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NNB-OSL-REP-000347 - Water Discharge Activity (WDA) Environmental Permit Application, September 2011
UKEPR-0002-113 Issue 05 - Pre-Construction Safety Report (PCSR) Sub-chapter 11.3, August 2012
UKEPR-0003-063 Issue 05 - Pre-Construction Environmental Report (PCER) Sub-Chapter 6.3, August 2012

Abstract: This report traces the evolution of the estimates of maximum chemical and radiochemical discharges from the initial studies for the UK EPR, through the GDA, up to the Environmental Permits delivered for Hinkley Point C in March 2013. The document serves as a source of OPEX for the elaboration of Environmental Permits for future UK EPR projects.

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UK EPR – Review of Maximum Chemical and Radiochemical Discharges and their Limits During Operation

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1. Glossary

AE	Architect Engineer (now known as Responsible Designer, RD)
APG	Steam Generator Blowdown System
BAT	Best Available Technique
BEEMS	British Energy Estuarine and Marine Studies
BoP	Balance of Plant
CA	Combustion Activity (Environmental Permit)
CEFAS	Centre for Environment, Fisheries & Aquaculture Science
CEIDRE	Centre d'Expertise et d'Inspection dans les Domaines de la Réalisation et de l'Exploitation
CNEN	Centre National d'Equipment Nucléaire
CRF	Circulation Water System
EA	Environment Agency
FA3	Flamanville 3 EPR
GDA	Generic Design Assessment
HPC	Hinkley Point C
HSE	Health and Safety Executive
iSoDA	Interim Statement of Design Acceptability
KER	Liquid Radwaste Monitoring and Discharge System
NNB GenCo	New Nuclear Build Generation Company
NPP	Nuclear Power Plant
OPEX	Operating Experience
ONR	Office for Nuclear Regulation
PEN	Penly
PCER	Pre-Construction Environmental Report
PCSR	Pre-Construction Safety Report
QNL	Quarterly Notification Level
RD	Responsible Designer (formerly AE)
REA	Reactor Boron and Water Make-up System
RRI	Component Cooling Water System
RSR	Radioactive Substances Regulations (Environmental Permit)
RTP	Rated Total Power
SDS	Demineralised Water Production System for FA3 (including seawater desalination)
SEK	Conventional Island Liquid Waste Discharge System
SG	Steam Generator
SoDA	Statement of Design Acceptability
SRI	Conventional Island Closed Cooling Water System
TEU	Liquid Waste Processing System
WDA	Water Discharge Activity (Environmental Permit)

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2. Scope

Estimates of the maximum chemical and radiochemical discharges, and the corresponding discharge limits, have evolved throughout:

- the initial studies for the UK EPR,
- the Generic Design Assessment process,
- the application for and delivery of environmental permits for Hinkley Point C.

This report traces these evolutions up to and including the environmental permits for HPC issued in March 2013. It explains why the values changed throughout the process, whether due to revised assumptions, updated OPEX data or discussions with the UK regulators.

The purpose of this document is to illustrate how and why the discharge limits have evolved throughout the design process to date. It is intended to serve as a source of OPEX for the preparation of environmental permit applications for future UK EPR projects.

However, it should be noted that the discharge limits for HPC may evolve further from those which are presented in this report. This document should **not be used as a reference for HPC discharge limits**; the latest version of the RSR, WDA and CA permits are the primary reference for these values.

Data for chemical and radiochemical species that originate in the nuclear and conventional islands are found consistently from early studies through to the environmental permits. As such, data for these substances can be directly applied to new projects. However, discharges which arise from BoP systems are more site dependent, and data concerning these parts of the plant should be assessed individually for a new project.

Some of the references for this document were written for French EPR projects and translated to English; there are thus some discrepancies in terminology due to the different regulatory contexts. Despite best efforts to standardise the terminology used in this report, there may be instances when different terms are used for similar subject matters.

The discharge values presented in this report are as they were submitted to the UK regulators. It is interesting to note that had the submissions been in France, the values would have been rounded using the guidelines in EDEAPC060365 (Définition des arrondis appliqués pour les substances chimiques lors de l'élaboration des DARPE/DMA, July 2006).

[redacted]

3. References

The following documents were used in preparing this report; for the more significant references a brief description is given, highlighting any major assumptions or relevant context.

[1] Valeurs maximales des rejets de substances chimiques liquides associées aux effluents radioactifs et aux eaux d'exhaure de la salle des machines pour la tranche EPR, ECEF050301 C, March 2006.

A study which estimates the maximum annual liquid chemical discharges for 1 EPR unit, taking into account the chemical conditioning regime for the FA3 EPR and necessary operating margins (e.g. outages, start ups and shutdowns).

It should be noted that this study predates [2]; while the chemical discharge data given by both are similar, some discrepancies in values exist between the two documents, making this first report a valuable reference in its own right.

[2] Memorandum – UK EPR Sites studies – Environmental Impact Assessment of 2 EPR units on a single site, ECEF082752, December 2008.

A memorandum outlining the radioactive gaseous discharges and the chemical & radioactive liquid discharges for 2 EPR units on a single site. The report provides values for both the maximum discharges and expected performance; these values were taken from the relevant issue (at the time) of the PCER sub-chapter 6.3.

It should be noted that this memorandum does not consider spent fuel, solid waste or chemical substances that are not associated with radioactive effluents.

[3] Entec UK Limited – Hinkley Point C Environmental Permit Application for Discharge to Surface Water, Interim Report, Doc Reg No. 26296 CW005R, July 2010.

A study by ENTEC UK Ltd. (commissioned by NNB) to support Environmental Permitting. Although this study has a wide remit, it does include valuable chemical concentration data and discharge values for discharges for HPC. These can be found in Tables 4.9.9 and 4.9.10 on pages 97 and 100 respectively. The main assumption used to calculate chemical loadings in this study is a cooling water flow rate of 64 m^3/s for two units.

This study includes some site-specific discharge sources, such as the demineralisation plant, whereas [6] and [7], only consider discharges from the nuclear and conventional islands. This can lead to discrepancies, but these are explained, where relevant, in this report.

[4] H1 Assessment of Non-Radiological Chemical Discharges from Hinkley Point C on the Marine Environment, 15011/TR/00117 Issue 07, AMEC, February 2011.

This report, written by AMEC for EDF, is a source of input data for the Environmental Impact Assessments. It draws on a number of references including an earlier version of [11].
Section 3.3 is the most relevant to this report, and the values are similar to those in [3] above. Nevertheless, it provides useful information on other assumptions, such as conversion factors between nitrogen (as N) & ammonia (NH_3) in water.

[redacted]

[5] Annexe 6.4.4: Etude d'Impact de Penly 3 – Valeurs maximales des rejets de substances chimiques liquides associées aux effluents radioactifs et aux eaux d'exhaure de la salle des machines pour la tranche EPR du CNPE de PENLY, ECEF100785 D, May 2011.

A study carried out to estimate the maximum annual liquid chemical discharges for an EPR reactor at the Penly site, taking into account the chemical conditioning of the circuits and operating margins e.g. outages, start ups and shutdowns.,

This study also provides justifications for the calculation of 24 hour and 2 hour discharges based on chemical concentrations and tank volumes.

[redacted]

[8] Water Discharge Activity (WDA) Environmental Permit Application, NNB-OSL-REP-000347, September 2011.

This submission details the source of non-radioactive emissions, anticipated liquid discharges and potential environmental impacts.

Following the initial submission, the EA issued a 'Schedule 5 Notice' (13th December 2011) to NNB, requesting a number of clarifications, which required further work on the chemical discharge values. The final, reworked values (i.e. post-Schedule 5) are the ones presented in this report.

It is at this point that NNB, decided to split the different liquid waste streams, creating Waste Streams B, C and D, which correspond to KER, APG and SEK respectively. However, in terms of quantitative discharge analysis it was deemed unfeasible to distinguish between waste streams B and C, therefore in the Schedule 5 responses, chemical loadings are split between waste streams B+C and D (see [15] and [16]).

[redacted]

[redacted]

[9] interim Statement of Design Acceptability (iSODA), Decision document, UK Environment Agency. December 2011.

An interim decision document summarising the Environment Agency's detailed assessment findings on environmental aspects of the UK EPR design, taking into account comments and issues raised during public consultations. The EA concluded that they "*are content with the environmental aspects of the design, that it should meet the high standards we expect, so will issue an Environment Agency interim Statement of Design Acceptability (iSODA)*".

The EA's subsequent 'Final Assessment Reports' can be considered as the SODA; as these documents do not differ from the iSODA they are not referenced separately.

[10] Pre-Construction Safety Report (PCSR) Sub-chapter 11.3, UKEPR-0002-113 Issue 05 and Pre-Construction Environmental Report (PCER) Sub-Chapter 6.3, UKEPR-0003-063 Issue 05, EDF/AREVA. August 2012.

Sub-chapters of the PCSR & PCER (discharge values identical in both) considering estimates of the effluents discharged and the waste produced by operation of an EPR reactor. These sub-chapters are the final iterations of these documents (5th issue), the first issues having being submitted in April 2008.

[11] CEFAS BEEMS Scientific Position Paper SPP068/S; Derivation of dilution and dispersion for Hinkley Point C, NNB-OSL-REP-00134, March 2012.

This document provides data on RTP CRF pump usage for two units at HPC. This is used to calculate a temperature differences for certain scenarios, which are then used to calculate conversion factors between ammonium (NH_4^+) and ammonia (NH_3).

[redacted]

[15] CEIDRE Technical Position: HPC WDA Sch5 notice – table of assistance required, EDECME120296, February 2012.

[redacted]

[16] CEIDRE Technical Position: HPC WDA Sch5 notice – FQR WDA SCh5 NNB further support on WDA, EDECME120666, July 2012.

[redacted]

[18] Environmental Permitting (England and Wales) Regulation 2010 – WDA Permit for Hinkley Point C Power Station EPR/HP3228XT, 13 March 2013.

This Permit sets out the Limits and Quarterly Notification Levels that are to be applied to the HPC EPR for chemical substances in liquids discharges. A description of the various discharge outlets (Waste Streams) is also included.

[19] Environmental Permitting (England and Wales) Regulation 2010 – CA Permit for Hinkley Point C Power Station EPR/ZP3238FH, 13 March 2013

This Permit sets out Limits that are to be applied at Hinkley Point C relating to gaseous chemical discharges arising from Combustion Activities.

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5. Liquid Chemical Discharges

When calculating discharge quantities (referred to as 'loading' or 'chemical load') the following volumes were considered:

System	Volume (m^3)
KER	750
SEK	750
RRI	450
REA Boron	100
SRI	75
Steam Generator (draining of)	500
APG (non recycled)	5000

The term 'Sum of waste streams' in the tables below is used for the sum of waste streams B+C & D, i.e. effluents from the nuclear and conventional islands.

5.1. Boric Acid (H_3BO_3)

Despite slight variations in the daily load, due to rounding, the estimate of boric acid discharges has not changed since the early studies.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		**WDA Submission (inc Schedule 5 amendments) (2 EPR Units)**		WDA Permit (2 EPR Units)	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-08		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		**Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11**		Ref 18: EPR/HP3228XT 13 March 2013	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**		Sum of waste streams	
Boric Acid (H_3BO_3)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	**day (kg)**	**year (kg)**	day (kg)	year (kg)
	-	7000	5630	7000	5630	14000	5630	14000	1018	3.8	1020	3.82	**5625**	**14000**	-	-

[redacted]

The WDA Permit does not incorporate a limit on boric acid, simply a limit on boron (cf. § 5.2).

5.2. Boron (B)

The initial studies considered a limit on boric acid; the EA has preferred to fix a limit on boron discharges. The values for boron discharge limits are equivalent to, and consistent with, those proposed for boric acid.

Source →	Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA Submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Boron	day (kg)	year (kg)	Maximum (µg/L)	Average (µg/L)	Maximum (µg/L)	Average (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	984	2448	178	0.67	178	0.669	984	2448	**984**	**2448**

A daily discharge limit of 984 kg and an annual discharge limit of 2448 kg for 2 EPR units were proposed in the WDA Submission. These values were retained by the EA in the WDA Permit for HPC.

[redacted]

5.3. Lithium hydroxide (LiOH)

Maximum annual discharges of lithium hydroxide are based on calculations that incorporate normal operating contingencies, such as contamination of an REA tank.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Lithium Hydroxide (LiOH)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	-	4.4	-	4.4	-	8.8	-	8.8	-	0.002	-	0.0024	4.4	8.73	**4.4**	**8.73**

A daily discharge limit of 4.4 kg and an annual discharge limit of 8.73 kg for 2 EPR units were proposed in the WDA Submission. These values were retained by the EA in the WDA Permit for HPC.

[redacted]

5.4. Hydrazine (N_2H_4)

Hydrazine is used to maintain a reducing potential and to act as an oxygen scavenger in the secondary circuit. It is also used as an oxygen scavenger in the primary circuit during reactor start up.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Hydrazine (N_2H_4)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	-	14	-	14	-	28	4	28	0.72	0.008	0.723	0.00765	4	27.3	-	-

A daily discharge limit of 4 kg and an annual discharge limit of 27.3 kg for 2 EPR units were proposed in the WDA submission. However, the WDA Permit requires the level of hydrazine in discharges to be below the Limit of Detection of the analytical method; as such the permit does not feature discharge limits for hydrazine. PO10 of the WDA Permit requires NNB to submit a Hydrazine Removal Plan to the EA before Hot Functional Testing to explain how this criterion will be satisfied.

5.5. Morpholine & Ethanolamine

The UK EPR design incorporates the potential to use either morpholine or ethanolamine to condition the secondary circuit (for pH control). It is likely that ethanolamine will be chosen, but as the plant is designed to operate with either amine, both were included in the WDA Submission.

The estimated maximum discharges for both of these amines have evolved very little since the initial studies; there are no inconsistencies to report.

5.5.1. Morpholine (C_4H_9ON)

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Morpholine (C_4H_9ON)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	-	840	95	840	95	1680	95	1680	17.2	0.46	17.2	0.459	92.25	1674	**92.25**	**1674**

A daily discharge limit of 92.25 kg and an annual discharge limit of 1674 kg for 2 EPR units were proposed in the WDA Submission. These values were retained by the EA in the WDA Permit for HPC.

5.5.2. Ethanolamine (C_2H_7ON)

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Ethanolamine (C_2H_7ON)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	-	460	25	460	25	920	25	920	4.52	0.25	4.52	0.251	24.75	919	**24.75**	**919**

A daily discharge limit of 24.75 kg and an annual discharge limit of 919 kg for 2 EPR units were proposed in the WDA Submission. These values were retained by the EA in the WDA Permit for HPC.

5.6. Nitrogen (N, NH_3, NH_4^+)

There has been considerable confusion with regards to nitrogen discharges. This stems from a combination of the following factors:

- sources,
- waste streams,
- consideration of ammonia (NH_3) and ammonium (NH_4^+),
- the distribution between NH_4^+ & NH_3.

This issue was highlighted by the EA Schedule 5 Notice, which required NNB to quantify the maximum chemical loadings for each waste stream (see [15]). This included a quantification of (unionised) ammonia (NH_3), due to its potential impact on the migration of fish in the Bristol Channel.

In terms of nitrogenous discharges (expressed as N), there has been relative coherence throughout the documents reviewed in this report. Some inconsistencies appeared when calculating the NH_4^+/NH_3 distribution.

[redacted]

The EA's 'Unionised Ammonia Calculator' spreadsheet, provided by NNB and verified using MulteQ™ modelling software, calculates an NH_4^+ to NH_3 conversion factor using the pH, temperature and salinity (cf. extract below).

Temp °C	Salinity psu	pH as pH units	Ammonia	Unionised ammonia	ka0	pkstar	dum1
40	23,3	8,11	1000	151,4 15,14*	1,56E-09 %	8,858741	0,000488

Enter data in a row for T, salinity, pH and total ammonia concentration
Ammonia and unionised ammonia are in the same units (i.e. can use mg/l or µg/l)

**15.14 represents the percentage of the measured ammonium that is, in fact, discharged as ammonia*

As such, there is an error in [3], which applied the conversion factor to nitrogen as N rather than to ammonium.

The following table summarises the parameters input to the EA's spreadsheet to calculate the conversion factors, which were used to estimate the maximum ammonia discharges in response to the WDA Schedule 5 Notice.

	Temperature (°C) (ambient + delta T due to pumps)	pH	Salinity (pps)	Conversion Factor (%)
Annual	23 + 12.5 = 35.5	8.11	23.3	11.68
Daily	23 + 17* = 40	8.11	23.3	15.14

**Using reference 11 and consensus from CNEPE and NNB Pre-Ops, the scenario for the daily maximum has been defined as one HPC UK EPR unit operating with 2 CRF pumps at 100% RTP and the other operating on 1 CRF pump at between 90 - 100% RTP (100% being the bounding case).*

The final ammonia (NH_3) values proposed by CEIDRE in the WDA Schedule 5 Notice response were an annual maximum discharge of 1518.4 kg and a daily maximum discharge of 62.3 kg. EDF has not previously been required to calculate the NH_4^+/NH_3 distribution, and so a direct comparison cannot be made with the historical documents.

[redacted]

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
Nitrogen (as **N**) (excluding hydrazine, morpholine and ethanolamine)	-	5060	320	5060	320	10120	324	11654	58.6	3.18	57.9	2.76	320	10130	**328**	**10130**
Ammoniacal Nitrogen (as NH_4^+)	-	-	-	-	-	-	-	-	-	-	-	-	73.13	13009	**73.13**	**13009**
Ammonia (NH_3)	-	-	-	-	-	-	-	-	-	-	13.2	0.323	-	-	**-**	**-**

The WDA Permit fixes annual limits of 10130 kg for nitrogen, expressed as N, and 13009 kg for ammoniacal nitrogen, expressed as NH_4^+. The limit for ammoniacal nitrogen takes account of unionised ammonia discharges, and is partly justified by the calculated NH_4^+/NH_3 distribution.

NB: These discharges can be separated between waste streams B+C and D (cf. [8]) as per the following percentages: 2.5% in waste stream B+C and 97.5% in waste stream D.

Further to the above, the EA posed the following question:

> *It would appear from the comments that an assumption is being made that all of the total nitrogen load of 5060 kg N / EPR unit is effectively being discharged as ammonia. This may be the case, and nitrate and nitrite may not be present, but it would be helpful if this could be clarified.*

The following argument was provided by CEIDRE:

The effluents from the plant (via waste streams B+C and D) are transferred to a storage tank where they are exposed to oxygen; as a consequence the ammonia can be oxidised to nitrite, which can be further oxidised to nitrate. Depending on the time spent in storage, the amount of ammonia in the discharge will decrease and the amount of nitrates will increase. However, it is difficult to be more specific about the distribution between the two.

When carrying out impact studies, an assumption is made that the total nitrogen load is in the form of both ammonia and nitrates (at 100% each) and thus the maximum potential ammonia and nitrate discharges are calculated.

5.7. Phosphate (PO_4^{3-})

Phosphate discharges to the local marine environment may increase the concentration of algae, leading to eutrophication and hypoxia, impacting the population of certain fish and other animal species. Hence phosphate discharges are restricted by the Environment Agency.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report Ju'y 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Phosphate (PO_4^{3-})	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	-	400	200	400	200	800	200	800	36.2	0.22	36.2	0.219	352.5	790	**352.5**	**790**

A daily discharge limit of 352.5 kg and an annual discharge limit of 790 kg for 2 EPR units were retained by the EA in the WDA Permit for HPC.

5.8. Detergents

According to [8], the detergents to be used in the UK EPR will be biodegradable commercial products containing no EDTA (ethylene diamine tetra-acetic acid) or phosphates. Despite slight variations in annual and daily loads, there are no inconsistencies to report.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Detergents	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	-	1600	270	1600	270	3200	270	3824	48.8	1	48.8	0.872	270	3200	**270**	**3200**

A daily discharge limit of 270 kg and an annual discharge limit of 3200 kg for 2 EPR units were proposed in the WDA Submission. These values were retained by the EA in the WDA Permit for HPC.

5.9. Suspended Solids

Suspended solids in SEK arise principally from either:

- effluent that is polluted by particulate,
- effluents from auxiliary plant in the conventional island that are cooled using raw water.

Suspended solids in KER are limited by upstream filtration systems. However, suspended solids in KER arise from the nuclear island and so may be active.

Despite slight variations in annual and daily loads, there are no inconsistencies to report.

NB Reference [3] is not included in the below table. The estimates of suspended solid discharges given by this reference are not relevant, as they incorporate an estimate of the discharges that would be generated by a seawater desalination plant (SDS). While this system is part of the design for FA3, it will not be present at HPC.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		**WDA submission (inc Schedule 5 amendments) (2 EPR Units)**		WDA Permit (2 EPR Units)	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 8: NNB-OSL-REP-000347 (first version from internet)		**Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11**		Ref 18: EPR/HP3228XT 13 March 2013	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**		Sum of waste streams	
Suspended Solids	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	**day (kg)**	**year (kg)**	day (kg)	year (kg)
	-	1400	420	1400	420	2800	75.9	0.765	**420.04**	**2799.96**	-	-

A maximum daily discharge of 420 kg and a maximum annual discharge value of 2800 kg for 2 EPR units were presented in the WDA Submission. The maximum discharges represent less than 10 % of the EQS/target or ambient background level, and so no limit was formally retained in the WDA Permit.

5.10. COD (Chemical Oxygen Demand)

COD quantifies the amount of organic pollutant found in waste water. It indicates the mass of oxygen consumed per litre of solution (mg dm^{-3} or ppm). A high COD would have an adverse effect on the local fauna and flora due to a lack of oxygen. Despite slight variations in annual and daily loads, there are no inconsistencies to report.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
COD (Chemical Oxygen Demand)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
	-	2525	330	2525	330	5050	330	5050	60	1.4	59.7	1.38	329.97	5049.95	**329.97**	**5049.95**

A daily discharge limit of 329.97 kg and an annual discharge limit of 5049.95 kg for 2 EPR units were proposed in the WDA Submission. These values were retained by the EA in the WDA Permit for HPC.

[redacted]

5.11. Metals

Despite slight variations in annual and daily loads, there are no inconsistencies to report. The initial studies were based on FA3 information. However, the fingerprint of metal discharges is site-specific; for future installations the metal discharge estimates may need to be adjusted according to the site water analysis.

NB The iron discharge estimates in [3] are not relevant, as they incorporate discharges that would be generated by a seawater desalination plant (SDS). While this system is part of the design for FA3, it will not be present at HPC.

Source →	Loadings as in ECEF100785 for EPR PEN (1 EPR Unit)		Loadings as in ECEF082752 (1 EPR Unit)		Loadings as in ECEF082752 (2 EPR Units)		Loadings as in Entec document (2 EPR Units)		Concentration as in ENTEC document (2 EPR Units)		Concentration as in WDA, table 4.1.8 (2 EPR Units)		WDA submission (inc Schedule 5 amendments) (2 EPR Units)		**WDA Permit (2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 **D** 03-05-11		Ref 2: Memorandum ECEF082752 09-12-08		Ref 2: Memorandum ECEF082752 09-12-09		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23-09-11		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Max (µg/L)	Avg (µg/L)	Max (µg/L)	Avg (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
Total metals	-	27.5	12	27.5	12	55	-	55	-	-	-	-	-	-	**-**	**-**
Aluminium	-	-	-	-	-	-	1.074	4.93	0.19	0.001	0.199	0.00134	1.10	5.26	**1.1**	**5.26**
Copper	-	-	-	-	-	-	0.084	0.385	0.015	0.0001	0.0145	0.0001	0.08	0.42	**0.08**	**0.42**
Chromium	-	-	-	-	-	-	1.692	7.755	0.306	0.002	0.307	0.00213	1.70	8.37	**1.7**	**8.37**
Iron	-	-	-	-	-	-	~~257~~	~~46036~~	~~46.5~~	~~12.6~~	1.29	0.00891	7.15	34.97	**7.15**	**34.97**
Manganese	-	-	-	-	-	-	0.672	3.08	0.122	0.001	0.121	0.00085	0.67	3.33	**0.67**	**3.33**
Nickel	-	-	-	-	-	-	0.09	0.413	0.016	0.0001	0.0163	0.00011	0.09	0.44	**0.09**	**0.44**
Lead	-	-	-	-	-	-	0.06	0.275	0.011	0.0001	0.0108	7.7E-05	0.07	0.30	**0.06**	**0.3**
Zinc	-	-	-	-	-	-	1.212	5.555	0.22	0.002	0.217	0.00153	1.20	6.00	**1.2**	**6.0**

[redacted]

[redacted]

The limits proposed for the various metals in the WDA Submission were retained in the HPC WDA Permit.

Nevertheless, it should be noted that the limit on copper discharges is restrictive. In order to comply with the requirement that the level of hydrazine is below the Limit of Detection of the analytical method (cf. § 5.4), a hydrazine destruction treatment must be applied in the KER and SEK tanks. The identified method is by reaction with hydrogen peroxide using a copper sulphate catalyst. This treatment may, however, be incompatible with the copper discharge limit currently fixed by the WDA Permit.

[redacted]

[redacted]

APPENDIX 2: Summary of Maximum Discharge Estimates & Limits for Chemical Discharges

Source →	Loadings as in ECEF100785 (PEN)		Loadings as in ECEF082752		Loadings as in ECEF082752		Loadings as in Entec document		Concentration as in ENTEC document		Concentration as in WDA, table 4.1.8		WDA submission (inc Schedule 5 amendments)		**WDA Permit**	
	(1 EPR Unit)		(1 EPR Unit)		(2 EPR Units)		(2 EPR Units)		(2 EPR Units)		(2 EPR Units)		(2 EPR Units)		**(2 EPR Units)**	
Reference, version and date →	Ref 5: ECEF100785 D 03/05/2011		Ref 2: Memorandum ECEF082752 09/12/2008		Ref 2: Memorandum ECEF082752 09/12/2009		Ref 3: Interim draft report July 2010		Ref 3: Interim draft report July 2010		Ref 8: NNB-OSL-REP-000347 (first version from internet)		Ref 8: NNB-OSL-REP-000347 & NNB-OSL-TEM-000048 docs 23/09/2011		**Ref 18: EPR/HP3228XT 13 March 2013**	
	Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		Sum of waste streams		**Sum of waste streams**	
Effluent Substances (as in WDA Table 4.1.8) ↓	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	day (kg)	year (kg)	Maximum (µg/L)	Average (µg/L)	Maximum (µg/L)	Average (µg/L)	day (kg)	year (kg)	**day (kg)**	**year (kg)**
Boric Acid (H_3BO_3)	-	7000	5630	7000	5630	14000	5630	14000	1018	3.8	1020	3.82	5625	14000	**-**	**-**
Boron	-	-	-	-	-	-	984	2448	178	0.67	178	0.669	984	2448	**984**	**2448**
Lithium Hydroxide (LiOH)	-	4.4	-	4.4	-	8.8	-	8.8	-	0.002	-	0.0024	4.4	8.73	**4.4**	**8.73**
Hydrazine (N_2H_4)	-	14	-	14	-	28	4	28	0.72	0.008	0.723	0.00765	4	27.3	**LoD**	**LoD**
Morpholine (C_4H_9ON)	-	840	95	840	95	1680	95	1680	17.2	0.46	17.2	0.459	92.25	1674	**92.25**	**1674**
Ethanolamine (C_2H_7ON)	-	460	25	460	25	920	25	920	4.52	0.25	4.52	0.251	24.75	919	**24.75**	**919**
Nitrogen (as N) (excluding hydrazine, morpholine and ethanolamine)	-	5 060	320	5060	320	10120	324	11654	58.6	3.18	57.9	2.76	320	10130	**328**	**10130**
Ammoniacal Nitrogen (as NH_4^+)	-	6500	-	-	-	-	-	10120	-	-	-	-	73.13	13009	**73.13**	**13009**
Ammonia	-	-	-	-	-	-	-	-	-	-	13.2	0.323	-	-	**-**	**-**
Phosphate (PO_4^{3-})	-	400	200	400	200	800	200	800	36.2	0.22	36.2	0.219	352.5	790	**352.5**	**790**
Detergents	-	1600	270	1600	270	3200	270	3824	48.8	1	48.8	0.872	270	3200	**270**	**3200**
Suspended Solids	-	1400	420	1400	420	2800	-	-	-	-	75.9	0.765	420.04	2799.96	**-**	**-**
COD (Chemical Oxygen Demand)	-	2525	330	2525	330	5050	330	5050	60	1.4	59.7	1.38	329.97	5049.95	**329.97**	**5049.95**
Total metals	-	27.5	12	27.5	12	55	-	55	-	-	-	-			**-**	**-**
Aluminium	-	-	-	-	-	-	1.074	4.93	0.19	0.001	0.199	0.00134	1.10	5.26	**1.1**	**5.26**
Copper	-	-	-	-	-	-	0.084	0.385	0.015	0.0001	0.0145	0.0001	0.08	0.42	**0.08**	**0.42**
Chromium	-	-	-	-	-	-	1.692	7.755	0.306	0.002	0.307	0.00213	1.70	8.37	**1.7**	**8.37**
Iron	-	-	-	-	-	-	-	-	-	-	1.29	0.00891	7.15	34.97	**7.15**	**34.97**
Manganese	-	-	-	-	-	-	0.672	3.08	0.122	0.001	0.121	0.000847	0.67	3.33	**0.67**	**3.33**
Nickel	-	-	-	-	-	-	0.09	0.413	0.016	0.0001	0.0163	0.000112	0.09	0.44	**0.09**	**0.44**
Lead	-	-	-	-	-	-	0.06	0.275	0.011	0.0001	0.0108	7.65E-05	0.07	0.30	**0.06**	**0.3**
Zinc	-	-	-	-	-	-	1.212	5.555	0.22	0.002	0.217	0.00153	1.20	6.00	**1.2**	**6.0**