

Environmental Risk Assessment - Phenol Emissions to Water

Hexion Barry Site

Hexion (UK) Limited

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1. Introduction

AECOM Infrastructure & Environment UK Limited (AECOM) has been commissioned by Hexion (UK) Limited ("Hexion") to assess the potential impacts associated with the Phenol emissions from the site located at Sully Moors Road, Barry, CF64 5YU ('site') on the Bristol Channel and if required the identification of options to reduce the impacts.

The site manufactures speciality chemical products and is regulated under the Environmental Permitting Regulations 2016 and holds Environmental Permit number PP3238LX.

The site Environmental Permit includes Improvement Condition 4 (IC4) which required the review of potential environmental impacts associated with water emissions from the site effluent treatment plant (ETP). AECOM (formerly URS) prepared an assessment of the water discharges from the site to the Bristol Channel using the regulators H1 assessment methodology in May 2013. Following submission of this assessment, Natural Resources Wales (NRW) has now requested that a more detailed assessment be undertaken with specific focus on the emissions of Phenol and the potential for their reduction as follows:

The latest update on IC4 was the site addressing the remaining three bullet points raised on NRW's response to an earlier Hexion submission. These bullet points were addressed by Hexion in an email dated 24th Oct 2013. NRW are satisfied with these responses. However, as the most recent H1 exercise (URS report for Hexion, 16th May 2013), which was commented on in CAR1 Jul 2013, pointed out, phenol releases modelled @ 10mg/l lead to a Predicted Environmental Concentration against the EQS (7.7ug/l) of 87% ST and 91.4% LT of the EQS – this suggests:

- *conduct detailed dispersion modelling to refine the result, as H1 is conservative*
- *although, with such large PECs, it is still likely that phenol emissions will still be contributing significantly as a % of the EQS*
- *improve operations to reduce phenol in the influent and / or improve treatment to reduce phenol in the effluent*
- *this requires an assessment of the biological load required for the bacteria population in the ETP and the treatment efficiency*

As part of the 2017 / 18 regulatory work plan, an assessment of the ETP, its efficiency, emissions and operational control, will be undertaken in a phased manner, based on a systemised framework defining the scope, methodology and evidence required. To that end IC4 remains open, but it is now very important that real progress is made to close this out. The objective is to identify if any improvements can be made and to propose an implementation timetable to be agreed by NRW – this stage has not been reached and the H1 study suggests more work in modelling and reducing phenol emission concentration is warranted. NRW will default to emission concentration, not annual mass released, as the parameter that could have adverse impact and therefore should be the focus.

The July 2016 BRef on CWWT in the Chemical Industry is also a driver for the above ETP BAT assessment. AK¹ has sought some clarification internally on BAT phenol limits – in the absence of limits, the default position is to assess against the EQS as the H1 exercise above did or more detailed modelling will do.

IC4 extended until 31st Dec 2017.

This report presents formal response to the extended scope of IC4.

¹ AK is the NRW Inspector (Andi Kemp).

2. Site Data

2.1 Details of the Lagoon Water System

Process drainage from the site is pumped to the U37B (Dirty) Lagoon for treatment in the site effluent treatment plant (ETP). The ETP provides primary treatment of the effluent via settlement, with secondary biological treatment using a biological aerated fixed film (BAFF) unit. The outlet from the ETP passes through lamellar separators prior to release of the treated effluent into the clean lagoon (U37A).

Rainwater from U39 and U25, and runoff water from the north east corner of the Hexion site is also pumped to the clean lagoon (U37A). The combined effluent within the clean lagoon (U37A) is then pumped through the effluent pipeline that runs parallel to the Cadoxton River and discharges into the Severn Estuary through a sea outfall which extends some 1,000m offshore. The discharge into the Severn Estuary is via a series of diffusers, which affords significant initial dilution of the materials released into the estuary.

2.2 Lagoon Water Quality

The effluent discharge from the clean lagoon (U37A) to the Bristol Channel is subject to a scheduled sampling and monitoring assessment, with a sample being taken and analysed for phenol content every 6 hours.

This raw analytical data is compiled on a quarterly basis with the average and maximum emissions during the period being reported to NRW. This quarterly data for the last 4 years of operation (2014 – 2017) is presented in Table 1.

Table 1. Clean Lagoon Discharge Phenol Content

Year	Sample Period	Monohydric Phenol (Max) (mg/l)	Monohydric Phenol (Average) (mg/l)	Effluent Flow (Max) (m ³ /day)	Effluent Flow (Average) (m ³ /day)
2014	Q1	9	7	4,551	2,096
2014	Q2	8	1.2	3,771	1,360
2014	Q3	4	0.8	3,661	1,089
2014	Q4	2	0.6	2,808	1,181
2015	Q1	9	6.4	4,408	1,666
2015	Q2	6	2.5	3,268	1,122
2015	Q3	8	0.8	3,854	1,256
2015	Q4	8	3	3,954	1,255
2016	Q1	9	3.5	3,812	1,368
2016	Q2	9	2.8	2,750	783
2016	Q3	5	0.923	1,744	609
2016	Q4	8	4.3	5,276	798
2017	Q1	8	4.1	2,270	901
2017	Q2	6	3.6	2,180	760
2017	Q3	6	1.3	1,530	528
Maximum Value		9	7	5,276	2,096
Average Value		7	2.85	3,322	1,118
Consent Levels		10		6,800	

Source: *Hexion quarterly water emissions reporting datasheets*

The following phenol concentration data has been used in the H1 assessment:

- Maximum Phenol Concentration: 10mg/l (based on the current consented emission limit)
- Average Phenol Concentration: 2.85 mg/l (based on the average phenol concentration over the 2014 – 2017 period)

2.3 Clean Lagoon Water Discharge Rate

The instantaneous rate of discharge from the clean lagoon (U37A) to the Bristol Channel is limited by the rating of the pumps used for discharging the water which are rated at 50,000 gallons per hour (227.3 m³/hour). The lagoon discharge pumps are deliberately sized such that they cannot exceed the consented maximum daily volumetric discharge (6,800m³). The maximum achievable volumetric discharge from the lagoons (assuming the pumps operate continuously at full rate over a 24 hour period) is 5,455 m³/day.

These pumps are fixed rate and operate on a level control system with discharge from the site being intermittent in nature dependant on the levels in the lagoon.

The frequency of operation of the pumps and hence the daily rate of discharge from the lagoon is highly dependent on the volume of rainwater entering the U37A clean lagoon.

The following flow data has been used in the H1 assessment:

- Mean effluent flow rate: 0.0129 m³/s (based on the average monitored effluent flow rate over the 2014 – 2017 period of 1,118m³/day))
- Maximum effluent flow rate: 0.0630 m³/s (based on the maximum pump discharge rate of 5,455m³/day)

2.4 Background Phenol Concentrations in the Bristol Channel

For the purposes of the H1 initial screening assessment, a background concentration of phenol in the Bristol Channel of 3.85 µg/m³ has been applied. This is based on the approach advised in the risk assessment guidance which proposes that a background concentration equivalent to 50% of the respective long term EQS for Phenol (7.7 µg/m³) should be applied as a conservative approach.

NRW was contacted and requested to provide recent background phenol concentration data for the Bristol Channel local to the site. One sampling location was identified (Sample Point 900147, at NGR: ST 1371066403) however no sampling has been undertaken at this point since April 2013, so current data on background phenol concentrations was not available.

Given that Hexion is now the only site which discharges Phenol into the Bristol Channel (now that the Eastman Chemicals site in Newport has ceased the discharge of Phenol) it is considered that the approach advised in the risk assessment guidance which proposes that a background concentration be applied which is equivalent to 50% of the respective long term EQS for Phenol (7.7 µg/m³) represents a significant over estimate of actual background concentrations in the Bristol Channel, and in reality the background phenol levels should be extremely low. For the purposes of the detailed aquatic dispersion modelling (Section 6) a background concentration of zero has been applied for phenol.

3. Environmental Impact Screening Assessment

The initial screening impact assessment has been undertaken by using the methodology defined in Environment Agency (EA) guidance on surface water pollution risk assessment for your environmental permit². This will identify whether the potential for significant pollution exists, which may require more detailed assessment using detailed dispersion modelling. This assessment has used the NRW / EA - H1 calculation tool to undertake the required calculations.

3.1 H1 Assessment Tool

The previous H1 assessment of aqueous impacts on the Bristol Channel was undertaken in 2013 based on emissions data from 2012 and 2013. Since this time the H1 assessment method for aqueous impacts has been updated and the phenol emissions profiles from the site may have changed.

A revised H1 assessment has therefore been undertaken focussing solely on phenol emissions from the site effluent treatment plant to the Bristol Channel to present a current screening assessment of potential impacts.

The H1 assessment calculates the process contribution (PC) for each discharged pollutant on the basis of the number of discharge points and the type of water body into which the pollutant is being discharged.

This assessment process applies an initial screening criterion to the concentration of the pollutant in the effluent relative to established Environmental Quality Standards (EQSs).

If the concentration of the pollutant fails the initial EQS screening criteria, then a number of other tests are also applied to the discharge.

The tests vary on the basis of the type of receiving water, i.e. freshwater; transitional and coastal waters (TRaC) – estuary and coastal; or TRaC – riverine.

As the discharge from the site is into the Bristol Channel i.e. a saline estuary, the following tests (shown in Table 2 below) were applied to the discharge point.

Table 2. H1 Assessment Part A: Description of Tests Applied to Discharges to TRaC Estuarine Bodies

Test	Description
Test 1	Is the effluent release concentration (RC) – long term or annual average (AA) and short term or maximum allowable concentration (MAC) < 100% of EQS? If either the long term or short term concentrations are above 100% of the EQS, then the next test (Test 2) is applied.
Test 2	Is the discharge to a riverine estuary or direct to a low water channel within a riverine estuary? If the answer to the test is 'yes' then the release point is classified as 'freshwater' and from this point on tests for freshwater release points need to be applied. If however, the answer is 'no' the tests for estuarine and coastal waters are continued.
Test 3	Is the discharge to a location with restricted dilution/dispersion characteristics?
	Is the discharge to a location less than 50m offshore of chart datum or to a location where the sea bed is less than 1m below Chart Datum? This test examines the buoyancy and dilution of the discharge from the STW in the receiving waters.
Test 4	Is the discharge negatively or neutrally buoyant? This test assesses whether or not the discharge is lighter/more buoyant than the receiving waters. If the discharge is negatively buoyant it would flow under the water surface and may have a higher polluting potential, and need further assessment via Test 5.

² Surface water pollution risk assessment for your environmental permit - <https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit>

Test	Description
	If the answers to Tests 3 and 4 are 'no' then Test 5 is not applicable.
Test 5	Is the Effective Volume Flux (EVF) > Allowable Effective Volume Flux (AEVF)? The basis of this test is that buoyant discharges which are unlikely to have an instantaneous mixing zone which is larger than a site-specific allowable mixing zone can be considered to be insignificant. The test is undertaken by comparing the discharge specific Effective Volume Flux (EVF) with the location specific Allowable Effective Volume Flux (AEVF). If the EVF is not greater than the AEVF, then the discharge is insignificant and is screened out.

The H1 tool requires input of both annual average and maximum concentrations of each substance of concern for assessment of both long term and short term impacts.

The H1 assessment tool calculates the process contribution (PC) for each discharged pollutant on the basis of the number of discharge points, and the type of water body in which the pollutant is being discharged. The Hexion site has only 1 discharge point into the Bristol Channel which is the pumped discharge from the clean lagoon (U37A) via the pipeline and sea outfall.

3.2 Input Data for the H1 Assessment

The data presented in Table 3 has been used to develop the H1 assessment calculations.

Table 3. Input Data to the H1 Calculations

Parameter	Data Source	Value
Average Discharge Rate	Average effluent flow rate over the 2014 – 2017 period of 1,118m ³ /day	0.0129 m ³ /s
Maximum Discharge Rate	Maximum pump discharge rate of 5,455m ³ /day	0.0630 m ³ /s).
Average Phenol Concentration in Discharge	Average of discharge monitoring data (2014 – 2017)	2,850 µg/l
Maximum Phenol Concentration in Discharge	Maximum Consented discharge concentration	10,000 µg/l ⁽¹⁾

Notes: (1) Note – Maximum monitored concentration (2014 – 2017) was 9 mg/l

3.3 Environmental Assessment Criteria

The environmental assessment criteria presented in Table 4 have been used to assess potential impacts for Phenol.

Table 4. Environmental Quality Standards for Estuaries and Coastal Waters

Pollutant	Limit (µg/l)	Averaging Period
Monohydric Phenol	7.7	Annual Average (AA)
Monohydric Phenol	46	Maximum Allowable Concentration (MAC) 95 th Percentile

Source: Surface water pollution risk assessment for your environmental permit - Estuaries and coastal waters specific pollutants and operational environmental quality standards (EQS)

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/601584/Estuaries_and_coastal_waters_specific_pollutants.csv

4. Summary of Environmental Risk Assessment

This section summarises the results calculated by the H1 assessment tool, as applied to the discharge from the clean lagoon (U37A) into the Bristol Channel.

The results of the H1 assessment are presented in Table 5.

The H1 Assessment Tool is included in Appendix A of this document.

Table 5. Part A Assessment Summary

		Average Emissions	Maximum Emissions
Parameter		Phenol	Phenol
RC-AA (µg/l)		2,850	
EQS-AA (µg/l)		7.7	
RC-MAC (µg/l)			10,000
EQS-MAC (µg/l)			46
Background Concentration (µg/l)		3.85	3.85
Test 1	Is RC-AA ≤100% of EQS-AA?	No	
	Pass/Fail	Fail	
	Is RC-MAC ≤100% of EQS-MAC?		No
	Pass/Fail		Fail
Test 2	Is the discharge to a riverine estuary or direct to a low water channel within a riverine estuary	No	No
		Pass Go to Test 3	Pass Go to Test 3
Test 3	Is the discharge to a location with restricted dilution/dispersion characteristics?	No Discharge is to an area of the Bristol Channel with good dispersion characteristics	No Discharge is to an area of the Bristol Channel with good dispersion characteristics
	Pass / Fail	Pass Go to Test 4	Pass Go to Test 4
Test 4	Is the discharge to a location less than 50m offshore of chart datum or to a location where the sea bed is less than 1m below Chart Datum?	No Discharge point is approximately 1km offshore in the Bristol Channel with a minimum water depth of 10.1 m above the diffuser arrangement	No Discharge point is approximately 1km offshore in the Bristol Channel with a minimum water depth of 10.1 m above the diffuser arrangement
	Is the discharge negatively or neutrally buoyant?	No Discharge is positively buoyant	No Discharge is positively buoyant
	Pass / Fail	Pass Go to Test 5	Pass Go to Test 5
	Is the EVF > the AEVF of 3.5?	Yes (9.58)	Yes (14.95)
Test 5	Pass / Fail	Fail Detailed dispersion modelling is required	Fail Detailed dispersion modelling is required
	Significant Release?	Yes	Yes

5. H1 Screening Assessment - Conclusion

The findings of the H1 screening assessment conclude that the phenol discharge from the clean lagoon (U37A) into the Bristol Channel cannot be screened out as being insignificant. Hence detailed aquatic dispersion modelling is required to provide a more detailed assessment of the initial dispersion of the phenol into the receiving environment to ascertain whether the potential for exceedance of the environmental quality standards at the extents of the initial mixing zone exist, and if so the potential impacts on the receiving environment.

6. Detailed Aquatic Dispersion Modelling

A detailed aquatic dispersion modelling assessment has been undertaken using the CORMIX model to assess the initial dilution and dispersion of the discharge from the clean lagoon (U37A) into the Bristol Channel.

The detailed modelling report is presented in Appendix B which identified the following results:

- Concentrations of phenol from the Barry sea outfall are not predicted to exceed the annual average ($7.7\mu\text{g}/\text{m}^3$) and maximum allowable concentration ($46\mu\text{g}/\text{m}^3$) EQSs at any time at the edge of the mixing zone, in the absence of other sources of phenol in the area.
- The maximum annual average concentrations are predicted to be less than 20% of the AA EQS at the edge of the mixing zone when assessed based upon current levels of discharge at an average of $2.85\text{ mg}/\text{l}$ of phenol and assuming neap tide conditions, which are conservative. The predicted concentrations at the edge of the mixing zone would be significantly reduced if assessed across the full range of tidal flow conditions.
- The 'worst case' maximum concentration at the edge of the mixing zone occurs momentarily at the turn of the tide during neap tidal cycles in winter when instantaneous maximum concentrations can approach 82% of the MAC EQS value, but this reduces to 37% when considered over the diurnal range of neap currents, and the concentrations are further reduced in summer conditions and over spring tide conditions. These calculations also assume that the maximum discharge concentration ($10\text{mg}/\text{l}$) occurs coincident to this period of minimum dilution.
- The outfall is predicted to achieve an initial dilution of at least 240 under current worst case conditions with significantly higher levels of dilution at other times. Plumes are predicted always to rise to the surface, and the size of the surface manifestation of the mixing zone is not predicted to exceed around 50 m in diameter, although this may surface several hundred metres from the outfall in strong currents.
- No European designated sites or areas are reached or impacted upon by the mixing zone from the outfall.
- It should be noted that this assessment has not undertaken real time assessment of all tidal flows and conditions over a full year, but has selected a range of indicator scenarios to provide an understanding of the range of dilutions occurring within the mixing zone following the discharge from the outfall. The results presented above are the worst case dilution levels based upon assessment of neap tidal situations. The concentrations at the edge of the mixing zone will typically be at levels somewhat lower than those presented above.
- More accurate predictions of annual average concentrations could be developed by considering the entire range of currents over a year, and/or by using a Monte Carlo analysis to build up a large number of permutations of discharge and currents. Such assessments would be expected to produce results which are somewhat lower than those stated above. However given that the worst case contribution to the AA EQS is predicted to be less than 20% of the AA EQS, and hence no significant water quality impacts would be expected, there is little benefit in undertaking such additional assessment as it would not change the overall conclusions.

7. Conclusion

A detailed aquatic dispersion model to determine the potential impact of phenol within the discharge from the clean lagoon (U37A) into the Bristol Channel demonstrates that the concentrations of phenol at the edge of the mixing zone from the discharge are below the EQS values, with long-term (annual average) contributions at less than 20% of the EQS and short-term (MAC) contributions normally below 40% of the EQS.

This modelling assessment refines the findings of the original H1 assessment undertaken in 2013 and clearly demonstrates that the existing discharge from the clean lagoon (U37A) will not lead to any potential for exceedance of either the AA or MAC EQS for phenol in the Bristol Channel. Given this revised impact assessment it is considered that NRW's suggestion that further work to reduce phenol concentrations in the effluent discharged from the clean lagoon is no longer warranted based upon the environmental impacts demonstrated by the modelling assessment.

Appendix A - H1 Assessment Tool – Electronic Copy

Appendix B – Sea Outfall Modelling Report- Barry

