged through the remaining lines.

The abated FED effluent will be pumped from the final delay tank by pumps rated at $40m^3/hr$, resulting in a maximum of $20m^3$ discharge during the discharge window of half an hour. Discharge will be made between High Water plus 1 hour and High Water plus 2.5 hours to optimise the dispersion.

4. EFFLUENT PROFILE

4.1 Introduction

The FED and the NOx scrubber liquor contains metals and these are present as either:

- trace contaminants in the process chemicals used (e.g. Mercury and Lead in Sodium Hydroxide used to neutralise the effluent);
- contaminants within the plant construction material (e.g. Iron, Nickel, Chromium, and to a lesser degree Copper and Zinc); or
- contaminants in the FED being processed (e.g. Boron, Iron, Nickel, Copper, Cadmium and Lead).

4.2 FED Effluent

Table 1 provides a summary of the concentrations of unabated and abated metals in FED dissolution effluent based on analysis undertaken between the 23rd - 29th May 2014. The removal efficiencies used are based on a major study undertaken by National Nuclear Laboratory and is contained in an Engineering Advice Note M/E/BWA/EAN/009/13[10]. These are being used until a more comprehensive data set is built up on abatement efficiencies being achieved through ADAP. The data shows the metal concentrations that arise from dissolving FED without the addition of the concentrated NOx scrubber liquor. The concentrations are indicative and may vary between batches (e.g. due to the type of FED being processed).

Table 1: FED Radioactive Effluent Unabated and Abated Metal Concentration

Substance	Maximum Concentration of Unabated FED based on batch 6 data, µg/l	Maximum Concentration of Abated FED, µg/l	Removal Efficiencies %
Boron	100	85	15
Cadmium	30	1.5	95
Chromium	1628	146.5	91
Copper	157	11	93
Iron	6867	68.7	99
Lead	258	2.6	99
Mercury	5	5	0
Nickel	684	184.7	73
Zinc	526	10.5	98

4.3 NOx Scrubber Liquor used in FED Dissolution

The NOx scrubber liquor, (nominally 3.5-4.4M nitric acid or 20-25% weight/weight), is trace radioactive and contains a number of metals at varying concentrations. The nitric acid and scrubber towers provide abatement of NOx emissions that are generated from the FED dissolution process. The metal profile of the unabated NOx scrubber liquor is summarised in Table 2. The data presented is based on analysis of unabated NOx scrubber liquor samples taken 24th September 2014. The predicted abated metal concentrations are based on the removal efficiencies in M/E/BWA/EAN/009/13 as already noted in Table 1. NOx scrubber liquor will be added at a rate of approximately 50 litres to a total liquid inventory of some 2,450 litres within each batch. The inventory is made up of approximately 1900 litres of water, a total of 400 litres of acid and 150 litres of wash waters. From this, a dilution factor of 49:1 is derived for the NOx scrubber liquor and is used in the calculation. These figures are indicative and may vary slightly between batches due to the type of FED being dissolved (e.g. Less acid is required for corroded FED). The theoretical maximum concentrations of the metals in this reaction mixture both before and after abatement are also presented in Table 2.

Table 2: NOx Scrubber Liquor Unabated and Abated Metal Concentrations

Substance	Maximum Concentration of Unabated NOx Scrubber Liquor based on samples taken 24/09/14 µg/l	Maximum Concentration of the combined unabated NOx Scrubber Liquor and FED effluent in the FED Reaction Vessel µg/l	Combined Concentration of Abated FED Effluent with NOx Scrubber Liquor in the FMDT µg/l
Boron	70	101.4	86.2
Cadmium	10	30.2	1.5
Chromium	22000	2068.0	186.1
Copper	170	160.4	11.2
Iron	110000	9067.0	90.7
Lead	30	258.6	2.6
Mercury	10	5.2	5.2
Nickel	7800	840.0	226.8
Zinc	920	544.4	10.9

4.4 NOx Scrubber Liquor Potentially Discharged Intermittently

NOx scrubber liquors may be discharged on an intermittent basis and directly into ADAP without pre-dilution in the FED reaction vessel. This is being included to provide operational flexibility and may be required to be done twice a year if the acid is not within the defined range. Table 3 provides a summary of the assessment of NOx scrubber liquor without pre-dilution in the FED Reaction Vessel using removal efficiencies noted in Table 1.

Table 3: Concentrations of Metals in NOx Scrubber Liquor Discharged Intermittently

Substance	Maximum Concentration of Unabated NOx Scrubber Liquor in the FMDT based on samples taken 24/09/14 µg/l	Concentration of Abated NOx Scrubber Liquor Potentially Discharged Intermittently µg/l	Removal Efficiencies based on Table 1 %
Boron	70	59.5	15
Cadmium	10	0.5	95
Chromium	22000	1980	91
Copper	170	11.9	93
Iron	110000	1100	99
Lead	30	0.3	99
Mercury	10	10.0	0
Nickel	7800	2106	73
Zinc	920	18.4	98

To demonstrate that the NOx scrubber discharges are compliant with the EA's 'not liable to cause pollution' test (i.e. the predicted environmental concentration being less than the EQS) the maximum allowable concentration of any constituent would be calculated as below:

$$n \times D_{av} \times (C_{EQS} - BC) - (n-1) \times C_{FED}$$

where:
n is the number of days since the last NOx scrubber liquor discharge;
D_{av} is the long-term average dilution, 48,000;
C_{FED} is the concentration of the relevant constituent in the FED discharge;
BC is the background concentration of the relevant constituent

This relies on the preceding FED discharges concentrations being below the 'not liable to cause pollution' threshold.

5. ASSESSMENT

5.1 Assumptions and Conservatisms used in the Assessment

A number of assumptions/conservatisms were used in carrying out this environmental risk assessment and include:

- treating all results less than the limit of detection (LoD) as positive results;

- the use of water hardness class 5 value of 1.5 µg/l for Cd in the assessment against the EQS MAC as this is more appropriate for the Blackwater Estuary than the standard limit of 0.45 µg/l. The class 5 values are given in the EA's guidance 'Assessment of Hazardous Pollutants within Surface Waters Discharges';
- the concentration of Chromium is taken as that for Chromium VI. The operational EQSs for Transitional and Coastal Waters is 0.6 µg/l for the EQS AA and 32 µg/l for the EQS MAC. These apply only to Chromium VI and not Chromium III. The speciation analysis from samples of NOx scrubber liquor taken between 21st May – 3rd June 2014 indicated that Chromium VI was approximately a third of the total dissolved Chromium, as illustrated in Figure 1;
- the use of removal efficiency rate produced from the major study undertaken by the National Nuclear Laboratory and summarised in M/E/BWA/EAN/009/13. These are lower than those being achieved in ADAP (e.g. for Boron we are using 15% instead of 90% observed in the plant, for Chromium 91% is used instead of 100 and for Nickel 73% instead of 83%);
- the use of tidal current generated by the TELEMAC model as opposed to the actual measurement made at Bradwell in 2012 by Port of London Authority. The TELEMAC model used by HR Wallingford underestimates the currents in the vicinity of the existing outfall structures resulting in conservative dilution and dispersion results. The Port of London measurements indicate a stronger dispersion than the model suggests. Thus the model may indicate poorer flushing in the estuary than would be achieved in practice;
- the maximum daily nitrogen loading calculated (for dissolving all of the FED) is based on discharging continuously over the shortest operational programme of one year;
- the mass of FED to be processed is estimated to be approximately 205 tonnes. The Nitrogen estimate within the model assumes approximately 20% increase over the chemical stoichiometry for the maximum load for nitrogen; and
- loss mechanisms such as de-nitrification and wind dispersion have not been included in the model. These are estimated to account for approximately 40% reduction in nitrate loading.

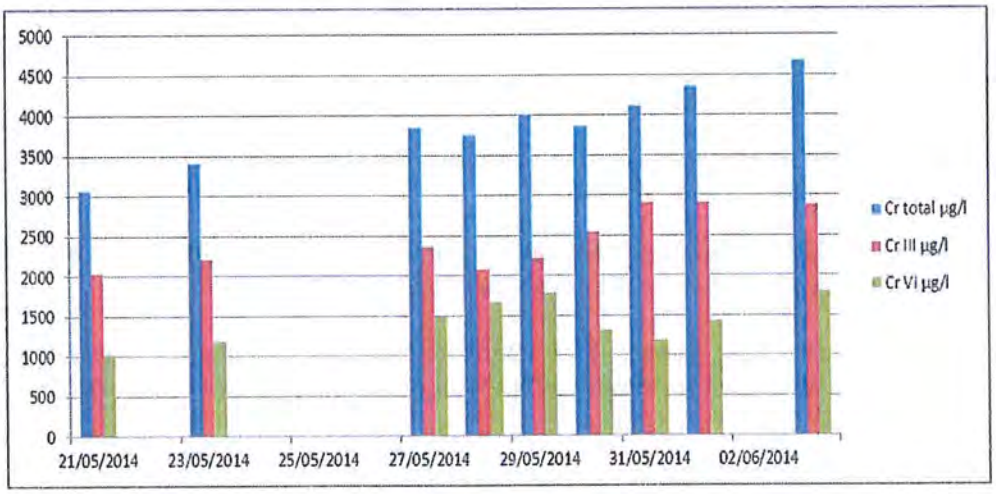


Figure 1 Speciation of Chromium into CrIII and CrVI

5.2 Environment Risk Assessment Strategy

A thorough and structured approach has been used in undertaking the environmental risk assessment and followed relevant EA guidance – H1 Annex D 1 Assessment of hazardous pollutants within surface water discharges and the European technical guidelines for the identification of mixing zones. The strategy for undertaking the environmental risk assessment in this report is schematically represented in Figure 2.

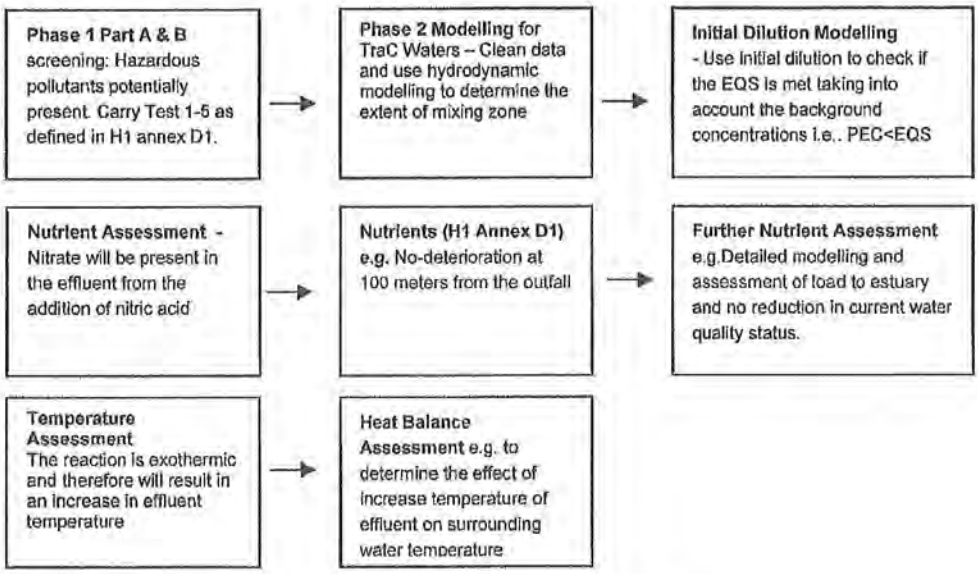


Figure 2: Environment Risk Assessment Strategy

5.3 Phase 1 - Part A Screening

There are two phases of assessment for transitional (estuaries) and coastal waters, referred to as TraC Waters. Phase 1 Part A consists of 5 screening tests. If all of these tests are met for all substances, the effluent is not liable to cause pollution. If they are not, a more detailed assessment is required under Phase 2, typically this is undertaken by use of environmental modelling.

5.3.1 TraC Screening Phase 1 Test 1 – Does effluent concentration of the substance in the discharge exceed 100% of EQS?

Table 4 provides a summary of the assessment for the combined FED effluent. The results from the test show that for the combined FED effluent:

- Boron, Iron, Lead and Zinc no longer require consideration because the concentration of these substances in the effluent would be less than 100% of the EQS AA.
- Cadmium, Chromium, Copper, Mercury and Nickel did exceed the EQS AA; these are taken forward for further assessment.
- Cadmium, Chromium and Mercury did not meet the EQS MAC, these are taken forward for further assessment.

To provide rigour, all substances are taken forward for further assessment even when they have passed this test.

Table 4: Screening Phase 1 Test 1 on Concentrations of Combined FED Effluent

Substance	Concentration of Abated FED Dissolution Effluent and NOx Scrubber Liquor in the FMDT, µg/l	EQS AA µg/l	EQS MAC µg/l	<100% of EQS AA	<100% of EQS MAC
Boron	86.2	7000	n/a	Yes	n/a
Cadmium	1.5	0.2	1.5	No	No
Chromium	186.1	0.6	32	No	No
Copper	11.2	5	n/a	No	n/a
Iron	90.7	1000	n/a	Yes	n/a
Lead	2.6	7.2	n/a	Yes	n/a
Mercury	5.2	0.05	0.07	No	No
Nickel	226.8	20	n/a	No	n/a
Zinc	10.9	40	n/a	Yes	n/a

5.3.2 TraC Screening Phase 1 Test 2 – Is the discharge to a riverine estuary or direct to a low water channel within an estuary?

The effluent is discharged into the Blackwater Estuary approximately 460 meters offshore from the site boundary into a dynamic water body. The active effluent discharge nozzle is located -5.8m Chart Datum (CD). On this basis, the discharge passes the test.

5.3.3 TraC Screening Phase 1 Test 3 – Is the discharge to a location with restricted dilution/dispersion?

As noted above, the effluent is discharged into the Blackwater Estuary approximately 460 metres offshore into a dynamic water body. On this basis, the discharge passes the test.

5.3.4 TraC Screening Phase 1 Test 4 – Is the discharge either to a location less than 50m offshore from where the sea-bed is at Chart Datum or to a location where the sea-bed is less than 1m below Chart Datum?

The discharge is through a dedicated outfall which is approximately 460 metres into the Blackwater Estuary from the boundary of the site and into a significant tidal estuary. The mean tidal range at Bradwell is between 4.8m on spring tides and 2.9m on neaps. The active effluent discharge port is located -5.8m CD. On this basis, the discharge passes the test.

5.3.5 TraC Screening Phase 1 Test 5 – Is the Effective Volume Flux (EVF) greater than the Allowable Effective Volume Flux (AEVF)?

This is only required for buoyant effluents that fail Test 4. The combined FED effluent and the NOx Scrubber Liquor are negatively buoyant, therefore are not suitable to be subject to this test. Detailed Phase 2 assessment is required.

5.3.6 Part B Screening: Is the Significant Load exceeded (Test valid for only Priority Hazardous Substances (PHS))

Mercury and Cadmium are the only PHSs identified in the effluent. The significant load in the discharge is calculated as follows:

- the mean discharge quality (µg/l) x the mean flow (litre/day)= µg/day;
- the result above is then divided by 1,000 to give mg/day;
- the result is then divided by 1,000 to give g/day;
- then divided by 1,000 to give kg/day;
- the result above is then multiplied by 365 to give kg/year.

The results for the PHSs in the combined FED effluent are presented in Table 5.

Table 5: Screening Test Part B Critical Load of Priority Hazardous Substances in Combined FED Effluent against the Critical Load

Substance	Concentration of Abated Combined FED Effluent in the FMDT ug/l	Significant Load		Annual Significant Load from Discharge in kg/yr	Annual Significant Load in kg/yr
		ug/day	kg/day		
Cadmium	1.5	3.00E+04	3.00E-05	1.10E-02	5
Mercury	5.2	1.04E+05	1.04E-04	3.80E-02	1

The results in Table 5 show that the Annual Significant Load for both Cadmium and Mercury are well below the set EA thresholds. Therefore, the discharge passes the test.

5. 4 Phase 2: Modelling

The Phase 2 modelling for substances which the precautionary Phase 1 highlighted as potentially significant was undertaken by HR Wallingford for the new discharge line. The modelling defines a mixing zone of 100m from the outfall structure for which an acceptable initial dilution is achieved. The initial dilutions used in this report consider two scenarios:

- short discharges every day, the long term average dilution factor at 100m is estimated as 48,000:1. This is used in assessment against the EQS AA.
- assessment against the EQS MAC, dilution factor of 240:1

A detailed description of the output from this work is presented in BRAD/EN/REP/138/FED - 'Annual Average Concentration of FED Constituents'[11]. The report should be read in conjunction with this document. Approximately 4,000 m^3 per year of FED dissolution effluent is to be discharged into the Blackwater Estuary which has an average volume of 232,000,000 m^3. This illustrates the large scale of the dilution achieved in the estuary and minor contribution from site discharges.

5.4.1 Variation in Effluent Plume

The modelling undertaken considers the contribution made by returning diffuse patches of effluent from previous discharges. This ensures that the contribution made by the site's discharges is comprehensively assessed at the edge of the identified mixing zone. The plume of the discharge is illustrated in Figure 3 and the effect of the returning patches of effluent illustrated in Figure 4 (both reproduced from BRAD/EN/REP/138/FED report).

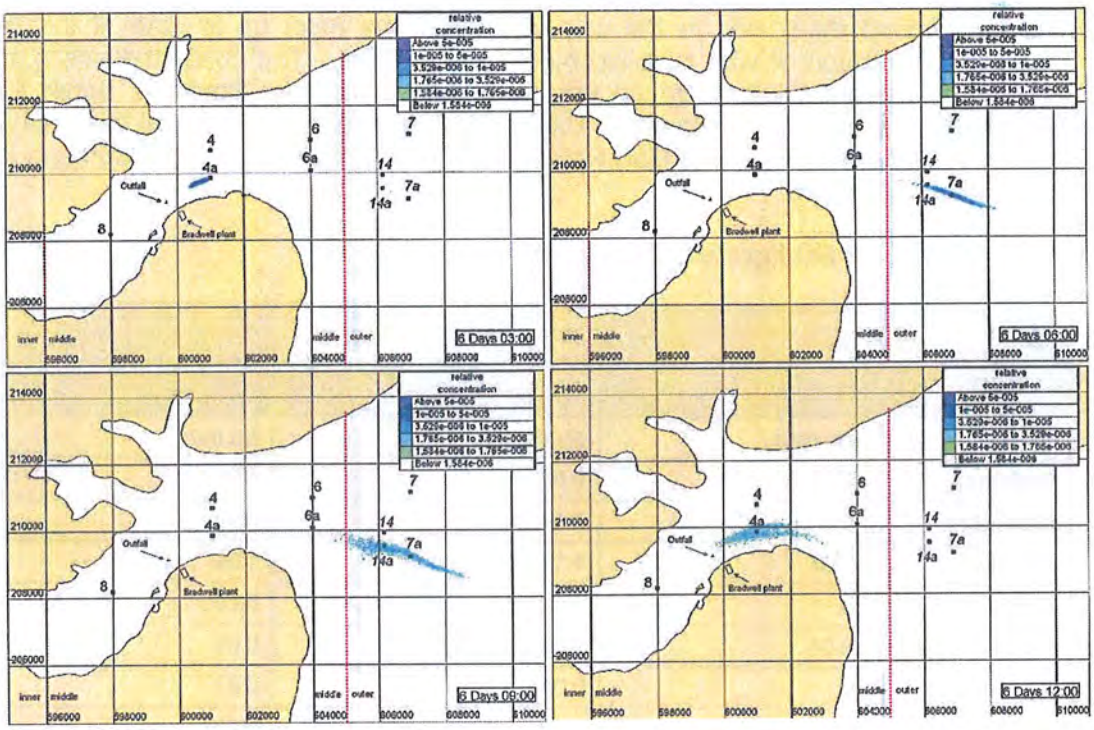


Figure 3: Representative movement of a single discharge patch during one tide

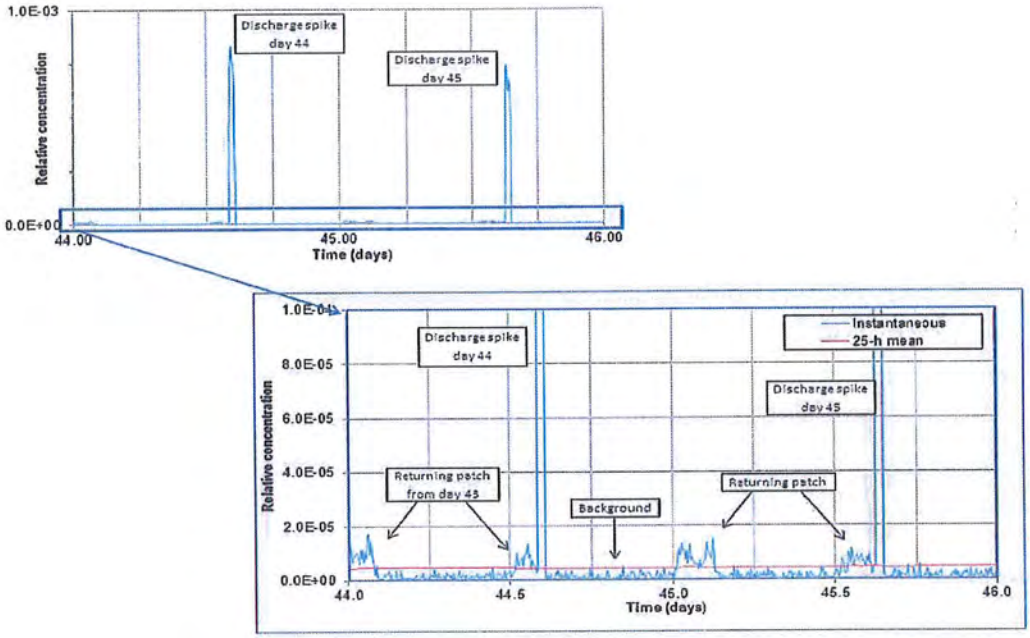


Figure 4: Variation of relative concentration 100m from the discharge tower, after 1.5 months with daily discharge

5.4.2 Assessment against the Predicted Environmental Concentration (PEC) Against the EQS AA and EQS MAC

This test assesses the predicted environmental concentration (PEC) of the substances against the EQS. The PEC is the concentration of the substances after initial dilution taking into account the background concentrations in the estuary.

The background data used in the calculation was the most up to date at the time of producing this report: it was supplied by the EA in 2014. The concentrations (µg/l) are averaged between results from an upstream data point from Bradwell, South East of Tollesbury, (National Grid Reference: TL9800008200) and downstream of Bradwell, South East of West Mersea (National Grid Reference TM0400011000). The background data is summarised in Table 6.

Table 6: Average Background Concentration

Substance	Average Concentration Upstream of Bradwell µg/l	Average Concentration Downstream of Bradwell µg/l	Average Concentration µg/l
Boron	No data	No data	No data
Cadmium	0.04	0.04	0.04
Chromium	0.5	0.5	0.50
Copper	1.07	1.11	1.09
Iron	0	100	50.00
Lead	0.04	0.05	0.05
Mercury	0	0.01	0.01
Nickel	0.97	0.92	0.95
Zinc	0.91	1.11	1.01

Table 7 provides a summary of the assessment of PEC against the EQS AA using the abated metal concentrations of the combined FED effluent. The concentration of the substances at the edge of the mixing zone, called the process contribution (PC), has been calculated using the 48,000:1 dilution factor for short daily discharges. This assessment shows that the PEC is less than the EQS AA for all substances. This demonstrates that substances in the effluent will not be liable to cause pollution and needs no further assessment.

Table 7: PEC against the EQS AA using the Abated Metal Concentrations of the Combined FED Effluent

Substance	Concentration of Abated Combined FED Effluent in the FMDT µg/l	PC using Dilution Factor 48,000:1 for short discharges µg/l	Average Background Concentration, µg/l	PEC (PC+ Background) µg/l	EQS AA µg/l	PEC as a % of EQS AA
Boron	86.2	1.80E-03	0	1.80E-03	7000	0.00003
Cadmium	1.5	3.13E-05	0.04	4.00E-02	0.2	20
Chromium	186.1	3.89E-03	0.50	5.04E-01	0.6	84
Copper	11.2	2.33E-04	1.09	1.09E+00	5	22
Iron	90.7	1.90E-03	50.00	5.00E+01	1000	5
Lead	2.6	5.42E-05	0.05	5.01E-02	7.2	1
Mercury	5.2	1.08E-04	0.01	1.01E-02	0.05	20
Nickel	226.8	4.74E-03	0.95	9.55E-01	20	5
Zinc	10.9	2.27E-04	1.01	1.01E+00	40	3

Table 8 provides a summary of the assessment of PEC against the EQS MAC using the abated metal concentrations of the combined FED effluent. This assessment shows that

the PEC is less than the EQS MAC for all applicable substances. This demonstrates that substances in the effluent will not be liable to cause pollution and needs no further assessment.

Table 8: PEC Against EQS MAC using Abated Metal Concentrations of Combined FED Effluent

Substance	Concentration of Abated FED Effluent and NOx Scrubber Liquor in the FMDT µg/l	PC using Dilution Factor 240:1 µg/l	Average Background Concentration µg/l	PEC (PC + Background) µg/l	EQS MAC µg/l	PEC as % of EQS MAC µg/l
Boron	86.2	3.59E-01	0	3.59E-01	n/a	n/a
Cadmium	1.5	6.25E-03	0.04	4.63E-02	1.5	3
Chromium	186.1	7.79E-01	0.50	1.28E+00	32	4
Copper	11.2	4.67E-02	1.09	1.14E+00	n/a	n/a
Iron	90.7	3.80E-01	50.00	5.04E+01	1000	5
Lead	2.6	1.08E-02	0.05	6.08E-02	7.2	1
Mercury	5.2	2.17E-02	0.01	3.17E-02	0.07	45
Nickel	226.8	9.49E-01	0.95	1.90E+00	n/a	n/a
Zinc	10.9	4.54E-02	1.01	1.06E+00	n/a	n/a

5.4.3 Comparison of EQS AA and EQS MAC Against Drinking Water Standards

Table 9 helps illustrate how stringent the EQS limits are that apply to permitted discharges by providing a comparison against drinking water standards (as defined in the 'Water Supply (Water Quality) Regulations 2000 (as amended)). The EQS MAC is used as this sets the maximum allowable concentration against the equivalent for drinking water.

Table 9: Comparison the EQS MAC against Drinking Water Standards

Substance	EQS MAC µg/l	Drinking Water Standard µg/l	Drinking Water Standard for biota* µg/l
Boron	n/a	1000	n/a
Cadmium	0.45	5	n/a
Chromium	32	50	n/a
Copper	n/a	2000	n/a
Iron	n/a	200	n/a
Lead	n/a	10	n/a
Mercury	0.07	1	20
Nickel	n/a	20	n/a
Zinc	n/a	n/a	n/a

*The EQS biota limit for Mercury relates to fish.

5.4.4 Effect of accumulated substances on estuary after cessation of FED effluent related discharges

Further, modelling of the effect of the metals in the FED effluent in the Blackwater Estuary concluded that approximately 6% of the total material discharged during the FED

dissolution process would remain in the estuary at the end of the FED programme. After 6 months, 90% of this would be lost from the estuary. Therefore, for every kilogramme of particular metal released, 60 grammes is predicated to remain at the end of the FED process, it will be wide spread over the estuary, reducing to about 6 grammes after 6.5 months. These figures are based on the retention calculations given in report 'BRAD/EN-REP/032/FED – FED Discharge Dispersion EX6399'.

Figure 5 illustrates the exponential loss of residual FED material in the estuary – this has been reproduced from BRAD/EN/REP/138/FED/Annual Average Concentration – Dedicated Discharge (Including HR Wallingford Report RT012-R01).

Figures 6 and 7 illustrate the pattern of the plume for nitrates over a 57 day period. Section 5.5 provides a summary of nitrate loading in the estuary.

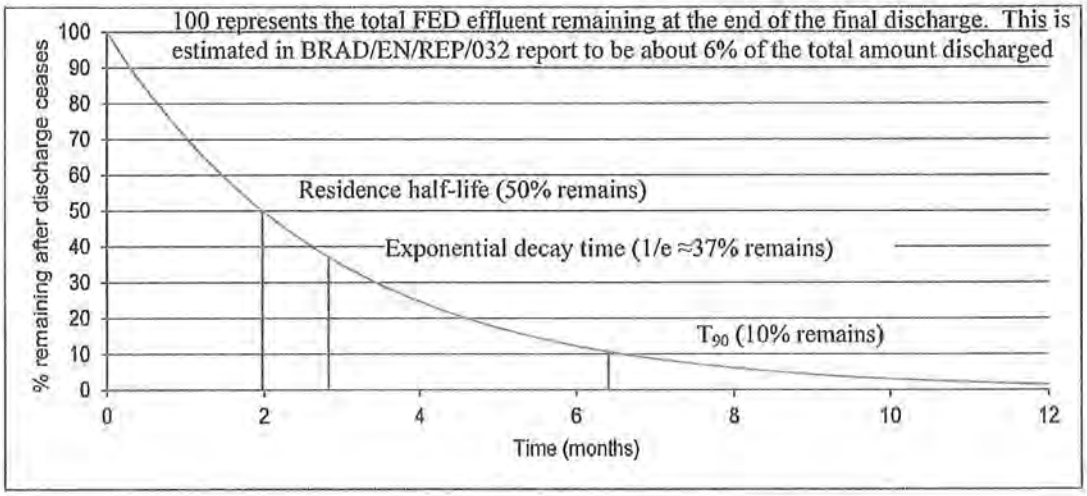


Figure 5: Exponential Loss of FED Material from the Estuary after Discharge Ceases

5.5 Assessment of Nitrate Loading

The Environmental Agency stipulated a no-deterioration threshold which should be achieved in the Blackwater Estuary. This requires that the FED discharges be less than 10% of existing background of Dissolved Inogranic Nitrogen (DIN) or nitrate in the estuary. In addition, the current classification of the water body is not to be jeopardised (i.e. continued achievement of "Moderate" and "Good" status for the Blackwater & Colne and Blackwater Outer, respectively).

The assessment of nitrate loading was modelled by HR Wallingford and is summarised in the report BRAD/EN/REP/FED/114/'FED Discharge Arrangements: Far Field Dispersion[12]. This is informed by previous HR Wallingford report BRAD/EN/REP/032/FED/Discharge Dispersion EX6399. The assessment of nitrate loading showed that:

- the retained nitrate from the discharge is well diffused. The intermittent nature of the discharge and the tidal movement of the subsequent patch of effluent mean that the impact at any fixed location is intermittent;
- overall, the FED discharge is expected to increase the average concentrations in the Blackwater Estuary by less than 10% of the background value;
- there will be instantaneous periods when the 10% background nitrate rate concentration threshold is exceeded, this will be for very short durations (30 minutes)and localised area each day. Close to the discharge point and within the

path of the plume, short duration peak concentrations of up to 1.5 mg/l as N (typically 1 mg/l) are predicated within the centre of the plume;

- the estimated input of Nitrogen from FED is 555 kg to 663 kg (2457 kg to 2934 kg Nitrate) per day for a maximum 'worse case' discharge duration of 49 weeks continuous operation based on 480 kg/d FED throughput. Using these figures, the expected load from the FED plant is in the order of 7.7% - 9.1% of the estimated load into the Blackwater and 5.9%-7.7% into the Blackwater plus Colne (middle and outer estuary);
- if de-nitrification is factored in, an average reduction of 40% would actually be seen in the upper estuary only. It can be concluded that the FED discharge could amount to 9.1% of the load entering the upper estuary and about 10% of the load entering the mid and outer estuary.
- when FED discharges finish, the localised peak concentrations near the outfall will immediately be eliminated; and
- residual nitrate concentration from FED dissolution in the estuary will gradually reduce back to the background concentration after FED dissolution ceases. About 6% of the total material discharged during the FED process will remain in the estuary at the end of the FED programme. For every kilogramme of nitrate released, up to 60 grammes is predicted to remain at the end of FED dissolution, reducing to about 6 grammes after 6 months. Neglecting chemical/biological losses such as plant uptake in the estuary, it would take just over 6 months for 90% of the remaining nitrates to be lost from the estuary. This is a conservative estimate as the model uses worse case loads and it does not take into account removal processes within the estuary such as de-nitrification, natural flushing and dilution of the estuary from river flow. If such losses were taken into account, it would take approximately 3 months for the residual nitrates to be lost from the estuary.

Figures 6 (spring tide) and Figure 7(neap tide) illustrate that the build-up concentration pattern moves with the tide to produce the daily average impacts. These have been reproduced from BRAD/EN/REP/114/FED/Discharge Arrangements: Far Field Dispersion.

From Figure 6 it can be seen that on the spring tide the concentration in most of the Upper Estuary is less than the Upper Estuary 10% no deterioration screening threshold concentration (0.078mg/l). The average concentration in most of the Mid Estuary is between the Mid and Upper Estuary screening threshold concentrations (0.039-0.078mg/l). The concentration in most of the Outer Estuary is less than the 10% Outer Estuary screening threshold concentration (0.035mg/l). Only in the narrow line along the axis of the plume does the average concentration exceed the screening threshold concentration for the upper estuary.

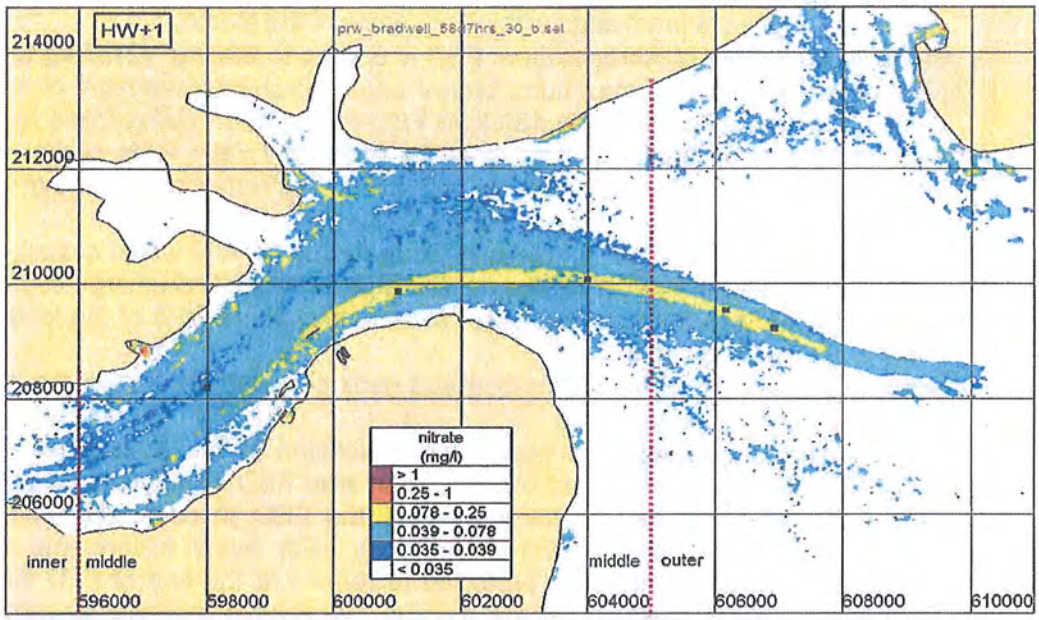


Figure 6: Predicated Nitrate Concentrations averaged over one day on a Spring Tide after 50 days of Discharge

On the neap tide (Figure 7) most of the concentration in the whole of the upper estuary remains below the 10% no-deterioration screening threshold concentration (0.078mg/l). The average concentration in most of the middle estuary is between the screening threshold concentrations for the Mid and Upper Estuary areas (0.039-0.078mg/l). However, there is an increased area, compared with the spring tide, where the concentration east of the discharge exceeds the upper estuary screening threshold.

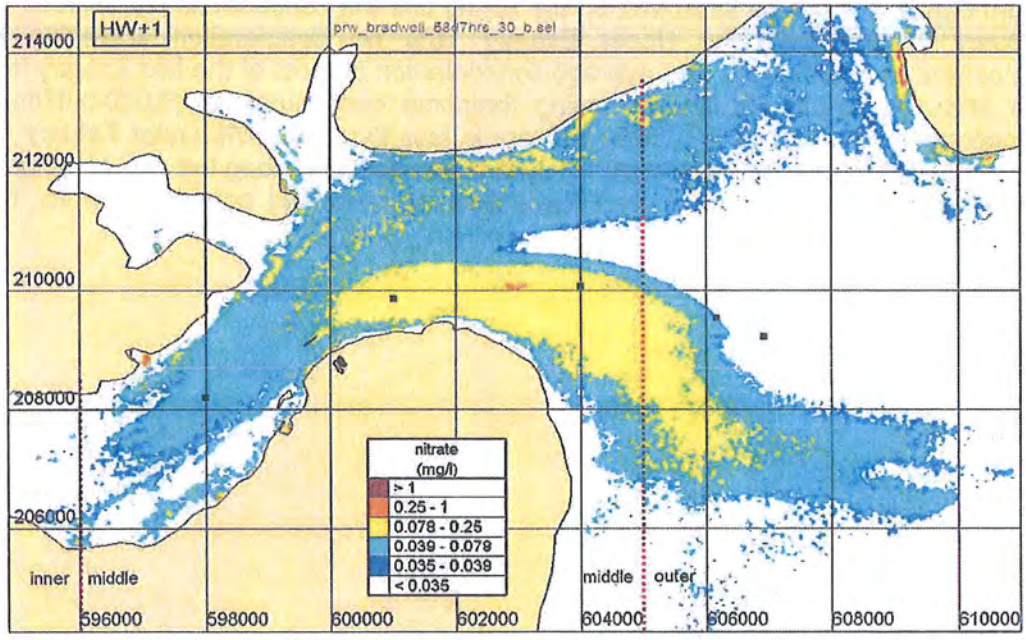


Figure 7: Predicted Nitrate Concentration averaged over one day on a Neap Tide after 57 days of Discharge

5.6 Temperature Assessment

A thermal assessment has been undertaken in order to determine the net increase in the temperature of the water from the effluent. From this the following issues have been evaluated:

a) if the increase will need to be considered within the results of the modelling studies; and

b) if there is likely to be any significant effect on the ecology of the receiving environment.

The assessment has been undertaken by dividing the highest excess temperature which represents the worst case scenario by the dilution factor achieved at the end of the mixing zone.

The FED abatement system receives influent at a maximum of 50°C from the FED dissolution process. Table 10 shows the effluent temperature in the sentencing tank for different ambient air temperatures. In this assessment, it has been assumed that the dilution water (the estuary) has a minimum winter temperature of 7°C (280K) and a maximum summer temperature of 20°C (293K) (CEFAS, 1999)[13]. Therefore, the highest excess temperature ΔT of the FED effluent in the estuary will be approximately 34.7°C. This is based on the worst case scenario event of discharging effluent with the highest temperature in the sentencing tank on a warm day (ambient air temperature 35°C) into the estuary with a minimum winter temperature of 7°C. However, this is unlikely to happen as the effluent temperature in the sentencing tank will be significantly lower during the winter periods. The effect of this excess temperature on the estuary has been assessed using the initial dilution of 240:1 achieved within the mixing zone. Even with the extremely conservative assumption stated above, the change in temperature at the end of the mixing zone within the estuary is estimated to be approximately 0.14°C. This is below the Water Framework Directive threshold of 2°C, above which the quality of water is deemed to be affected.

Table 10: Effluent Temperature Information For Different Ambient Air Temperatures

Heat Transfer Modelled Results (°C)					
Ambient Air Temperature (inside container)	5	10	15	25	35
Final Temperature in Sentencing Tanks	21.12	24.55	27.97	34.82	41.67

6 ASSESSMENT AGAINST OTHER RELEVANT ENVIRONMENTAL LEGISLATION

The impact of the discharge on the receiving water was assessed against relevant environmental legislation and designations associated with the receiving water. The Blackwater Estuary and other designated habitats within its vicinity are of international, national and local importance. As a result, any regulated activities within the vicinity of the designated site boundaries, or in their upstream catchments, may require an assessment to ensure they will not be adversely affected.

6. 1 WATER FRAMEWORK DIRECTIVE

The current water quality status and a summary of dissolved inorganic nitrogen (DIN) data for the Blackwater Outer and Essex are given in Table 11 and Table 12.

Table 11: UKTAG Water Quality Status for Blackwater Estuary

Estuary Area	Location	DIN Status - current	DIN Status – 2015
Blackwater & Colne	Upper Estuary	Moderate	Moderate
Blackwater Outer	Mid Estuary	Good	Good
Essex	Outer Estuary	Good	Good

Source: UK Technical Advisory Group, Water Framework Directive

Table 12: Winter DIN Concentrations (2005-2010)

Waterbody	Location	DIN Av. (mg/l as N)	DIN 99%ile (mg/l as N)
Blackwater & Colne	Upper Estuary	1.8	4.46
Blackwater Outer	Mid Estuary	0.67	1.99
Essex	Outer Estuary	0.54	1.37

Source: EA Data 2005-2010 (winter values)

These water quality status assessments are based upon the UKTAG methodology which relates nutrient thresholds to turbidity. Following the assessment process for transitional waters and corresponding to the winter 99%ile DIN threshold of 2.52 mg/l, the water quality for the Blackwater Outer and Essex are confirmed as Good, whilst the Blackwater & Colne is Moderate. The water quality in all cases is assumed to demonstrate a medium degree of turbidity and has an average winter DIN which exceeds 0.42 mg/l (30µMol/l) in all cases.

Predictive water quality modelling undertaken by HR Wallingford concludes that a worst case average increase in DIN of 10% in the middle and outer estuary may occur as a result of the project. This would therefore increase the current average DIN values to 2.0, 0.74 and 0.6 mg/l N respectively.

The salinity of the Mid and Outer Estuary is described as transitional. The measured and reported salinity is less than 30mg/l which supports the current assessment of the water quality status for both estuarine regions. Whilst the winter mean values still exceed the 0.42 mg/l value, a 10% increase of the 99%ile values for the Mid and Outer Estuary to 2.2 and 1.5 mg/l respectively, would still be within the threshold of 2.52mg/l. This would ensure that the status of the Mid and Outer Estuary remains as Good. The upper estuary 99%ile was above the 2.52mg/l threshold at 4.46mg/l putting it in the Moderate classification. A 10% increase in background DIN to 4.9mg/l would leave it within this classification.

6.2 WATER FRAMEWORK DIRECTIVE (2013/39/EC)

The H1 Annex D1 assessment demonstrates that the predicted environmental concentrations of all the priority and priority hazardous substances within the effluent are below the EQS. As such, the proposed discharge will therefore have no significant effect on the current status of the estuary.

6.3 HABITATS DIRECTIVE

Discharges through the newly installed pipes will have no effect on the Designated SAC/SPA in terms of coastal squeeze and flood management.

In terms of eutrophication, it is anticipated that, the overall average increase in nitrate concentration in the estuary will be less than 10% of the known background. There will however be localised areas within the plume which will exceed the 10% threshold for short durations. Close to the discharge point and within the path of the plume, short-duration peak

concentrations of up to 1.5 mg/l as N (typically 1 mg/l) are predicted within the centre of the plume.

The conservative modelling results also showed that there is potential for some build-up of nitrate in the estuary. As the retained nitrate is well diffused, and the discharge does not affect the flow patterns in the estuary to any significant extent, the most reasonable predictor of the overall increase in concentration in the estuary resulting from the FED discharge would be that the average increase would be in proportion to the increase in load relative to the background load from agriculture and sewage treatment.

Based on available data and ignoring natural loss mechanisms, it is expected that the worst case discharges from Bradwell would increase the current background N concentrations in proportion to the scale of the contribution i.e. 5.9-7.1%. As the loss mechanisms in the Upper Estuary results in some decrease in the background load reaching the discharge area, the FED load represents a higher proportion of the local background, estimated as 10% if the maximum daily output were sustained all year.

The assessment of the potential effects on the UKTAG WFD classification of the area demonstrates that although the average nitrate/DIN values may increase by 8 to 10%, it will not affect the various water areas current status. In addition to this, in terms of nutrient effects on primary production, the ratios of Nitrogen: Phosphorous (N:P) can give an indication as to suitability of production conditions. The average N:P ratio for the Mid and Outer Estuary areas indicate the phosphorous appears to be the limiting factor in these areas. As the proposed FED discharge does not contain any phosphorous, this balance will not be affected.

In addition to the above, the risk of water quality deterioration by discharges from the Bradwell FED dissolution project is further mitigated by a number of factors:

- The maximum nitrogen loadings used in the assessment are based on approximately 20% above stoichiometric chemical requirements.
- The average increase in dissolved inorganic nitrogen is marginal (10% or less) and does not present a significant contribution to the concentrations already present.
- The risk of increased algal primary production is significantly limited by the light transmittance of the water due to effects of suspended solids and turbidity.
- Long-term objectives (2015) of the water quality status of all the areas of the estuary should not be affected by the project.

6.4 THE EC WATER FRAMEWORK DIRECTIVE (2000/60/EC) - 'PROTECTED AREAS'

The Shellfish Waters Directive was repealed by the EC Water Framework Directive in December 2013. Protected areas must be afforded at least the same level of protection as was given by the Shellfish Waters Directive. As discussed previously, the H1 Annex D1 assessment of the final effluent demonstrates that all priority and priority hazardous substances will achieve the required EQS standard. In addition, nitrate levels will also be below the required 10% "no-deterioration" threshold, well within 100m of the outfall on all tidal states. The nearest known oyster beds from the outfall are located approximately 600m and 8km. At these distances priority and priority hazardous substances would have been dispersed and diluted to the extent that the respective EQS will not be challenged. The nitrate concentration of the nearest bed is predicted to remain below the instantaneous peak of 0.15mg/l which corresponds to a dilution of around 150,000 relative to initial concentration. The effluent plume does not reach the farthest bed at significant concentrations (i.e. nitrate concentrations of the order of 10^{-3}mg/l). Consequently, there will not be any effect on the current status of the 'protected areas' shellfish waters or shellfish monitoring points.

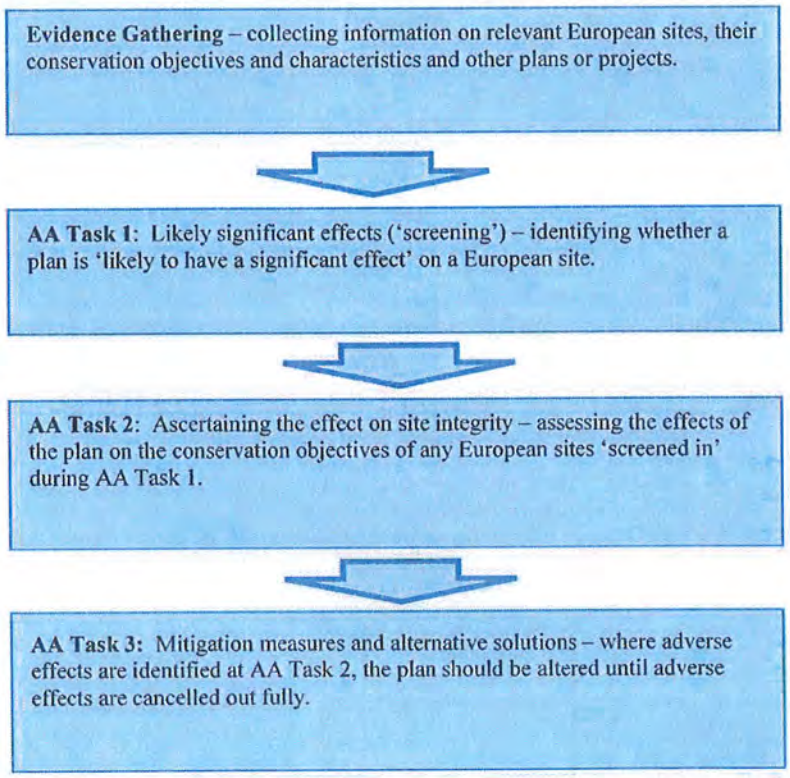
Table 13: Summary of Assessment of Status of Key Water Standards in Blackwater Estuary

Designation	Current Status	Assessment of potential impact
Water Framework Directive/ Anglian River Basin District – Dissolved Inorganic Nitrogen	Discharge into - Blackwater & Colne - "moderate", Immediately downstream - Blackwater Outer - "good", Downstream - Essex - "good".	The modelling has confirmed that the average concentration of either nitrate or DIN will not exceed the 10% threshold. Allowing a 10% increase of the 99%ile winter DIN concentrations compared to the maximum limit for "Good" and "Moderate" status, conservatively demonstrates that the current status of each section of the Blackwater Estuary remains unchanged. As such there will be no risk of a reduction in water quality status as a result of FED dissolution at Bradwell.
Water Framework Directive (2013/39/EC)	Discharge area – Mid Estuary – Background concentration of priority and priority hazardous substances are all below their individual EQS's.	The H1 Annex D1 assessment of the final effluent demonstrates that all Priority and Priority Hazardous substances will achieve the required EQS standard (i.e. PEC < EQS). In addition, all metal levels will also be below the required "no-deterioration" threshold, well within 100m of the outfall on all tidal states. As such, the discharge will have no significant effect on the current status of the receiving water.
Habitats Directive	Current status "unfavourable" due to coastal squeeze and the need for "Flood Risk Management". Eutrophication	The proposed project will have no effect on the Designated SAC/SPA in terms of coastal squeeze and flood management. In terms of eutrophication, the results from the dispersion modelling study undertaken by HR Wallingford confirm that the average nitrate / DIN concentration will not exceed the background levels by more than 10% throughout the duration of the Bradwell FED dissolution project. In terms of maximum concentrations, these occasionally exceed the 10% threshold but in reality, wind perturbations and non-tidal currents would affect the trajectory and spread the impact over a wider area at a lower concentration. The results presented are therefore considered worse case and lower resulting concentrations will occur in reality. Other factors within the estuary will also mitigate the risk of water quality deterioration during the project such as de-nitrification. Further discussion of the potential effects on Natura 2000 sites can be found in section 6.5.
Water Framework Directive 2000/60/EC- Protected Areas	5 monitoring points in closest proximity - Guideline and Imperative standard passes.	Priority and priority hazardous substances will be well below the required 100% of the EQS. All levels will be below the required no-deterioration threshold well within 100m of the outfall on all tidal states. There will therefore be no effect on the current status of the' protected areas' under the EC Water Framework Directive (shellfish waters or shellfish monitoring points).

6.5 NATURA 2000 SITES

The Blackwater Estuary and surrounding area is of high nature conservation value and as such there are a number of European Protected Sites designated for their habitats, wildlife and birds. Special Areas of Conservation (SACs) are designated under the provisions of the Habitats Directive (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora), as enacted in the UK by 'The Conservation (Natural Habitats, & c.) Regulations, 2010 as amended'. Special Protected Areas (SPAs) are designated under the provisions of the Birds Directive (Council Directive 79/409/EEC on the Conservation of Wild Birds), which requires member states to take special measures to conserve habitats for certain rare or vulnerable species and for regularly occurring migratory species of birds. Collectively SACs and SPAs are referred to as Natura 2000 sites.

For Natura 2000 sites, the process by which the impacts of a project are assessed against the conservation objectives of a European site is known as Habitats Regulations Assessment (HRA). The HRA determines whether there will be any likely significant effects (LSE) on any European site and, if so, whether these effects will result in an adverse effect on its integrity. The current European Commission guidance details a four-stage process (see diagram below) for HRA, although not all stages will be necessarily required:



The Environment Agency H1 Annex D1 reinforces the need to protect Natura sites and states that the specific guidance for the Habitats Directive should be met. In order to undertake a thorough assessment of the potential effects of the proposals, a stage approach has been adopted. Firstly those SAC/SPAs within the Blackwater Estuary area are identified and an initial screening as to whether there is potential for the SAC/SPA to be affected is undertaken. Subsequent to this a more detailed review and secondary screening is completed for the qualifying features of the relevant SAC/SPA. Finally potential

impacts from the proposed discharge are identified and, for the screened features, an assessment is undertaken based on the results of the water quality assessment.

Figure 8 shows the locations of the SAC/SPAs in relation to the Bradwell Site. Table 14 gives the name of the SAC/SPA, its proximity to the discharge location and the conclusions of the initial screening assessment. For ease of reference, those which will be further assessed are highlighted.

Figure 8: Locations of SPAs and SAC in Vicinity of Blackwater Estuary

Table 14: Initial Screening of Natura 2000 Sites in Vicinity of the Blackwater Estuary

Designation	Proximity to site	Included/ reason
Essex Estuaries SAC.	**Immediately adjacent.**	**Yes – potential for water quality to be affected.**
Dengie SPA (Mid-Essex Coast Phase 1).	**Immediately adjacent.**	**Yes – potential for water quality to be affected.**
Blackwater Estuary SPA (Mid-Essex Coast Phase 4).	**Immediately adjacent.**	**Yes – potential for water quality to be affected.**
Outer Thames SPA.	Approx 5km to east.	No – water quality not directly affected. If potential effect on Blackwater Estuary/ Dengie SPA is identified further assessment will be undertaken.
Colne Estuary SPA (Mid-Essex Coast Phase 2).	Approx 5km to the north.	No – water quality in estuary not affected. If potential effect on Blackwater Estuary/ Dengie SPA is identified further assessment will be undertaken.
Abberton Reservoir SPA Site.	Approx. 8km to the northwest.	No – water quality in reservoir not affected. If potential effect on Blackwater Estuary/ Dengie SPA is identified further assessment will be undertaken.
Crouch and Roach Estuaries SPA (Mid-Essex Coast Phase 3).	Approx. 13km to the south.	No – water quality in estuary not affected. If potential effect on Blackwater Estuary/ Dengie SPA is identified further assessment will be undertaken.
Foulness SPA (Mid-Essex Coast Phase 5).	Approx. 12.5km to the southeast.	No – water quality in estuary not affected. If potential effect on Blackwater Estuary/ Dengie SPA is identified further assessment will be undertaken.

In terms of secondary screening, the Essex Estuaries report (English Nature 2006)[14] identifies a range of activities which may cause disturbance or deterioration to the key interest features of the SAC. For the purpose of this assessment the secondary screening of the SAC/SPA features has been based on the summary of operations identified within that report. These operations identified are identified as:

- Physical loss – removal or smothering.
- Physical damage – siltation or abrasion.
- Non-physical disturbance – noise/visual.
- Toxic contamination – introduction of synthetic or non-synthetic compounds.
- Non-toxic contamination – changes to nutrient loading; organic loading, turbidity, salinity or temperature.
- Biological disturbance – introduction of microbial pathogens or non-native species.

Table 15 below summarises the secondary screening process. For each site highlighted in the previous table, the qualifying features are briefly identified. A review is then undertaken of the various activities identified above and the reason, or not, for further assessment is given.

Table 15: Secondary Screening of Features within Natura 2000 Sites

Natura 2000 Site/Features	Further assessment	No further assessment
Essex Estuaries SAC:		
Annex I habitats that are a primary reason for selection of this site: • Estuaries. • Mudflats and sandflats not covered by seawater at low tide. • *Salicornia* and other annuals colonising mud and sand. • Spartina swards (*Spartinion maritimae*). • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*). • Mediterranean and thermo-atlantic halophilous scrubs (*Sarcocornetea fruticosi*). Annex I habitats present, but not a primary reason for selection of this site: Sandbanks which are slightly covered by seawater all the time.	Toxic contamination - the proposed discharge includes Priority and Priority Hazardous substances which could affect species associated with the SAC. Non-toxic compounds such as additional nutrient load have the potential to affect all the features of the SAC through eutrophication.	The discharge will be through a new discharge line installed under a marine licence. It is not expected that there will be any physical loss or damage as a result of this discharge as it will be within consented flows. Furthermore, the discharge will not affect existing hydrodynamic and sediment deposition regime within the estuary. There will be no additional noise or visual disturbance around the end of the outfall as a result of the temporary discharge. There will be no significant organic loading or suspended solids within the discharge. There will be no significant changes to salinity or turbidity above that occurring as a result of the current outfall operation. There will be no "biological disturbance" as a result of the proposals or introduction of non-synthetic compounds. Non-toxic contamination - Changes in localised water temperature around the outfall would be remote from features of the SAC.
Dengie SPA (Mid-Essex Coast Phase 1)		
Designated as SPA as supports: • Internationally important assemblages of waterfowl. • Internationally important populations of regularly occurring migratory species. • Internationally important populations of regularly occurring Annex I species.	Toxic contamination - the proposed discharge includes Priority and Priority Hazardous substances which could affect the SPA. Non-toxic compounds such as additional nutrient load which have the potential to affect the birds' or the prey habitat/feeding grounds associated with the SPA. Non-toxic contamination - Changes in localised water temperature around the outfall can also have effects on indigenous prey species and therefore could indirectly affect the birds of the SPA.	The discharge will be through a new discharge line installed under a marine licence. It is not expected that there will be any physical loss or damage as a result of this discharge as it will be within consented flows. There will be no additional noise or visual disturbance around the end of the outfall as a result of the temporary discharge. There will be no significant organic loading, suspended solids, or changes to salinity /turbidity above that occurring as a result of the current outfall operation. There will be no "biological disturbance" as a result of the proposals or introduction of non-synthetic compounds.

Blackwater Estuary SPA (Mid-Essex Coast Phase 4)		
Designated as SPA for same features as for Dengie SPA.	Yes – as per Dengie SPA.	No – as per Dengie SPA.

As identified above there are a number of features and species of the SAC and SPAs which could have the potential to be affected by the intermittent effluent discharge. In terms of specific potential impacts, these have been further classified as follows:

- Toxic contamination - Direct impact on species as a result of changes to water quality (heavy metals) during normal operation.
- Toxic contamination - Direct impact on species as a result of changes to water quality (heavy metals) during unplanned operational conditions.
- Non-toxic contamination - Effluent acts as chemical/thermal barrier to movement of marine species.
- Toxic/Non-toxic contamination - Indirect impact on key species through effects on their prey species (chemical/thermal).
- Non-toxic contamination - Increased eutrophication resulting in an accelerated growth of algae and higher forms of plant life, which may result in an undesirable disturbance to the balance of organisms present in the estuary and to the quality of the water.

In order to assess the potential effects on the integrity of the Natura 2000 sites the results of the water quality assessment in the previous chapters have been used. The results have been presented in tabular format for ease of reference. For each Natura 2000 site feature highlighted in Table 15, the potential effects are identified. The results of the water quality assessment are then briefly discussed and, where appropriate, mitigation is recommended, and the overall assessment of impact in terms of the integrity of the site is provided. These are summarised in Table 16.

The impact of hazardous substances on ecology of the SAC/SPA has been assessed using the environment agency H1 Annex D1 assessment EQS thresholds and for nutrients a 'no deterioration' threshold agreed with the Environment Agency.

Finally as the potential effects on one SPA would be similar to another SPA in the area, the assessment table has been grouped for the SPA sites to minimise repetition.

Table 16: Assessment of Natura 2000 Sites in Blackwater Estuary

Designation/Features	Potential impact	Assessment /Likely Significant Effect	Mitigation/Overall Assessment
Essex Estuaries SAC			
• Estuaries. • Mudflats and sandflats not covered by seawater at low tide. • Sandbanks which are slightly covered by seawater all the time. • *Salicornia* and other annuals colonising mud and sand. • Spartina swards (*Spartinion maritimae*). • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*). • Mediterranean and thermo-atlantic halophilous scrubs (*Sarcocornetea fruticosi*).	Direct impact as a result of changes to water quality during normal operation.	The results of the H1 Annex D1 Phase 2 modelling water quality assessment demonstrated that the Predicted Environmental Concentrations for all substances is below the EQS level. This is achieved with the worst possible dispersion conditions (i.e. lowest simulated neap tide current speed of 0.13m/s achieving a dilution of 240:1). In reality this dispersion condition rarely occurs at the Bradwell site and it is likely that better conditions will be achieved for most of the time during the operation of the FED plant.	As the no-deterioration threshold is achieved well within a standard mixing zone (100m) there will be no direct impact on the integrity of the SAC.
	Direct or indirect impact during unplanned operational conditions.	Primary operational process parameters will be detected online and if "out of specification" effluent is detected it will be retained within the abatement system and not discharged to the final monitoring delay tank (FMDT). The location and nature of the problem will be determined and appropriate actions will be taken to remediate the problem prior to resuming operations. Any "out of specification" effluent will be returned for reprocessing to ensure that applicable quality parameters are met. As such there will be no unplanned discharges to the marine environment.	As there will be no unplanned or "out of specification" discharges to the environment, there will be no direct or indirect impact on the SAC features.
	Indirect impact on key species of prey.	As identified above there will be no direct impacts on ecology as a result of water quality. As such there will be no indirect effect on prey species.	Based on the water quality assessment there will be no indirect effect on prey species and therefore no impact on associated SAC features.
	Increased nutrients leading to eutrophication which could affect plant species colonising mud and sand areas, saltmarsh or salt meadows.	Numerical modelling has demonstrated that some nitrogen will be retained in the estuary. The anticipated overall average nitrate increase in the estuary (based on worst case loads) is estimated to be less than 10% of available background data. The modelling indicates that, through tidal dispersion, the nitrate would reduce by a third within 4 weeks and to background concentration within an estimated 3 months. In addition the results from the dispersion modelling study confirm that the average nitrate / DIN concentration will not exceed the background levels by more than 10% throughout the project. There are very few occasions where instantaneous concentrations of nitrate exceed the 10%	The modelling assessment demonstrates that although there would be retention of nitrogen within the estuary, and occasional exceedance of the 10% threshold, due to mitigating circumstances such as low light penetration from the turbidity of water and a general surplus of nitrogen to support primary production, there will be no significant increased risk of eutrophication during the short-term

Designation/Features	Potential impact	Assessment /Likely Significant Effect	Mitigation/Overall Assessment
		threshold. This happens in a very short period (e.g. less than 30minutes) and does not represent the average nitrate concentrations. Furthermore, wind perturbations and non-tidal currents affect the trajectory and spread the impact over a wider area at a lower concentration. The results presented are therefore considered worse case and lower resulting concentrations will occur in reality. Other factors, such as denitrification, within the estuary will also mitigate the risk of water quality deterioration during the project. As a whole, water quality data indicates that there appears to be an excess of nitrogen within the estuary (which corresponds to the DIN rating) and that phosphorous tends to be the limiting factor in terms of plant growth. The proposed FED discharge will not contribute phosphorous to the estuary.	operation of the FED project.
Dengie SPA (Mid-Essex Coast Phase 1) and Blackwater Estuary SPA (Mid-Essex Coast Phase 4)			
• Internationally important assemblages of waterfowl. • Internationally important populations of regularly occurring migratory species. • Internationally important populations of regularly occurring Annex I species.	Direct impact on SPA bird species as a result of changes to water quality during normal operation.	The results of the H1 Annex D1 Phase 2 modelling water quality assessment demonstrated that the Predicted Environmental Concentration of the effluent is less than the EQS for all Priority and Priority Hazardous metals. The "no-deterioration threshold" (no more than 10% of existing background/environmental benchmark) for nitrate on spring and neap tides, would be met for most of the times at around 100m from the outfall for an average and peak daily throughput.	As the no-deterioration threshold is achieved well within a standard mixing zone, there should be no direct impact on the integrity of the SPA.
	Direct or indirect impact SPA bird species during unplanned operational conditions.	Primary operational process parameters will be detected online and if "out of specification" effluent is detected it will be retained within the abatement system until the problem is identified and sorted. Any "out of specification" effluent will be returned for reprocessing to ensure that applicable quality parameters are met. As such there will be no unplanned discharges to the marine environment.	As there will be no unplanned or out of standard discharges to the environment, there will be no direct or indirect impact on the SPA features.
	Localised increase in temperature affecting prey species.	The results of the water quality assessment (section 5.6) demonstrate that in terms of temperature, the effluent will result in a 0.14°C increase in the water temperature within the mixing zone. This slight increase in temperature is below the 2°C threshold stated in the Water Framework Directive below which the quality of water is not deemed to be affected. The slight increase in temperature should not result in any positive or negative effects on the localised ecology	The slight increase in temperature will not result in any changes to the localised ecology nor prey species movement. As such there should be no impact on the prey species of the SPA.

Designation/Features	Potential impact	Assessment /Likely Significant Effect	Mitigation/Overall Assessment
		nor on the movement of prey species.	
	Indirect water quality impact on prey species.	The results of the water quality assessment demonstrate that the effluent is quickly diluted and dispersed, with the no-deterioration threshold being achieved within a standard mixing zone. As such there will be no indirect impacts on prey species as a result of water quality.	Based on the water quality assessment there should be no indirect effect on prey species and therefore no impact on associated SPA features.
	Increased nutrients leading to eutrophication which could affect bird habitat and associated prey species.	Numerical modelling has demonstrated that some nitrogen will be retained in the estuary. The anticipated overall average nitrate increase in the estuary (based on worst case loads) is estimated to be less than 10% of available background data. The modelling indicates that, through tidal dispersion, the nitrate would reduce by a third within 4 weeks and to background concentration within an estimated 3 months. In addition the results from the dispersion modelling study confirm that the average nitrate / DIN concentration will not exceed the background levels by more than 10% throughout the project. In terms of maximum concentrations, these occasionally exceed the 10% threshold for short periods (e.g. less than 30minutes) but in reality, wind perturbations and non-tidal currents would affect the trajectory and spread the impact over a wider area at a lower concentration. The results presented are therefore considered worse case and lower resulting concentrations will occur in reality. Other factors, such as de-nitrification, within the estuary will also mitigate the risk of water quality deterioration during the project. As a whole, water quality data indicates that there appears to be an excess of nitrogen within the estuary and that phosphorous tends to be the limiting factor in terms of plant growth. The proposed FED discharge will not contribute phosphorous to the estuary.	The modelling assessment demonstrates that although there would be retention of nitrogen within the estuary, and occasional exceedance of the 10% threshold, due to mitigating circumstances such as low light penetration from the turbidity of water and a general surplus of nitrogen to support primary production, there will be no significant increased risk of eutrophication during the short-term operation of the FED project.

6.6 NATURE CONSERVATION ASSESSMENT

With regard to Nature Conservation as a whole, and Environmental Permits, the Environment Agency H1 Guidance states that all possible conservation receptors should be identified and included within the assessment. This should encompass nature conservation sites, heritage and landscape designations and European species that could be affected by the activity, and it goes on to define the scope as conservation sites or species:

- within the boundary of the activity,
- outside the boundary of the activity where a designated feature could be directly affected, or
- outside the boundary of the activity where a designated feature could be indirectly affected.

The nature conservation sites to be considered include:-

- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- Ramsar
- Site of Special Scientific Interest (SSSI)
- Marine Conservation Zone
- National Nature Reserve (NNR)
- Local Nature Reserve (LNR)
- Ancient Woodland
- Local Wildlife Site.
- Areas of Outstanding Natural Beauty (AONB)
- Heritage Coast
- National Parks

Table 17 below presents a summary of conservation designations/ protected species that have the potential to be affected by the project (excluding the SAC/SPA). The proximity to the discharge/site, the key reason for the designation and the justification for inclusion or not within the Environmental Risk Assessment is then given.

Table 17: Screening of Other Environmental Designations and Protected Species, Blackwater Estuary

Designation	Proximity to site	Key features	Included/ reason
Dengie Ramsar.	**Immediately adjacent**	**The site is designated as a Ramsar Site as it supports:** • **Important saltmarsh communities.** • **Rare plant and invertebrate species.** • **Important bird assemblages - bar-tailed godwit, hen harrier, grey plover, knot and dark bellied brent goose.**	**Yes – potential for water quality (metals and nutrients) within estuary to be affected and therefore potential for an effect on birds, invertebrates and plant species in the estuary.**
Blackwater Estuary Ramsar.	**Immediately adjacent**	**The site is designated as a Ramsar as it supports:** • **Important saltmarsh communities.** • **Rare invertebrate species.** • **Important bird assemblages - little tern, avocet, hen harrier, ruff, blacktailed godwit, dark bellied brent goose, dunlin, grey plover, redshank, ringed plover, shelduck, golden plover.**	**Yes – as above.**
Colne Estuary Ramsar.	Approx 5km to the north	Designated Ramsar site as it supports: • Important saltmarsh communities. • Rare plant and invertebrate species. • Important bird assemblages.	Not at this stage – water quality in estuary unlikely to be directly affected. If potential effect on Blackwater Estuary/ Dengie /Ramsar is identified further assessment will be undertaken.
Foulness /Ramsar.	Approx 12.5km to the southeast.	As above.	No – as above.
Crouch and Roach Estuaries Ramsar.	Approx 13km to the south	As above.	No – as above.
Abberton Reservoir Ramsar Site.	Approx 8km to the northwest	As above.	No – water quality in reservoir not affected. If potential effect on Blackwater Estuary/ Dengie Ramsar is identified, further assessment will be undertaken.
Blackwater Estuary SSSI (forms a component part of Essex Estuaries SAC and Blackwater Estuary SPA/Ramsar).	**Immediately adjacent.**	**Largest estuary in Essex north of the Thames. Mud flats fringed by saltmarsh on the upper shores support internationally and nationally important numbers of wildfowl which overwinter here. The surrounding terrestrial habitats, the sea wall, ancient grazing marsh and its associated fleet and ditch systems, plus semi-improved grassland are also of**	**Yes – potential for water quality within estuary to be affected. Any additional features above those of SAC/SPA /Ramsar will be reviewed and evaluated further, where appropriate.**

Designation	Proximity to site	Key features	Included/ reason
		high conservation interest. Habitats support an outstanding assemblage of nationally scarce plants and nationally important assemblage of invertebrates. Within the site is Blackwater Estuary NNR.	
Dengie SSSI (forms a component part of Essex Estuaries SAC and Dengie SPA/Ramsar)	**Immediately adjacent.**	**A large and remote area of tidal mudflat and saltmarsh. The saltmarsh is the largest continuous example of its type in Essex with the foreshore, supporting an outstanding assemblage of rare coastal flora. Also supports internationally and nationally important wintering populations of wildfowl and waders and in summer supports a range of breeding coastal birds. Part of site from Sales Point to Holliwell is a NNR.**	**Yes – potential for water quality within estuary to be affected. Any additional features above those of SAC/SPA /Ramsar will be reviewed and evaluated further within this ER, where appropriate.**
Sandbeach Meadows SSSI	4km southeast.	Sandbeach Meadows is an area of seven fields which are sympathetically managed and support nationally important numbers of dark-bellied brent geese in winter.	No – grazing marshes occasionally support dark-bellied brent geese unlikely to be affected.
Dengie NNR (component part of Essex estuaries SAC, Dengie SPA/Ramsar and SSSI sites).	Immediately adjacent.	Component part of the Essex Estuaries SAC and Dengie SPA/Ramsar and SSSI sites.	No - covered by assessment for SAC and SPA/Ramsar.
Blackwater Estuary NNR (component of Essex estuaries SAC, Blackwater Estuary SPA/Ramsar and SSSI sites).	Two areas 1.5km and 2km northwest of site.	Component part of the Essex Estuaries SAC and Blackwater Estuary SPA/Ramsar and SSSI sites.	No - covered by assessment for SAC and SPA/Ramsar.
Colne Estuary NNR (component part of Essex estuaries SAC, Colne Estuary SPA/Ramsar and SSSI sites)	Three areas, closest being 5.5km to northeast.	Component part of the Essex Estuaries SAC and the Colne Estuary SPA/Ramsar and SSSI sites.	No – water quality in Colne Estuary unlikely to be directly affected. Assume assessment of potential effect on birds would be covered within Blackwater Estuary Ramsar assessment.
11 Local Nature Reserves	Within 11 to 20km of the site.	Reserves include "meadows", "fields", a "park", a "wood", a "mead" and a "brook".	No – sites are distant and unlikely to be affected by estuary water quality.
Blackwater, Crouch, Roach and Colne Estuaries Marine Conservation Zone	**Immediately Adjacent**	**To maintain in favourable condition "intertidal mixed sediments' and 'Clacton Cliffs and Foreshore' and to recover to favourable condition the 'Native Oyster' and the 'Native Oyster beds'**	**Yes – Potential for water quality in the estuary to be affected and therefore potential impact on oysters in the estuary. Impact on water quality and specifically on**

Designation	Proximity to site	Key features	Included/ reason
			oysters beds have been considered in the modelling reports attached and the risk assessment
Old Hall Marshes RSPB reserve	Approx. 5km northwest.	Component part of Blackwater Estuary SPA/Ramsar.	No – assume assessment of potential effect on birds would be covered within Blackwater Estuary Ramsar assessment.
Essex Biodiversity Action Plan (BAP) – Habitats	**Varying distances.**	**Ten habitat types are included within the Essex BAP including Ancient/species rich hedgerows and green lane; Ancient woodland; Cereal field margin; Coastal grazing marsh; Seagrass beds; Heathland; Old orchards; Reedbeds; Saline lagoons and Urban areas.**	**Yes - Seagrass beds may potentially be affected depending on their distance from the discharge. The assessment of seagrass beds will be addressed under the Ramsar designations.**
Essex Biodiversity Action Plan (BAP) - Species	**Varying distances.**	**There are 25 species within the Essex BAP Maldon area. Some are of relevance.**	**Yes - The species which will be considered further within this ER will include Harbour Porpoise, Otter, Allis and Twait Shad.**
Local Wildlife Sites (LoWS) formerly Sites of Importance for Nature Conservation (SINC)	Varying distances.	Over 1600 LoWS in Essex. Local Wildlife Sites complement SSSIs and nature reserves by helping to maintain links between these sites.	Assumed assessment of most relevant SAC/SPA/Ramsar/SSSI/ BAP species will address potential issues of LoWS.
Heritage coast	Not applicable.	Not applicable	
National Park	Not applicable.	Not applicable	
AONB	Not applicable.	Not applicable	
Peregrine Falcon	On site.	Peregrine Falcons are present on the Bradwell site. Species is protected under Schedule 1 of the Wildlife and Countryside Act 1981 and is on the Red List of Birds of Conservation Concern.	No – the discharge from the project will not affect this species. The level of disruption as a result of the project will be no greater than current activities on site.

As with the assessment of potential impact on the SAC/SPAs there are a number of ways in which the discharge could affect the species or habitats in question. These can be classified into the following areas:

- Toxic contamination - Direct impact on species as a result of changes to water quality (heavy metals) during normal operation.
- Toxic contamination - Direct impact on species as a result of changes to water quality (heavy metals) during unplanned operational conditions.
- Non-toxic contamination - Effluent acts as chemical/thermal barrier to movement of marine species.
- Toxic/Non-toxic contamination - Indirect impact on key species through effects on their prey species (chemical/thermal).
- Non-toxic contamination - Increased eutrophication resulting in an accelerated growth of algae and higher forms of plant life, which may result in an undesirable disturbance to the balance of organisms present in the estuary and to the quality of the water.

Those areas that can be screened out of the assessment include:

- No physical loss or damage to habitats, or additional noise or visual disturbance from the discharge.
- No significant organic loading or suspended solids.
- No significant changes to salinity or turbidity above that occurring as a result of the outfalls current operation.
- No "biological disturbance" as a result of the proposals or introduction of non-synthetic compounds.

As with the SAC/SPA assessment many of the species or habitats of the different Ramsar, SSSI, NNR etc. would be affected in a similar way by a number of the potential impact areas. To save extensive repetition the Ramsar/SSSI etc. have been grouped.

Table 18 presents the assessment of potential effects for those features which were highlighted in Table 17.

Table 18: Assessment of Other Environmental Designations and Protected Species in Blackwater Estuary

Dengie Ramsar / Blackwater Estuary Ramsar and Blackwater Estuary/ Dengie SSSI			
Dengie Ramsar supports: • Important saltmarsh communities. • Rare plant and invertebrate species. • Important bird assemblages - bar-tailed godwit, hen harrier, grey plover, knot and dark bellied brent goose. **Blackwater Estuary Ramsar** supports: • Important saltmarsh communities. • Rare invertebrate species. • Important bird assemblages - little tern, avocet, hen harrier, ruff, blacktailed godwit, dark bellied brent goose, dunlin, grey plover, redshank, ringed plover, shelduck, golden plover. **Blackwater Estuary SSSI** • Mud flats fringed by saltmarsh on the upper shores. • internationally and nationally important numbers of wildfowl which overwinter. • Other terrestrial habitats of high conservation interest include the sea wall, ancient grazing marsh and its associated fleet and ditch systems, and semi-improved grassland. • Outstanding assemblage of	Direct impact on bird species or habitats as a result of changes to water quality during normal operation.	The results of the H1 Annex D1 assessment demonstrated that the Predicted Environmental Concentration is below the EQS level for all Priority and Priority Hazardous metals.	As the no-deterioration threshold is achieved within a standard mixing zone, there will be no direct impact on features of the Ramsar/SSSI.
	Direct or indirect impact bird species or habitats during unplanned operational conditions.	Primary operational process parameters will be detected online and if "out of specification" effluent is detected it will be retained within the abatement system and the problem will be identified and sorted. Once sorted the "out of specification" effluent will be reprocessed to the required standard. As such there will be no unplanned discharges to the marine environment.	As there will be no unplanned or out of standard discharges to the environment, there will be no direct or indirect impact on the Ramsar/SSSI features.
	Localised increase in temperature affects prey species.	The results of the assessment undertaken in Section 5.6 demonstrate that in terms of temperature, the effluent will result in a 0.14°C increase above ambient temperature in the estuary. The slight increases in temperature will not result in any positive or negative effects on the localised ecology as it is below the 2°C threshold set out in the Water Framework Directive.	The slight increases in temperature should not result in any changes to the localised ecology. As such there will be no impact on the prey species of the Ramsar/SSSI.
	Indirect water quality impact on prey species.	The results of the water quality assessment demonstrate that the effluent is quickly diluted and dispersed. As such there will be no indirect impacts on ecology or prey species as a result of water quality.	Based on the water quality assessment there will be no indirect effect on prey species and therefore no impact on associated Ramsar/SSSI features.
	Increased nutrients leading to eutrophication which could affect saltmarsh/mudflat communities and flora, or indirectly birds.	Numerical modelling has demonstrated that some nitrogen will be retained in the estuary. The anticipated overall average nitrate increase in the estuary (based on worst case loads) is estimated to be less than 10% of available background data. The modelling indicates that, through tidal dispersion, the nitrate would reduce by a third within 4 weeks and to background concentration within an estimated 3 months. In addition the results from the dispersion modelling study confirm that the average nitrate / DIN concentration will not exceed the background levels by more than 10% throughout the project. In terms of maximum concentrations, these occasionally exceed the 10% threshold for short periods (e.g.	The modelling assessment demonstrates that although there would be retention of nitrogen within the estuary, and occasional exceedance of the 10% threshold, due to mitigating circumstances such as low light penetration from the turbidity of water and a general surplus of nitrogen to support primary production, there will be no significant increased risk of

nationally scarce plants and nationally important assemblage of invertebrates. • Includes Blackwater Estuary NNR. **Dengie SSSI** • A large and remote area of tidal mudflat and saltmarsh. • Supports an outstanding assemblage of rare coastal flora, internationally and nationally important wintering populations of wildfowl and waders and in summer supports a range of breeding coastal birds. • Part of site from Sales Point to Holliwell is a NNR.		less than 30minutes) but in reality, wind perturbations and non-tidal currents would affect the trajectory and spread the impact over a wider area at a lower concentration. The results presented are therefore considered worse case and lower resulting concentrations will occur in reality. Other factors, such as denitrification, within the estuary will also mitigate the risk of water quality deterioration during the project. As a whole, water quality data indicates that there appears to be an excess of nitrogen within the estuary (which corresponds to the DIN rating) and that phosphorous tends to be the limiting factor in terms of plant growth. The proposed FED discharge will not contribute phosphorous to the estuary.	eutrophication during the short-term operation of the FED project.
Essex Biodiversity Action Plan (BAP) – Species			
• Harbour Porpoise, • Otter, • Allis shad • Twait Shad.	Direct impact on the Essex BAP species as a result of changes to water quality during normal operation.	The results of the H1 Annex D1 assessment demonstrated that the Predicted Environmental Concentration is below the EQS level for all Priority and Priority Hazardous metals.	As the no-deterioration threshold is achieved within a standard mixing zone, there will be no direct impact on the BAP species.
	Direct or indirect impact LBAP species during unplanned operational conditions.	Primary operational process parameters will be detected online and if "out of specification" effluent is detected it will be retained within the abatement system and the problem will be identified and sorted. Once sorted the "out of specification" effluent will be reprocessed to the required standard. As such there will be no unplanned discharges to the marine environment.	As there will be no unplanned or out of standard discharges to the environment, there will be no direct or indirect impact on the BAP species.
	Localised increase in temperature acts as barrier to species movement.	The results of the assessment undertaken in Section 5.6 demonstrate that in terms of temperature, the effluent will result in a 0.14°C increase above ambient temperature in the estuary. The slight increases in temperature will not result in any positive or negative effects on the localised ecology as it is below the 2°C threshold set out in the Water Framework Directive.	The slight increases in temperature will be indistinguishable and will not act as a barrier to movement of the BAP species.

	Indirect water quality impact on prey species.	The results of the water quality assessment demonstrate that the effluent is quickly diluted and dispersed. As such there will be no indirect impacts on BAP species prey as a result of water quality.	Based on the water quality assessment there will be no indirect effect on prey species and therefore no impact on the BAP species.

7 CONCLUSION

The overall environmental impact from the FED related discharges through the existing discharge route are unaffected by the request for a change in duration. Consequently, the environmental risk assessment of the current discharge route remains unchanged.

The assessment of the FED related discharges through the new discharge line concludes that the combined FED dissolution effluent (i.e. with the NOx scrubber liquor added to each batch), continues to meet the EA's 'not liable to cause pollution' test of the PEC being less than the EQS at the edge of the mixing zone. Refer to Table 11 for the PEC < EQS AA and Table 12 for PEC < EQS MAC for the discharges.

To put this assessment into context, the EQS MAC for Cadmium, Chromium and Mercury is more stringent than drinking water standards; as defined in the 'Water Supply (Water Quality) Regulations 2000' (as amended). The discharges to the estuary will be significantly lower than the concentration limits set for drinking water where a comparable limit exists; refer to Table 9.

The modelling of the cumulative effect of the metals in the FED effluent in the Blackwater Estuary concluded that approximately 6% of the total material discharged during the FED dissolution process would remain in the estuary at the end of the FED programme. After 6 months, 90% of this would be lost from the estuary. Therefore, for every kilogramme of particular metal released, 60 grammes is predicated to remain at the end of the FED process, it will be wide spread over the estuary, reducing to about 6 grammes after 6 months. These figures are based on the retention calculations given in report 'BRAD/EN-REP/032/FED – FED Discharge Dispersion EX6399' and did not take account of any chemical and sediment loss mechanisms.

Overall, FED related discharges are predicted to increase the average nitrate concentrations in the Blackwater Estuary by less than 10% of the background value. Therefore it meets the agreed EA 'no detriment threshold'. There will be localised areas within the plume where there will be higher concentrations for short periods (e.g. half hour in a day). However, non-tidal effects will reduce the concentrations and may eliminate these exceedances. The residual nitrate concentration left in the estuary from FED dissolution will gradually reduce back to the background after cessation of discharge. The modelling indicates that, through tidal dispersion, the nitrate would reduce by a third within 4 weeks and to background concentration within an estimated 3 months. This is a pessimistic estimate as the model is conservative. It uses worse case loads and does not take into account removal processes within the estuary, such as de-nitrification, natural flushing and dilution of the estuary from river flow.

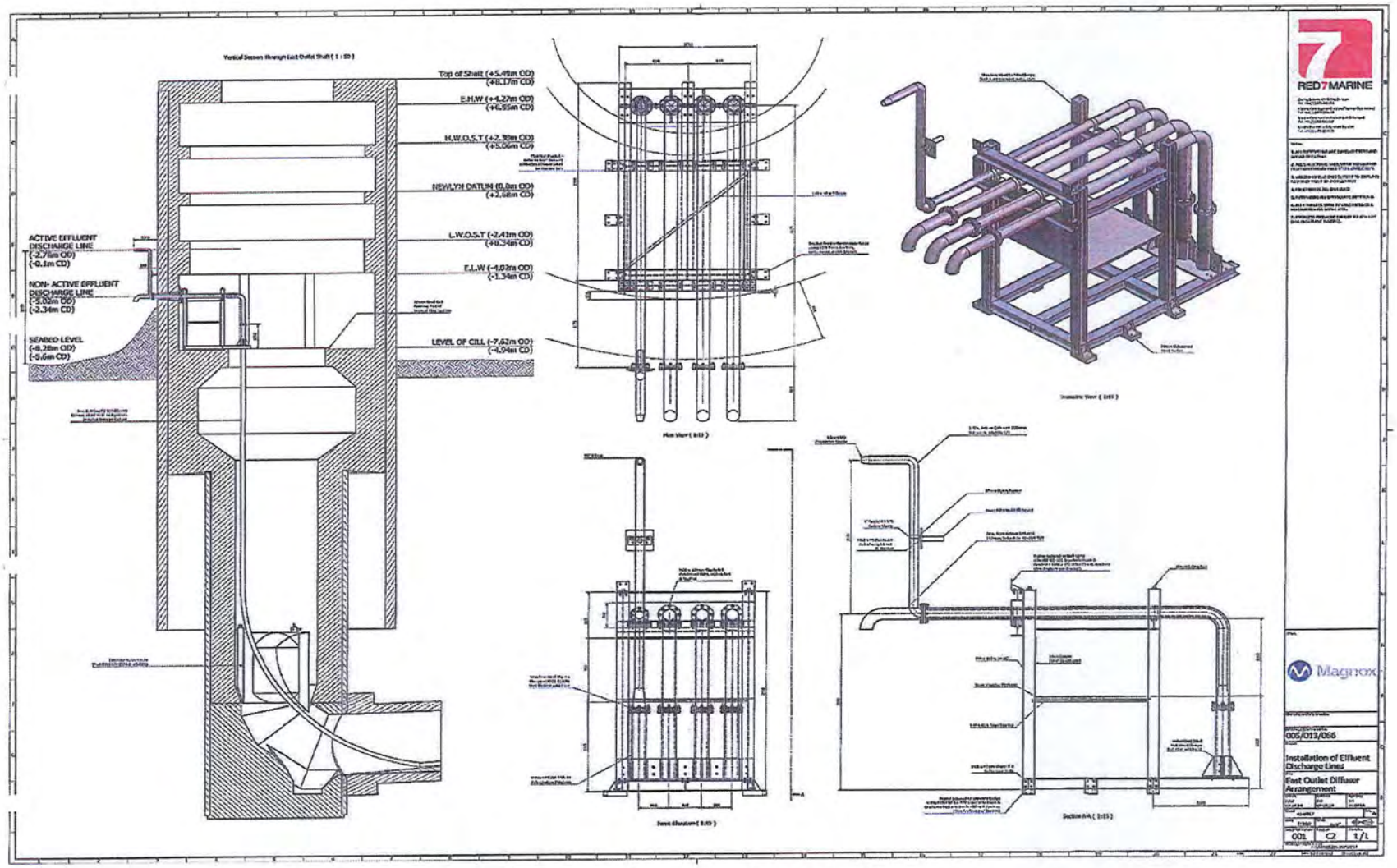
The detailed assessment of potential impacts on designations and other legislation concluded that discharge of FED related effluents through the new line would not have any adverse effect. Further, the water quality status of the Blackwater Estuary would remain unchanged. A summary of the results of all the tests undertaken in this report is provided in Table 19.

The effluent will continue to be monitored prior to discharge and would only be discharged if it was compliant with requirements placed in the permit by the EA.

Table 19: A summary of the results of all the tests undertaken

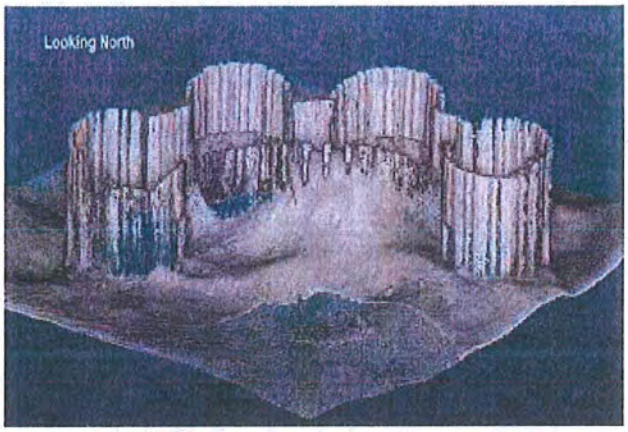
Test/Assessment	Combined NOx Scrubber and FED Dissolution Effluent	NOx Scrubber Liquor for Intermittent Discharge	Comment
TraC Phase 1 Part A, Test 1 (Abated Effluent Prior Discharge <100% of EQS AA)_	B, Fe, Pb and Zn passed	B, Pb, and Zn passed	Combined effluent did not pass this test on Cd, Cr, Cu, Hg, Ni. NOx scrubber did not pass on Cd, Cr, Cu, Fe, Hg, Ni
TraC Phase 1 Part A, Test 5 (Abated Effluent Prior Discharge <100% of EQS MAC)		Cd passed	Combined Effluent failed Cd, Cr, and Hg NOx scrubber liquor Cr and Hg failed
TraC Phase 1 Part A, Test 2 (Dilution & Dispersion)	Test Passed	Test Passed	Discharge location and dilution meets test 2
TraC Phase 1 Part A, Test 3 (Dilution & Dispersion)	Test Passed	Test Passed	Discharge location and dilution meets test 3
TraC Phase 1 Part A, Test 4 (Dilution & Dispersion)	Test Passed	Test Passed	Discharge location and dilution meets test 4
TraC Phase 1, Test 5 (EVF v AEVF)	Negatively buoyant effluent therefore proceed to Phase 2 test	Negatively buoyant effluent, therefore proceed to Phase 2 test.	Both the combined FED and NOx Scrubber Liquors are negatively buoyant effluents.
TraC Phase 1, Part B Critical Load	Test Passed	Test Passed	All results were well within this test
TraC Phase 2, Modelling	Plume modelled	Plume modelled	Meets EQS AA and MAC. Plume modelled
TraC Phase 2 Modelling-After Mixing Zone PEC <100% of EQS AA	B, Cd, Cr, Cu, Fe, Pb, Ni and Zn passed	B, Cd, Cr, Cu, Fe, Pb, Ni and Zn passed	All results were well within this test
TraC Phase 2 Modelling-After Mixing Zone PEC <100% of EQS MAC	B, Cd, Cr, Cu, Fe, Pb, Ni and Zn passed	B, Cd, Cr, Cu, Fe, Pb, Ni and Zn passed	All results were well within this test
Nitrate - No Deterioration <10% of Background	Test Passed	Test Passed	Overall criteria meet
Temperature	Test Passed	Test Passed	Acceptable temperature as a result of discharge
Other Legislation, comprehensively assessed under environmental risk assessment (BRAD/EN/REP/032/FED)			Due to insignificant impact from discharges conclusion of previous risk assessment stands

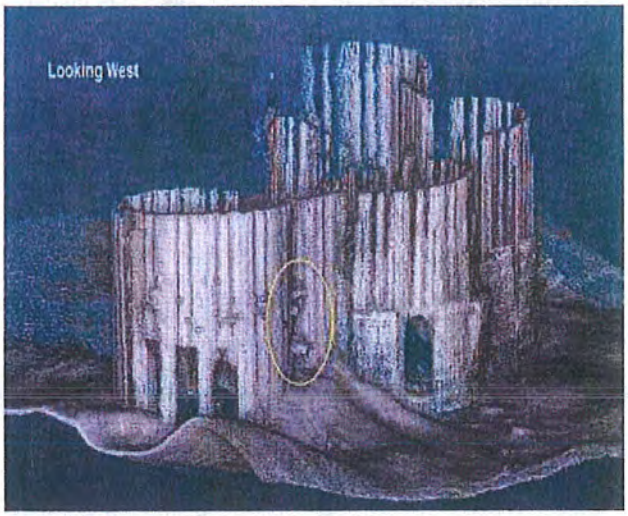
Appendix A – Design of New Discharge Line

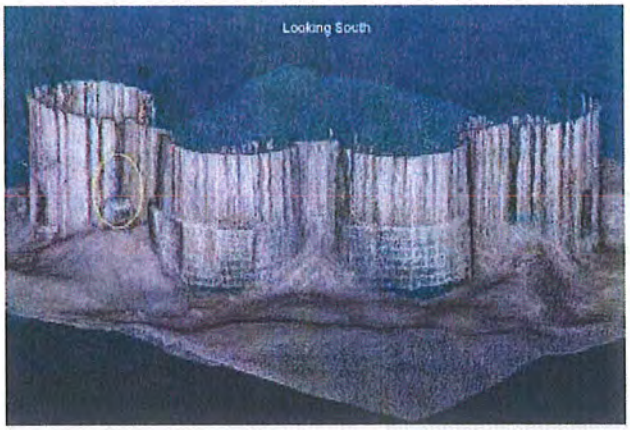


Appendix B Silt Build up Around the Outfall Structure

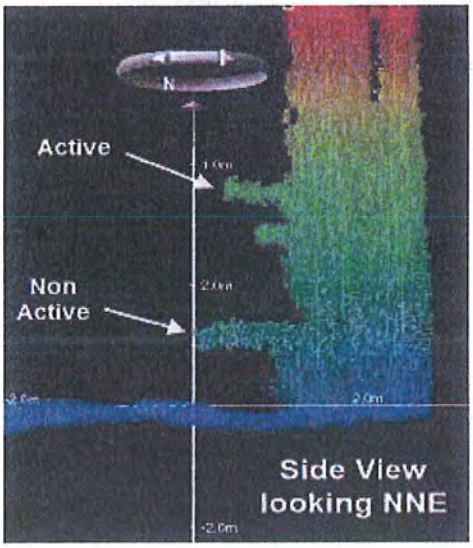
The images have been produced from a high resolution multi-beam echo sounder survey undertaken by Port of London Authority in 2014.







Discharge Ports



The images show build up of sand around the outfall structure, with increases since the previous survey last July. Whilst there have been changes, the trends are not as severe as previously seen as the majority of the extended areas. There has been a localised build up of silt around the discharge ports. The FED &AE discharge nozzle is near 4 meters as opposed to the optimum 5.5 m from the sea bed. HR Wallingford have advised that the modeling is based on ambient height of the sea bed.

REFERENCES

1 BRAD/EN/REP/023/FED Environmental Risk assessment in Support of FED Treatment (Including Hyder Report)

2 Morris K and Wickenden D, 2014. Potential for the Mitigation of BWA Waste NOx Scrubber Liquor via FED Dissolution and/or ADAP EAN: M/EF/BWA/EAN/0015/14

3 HR Wallingford, 2011. BRAD/EN/REP/032/FED/Discharge Dispersion EX6399

4 Lock G.K and Barefield S, 2012. BRAD/EN/REP/023/FED/Environmental Risk Assessment in Support of Fuel Element Debris

5 BRAD/EN/REP/123/FED/Addendum to Environmental Risk Assessment BRAD/EN/REP/023/FED NOx Scrubber Liquors and FED Effluent.

6 BRAD/EN/REP/128/HR Wallingford Report RT011 Annual Average Concentration of FED Constituents

7 Environment Agency, 2014. H1 Annex D1 Assessment of hazardous pollutants within surface water discharges

8 European Commission, 2010. Technical Guidelines for the identification of mixing zones pursuant to Art. 4(4) of the Directive 2008/105/EC

9 HR Wallingford 2013. BRAD/EN/REP/FED/082 FED Discharge Outfall EBR4908-RT008-R01

10 Wickenden D, 2014. Abatement of Bradwell FED Dissolution Liquors by Precipitation' M/E/BWA/EAN/009/13

11 BRAD/EN/FED/138/FED, Annual Average Concentration of FED constituent, EBR4908-RT012- R05

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