Generic design assessment

UK EPR™ nuclear power plant design by AREVA NP SAS and Electricité de France SA

Final assessment report

Aqueous radioactive waste disposal and limits

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Protective status

This document contains no sensitive nuclear information or commercially confidential information.

Process and Information Document[1]

The following sections of Table 1 in our Process and Information document are relevant to this assessment:

1.5 – show that the best available techniques will be used to minimise the waste discharged.

2.1 – describe how aqueous waste will arise, be managed and disposed of.

2.2 – design basis estimates for monthly discharges of aqueous waste.

2.3 – proposed annual for aqueous discharges.

Radioactive Substances Regulation Environmental Principles[2]

The following principles are relevant to this assessment:

RSMDP3 - Use of BAT to minimise waste

RSMDP12 – Limits and levels on discharges

Report author

Green, R.

1. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Environment Agency, Jan 2007.

   http://publications.environment-agency.gov.uk/pdf/GEHO0107BLTN-e-e.pdf

2. Regulatory Guidance Series, No RSR 1: Radioactive Substances Regulation - Environmental Principles (REPs), 2010.

   http://publications.environment-agency.gov.uk/pdf/GEHO0709BQSB-e-e.pdf

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Summary

1 This report presents the findings of our assessment of aqueous radioactive waste disposals from the UK EPR™ based on information submitted by EDF and AREVA in their Pre-Construction Environmental Report (PCER) and supporting documents. We compare discharges with other comparable stations across the world and set out our proposed annual disposal limits and quarterly notification levels (QNL).

2 Our conclusions remain unchanged since our consultation. However many respondents were concerned about compliance with the UK's obligations under OSPAR. Our concern under this topic is to ensure that BAT are used to minimise aqueous radioactive waste discharges. We undertook more assessment and confirmed that the liquid waste processing system (LWPS) design in the UK EPR was BAT to minimise discharges of aqueous radioactive waste but that future operators would need to optimise their use of the LWPS to demonstrate BAT in operations. Two assessment findings were identified and are shown below.

3 We concluded that the UK EPR utilises the best available techniques (BAT) to minimise discharges of aqueous radioactive waste:

a) during routine operations and maintenance;

b) from anticipated operational events.

4 We concluded that the aqueous radioactive discharges from the UK EPR should not exceed those of comparable power stations across the world.

5 We conclude that any operational, single UK EPR unit should comply with the limits and levels set out below for the disposal of aqueous radioactive waste to the sea. The limits and levels will be the starting point for any site-specific permit, but will be reviewed as part of the site permitting process based on any additional information provided by a future UK EPR operator. The limits would also be reviewed periodically thereafter, as data becomes available from operational UK EPR reactors.

6 Note that the base case discharges for the UK EPR do not include any associated waste and spent fuel storage facilities, our limits do not include any allowance for possible aqueous disposals from these facilities.

Radionuclides or group of radionuclides	Proposed Annual limit GBq	Proposed Quarterly notification level GBq
Tritium	75,000	45,000
Carbon-14	95	9
Cobalt-60	1.5	0.12
Caesium-137	0.5	0.04
All other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137)	3	0.24

7 As part of our assessment we identified the following assessment findings:

a) Future operators shall, during the detailed design phase, provide their proposals for the operational management of the Liquid Waste Processing System to minimise the discharge of radioactivity from the site so that exposures of any member of the public and the population as a whole are kept as low as reasonably achievable (ALARA) and to protect the environment. The proposals

should be supported by a BAT assessment to show that the use of the evaporator, the choice of filter porosity and the demineralisation media have been optimised to minimise the dose to members of the public. The future operator shall also provide evidence that the Water Treatment Systems have sufficient capacity and resilience to cope with all the aqueous radioactive waste arisings consigned to the evaporator by the proposals. The proposals should consider all plant states, including for example outages and unavailability due to maintenance or breakdown. (UK EPR-AF08)

b) Future operators shall, during the detailed design stage, provide a predicted mass balance showing how their proposed aqueous radioactive waste management regime will affect the disposal of carbon-14 to the gaseous, solid or aqueous routes. For each route the form of carbon-14 expected shall be provided. For solid wastes the quantities of each type of waste shall be provided with expected carbon-14 content. (UK EPR-AF09)

8 Our findings on the wider environmental impacts and waste management arrangements for the UK EPR reactor may be found in our Decision Document (Environment Agency, 2011a).

1 Introduction

9 We originally published this report in June 2010 to support our GDA consultation on the UK EPR design. The consultation was on our preliminary conclusions. It began on 28 June 2010 and closed on 18 October 2010.

10 We received additional information from EDF and AREVA after June 2010 and also undertook additional assessment in response to consultation responses. This report is an update of our original report covering assessment undertaken between June 2010 and the end of March 2011 when EDF and AREVA published an update of their submission. Where any paragraph has been added or substantially revised it is in a blue font.

11 We do not specifically deal with consultation responses in this report, they are covered in detail in the Decision Document (Environment Agency, 2011a). However, where a response prompted additional assessment by us this is referenced, the key to GDA reference numbers is in Annex 7 of the Decision Document. The conclusions in this report have been made after consideration of all relevant responses to our consultation.

12 In addition to using BAT to prevent and, where that is not practicable, minimise the creation of radioactive waste (as discussed in our report EAGDAR UK EPR-03, see Environment Agency, 2011b), we also expect new nuclear power plant to use BAT to minimise the impact of discharges of radioactive waste to the environment.

13 This report assesses the aqueous radioactive waste created and whether the UK EPR uses BAT to minimise the impact of its discharge. We compare discharges with other comparable stations across the world and propose disposal limits and notification levels for those discharges.

14 We set out in our Process and Information Document (Environment Agency, 2007) (P&ID) the requirements for a Requesting Party to provide information that:

a) shows BAT will be used to minimise the discharge and disposal of aqueous radioactive wastes (reference 1.5);

b) describes sources of radioactivity and matters which affect aqueous wastes arising (reference 2.1);

c) gives design basis estimates for monthly discharges of aqueous radioactive waste (reference 2.2); and

d) gives their proposed annual limits with derivation for aqueous radioactive waste (reference 2.3).

1.1 BAT to minimise discharges of aqueous radioactive waste

15 Statutory Guidance (DECC, 2009a) to us in 2009 reinforced the requirement to use BAT, paragraph 23:

> "*In relation to any designs for new nuclear power stations, the Environment Agency should ensure that BAT is applied so that the design is capable of meeting high environmental standards. This requirement should be applied at an early stage so that the most modern or best available technology can be incorporated into the design of the stations, where this would ensure improved standards. The application of BAT should ensure that radioactive wastes and discharges from any new nuclear power stations in England and Wales are minimised and do not exceed those of comparable stations across the world*."

16 In our Radioactive Substances Regulation Environmental Principles (REPs, Environment Agency, 2010a), principle RSMDP3 (Use of BAT to minimise waste) states that:

"*The best available techniques should be used to ensure that production of radioactive waste is prevented and where that is not practicable minimised with regard to activity and quantity.*"

17 The methodology for identifying BAT is given in principle RSMDP4 and the application of BAT is described in principle RSMDP6. We also published in 2010 our guidance '*RSR: Principles of optimisation in the management and disposal of radioactive waste*' (Environment Agency, 2010b). The guidance initially says:

'BAT are the means an operator uses in the operation of a facility to deliver an optimised outcome, ie to reduce exposures to ALARA' [ALARA: as low as reasonably achievable, economic and social factors being taken into consideration, applied to radiological risks to people].

18 BAT replaces, and is expected to provide the same level of environment protection as, the previously used concepts of best practicable environmental option (BPEO) and best practicable means (BPM). BAT includes an '*economic feasibility*' element. [Clarification prompted by respondent GDA126]

19 We keep BAT under consideration and review permits regularly to see if improvements are needed to reflect developments and improvements, for example in plant, techniques or operator practice. Our permits include conditions requiring the use of BAT and BAT requires that operators continually assess whether more can be done to reduce discharges. [Clarification prompted by respondent GDA38]

20 In this report we assess the techniques EDF and AREVA use in the UK EPR to minimise the discharge and impact of aqueous radioactive wastes and present our conclusions on whether BAT is demonstrated.

21 EDF and AREVA provided their submission to GDA in August 2007. We carried out our initial assessment and concluded we needed additional information. We raised a Regulatory Issue on EDF and AREVA in February 2008 setting out the further information that we needed. In particular we believed P&ID reference 1.5 had not been addressed by the submission and required "*a formal BAT assessment for each significant waste stream*".

22 EDF and AREVA completely revised their submission during 2008 and provided a Pre-Construction Environmental Report (PCER) with supporting documents.

23 We assessed information contained in the PCER but found that while much improved from the original submission it still lacked the detail we require to demonstrate BAT is used. We raised two Regulatory Observations (ROs) on EDF and AREVA in May and June 2009 that had actions to provide:

a) a detailed BAT assessment for carbon-14 to demonstrate that its discharges had been minimised, we specifically addressed carbon-14 as its impact was the highest of the discharged radionuclides;

b) more general BAT assessments to show the significance of individual radionuclide arisings and that significant arisings had been minimised.

24 We raised 33 Technical Queries (TQs) on EDF and AREVA during our assessment. Six were relevant to this report:

a) TQ-EPR-025: Quantity of carbon-14 in proposed discharge to sea.

b) TQ-EPR-181: Liquid radioactive waste filters.

c) TQ-EPR-182: Fuel management regimes and their impact on proposed liquid and gaseous radioactive waste discharges.

d) TQ-EPR-183: Liquid waste discharge pond.

e) TQ-EPR-187: Liquid waste tanks.

f) TQ-EPR-231: Discharge of actinides.

g) TQ-EPR-1086: Sizing of liquid filters and demineralisation beds.

25 We also liaised with Office for Nuclear Regulation[1] (ONR) on matters of joint interest and used their Step 3 and Step 4 reports to inform our assessment.

26 EDF and AREVA responded to all the ROs and TQs. They reviewed and updated the PCER in March 2010 to include all the relevant information provided by the ROs and TQs up until then. This version of the PCER was referenced by our Consultation Document and publicly available on the UK EPR website.

27 Additional information on some topics was submitted by EDF and AREVA after March 2010. EDF and AREVA reviewed and updated the PCER to include all submitted information in March 2011. This report only uses and refers to the information contained in the updated PCER and its supporting documents, publicly available on the UK EPR website (http://www.epr-reactor.co.uk).

1.2 Comparison of discharges with other stations

28 We commissioned a study to help us compare discharges from designs put forward for GDA with currently operating nuclear power plant. Our Science Report SC070015/SR1 "*Study of historic nuclear reactor discharge data*" was published in September 2009 (Environment Agency, 2009a). We used data from this report and our own sources to establish annual discharge ranges for significant radionuclides for "*comparable stations across the world*", see Annex 4 of our Decision Document (Environment Agency, 2011a).

29 This report compares the aqueous discharges from the UK EPR with the ranges quoted in Annex 4 of the Decision Document.

Radionuclides or group of radionuclides	**UK EPR expected annual discharge[1]**	**UK EPR normalised to 1000 MWe**	**Range for 1000 MWe station**
Tritium (TBq)	52	30	2 - 30
Carbon-14 (GBq)	23	13	3 - 45
Iodine radionuclides (MBq)	7	4	10 - 30
Other radionuclides not specifically limited (GBq)	0.6	0.35	<1 - 15

[1] taken as the EDF and AREVA '*Annual expected performance excluding contingency*' (PCERsc3.4 Table 1).

[1] The Office for Nuclear Regulation (ONR) was created on 1st April 2011 as an Agency of the Health and Safety Executive (HSE). It was formed from HSE's Nuclear Directorate and has the same role. In this report we therefore generally use the term "ONR", except where we refer back to documents or actions that originated when it was still HSE's Nuclear Directorate.

1.3 Discharge limits and levels

1.3.1 Radionuclides on which limits should be set

30 We recommended in the P&ID that RPs should take account of our Science Report SC010034/SR "*Development of Guidance on setting limits on discharges to the Environment from nuclear sites"* (Environment Agency, 2005). The report sets outs that limits should be set on radionuclides and / or groups of radionuclides which:

a) are significant in terms of radiological impact for humans and non human species, including radionuclides that may be taken up in food;

b) are significant in terms of the quantity of radioactivity discharges, whether or not they are significant for radiological impact;

c) have long radioactive half-lives, that may persist and / or accumulate in the environment and that may contribute significantly to collective dose;

d) are good indicators of plant performance and process control; or

e) provide for effective regulatory control and enforcement.

This advice from the report was essentially confirmed in the *Considerations* section of RSMDP12 in our REPs.

31 In addition our Considerations document (Environment Agency, 2009b) recommends the following criteria for identifying radionuclides or groups of radionuclides for which to set plant limits:

a) Critical group dose from the established worst case plant discharges (EWCPD) is greater than 1 μSv per year;

b) Collective dose from the EWCPD is greater than 0.1 manSv;

c) The EWCPD exceeds 1TBq per year;

d) Discharges of the radionuclide are a good indicator of plant performance or process control, or limits are otherwise felt to be necessary for effective regulatory control and enforcement.

32 We used the above advice and criteria to determine appropriate radionuclides and groups of radionuclides on which to set limits.

1.3.2 Time basis of limits

33 We decided that the most appropriate limit basis was that of a rolling 12 month period. This provides an element of flexibility for the site operator with respect to normal fluctuation in discharges on a month by month basis whilst exerting a smoothing effect. This encourages operators to ensure that discharges are made, wherever possible, at relatively consistent levels and to avoid short term elevations in the amount of radioactivity discharged which may increase the impact on humans or non-human species.

34 Discharge limits set on a rolling 12 month basis also allow derivation of information about discharges in any calendar year and such information is used to assess impact in terms of dose which is generally expressed in terms of dose in a calendar year. Additionally discharge limits set on a 12 month rolling basis allow reporting on annual discharges required under such things as the OSPAR Convention and in UK publications such as the annual publication on Radioactivity in Food and the Environment.

35 We discarded the concept of discharge limits set in terms of activity discharge per cycle as this adds complexity to the regulatory process as in practice cycle lengths may vary from the operational aims of an 18 month cycle and it is difficult to set limits to take into account any unexpected changes in cycle length.

36 For simplicity we use the term *Annual Limit* later in this report and in the Consultation Document but it should be taken that this would be expressed in a permit as a *12 month rolling limit*. It should be noted that the values presented by EDF and AREVA are based on calendar year values and do not account for the impact of 12 month rolling limit.

1.3.3 Limit setting

37 Our limit setting report recommends the use of a formula to determine the headroom which is appropriate to apply to average discharges to give operational flexibility and to take into account other conditions which might change during the period for which the limits would apply. The report recommends the use of the formula to calculate the "worst case annual plant discharge" (WCPD):

38 WCPD = (1.5 x D x T x A x B) + C + L + N – I where:

a) 1.5 is an Environment Agency established factor which relates 'worst case' to average discharges and takes account of the requirement to minimise headroom.

b) D is the representative average 12-month plant discharge. The average excludes discharges due to faulty operation of plant but includes discharges arising from minor unplanned events.

c) T is a factor, which allows for any future increases in throughput, power output etc relative to the review period.

d) A is a factor, which allows for plant ageing – that is, for increases in discharges which result from changes within the plant as it ages that cannot be remedied or controlled by the operator.

e) B is a factor, which allows for other future changes that are beyond the control of the operator.

f) C is an allowance for decommissioning work beyond that carried out in the review period (and included in D).

g) L is an allowance for dealing with legacy wastes, beyond those dealt with in the review period (and included in D).

h) N is an allowance for new plant.

i) I is the reduction in discharges expected as a result of introducing improvement schemes before the new authorisation comes into force.

39 The discharge setting report recommends that WCPD for new plant should be a factor of 2 times the best estimate of discharges of radioactive waste.

40 Subsequent to the report, Statutory Guidance (DECC, 2009a) to us states that we should set limits:

a) *based on the use of BAT; and*

b) *at the minimum levels necessary to permit "normal" operation of a facility.*

41 Statutory Guidance also states that "*Where the prospective dose to the most exposed group of members of the public from discharges from a site at its current discharge limits is below 10 μSv y^{-1} the Environment Agency should not seek to reduce further the discharge limits that are in place, provided that the holder of the authorisation applies and continues to apply BAT*". While this applies to existing sites we consider the 10 μSv y^{-1} is an appropriate benchmark to consider when deciding if BAT are used and an appropriate limit based on the use of BAT.

42 We have assessed that the impact of radioactive discharges from the UK EPR to the most exposed person to be 31 μSv y^{-1} (our report EAGDAR UK EPR-11, see Environment Agency 2011c). This indicates we need to actively challenge the EDF

and AREVA BAT assertions. We indicate in our assessment below the impact attributable to each considered radionuclide or group of radionuclides and have targeted our assessment time at those with the highest contribution to the total. Where some radionuclides have only minimal contribution (much less than 10 µSv y^{-1}) to the impact we have reduced our assessment time.

43 Our REPs reiterate the Statutory Guidance in relation to limits in the *Considerations* for principle RSMDP12:

a) *limits should be based on the level of releases achievable by the use of BAT by operators;*

b) *limits should be set such that there is a minimum headroom between actual levels of discharge expected during normal operation and the discharge limit.*

44 EDF and AREVA did not use the methodology of our limit setting guidance. They presented discharge data for radionuclides and groups of radionuclides in the PCER as:

a) "annual expected performance" – is the estimate of discharges from the UK EPR provided by EDF and AREVA based on 'best quartile' of predecessor plant allowing for design improvements. It is a 'best' estimate of the annual average discharge containing no contingency margin and no allowance for any operational failure;

b) "maximum annual discharge" – combines the "expected performance" with contingencies derived from operation feedback data from predecessor reactors adapted to improvements expected from the UK EPR. The "maximum" may also include contingencies associated with management options. EDF and AREVA use a qualified descriptive justification to get from "expected performance" to "maximum".

45 We have assessed the EDF and AREVA "maximum" proposals and where we believe justified have accepted them. Otherwise we have reviewed the information contained in the PCER and used it as far as possible within our own limit setting guidance to propose limits.

1.3.4 Notification level setting

46 Our REPs state, in the *Considerations* for principle RSMDP12, that advisory levels should be set that:

a) *prompt review of whether the best available techniques are being used; and*

b) *ensure early assessment of the potential impact of increased discharges*.

47 Advisory levels should also require early reporting of:

a) *operational performance issues leading to increases in discharges; and*

b) *events that have given rise to higher than normal short term discharges*.

48 We have in the past set quarterly, weekly or daily advisory levels. We consider that as the radioactivity discharges from the UK EPR are of a relatively low quantity and reasonably even over time that only quarterly notification levels (QNL) should be set.

49 The QNL is defined precisely by a condition in any permit we issue, a typical condition would be:
'*If, in any quarter, the activity in waste discharged of any radionuclide or group of radionuclides specified in (the relevant Table) exceeds the relevant Quarterly Notification Level, the operator shall provide the Agency with a written submission which includes:*

a) *Details of the occurrence;*

b) *A description of the techniques used to minimise the activity of waste discharged;*

c) *A review of those techniques having regard to the following:*

   i) *The operator shall use the best available techniques to minimise the activity of radioactive waste produced on the premises that will require disposal to be disposed of on or from the premises;*

   ii) *The operator shall use the best available techniques in respect of the disposal of radioactive waste pursuant to this permit to:*

      a) *minimise the activity of gaseous and aqueous radioactive waste disposed of by discharge to the environment;*

      b) *minimise the volume of radioactive waste disposed of by transfer to other premises;*

      c) *dispose of radioactive waste at times, in a form, and in a manner so as to minimise the radiological effects on the environment and members of the public.*

Not later than 14 days from making the record which demonstrates such excess.'

50 The exceedence of a QNL set in a permit is not an offence. But it would be an offence for an operator to fail to notify us of the exceedence of a QNL in accordance with the relevant condition of the permit.

51 Normally we would use operational discharge data over at least 5 years to set QNLs. But as the UK EPR has not yet operated anywhere in the world we cannot do this at GDA. The simplest way to set a QNL would be to take a proportion of the annual limit say 25%. However annual limits have contingency factors built in and we need to get early warning if discharges are above normal (without any contingency) so that we can ensure that BAT are still being used. We have therefore usually taken the "expected performance" figures quoted in the PCER as our start point to set QNLs. The detail of how we set each QNL is given below.

52 It is possible that operational discharge data from EPRs currently under construction will become available during specific site permitting. We will review this and may need to revise the QNLs for any permit we issue.

53 Two respondents, both future operators (GDA106 and GDA127), were concerned that our rationale for setting QNLs as well as not being able to be based on operating data did not take account of operator or site-specific factors. We accept that different operators may have different waste management practices and there may be site-specific factors. Operators may propose their own basis for QNLs when applying for their permit. We have proposed an initial set of QNLs to show that we intend QNLs to reflect actual predicted discharges and provide notification to us for unusual discharges. The limits have contingencies built in and should not be considered as a starting point for QNLs.

54 An individual respondent (GDA123) considered some QNLs set at too high a level. When we have set a QNL at high level compared to a limit this is because we expect most of an annual discharge to be made in one quarter around a shutdown. We accept this may give us inadequate notification of high discharges in 'normal' operating times, we are considering using two levels of QNL, one for 'normal' operation and one for a shutdown period. This will need to be decided at site-specific permitting when we have the operators' proposed discharge management regime.

55 An individual respondent (GDA126) suggests QNLs should be based on limits but we use QNLs to help us ensure BAT is being used. QNLs should be based on expected normal discharges without any contingencies, a notification will warn us of unusual discharges and we can question if BAT was used. QNLs are therefore

based directly on BAT, while limits take account of BAT but also include an allowance for reasonable contingencies.

56 An individual respondent (GDA38) asked that limits and QNLS be kept under review to ensure they are appropriate. We confirm that we review limits and QNLs whenever circumstances warrant this but also on a regular periodic basis.

2 Assessment

2.1 Assessment Methodology

57 The basis of our assessment was to:

a) read appropriate sections of the PCER and its supporting documents;

b) hold technical meetings with EDF and AREVA to clarify our understanding of the information presented and explain any concerns we had with that information;

c) raise Regulatory Observations and Technical Queries where we believed information provided by EDF and AREVA was insufficient;

d) assess the techniques proposed by EDF and AREVA to minimise the discharge of aqueous radioactive waste using our internal guidance and regulatory experience and decide if they represent BAT;

e) liaise with ONR on matters of joint interest;

f) decide on any GDA Issues;

g) identify assessment findings to carry forward from GDA.

h) compare aqueous discharges from the UK EPR to ranges quoted in Annex 4 of the Decision Document (Environment Agency, 2011a);

i) assess the EDF and AREVA proposals for limits, compare with our own methodology and then propose our own limits and levels.

2.2 Assessment Objectives

58 We started our assessment with some key questions to answer:

a) have all sources of aqueous radioactive waste been identified?

b) have options for minimising the discharge of significant radionuclides that will be present in aqueous waste been presented?

c) are the options chosen for the UK EPR BAT?

d) are the discharges comparable to operating stations across the world?

e) have annual aqueous disposal limits been proposed by EDF and AREVA?

   i) is the derivation of the limits clear?

   ii) are contingencies acceptable?

   iii) have they taken account of our limit setting guidance (Environment Agency, 2005)?

2.3 EDF and AREVA documentation

59 The Pre-Construction Environmental Report is divided into chapters and sub-chapters (provided as separate documents) and has supporting documents. We referred to the following documents to produce this report:

Document reference	Title	Version number
UKEPR-0003-011	PCER-Sub-chapter 1.1 - Introduction	04
UKEPR-0003-030	PCER – Chapter 3 – Aspects having a bearing on the environment during operation phase	03
UKEPR-0003-061	PCER – Sub-chapter 6.1 – Sources of radioactive materials	04
UKEPR-0003-063	PCER – Sub-chapter 6.3 – Outputs for the Operating Installation	04
UKEPR-0003-064	PCER – Sub-chapter 6.4 - Effluent and waste treatment systems design architecture	04
UKEPR-0003-080	PCER – Chapter 8 – Best Available Techniques	02
UKEPR-0003-110	PCER – Chapter 11 – Radiological impact assessment	02
UKEPR-0011-001	GDA UK EPR-BAT Demonstration	04
UKEPR-0010-001	GDA UK EPR – Integrated Waste Strategy Document	02
EDECME100828	UK EPR GDA – Assessment for the filtration and demineralisation systems of the CSTS, LWPS and SGBS systems	D

60 We use short references in this report, for example:

a) PCER sub-chapter 6.2 section 1.2.1 = PCERsc6.2s1.2.1;

b) BAT Demonstration section 3.2 = EPRBs3.2.

2.4 Origins of aqueous radioactive waste

61 The PCERsc3.4s5.2.2 (see also Figure 1 reproduced in Annex 1 of this report) describes three categories of liquid radioactive effluent:

a) liquid associated with the reactor coolant, not chemically polluted;

b) spent liquid comprising polluted reactor coolant, chemical effluent and floor drainage;

c) drainage water from the Turbine Hall including blowdown from the secondary circuit.

62 The PCERsc6.2s1.1.1 gives more detail on the collection of effluents into 3 drain systems:

a) process drain (PD): collects potentially polluted primary coolant that cannot be recycled;

b) chemical drain (CD): collects potentially chemically polluted water from the Nuclear Auxiliary Building, Reactor Building and Fuel Building;

c) floor drains (FD) of 3 types:

i) FD1: collects potentially contaminated leaks and floor washings from controlled areas;

ii) FD2: collects normally uncontaminated leaks and floor washings from controlled areas;

iii) FD3: normally uncontaminated leaks and floor washings from outside controlled areas. FD3 is normally sent directly to a discharge tank for non-radioactive wastes (in the Site Liquid Waste Discharge System (SiteLWDS)).

63 The effluents from the PD, CD, FD1 and FD2 are collected in separate buffer tanks before treatment in the Liquid Waste Processing System (LWPS). Effluent from the LWPS is collected in disposal tanks (the Liquid radioactive monitoring and discharge system (LRMDS) tanks). The contents of these tanks are analysed before disposal to the sea is allowed under a managed procedure.

64 Drainage from the Turbine Halls is normally sent to the SiteLWDS except for blowdown water from the secondary circuit. This is normally recycled after treatment, but, if recycling is not possible, blowdown is sent to the LRMDS tanks.

65 An overall diagram of the effluent systems is given in PCERsc6.4s1 Figure 1, reproduced in Annex 1 of this document.

66 The UK EPR uses filtration alone or combined with demineralisation and / or evaporation in the LWPS to minimise discharges of liquid radioactive waste. These techniques are specifically targeted at the reduction of fission and activation products and are assessed later in this report. PCERsc6.4s2.1 Figure 2, reproduced in Annex 1 of this report, shows the principle of routing of effluents.

67 PCERsc3.4s5.2.4 Table 1 states that the UK EPR will make radioactive discharges to the sea as given in the Table below. We have added to that Table our proposed annual disposal limits and QNLs, which are explained further later in our report.

Category	Annual expected performance excluding contingency GBq	Maximum annual liquid radioactive discharge GBq	Proposed Environment Agency Disposal Limits GBq	Proposed Environment Agency QNL GBq
Tritium	52,000	75,000	75,000	45,000
Carbon-14	23	95	95	9
Iodine radionuclides	0.007	0.05	None	None
Cobalt-60	0.18	3	1.5	0.12
Caesium-137	0.0567	0.945	0.5	0.04
All other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137)	0.4	6	3	0.24

68 PCERsc3.4s5.2.4 Table 2 gives the distribution of fission and activation products in radionuclides discharged as aqueous waste. The most significant are cobalt-60 and cobalt-58. We are content this lists the significant individual radionuclides that need to be considered.

Radionuclide	Expected performance	Maximum annual activity
Ag 110m	0.0342 GBq	0.57 GBq
Co 58	0.1242 GBq	2.07 GBq
Co 60	0.18 GBq	3 GBq
Cs 134	0.0336 GBq	0.56 GBq
Cs 137	0.0567 GBq	0.945 GBq
Mn 54	0.0162 GBq	0.27 GBq
Sb 124	0.0294 GBq	0.49 GBq
Te 123m	0.0156 GBq	0.26 GBq
Ni 63	0.0576 GBq	0.96 GBq
Sb 125	0.0489 GBq	0.815 GBq
Cr 51 / Others	0.0036 GBq	0.06 GBq

Sub-chapter 3.4 – Table 2: Distribution of fission and activation products in radionuclides discharged in liquid form (expected performance and maximum values)

69 We will set limits and levels on the quantities of radioactivity that can be discharged into the environment where these are necessary to secure proper protection of human health and the environment. We have assessed the information within the PCER against the criteria in our limit setting guidance (Environment Agency, 2005) as follows:

a) critical group dose greater than 1 µSv y^{-1}: carbon-14 at 14 µSv y^{-1} and "all other radionuclides" at 3.3 µSv y^{-1} (total including cobalt-60 and caesium-137);

b) discharge exceeds 1 TBq y^{-1}: tritium;

c) indicator of plant performance:

i) cobalt-60 indicates effectiveness of corrosion controls and the filter and demineralisation system in the Liquid Waste Processing System;

ii) caesium-137 is an indicator of fuel cladding failures.

70 We have set out our proposed disposal limits for tritium, carbon-14, cobalt-60, caesium-137 and other radionuclides in the Table above. "All other radionuclides" will be more completely defined in any permit we issue, for example "*All other radionuclides means the sum of all radionuclides as measured by the methods defined in this permit except those specified individually in the Table*". We do not consider it proportionate to set a limit for iodine radionuclides as discharge levels and impact are low and measured levels may well be below detection thresholds of monitoring methods.

71 EDF and AREVA state that alpha-emitting radionuclides should not be present in detectable amounts in the aqueous discharge and that the '*absence of gross alpha activity*' will be confirmed by monitoring of each tank of aqueous effluent before discharge. We will not include alpha-emitters as a category for disposal limits.

72 An individual respondent (GDA62) asked for additional information on alpha-emitting radionuclides detection. The detection method will be specified by future operators, we will require the best available techniques at time of installation[2]. There is no expected discharge of alpha-emitters, detection is there as a precaution. The source and type of potential alpha-emitters is described in section 8.3.6 of the Decision Document. There would need to be significant fuel defects as well as significant failures in the Liquid Waste Processing System (LWPS) before alpha-emitters could be detected at the discharge tanks. There is also a gross gamma activity detector installed in the main discharge line of the UK EPR, this would detect abnormally high radioactivity in discharges due to any upstream failure (gamma-emitting radionuclides in this case act as an indicator for increased levels of all other radionuclides including alpha-emitters). It is wired to valves in the discharge pipes so that at the set detection level the valves will close to prevent discharge. (PCERsc7.3s2.1.4.3)

73 PCERsc6.3s6.2 to s6.5 quantifies disposals, these are given as "expected performance" that has no allowance for any contingencies and "maximum" (we have taken as proposed disposal limit) that allows for contingencies to cover situations foreseeable in normal operations but not any incidents. The PCERsc6.2s1.2.2 covers the nature and treatment of the aqueous disposals. We have summarised the PCER information below.

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[2] We are revising our monitoring guidance M12 but this will be available for future operators to apply. We also require monitoring to conform to the European Commission's (EC) recommendation 2004/2/Euratom) on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation. See our joint guidance with SEPA: http://www.sepa.org.uk/radioactive_substances/publications/idoc.ashx?docid=cefd6d99-5000-4fd5-b028-5f8a39efc7a0&version=-1

74 Our assessment concluded that:

a) all sources of aqueous radioactive waste have been identified;

b) the nature, form and quantity of aqueous radioactive waste has been identified in enough detail to demonstrate that treatment processes and disposal routes can be envisaged for all aqueous radioactive waste;

c) the data EDF and AREVA has provided relating to the sources of aqueous radioactive waste is comprehensive, justified and reasonable at the GDA stage.

2.5 Specific radionuclides, BAT, disposals and limits

2.5.1 Tritium

75 Tritium is present as tritiated water in the reactor coolant. EDF and AREVA state there are currently no available techniques to remove tritium from the reactor coolant. Therefore to avoid the build up of tritium in the coolant (to reduce radiological hazard) a portion of the coolant must be discharged (and replaced). This is the main source of tritium for aqueous discharge.

76 Tritium can also be found in the water contained in the secondary circuit if there are leaks in the steam generators. Any water drained from the circuit will enter the LWPS and be contained in storage tanks before monitoring and discharge. This discharge route does not affect the overall discharge of tritium.

77 EDF and AREVA review aqueous abatement techniques (EPRBs3.3) but do not consider any represent BAT:

a) decay by delay is not an option as the half-life of tritium is 12 years;

b) filtration has no effect on tritium in liquid effluents;

c) evaporation is not an option as tritiated water would carry over to the condensate, leaving little in the concentrate for treatment and disposal as solid waste;

d) EDF and AREVA refer to IAEA Technical Report No. 421 that lists some theoretical techniques that may have potential for use in the future, but none are currently technically developed for PWRs;

e) tritiated water could be collected and cemented to solid waste. This would produce large volumes of solid waste for disposal (probably ILW) and the tritium may not be immobilised effectively;

f) isotopic retention is an undeveloped technique.

78 Tritium discharges have a low impact on the environment (see below: 0.018 μSv y^{-1} to an adult). Therefore our assessment confirmed that the use of any of the aqueous abatement techniques considered is not proportionate for the UK EPR, we conclude that the UK EPR uses BAT to minimise the discharge of aqueous tritium.

79 The “expected performance value” of 52 TBq y^{-1} and “maximum” of 75 TBq y^{-1} were taken from calculations assuming 91% or 100% power production respectively and various reactor chemistry options (PCERsc6.3s6.2.1.4). EDF and AREVA then reviewed operational experience of predecessor plant to validate the calculations.

80 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years we consider that the range of discharge to water of tritium is 2 to 30 TBq per year for a 1000 MWe power station. (see Annex 4 of Decision Document). The “expected performance” aqueous discharge of tritium from UK EPR is 52 TBq, as tritium production is directly related to power we need to correct against the 1735 MWe of the UK EPR to give 30 TBq/1000 MWe. While the UK EPR is at the top of our range we did note that the design minimises gaseous discharge of tritium (Environment Agency, 2011b), this means most tritium

will be in the aqueous discharge (we concluded in our report EAGDAR UK EPR-03 (Environment Agency, 2011b) that this is the best environmental option, as discharges to the marine environment have a lower impact than to the air. We conclude that aqueous discharge of tritium is comparable to other power stations across the world.

81 EDF and AREVA state that monthly discharges are related to the time in the generation cycle. Also contingency is needed to allow operational flexibility to delay discharges for a period to allow for maintenance or faults in the LWPS. Values at 25% of the annual are quoted: 13 TBq/month "expected performance" and 18.75 TBq/month "maximum".

82 The radiological impact from the "maximum" disposal of tritium to the sea is stated as a dose to adults of 0.018 µSv y^{-1}, to children of 0.0049 µSv y^{-1} and infants of 0.0017 µSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G. We consider these to be of low significance.

83 EDF and AREVA propose a liquid disposal limit for tritium of 75 TBq per year. The headroom over the "expected performance" of 52 TBq y^{-1} allows for up to 100% production or other management options that may affect tritium discharges. (PCERsc6.3s6.2.2.2)

84 We concluded above that the UK EPR uses BAT to minimise the liquid discharge of tritium with an "expected performance" value of 52 TBq y^{-1}. We accept the headroom proposed by EDF and AREVA as a reasonable contingency factor and we will set the annual disposal limit at 75 TBq.

85 As tritium production depends on power production rather than abatement techniques we consider that a quarterly notification level based on the maximum disposal (75 TBq y^{-1}) is appropriate in this case. We will take the stated maximum monthly estimate of 25% of annual (18.75 TBq) and add 2 months at the "expected" level of 13 TBq to give (rounded up) 45 TBq per quarter. This should highlight adverse trends in disposals and require an operator to demonstrate that BAT is still being applied if a QNL is exceeded.

86 A respondent (GDA106) said that our QNL for tritium appeared to be based on uniform discharge while different operational regimes could result in several months arisings to be discharged in a single month. We will consider future operators' proposed regimes in determining QNLs at the site-specific stage.

2.5.2 Carbon-14

87 As described in our report EAGDAR UK EPR-03 (Environment Agency, 2011b) 5-20% of carbon-14 produced (444 GBq y^{-1}) will be present in the aqueous or solid wastes. (PCERsc6.3s6.3.1)

88 EDF and AREVA propose no specific techniques for C-14 reduction in aqueous wastes from the UK EPR but have considered (EPRBs3.2):

a) decay by delayed discharge is not an option as the half-life of C-14 is 5710 years;

b) filters and demineralisers do remove some C-14 but this is dependent on the form of the C-14 and these items are optimised for corrosion products removal as these have the potential to have a more significant impact on the environment if not abated. Further treatment may be possible by filters and demineralisers but reductions are difficult to calculate and may only affect C-14 in inorganic forms while much may be organic. Further, increasing C-14 content on filter media and resins can give matters for solid waste disposal (current disposal facilities have a strict acceptance criterion for C-14). Further treatments by these techniques are not proposed.

c) evaporation of some liquid effluent is undertaken in the UK EPR. Evaporation of all liquid effluent is possible but would require "*significant amounts of additional energy* [13 GWh to evaporate the predicted 19000 m^3 of liquid effluents from Flamanville units 1 and 2] *whilst conversion* [of the concentrate] *to solid waste would produce large volumes of solid waste*". Further, past operational experience has shown that while much C-14 would be retained in concentrates there is still significant C-14 activity in distillates and these must be discharged (in GDA to the sea). EDF and AREVA do not intend to consider additional evaporation for the UK EPR but offer no formal options assessment.

89 EDF and AREVA claim that while techniques have been used in the UK EPR to minimise the presence of C-14 in aqueous wastes (see EAGDAR UK EPR-03) there are no techniques that are BAT for reduction of the C-14 content of those wastes.

90 Our own assessment supported the EDF and AREVA claim. We conclude that, at this time, the UK EPR uses BAT to reduce the discharge of carbon-14 to the sea as there are no applicable reduction techniques available.

91 The "expected performance" value of 23 GBq y^{-1} was estimated from the basic source term of 444 GBq y^{-1} applying operational feedback experience from the predecessor 1300 MWe reactors. This is also about 5% of the source term so equates well to the expected distribution. (PCERsc6.3s6.3.2.1)

92 EDF and AREVA propose a "maximum" value of 95 GBq y^{-1}. This is because:

a) the 444 GBq y^{-1} term was based on reactor availability of 91% and it is hoped the UK EPR will exceed this value;

b) the distribution of carbon-14 between gas and liquid in the UK EPR could be different to existing reactors, operational experience of an EPR is needed to confirm performance;

c) the 444 GBq y^{-1} source term assumed a coolant nitrogen content of 10 ppm, if a higher content is found in operation then the nitrogen source term will increase.

93 From our limited information about PWRs operating over the last 10 to 15 years we consider that the range of discharge to water of carbon-14 is 3 to 45 GBq per year for a 1000 MWe power station (see Annex 4 of Decision Document). The "expected performance" aqueous discharge of carbon-14 from UK EPR is 23 GBq, (13.3 GBq normalised to 1000 MWe) well within this range. We conclude that aqueous discharge of carbon-14 from the UK EPR is comparable to other power stations across the world.

94 EDF and AREVA state that monthly discharges of carbon-14 are very dependent on power produced and generally unaffected by operating contingencies. However operational management of aqueous discharges, as noted for tritium above, may affect level of discharge in any month. A "maximum" monthly discharge of 24 GBq is proposed based on 25% of the annual "maximum".

95 The radiological impact from the "maximum" disposal of carbon-14 to the sea is stated as a dose to adults of 14 μSv y^{-1}, to children of 4.2 μSv y^{-1} and infants of 1.4 μSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G. This is the most significant contributor to the total dose from a UK EPR.

96 We concluded above that the UK EPR uses BAT to minimise the aqueous discharge of carbon-14 with an "expected performance" value of 23 GBq y^{-1}. While the level of headroom proposed is high, an additional 72 GBq y^{-1} to allow for the uncertainty of split between gas and liquid and level of nitrogen in the coolant, we do recognise the uncertainties at this time and will set an indicative annual disposal limit at 95 GBq, this gives a pessimistic impact assessment. We will review this limit at the earliest opportunity once operational experience is available.

97 We will set a quarterly notification level based on the "expected performance" to give us early indication if this performance cannot be met in operation. We have allowed for 25% of annual discharge in 1 month (say 6 GBq) and average discharge (say 1.5 GBq) for 2 months. This gives a QNL of 9 GBq.

98 A respondent (GDA106) said that our QNL for carbon-14 appeared to be based on uniform discharge while different operational regimes could result in several months arisings to be discharged in a single month. We followed information from EDF and AREVA as noted above to set our QNL and do not agree with this comment. We may decide on two QNLs in future permits – one for 'normal' quarters and one for a quarter including shutdown.

2.5.3 Iodine radionuclides

99 As described in our report EAGDAR UK EPR-03 (Environment Agency, 2011b) iodine radionuclides are formed in the fuel and are only present in the coolant in the event of fuel cladding defects. Iodines tend to dissolve and are therefore mostly found in liquid effluents. While it is not their primary function, the demineralisers in the Coolant Purification System do absorb significant amounts of iodines. Also effluents are held up in tanks in the Liquid Waste Processing System awaiting treatment or discharge, the delays will allow the shorter half-life iodine radionuclides to decay. (PCERsc6.3s6.4.1.1 and EPRBs3.6)

100 The EDF and AREVA BAT case for iodine radionuclides relies on:

a) improved fuel integrity;

b) removal in the demineralisers.

101 We conclude that the very low levels of discharge and impact (see below) support the case that BAT is employed without a detailed assessment.

102 The "expected performance" is stated as 7 MBq y^{-1}. This is supported by operational feedback from predecessor reactors but results of measurements are often below detection thresholds so that the 7 MBq value is actually a "limit of detection" value.

103 The "maximum" value proposed is 50 MBq y^{-1}. This allows for some 40 MBq headroom over the "expected value" and relates to operational experience of predecessor reactors when this value was achieved on rare occasions. The headroom allows for contingencies of fuel and treatment system failure. (PCERsc6.3s6.4.1.3)

104 From our limited information about PWRs operating over the last 10 to 15 years we consider that the range of discharge to water of iodine radionuclides is 10 to 30 MBq per year for a 1000 MWe power station. The "expected performance" aqueous discharge of iodine radionuclides from UK EPR is 7 MBq (4 MBq normalised to 1000 MWe), below this range. We conclude that aqueous discharge of iodine radionuclides from the UK EPR is comparable to other power stations across the world.

105 Monthly discharges in normal operation are stated as being at detection threshold and equivalent to 0.7 MBq. However a worst case scenario could see almost all the "maximum" annual discharge in 1 month – the "maximum" monthly discharge value is quoted as 50 MBq.

106 The radiological impact from the "maximum" disposal of iodine radionuclides to the sea is stated as a dose to adults of 7.6×10^{-5} (0.000076) μSv y^{-1}, to children of 3.8×10^{-5} μSv y^{-1} and infants of 2.2×10^{-5} μSv y^{-1} – from PCERsc11.1 Annex 3 Tables E, F and G. We consider this impact to be almost insignificant.

107 We concluded that BAT is used to minimise the discharge of iodine radionuclides to the sea with a "predicted performance" of 7 MBq y^{-1}. We have decided that at this

level of discharge and bearing in mind the very low impact it is not proportionate to set a limit or quarterly notification level for the discharge of iodine radionuclides to the sea.

2.5.4 Other radionuclides

108 Aqueous wastes can contain other radionuclides in addition to those specifically considered above. These are both particulate and dissolved activated corrosion products (particularly cobalt-58 and cobalt-60) and fission products (particularly caesium-134 and caesium-137). (PCERsc6.3s6.4.2.1) The main source of these is the coolant. The coolant is recycled through filters in the Chemical and Volume Control System (CVCS) and filters and demineralisers in the Coolant Storage and Treatment System (CSTS) where high decontamination factors are achieved. EDF and AREVA say they rely on these systems for primary reduction of these other radionuclides. However low concentrations are still found in managed discharges and minor leaks of coolant reaching the Liquid Waste Processing System (LWPS). The LWPS provides final treatment through filters and / or filters and demineralisers and / or filters and an evaporator before transfer to the LRMDS tanks.

109 PCERsc8.2s3.3.3 lists some available techniques to treat liquid effluents:

a) chemical precipitation;

b) hydro-cyclone centrifuging;

c) cross-flow filtration;

d) ion exchange (demineralisation);

e) reverse osmosis;

f) evaporation.

110 PCERsc8.2s3.3.3.4 discusses some techniques under development for potential use for the treatment of EPR effluents:

a) membrane technologies such as cross-flow, micro- and ultra-filtration might be used to retain particles down to 0.01 micron size;

b) reverse osmosis might be suitable to remove dissolved substances from effluent;

c) electrolysis might be used to remove electro-active materials such as corrosion products;

d) isotopic retention is an electrochemical process using a metallic catalyst that can reduce the concentration of some radionuclides.

111 EDF and AREVA claim that only the following techniques are BAT for use in the UK EPR:

a) filtration for removing particulate matter using single-use cartridge filter technology;

b) ion exchange systems for removing dissolved active materials;

c) evaporation for effluents which are incompatible with ion exchange resins, the concentrate is treated for disposal.

112 EDF and AREVA argue that other techniques are not currently developed for use in PWRs while those chosen are in standard use. Further the chosen techniques are adequate to optimise discharges.

113 Our assessment concluded that, at this time, filtration by cartridge filter, ion exchange and, for effluents incompatible with ion exchange, evaporation, as incorporated in the UK EPR Liquid waste management system (LWPS), are BAT. However the operational management of the LWPS will be critical to ensure that the

impact of aqueous discharges on the environment will be minimised, see our assessment finding UK EPR-AF08 later in this section.

114 A diagram of the LWPS is provided as Figure 5 in the IWSp37 (reproduced in the Annex of this report) and more detailed descriptions are in PCERsc6.2s1.1.3.

115 Effluents are collected at the front end of the LWPS by tanks. Tank contents, depending on their analysis, may be treated by filtration, filtration and ion exchange and / or by filtration and evaporation. After treatment the contents are pumped by way of a final filter to a set of discharge tanks.

116 In the UK EPR, single use cartridge filters are available to select as required by operations in the LWPS. (PCERsc8.2s3.3.3.1) Filtration is discussed in our assessment report on best available techniques to prevent or minimise the creation of radioactive waste (Environment Agency, 2011b).

a) floor drain system – 25 micron;

b) process drain system – 25 followed by 5 micron before demineraliser, 25 micron after (to remove any resin particles);

c) chemical drain system – 25 micron;

d) final filter before discharge tanks – 5 micron.

117 All filters are fitted with instruments to measure the pressure difference over the filter element. The pressure will increase as filters are used and retain particles. EDF and AREVA say they will only change filter elements when required, for example when a set pressure is exceeded or for some filters when a set radioactivity level is reached, rather than on a regular frequency. We confirm that this contributes to BAT to minimise the volume of solid waste arisings from use of filters.

118 We raised TQ-EPR-1086 on EDF and AREVA to provide a BAT case for the filter sizes chosen. The response to this TQ was after our consultation and provided information supported by EDF operational experience in a report EDECME100828 Revision D. A summary of this information is available in the latest revision of the PCER (PCERsc8.2s3.3.3.1).

119 The process drain system contains a demineralisation system with 3 beds (PCERsc8.2s3.3.3.2):

a) strong high-capacity anionic or macro-porous resins;

b) strong high-capacity gel-type cationic resins;

c) mixed-bed-type.

120 EDF and AREVA state that: '*The choice retained for the UK EPR is one high-capacity cationic bed, one high capacity anionic bed and one mixed bed. Each bed can be by-passed. This enables flexible treatment, for example if there is a problem with one of the beds (filling the third space will allow for maintenance to be carried out on the bed, without interruption of the filtering process); it also allows flexibility in dealing with specific pollutants (silver, tritium…), as one bed can be used for a specific treatment if necessary.*'

121 We raised TQ-EPR-1086 on EDF and AREVA to provide a BAT case for the design of the demineralisation system. The response to this TQ was after our consultation and provided some additional information supported by EDF operational experience in a report EDECME100828 Revision D. A summary of this information is available in the latest revision of the PCER (PCERsc8.2s3.3.3.2).

122 The chemical drain system has an evaporator available. This separates chemically polluted effluents into a distillate (only weakly active / polluted) and a concentrate containing most of the activity / pollution. The distillate is sent to the discharge tanks after monitoring. The concentrate is sent to the Solid Effluent Treatment

System for treatment before disposal. We conclude that the provision of the evaporator on the UK EPR is BAT to treat otherwise untreatable aqueous wastes.

123 Our assessment of previous information and that supplied under TQ-EPR-1086 concluded that, in principle, the liquid waste processing system (LWPS) equipment of the UK EPR contributes to BAT for minimising the discharge of fission and activation products.

124 However, as the impact of other radionuclides is not insignificant, we require a demonstration that the LWPS uses BAT to minimise the discharge to sea of other radionuclides. The information provided by EDF and AREVA in response to TQ-EPR-1086 included a comparison of LWPS international best practice but indicated that final optimisation of the LWPS would need to be at the site-specific stage. EDF and AREVA said that decisions made by the operator will dictate the optimisation of the LWPS, for example when and whether the evaporator is used and optimal filter porosities and demineralisation media. We accept that operational management of the LWPS will affect discharges. We have therefore accepted in the above conclusion that equipment comprising the LWPS represents BAT but we will require future operators to demonstrate that their proposed management of the LWPS will also be BAT. This requirement is covered within assessment finding UK EPR-AF08 which follows.

125 EDF and AREVA claim that the “expected performance” for discharge of other radionuclides (the total including cobalt-60 and caesium-137) is 0.6 GBq y^{-1}. This value is supported by operational data from predecessor reactors with an allowance for improvements in effluent treatment in the UK EPR. This value is without contingency allowances for such issues as leaking fuel. EDF and AREVA expect the UK EPR to discharge 10% less other radionuclides than the predecessor 1300 MWe unit. (PCERsc6.3s6.4.2.2)

126 EDF and AREVA propose a “maximum” annual disposal of 10 GBq. The headroom above “expected performance” is not specifically quantified but allows for contingencies such as fuel cladding defects combined with failure or unavailability of liquid treatment systems. (PCERsc6.3s6.4.2.3)

127 From our examination of historic discharges from European and US PWRs operating over the last 10 to 15 years we consider that the range of discharge to water of fission and activation products is <1 to 15 GBq per year for a 1000 MWe power station. The “expected performance” aqueous discharge of other radionuclides from UK EPR is 0.6 GBq (0.35 GBq normalised to 1000 MWe), well within this range. We conclude that the aqueous discharge of other radionuclides from the UK EPR is comparable to other power stations across the world.

128 EDF and AREVA say that monthly discharges are difficult to predict as they are dependent on effluent management policy adopted and operational conditions. The monthly discharge during shutdown could be 6 times higher than other months. In normal operating conditions monthly discharge could be up to 0.3 GBq. In extreme circumstances the whole of the “maximum” detailed above, 10 GBq, could be discharged in 1 month.

129 The radiological impact from the “maximum” disposal of other radionuclides to the sea is stated as a dose to adults of 3.3 μSv y^{-1}, to children of 0.5 μSv y^{-1} and to infants of 0.06 μSv y^{-1} - from PCERsc11.1 Annex 3 Tables E, F and G. The greatest part of the dose is attributable to cobalt-60. We consider that the impact is a significant contribution to dose from a UK EPR.

130 We concluded above that the UK EPR uses BAT to minimise the discharge to sea of other radionuclides with an “expected performance” of 0.6 GBq y^{-1}. We set disposal limits based on BAT with minimum headroom to cover expected operational events. We believe that equipment failures should be rectified promptly and should not have a significant impact on annual discharges. We do not accept the EDF and AREVA proposal for “maximum” annual disposal. We have

considered past operational data and will allocate an additional 2 GBq y^{-1} above the "expected performance" to allow for increased discharges due to fuel cladding defects or other contingencies. Our predicted maximum is thus 2.6 GBq y^{-1} and we will apply a x2 factor to set a disposal limit of 5 GBq y^{-1}. We wish to set limits separately for cobalt-60 and caesium-137 so will allocate the total 5 GBq as:

a) Cobalt-60 – 1.5 GBq y^{-1};

b) Caesium-137 – 0.5 GBq y^{-1};

c) Other radionuclides not specifically limited – 3 GBq y^{-1}.

131 We wish to set a quarterly notification level based on the "expected performance" to give us early indication if performance cannot be met in operation. We have allowed for 0.3 GBq in 1 month and average discharge for 2 months (say 0.05 GBq). This gives a QNL of 0.4 GBq for a total including Co-60 and Cs-137. We have apportioned this as follows:

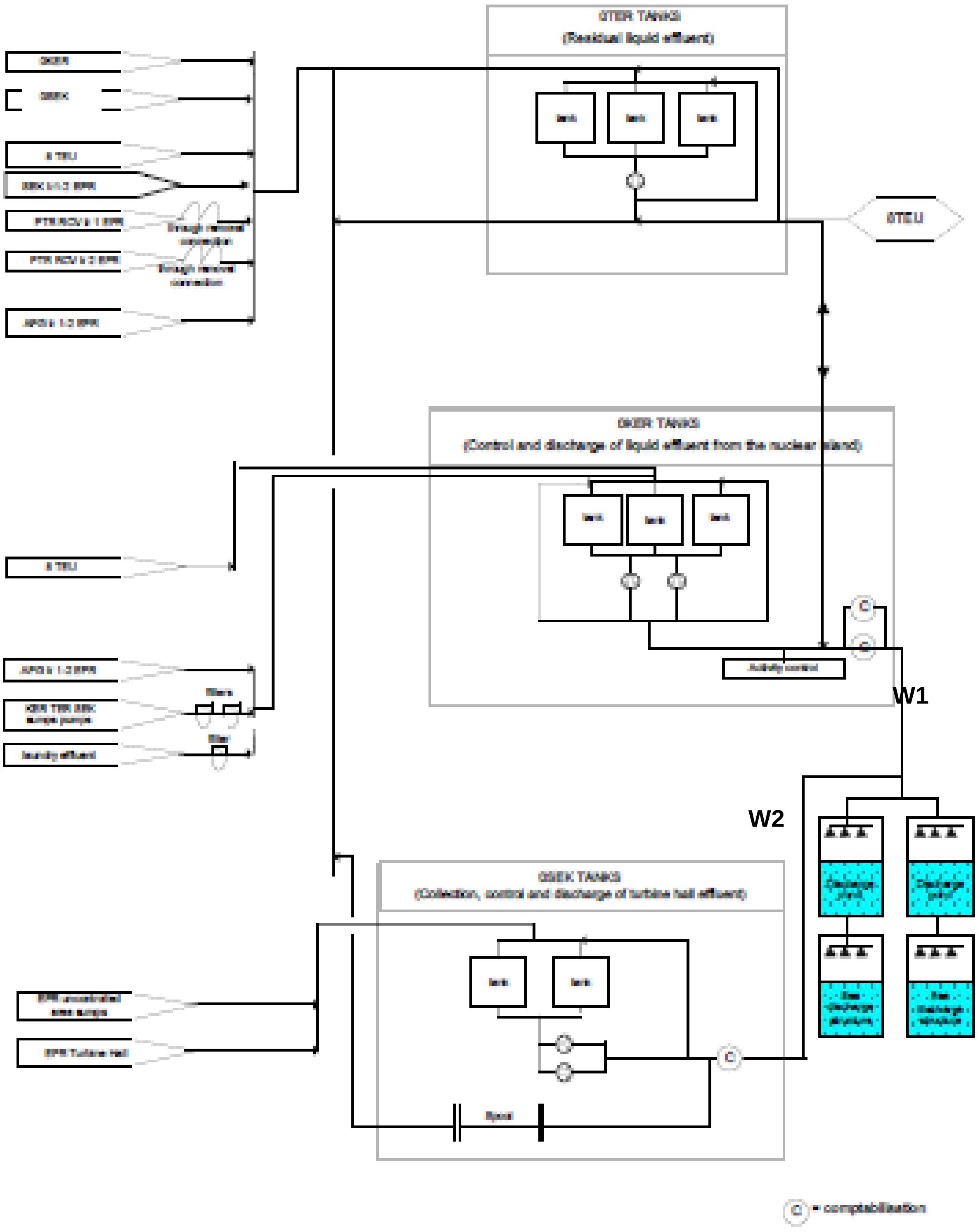
a) Cobalt-60 – 0.12 GBq;

b) Caesium-137 – 0.04 GBq;

c) Other radionuclides not specifically limited – 0.24 GBq.

2.6 Disposal to the environment

132 We have identified three effluent release points for the UK EPR based on the diagram provided in PCERsc6.4s2.3 Figure 1 (page 86)) for a sea site with two units:



133 We have allocated references to discharge points, as we would in a permit, as below:

a) W1 – combined discharge line from 2 sets of tanks:

i) from the LRMDS tanks in the liquid radwaste monitoring and discharge system (LRMDS). These tanks collect effluent treated by the liquid waste processing system (LWPS) and the effluent from the steam generator blowdown system (SGBS).

ii) from the ExLWDS tanks in the additional liquid waste discharge system (ExLWDS). These tanks are kept in reserve in case of issues with the LWPS or the LRMDS. The contents of these tanks can be sent back into the LWPS for treatment or discharged, as appropriate.

b) W2 – discharge line from the SiteLWDS (OSEK above) tanks in the Conventional island liquid waste discharge system (SiteLWDS). These tanks collect effluent from radiologically uncontrolled areas such as the Turbine Hall. In normal operation effluents collected by this system are uncontaminated but may show low levels of tritium in the event of any leaks from the primary to the secondary systems.

c) W3 – return line of circulating seawater cooling system. The seawater should be uncontaminated in normal operation. The seawater system serves various systems, each of which should have internal sample points for detection of contamination at point of return to the main system (PCERsc3.4s3.1.1):

i) circulating water system to main condenser;

ii) essential services water system;

iii) service water circuit for conventional auxiliaries;

iv) ultimate cooling system.

134 EDF and AREVA say that number and sizing of the LRMDS, ExLWDS and SiteLWDS tanks is a site-specific issue depending on number of reactors on a site and any discharge timing restrictions. At the Flamanville reference site there are 6 LRMDS, 3 ExLWDS and 4 SiteLWDS tanks (all of 750 m^3) that serve two existing 1300 Mwe reactors, one EPR in construction and possibly another EPR in the future. We consider that the size of discharge tanks is an important BAT issue. We need to see that enough capacity is available not only to cope with normal operations but also to cope with foreseeable events such as equipment failures. We will not comment on tank sizes at GDA but will expect site-specific applications to provide a formal BAT case, justifying the number and volumes of discharge tanks proposed.

135 If we permit aqueous radioactive waste discharges from a UK EPR at the site-specific stage, our permit will allow discharge of liquid radioactive waste through points W1 and W2 under specific disposal limits and conditions. Discharges will not be continuous but on a tank by tank basis, when a tank needs to be discharged its contents will be sampled and analysed. Data on the volume to be discharged and its radioactivity will be used within a management procedure to authorise the time and rate of discharge to ensure compliance with permit conditions. We will require the discharge lines to be fitted with MCERTS[3] flowmeters and flow proportional samplers at points W1 and W2 to provide permit compliance data.

136 The returning seawater should be uncontaminated. We will not require flow metering of this, flow will be directly related to pumps in service. We will not require continuous sampling as we consider risk of contamination is very low. However we will require safe and permanent access to the return flow at point W3 for spot

[3] The Environment Agency's Monitoring Certification Scheme, see www.mcerts.net

sampling to confirm no radioactive contamination or other contamination such as oil or chemicals.

137 The disposal route from points W1 and W2 is initially to join the high volume direct sea water cooling flow (67 $m^3 s^{-1}$) at the discharge pond. The combined flow is then sent to an outfall discharging some distance out from the shore. While we do not accept dilution as a reduction technique, once discharges have been minimised by other techniques pre-dilution in a large flow before discharge to the environment is desirable to reduce initial concentrations before dispersion in the receiving waters.

138 We have not considered at GDA other site liquid discharges such as surface water. The design of such systems will be site-specific and there should be no contamination in normal operation. We will review site drainage at site-specific permitting and, as a minimum, require accessible sampling points at final discharge locations for confirmation spot sampling.

139 For GDA, EDF and AREVA selected Irish Sea / Cumbrian Waters for predicting dispersion of liquid radioactive discharges using the model PC Cream. They said this would give pessimistic results for the dose impact calculations. The calculated total annual dose impact to the most exposed members of the public from “maximum” discharges was 17 μSv for an adult, 4.7 μSv for a child and 1.5 μSv for an infant. Dose was largely due to eating sea food. The doses are sufficiently low that we conclude that dispersion under GDA conditions is BAT.

140 The design and location of outfalls will be a highly site-specific matter. The operator for each specific site will need to demonstrate by modelling that the outfall proposed will be BAT for adequate dispersion in local waters.

2.7 The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR)

141 Several respondents (GDA82, 95, 133, 149 and 153) as well as attendees at our stakeholder seminar raised the topic of compliance with the UK's obligations under OSPAR. In particular the use of evaporation to treat aqueous radioactive waste was suggested. We have included in this section a summary of OSPAR, relevant information, and our conclusions on this matter.

142 The UK is a Contracting Party to the OSPAR Convention and the Government has published its 'UK Strategy for Radioactive Discharges' (DECC, 2009b) which sets out a framework for implementing the UK's obligations in respect of the OSPAR Radioactive Substances Strategy[4]. The outcomes expected of the UK Strategy will be:

a) progressive and substantial reductions in radioactive discharges;

b) progressive reductions in concentrations of radionuclides in the marine environment resulting from radioactive discharges, such that by 2020 they add close to zero to historic levels;

c) progressive reductions in human exposures to ionising radiation resulting from radioactive discharges, as a result of planned reductions in discharges.

143 The OSPAR Convention also includes the requirement for Contracting Parties to use Best Available Techniques (BAT) to minimise discharges of radioactivity to the marine environment. The Government gave us guidance in 2009 to base our regulation of radioactive discharges on the use of BAT and highlighted the importance of BAT in the optimisation of doses and the setting of discharge limits (DECC, 2009a). We anticipated the requirement to use BAT and throughout GDA required EDF and AREVA to demonstrate that the UK EPR uses BAT from the initial generation of radioactivity (our report Environment Agency, 2011b) to final discharge. We consider our approach to GDA contributes significantly to the outcomes of the UK Strategy noted above.

144 This document has set out our conclusions that the UK EPR design incorporates equipment that contributes to BAT to minimise discharges of radioactivity to the sea. This shows compliance with part of the UK obligations under OSPAR. The UK EPR design includes an evaporator capable of treating certain aqueous radioactive waste streams. The GDA operational proposal is to only treat aqueous wastes incompatible with ion exchange (design basis 3000 m^3 y^{-1}) but the evaporator has the capacity to process substantially more aqueous waste. Future operators will be responsible for the aqueous waste management and decisions on quantities to be evaporated. Future operators will also be responsible for choosing the optimal filter porosities and demineralisation media. We have therefore decided to add an assessment finding on this topic:

Future operators shall, during the detailed design phase, provide their proposals for the operational management of the Liquid Waste Processing System to minimise the discharge of radioactivity from the site so that exposures of any member of the public and the population as a whole are kept as low as reasonably achievable (ALARA) and to protect the environment. The proposals should be supported by a BAT assessment to show that the use of the evaporator, the choice of filter porosity and the demineralisation media have been optimised to minimise the dose to members of the public. The future operator shall also provide evidence that the Water Treatment Systems have sufficient capacity and resilience to cope with all the aqueous radioactive waste arisings consigned to the evaporator by the

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[4] Ministerial Meeting of the OSPAR Commission, Summary Record OSPAR 98/14/1-E, Annex 35.

proposals. The proposals should consider all plant states, including for example outages and unavailability due to maintenance or breakdown. (UK EPR-AF08)

145 The impact of radioactive discharges to the marine environment from the UK EPR design will be less than the currently operating nuclear power plants in the UK, and as these are replaced we anticipate a reduction in the total UK discharges.

146 We note that EDF and AREVA predict discharges of carbon-14 from the UK EPR that will be higher than the existing PWR at Sizewell. For example, Sizewell B reported an estimated discharge of 3.3 GBq in 2008 (2.7 GBq normalised to 1000 MWe) whilst the predicted annual discharge from a UK EPR is 23 GBq (13.3 GBq normalised to 1000 MWe.

147 Carbon-14 is a naturally occurring radionuclide, global annual production of natural carbon-14 is around 1000 TBq, and present in the sea at levels up to 5 Bq m^{-3}. While discharges to sea from a UK EPR could achieve 50 Bq m^{-3} carbon-14 at the point of discharge this will be rapidly dispersed and is unlikely to affect the background concentration beyond a few hundred metres. We conclude that the discharge of carbon-14 from a UK EPR will not conflict with the OSPAR aim of achieving concentrations in the environment near background values for naturally occurring radioactive substances.

148 We do not have information on the effect of evaporation on carbon-14 contained within the aqueous wastes treated. The carbon-14 will be distributed mainly between the concentrate (which will become solid waste after treatment) and the distillate (which will be discharged to sea) while gaseous forms of carbon-14 will separate out and be discharged to the air through the Gaseous Waste Processing System. We will need the future operators to tell us how their proposed management of aqueous wastes will affect the distribution of carbon-14 over all discharge routes. We have therefore included an assessment finding:

Future operators shall provide a predicted mass balance during the detailed design stage showing how their proposed aqueous radioactive waste management regime will affect the disposal of carbon-14 to the gaseous, solid or aqueous routes. For each route the form of carbon-14 expected shall be provided. For solid wastes the quantities of each type of waste shall be provided with expected carbon-14 content. (UK EPR-AF09)

149 We have set out our assessment of the impact of radioactive discharges to the sea from the UK EPR in chapter 14 of this document. We conclude that doses to the public (28 μSv y^{-1}) from the UK EPR will be as low as reasonable achievable for the generic site. Future operators will need to confirm that assessment for each specific site proposed for a new nuclear power plant.

3 Public comments

150 The public involvement process remained open during our assessment see http://www.hse.gov.uk/newreactors/publicinvolvement.htm

151 We did not receive any public comments by this route during this assessment relating to aqueous radioactive waste disposal and limits.

152 The conclusions in this report have been made after consideration of all relevant responses to our consultation, in particular in relation to OSPAR.

4 Conclusion

153 Our conclusions remain unchanged since our consultation. However many respondents were concerned about compliance with the UK's obligations under OSPAR. Our concern under this topic is to ensure that BAT are used to minimise aqueous radioactive waste discharges. We undertook more assessment and confirmed that the liquid waste processing system (LWPS) design in the UK EPR was BAT to minimise discharges of aqueous radioactive waste but that future operators would need to optimise their use of the LWPS to demonstrate BAT in operations. Two assessment findings were identified and are shown below.

154 We concluded that the UK EPR utilises the best available techniques (BAT) to minimise discharges of aqueous radioactive waste:

a) during routine operations and maintenance;

b) from anticipated operational events.

155 We concluded that the aqueous radioactive discharges from the UK EPR should not exceed those of comparable power stations across the world.

156 We conclude that any operational, single UK EPR unit should comply with the limits and levels set out below for the disposal of aqueous radioactive waste to the sea. The limits and levels will be the starting point for any site-specific permit, but will be reviewed as part of the site permitting process based on any additional information provided by a future UK EPR operator. The limits would also be reviewed periodically thereafter, as data becomes available from operational UK EPR reactors.
Note that the base case discharges for the UK EPR do not include any associated waste and spent fuel storage facilities, our limits do not include any allowance for possible aqueous disposals from these facilities.

Radionuclides or group of radionuclides	**Proposed Annual limit GBq**	**Proposed Quarterly notification level GBq**
Tritium	75,000	45,000
Carbon-14	95	9
Cobalt-60	1.5	0.12
Caesium-137	0.5	0.04
All other radionuclides (excepting tritium, carbon-14, cobalt-60 and caesium-137)	3	0.24

157 As part of our assessment we identified the following assessment findings:

a) Future operators shall, during the detailed design phase, provide their proposals for the operational management of the Liquid Waste Processing System to minimise the discharge of radioactivity from the site so that exposures of any member of the public and the population as a whole are kept as low as reasonably achievable (ALARA) and to protect the environment. The proposals should be supported by a BAT assessment to show that the use of the evaporator, the choice of filter porosity and the demineralisation media have been optimised to minimise the dose to members of the public. The future operator shall also provide evidence that the Water Treatment Systems have sufficient capacity and resilience to cope with all the aqueous radioactive waste arisings consigned to the evaporator by the proposals. The proposals should consider all plant states, including for example outages and unavailability due to maintenance or breakdown. (UK EPR-AF08)

b) Future operators shall, during the detailed design stage, provide a predicted mass balance showing how their proposed aqueous radioactive waste management regime will affect the disposal of carbon-14 to the gaseous, solid or aqueous routes. For each route the form of carbon-14 expected shall be provided. For solid wastes the quantities of each type of waste shall be provided with expected carbon-14 content. (UK EPR-AF09)

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(DECC, 2009b)	UK Strategy for Radioactive Substances, DECC, July 2009 http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=What%20we%20do%5CUK%20energy%20supply%5CEnergy%20mix%5CNuclear%5Cradioactivity%5C1_20090722135916_e_@@_dischargesstrategy.pdf&filetype=4
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(Environment Agency, 2009b)	Considerations for Radioactive Substances Regulation under the Radioactive Substances Act at Nuclear Sites in England and Wales, Environment Agency, Jan 2009 (version 2).
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(Environment Agency, 2011c)	EAGDAR UK EPR-11: Generic design assessment. UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS. Final assessment report: Radiological impact on members of the public. http://publications.environment-agency.gov.uk/pdf/GEHO12BTNJ-e-e.pdf

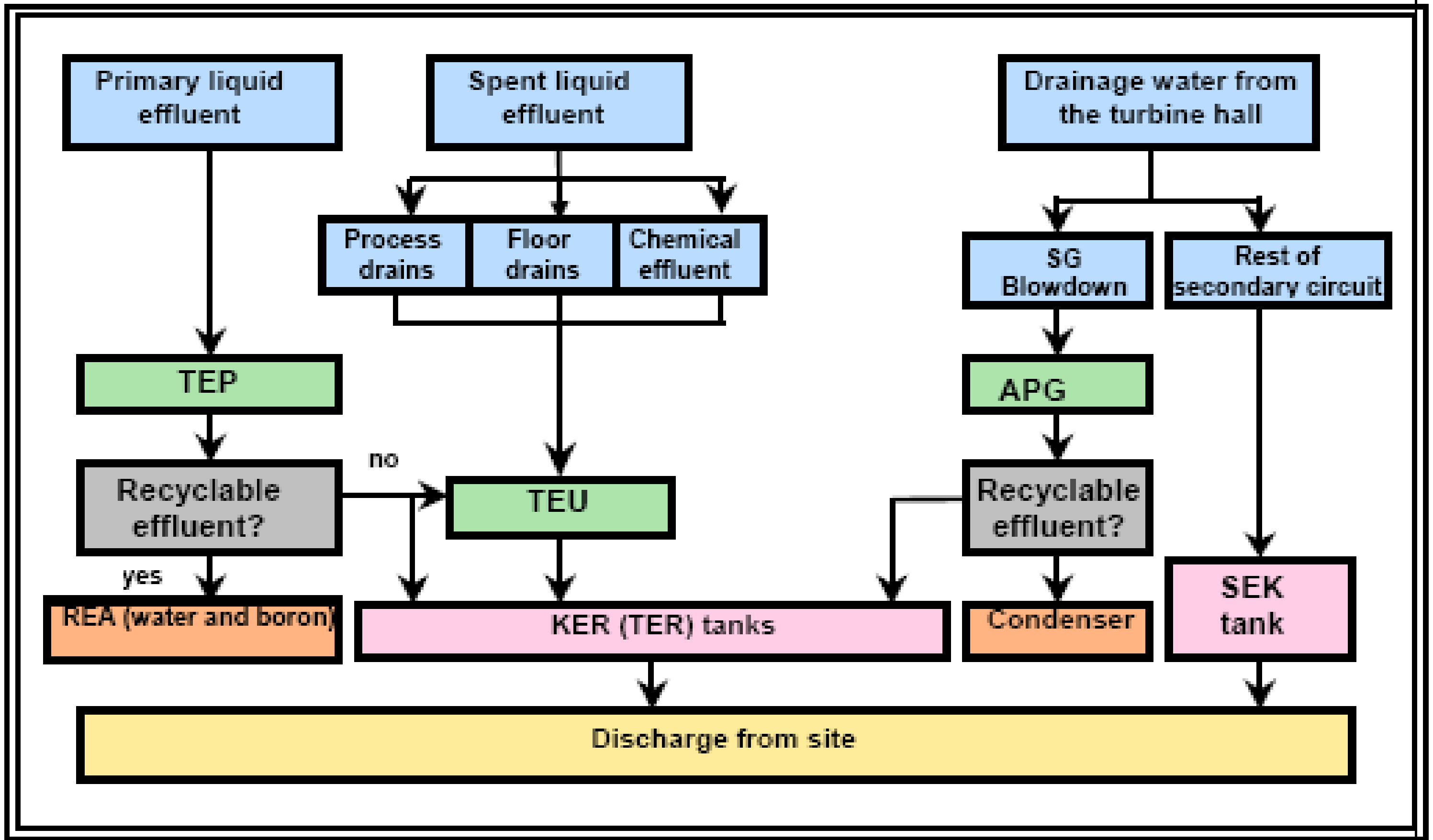
While every effort has been made to ensure the accuracy of the references listed in this report, their future availability cannot be guaranteed.

Abbreviations

BAT	Best available techniques
C&I	Control and Instrumentation
CILWDS	Conventional island liquid waste discharge system
CSTS	Coolant Storage and Treatment System
CVCS	Chemical and Volume Control System
EPR 10	Environmental Permitting (England and Wales) Regulations 2010
EPRB	GDA UK EPR – BAT demonstration, document UKEPR-0011-001
EPRB 3.5s1.2	EPRB form 3.3 section 1.2 (example reference)
ETB	Effluent Treatment Building (this is also referred to as the 'Waste Treatment Building')
ExLWDS	Additional liquid waste discharge system
FAPs	Fission and Activation Products
GDA	Generic design assessment
GWPS	Gaseous Waste Processing System
HSE	Health and Safety Executive
HVAC	Heating, ventilation and air conditioning system
IWS	GDA UK EPR – Integrated Waste Strategy Document UKEPR-0010-001 Issue 00
JPO	Joint Programme Office
LRMDS	Liquid radwaste monitoring and discharge system
LWPS	Liquid Waste Processing System
NVDS	Nuclear Vent and Drain System
ONR	Office for Nuclear Regulation, an Agency of the HSE (formerly HSE's Nuclear Directorate)
P&ID	Process and information document
PCER	Pre-Construction Environmental Report
PCERsc3.3s4.1	PCER sub-chapter 3.3 section 4.1 (example reference)
PCSR	Pre-Construction Safety Report
PWR	Pressurised water reactor
QNL	Quarterly Notification Level
RCS	Reactor Coolant System
REPs	Radioactive substances regulation environmental principles
RI	Regulatory Issue
RO	Regulatory Observation
RSA 93	Radioactive Substances Act 1993
SG	Steam Generator
TQ	Technical Query
VCT	Volume Control Tank
WCPD	Worst Case Annual Plant Discharges

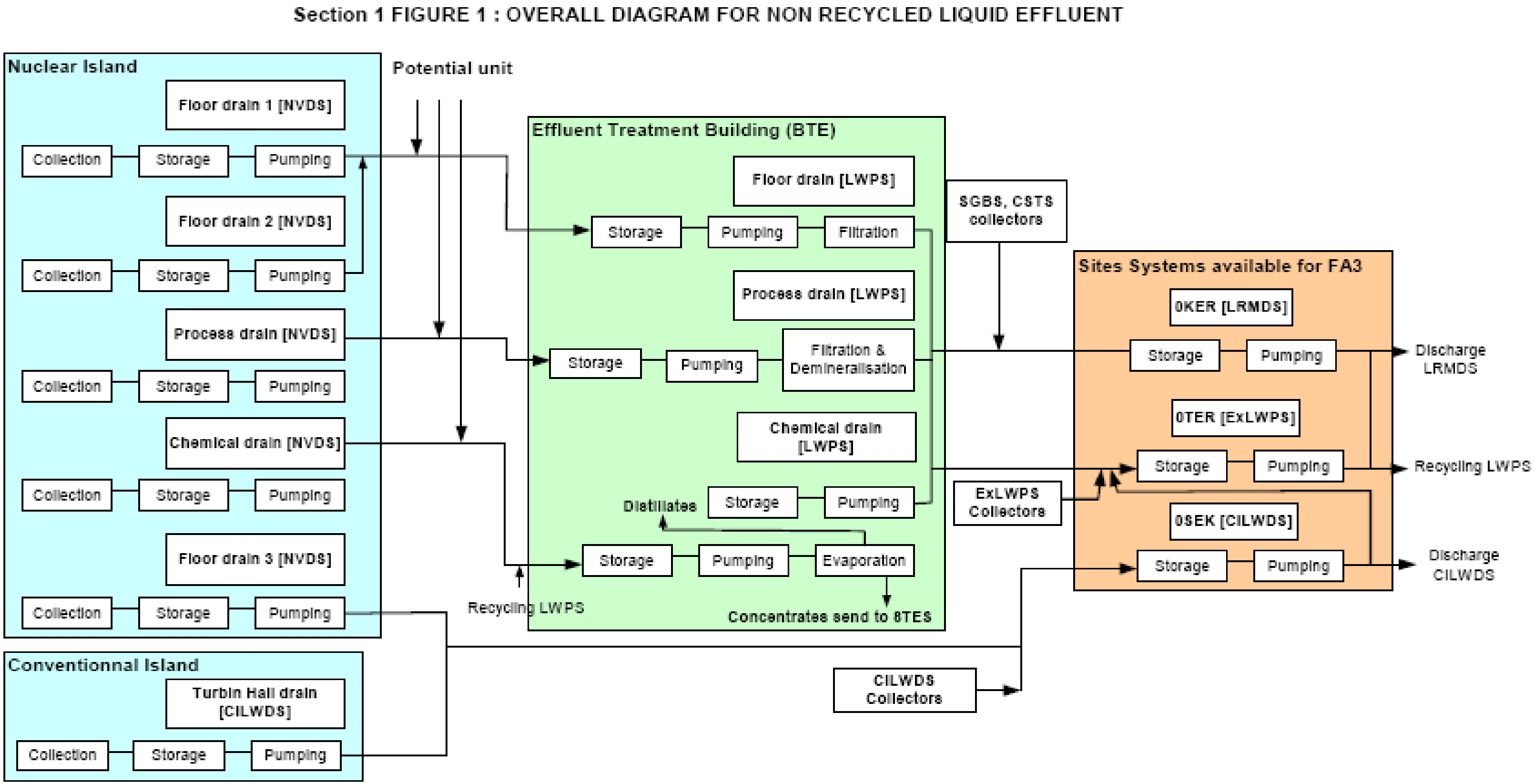
Annex 1: Figures from PCER

PCERsc3.4 Figure 1



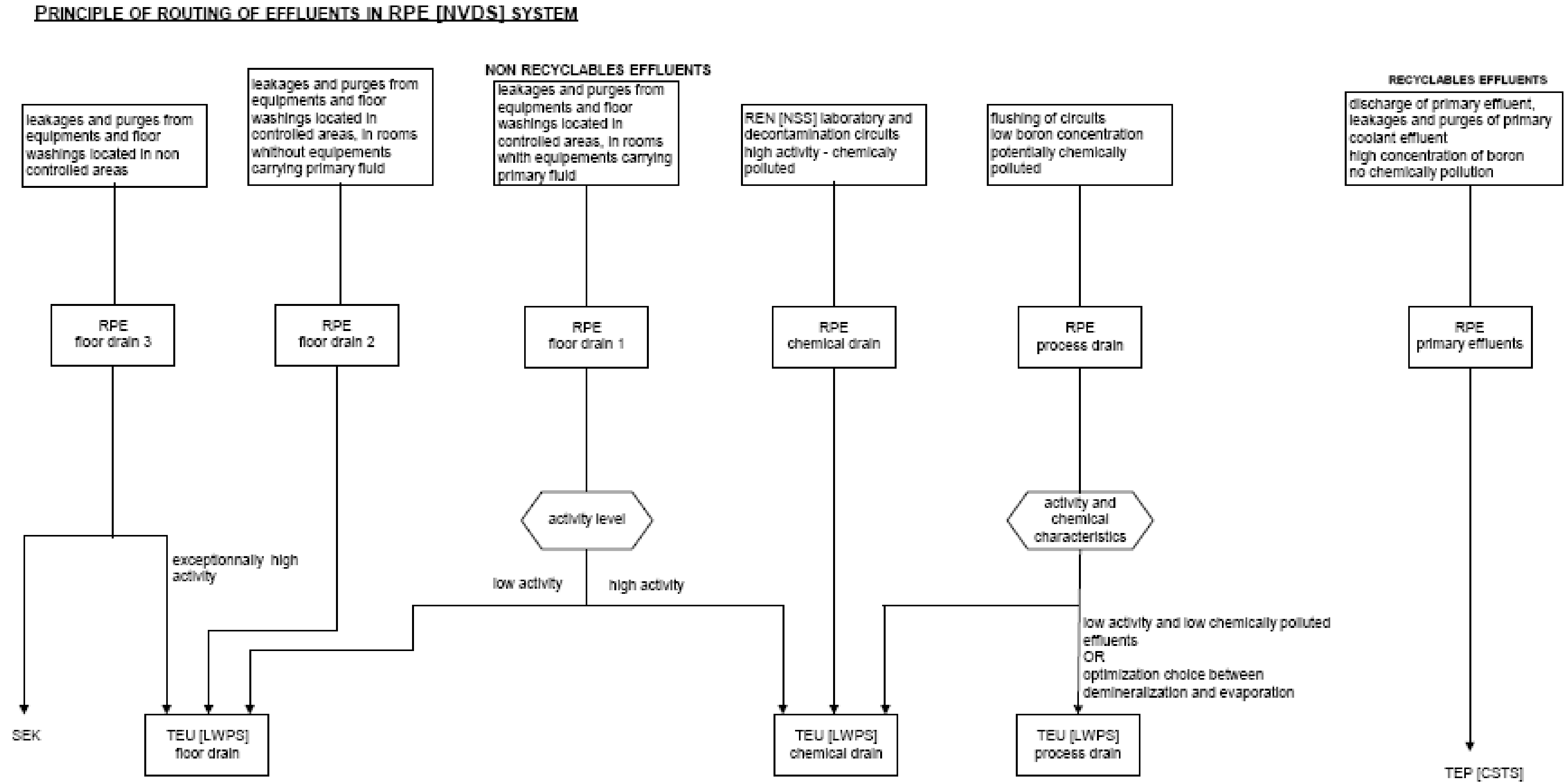
Sub-chapter 3.4 - Figure 1: Nature of liquid radioactive discharge

PCERsc6.4s1 Figure 1



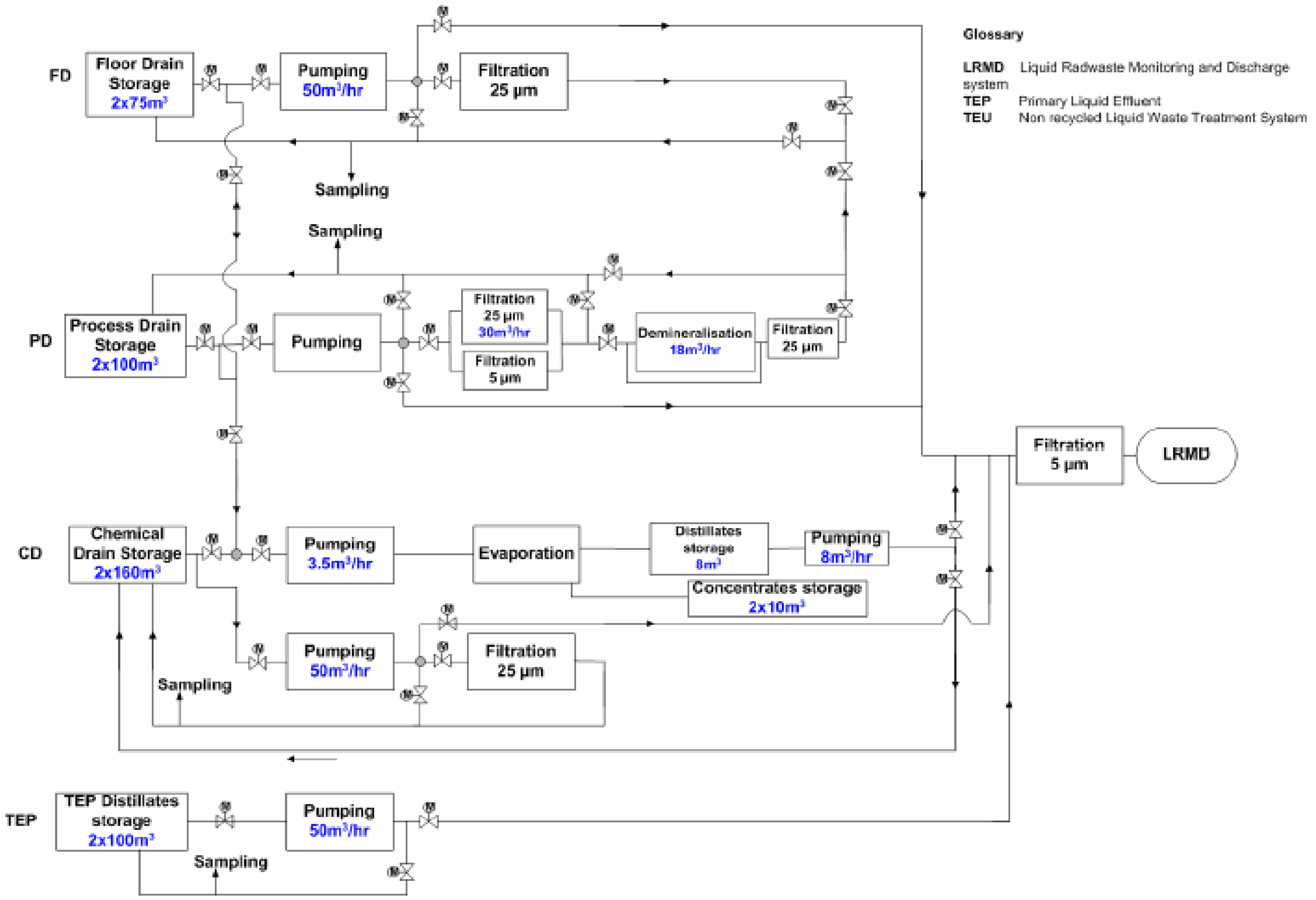
PCERsc6.4s2.1 Figure 2

Section 2.1 FIGURE 2: RULES FOR CHANNELING EFFLUENT IN THE RPE [NVDS]



IWS Figure 5

Figure 5: The Treatment of Non-Recycled Liquid Effluents



Annex 2: BAT and OSPAR

158 The UK Discharge Strategy (DECC, 2009b), which is Government policy, has objectives:

a) to implement the UK's obligations, rigorously and transparently, in respect of the OSPAR Radioactive Substances Strategy (RSS) intermediate objective for 2020;

b) to provide a clear statement of Government policy and a strategic framework for discharge reductions, sector by sector, to inform decision making by industry and regulators.

159 The expected outcomes of the Strategy are, by 2020, of:

a) progressive and substantial reductions in radioactive discharges [to the extent described in the strategy];

b) progressive reductions in concentrations of radionuclides in the marine environment resulting from radioactive discharges, such that by 2020 they add close to zero to historic levels;

c) progressive reductions in human exposures to ionising radiation resulting from radioactive discharges, as a result of planned reductions in discharges.

160 The Statutory Guidance (DECC, 2009a) provides guidance to the Environment Agency with regard to the Discharge Strategy. In brief this states that "*in relation to its radioactive discharge functions, the Environment Agency should base its regulatory decisions on applying the environmental principles set out in the 2009 UK Strategy*." These principles are:

a) regulatory justification of practices by the Government;

b) optimisation of protection on the basis that radiological doses and risks to workers and members of the public from a source of exposure should be kept as low as reasonably achievable (the ALARA principle)**;**

c) application of limits and conditions to control discharges from justified activities;

d) sustainable development;

e) the use of Best Available Techniques (BAT);

f) the precautionary principle; the polluter pays principle;

g) the preferred use of 'concentrate and contain' in the management of radioactive waste over 'dilute and disperse' in cases where there would be a definite benefit in reducing environmental pollution, provided that BAT is being applied and worker dose is taken into account.

161 The Government has stated in the Statutory Guidance [paragraph 4] that it considers it appropriate that the Environment Agency pursue the objectives set out in the *UK Strategy for Radioactive Discharges*. But this does not mean that there is a policy or legal requirement that we regulate discharges and set limits to ensure that the Discharge Objectives are met at a site, sectoral or national level. Instead the Discharge Strategy states at paragraph 1.6.3 that:

a) *"The Government believes that the application of these principles through the regulatory framework will continue to drive the delivery of progressive reductions in discharges, where practicable, in order to meet the OSPAR intermediate objective for 2020*".

162 In GDA we concentrated on assessing BAT and expected that Requesting Parties would use the latest technology or techniques in their designs to ensure reduced discharges of radioactivity. Any new nuclear power plant we permit to operate in the UK will use BAT to conform to principle e) of the 2009 UK Strategy as noted

above and will, overall, have lower discharges (against electrical output) than current nuclear power plant.

Best available techniques

163 GDA has been done on the basis that new designs need to demonstrate Best Available Techniques are used. This report gives a full evaluation of BAT for aqueous discharges and we concluded that the UK EPR was BAT. Improvements have been made to the UK EPR design to reduce initial generation of radionuclides – for example reduction in use of cobalt containing materials such as Stellites and better corrosion control by reactor chemistry and the use of zinc injection. Use of abatement techniques such as filters and ion exchange is as existing plant with EDF and AREVA claiming that advanced techniques such as ultra-filtration are unproven for nuclear power plants and entail excessive cost when compared to impact – 3.27 μSv y^{-1} for the UK EPR.

164 EDF and AREVA do not consider evaporation of all aqueous waste as BAT for GDA where the generic site is coastal, the use of filtration and ion exchange is proposed for most aqueous effluent with an evaporator available for liquids incompatible with ion exchange resins. A factor against evaporation is that it would only really affect corrosion products such as Co-60 and these represent low discharge quantities at total limit values of 5 GBq y^{-1}. EDF and AREVA say that evaporation has little effect on the larger discharges of tritium, limit value 75 TBq y^{-1} or C-14, limit value 95 GBq y^{-1}. We need future operators to predict how their use of an evaporator will effect the disposal of C-14 (assessment finding UK EPR-09).

165 The UK EPR also has a boron recycle system using an evaporator. To reduce boron in coolant a bleed is taken to an evaporator, the concentrate containing boron is then stored for reuse after refuelling, the distillate (water) is recycled into the reactor circuit. This system reduces the volume of effluent.

166 We have concluded in this report that the UK EPR design includes appropriate equipment within the LWPS for the initial demonstration of BAT to minimise the discharge of aqueous radioactive waste. However techniques includes the management of waste and future operators will need to demonstrate that their proposed use of the evaporator and that the filter porosities and demineralisation media they choose represent BAT for operation of the LWPS (assessment finding UK EPR-AF08).

Discharges

167 We provide below some data that illustrates how the predicted discharges from a UK EPR to the sea will compare with current discharges from the existing plants Hinkley Point B (output 870 MWe) and Sizewell B (output 1191 MWe). It can be seen that, with the exception of carbon-14, the UK EPR shows reduced discharges. Note that this comparison is intended to show that BAT for new plants will generally lead to lower discharges, it is not intended to reflect on the UK Discharge Strategy that applies at a national level. Further current discharges may reflect reduced operation time due to maintenance or refuelling while the UK EPR figure assumes 91 % availability to generate full power. Figures are shown as actual and as normalised to 1000 MWe.

Tritium

168 The UK EPR reduces use of boron by use of a burnable poison and uses lithium hydroxide with <0.1% Li-6 to reduce tritium production compared to predecessor PWRs.

169 Current discharges (reported in 'My Backyard' on our website) TBq:

	Hinkley Point B	Sizewell B
2008	78	52
2009	110	53
2010	150	25
Mean	113	43
Normalised	130	36

170 Predicted average / at limit discharges for new plant:

a) UK EPR = 52 TBq / 75 TBq

b) UK EPR normalised = 32 TBq / 46 TBq

171 The UK EPR will discharge substantially less tritium (against electrical output) than existing plant.

Carbon-14

172 C-14 is unavoidably produced in PWRs by activation of oxygen within the water molecules of the reactor coolant. Most C-14 is discharged to air but some 5-20% can be present in water discharges in various forms.

173 Current discharges (My Backyard) GBq:

	Hinkley Point B	Sizewell B
2008	1	3.3
2009	1	3
2010	1	1.5
Mean	1	2.6
Normalised	1.1	2.2

174 Predicted average / at limit discharges for new plant:

a) UK EPR = 23 GBq / 95 GBq

b) UK EPR normalised = 14 GBq / 58 GBq

175 The UK EPR design basis is 440 GBq y^{-1} production of C-14. The difference in discharge to water average or maximum relates to factors of 5 or 20 % used to partition between gaseous and aqueous routes. EDF has been required to measure C-14 to water more accurately in France and support their prediction of 5% with measured data. The 20 % is to allow for worst case as the partition rate for an EPR is as yet unknown. They state that measurement techniques are critical to measure C-14 and most current techniques involving drying samples etc drive off the C-14 so measurements are deficient.

176 We have not been able to identify techniques to abate C-14 in aqueous discharges. As noted above evaporation may just cause most C-14 (depending on form) to go with the distillate and be discharged to sea.

177 We noted in our Decision Document that the range of discharge for existing European and USA plants was 3-45 GBq y^{-1} C-14 for a 1000 MWe plant. The range covers the average discharge predicted for the UK EPR so the design is comparable to world wide power stations.

178 C-14 is a naturally occurring radionuclide, global annual production of natural C-14 is around 1000 TBq, so power stations make a small contribution to global levels. The Atlantic has around 5 Bq/m^3 C-14. A UK EPR with the maximum discharge of C-14 will have a concentration of approximately 50 Bq/m^3 in the cooling water outflow. A dispersion factor of 10 should be readily achieved within a few 100 metres of discharge point. Therefore we do not believe that the discharge of C-14 from new plant will alter the background level in the wider oceans.
Further, in terms of dose impact to people, the collective dose to the UK population from a UK EPR is estimated at 0.11 man Sv (total) while the collective dose to the

UK population from natural carbon-14 is estimated as about 480 man Sv.

Activated corrosion products – Co-60

179 The production of activated corrosion products, in particular Co-60, has been significantly reduced by use of BAT in the new designs.

180 Current discharges (My Backyard) MBq:

	Hinkley Point B	Sizewell B
2008	230	990
2009	380	790
2010	230	740
Mean	280	840
Normalised	322	705

181 Predicted average / maximum Co-60 discharges for new plant:

a) UK EPR = 180 MBq / 300 MBq

b) UK EPR normalised = 110 MBq / 184 MBq

182 The UK EPR will discharge significantly less activated corrosion products than the older plant they will replace.

Fission products

183 FPs should only be present in aqueous discharges from fuel pin failures. Pin manufacture has considerably improved and for new plant pin failures will be less than 10 in a million in a year (UK EPR has 63865 fuel pins so you could expect <1 failure per year but reality may group failures in 1 reactor loading). So BAT starts with an assurance that quality fuel is used. For abatement we already say that the liquid waste systems using filters and ion exchange contribute to BAT and these will minimise discharge of FPs.

184 Current discharges (My Backyard):
Caesium-137 GBq

	Hinkley Point B	Sizewell B
2008	4.2	4.5
2009	4.5	4.8
2010	3	5.7
Mean	3.9	5
Normalised	4.5	4.2

Predicted average / maximum discharges for new plant:

a) UK EPR = 0.057 GBq / 0.95 GBq Cs-137

b) UK EPR normalised = 0.03 GBq / 0.58 GBq Cs-137

185 The discharges of Cs-137 from the UK EPR will be substantially less than from the existing plants.

186 Current discharges (My Backyard):
Iodine-129 MBq

	Hinkley Point B	Sizewell B
2008	<100	<100
2009	<100	<100
2010	<100	<100
Mean	<100	<100
Normalised	-	<100

Predicted average / maximum discharges for new plant:

a) UK EPR = 7 MBq / 50 MBq total iodines

b) UK EPR normalised = 4.3 MBq / 30.7 MBq total iodines

187 We concluded that iodine radionuclides discharged from the UK EPR are at such a low level that monitoring would be at or below levels of detection and therefore limit setting is unreasonable. Considered with the short half lives of the iodine radionuclides we consider their discharges, and therefore any additional concentration in the environment will be 'close to zero'.

GEHO0511BTND-E-E

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