



Air Quality Technical Note 1

DATE:	07 October 2022	CONFIDENTIALITY:	Public
PROJECT NAME:	Drax BECCS DCO	PROJECT NUMBER:	EN010120
DOCUMENT NO. REV. NO:	5.1 1	DOCUMENT OWNER :	WSP UK Limited
AUTHOR:	Damian Pawson	APPROVER :	Bethan Tuckett-Jones
SUBJECT: Updated Amines Impacts following Permit Application			

FOREWORD

The Environmental Statement (ES) submitted with the Drax BECCS DCO application (June 2022) has been updated following the receipt of additional information and design parameters, specifically in relation to the operational phase air quality assessment, as reported in **Chapter 6 (Air Quality)** of the ES (**APP-042**). This Technical Note provides details of the relevant updates and associated discussion of the changes to the air quality assessment results. The details and discussion presented below demonstrate that these changes do not affect the conclusions of the ES.

INTRODUCTION

Subsequent to the submission of the Environmental Statement (ES) for the Drax BECCS DCO application (June 2022), further information was received from the suppliers (Mitsubishi Heavy Industries, MHI) of the carbon capture and storage (CCS) plant that necessitated the updating of the model and assessment assumptions for amines. Namely:

- The annual and daily emission limit values (ELVs) for the primary amine (termed ‘Amine 1’ in the ES) were increased; and
- Process specific hourly and daily mean environmental assessment levels (EALs) for the primary and secondary amines (termed ‘Amine 1’ and ‘Amine 2’ respectively in the ES) were provided by MHI.

The updated information and associated outcomes of the revised amines modelling were incorporated into the Environmental Permit Variation Application, which was submitted to the Environment Agency in August 2022. As such, to align with the permit information, this Technical Note provides details of the updates made since submission of June 2022 ES.

Further minor updates to the air quality modelling, which were included in the Environmental Permit Variation Application, are also presented in this Technical Note and relate to the operation phase air quality model and assessment results, specifically the:

- Inclusion of trace emissions of aldehyde from the Main Stack following receipt of emission rate data from MHI following submission of the ES;

- Reporting of hourly average concentrations of ammonia (NH₃) and hydrogen chloride (HCl) as the 100th percentile of hourly concentrations for a given assessment year, representing a more conservative assessment relative to the ES; and
- Addition of human receptor air quality assessment results for the With Proposed Scheme scenario, including mitigation.

Further details of each of the above changes a) - e) are provided below. Where relevant, cross-references are made to the associated ES documents where the updated information and results apply.

However, all updates to the assessment information presented in this Technical Note, which supersede the equivalent data presented in the June 2022 ES, represent no material change to the conclusions of the ES and the air quality-related aspects of the **Habitats Regulation Assessment (HRA; APP-185)**.

EMISSION LIMIT VALUES (ELV)

Table 1 shows the emission concentrations and mass emission rates for primary and secondary amines and nitrosamines as modelled for the June 2022 ES and as updated in August 2022 for the permit application. The changes applied to the emissions of primary amines ('Amine 1') only.

Table 1 - Stack Emission Parameters for the With Proposed Scheme Scenario

Parameter	As Reported in June 2022 ES		As Updated in August 2022 Permit Application ⁽¹⁾	
	Annual Limit	Daily Limit	Annual Limit	Daily Limit
Emission Concentrations (for each BECCS Unit)				
Amine 1 (mg/Nm ³)	0.5	1.5	1	2
Amine 2 (mg/Nm ³)	0.3	1.0	0.3	1
Nitrosamine 1 (mg/Nm ³)	0.0001	0.0001	0.0001	0.0001
Nitrosamine 2 (mg/Nm ³)	0.0001	0.0001	0.0001	0.0001
Mass Emission Rates (2 BECCS Units, combined stack)				
Amine 1 (g/s)	0.444	1.333	0.889	1.778
Amine 2 (g/s)	0.267	0.889	0.267	0.889
Nitrosamine 1 (g/s)	0.00009	0.00009	0.00009	0.00009
Nitrosamine 2 (g/s)	0.00009	0.00009	0.00009	0.00009
Notes:				
⁽¹⁾ Changes from June 2022 ES are highlighted in bold and supersede the equivalent data presented in Tables 6.6 and 6.7 of Chapter 6 Air Quality (APP-042) and Tables 1.1 and 1.2 of Appendix 6.3 (APP-127) of the June 2022 ES.				



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ENVIRONMENTAL ASSESSMENT LEVELS (EALS)

EALs were proposed by the Environment Agency for monoethanolamine (MEA) at hourly and daily averaging periods. Subsequent to the publication of the ES, the supplier (MHI) provided EALs that were specific to the process amines rather than MEA. The process-specific amine compounds were assessed in the ‘core model scenarios’, as reported in **Chapter 6 (Air Quality) (APP-042)** of the ES. As such, the revised EALs provided by the supplier were applied to the assessment.

Error! Reference source not found. shows the original (June 2022 ES) and revised EALs and how they were applied in the ES and permit application.

The EALs provided by the supplier were higher than the equivalent MEA values for the primary amine, but lower than MEA for the secondary amine. The revised EALs were applied on a conservative basis, by assessing the sum of the modelled amine concentrations (i.e. Amine 1 + Amine 2) at each receptor against the lowest provided EALs at hourly and daily averaging periods respectively.

The EAL for N-nitrosodimethylamine (NDMA) was stated by the suppliers to be a reasonable proxy for the process-specific nitrosamines and, as noted in the ES, applied conservatively to the sum of all nitrosamines and nitramines.

Table 2 - Assessed EALs for each amine compound

Pollutant	Environment Agency EAL		As Applied in June 2022 ES		Supplier Recommended EAL		As Applied in August 2022 Permit Application ⁽¹⁾	
	Hourly	Daily	Hourly	Daily	Hourly	Daily	Hourly	Daily
MEA (µg/m ³)	400	100	-	-	-	-	-	-
Amine 1 (µg/m ³)	-	-	400	100	1,120	280	53	13
Amine 2 (µg/m ³)	-	-	(Sum of 1+2)	(Sum of 1+2)	53	13	(Sum of 1+2)	(Sum of 1+2)
<p>Notes: Changes from June 2022 ES are highlighted in bold and supersede the equivalent value(s) presented in Table 6.1 and paragraph 6.12.10 of Chapter 6 (Air Quality) (APP-042).</p>								

REVISED AMINE MODELLING: RESULTS

The tables below show the original (June 2022 ES) and revised (August 2022 permit application) model results for amines at the point of maximum impact in the study area (based on 5 years of hourly meteorological data), both without and with the operational phase mitigation outlined in **paragraph 6.10.8 in Chapter 6 (Air Quality) (APP-042)**¹. The results are presented separately for the ES ‘core model scenarios’ (non-BECCS units operating on a ‘mid-merit’ basis), and the ES ‘worst case emissions profile’ scenario (all units operating at full load for 8,760 hours per year).

The full set of amine results tables for the above scenarios have been updated and are presented in **Appendix 6.4 (Operational Phase Air Quality Results Tables: Human Receptors) (document ref. 6.3.6.4)**. The revised amines modelling has no material impact on ecological receptors due to the low contribution from amines to nutrient nitrogen (N) deposition and acid deposition and hence no change to the conclusions of the **HRA (APP-185)**. However, for completeness, the full set of N-deposition and acid deposition results tables for the above scenarios have been updated and are presented in **Appendix 6.5 (Operational Phase Air Quality Results Tables: Ecological Receptors) (document ref. 6.3.6.5)**.

¹ The requirement for mitigation in the ES was driven by the impacts on ecological receptors. The EALs for amines relate to the protection of human health. Since the ‘With mitigation’ results are lower than the ‘Without mitigation’ results, they were not presented in the ES. However, for completeness and to align with the August 2022 permit application, the ‘With mitigation’ human health results have been added to revised Appendix 6.4 (APP-128); specifically Tables 1.25 to 1.33 (Core Scenarios) and Tables 1.34 to 1.42 (Worst Case Emissions Profile).

Based on the updated results, **paragraph 6.9.23 in Chapter 6 (Air Quality) (APP-042)** is superseded by the following changes specific to the amine results both without and with the operational phase mitigation measures (changes indicated by **bold text**):

6.9.23 *The modelled impacts for all assessed pollutants, **including amines as MEA**, are below 1% of the relevant AQALs, with the exception of... annual mean nitrosamine (as NDMA), where the maximum modelled impacts equate to... **10.2% of the NDMA EAL (without mitigation) and 9.6% (with mitigation)**. **Given that the mitigation will be implemented as part of the Proposed Scheme, and to align with the August 2022 permit application, the maximum NDMA impact corresponds to a 'slight adverse' magnitude of change within the context of the significance criteria presented in Table 6.9 (Chapter 6 Air Quality)**. For all other assessed pollutants and averaging periods, the maximum modelled impacts are classified as 'negligible'.*

The above updated text and associated revised model results do not change the conclusions of the operational phase air quality assessment reported in **Chapter 6 (Air Quality)** of the ES (**APP-042**).

Finally, **paragraph 6.12.9 in Chapter 6 (Air Quality) (APP-042)**, which provides a qualitative and conservative judgement on potential cumulative amine and nitrosamine impacts (Proposed Scheme and Keadby 3 project) can be updated to provide revised values, as below (changes indicated by **bold text**):

6.12.19 *As detailed in paragraphs 6.5.30 and 6.5.31, a quantitative modelling assessment of cumulative impacts for amine and nitrosamine concentrations was not considered appropriate. However, to provide a qualitative and conservative judgement on potential cumulative impacts, the maximum modelled PC concentrations from both the Proposed Scheme and Keadby 3 (Keadby Generation Ltd, May 2021) project were summed, as follows:*

Amine (as MEA) cumulative maximum 1-hour mean PC ($\mu\text{g}/\text{m}^3$)
*= **0.287 (Proposed Scheme)** + 25.2 (Keadby 3) = **25.487 $\mu\text{g}/\text{m}^3$***

Amine (as MEA) cumulative maximum 24-hour mean PC ($\mu\text{g}/\text{m}^3$)
*= **0.070 (Proposed Scheme)** + 0.22 (Keadby 3) = **0.290 $\mu\text{g}/\text{m}^3$***

Nitrosamine (as NDMA) cumulative maximum annual mean PC (ng/m^3)
*= **0.020 (Proposed Scheme)** + 0.064 (Keadby 3) = **0.084 ng/m^3***

6.12.10 *The EALs for MEA and NDMA are not exceeded, with the maximum cumulative values representing 6.4% of the 1-hour mean EAL for MEA ($400 \mu\text{g}/\text{m}^3$), 0.3% of the 24-hour mean EAL for MEA ($100 \mu\text{g}/\text{m}^3$), and **42% of the annual mean EAL for NDMA ($0.2 \text{ng}/\text{m}^3$)**, respectively.*

- 6.12.11 *Within the context of the significance criteria presented in Table 6.9, these maximum cumulative impacts equate to ‘slight adverse’ for the MEA 1-hour averaging period, ‘negligible’ for the MEA 24-hour averaging period, and ‘moderate adverse’ for annual mean NDMA.*
- 6.12.12 *However, given the conservatism applicable to the above values, including the worst case assumption that maximum concentrations from both schemes would occur at the same location and time anywhere within the operational phase study area, and that values from both schemes represent the sum of nitramine and nitrosamine concentrations (see **paragraph 6.5.54**), the cumulative impact on amines and nitrosamines is considered to be not significant.*

Based on the revised results and the above updated text, there is no material change to the conclusions of the operational phase air quality assessment reported in **Chapter 6 (Air Quality)** of the ES (**APP-042**).

Table 3 - Revised modelled maximum amine impacts (Core Scenario)

	Hourly EAL	Max Hourly Proposed Scheme Impact (PC)		Daily EAL	Max Daily Proposed Scheme Impact (PC)	
	µg/m ³	µg/m ³	As % of EAL	µg/m ³	µg/m ³	As % of EAL
Without Mitigation						
ES June 2022 ⁽¹⁾	400 ⁽²⁾	0.239	0.1%	100 ⁽²⁾	0.058	0.1% ⁽³⁾
Permit App. Aug 2022	53 ⁽²⁾	0.287	0.5%	13 ⁽²⁾	0.070	0.5%
With Mitigation						
ES June 2022	<i>Not presented in ES (see Footnote 1, Page 4)</i>					
Permit App. Aug 2022	53 ⁽²⁾	0.258	0.5%	13 ⁽²⁾	0.063	0.5%
Notes:						
(1) As presented in Table 6.15, Chapter 6 (Air Quality) (APP-042) and Table 1.8, Appendix 6.4 (APP-128) and now superseded by the data presented for the August 2022 permit application. Accordingly, the full set of revised results are presented in Table 1.9 of the updated Appendix 6.4 (document ref. 6.3.6.4).						
(2) Hourly and daily EALs for MEA were used in Chapter 6 (Air Quality) (APP-042) to align with Environment Agency published EALs. However, hourly and daily EALs for process-specific amine compounds have been used for August 2022 permit application, following receipt of information from supplier (MHI), which supersedes the use of the EALs for MEA.						
(3) In Table 6.15, Chapter 6 (Air Quality) (APP-042), the maximum daily impact is presented as 0.5% of the EAL. However, this was a typographical error and should read as 0.1% of the EAL.						

Table 4 - Revised modelled maximum amine impacts (Worst Case Emissions Profile Scenario)

	Hourly EAL	Max Hourly Proposed Scheme Impact (PC)		Daily EAL	Max Daily Proposed Scheme Impact (PC)	
	µg/m ³	µg/m ³	As % of EAL	µg/m ³	µg/m ³	As % of EAL
Without Mitigation						
ES June 2022 ⁽¹⁾	400 ⁽²⁾	0.150	0.0%	100 ⁽²⁾	0.032	0.0%
Permit App. Aug 2022	53 ⁽²⁾	0.287	0.5%	13 ⁽²⁾	0.070	0.5%
With Mitigation						
ES June 2022	<i>Not presented in ES (see Footnote 1, Page 4)</i>					
Permit App. Aug 2022	53 ⁽²⁾	0.258	0.5%	13 ⁽²⁾	0.063	0.5%
Notes:						
(1) As presented in Table 1.19, Appendix 6.4 (APP-128) and now superseded by the data presented for the August 2022 permit application. Accordingly, the full set of revised results are presented in Table 1.21 of the updated Appendix 6.4 (document ref. 6.3.6.4).						
(2) Hourly and daily EALs for MEA were used in Chapter 6 Air Quality (APP-042) to align with Environment Agency published EALs. However, hourly and daily EALs for process-specific amine compounds have been used for August 2022 permit application, following receipt of information from supplier (MHI), which supersedes the use of the EALs for MEA.						

Table 5 - Revised modelled maximum nitrosamine (as NDMA) impacts (Core Scenario)

	Annual EAL	Max Hourly Proposed Scheme Impact (PC)	
	ng/m ³	ng/m ³	As % of EAL
Without Mitigation			
ES June 2022 ⁽¹⁾	0.2	0.017	8.7%
Permit App. Aug 2022	0.2	0.020	10.2%
With Mitigation			
ES June 2022	<i>Not presented in ES (see Footnote 1, Page 4)</i>		
Permit App. Aug 2022	0.2	0.019	9.6%
Notes:			
(1) As presented in Table 6.15, Chapter 6 (Air Quality) (APP-042) and Table 1.9, Appendix 6.4 (APP-128) and now superseded by the data presented for the August 2022 permit application. Accordingly, the full set of revised results are presented in Table 1.10 of the updated Appendix 6.4 (document ref. 6.3.6.4).			

Table 6 - Revised modelled maximum nitrosamine (as NDMA) impacts (Worst Case Emissions Profile Scenario)

	Annual EAL	Max Hourly Proposed Scheme Impact (PC)	
	ng/m ³	ng/m ³	As % of EAL
Without Mitigation			
ES June 2022 ⁽¹⁾	0.2	0.013	6.6%
Permit App. Aug 2022	0.2	0.016	7.8%
With Mitigation			
ES June 2022	<i>Not presented in ES (see Footnote 1, Page 4)</i>		
Permit App. Aug 2022	0.2	0.015	7.4%
Notes: (1) As presented in Table 1.20, Appendix 6.4 (APP-128) and now superseded by the data presented for the August 2022 permit application. Accordingly, the full set of revised results are presented in Table 1.22 of the updated Appendix 6.4 (6.3.6.4).			

INCLUSION OF ALDEHYDE EMISSIONS FROM MAIN STACK

Subsequent to the submission of the June 2022 ES, further information was received by the CCS supplier (MHI) in relation to the trace emissions of aldehyde from the Main Stack and specifically in relation to the operation of the two BECCS units only. The addition of aldehyde emissions and associated model results at human receptors in the With Proposed Scheme scenarios was included within the August 2022 Permit Variation Application and thus have been included within this Technical Note.

The stack emission parameters relating to the aldehyde emissions from the BECCS units are provided in **Table 7**. The associated modelled maximum concentrations in the With Proposed Scheme scenarios are presented in **Table 8** (Core Scenario) and **Table 9** (Worst Case Emissions Profile), the maximum process contribution impact presented as a percentage of the respective annual and hourly EALs.

The full set of aldehyde results tables for the above scenarios are presented in the revised **Appendix 6.4 (document ref. 6.3.6.4)**; specifically **Tables 1.8 (Core Scenario without mitigation)**, **1.20 (Worst Case Emissions Profile without mitigation)**, **1.31 (Core Scenario with mitigation)**, and **1.40 (Worst Case Emissions Profile with mitigation)**.

The modelled maximum aldehyde concentrations equate to less than 0.2% of the annual mean EAL in all scenarios and less than 1.5% of the hourly mean EAL in all scenarios, thereby representing negligible impacts associated with the operational phase of the Proposed Scheme. Therefore, there is no material change to the conclusions of the

operational phase air quality assessment reported in **Chapter 6 (Air Quality)** of the ES (APP-042).

Table 7 - Stack Emission Parameters for the With Proposed Scheme Scenario

Parameter	As Reported in June 2022 ES		As Updated in August 2022 Permit Application ⁽¹⁾	
	Annual Limit	Daily Limit	Annual Limit	Daily Limit
Averaging Period				
Emission Concentrations (for each BECCS Unit)				
Aldehyde (mg/Nm ³)	n/a	n/a	7	10
Mass Emission Rates (2 BECCS Units, combined stack)				
Aldehyde (g/s)	n/a	n/a	6.2	8.9

Table 8 - Modelled maximum aldehyde impacts (Core Scenario)

	Annual EAL	Max Hourly Proposed Scheme Impact (PC)		Daily EAL	Max Daily Proposed Scheme Impact (PC)	
		µg/m ³	As % of EAL		µg/m ³	As % of EAL
Without Mitigation						
Permit App. Aug 2022	5	0.006	0.1%	87	1.20	1.4%
With Mitigation						
Permit App. Aug 2022	5	0.006	0.1%	87	1.00	1.2%

Table 9 - Modelled maximum aldehyde impacts (Worst Case Emissions Profile Scenario)

	Annual EAL	Max Hourly Proposed Scheme Impact (PC)		Daily EAL	Max Daily Proposed Scheme Impact (PC)	
		µg/m ³	As % of EAL		µg/m ³	As % of EAL
Without Mitigation						
Permit App. Aug 2022	5	0.004	0.1%	87	1.20	1.4%
With Mitigation						
Permit App. Aug 2022	5	0.006	0.1%	87	1.00	1.2%

Addition of human receptor air quality assessment results for the With Proposed Scheme scenario, including mitigation.

REPORTING OF AMMONIA AND HYDRGEN CHLORIDE SHORT - TERM CONCENTRATIONS

Revised results tables are presented in the updated Appendix 6.4 (document ref. 6.3.6.4) for hourly average concentrations of NH₃ and HCl. These are now presented as the 100th percentile of hourly concentrations for a given assessment year, which represents a more conservative assessment relative to the equivalent data presented in the June 2022 ES (based on 99.79th percentile).

This update does not change the conclusions of the operational phase air quality assessment reported in **Chapter 6 (Air Quality)** of the ES (**APP-042**).

UPDATE TO APPENDIX 6.4 (DOCUMENT REF. 6.3.6.4) AND APPENDIX 6.5 (DOCUMENT REF. 6.3.6.5)

As referenced throughout this Technical Note, **Appendix 6.4 (Operation Phase Air Quality Assessment Results Tables: Human Receptors)** (document ref. 6.3.6.4) and **Appendix 6.5 (Operational Phase Air Quality Results Tables: Ecological Receptors)** (document ref. 6.3.6.4) have been revised to capture all non-material updates to the operational phase air quality model results. Specifically, these relate to:

- **Appendix 6.4 (document ref. 6.3.6.4):**
 - Addition of ‘Core Model Scenarios (With Mitigation)’ results (Tables 1.25 to 1.33)
 - Addition of ‘Sensitivity Test: Worst Case Emissions Profile (With Mitigation)’ results (Tables 1.34 to 1.42)
 - Revised data provided in Table 1.6 (Core Scenario - NH₃ hourly average concentrations)
 - Revised data provided in Table 1.7 (Core Scenario - HCl hourly average concentrations)
 - Addition of Table 1.8 (Core Scenario - Annual and hourly average aldehyde concentrations)
 - Revised data provided in Table 1.9 (Core Scenario – Hourly and daily average amines concentrations)
 - Revised data provided in Table 1.10 (Worst Case Emissions Profile – Annual average nitrosamine concentrations)
 - Revised data provided in Table 1.18 (Worst Case Emissions Profile - NH₃ hourly average concentrations)

- Revised data provided in Table 1.19 (Worst Case Emissions Profile - HCl hourly average concentrations)
- Addition of Table 1.20 (Worst Case Emissions Profile - Annual and hourly average aldehyde concentrations)
- Revised data provided in Table 1.21 (Worst Case Emissions Profile – Hourly and daily average amines concentrations)
- Revised data provided in Table 1.22 (Worst Case Emissions Profile – Annual average nitrosamine concentrations)
- **Appendix 6.5 (document ref. 6.3.6.5)**
 - Revised data provided in all scenario results tables that report N-deposition and acid deposition only.

CONCLUSIONS

The revised data presented in this Technical Note and the associated updates to Appendix 6.4 (document ref. 6.3.6.4) and Appendix 6.5 (document ref. 6.3.6.5), which capture the information received from the CCS supplier (MHI) since the publication of the June 2022 ES and which align with the August 2022 Permit Variation Application, do not affect the conclusions of the June 2022 ES **Chapter 6 (Air Quality) (APP-042)** and **HRA (APP-185)**.