Radioactive Substances Series

Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges

OSPAR Commission

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The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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EXECUTIVE SUMMARY

PARCOM Recommendation 91/4 concerns the use of Best Available Techniques (BAT), to minimise and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment. The Recommendation requests that Contracting Parties to the OSPAR Convention report on a four-year basis on progress in the implementation of BAT in such facilities. All Contracting Parties that have a nuclear industry have submitted implementation reports during the third round of implementation reporting (1995-1998). The information was submitted according to the OSPAR “Guidelines for the submission of information about, and assessment of, the application of BAT in nuclear facilities”.

This summary of the implementation reports highlights (i) data completeness, representativity and quality; (ii) time trends of discharges, environmental radioactivity and radiation doses; and (iii) observations and conclusions with regard to data submission, appropriateness of the reporting format, and comparison to BAT/BEP criteria as indicated in the Guideline.

The discharge data submitted is largely complete, representative and have relevant quality. The information on dose assessment and radiation doses varies in detail. The information on environmental radioactivity has been less detailed and is less complete.

According to the Guidelines, a number of BAT/BEP indicators are tested during the third round of implementation. A general conclusion is that the use of these BAT/BEP indicators can be further developed in the next implementation round, and that a few of them can be deleted. The most commonly used indicator is downward trends. The following conclusions can be drawn concerning trends of discharges for groups of nuclear facilities.

- The annual total discharges of radionuclides other than tritium from all pressurised water reactors (PWRs) show a continuous decreasing trend, about 40% from 1995 to 1998. The average discharges, normalised to energy production, show a decrease with about 75% during the third implementation round compared to the second implementation round.
- The annual total discharges of radionuclides other than tritium from all boiling water reactors (BWRs) are about 70% higher in 1996 and 1997 compared with the discharges in 1995. The discharges in 1998 are back at the same level as in 1995. The average normalised discharges from BWRs during the third implementation round are the same as during the second implementation round.
- The average normalised data for gas cooled Magnox reactors for the years 1993 to 1998 show no clear trends for other radionuclides than tritium. For advanced gas cooled reactors (AGRs) there appears to be a decrease for other radionuclides than tritium in 1996 to 1998 compared with the preceding years.
- For Sellafield, there is no discernable trend in discharges of total beta-emitting radionuclides during the time period, technetium-99 (Tc-99) excluded. The discharges of Tc-99 increased substantially from 1993 to 1995 with a maximum discharge of 190 TBq in 1995, where after a decrease of discharges has occurred to 53 TBq in 1998. For alpha-emitting radionuclides the discharges are an order of magnitude lower in 1998 compared with 1993. For La Hague, there is a decreasing trend in the long-term discharges of beta-emitting radionuclides, a factor of 5 in 1999 compared with 1994. Also the discharges of alpha emitters show a decreasing trend, a factor of 3 during the same time period.
- For the fuel production and enrichment plants the discharges of alpha-emitters are reasonably constant (no clear trends) throughout the reported years.

- The total discharges from all research facilities show a decreasing trend from 1993 to 1998 for both tritium and other radionuclides than tritium.

The necessary criteria to positively identify BAT are still to some extent missing. However, the BAT/BEP indicators in the present Guidelines constitute substantial progress towards making a balanced evaluation of a positive identification of BAT. It may also be that the question whether BAT is applied is not one that can be answered once and for all. The answer is dependent on factors changing in time like the availability of technical systems for discharge reduction. Also economic factors should be taken into account. An overall conclusion may be that definite criteria for identifying BAT is not a goal as such. The present criteria, as stated in the Guidelines, and applied to a greater extent, would then seem to fulfil the purpose to positively identify BAT.

RÉCAPITULATIF

La Recommandation PARCOM 91/4 concerne le recours à la meilleure technologie disponible, ou BAT, afin de minimiser et, s'il y a lieu, d'éliminer toute pollution causée par les rejets radioactifs, dans le milieu marin, de l'ensemble des industries nucléaires, y compris les réacteurs de recherche et les usines de retraitement. Il est demandé, dans la recommandation, que les Parties contractantes à la Convention OSPAR rendent compte tous les quatre ans de la progression de la mise en oeuvre de la BAT dans ces installations. Toutes les Parties contractantes ayant une industrie nucléaire ont remis des rapports de mise en oeuvre au cours de la troisième campagne de notification de la mise en oeuvre (1995-1998). Les renseignements ont été communiqués conformément aux « Lignes directrices relatives à la communication des informations sur, et à l'appréciation de l'application de la BAT dans les installations nucléaires ».

Le présent résumé des rapports de mise en oeuvre met en évidence (i) le degré d'exhaustivité des données, leur représentativité et leur qualité; (ii) les tendances chronologiques des rejets, de la radioactivité dans l'environnement et des doses de rayonnement ; et (iii) les observations et les conclusions concernant la communication des données, l'adéquation du formulaire de rapport et la comparaison des critères de BAT/BEP indiqués dans les lignes directrices.

Les données des rejets communiquées sont en grande partie complètes, représentatives et sont de la qualité voulue. Les renseignements relatifs à l'évaluation des doses et aux doses de rayonnement sont variables dans le détail. Les informations relatives à la radioactivité dans l'environnement se sont avérées moins détaillées et moins complètes.

Conformément aux lignes directrices, plusieurs indicateurs de BAT/BEP ont été testés pendant la troisième campagne de notification de la mise en oeuvre. L'une des conclusions générales est que ces indicateurs de BAT/BEP peuvent être développés plus encore lors de la prochaine campagne, et que quelques uns d'entre eux peuvent être supprimés. L'indicateur le plus couramment utilisé est constitué par les tendances à la baisse. Les conclusions suivantes peuvent être tirées en ce qui concerne les tendances des rejets des groupes d'installations nucléaires.

- Les rejets annuels totaux de radionucléides autres que le tritium, de tous les réacteurs à eau sous pression, présentent une tendance continue à la baisse, soit environ 40% de 1995 à 1998. La moyenne des rejets, normalisée en fonction de la production d'énergie, a baissé d'environ 75% pendant la période objet de la notification, ceci par rapport à la deuxième campagne de mise en oeuvre.
- En 1996 et 1997, par rapport à 1995, les rejets annuels totaux de radionucléides autres que le tritium, de tous les réacteurs à eau bouillante ont augmenté d'environ 70%. En 1998, ils sont revenus au même niveau qu'en 1995. Pendant la troisième campagne de notification, la moyenne des rejets normalisés des réacteurs à eau bouillante s'est avérée être la même que pendant la deuxième campagne.
- De 1993 à 1998, les données moyennes normalisées des réacteurs Magnox ne présentent aucune tendance claire dans le cas des radionucléides autres que le tritium. En ce qui concerne les réacteurs à gaz avancés, il semble que les radionucléides autres que le tritium aient baissé de 1996 à 1998 par rapport aux années précédentes.
- A Sellafield, il n'y a aucune tendance décelable dans les rejets de radionucléides émetteurs bêta total pendant la période en question, ceci à l'exclusion du Tc 99. Les rejets de Tc 99 ont nettement augmenté de 1993 à 1995, pour atteindre un maximum de 190 TBq en 1995, après quoi ils ont été ramenés à 53 TBq en 1998. En ce qui concerne les radionucléides émetteurs alpha, les rejets sont d'un ordre de grandeur inférieurs en 1998 par rapport à ce qu'ils étaient

en 1993. A l'usine de La Hague, on constate sur le long terme une tendance à la baisse des rejets de radionucléides émetteurs bêta, et ont été divisés par 5 en 1999 par rapport à ce qu'ils étaient en 1994. Par ailleurs, les rejets d'émetteurs alpha présentent une tendance à la baisse, puisqu'ils ont été divisés par 3 pendant la même période.

- Dans le cas des équipements de fabrication et d'enrichissement du combustible, les rejets d'émetteurs alpha sont raisonnablement constants (pas de tendance claire) sur l'ensemble des années objet des rapports.
- Le total des rejets de toutes les installations de recherche manifeste une tendance à la baisse de 1993 à 1998 tant dans le cas du tritium que dans celui des radionucléides autres que le tritium.

Les critères qui permettraient de déterminer effectivement la BAT manquent encore dans une certaine mesure. Toutefois, les indicateurs de BAT/BEP donnés dans les lignes directrices actuelles constituent un progrès important dans le sens de la détermination, dans des conditions équilibrées, de ce qui constitue effectivement la BAT. Il se peut aussi qu'il soit impossible de répondre une fois pour toutes à la question de savoir si la BAT est appliquée. La réponse dépend en effet de facteurs qui évoluent dans le temps, tels que l'existence de systèmes techniques permettant de réduire les rejets. Par ailleurs, il conviendrait de tenir compte des facteurs économiques. Une conclusion générale pourrait être que la fixation de critères définis, permettant de déterminer la BAT, ne constitue pas un objectif en tant que tel. Il semblerait que dans ces conditions, les critères actuels, tels qu'ils figurent dans les lignes directrices et dans la mesure où ils seraient plus largement appliqués, répondent à l'objectif qui consiste à déterminer effectivement la BAT.

1 INTRODUCTION

1.1 PARCOM Recommendation 91/4 on Radioactive Discharges

PARCOM Recommendation 91/4 concerns the use of Best Available Techniques (BAT), to minimise and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment. The Recommendation requests that Contracting Parties to the OSPAR Convention report on a four-year basis on progress in the implementation of BAT in such facilities. This report summarises the implementation reports submitted by Contractiong Parties during the third round of implementation reporting for the years 1995-1998. For more detailed information, reference is made to the national implementation reports (Annex 1) that can be made available by the OSPAR Secretariat on request.

Examination of the third round implementation reports started at the 2000 meeting of the Working Group on Radioactive Substances (RAD 2000) with reports from the Netherlands, Sweden and the United Kingdom (UK), continued at the 2001 meeting of the Working Group on Radioactive Substances (RSC 2001) with reports from France, Germany, Norway and Switzerland, and finished at RSC 2002 with reports from Belgium, Denmark, Portugal and Spain.

The Contracting Parties were requested to submit information according to the OSPAR "Guidelines for the submission of information about, and assessment of, the application of BAT in nuclear facilities" (OSPAR reference number: 1999-11, Summary Record OSPAR 99/15/1, Annex 9), referred to as the "Guidelines" (see Annex 2) in the following. These Guidelines were established on a trial basis at OSPAR 1999, Kingston Upon Hull, to be carried out in the intersessional period 1999-2000. RAD agreed, at its meeting in 2000 in Luxembourg, that all Contracting Parties concerned should apply these guidelines for the preparation of their national implementation reports.

The second round of implementation reports was completed in 1995. In 1997, RAD agreed that a summary report should be prepared, based on the information in the second round of implemention reports from the Contracting Parties. The summary report was published in 1999 (OSPAR Commission 1999). At RAD 2000, it was agreed that a summary report of the national implementation reports should be prepared also for the third round of reporting according to the PARCOM Recommendation 91/4. At its 2001 meeting in Tromsø, RSC agreed on the outline for the summary report of the third round of implementation reporting (RSC 01/14/1 Annex 6). In particular, the summary report should highlight (i) data completeness, representativity and quality; (ii) time trends of discharges, environmental radioactivity and radiation doses; and (iii) observations and conclusions with regard to data submission, appropriateness of the reporting format, and comparison to BAT/BEP criteria as indicated in the Guidelines.

1.2 Guidelines for submission and assessment

According to the Guidelines, the Contracting Parties should submit information about, and assessment of, the application of BAT in nuclear facilities structured as "General Information" and "Site-specific Information". A short description of the requested information is given in the following, the complete Guidelines can be found in Annex 2.

In addition to the information requested in the Guidelines, information should also be submitted with respect to the achievements of the requirements set out in the OSPAR Strategy with respect to radioactive substances. Explanations should be provided on the progressive and substantial reduction in discharges, emissions and losses of radioactive substances and a description of ongoing or planned activities for further measures, if necessary, to achieve the requirements set out in the OSPAR Radioactive Substances Strategy (reference number: 2003-21).

1.2.1 General information

The Guidelines request information on the implementation in national legislation of BAT/BEP in terms of the OSPAR Convention, in particular what is considered as BAT and how each Contracting Party applies BAT. The role of the BAT/BEP approach should be emphasised with a view to achieving the objective of OSPAR's Radioactive Substances Strategy:

> *"…to prevent pollution of the maritime area from ionising radiation through progressive and substantial reduction of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, inter alia, be taken into account:*
>
> - *legitimate uses of the sea;*
> - *technical feasibility;*
> - *radiological impacts on man and biota".*

The general information should also, *inter alia*, include information on dose constraints (limits) for nuclear facilities, discharge limits and monitoring programmes of environmental concentrations of radioactive substances as well as environmental norms and standards.

1.2.2 Site-specific information

The site-specific information should include information on site characteristics, discharges, environmental impact and radiation doses to the public, respectively (Annex 2). A list of nuclear facilities covered by the report is given in Annex 3, and a map indicating the locations of these facilities are shown in Annex 4.

The information to be submitted on *site characteristics* should include, *inter alia*, name of site, type of facility, location and receiving waters as well as relevant production data (for example electrical output, tonnes uranium processed) for the last six years.

In accordance with Article 2, 3 (b)(i) and Appendix 1 on BAT/BEP of the OSPAR Convention, discharges to the marine environment, as well as emissions of concern to the marine environment, are limited through application of technical and managerial practices. The information to be submitted in order to show compliance with this objective on *discharges* include, *inter alia*, data on annual discharges for at least the last six years, description of systems in place to reduce, prevent or eliminate discharges to the marine environent as well as the efficiency of these systems. In all, nine different types of information shall be submitted.

Marine ecosystems shall be protected in accordance to Article 2, 1 (a) of the OSPAR Convention. The information to be submitted in order to show compliance with this objective on *environmental impact* include, *inter alia*, data for at least the last six years on concentrations of radionuclides of concern in environmental samples, environmental monitoring programme and systems for quality assurance of environmental monitoring. Seven different types of information shall be submitted.

Human health shall be protected in accordance to Article 2, 1 (a) of the OSPAR Convention. The information to be submitted in order to show compliance with this objective on *radiation doses to the public* include, *inter alia*, data for at least the last six years on average annual effective dose to individuals in the critical group, basis for the methodology to estimate doses and systems for quality assurance of processes involved in dose estimates. Ten different types of information shall be submitted.

For the different types of information a number of BAT/BEP indicators have been defined, for example downward trends (Annex 2). Lack of data or failure to meet the BAT/BEP indicators shall be explained.

Finally, the three sections in the Guidelines (discharges, environmental impact and radiation doses to the public) shall include a summary giving a balanced evaluation of the Contracting Party´s ability to achieve the objective, taking into account the BAT/BEP indicators, data completeness, causes for deviation from indicators and other information.

2 INFORMATION RECEIVED FROM CONTRACTING PARTIES

All Contracting Parties, that have a nuclear industry, have submitted implementation reports (Annex 1). But not all of the Contracting Parties have submitted all the information requested, or presented the information in accordance with the format of the Guidelines. However, it should be noted that the RAD/RSC[1] has agreed that with respect to the implementation of PARCOM Recommendation 91/4

a. all Contracting Parties had fulfilled the reporting requirements;

b. the reports were in line with the guidelines;

c. that the information presented included indications that BAT had been applied in the nuclear installations of the Contracting Parties[2].

This chapter gives an overview of the submitted information according to the main headings of the Guidelines, “General” and “Site-specific information”, respectively. Additional comments on the information given by the the Contracting Parties in relation to the Guidelines, as well as recommendations, are given in Chapter 6, “Conclusions”.

2.1 General Information

The information submitted under the heading “General Information” of the Guidelines is almost complete for most Contracting Parties in the sense that at least some information has been submitted on all questions in the Guidelines. The exceptions from this conclusion are Denmark and Portugal where the information submitted is more limited. The level of detail in the submitted information differs betwen the Contracting Parties. For example, some Contracting Parties give rather detailed information about their monitoring programmes, while others only give very general information. For all Contracting Parties, the requested information on “environmental goals and standards (other than dose standards for human)” is sparse. Only Switzerland and the Netherlands have submitted some relevant information.

Concerning the implementation of BAT/BEP in national legislation and regulations, all Contracting Parties (except Denmark and Portugal) report that this has been implemented. In some countries, BAT is explicitly mentioned and applied in the legislation, in other countries the legislation is based on more traditional radiation protection criteria which are interpreted to include also BAT. As the BAT concept is central to PARCOM Recommendation 91/4, a summary of what is considered as BAT and how BAT has been applied nationally is given below as reported by the Contracting Parties.

1 RAD 2000 Summary Record, Agenda Item 4; RSC 2001 Summary Record, Agenda Item 5; RSC 2002 Summary Record, Agenda Item 5.

2 The conclusion c) was not supported by the delegation of Ireland on the basis of the information presented by France on the reprocessing plant in La Hague, and by the delegations of Ireland and Norway, particularly with respect to the discharges of technetium-99 from Sellafield.

2.1.1 National implementation of BAT

BELGIUM

The policy of implementation of BAT is illustrated in the Belgian report by a graph that shows the evolution of the quantity of liquid and solid waste generated by the nuclear power stations. It is stated that although the total electrical production remains more or less constant and has even increased slightly since 1997, the radioactive discharges tend to decrease. This is even more obvious when compared with the volume of solid waste generated per energy produced (expressed as m^3/TWh). According to the report, this demonstrates the efforts made by the Belgian electricity companies to reconcile the aims of optimisation of industrial operation, particularly with regard to reduction of the volume of waste produced and associated costs, while minimising discharges as much as possible (BAT concept with regard to liquid and solid waste).

DENMARK

No information provided.

FRANCE

For emissions and discharges, BAT is implemented in French legislation as follows. The equipment has to be designed, operated and maintained so as to limit the discharge of effluents. These discharges have to be, as much as possible, collected at their source, canalised and, if necessary, treated in such a way that corresponding discharges are kept as low as reasonably possible. Anyhow, discharge limits will be settled for authorisation on the basis of the use of the best available technologies at an economically acceptable cost, and of the specific environmental characteristics of the site." It is further said in the French report that the rationale for setting discharge limits relies upon both BAT and dose constraints. It is stated that the implementation of BAT in terms of the OSPAR Convention is clearly transcribed in the French national legislation.

In accordance with a statement made in SINTRA, the Nuclear Safety Authority (DSIN, the French Nuclear Installation Safety Directorate) intends to reduce the release limit values to bring them closer to real release values. It is of particular importance that defined release limit values be as low as is technically and economically feasible, thus forcing operators to lower releases by using the best available techniques at an acceptable cost, while complying with the quality of the natural environments.

GERMANY

For nuclear installations in Germany, the state of scientific and technological advancement, taking into account BAT, is defined in technical guidelines, such as safety standards issued by the "Kerntechnischer Ausschuß (KTA)". The safety standard series (KTA 3601-3606) contains requirements for technical standards in "Activity Control and Activity Management". Within the context of discharges into water, the safety standard KTA 3603 provides technical requirements and detailed information on techniques for "Facilities for the Treatment of Radioactively Contaminated Water in Nuclear Power Plants". In addition to the requirements for the design of the systems, these safety standards also contain requirements concerning absolute reliability in terms of safety, regular testing and maintenance of the installed systems.

THE NETHERLANDS

The provisions for radiation protection (in the Dutch Nuclear Energy Act) are based on the three principles of radiation protection: justification, optimisation and dose limits. Optimisation is applied by the ALARA concept; exposure to ionising radiation should be kept as low as reasonably achievable, economic and social factors taken into account. The terms BAT/BEP are not explicitly referred to in the Nuclear Energy Act. BAT/BEP in terms of the OSPAR Convention are implemented in the Dutch national regulation by the ALARA principle.

NORWAY

In the discharge authorisations for the nuclear activities at the Institute for Energy Technology, issued by the Norwegian Radiation Protection Authority, BAT is required in the sense that the establishment should endeavour to use the technology that at the given time leads to the lowest discharges of radionuclides to the environment reasonably achievable. It is further said in the Norwegian report that when issuing authorisations for nuclear installations, Norwegian practice is to focus on BAT and the principles of "cradle to grave" and the precautionary principle.

PORTUGAL

No information provided.

SPAIN

The requirements on the system applied to limit emissions and discharges are established in regulations (Royal Decree). It is specifically stipulated that facilities generating radioactive wastes must be provided with adequate treatment and removal systems in order to ensure that doses due to releases are lower than the limits established in the administrative licences and that they are kept at the lowest possible value. The authorisation procedure demands from the site operator, *inter alia*, a description of how the applied best practical means will be within nationally and internationally accepted criteria. Licensees have to demonstrate that every reasonable effort is made, from the generation of wastes to the operation procedures of the effluent treatment systems, to reduce discharges and emissions, in order to keep the radiological impact as low as is technically and economically feasible. By making the operators to apply the best available technologies and to improve the operation procedures releases are minimised, maintaining the quality of the natural environment. Therefore, the Spanish regulatory system in the field of controlling radioactive substances, sets up a framework for the effective application of a clearly stated policy under which the equivalent of BAT is required, which follows closely the requirements and recommendations of competent international bodies, and which adopts principles calculated to ensure the application of the precautionary principle and the prevention of pollution.

SWEDEN

The aim of the Radiation Protection Act is the protection of man and the environment against harmful effects of radiation. The explanatory text to the Radiation Protection Act clarifies that radiation protection shall be in reasonable accordance with technical and methodological development, and shall be improved as technological and methodological development so permits (i.e. BAT shall be applied, although the term is not used in the Act *per se*). Furthermore, the Environmental Code, which is a comprehensive legislation covering a wide range of environmental issues, including provisions on environmental impact assessments, licensing procedures, etc. is applicable to activities generating ionising radiation in the environment. The Code specifically identifies BAT as a means for achieving the goal of preventing, eliminating or reducing the impact on health and the environmental of human. Finally, BAT has recently been introduced as a means for discharge limitation from nuclear facilities in regulations issued by the Swedish Radiation Protection Authority.

SWITZERLAND

Since 1994 the Federal Act and Ordinance on Radiation Protection of Switzerland are based on the recommendations of the ICRP Publication 60. From 2000 new dose factors are used, complying with IAEA Safety Series No. 115. The fundamental concepts of justification, optimisation, radiation dose limitation and the 10 microSv per year concept as described in the IAEA Safety Series 89 and the Euratom Treaty is adopted by Swiss legislation. In this context the BAT/BEP is implemented in the Swiss national legislation according to the terms of the OSPAR Convention.

UNITED KINGDOM

Discharges, emissions and accumulation of radioactive wastes are controlled and regulated within the UK by way of authorisations issued under the Radioactive Substances Act. Such authorisations for nuclear facilities not only set numerical release limits but also require the operator to use, within a particular waste management option (for example discharges to a water medium), the best practicable means (BPM) to limit the activity of the waste discharged. BPM is defined thus: "It is, within a particular management option, that level of management and engineering control that minimises, as far as practicable, the release of radioactivity to the environment whilst taking account of a wider range of factors, including cost-effectiveness, technological status, operational safety, and social and environmental factors. In determining whether a particular aspect of the proposal represents the BPM, the operator will not be required to incur expenditure, whether in money, time or trouble, which is disproportionate to the benefits likely to be derived."

The use of BPM is intended to secure the Best Practicable Environmental Option; this is a concept developed by the Royal Commission on Environmental Pollution and implies that decisions on waste management, radioactive or otherwise, have been based on an assessment of alternative options evaluated on the basis of factors such as the occupational and environmental risks, the environmental impacts, the costs and the social implications. Requirements of BAT as defined in the OSPAR Convention are therefore discharged under the broader requirement placed on nuclear sites in the UK to use BPM to reduce the activity in all waste discharged. The UK regulatory system, in the field of controlling radioactive substances, therefore sets up a framework for the effective application of a clearly stated policy under which the equivalent of BAT is required, which follows closely the requirements and recommendations of competent international bodies, and which adopts principles calculated to ensure the application of the precautionary principle and the prevention of pollution.

2.2 Site-specific Information

The following brief overview of received documentation identifies some major data gaps and inconsistencies in the submitted site-specific information. Assessments of the information submitted on Discharges, Environmental Impact and Radiation Doses to the Public, respectively, are presented in Chapters 3-5.

2.2.1 Site characteristics

The information on site characteristics is more or less complete for all Contracting Parties with the exception of Belgium and Portugal where some information is missing. The report from France is focused on the reprocessing facilities in La Hague and there is no site characteristics given for nuclear power reactors. According to the Guidelines, production data should be submitted for the last six years. With the exception for Portugal, which only give data for four years, and France, which have not submitted data for the nuclear power reactors, all Contracting Parties have reported these data.

2.2.2 Discharges

The information submitted by the Contracting Parties is reasonably complete but shows large variations in detail between the different questions in the Guidelines and between Contracting Parties. With a few exceptions (Belgium, Denmark, Portugal), the information on annual liquid discharges is complete. However, there are various degrees of detail in the submitted nuclide specific data, from just a few key radionuclides to all nuclides actually measured. It is not possible to judge to what extent the reported nuclides reflect all measured or detected nuclides or whether some restrictions, for example only nuclides with half-lifes exceeding a certain value, are reported even if measured. The report from France is focused on the reprocessing facilities in La Hague.

There is limited information on the efficiency of retention systems in terms of e.g. retention times and distribution between waste streams destined for discharge and waste streams destined for disposal. Exceptions are France (for La Hague), the Netherlands, Sweden, Switzerland and UK. Belgium, Denmark and Portugal give less detailed information. Also the information on systems for quality assurance performance of retention systems and data management are less complete or missing. In general, the BAT/BEP indicators are not discussed as thoroughly as may have been expected. As there is no information on uncertainties, which is not requested in the Guidelines, it is in general difficult to assess whether there is a significant change (e.g. downwards) in time.

2.2.3 Environmental impact

There are gaps in the information submitted on environmental impact. For concentrations in the environment only a limited amount of data is submitted. In cases where such data are submitted only selected radionuclides and sample types are reported. In some cases (for example Spain, Switzerland and Germany) the lack of reported data is explained by difficulties to relate measurements in the environment to a specific point of discharge or to too low radionuclide concentrations in general in the environment. There are few reported national target values of radioactive substances in environmental samples or doses to marine organisms. There is also limited information on systems for quality assurance of environmental monitoring. As there is no information on uncertainties, it is difficult to assess whether there is a significant change (e.g. downwards) in time.

2.2.4 Radiation doses to the public

The reported data on average annual effective doses to individuals in the critical group are reasonably complete. Belgium reports some data, Denmark and Portugal report no data at all. France reports doses caused by discharges from La Hague, but no data for the nuclear power reactors. Some Contracting Parties, according to the reporting format, report both doses caused by current discharges and separately total doses including also those resulting from historic discharges. Other Contracting Parties report either doses resulting from current discharges or the total doses including historic discharges. The type of data reported is partly dependent on whether the doses are estimated from measured discharges or from environmental measurements. Some Contracting Parties report doses that are estimated for real critical groups. For hypothetical critical groups various degrees of realism have been used. When the doses are based on measurements of concentrations in the environment the doses may also include contributions from other sources. Together, all these factors introduce uncertainties in the comparison of the doses between countries. The reported doses to individuals often show "less than" values, which make them difficult to interpret and to use in an assessment. There is limited information on site specific target annual effective dose. As there is no information on uncertainties, it is difficult to assess whether there is a significant change (e.g. downwards) in time.

2.3 Achievements according to the OSPAR strategy

In addition to the information requested in the Guidelines, information should also be submitted with respect to the achievements of the requirements set out in the OSPAR Strategy with respect to radioactive substances. No such information has been submitted by the Contracting Parties, at least not under a separate heading. The Contracting Parties might have felt that the requested information was already entered under existing headings. However, such information has later been given in the national plans[3] submitted during 2002, and will be assessed separately.

3 DISCHARGES

The reporting by the Contracting Parties takes place over a three-year period (2000-2002). Therefore, the requested six-year data are in fact from different periods of time. To be consistent with the evaluation for the second round of implementation reporting, which covered the years 1991 to 1994, and to be able to compare the results from the second and third rounds, the evaluation and assessment of the third

[3] In accordance with the Programme for the More Detailed Implementation of the Strategy with regard to Radioactive Substances (reference number 2001-3). See also the 2003 Programme report adopted by the OSPAR Commission (OSPAR 2003 Summary Record, Annex 30).

implementation round basically covers the four-year period from 1995 to 1998. However, to show trends in discharges for a longer time period, the assessment presented in this chapter also includes data from surrounding years when appropriate and when available in the reports.

In their reports, the Contracting Parties compare discharges normalised to energy production with data given in the UNSCEAR 1993 report. Since the UNSCEAR 2000 report is now available, all comparisons in this summary report are made with respect to these more recent data, which is in line with the Guidelines. In addition, the comparisons are made year by year for each of the years 1995-1997 (UNSCEAR data are not available for 1998) instead of the average value for these years. However, average values for 1991-1994 and 1995-1998 are used to compare changes in discharges between the second and third rounds of implementation reporting.

3.1 Data completeness, representativeness and quality

The discharge data submitted by the Contracting Parties are largely complete, representative and have relevant quality. However, the time series given for discharges vary between different facilities and between Contracting Parties. Some Contracting Parties only report (nuclide specific) absolute values (Bq/year) or normalised values (Bq/year normalised to electricity produced) while others report both. The assessment in this summary report is based on the data actually submitted in the national reports. However, in a few cases where data are missing in an implementation report, supplementary data, originating from the yearly reports to OSPAR on liquid discharges from nuclear installations or from the latest UNSCEAR report, have as an exception been used in this summary. Where these other data sources have been used this has been indicated as footnotes in the appropriate tables. Emissions to air have not been considered in this summary report.

3.2 Time trends

The time trends in discharges of radioactive substances are presented for nuclear power reactors (divided into different reactor types); research (reactors) and development facilities; reprocessing plants; and fuel fabrication plants; respectively.

3.2.1 Nuclear reactors

The time trends of discharges are given for pressurised water reactors (PWR), boiling water reactors (BWR) and gas cooled reactors (GCR, divided into Magnox reactors and advanced gas cooled reactors, AGR), respectively. The assessment is primarily based on tritium discharges and discharges of radionuclides other than tritium, in absolute terms as well as normalised to the energy output. Nuclide-specific trends are given for Co-60 and Cs-137. For PWRs and BWRs, the global normalised average according to UNSCEAR 2000 is used to construct a range with the span of one order of magnitude around the global mean value. In accordance with the evaluation of the second round of implementation reporting, values “above range” may then indicate that BAT is not applied for a specific source, whereas values “within range” or “below range” indicate that BAT may be applied. For the third implementation round comparisons with UNSCEAR data are only possible for 1995 to 1997 as no later data are available. It should be noted that comparisons can only be made on the basis of long-term performance. For example, fluctuations between individual years may be due to long outages, which reduce the electrical output but not necessarily the discharges.

The total discharges for all PWRs, BWRs, Magnox and AGRs, respectively, to the Convention waters for the time period 1995 to 1998 are shown in Figures 1 and 2. The total discharges of tritium show an increase (about 20%) mainly caused by increased discharges from AGRs and PWRs reflecting primarily an increase in energy production. The discharges of other radionuclides than tritium are reduced or stable depending on reactor type (see below).

PWR

The reported discharges for PWRs are summarized in Tables 1 to 4.

The absolute discharges of *tritium* vary between 0,03 TBq/year (Belleville 1995) and 81 TBq/year (Paluel, 1997) during the time period 1995-1998 (Table 1). Both the total tritium discharges from all PWRs and the annual average tritium discharges for all PWRs indicate an increase during the four years 1995 to 1998 while this is less pronounced for the average normalised discharges taking into account the energy production[4]. The annual average normalised tritium discharges for all PWRs are below the corresponding UNSCEAR average value (Table 2). In addition, for each of the PWRs the maximum normalised discharge is in or below the UNSCEAR range. While the UNSCEAR average value has decreased from 21 TBq/GWa for the period 1991-1994 to 18,7 TBq/GWa for the period 1995-1998, the corresponding value for the reactors in the OSPAR countries has increased from 13,9 to 16,2 TBq/GWa, respectively (Table 5). However, the value for the reactors in the OSPAR countries is still below the global average.

The annual total discharges of *radionuclides other than tritium* from all PWRs show a continous decreasing trend, summing up to about 40% from 1995 to 1998 (Table 3). For the individual reactors (or sites) the annual normalised discharges from all reactors except three are within or below the UNSCEAR range (Figure 3). The reactors above-range are Beznau in Switzerland (during 1995-1997), Ringhals 2-4 in Sweden (during 1995 and 1997) and Sizewell B (1997). There is no UNSCEAR value for 1998, but it cannot be excluded that these reactors will be above range also for 1998. For Beznau, the increase of the liquid discharges in 1998 was caused by preparatory work to a replacement of the steam generators in unit 2, which was carried out in 1999. In 1999 the discharge value was back to the same level as 1997 (Table 4). Over a longer time period, the normalised discharges from all three sites show a stable to decreasing trend. In comparison with the UNSCEAR 1993 range, which was used in the national reports, all PWRs are within or below the UNSCEAR range.

The average normalised discharges of *radionuclides other than tritium* for the whole time period from 1995 to 1998 is 4,9 GBq/GWa compared with the UNSCEAR value of 8,2 GBq/GWa. The corresponding values for the second round of implementation were 20,8 and 16 GBq/GWa, respectively (Table 5). It can be concluded that the average normalised discharge from PWRs in the OSPAR countries during the third implementation round shows a decrease compared to the second implementation round with about 75%.

To investigate potential downward trends in *nuclide specific* discharges, the radionuclides Co-60 and Cs-137 are chosen as examples as these are frequently reported by the Contracting Parties. These radionuclides also contribute substantially to the radiation dose to the critical group. The discharge time trends of Co-60 and Cs-137 may, however, deviate from the discharge time trends for the sum of all radionuclides (excluding tritium). Figures 4 and 5 show the total discharges (in Bq/year) from all PWRs in France, Germany, the Netherlands, Spain, Sweden and Switzerland, respectively. Although there are deviations for single years, the discharges are constant or decreasing during the reported 5 to 8 years. The increase of discharges from German reactors are due to a 15-fold increase of Co-60 in Biblis B in 1998. There is no explanation to this increase. At Borssele (the Netherlands), there was a general increase of beta and gamma emitters during 1997 due to a large retrofitting programme.

BWR

The reported discharges for BWRs are summarized in Tables 6 to 9.

The absolute discharges of *tritium* vary between 0,01 TBq/year (Wurgassen 1997, 1998) and 1,10 TBq/year (Barsebäck, 1996, and Leibstadt, 1997) during 1995-1998. The annual average tritium discharges for all BWRs as well as the average annual normalised discharges show slightly higher values

[4] The normalised discharge for 1998 does not include French reactors as there are no data provided on energy production.

in 1996 and 1997 but the discharges are still rather constant during the four years 1995 to 1998. The annual normalised tritium discharges from BWRs are exclusively in or below the range of UNSCEAR values (Table 7). Also, for each of the BWRs the normalised discharges are in or below the UNSCEAR range. While the UNSCEAR average values show a minor decrease (0,96 and 0,87 TBq/GWa) between the periods 1991-1994 and 1995-1997, the reactors in the OSPAR countries show a more clearly decreasing trend from 1,29 to 0,83 TBq/GWa (Table 10).

The annual total discharges of *radionuclides other than tritium* from all BWRs are 77% higher in 1996 and 61% higher in 1997 when compared with the discharges in 1995 (Table 8). The discharges in 1998 are back at the same level as in 1995. The increases are caused by discharges from Barsebäck in 1996 and in 1997 by Ringhals 1(see below). For the individual reactors (sites) the annual normalised discharges are above the UNSCEAR range for four sites (Figure 6), the other four sites being below the UNSCEAR range. The four facilities giving rise to the above-range discharges are Muehleberg in Switzerland, Doodewaard in the Netherlands and Barsebäck and Ringhals 1 in Sweden. Doodewaard was shut down in 1997, and there are no reported discharges in 1998. The transient peak for Barsebäck in 1996 is caused by an intensive testing campaign initiated by safety regulations. This resulted in large volumes of wastewater and elevated discharges of Co-58 and Co-60 during August 1996. The peak for the Ringhals discharges during 1997 was due to an outage for 212 days (resulting in a net electrical production less than half of the normal) to perform upgrading to, *inter alia*, reduce future doses. For both Barsebäck and Ringhals there are decreased normalised discharges after the peak values. For Muehleberg, the normalised discharges are again lower in 1999 (Table 9). The decrease is due to a supplementary system (installed in 1998) for cleaning already clarified water, and an improved management with re-use of certain wastewater streams.

The average normalised discharges of *radionuclides other than tritium* for 1995-1998 (65,5 GBq/GWa) is exceeding the maximum value of the UNSCEAR range (35,7 GBq/GWa) (Table 10). There is no change in the "OSPAR-average" since the last four-year period (65,5 and 64,9 GBq/GWa, respectively) while the UNSCEAR value has decreased substantially resulting in this above-range situation.

Liquid discharges of Co-60 and Cs-137 from the BWRs are shown in Figures 7 and 8. Considering the variations between years there are no clear trends. The new treatment system in Muehleberg (described above) is expected to result in a decrease of discharged Cs-137. The amount of metallic waste increased due to several component replacements. Most of this metallic waste could be decontaminated to below clearance limits, largely by using citric acid. In 1998 a process for the distillation of the citric acid arising from decontamination was installed, which led to a reduction of discharges in 1999. (The time trends for Barsebäck and Ringhals 1 are explained above.)

GCR

There are only a few reactors of this type operating elsewhere in the world, and accordingly the UNSCEAR data are mainly based on the UK reactors. Comparisons with UNSCEAR values are therefore not meaningful. However, intercomparisons between years and between implementation rounds allow evaluations of long-term trends in discharges. The assessment is made for Magnox reactors and AGRs separately. The reported discharges for these reactors are summarized in Tables 11 to 14.

For Magnox reactors, the absolute discharges of tritium vary between 0,01 TBq/year (Hunterston A in 1997, energy generation ceased in 1989/90) and 9,88 TBq/year (Wylfa, 1996) during 1995-1998 (Table 11). The annual average discharges of tritium are rather constant in 1985 to 1998. The average normalised data for Magnox reactors for the years 1993 to 1998 show no clear trends neither for tritium nor for *other radionuclides* (Figure 9). Sizewell A, however, deviates from this pattern, in particular concerning larger normalised discharges of other radionuclides than tritium in 1996 (Figure 9) and higher normalised discharges of tritium for the period 1995-1998 (Table 12). The peak value in 1996 can be explained by a substantially lower electricity generation at the same time as the discharges remained at the same level as preceeding years.

For AGRs, the absolute discharges of tritium vary between 15 TBq/year (Dungeness B in 1995) and 460 TBq/year (Heysham 1, 1997) during 1995-1998. The reduction in normalised tritium discharges from Dungeness B in 1995 seems to be a combined effect of reduced discharges (15 times) and reduced electricity generation (3 times) compared to the preceeding year. Also the peak value in 1995 for normalised discharges of *radionuclides other than tritium* (Figure 10) is interpreted as an effect of mainly reduced electricity generation. The average normalised data for AGRs for the years 1993 to 1998 show no clear trends for tritium whereas there appears to be a decrease for other radionuclides than tritium in 1996 to 1998 compared with the preceding years (Figure 10).

Figure 11 shows that there are no clear trends for the discharges of Cs-137 from Magnox reactors. The discharges of S-35 from AGRs show a decrease of discharges from 1993 to 1995 followed by a more constant level of releases for the third implementation round. The discharges of Co-60 from AGRs are constant or slowly decreasing with the exception of the higher discharges from Hartlepool in 1996.

3.2.2 Fuel reprocessing facilities

The discharge data for the two reprocessing facilities, La Hague in France and Sellafield in UK, are summarised in Tables 15 to 17. There are too few reprocessing facilities in the world to allow a comparison with UNSCEAR data.

For Sellafield, the tritium discharges have been steady during the time period 1995-1998 (Table 15). There is no discernable trend in discharges of total beta-emitting radionuclides during the time period (Table 16), Tc-99 excluded. For alpha-emitting radionuclides (Table 17) the discharges are one order of magnitude lower in 1998 compared with 1993, a result of the introduction of the Enhanced Actinide Removal Plant (EARP) in 1995. The discharges of Tc-99 increased substantially from 1993 to 1995 with a maximum discharge of 190 TBq in 1995, whereafter a decrease of discharges have occurred to 53 TBq in 1998 (Figure 13). Decreases in discharges (Figure 13) during the period 1993 to 1998 have been noted for the fission products Zr-95/Nb, Ru-106, Cs-134, Cs-137, and Ce-144 whilst I-129 has shown a marginal increase (3 times), and Sr-90 has been reasonably constant. C-14 discharges have been steady but an increase (appr. 20 times) in Co-60 is noted due to storage of particular sources of BWR fuel in the Thermal Oxide Reprocessing Plant (THORP) facility when thermal oxide fuel reprocessing commenced in 1994. The normalised discharges of tritium and beta-emitters are reasonably steady over the period while the normalised discharges of alpha emitters have been reduced by an order of magnitude in 1998 compared with 1993.

For La Hague, the discharges of tritium have been fairly constant during the period 1995-1998 (Table 15). There is a decreasing trend in the long-term discharges of beta-emitting radionuclides (Table 16), a factor of 5 in 1999 compared with 1994. Also the discharges of alpha emitters (Table 17) show a decreasing trend, a factor of 3 during the same time period. The normalised trends are similar. There have been reductions of Cs-134, Cs-137 and Sr-90 (Figure 14). The discharges of Ru-106, which give the major contribution to radiation dose, vary during the time period. I-129 is presently, with the technique available, discharged into the sea without conditioning.

3.2.3 Fuel production facilities

The data for the fuel production and enrichment facilities are summarised in Table 18. Springfields in UK is the largest source for discharges of alpha emitting radionuclides to the Convention waters (Figure 15). For each of the facilities the discharges of total alpha are reasonably constant (no clear trends) throughout the reported years. The variations in discharges of beta activity for Springfields (Table 18) reflect the level of uranium ore concentrate processed. Since 1996 the discharges of non-uranic alpha emitters (<5% of total alpha) and tritium from Capenhurst show downward trends.

3.2.4 Research reactors and development facilities

The data submitted (Tables 19 and 20) in the national reports do not allow any meaningful normalisation to be performed. It is possible, however, to compare the time trends of absolute discharges, expressed as Bq per year (Figures 16 and 17). The total discharges from all research facilities show a decreasing trend from 1993 to 1998 (it is not possible to conclude anything for 1999 due to lack of data) for both tritium and other radionuclides. The discharges, tritium excluded, are dominated by the discharges from Dounreay that are approximately two orders of magnitude larger than from any other facility. For the tritium discharges, Karlsruhe and Winfrith are the largest contributors. The discharges from Karlsruhe show a continous decrease 1993-1998.

The principal radionuclides in the discharges from Dounrey are fission products (mainly Cs-137, Ru-106 and Sr-90) from reprocessing, K-40 and Na-22 from coolant destruction, Co-60 and tritium from decommissioning, and actinides and fission products from other facilities. There is a significant reduction of discharges of fission products after the cessation of reprocessing in 1996.
At the research centre in Karlsruhe, emissions to the air and discharges to the water are mainly caused by the handling of open radiation materials in various facilities and laboratories. Contributions also arise by the decommissioning of the research reactors and the pilot reprocessing plant.

3.3 Observations

For some facilities, the measured discharges emanate from sources of different kind which are not possible to separate. This may give rise to a certain degree of bias and overestimation of the discharges, but do not seem in general to influence the time trends from a particular facility. Another factor that may bias the interpretation, and in particular the comparison of absolute discharges from different facilities, is which radionuclides are actually reported. In some cases all measured or detected radionuclides are reported, in other cases only selected radionuclides are reported. A criterion for such a selection may be that radionuclides with short halflifes are not reported. Such inconsistences introduce a degree of uncertainty in the analysis, the magnitude of which is difficult to estimate.

In their reports, the Contracting Parties compare their normalised discharges with those in the UNSCEAR 1993 report. As UNSCEAR 2000 has now become available, it is possible to make comparisons for the years that are actually covered in the third implementation round, with the exception of one year (1995-1998 compared to 1995-1997). As a consequence it can be concluded that this change of reference years in some cases lead to discharge values above-range compared to what was originally reported by Contracting Parties.

The BAT indicators listed in the Guidelines have been used to various degrees by the Contracting Parties.

4. ENVIRONMENTAL RADIONUCLIDE CONCENTRATIONS

4.1 Data completeness and representativeness

In the third round of implementation reporting, the Contracting Parties should for the first time also submit information on environmental impact. There are at present no establised BAT/BEP indicators for environmental impact, but one indicator specified in the Guidelines is the time trend in concentrations (see Chapter 4.2). According to the Guidelines (Annex 2) the submitted information should include concentrations of radionuclides of concern in environmental samples for at least the last six years before reporting. Furthermore, information should be included about nuclide libraries, environmental monitoring programmes, national target values and quality assurance of data. In the following, the submitted information on these issues are briefly summarised for each contracting Party.

4.1.1 Belgium

CONCENTRATIONS
No information provided.

NUCLIDE LIBRARIES
No information provided.

ENVIRONMENTAL MONITORING PROGRAMME
Monotoring is carried out around the Belgian nuclear sites and on Belgian territory close to the French power stations Chooz and Gravelines. The monitoring programme includes sampling and measurement of activity in air/rainwater, river water, seawater, drinking water, river and marine sediments, sea flora and fauna, and samples from the food chain. The sites chosen for collection of samples are selected to represent the exposure conditions and the environmental situation. The sampling frequency is defined in order to have information as representative as possible taking technical and other possibilities into account. In the Belgian report information is given concerning type of measurements, type of analyses and their frequency. It is also mentioned in the report that there is a national automatic network of atmospheric measurements (TELERAD) of radioactivity.

NATIONAL TARGET VALUES
No information provided.

QUALITY ASSURANCE
No information provided.

4.1.2 Denmark

No information provided.

4.1.3 France

The French report gives general information concerning nuclear installations and specific information for the reprocessing facility in La Hague.

CONCENTRATIONS
No nuclide specific data are given on concentrations in the environment.

NUCLIDE LIBRARIES
Relevant radionuclides are listed.

ENVIRONMENTAL MONITORING PROGRAMME
There are two programmes. The *operator* has to install a specific laboratory at the site for measuring radioactivity in the environment. The operator has also to install and maintain two mobile laboratories permanently ready to operate on or outside the site. The nature, frequency and localisation of sampling and measurements are set in the authorisation. They comprise sampling of surface and underground waters, sediments and fauna and flora. The operator has also to monitor the environment, for instance physical and chemical properties of waters, the development of aquatic flora, the development of benthic and microbial species, considering pathologic risks, the development of aquatic fauna, the evolution of sediments, and if necessary of the thermal impact of discharges. The *regulator* (OPRI) has its own program of sampling and analyses. OPRI duplicates some of the measurements performed by the nuclear installations. It also makes additional measurements of water, air, and plant samples, and of food

consumed by humans and animals. Every year OPRI carries out a radioecological measuring survey of the terrrestrial, marine, and aquatic environments surrounding EDF nuclear facilities. This involves taking over 500 samples of a wide array of biological indicators, including *inter alia* the grass, moss, fish, algae and fruit. Every ten years, a comprehensive radioecological report assesses all changes compared to the initial impact study that was the original 'point zero'. Specialized, private or public laboratories, such as IPSN (Institute for Nuclear Safety and Protection), may also conduct *ad hoc* studies.

NATIONAL TARGET VALUES

At present there are no target values.

QUALITY ASSURANCE

The technical conditions of sampling, analyses and the equipment to be used have to comply with the rules set by the authorities. The regulator (OPRI) periodically organises intercomparison campaigns to check the quality of operator's sampling and analyses.

The Environmental Laboratory of La Hague complies with NF EN 9002 quality standard and is in the process of qualification to NF EN 14001 environmental standard. Concerning the analyses and measurements, these are accredited by the COFRAC (French national accreditation organism) as meeting the requirements of NF EN 45001 standard for calibration and testing. This involves regular calibration of detectors with secondary standards traceable to primary standards and intercomparisons exercises with other laboratories, both national and international (independent of the regulatory intercomparisons with OPRI).

4.1.4 Germany

CONCENTRATIONS

For nuclear power plants and nuclear fuel plants, the analyses of environmental samples (river water, plants, milk, meat, fish, soil) show that there are no detectable alpha- and beta-activity concentrations (excluding tritium) that can be attributed to radioactive discharges from the plants. Tritium discharges from pressurised water reactors can increase the tritium concentrations in surface water of small rivers by 10 Bq/l (e.g. river Ems).

The analyses of environmental samples (river water, plants, milk, meat, fish, soil) from the region of Geesthacht, Jülich, HMI and Rossendorf show that there are no detectable alpha- and beta-activity concentrations that can be attributed to radioactive discharges from these facilities. Tritium discharges from Karlsruhe are responsible for tritium concentrations up to 600 Bq/l in surface water of a small lake near the river Rhine.

NUCLIDE LIBRARIES

According to regulations issued by the authorities.

ENVIRONMENTAL MONITORING PROGRAMME

The environmental programme in the vicinity of nuclear power stations is described in the regulatory guideline on emission and environmental control. The different measurements programmes are listed according to nuclear installations (no details are given in the German report). The environmental programme is undertaken by the operators and by governmental laboratories.

In addition to the site-oriented surveillance of nuclear power plants, a nation-wide system, the so-called Integrated Measurement and Information System for the Surveillance of Environmental Radiation (IMIS), was installed in accordance with the Precautionary Radiation Protection Act. IMIS is intended to provide data on the radiation level in the entire region of the Federal Republic of Germany. Parts of this system have been in operation since the late fifties. Even slight changes in environmental radiation are quickly and reliably detected and evaluated by this system, making it possible to give early warnings to the public if so required. IMIS is permanently in routine operation. In the event of increased values the Federal Ministry for the Environment will cause IMIS to switch from routine to intense operation, which means that measurements and samples will be taken more frequently.

NATIONAL TARGET VALUES
No information provided.

QUALITY ASSURANCE
The environmental programme (performed by the National Institute for Coastal and Marine Management) is undertaken by the operators and by governmental laboratories. The operator's laboratories undertake analyses in accordance with procedures set down in Implementation Documents published by the Federal Ministry for the Environment. Quality control procedures also involve regular calibration of detectors and yearly comparison exercises with other laboratories. All laboratories have secondary standards traceable to primary standards. Therefore, the quality of environmental and discharge sample measurement, and the assessment of impact of discharges and emissions on members of the general public is based not only on the work of the operators but also on a national system of regulators, governmental bodies and independent advisors.

4.1.5 The Netherlands

CONCENTRATIONS
According to the Dutch report it is not expected that the environmental monitoring data can be associated to a unique discharge source. However, discharges from Dutch and foreign nuclear installations lead to an increase of the activity concentrations in the environment. Concentrations (alpha, beta, tritium and Ra-226) are given for water samples.

NUCLIDE LIBRARIES
The reported activity concentrations are total alpha, total and rest beta, tritium, Pb-210/Po-210, Sr-90 and Ra-226. Of the detected gamma emitting radionuclides in environmental samples only Co-58, Co-60, Cs-134, Cs-137, I-131 and Mn-54 are reported.

ENVIRONMENTAL MONITORING PROGRAMME
The environmental monitoring program consists of measuring water samples and suspended particles. The frequency of sampling is variable per year, per nuclide and per location. For each of the alpha, rest beta and tritium activity measurements an average sampling frequency of 20 times per year per location is kept. Ra-226 activity is measured with an average sampling frequency of 3 times per year per location.

NATIONAL TARGET VALUES
National target levels of activity of radionuclides in the environment are defined for inland water:

- total alpha activity concentration: 0,1 Bq/l
- rest beta activity concentration: 0,2 Bq/l
- tritium activity concentration: 10 Bq/l.

QUALITY ASSURANCE
The methodology of environmental monitoring of gamma emitting nuclides is according to Dutch quality assurance standards. Beta and alpha emitters are monitored according to standards issued by "Kerntechnischer Ausschuss" (German Standard KTA 1504).

4.1.6 Norway

CONCENTRATIONS
Some examples of concentrations in the environment are given in the report, but no time trends.

NUCLIDE LIBRARIES
A standard nuclide library for the detector is used for gamma spectrum analysis.

ENVIRONMENTAL MONITORING PROGRAMME
The environmental monitoring programme is carried out by the operator of the nuclear site. The programme includes river water, sediment, fish and water plants sampled several times during the year. The programme has been approved by the Norwegian Radiation Protection Authority (NRPA).

The NRPA also coordinates national monitoring programmes for radioactive contamination of the marine and terrestrial environments. The principal objective of the marine monitoring programme is to document levels, distributions and trends of anthropogenic and naturally occurring radionuclides along the Norwegian coast, in the North Sea, the Norwegian Sea and the Barents Sea, and to make information regarding radioactive contamination available to authorities, the fishing industry, media and the public in general. Included in the programme is also collection of updated information on both Norwegian and other sources of radioactive contamination and consequence assessments.

NATIONAL TARGET VALUES
Not developed.

QUALITY ASSURANCE
All work tasks, including measurement of activity are described in detail in working instructions and procedures in a quality control and assurance system. Criteria for non-conformity are also defined in these procedures.

4.1.7 Portugal

No information provided.

4.1.8 Spain

CONCENTRATIONS
Data on concentrations are given for surface water and sediments for all sites.

NUCLIDE LIBRARIES
The minimum nuclide libraries for gamma-spectrometry contain Mn-54, Co-58, Co-60, Fe-59, Zn-65, Nb-95, I-131, Cs-134, Cs-137, La-140 and Ce-144, in addition to total beta, Sr-90, I-131 and tritium.

ENVIRONMENTAL MONITORING PROGRAMME
The main requirements for the environmental monitoring programmes are defined in the CSN (Consejo de Seguridad Nuclear) Safety Guide 4.1. The number and locations of sampling points, the type of samples to be selected and the required analysis are defined in the preoperational phase, intended to characterise the site radiologically before it is affected by the facility's operation. The main pathways of human exposure to radiation are monitored as well as other ecosystem elements that are good indicators of the evolution of radioactivity in the environment. The environmental monitoring programme include samples of drinking water, river water, marine water, ground water, soil, sediments, biota, milk, fruits, cereeals, meat, eggs, fish, seafood and honey with a frequence of sampling between every fortnight and once per year.

The environmental monitoring programmes are performed by the operators and the CSN executes an independent programme, including the same type of samples and analysis, the scope of which has been established at 5% of the operator's programme. The CSN also performs periodic inspections and audits to verify that the facilities comply with the programmes, which are updated annually.

In addition to the surveillance in the vicinity of nuclear installations, a nation-wide system is established in order to detect quickly and reliably changes in environmental radiation, making it possible to give early warnings to the public if so required. The national network comprises on-line monitoring and sampling stations where specific surveillance programs are performed, including the atmosphere, soils, and continental and coastal waters. For surface waters, analysis of tritium, gross beta, residual beta, Sr-90, and gamma spectrometry are performed quarterly.

NATIONAL TARGET VALUES
No information provided.

QUALITY ASSURANCE
A quality control programme is used, including the analysis of duplicated samples by two different laboratories, over a range of 5% -15% of the total environmental programme.

4.1.9 Sweden

CONCENTRATIONS
As examples, data are given for a six years period of time on radionuclide concentrations in three types of environmental samples from the marine environment, i.e. sediment, eel (*Anguilla anguilla*), and bladder wrack (*Fucus vesiculosus*). The samples have been taken at stations close to the discharge points and are examples of the available data.

NUCLIDE LIBRARIES
The compulsory nuclide library used in environmental monitoring is given in the report.

ENVIRONMENTAL MONITORING PROGRAMME
The environmental samples consist of local fauna and flora (algae, fish, shellfish, mosses, game), sediment, as well as local food produce (grain, milk etc.). A basal programme is performed in essentially the same fashion from year to year. In addition, an extended programme is performed every fourth year. Sample locations, types of samples, sampling frequency and time for sampling for the marine environment in the vicinity of the Ringhals and Barsebäck are specified in further detail in the report. The programme has been approved by the Swedish Radiation Protection Authority (SSI).

NATIONAL TARGET VALUES
Not specified.

QUALITY ASSURANCE
To verify that the facilities comply with the programme, SSI performs inspections and takes random double samples for measurements at the SSI laboratories. SSI performs yearly inter-comparisons, where the operators analyse samples (liquid samples, filter samples or environmental samples of unknown activity) prepared by SSI.

4.1.10 Switzerland

CONCENTRATIONS
Data on concentrations in river water are given for four years. All Swiss nuclear facilities release their liquid discharges into the same river system. Three of the plants and the research facility Paul Scherrer Institute are located at the river Aare, which flows into the river Rhine. One plant is located at the river Rhine. As a result of this, the environmental monitoring data can only partly be associated to a unique discharge source. There are three locations in this river system where samples of river water and sediments are taken permanently.

NUCLIDE LIBRARIES
A number of beta/gamma radionuclides are measured in environmental samples and given in the report.

ENVIRONMENTAL MONITORING PROGRAMME
The authorities have issued regulations on a complete programme on environmental monitoring of radioactivity and direct radiation in the vicinity of each facility The environmental monitoring programme includes measurements of dose rate and integral dose as well as samplings and measurements of air, drinking water, rainwater, river water, sediments in the river, soil, plants and food. The programme is reviewed annually and subsequently modified as necessary.

NATIONAL TARGET VALUES
There are limits for the concentration of radioactive substances in the atmosphere and water (immission limits). The Radiological Protection Ordinance defines a weekly mean value of the concentration in water accessible to the public, which must not exceed 2% of the exemption limits defined for each nuclide. The Ordinance applies for water with a specific activity exceeding 1% of the exemption limit.

The Swiss Ordinance on Foreign Substances and Ingredients defines limits and as an additional constraint tolerance values for radioactivity in food. The tolerance values basically fulfil the 10 microSv per year concept.

QUALITY ASSURANCE
No formal quality assurance system is applied but annual quality checks are done.

4.1.11 United Kingdom

CONCENTRATIONS
Examples of concentrations in selected marine environmental samples (shrimps, fish (cod, flounder, sole, salmon, bass, brown trout, perch, plaice, pike), native oysters, pacific oysters, lobster, winkles, crabs, mussels, and mud) are given for each site and for radionuclides of concern for the years 1993 to 1998.

NUCLIDE LIBRARIES
The radionuclide libraries used by the operators for assessing the contents of discharges and emissions and for measuring environmental samples are given in the report together with the libraries used by the regulators (the Environment Agency and SEPA) and MAFF.

ENVIRONMENTAL MONITORING PROGRAMME
All operators undertake environmental monitoring, not only to comply with conditions in authorisations but also to provide the general public with information regarding the impact of the facility on the local environment. Monitoring programmes take in sampling of both marine food chain and indicator species, local food produce, direct radiation from facilities, and external radiation from publicly accessible places (e.g. beaches).

Independent monitoring is undertaken by the regulators and by government bodies as follows:

In England and Wales, the Environmental Agency (EA) undertakes a programme of monitoring to provide checks on site operators' data and an independent assessment of the exposure to non-food pathways. It encompasses liquid effluents (as described above), quality checking of solid waste disposals, measurement of radiation and radioactivity in the environment, air, rainwater and drinking water sources. This work is undertaken by contractors according to technical and quality assurance specifications laid down by the EA. Results are openly published on an annual basis.

Also in England and Wales, the Ministry of Agriculture, Fisheries and Food (MAFF) undertakes a programme of surveillance of radioactivity in a range of foodstuffs, both marine and terrestrial, and other materials close to nuclear sites throughout the UK, and the results are used to estimate the doses to members of critical groups (which are identified through habit surveys). The programmes take in locations remote from nuclear sites; for example, many areas along the coastline of the Irish Sea are monitored. In addition, the programmes encompass Northern Ireland, the Isle of Man and the Channel Islands. Results are openly published annually.

In Scotland, a combined monitoring is undertaken by the Scottisch Environment Protection Agency (SEPA) which encompasses those areas covered by MAFF's programme and the EA's programme in England and Wales. The results are jointly published along with those from MAFF's programme annually.

NATIONAL TARGET VALUES
No information provided.

QUALITY ASSURANCE
The quality of environmental (and discharge) sample measurements, and the assessment of impact of discharges and emissions on members of the general public is based not only on the work of operators but also on a national system of independent regulators (eg. EA, SEPA), advisers (eg NRPB) and government bodies, each relying on accreditation to an appropriate International Standards Organisation (ISO) or other standard. Quality is therefore an in-depth feature of the system and arises from both the standard of individual laboratories and from cross-checking results and intercomparison of assessment techniques.

Operators' laboratories possess radiation standards which are traceable to national standards and they are required to undertake analyses in accordance with procedures set down in Implementation Documents (which are agreed with the regulators and are descriptions of the procedures the operator will use to comply with conditions in the RSA93 Authorisation).

Laboratories undertaking analyses for the EA and SEPA are required to do so in accordance with technical and quality assurance specifications laid down by the respective Agencies. The laboratories who perform analyses for MAFF are accredited by the United Kingdom Accreditation Service whereby they meet the requirements of ISO/IEC Guide 25 and EN 45001, the European standard for the operation of calibration and testing laboratories; this implies compliance with the ISO 9000 series of standards. Quality control procedures also involve regular calibration of detectors and intercomparison exercises with other laboratories, both national and international. All laboratories have secondary standards traceable to primary standards.

4.2 Time trends

According to the Guidelines, the Contracting Parties were asked to submit concentrations of radionuclides of concern in environmental samples for at least the last six years. As stated above, the Netherlands has reported data on seawater, Spain on surface water and sediments, and Switzerland on river water. Sweden and UK have in addition submitted nuclide specific data on concentrations also in other environmental compartments. A selection of the submitted data from Sweden and UK is presented here.

Figures 18 and 19 show concentrations (in dry weight) of different radionuclides in eel (*anguilla anguilla*) and bladder wrack (*fucus vesiculosus*) in the marine environment outside the Ringhals nuclear power plant in Sweden. The concentrations of Cs-137 are partly due to other sources, mainly the Chernobyl accident, while the other radionuclides originate mainly from discharges from the four reactors in Ringhals. No clear trends can be observed.

Figure 20 shows concentrations of different radionuclides (in wet weight) in cod, crab, lobster, and mussels in the marine environment outside Sellafield in UK. The concentrations originate from a number of different facilities within the Sellafield plant. For the concentrations shown, there is no clear time trends with the exception of the clear increase of Tc-99 in lobsters due to the increased discharges starting in 1994.

4.3 Observations

A general observation is that there is fairly little information submitted in particular on concentrations of radionuclides of concern in environmental samples and for at least six years. Some Contracting Parties report that either there are no detectable concentrations in the environment (Germany) that can be attributed to the facility, or that it is not possible to associate the detected concentrations to a particular discharge source (The Netherlands), or can only be partly linked to a unique source (Switzerland). Only Sweden and UK have submitted time series for various environmental compartments. The data from France are difficult to interpret as the concentrations are not nuclide specific.

Another observation is the general lack of national target levels of radioactive substances in environmental samples, and radiation doses to the environment. The lack of data on doses to marine organisms is expected realizing that there are at present no established international consensus on how such doses should be assessed.

The Contracting Parties can improve their Summary Evaluations which shall take into account the BAT/BEP indicators, data completeness and causes for deviations from indicators. The environmental quality criteria, indicators for concentrations of radionuclides in environmental samples, still have to be developed. Meanwhile, downward trends in data may be used.

5 RADIATION DOSES TO THE PUBLIC

5.1 Data completeness, representativeness and quality

The Contracting Parties have submitted information on dose assessment and radiation doses to various degrees of detail. A brief summary of the information submitted is given for each Contracting Party. The summary, taken from the reports, includes *inter alia* information submitted on dose constraints, annual effective doses, critical group and dose assessment methods.

5.1.1 Belgium

There is no data in the report on annual doses as a consequence of discharges from the nuclear installations, no definition of critical group(s), no methodology for estimating doses or explanations for lack of data. The dose limit for the general public is 1 mSv/year. Data obtained from TL dosimeters are submitted for locations around the facilities. These give doses between 0,6 and 1,2 mSv/year mainly caused by radionuclides of natural origin.

5.1.2 Denmark

There is no data on annual doses resulting from the nuclear installation, definition of critical group(s), methodology for estimating doses or explanations for lack of data.

5.1.3 France

Information is given for radiation doses from La Hague but not from other nuclear installations. The official dose limits for members of the public is 5 mSv/year during the time period covered by this report, but it will be lowered to 1 mSv/year according to EURATOM 96/29 Directive. For La Hague, the operator applies a dose constraint of about 0,1 mSv/year for setting discharge limits. An expert group appointed by the French Ministry of Health in 1996 recommended that a real group of persons should be chosen as the reference (critical) group and that all exposure pathways should be taken into account. This excludes a purely hypothetical group. The critical group relative the marine pathways outside La Hague is fishermen in Goury who are the most exposed people to this source both from external (for example sea spray and contact with fishing gear) and internal irradiation. It is conservatively assumed that all seafood ingested is of local origin. Diet is based on enquires. Doses to Goury fishermen (adults) from marine pathways are given in Table 23.

General conclusions concerning the marine exposure pathways from all data given in the report are: children are less exposed than adults; the dose to adults resulting from real releases are more than an order of magnitude less than the dose constraint; there is an indication of a decreasing trend of doses to adults 1994-1999; the external dose is a few percent of the internal dose; and more than 50% of the dose is due to Ru-106, mainly through ingestion of crustaceans.

5.1.4 Germany

The dose limit applied in Germany for members of the public is 1,5 mSv/year, but 1 mSv/year according to the EURATOM Directive 96/29 is in the process of being implemented. Dose limits resulting from radioactive discharges and emissions of nuclear installations are specified in the Radiation Protection Ordinance for aerial and liquid releases each: (i) individual effective dose, partial body dose for gonads, uterus, red bone marrow 0,3 mSv/year; (ii) partial body dose of all organs and issues unless under (i) or (iii) 0,9 mSv/year; (iii) partial body dose of bone surface and skin 1,8 mSv/year. Emissions and discharges from other nuclear installations must be taken into account.

The dose is calculated at the most unfavourable receiving points taking into account the relevant exposure pathways and living habits. On the basis of these assumptions and further parameters used in the models, it can be assumed that the radiation exposure to individuals will not be underestimated. The Federal Office for Radiation Protection (BfS) yearly calculates the radiation dose to individuals in the public from all nuclear facilities in Germany. The calculations are based on discharge data measured by the operators. The transfer factors, procedures for calculation of activity concentrations of radionuclides in different media, consumption rates for adults and children, dose factors for internal and external exposure for organs and exposure pathways for adults and children (1 year) for the calculation of internal and external radiation exposure are defined in the General Administrative Provision to §45 of the Radiation Protection Ordinance. The doses are given in Tables 21 to 23.

5.1.5 Norway

The dose limit for discharges is 0,001 mSv/year for the most exposed members of the public. The dose limit for emissions to air is 0,1 mSv/year of which iodine isotopes should not contribute more than 0,01 mSv/year. The critical group is hypothetical and defined by its food consumption and living habits. The dose estimates are based on theoretical radionuclide concentrations in the environment calculated from measured discharge values. The doses are to adults, but doses to children do not deviate significantly from adults. All modelling of transfer of radionuclides in the environment and resulting doses to critical group are based on the use of the code PC-CREAM. The doses are given in Table 23.

5.1.6 The Netherlands

The dose limit for members of the public from all sources is 1 mSv/year. A source limit of 0,1 mSv/year is applied for a single source for example for the normal operation of a nuclear power plant. In addition, there are risk criteria for accidents to which nuclear installations have to demonstrate compliance. The reference (critical) group is a hypothetical homogenous group for which the individual dose (to adults) due to the source is highest. Reference behaviour is the behaviour, given a certain contamination in the environment that leads to the highest dose. This behaviour contains all habits of living. To detertemine reference behaviour only realistic assumptions are taken into account. The considered exposure pathways are consumption of seafood (mussels, shrimps and sea fish), ingestion of drinking water and ingestion via deposition to surface water from emissions to air. The doses are estimated based on models and actual discharge data. Site-specific factors to estimate dose from discharges have been calculated for the most relevant radionuclides. For Borssele, site internal targets for the annual effective dose have been defined. For example, for the year 2000 an effective dose target of 5,5 nSv per year as a consequence of all discharges (gaseous and liquid) is defined. The doses are given in Tables 21 and 23.

5.1.7 Portugal

There is no data in the report on annual doses resulting from the nuclear installation, definition of critical group(s), and methodology for estimating doses or explanations for lack of data.

5.1.8 Spain

The dose limit for members of the public is 1 mSv/year. From 1993 the effective dose is 0,3 mSv/year for nuclear power plants and other nuclear fuel cycle installations. Actual discharge limits must be lower than or equal to the constraint value. For nuclear power plants a global dose limit for emissions and discharges of 0,1 mSv/year was established in 1996. This value was determined taking into account the former effluent limits, based on the design objectives of the treatment systems.

Calculation of doses to the public due to liquid and gaseous releases from nuclear facilities are intended to verify that discharge limits are complied with in the most unfavourable scenario and are, therefore, very conservative. In addition, dose assessments based on actual discharge data and on environmental measurements are also made by CSN periodically. Critical groups are supposed to be located in the area where maxiumum air concentrations and aerosol deposits are estimated and foods are assumed to be produced in the area of maximum aerosol deposits. The methodology used in dose calculations is the same for all Spanish nuclear facilities and include local characteristics, population habits and land and water use. The doses are given in Tables 21and 23.

5.1.9 Sweden

The dose limit for individuals in the general public from all practices is 1 mSv/year. For nuclear power plants the dose constraint is 0,1 mSv/year. Dose reduction below this value is achieved through optimisation. The doses are assessed by site-specific model calculations. For each nuclear facility and for each nuclide released, site-specific release-to-dose values have been calculated for hypothetical critical groups. The calculations take into consideration local dispersion conditions as well as moderately conservative assumptions on diet and contribution of locally produced foodstuffs to the diet of the group. For nuclear power plants, such site-specific release-to-dose values have been defined for approximately 50 radionuclides discharged into the marine recipient. Internal targets for annual effective dose have been defined for the site. The doses are given in Tables 21 and 22.

5.1.10 Switzerland

The dose limit for members of the public is 1 mSv annual effective dose including exposure due to historic discharges. A source-related dose constraint is set for nuclear installations at 0,2 mSv/year for emissions to air and discharges to water and 0,1 mSv/year for direct radiation. In addition, there are additional constraints related to incidents. The dose calculations are done for an individual who is living and working at the place with the highest total dose from immersion, inhalation, ground radiation and ingestion. It is assumed that food consumed is produced at this place. The drinking water and fish consumed are from the river downstream of the facility. The models and parameters used to estimate doses are taken or derived from international recommendations e.g. IAEA, ICRP or foreign regulations e.g. German guidelines. According to the Swiss Radiation Protection Ordinance activities which result in an effective dose less than 10 microSv per year are deemed justified and optimised. The dose from the annual discharges is estimated to be below 1 microSv/year for all Swiss facilities. If also historic discharges are taken into account, the estimated doses vary between below 15 and below 2 microSv/year depending on facility and year. According to Swiss legislation no further efforts are necessary to reduce releases and resulting doses for the population. The doses are given in Tables 21 to 23.

5.1.11 United Kingdom

The dose limit applied within the UK for members of the general public is 1 mSv/year for all artificial sources excluding medical exposures. It includes exposure due to historic disposals of radioactive waste. A source constraint of 0,3 mSv/year applies to current and perspective radioactive waste diposals from a single source. It excludes doses arising from historic disposals. Strictly, this applies only to new facilities. If an existing facility is unable to comply with this constraint, the operator must demonstrate that the dose is ALARA and that the dose limit is not exceeded. If there are two or more nuclear facilities with contiguous boundaries at a single location, a site constraint of 0,5 mSv/year applies in regard to current and prospective radioactive waste disposals from the location but not from direct radiation and historical disposals. It applies to all plant regardless of age. In addition, there is an optimisation treshold of 0,02 mSv/year below which operators are not required to secure further reductions in exposures to members of the general public, providing that they have atisfied the regulators that BPM is being applied to limit discharges.

Calculation of radiation dose to the general public from a nuclear facility is based on assessment of ingestion through consumption of foodstuffs and external radiation from contaminated materials arising from discharges. Habit surveys together with measurements on marine (and terrestrial) foodchain components and external radiation identify the members of the public who will be the most exposed. Where no measurements have been possible, mathematical models have been used to provide supplemental information. Application of dosimetric data to the survey and sample mesaurement information yields the doses to members of the general public and identifies the critical group for each pathway. These critical groups are set down in the tables for the individual premises. From this it will be seen that dose estimates reflect what is actually found in the environmenet and therefore represent both current and past discharges including emissions of radionuclides of concern to the marine environment. To separate the effects of current and historic discharges are therefore not possible other than by either complex environmental modelling or by the identification of radionuclides clearly identifiable with histortic discharges and disaggregation of the dose arriving from them. The doses are given in Tables 21 to 23.

5.2 Time trends

The time trends are presented for nuclear power reactors (divided into the different reactor types, reprocessing plants and research reactors and development facilities, respectively.

Doses are given in Tables 21 to 23.

5.2.1 Nuclear reactors

PWR

There are 37 reactor sites with PWRs covered by the OSPAR convention. Of these, doses to individuals of the critical group are reported for 20 sites. Of these, 9 sites have reported dose values less than 1 or 0,1 microSv per year. For the remaining sites the doses vary between practically zero (0,28 nSv/year) and 4,79 microSv per year (Table 21). All doses are substantially lower than 1 mSv/year, the most common dose limit used by, or to be used by, the Contracting Parties. There are no clear trends for the time period 1995 to 1998 neither for the individual sites nor for the average value. There are too few data for 1999 and 2000 to draw any conclusions. The Spanish reactors generally give a higher dose to the critical group, but still substantially below the dose limit. It is unclear whether these doses also include doses from emissions to air.

BWR

Of the 9 reactor sites with BWRs dose values are reported for 4 sites. For the remaining sites only less than values are reported (Table 22). The Swedish reactor Ringhals 1 is included in the doses from the site (1 BWR and 3 PWRs) and reported among the PWRs. The doses vary between 0,05 and 0,22 microSv per year and with a rather constant average value for the sites. The doses are far below the dose limit of 1 mSv per year.

GCR MAGNOX

The average value for the Magnox reactors is 16 microSv per year for the period 1995 to 1998 (Table 22), which is substantially lower than 1 mSv/year but higher than during the second implementation period 1991 to 1994 when the average was 4 microSv per year. It should be noted that for 4 sites (Dungeness, Heysham, Hinkley Point and Hunterston) the doses include also the AGRs at the site. The maximum dose during the period is 43 microSv per year (Trawsfynydd 1996, discharges to an inland lake). There is no clear trend for the average value.

It should be noted that all coastal sites are affected to varying degrees by the discharges from Sellafield.

GCR AGR

There are 7 reactor sites with AGRs. However, for 4 sites the doses from the AGRs are included in total doses from the site (Table 22) and reported as doses from GCR Magnox. Accordingly, doses are only available for 3 sites. The doses are constant during the period 1993-1998. For Heysham, the doses are mostly due to the discharges from Sellafield.

5.2.2 Fuel reprocessing facilities

The reprocessing facility in La Hague shows very little variation in doses during 1995 to 1998, between 4,05 and 4,5 microSv per year (Table 23). For the Sellafield facility the corresponding doses are between 100 and 150 microSv per year with no clear trend. According to the UK report, a reasonable estimate of the doses to this critical group due to current and historic discharges respectively may be made by assuming that the latter is mainly due to Pu isotopes and Am-241. The estimate shows that the historic discharges contribute to between 30 and 80% of the total dose depending on year.

5.2.3 Fuel production facilities

There are 7 fuel production facilities. Five of these report discharges with less than values (<5, <0,1 and <0,04 microSv/year), and for one facility there are no reported values. Only one facility remains, Springfields. Seen over the six-year period 1993 to 1998, the doses are reasonably stable.

5.2.4 Research reactors and development facilities

There are 15 sites with research and development facilities. Doses are reported from 13 of these. Five of these only report less than values (<5, <1, <0,1 or <0,009 microSv per year). For the remaining 8 sites the doses vary between 96 microSv per year and 8 nanoSv per year, the average being 7,8 microSv per year. The average values during the time period 1995 to 1998 are almost constant.

Karlsruhe and Dounrey report the highest doses to critical groups. For Dounrey, the doses from the food chain are between 0,008 and 0,03 mSv/year. The reduction in 1998 may be a result of decreased activity in marine samples following reprocessing cesssation. The variations in doses from discharges from Karlsruhe are due to different volumes of radioactive materials handled as a result of changes in the research and development programmes and the progress in the decommissioning of nuclear facilities.

5.3 Observations

The radiation doses to individuals of the public are in general low or very low for the facilities covered in this report. The doses are below or substantially below 1 mSv/year, and the national dose limits/constraints are never exceeded during the time period 1993 to 1998. According to Swiss legislation no further efforts are necessary to reduce releases and resulting doses for the population. The average values of doses for the different types of facilities, if these are meaningful to calculate, do not show any clear downward trends.

There are differences in how the critical group is defined, from very conservative hypothetical groups to identifiable individuals of the public. This of course leads to some uncertainties in a comparison between the facilities. These uncertainties are not serious as long as the doses are (very) low.

It is not possible to interpret the meaning of less than values on doses and accordingly whether there is a real difference between reported low doses and doses given as less than a specified dose.

6 CONCLUSIONS

This Summary Report highlights (i) data completeness, representativity and quality; (ii) time trends of discharges, environmental radioactivity and radiation doses; and (iii) observations and conclusions with regard to data submission, appropriateness of the reporting format, and comparison to BAT/BEP criteria as indicated in the Guideline. These questions have been discussed in Chapters 2 and 5. Some observations and conclusions are summarised in this chapter.

6.1 Conduct of the third round of implementation reporting

All Contracting Parties, that have a nuclear industry, have submitted reports in the third round of implementation reporting on PARCOM Recommendation 91/4. Most Contracting Parties have submitted reasonably complete and adequate information in accordance with the Guidelines.

The discharge data submitted is largely complete, representative and have relevant quality. The information on dose assessment and radiation doses vary in detail. The information on environmental impact has been less detailed and complete. In particular, the requested information on “environmental goals and standards” is sparse. There is, however, at present little international consensus on the formulation of such environmental goals (see also Chapter 6.2). The environmental quality criteria developed as part of the OSPAR Strategy may become a guide in future reporting on this matter. Present international work on a system for protection of the environment, for example the work performed by the International Commission on Radiological Protection (ICRP) and research projects financed by the European Commission, may also contribute to establish environmental goals.

The Guidelines’ sections on Discharges, Environmental Impact and Radiation Doses to the Public include a question, Summary Evaluation, where the Contracting Parties should, based on the information given in their reports, evaluate to what extent the listed BAT/BEP indicators show that BAT has been used. This can be considered a key issue in the implementation reporting. A general observation is that this evaluation made by the Contracting Parties can still be improved and better structured. This is especially true for the two sections on Discharges and Environmental Impact, whereas the evaluation is more thorough for the section on Radiation Doses to the Public. Some Contracting Parties have combined the three evaluations into one evaluation.

The BAT/BEP indicator “Downward trend” is more or less directly linked to reduction of discharges and to the OSPAR Strategy, but may be difficult to assess not knowing the “uncertainties” involved. This may be particularly true for concentrations in the environment where other sources to contamination including historic discharges can not be excluded and even sometimes give the largest contribution to a measured concentration. For concentrations in the environment only a limited amount of data is submitted by the Contracting Parties. In cases where such data is submitted only selected radionuclides and sample types are reported.

The brief summary on the national implementation of BAT/BEP (see Chapter 2) indicates that there are differences in how BAT/BEP is interpreted by the Contracting Parties. The implementation of BAT/BEP in national legislation also differs. In some countries, BAT is explicitly mentioned and implemented in the legislation, in other countries the legislation is based on more traditional radiation protection criteria which are interpreted to include also BAT. This is also a source to inconsistencies when comparing reports from the Contracting Parties.

6.2 Experiences from following the Guidelines

An overall conclusion of this Summary Report is that the Guidelines are generally clear and instructive. This is also in agreement with the experiences reported[5] by the Contracting Parties submitting reports to RAD 2000. However, there were comments by the Contracting Parties that the Guidelines requested a high degree of detail of data and that they could probably be better focussed. It was also not clear whether some indicators described the application of BAT. A conclusion of RAD 2000 was that the Guidelines considerably improved the transparency and structure of the information provided by the Contracting Parties and also the possibilities to compare the individual implementation reports. It was further concluded that a review of the Guidelines should take place after the completion of the third round of implemention reporting.
As an input to a review of the Guidelines, and in accordance with observations made in this summary report, some proposals for improvements and changes are given in the following. Much of the information submitted by the Contracting Parties, data in particular, is in different formats. In spite of the rather clear structure of the Guidelines in this respect, the information is often given in such a way that comparisons between Contracting Parties are made more difficult. This is for example the case for data on discharges. It is therefore recommended that in the next round of implementation reporting, data on discharges should be submitted according to a predefined format. The nuclide-specific data on discharges that are already submitted and evaluated each year (in a defined format with specified radionuclides) should be used better in the future also for the purpose of PARCOM Recommendation 91/4. This is already stated in the Guidelines but not followed to the extent possible. Using already existing reporting formats also has the benefit of avoiding duplication of work. However, some extension of data submitted for the yearly report may be considered.

There are differences in reporting the concentrations of radionuclides in the environment. Some Contracting Parties report that either there are no detectable concentrations in the environment that can be attributed to the facility, or it is not possible to associate the detected concentrations to a particular discharge source or they can only be partly linked to a specific source. Only two Contracting Parties have submitted time series for various environmental compartments. It is recommended that the question on reporting concentrations is further investigated including also the possibility of defining the environmental compartments and the radionuclides that should be reported. Concentrations in the environment is also of importance for the OSPAR Strategy.[6]

The major difference in reporting radiation doses to the public is whether a specific dose value or a “less than” value is reported. A clarification of how to interpret and evaluate these different data is needed. The distinction between doses resulting from one year’s discharges and doses including also historic discharges could also be made more clear.

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5 RAD 2000 Summary Record, Agenda Item 4.

6 RSC 2003 agreed on intersessional work for the development of a coordinated environmental programme for radioactive substances.

Some of the information requested seem to be of less importance and may possibly be deleted in the future, or reported only when there are changes compared with earlier reporting. As examples, it may be considered if some of the following information could be deleted or simplified in the fourth round of implementation reporting in order to reduce the amount of information to be submitted.

General Information (see Annex 2)

Other basis for national legislation/regulation – proposed to be deleted

Reporting to national authorities – proposed to be deleted

International reporting – proposed to be deleted

Site-specific Information – Discharges (see Annex 2)

2.1 Description of systems in place to reduce, prevent or eliminate discharges of radioactive substances. – Proposal: Investigate whether this could be simplified by reporting the type of systems in place according to a predefined list (for example delay tank(s), evaporator, chemical treatment, reconditioning etc).

2.2 Efficiency of systems listed in 2.1. – Proposal: Investigate whether the efficiency could be expressed simply as discharged activity relative to total activity generated (which is basically according to present Guidelines, but limited information is given in the submitted reports). The efficiency of the system could be an important BAT indicator.

2.3 Nuclide libraries used for measuring discharges – proposed to be deleted. With a predefined list of radionuclides that shall be reported, the need for information on nuclide libraries is less important.

2.4 Nuclide-specific data. - See comment above.

Site-specific Information – Environmental Impact (see Annex 2)

3.2 Nuclide libraries used for measuring radioactivity in environmental samples – proposed to be deleted. With a predefined list of radionuclides that shall be reported, the need for information on nuclide libraries is less important.

Site-specific Information – Radiation Doses to the Public (see Annex 2)

4.5 Basis for methodology to estimate doses – proposed to be deleted.

A general observation is that even if the information submitted in the national implementation reports have been relevant for a decision by RAD/RSC to agree that the requirements according to PARCOM Recommendation 91/4 have been fulfilled, the information and data are not always complete enough for a more thorough evaluation.

6.3 Status of implementation of PARCOM Recommendation 91/4

The requirements of PARCOM Recommendation 91/4, and the requirements in the Guidelines, have placed a focus on the application of BAT in the protection of the marine environment.

Concerning the implementation of PARCOM Recommendation 91/4, the RAD/RSC[7] has agreed that

a. all Contracting Parties had fulfilled the reporting requirements of this OSPAR measure;

b. the reports were in line with the guidelines;

c. the information presented included indications that BAT had been applied in the nuclear installations of these Contracting Parties[8].

[7] RAD 2000 Summary Record, Agenda Item 4; RSC 2001 Summary Record, Agenda Item 5; RSC 2002 Summary Record, Agenda Item 5.

This is also the conclusion the Contracting Parties draw in their respective reports.

In the Guidelines, a number of BAT/BEP indicators have been proposed to be tested during the third round of implementation. A general conclusion is that the Contracting Parties could have considered and discussed the BAT/BEP indicators more thoroughly. The most commonly used indicator is downward trends in primarily discharges and comparison with the *ad hoc* range around the UNSCEAR average values for discharges. Based on the evaluation in this summary report, the following conclusions can be drawn concerning trends of discharges for groups of nuclear facilities.

- The annual total discharges of other radionuclides than tritium from all PWRs show a continous decreasing trend, summing up to about 40% from 1995 to 1998. The average normalised discharges during the third implementation round show a decrease compared to the second implementation round with about 75%.
- The annual total discharges of other radionuclides than tritium from all BWRs are about 70% higher in 1996 and 1997 compared with the discharges in 1995. The discharges in 1998 are back at the same level as in 1995. The average normalised discharge from BWRs during the third implementation round is the same as during the second implementation round.
- The average normalised data for Magnox reactors for the years 1993 to 1998 show no clear trends for other radionuclides than tritium. For AGRs there appears to be a decrease for other radionuclides than tritium in 1996 to 1998 compared with the preceeding years.
- For Sellafield, there is no discernable trend in discharges of total beta-emitting radionuclides during the time period, Tc-99 excluded. For alpha-emitting radionuclides the discharges are an order of magnitude lower in 1998 compared with 1993. The discharges of Tc-99 increased substantially from 1993 to 1995 with a maximum discharge of 190 TBq in 1995, whereafter a decrease of discharges have occurred to 53 TBq in 1998. For La Hague, there is a decreasing trend in the long-term discharges of beta-emitting radionuclides, a factor of 5 in 1999 compared with 1994. Also the discharges of alpha emitters show a decreasing trend, a factor of 3 during the same time period.
- For the fuel production and enrichment plants the discharges of total alpha are reasonably constant (no clear trends) throughout the reported years.
- The total discharges from all research facilities show a decreasing trend from 1993 to 1998 for both tritium and other radionuclides than tritium.

The evaluation in this summary report further shows that the reported concentrations of radionuclides in the environment do not show any clear trends. The reported radiation doses are either small or very small and always below the various dose constraints (limits) in force.

PARCOM Recommendation 91/4 concerns the use of BAT to minimise and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment. The question is then whether BAT has been applied or not. In the analysis made prior to the revision of the Guidelines it was concluded that the criteria in the previous guidelines (for the second round of implementation reporting) had failed to positively identify BAT. Examples of shortcomings were:

- lack of environmental criteria. - These environmental criteria are still lacking. In the earlier analysis, it was realised that in the absence of environmental criteria, the information submitted by Contracting Parties on environmental impact would be limited for the time being.

[8] The conclusion c) was not supported by the delegation of Ireland on the basis of the information presented by France on the reprocessing plant in La Hague, and by the delegations of Ireland and Norway, particularly with respect to the discharges of technetium-99 from Sellafield.

- use of a dose limit of 1 mSv as criterion (not targeted to a point source but to total exposure from practices). - This has changed, and dose constraints are most often used to regulate the discharges from a particular source.
- normalised discharge data (nuclide libraries used by different Contracting Parties might not be comparable. - This has improved and is now more a question of which nuclides are actually part of the normalisation (i.e. included in “other radionuclides than tritium”).

In the earlier analysis it was further considered that:

- the previous BAT guidelines contained instructions for reporting on technical systems. However, such information might not readily be used to assess whether BAT was applied because of differences in the basic characteristics between different nuclear facilities. - See the changes proposed above.
- the inclusion of BEP elements would improve the BAT Guidelines with a view to achieving the most suitable combination of control measures and strategies. Information on aspects like quality assurance and target values (as part of management systems) would help to draw more specific conclusions whether BAT was applied. - This information can be further elaborated in fortcoming reports.

The statement that previous guidelines had failed to positively identify BAT may to some extent still be valid. However, the BAT/BEP indicators in the present Guidelines constitute substantial progress towards making a balanced evaluation of a positive identification of BAT. It may also be that the question whether BAT is applied is not one that can be answered once and for all. The answer is dependent on factors changing in time like the availability of technical systems for discharge reduction. Also economic factors should be taken into account. An overall conclusion may be that definite criteria for identifying BAT is not a goal as such. The present criteria, as stated in the Guidelines, and applied to a greater extent, would then seem to fulfil the purpose to positively identify BAT.

6.4 Observations of relevance to the OSPAR Strategy

In addition to the information requested in the Guidelines, information should also be submitted with respect to the achievements of the requirements set out in the OSPAR Strategy with respect to radioactive substances. No such information has been submitted by the Contracting Parties, at least not under a separate heading. The Contracting Parties might have felt that the requested information was already entered under existing headings. However, such information has later been given in the national plans submitted during 2002, and will be assessed separately.

ANNEX 1 LIST OF RECEIVED DOCUMENTS

RAD 00/4/3 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Working Group on Radioactive Substances (RAD). Luxembourg 18-21 January 2000.* Implementation Report on PARCOM Recommendation 91/4 on Radioactive Discharges. Presented by Sweden.

RAD 00/4/4 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Working Group on Radioactive Substances (RAD). Luxembourg 18-21 January 2000.* PARCOM Recommendation 91/4 on Radioactive Discharges. Report submitted to the OSPAR Commission on the Application of Best Available Technology in Nuclear Facilities. Presented by the United Kingdom.

RAD 00/4/5 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Working Group on Radioactive Substances (RAD). Luxembourg 18-21 January 2000.* 2000 Report in Information about, and the Assessment of, the Application of BAT in Nuclear Facilities. Report on the Implementation of PARCOM Recommendation 91/4. Presented by the Netherlands.

RSC 01/5/3 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic .Meeting of the Radioactive Substances Committee (RSC). Tromsö 15-19 January 2001.* PARCOM Recommendation 91/4 on Radioactive Discharges. Report submitted to the OSPAR Commission on the Application of Best Available Techniques in Nuclear Facilities. Presented by Germany.

RSC 01/5/4 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic .Meeting of the Radioactive Substances Committee (RSC). Tromsö 15-19 January 2001.* PARCOM Recommendation 91/4 on Radioactive Dischargers. Report submitted to the OSPAR Commission on the Application of Best Available Techniques in Nuclear Facilities. Presented by Switzerland.

RSC 01/5/5 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic .Meeting of the Radioactive Substances Committee (RSC). Tromsö 15-19 January 2001.* PARCOM Recommendation 91/4 on Radioactive Discharges. Implementation Report 2000. Presented by Norway.

RSC 01/5/6 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Radioactive Substances Committee (RSC). Tromsö 15-19 January 2001.* PARCOM Recommendation 91/4 on Radioactive Discharges. Presented by France.

RSC 02/5/2 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Radioactive Substances Committee (RSC). Hamburg 22-25 January 2002.* Implementation Report on PARCOM Recommendation 91/4 Regarding Radioactive Waste from Nuclear Plants. Submitted by Belgium.

RSC 02/5/3 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Radioactive Substances Committee (RSC). Hamburg 22-25 January 2002.* PARCOM Recommendation 91/4 on Radioactive Discharges. Implementation Report. Presented by Denmark.

RSC 02/5/4 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Radioactive Substances Committee (RSC). Hamburg 22-25 January 2002.* PARCOM Recommendation 91/4 on Radioactive Discharges. Implementation Report. Presented by Portugal.

RSC 02/5/5 *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Radioactive Substances Committee (RSC). Hamburg 22-25 January 2002.* PARCOM Recommendation 91/4 on Radioactive Discharges. Implementation Report. Presented by Spain.

ANNEX 2 GUIDELINES FOR THE SUBMISSION OF INFORMATION ABOUT, AND ASSESSMENT OF, THE APPLICATION OF BAT IN NUCLEAR FACILITIES

GENERAL INFORMATION

INFORMATION TO BE SUBMITTED
Implementation of BAT/BEP in terms of the OSPAR Convention in national legislation/regulation National regulatory concepts, e.g. what is considered as BAT and how BAT is being applied by each Contracting Party **Other basis for national legislation/regulation** Relevant recommendations and obligations, e.g. EU Basic Safety Standards, Recommendations of the International Commission on Radiological Protection, other conventions, etc. **Dose constraints/limits for nuclear facilities** Rationale for setting dose constraints/limits **Discharge limits** Rationale for setting discharge limits **Monitoring programmes of environmental concentrations of radionuclides** **Environmental norms and standards (other than dose standards for humans, e.g. standards for drinking water)** **National authority responsible for supervision etc. of discharges** **Nature of inspection and surveillance programmes** **Reporting to national authorities** **International reporting**

Annex 2 cont.

SITE -SPECIFIC INFORMATION 1. SITE CHARACTERISTICS

INFORMATION TO BE SUBMITTED
1.1 Name of site **1.2 Type of facility** E.g. power plant (PWR, BWR, GCR, AGR), reprocessing plant, fuel fabrication plant, waste treatment plant, etc., or a combination of these (number of units of each type) **1.3 Year for commissioning/licensing/decommissioning** Specified for the main installations within the site **1.4 Location** **1.5 Receiving waters and catchment area, including, where relevant, information on water flow of receiving rivers** **1.6 Production** Installed electrical effect and annual electrical output for the last six years (power reactors) Tonnes U processed (reprocessing and fuel fabrication plants) Thermal effect (research reactors) Other relevant data (e.g. for waste treatment plants) **1.7 Other relevant information**

Annex 2 cont.

SITE-SPECIFIC INFORMATION 2. DISCHARGES

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Discharges to the marine environment, as well as emissions of concern to the marine environment, are limited through application of technical and managerial practices in accordance with Article 2, 3 (b) (i), as well as Appendix 1 on BAT/BEP of the OSPAR Convention	**2.1** Description of system(s) in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment, as well as emissions of radioactive substances of concern to the marine environment.	System(s) in place are relevant to the type and other characteristics of the installation
	2.2 Efficiency of systems in terms of, e.g., retention times and distribution between waste streams destined for discharge and waste streams destined for disposal.	Efficient reduction of radioactive discharges relative to total activity of generated waste
	2.3 Nuclide libraries used for measuring discharges and for identifying and measuring emissions of concern for the marine environment.[9]	Libraries include nuclides that are relevant to the type of installation(s), and to the specific environmental situation and exposure conditions
	2.4 Annual liquid discharges: • nuclide-specific data as given in the OSPAR Annual Report on Liquid Discharges; • data on beta emitters (excluding tritium), tritium and alpha emitters (normalised data with regard to net electrical output (power reactors) or tonnes U processed (reprocessing plants and fuel fabrication plants). Factors influencing the normalisation should be reported); Data for at least the last six years should be submitted.	Downward trends Comparison with values of similar installations world-wide, based on the most recent compilations published by OSPAR, UNSCEAR or CEC
	2.5 Emissions to air of concern for the marine environment. Only nuclides with half-life >30 days should be considered, however, as a minimum, information on tritium, C-14 and I-129 should be submitted. Data for at least the last six years.	Downward trends

[9] If this information is general for the nuclear sector and/or part of a statutory programme, this information may be entered under GENERAL INFORMATION

Annex 2 cont.

SITE-SPECIFIC INFORMATION 2. DISCHARGES *(Continued)*

OBJECTIVE	**INFORMATION TO BE SUBMITTED**	**BAT/BEP INDICATOR**
Discharges to the marine environment, as well as emissions of concern to the marine environment, are limited through application of technical and managerial practices in accordance with Article 2, 3 (b) (i), as well as Appendix 1 on BAT/BEP of the OSPAR Convention	**2.6** Systems for quality assurance of: • performance of retention systems etc. • data management.	Relevant and reliable systems are in place
	2.7 Site specific target discharge values.	Relevance of target and closeness to target value
	2.8 Any relevant information not covered by the requirements specified above.	
	2.9 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	
		SUMMARY EVALUATION: **A BALANCED EVALUATION OF THE CP'S ABILITY TO ACHIEVE THE OBJECTIVE, TAKING INTO ACCOUNT** • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • Other information

Annex 2 cont.

SITE-SPECIFIC INFORMATION 3. ENVIRONMENTAL IMPACT

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Marine ecosystems shall be protected, in accordance with Article 2, 1 (a), of the OSPAR Convention.	**3.1** Concentrations of radionuclides of concern in environmental samples. Data for at least the last six years.	Development of environmental quality criteria is a part of the OSPAR Strategy with Regard to Radioactive Substances. Progress on work on such criteria should be reported by the year 2003, and may subsequently - if suited for this purpose - be used as a BAT/BEP indicator Downward trend
	3.2 Nuclide libraries used for measuring radioactivity in environmental samples.[10]	Libraries include nuclides that are relevant to the type of installation(s), and to the specific environmental situation and exposure conditions
	3.3 Environmental monitoring programme, frequency of sampling, organisms and or other types of environmental samples considered.	The environmental monitoring programme is relevant, taking sample types, frequencies and the local environment into account
	3.4 National target levels of radioactive substances in environmental samples, and/or doses to marine organisms.	Relevance and closeness to target levels
	3.5 Systems for quality assurance of environmental monitoring.	Relevant and reliable systems are in place
	3.6 Any relevant information not covered by the requirements specified above.	
	3.7 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	
		SUMMARY EVALUATION: A balanced evaluation of the CP's ability to achieve the objective, taking into account • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • Other information

[10] If this information is general for the nuclear sector and/or part of a statutory programme, this information may be entered under GENERAL INFORMATION

Annex 2 cont.

SITE-SPECIFIC INFORMATION 4. RADIATION DOSES TO THE PUBLIC

OBJECTIVE	**INFORMATION TO BE SUBMITTED**	**BAT/BEP INDICATOR**
Human health shall be protected, in accordance with Article 2.1 (a) of the OSPAR Convention.	**4.1** Average annual effective dose to individuals within the critical group(s) via the marine exposure pathway(s), and caused by current discharges. Data should be submitted for the last six years.	Downward trend
	4.2 Total exposures (i.e. including those from emissions and historic discharges/emissions).	The exposure is well within the constraint (or similar), provided the constraint gives reasonable allowance for other practices so that the annual effective dose from all practices is kept below 1 mSv
	4.3 The definition of the critical group(s), including information on age distribution, size and other relevant information, and on whether the critical group is real (identified) or hypothetical. **4.4** Information on exposure pathway(s) considered, and whether these are treated individually or collectively.	The critical group is relevant, taking local conditions and habits, as well as the exposure situation, into account
	4.5 Basis for methodology to estimate doses (models, actual measurements, and verification of data, as appropriate).[11] **4.6** Site-specific factors for significant nuclides, used to estimate the dose to critical group members from discharge values.	The dose estimates are reliable and sufficiently realistic
	4.7 Site specific target annual effective dose.	Relevance of target and closeness to target value
	4.8 Systems for quality assurance of processes involved in dose estimates.	Relevant and reliable system is in place
	4.9 Any relevant information not covered by the requirements specified above.	
	4.10 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	
		SUMMARY EVALUATION: A balanced evaluation of the CP's ability to achieve the objective, taking into account • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • Other information

[11] If this information is general for the nuclear sector and/or part of a statutory programme, this information may be entered under GENERAL INFORMATION

Annex 2 cont.

Additional information to be submitted with respect to the achievement of the requirements set out in the OSPAR Strategy with regard to Radioactive Substances

Explanations on progressive and substantial reduction in discharges, emissions and losses of radioactive substances and a description of ongoing or planned activities for further measures, if necessary, to achieve the requirements set out in the OSPAR Strategy with regard to Radioactive Substances (cf. OSPAR 98/14/1, Annex 35.

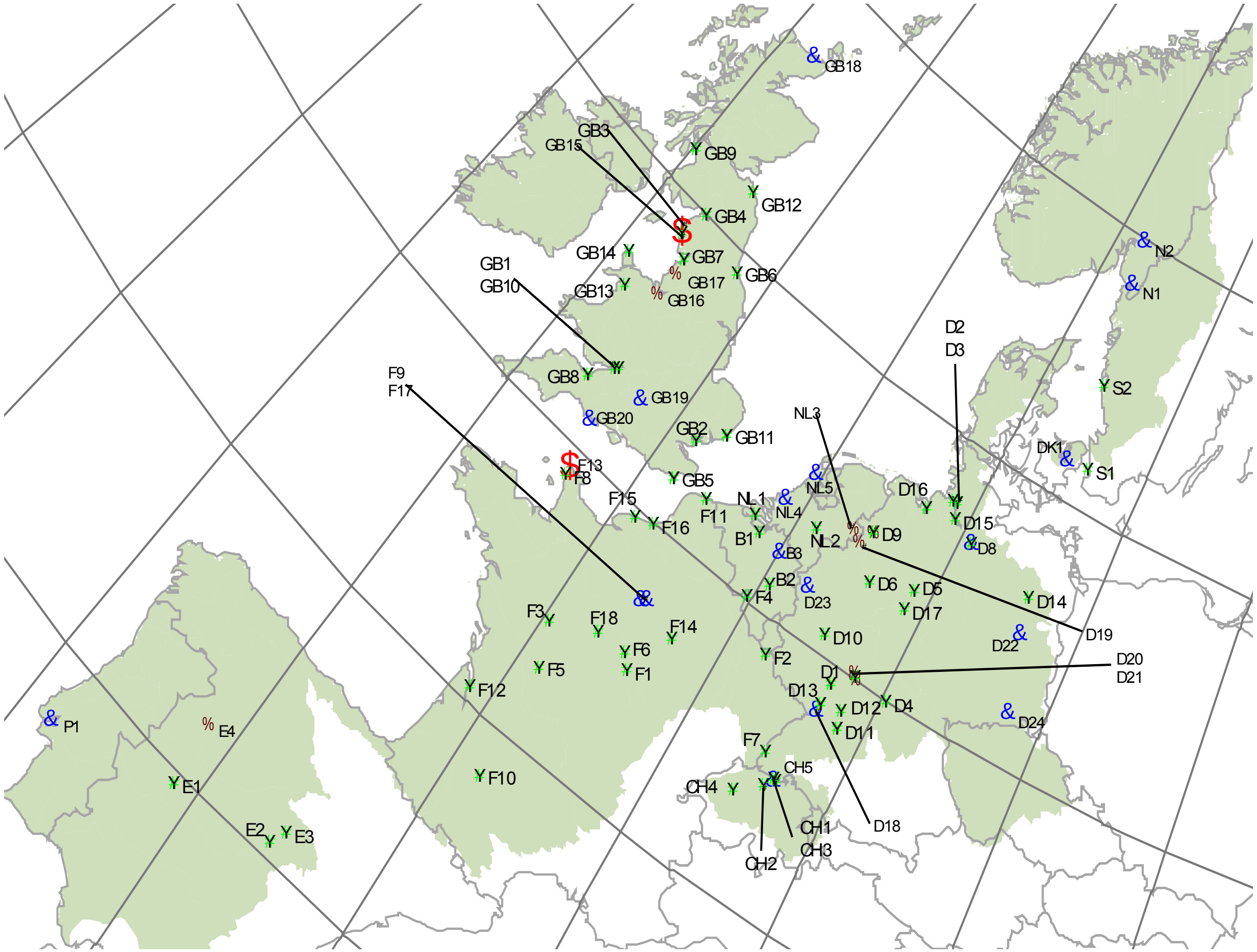
ANNEX 3 LIST OF NUCLEAR FACILITIES COVERED BY THE REPORT

Country Identification number	Name	Receiving waters	Type of facility	Installed capacity MW(e)
Belgium				
B1	Doel	Schelde	4 PWR	2680
B2	Tihange	Meuse	3 PWR	2800
B3	Mol	River Mol-Neet	Research and development	
Denmark				
DK1	Riso	Kattegat via Roskilde Fjord	Research and development	
France				
F1	Belleville	Loire	2 PWR	2600
F2	Cattenom	Mosel	4 PWR	5200
F3	Chinon	Loire	4 PWR	3600
F4	Chooz	Meuse	2 PWR	2900
F5	Civaux	Vienne	2 PWR	2900
F6	Dampierre-en-Burly	Loire	4 PWR	3600
F7	Fessenheim	Rhine	2 PWR	1800
F8	Flamanville	Channel	2 PWR	2600
F9	Fontenay-aux-Roses	Seine	Research and development	
F10	Golfech	Garonne	2 PWR	2600
F11	Gravelines	North Sea	6 PWR	5400
F12	Le Blayais	Gironde	4 PWR	3600
F13	La Hague	English Channel	Reprocessing	
F14	Nogent-sur-Seine	Seine	2 PWR	2600
F15	Paluel	Channel	4 PWR	5200
F16	Penly	Channel	2 PWR	2600
F17	Saclay	Etang de Saclay	Research and development	
F18	Saint Laurent	Loire	2 PWR	1800
Federal Republic of Germany				
D1	Biblis A	Rhine	1 PWR	1225
D1	Biblis B	Rhine	1 PWR	1300
D2	Brokdorf	Elbe	1 PWR	1440
D3	Brunsbüttel	Elbe	1 BWR	806
D4	Grafenrheinfeld	Main	1 PWR	1345
D5	Grohnde/	Weser	1 PWR	1430
D6	Hamm-	Lippe	1 THTR	296
D7	Kahl	Main	1 BWR	16
D8	Krümmel/	Elbe	1 BWR	1316
D8	Geesthacht	Elbe	Research and development	
D9	Lingen/Emsland	Ems	1 PWR	1363
D9	Lingen	Ems	1 BWR	268
D9	Lingen	Ems-via municipal sewer system	Fuel fabrication	
D10	Mülheim-Kälich	Rhine	1 PWR	1302
D11	Neckar-Westheim 1	Neckar	1 PWR	840
D11	Neckar-Westheim 2	Neckar	1 PWR	1365
D12	Obrigheim	Neckar	1 PWR	357
D13	Philippsburg 1	Rhine	1 BWR	926

Country Identification number	Name	Receiving waters	Type of facility	Installed capacity MW(e)
D13	Philippsburg 2	Rhine	1 PWR	1424
D14	Rheinsberg	Havel	1 PWR	70
D15	Stade	Elbe	1 PWR	672
D16	Rodenkirchen-Unterweser	Weser	1 PWR	1350
D17	Würgassen/Beverungen	Weser	1 BWR	640
D18	Karlsruhe	Rhine	Research and development	
D19	Gronau	Vechte, Ijsselmeer	Fuel enrichment	
D20	Hanua	Main, via municipal sewer system	Fuel fabrication	
D21	Karlstein	Main, via municipal sewer system	Fuel fabrication	
D22	HMI Berlin	Havel	Research and development	
D23	Julich	Rur	Research and development	
D24	Rossendorf	Elbe	Research and development	
The Netherlands				
NL1	Borssele	Scheldt Estuary	1 PWR	485
NL2	Doodewaard	Waal	1 BWR	58
NL3	Almelo	Municipal sewer system	Fuel enrichment	
NL4	Delft	Sewage system	Research and development	
NL5	Petten	North Sea	Research and development	
Norway				
N1	Halden	River Tista (Skagerrak)	Research and development	
N2	Kjeller	River Nitelva (Skagerrak)	Research and development	
Portugal				
P1	Campus de Sacavém	Tagus River	Research and development	
Spain				
E1	Almaraz	Tagus	2 PWR	1956
E2	José Cabrera	Tagus	1 PWR	160
E3	Trillo	Tagus	1 PWR	1066
E4	Juzbado	River Tormes-Duero	Fuel fabrication	
Sweden				
S1	Barsebäck	Öresund	BWR	600
S2	Ringhals 1-4	Kattegat	BWR, 3 PWR	3540
Switzerland				
CH1	Beznau	Aare	2 PWR	380/380
CH2	Gösgen	Aare	1 PWR	1015
CH3	Leibstadt	Rhine	1 BWR	1200
CH4	Mühleberg	Aare	1 BWR	372
CH5	Paul Scherrer Institute	Aare	Research and development	
United Kingdom				
GB1	Berkeley	Severn Estuary	2 GCR	0
GB2	Bradwell	North Sea	2 GCR	245
GB3	Calder Hall	Irish Sea	4 GCR	198
GB4	Chapelcross	Solway Firth	4 GCR	192
United Kingdom cont.				
GB5	Dungeness A	English Channel	2 GCR	440
GB5	Dungeness B	English Channel	2 AGR	1110

Country Identification number	Name	Receiving waters	Type of facility	Installed capacity MW(e)
GB6	Hartlepool	North Sea	2 AGR	1210
GB7	Heysham 1	Morecambe Bay	2 AGR	1150
GB7	Heysham 2	Morecambe Bay	2 AGR	1250
GB8	Hinkley Point A	Severn Estuary	2 GCR	0
GB8	Hinkley Point B	Severn Estuary	2 AGR	1220
GB9	Hunterston A	Firth of Clyde	2 CGR	0
GB9	Hunterston B	Firth of Clyde	2 AGR	1150
GB10	Oldbury	Severn Estuary	2 GCR	434
GB11	Sizewell A	North Sea	2 GCR	420
GB11	Sizewell B	North Sea	1 PWR	1175
GB12	Torness	North Sea	2 AGR	1264
GB13	Trawsfynydd	Trawsfynydd	2 GCR	0
GB14	Wylfa	Irish Sea	2 GCR	950
GB15	Sellafield	Irish Sea	Reprocessing	
GB16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Fuel enrichment	
GB17	Sprinfields	Irish Sea via River Ribble	Fuel fabrication	
GB18	Dounreay	Pentland Firth	Research and development	
GB19	Harwell	River Thames	Research and development	
GB20	Winfrith	Weymouth Bay (English Channel)	Research and development	

ANNEX 4 MAP INDICATING LOCATION OF NUCLEAR FACILITIES WITH IDENTIFICATION NUMBER



Legend

Y Nuclear Power Stations

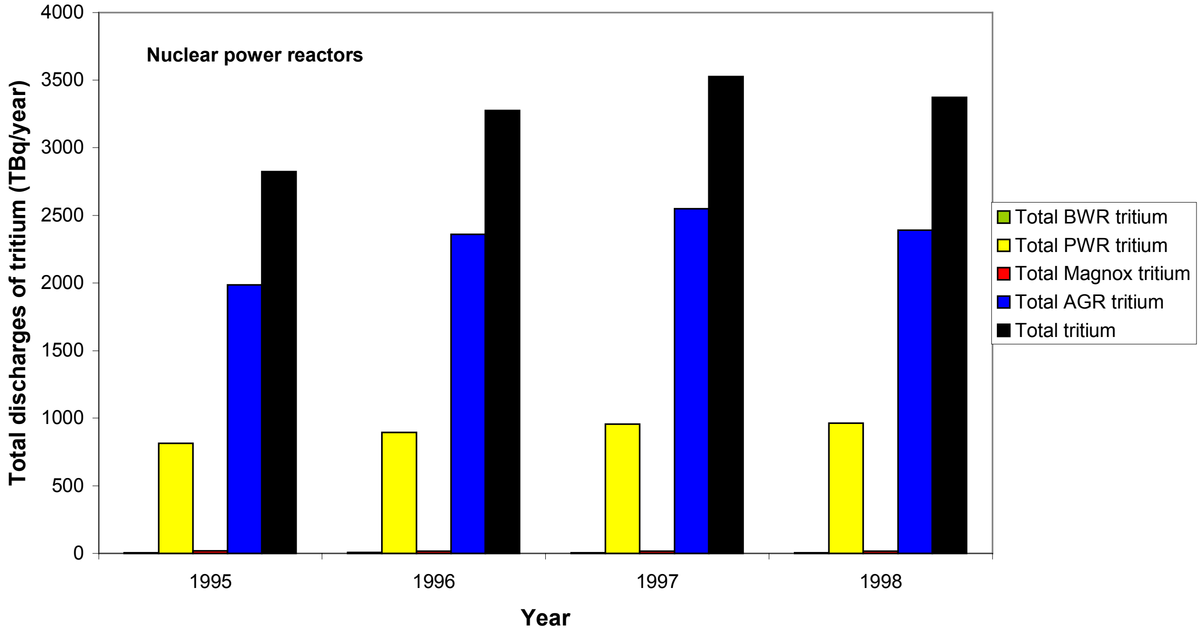
$ Nuclear Fuel Reprocessing Plants

% Nuclear Fuel Fabrication and Enrichment Plants

& Research and Development Facilities

FIGURES

Figure 1: The total discharges of tritium from all PWRs, BWRs, Magnox and AGRs for the time period 1995-1998. (Not visible in this scale: BWR appr. 4 TBq/year and Magnox appr. 16 TBq/year)



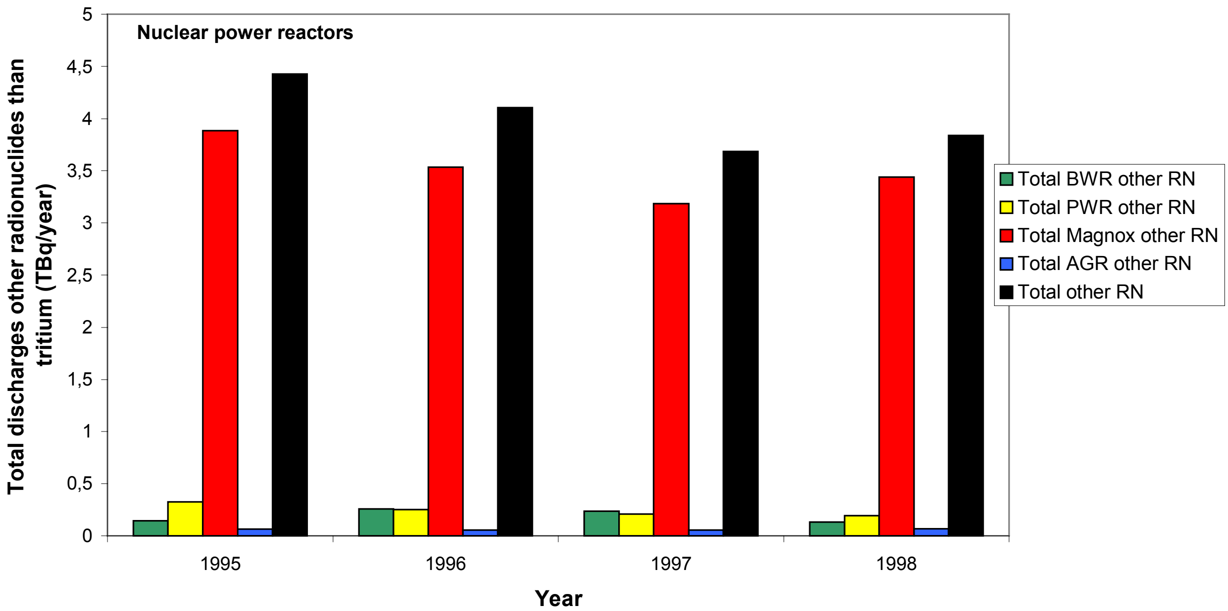


Figure 2: The total discharges of other radionuclides than tritium from all PWRs, BWRs, Magnox and AGRs for the time period 1995-1998.

Figure 3: Annual normalised discharges of other radionuclides than tritium from PWRs 1995-1998.

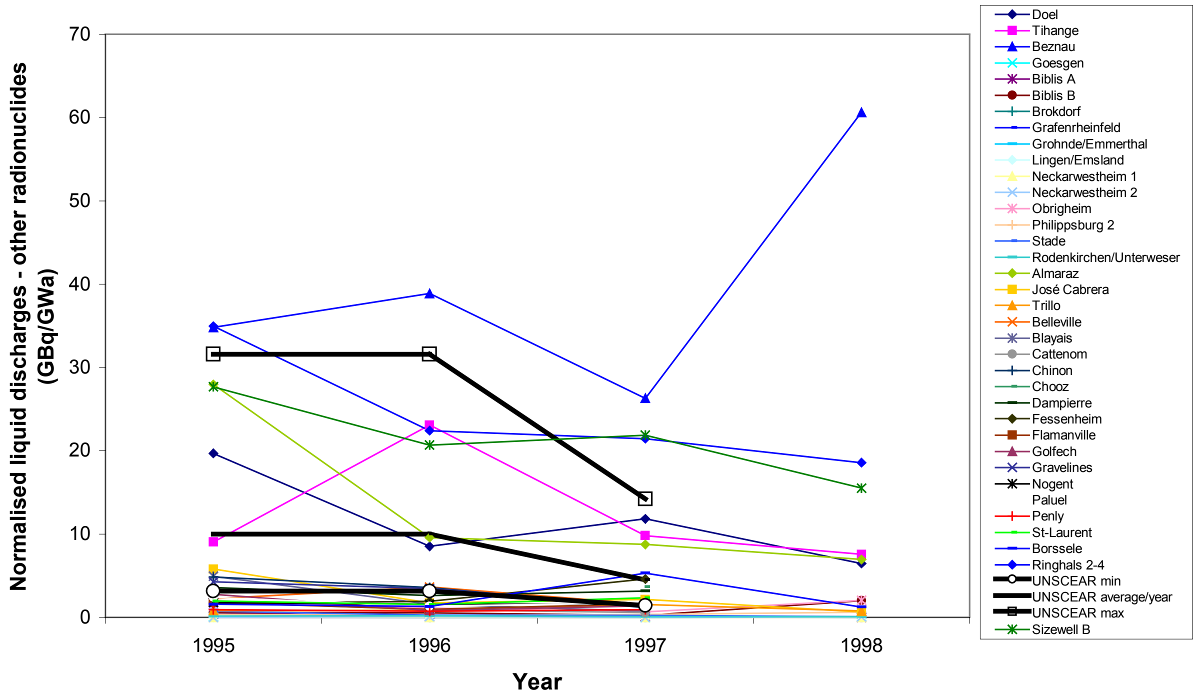


Figure 4: Total discharges of Co-60 from PWRs in France (14 sites), Germany (11 sites), The Netherlands (1 site), Spain (3 sites), Sweden (1 site) and Switzerland (2 sites).

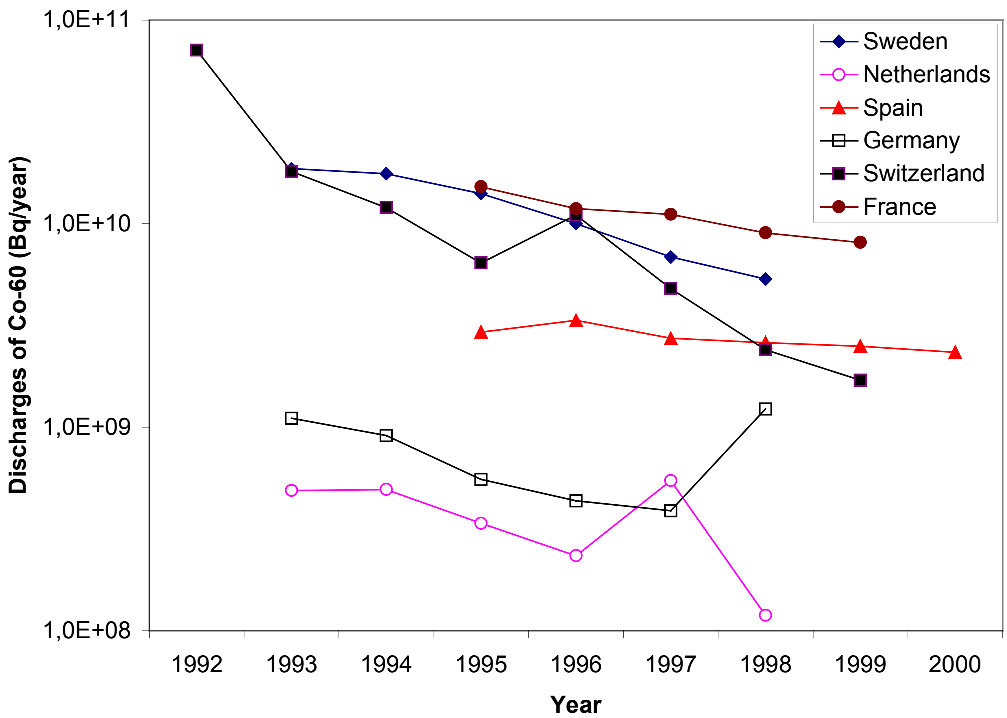


Figure 5: Total discharges of Cs-137 from PWRs in France (14 sites), Germany (11 sites), The Netherlands (1 site), Spain (3 sites), Sweden (1 site) and Switzerland (2 sites).

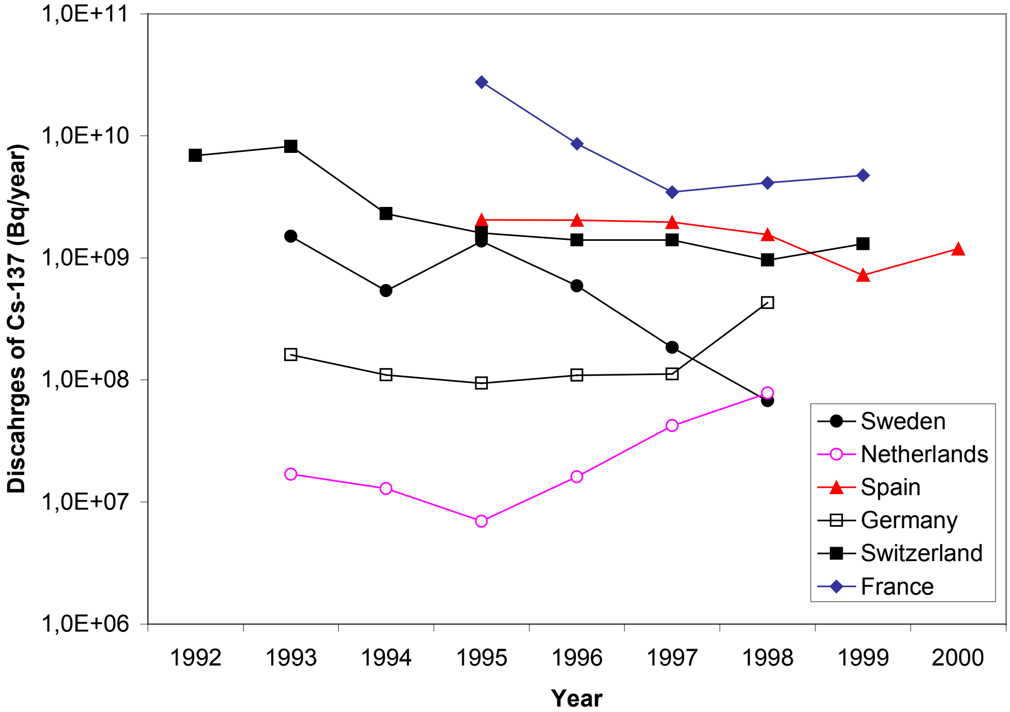


Figure 6: Annual normalised discharges of other radionuclides than tritium from BWRs 1995-1998

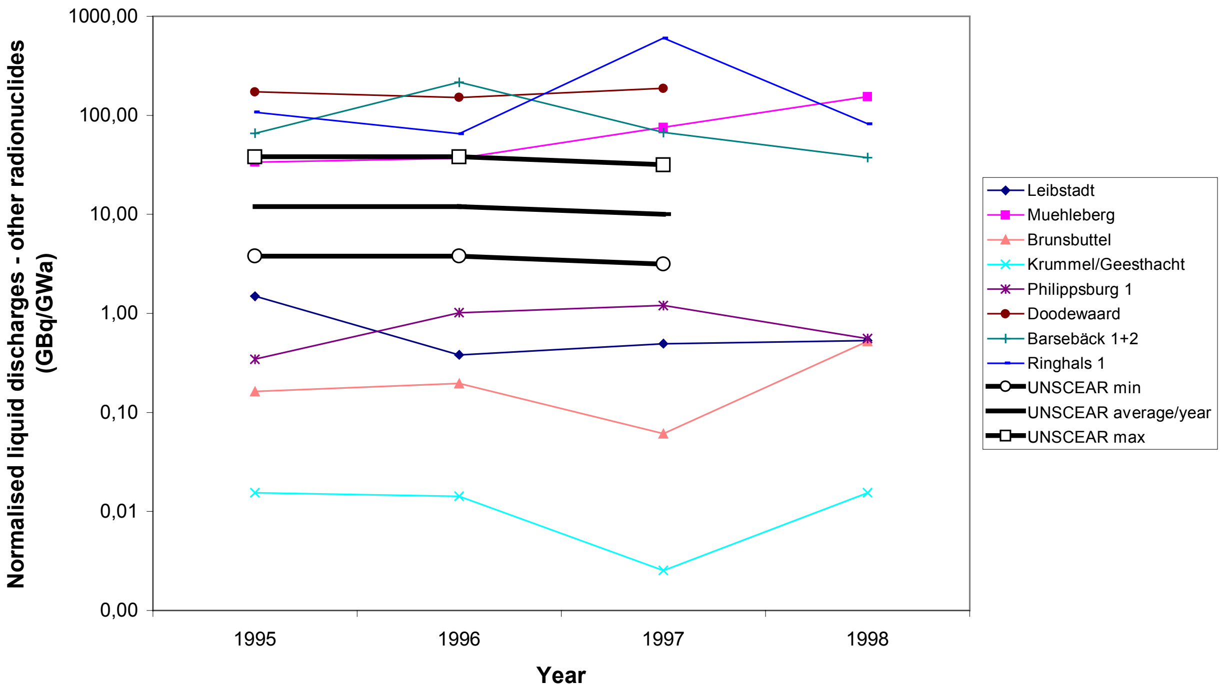


Figure 7: Total discharges of Co-60 from BWRs in Germany (4 sites), the Netherlands (1 site), Sweden (1 site) and Switzerland (2 sites)

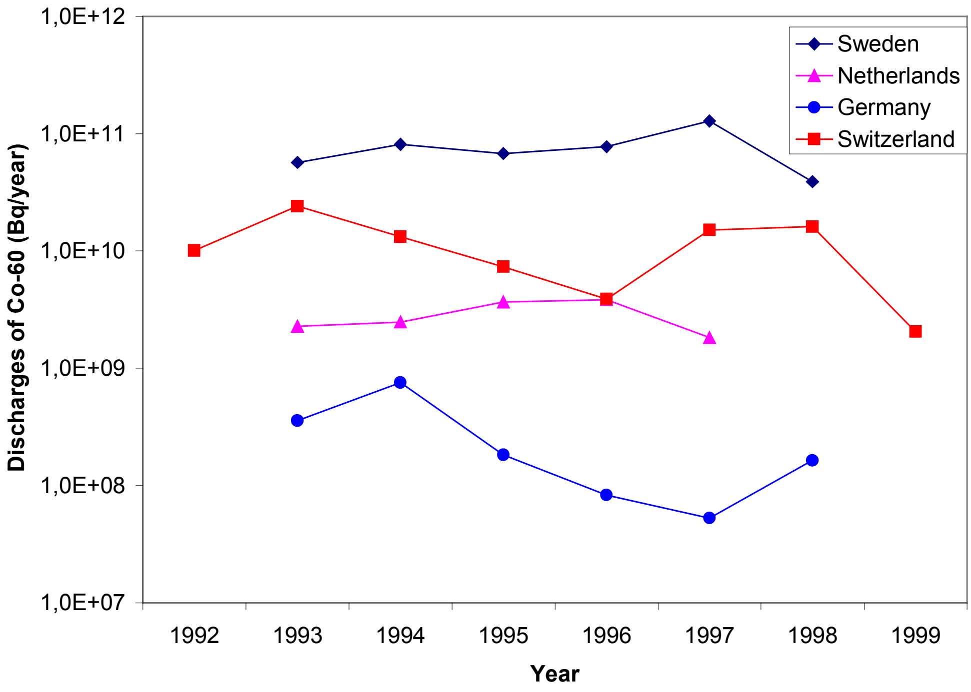


Figure 8: Total discharges of Cs-137 from BWRs in Germany (4 sites), the Netherlands (1 site), Sweden (1 site) and Switzerland (2 sites)

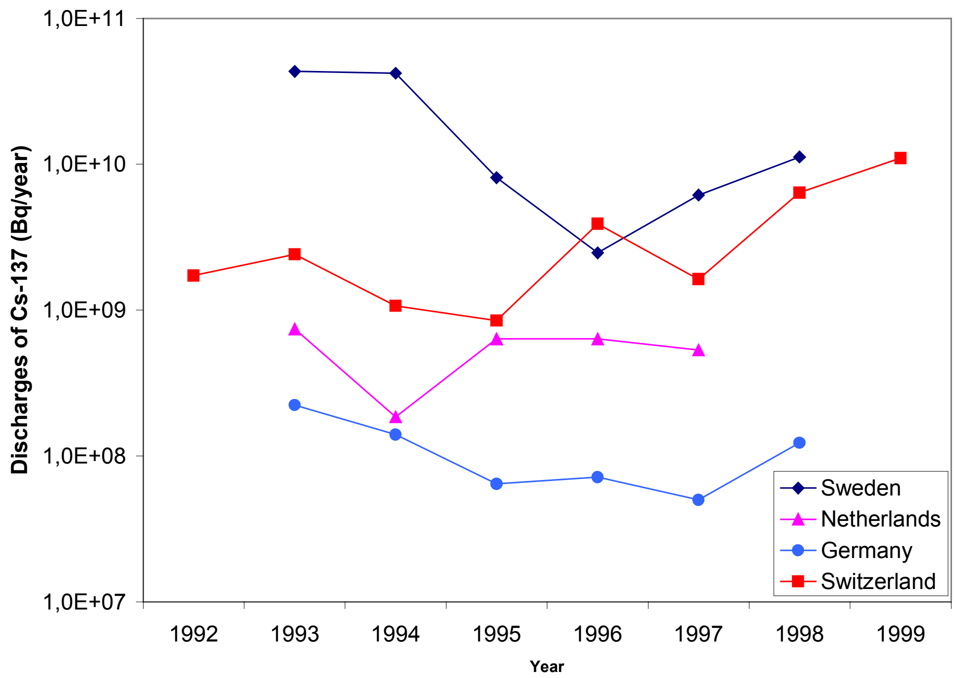


Figure 9: Annual normalised data for discharges of other radionuclides than tritium for Magnox reactors 1993-1996

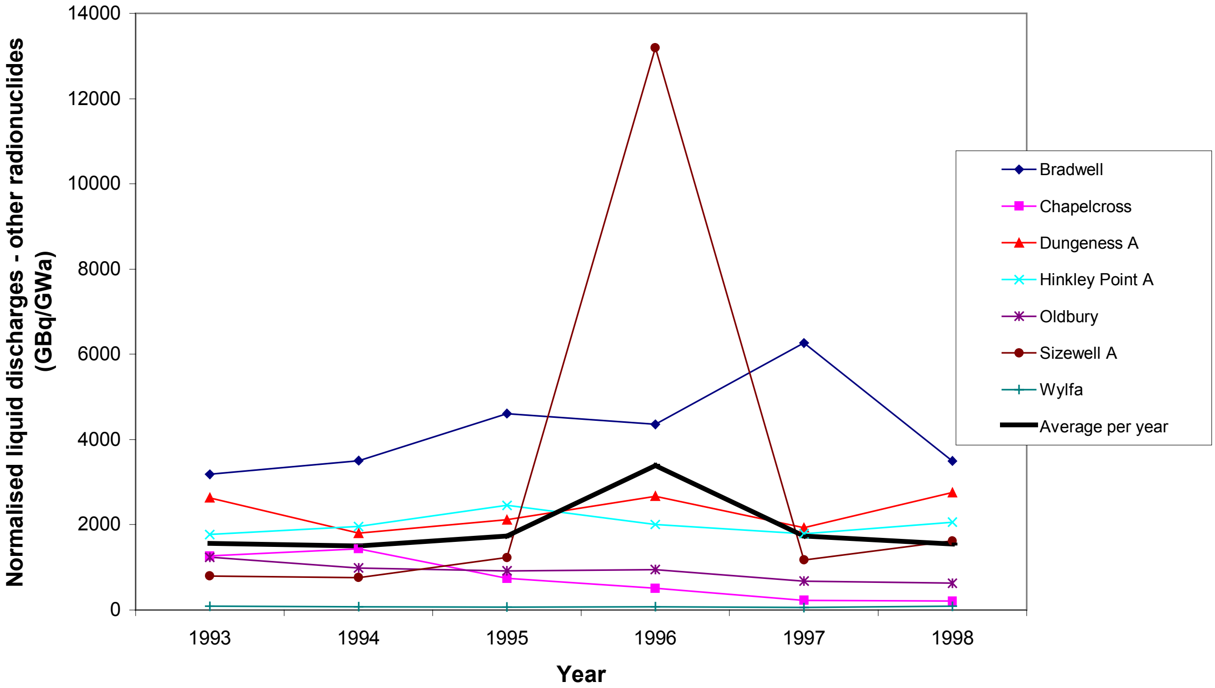


Figure 10: Annual normalised discharges of other radionuclides than tritium for AGRs 1993-1998

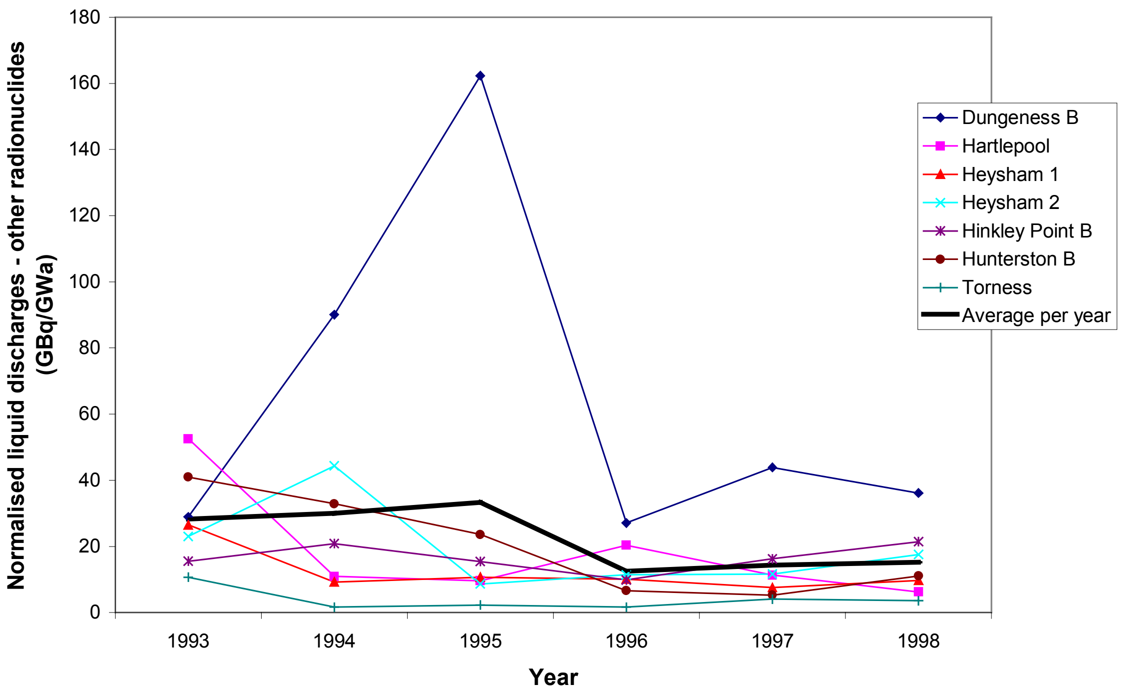


Figure 11: Discharges of Cs-137 from Magnox reactors

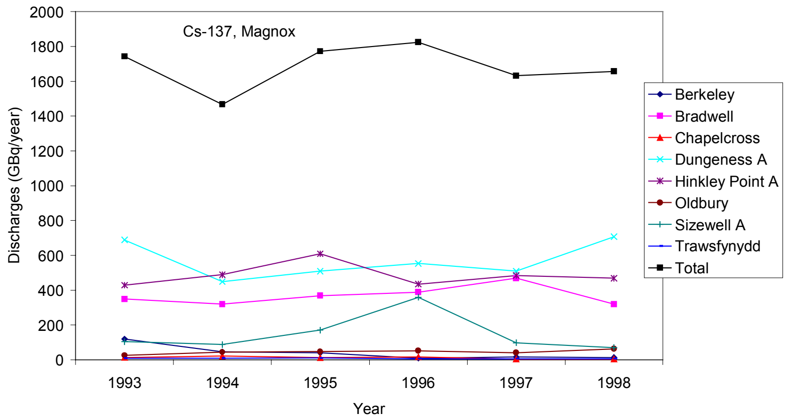


Figure 12: Discharges of Co-60 from AGRs

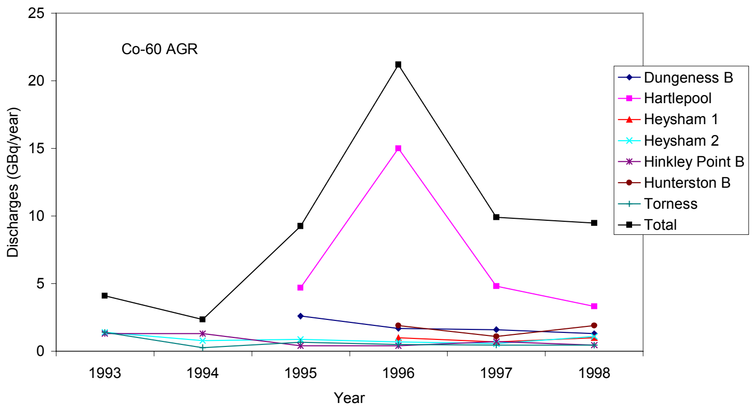
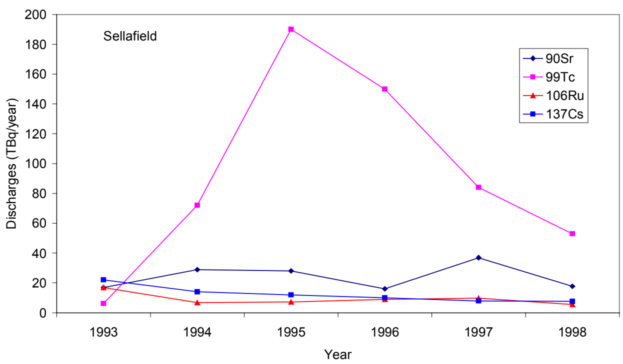


Figure 13: Discharges of Sr-90, Tc-99, Ru-106 and Cs-137 (left figure) and C-14, Co-60, Zr-95+Nb-95, I-129, Cs-134 and Ce-144 (right figure) from Sellafield



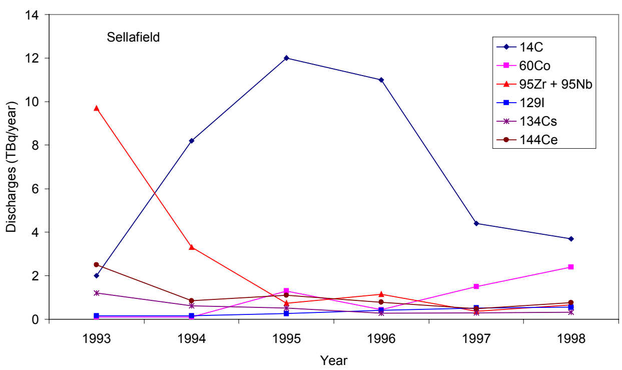
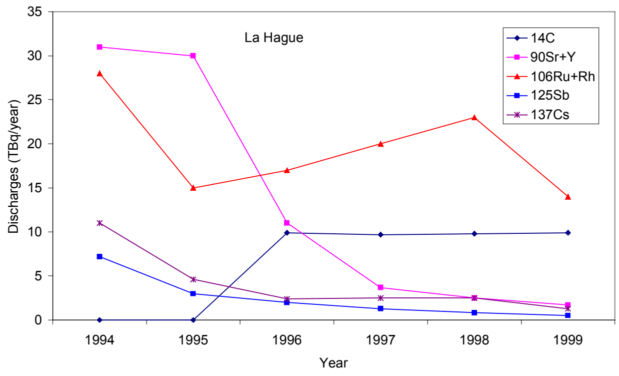


Figure 14: Discharges of C-14, Sr-90+Y, Ru-106+Rh, Sb-125 and Cs-137 (left figure) and C0-60, Ni-63, Tc-99, I-129 and Cs-134 (right figure) from La Hague.



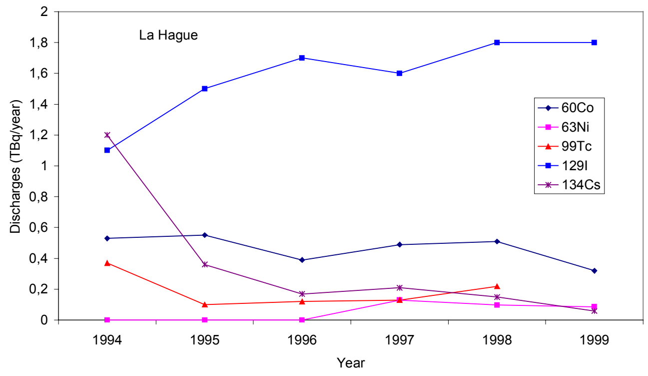


Figure 15: Radioactive discharges of total alpha from fuel manufacture and enrichment plants

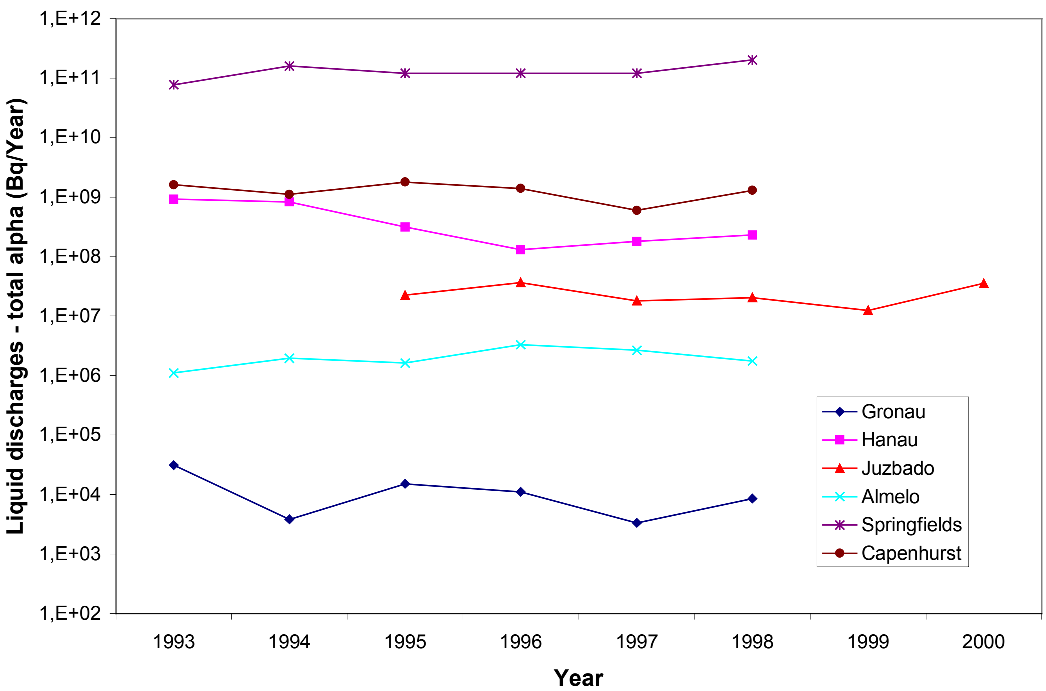


Figure 16: Radioactive tritium discharges from research and development facilities

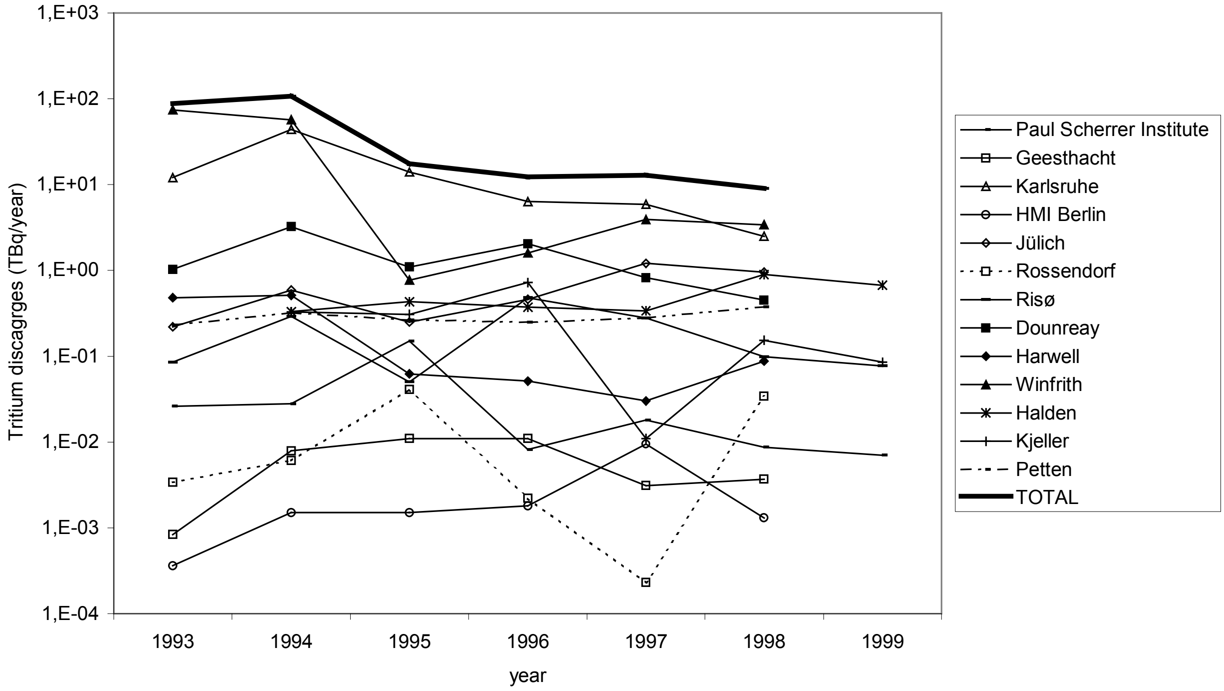


Figure 17: Radioactive discharges of other radionuclides than tritium from research and development facilities

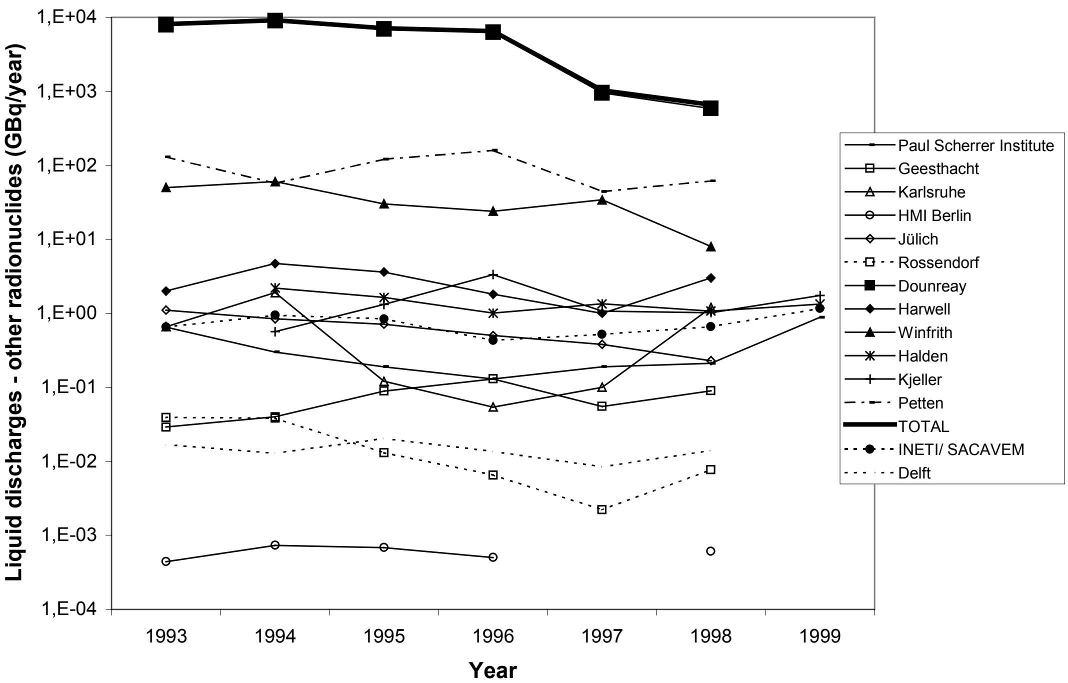


Figure 18: Environmental data on eel from Ringhals, Sweden

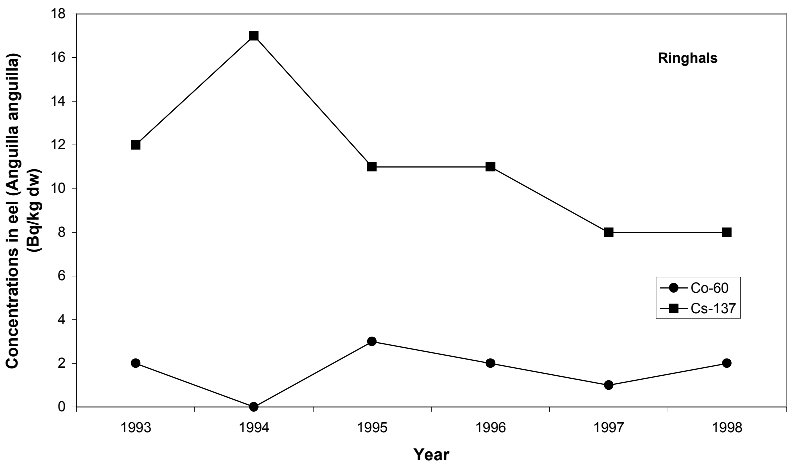


Figure 19: Environmental data on bladder wrack from Ringhals, Sweden

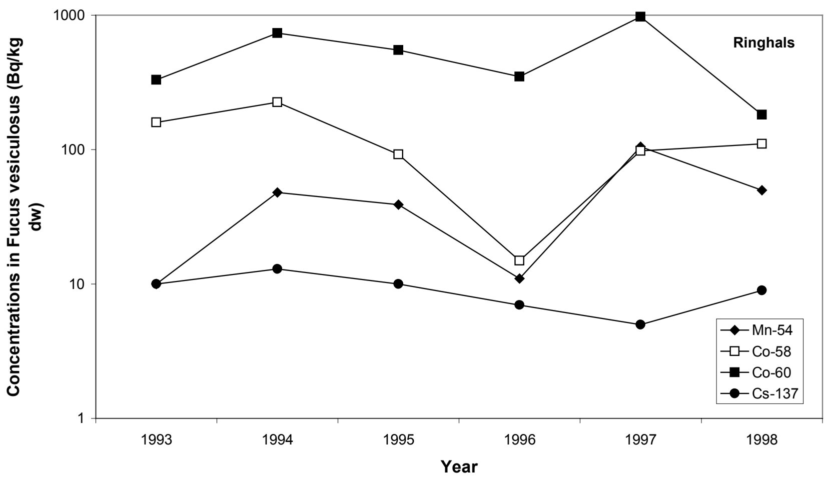
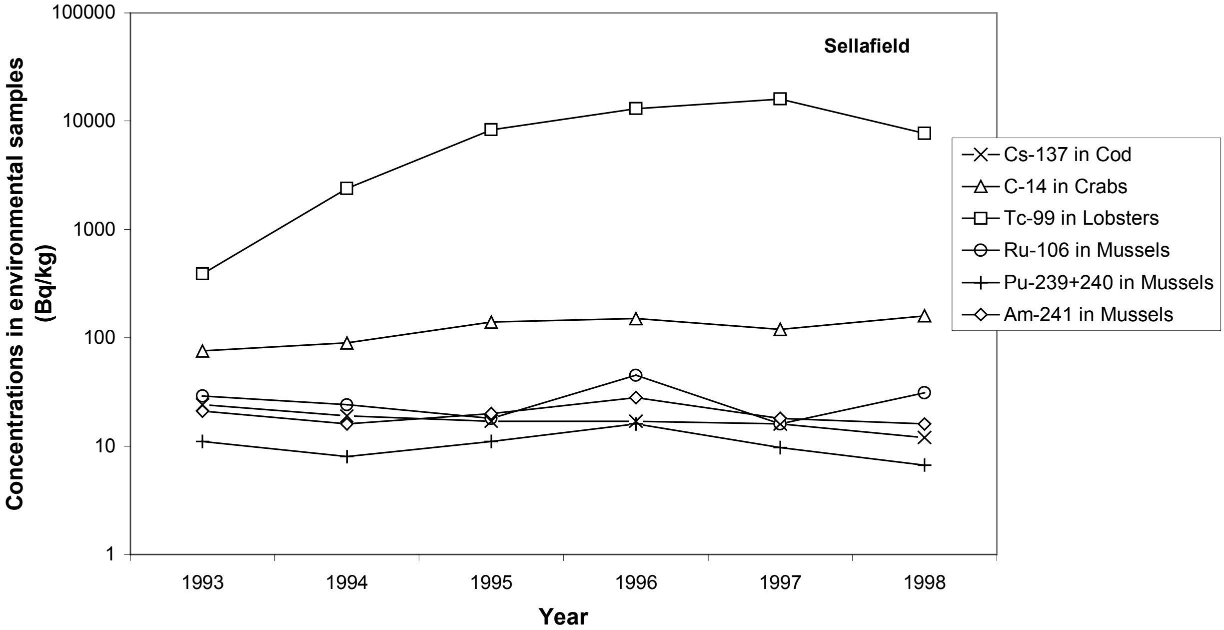


Figure 20: Environmental data on cod, crab, lobster and mussels outside Sellafield in UK



TABLES

Table 1: Radioactive discharges of tritium from pressurised water reactors (PWR)

OSPAR Reference number	**Installation/facility**	**Number of units**	**Liquid discharges - tritium (TBq/year)**								
			1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
B1	Doel[12]	4		32,8	32,8	47	31,3	38,4	47,1		
B2	Tihange	3		35,2	33,1	41,2	44,7	47,3	32,9		
CH1	Beznau	2	7,2	12	11	12	12	12	11	8,8	
CH2	Goesgen	1	12	13	11	14	13	14	13	14	
D1	Biblis A	1		15	9,9	8,4	3,6	13	13		
D1	Biblis B	1		15	16	13	11	12	17		
D2	Brokdorf	1		14	14	12	14	17	18		
D4	Grafenrheinfeld	1		13	13	13	16	16	15		
D5	Grohnde/Emmerthal	1		15	18	12	10	7,4	16		
D9	Lingen/Emsland	1		9,5	13	10	1,2	15	15		
D10	Mülheim-Kärlich	1		0,46	0,32	0,25	0,049	0,18	0,36		
D11	Neckarwestheim 1	1		11	15	14	13	14	10		
D11	Neckarwestheim 2	1		19	23	21	21	19	16		
D12	Obrigheim	1		5,4	4,4	4,6	5,7	5,1	5,2		
D13	Philippsburg 2	1		13	13	17	15	16	17		
D15	Stade	1		0,48	0,36	0,27	0,29	0,27	0,26		
D16	Rodenkirchen/Unterweser	1		8,5	7,7	6	12	15	6,9		
E1	Almaraz	2				42,8	49,3	54,1	67,4	48,6	67,4
E2	José Cabrera	1				1,02	2,59	2,16	2,43	5,93	4,02
E3	Trillo	1				14	19,4	28,3	17,8	10,5	15,7
F1	Belleville	2				0,03	36	33	25	32	
F2	Blayais	4				46	53	40	47	46	
F3	Cattenom	4				80	72	74	73	87	
F4	Chinon	4				44	44	59	46	41	
F5	Chooz	1				0,56	1,8	13	10	20	
F6	Dampierre	4				44	44	38	37	40	
F7	Fessenheim	2				21	20	22	22	21	
F8	Flamanville	2				31	35	25	30	25	
F9	Golfech	2				27	22	33	24	23	
F10	Gravelines	6				39	51	58	58	68	
F11	Nogent	2				25	32	22	42	50	
F12	Paluel	4				75	70	81	74	84	
F13	Penly	2				24	29	24	32	33	
F14	St-Laurent	2				16	20	17	19	24	
GB11	Sizewell B	1				11	38	44	48		
NL1	Borssele	1		6,0	6,1	6,2	6,0	4,2	7,5		
S2	Ringhals 2-4	3		43,6	34,5	21,0	24,6	22,5	25,6		
	Sum per year					814,3	893,6	956,0	961,5		
	min per year					0,03	0,05	0,18	0,26		
	Average per year					22,0	24,2	25,8	26,0		
	max per year					80	72	81	74		
	Average 1995-1998										

12 Data from UNSCEAR 2000 and OSPAR for 1998 for the two Belgian reactors.

Table 2: Normalised radioactive discharges of tritium from pressurised water reactors (PWR)

OSPAR Reference number	Installation/facility	Number of units	Normalised liquid discharges - tritium (TBq /GWa)								
			1992	1993	1994	1995	1996	1997	1998	1999	2000
B1	Doel[13]	4		14,3	15,8	24,4	14,1	17,2	19,0		
B2	Tihange	3		14,6	13,4	16,6	19,7	19,1	12,4		
CH1	Beznau	2	13	21,8	16,7	19,5	19,1	18,1	16,3	15,3	
CH2	Goesgen	1	14,1	15,3	12,6	15,7	14,4	15,6	14,6	16,3	
D1	Biblis A	1		15,0	10,9	27,4	7,4	13,4	10,7		
D1	Biblis B	1		16,5	16,5	13,6	11,5	11,6	17,0		
D2	Brokdorf	1		12,3	11,4	10,1	11,0	12,6	37,8		
D4	Grafenrheinfeld	1		12,2	11,2	10,9	13,9	13,1	13,6		
D5	Grohnde/Emmerthal	1		11,7	14,5	9,3	7,9	5,2	11,9		
D9	Lingen/Emsland	1		7,5	10,3	7,9	0,9	11,7	11,5		
D10	Mülheim-Kärlich[14]	1									
D11	Neckarwestheim 1	1		16,1	19,5	19,2	17,5	18,2	13,7		
D11	Neckarwestheim 2	1		15,7	18,3	16,4	16,2	15,4	12,4		
D12	Obrigheim	1		17,2	13,9	17,6	17,1	15,3	15,7		
D13	Philippsburg 2	1		10,3	10,5	13,4	11,5	12,0	13,1		
D15	Stade	1		0,9	0,6	0,5	0,5	0,5	0,4		
D16	Rodenkirchen/Unterweser	1		6,5	8,3	6,2	10,1	12,6	8,7		
E1	Almaraz	2				28,0	32,8	37,4	42,4	28,2	39,7
E2	José Cabrera	1				25,6	23,1	23,1	19,3	46,8	32,0
E3	Trillo	1				16,4	22,3	31,9	23,7	13,5	16,8
F1	Belleville[15]	2				0,0	21,6	15,8			
F2	Blayais	4				16,2	17,2	13,4			
F3	Cattenom	4				21,5	17,7	18,3			
F4	Chinon	4				15,3	15,8	20,8			
F5	Chooz	1						13,0			
F6	Dampierre	4				17,5	16,5	15,3			
F7	Fessenheim	2				16,8	14,2	16,6			
F8	Flamanville	2				16,3	17,0	14,2			
F9	Golfech	2				15,8	10,8	16,2			
F10	Gravelines	6				9,2	12,5	14,4			
F11	Nogent	2				14,7	16,8	11,0			
F12	Paluel	4				20,0	20,6	21,2			
F13	Penly	2				12,3	13,2	12,7			
F14	St-Laurent	2				14,4	15,1	13,4			
GB11	Sizewell B	1				17,9	39,3	45,9	41,3		
NL1	Borssele	1		16,0	16,0	16,0	15,0	17,0	18,0		
S2	Ringhals 2-4	3		24,3	15,6	10,7	11,4	10,3	11,6		
	Sum per year										
	min per year					0,02	0,5	0,5	0,4		
	Average per year			13,8	13,1	15,2	15,6	16,5	17,5	24,0	29,5
	max per year					28,0	39,3	45,9	42,2		
	Average 1995-1998					16,2					
	UNSCEAR min			6,6	5,7	6,0	6,0	5,7			
	UNSCEAR average per year			21,0	18,0	19,0	19,0	18,0			
	UNSCEAR max			66,4	56,9	60,0	60,0	56,9			
	UNSCEAR average 1995-1997					18,7					

13 Data from UNSCEAR 2000 and OSPAR for 1998 for the two Belgian reactors.

14 No electricity generation.

15 Energy production from UNSCEAR 2000 (except for 1998) for all French reactors.

Table 3: Radioactive discharges of other radionuclides than tritium from pressurised water reactors (PWR)

OSPAR Ref. No	Installation/facility	No of units	Liquid discharges - other radionuclides than tritium (GBq/year)								
			1992	1993	1994	1995	1996	1997	1998	1999	2000
B1	Doel[16]	4		2,4E+01	8,6E+00	3,8E+01	1,9E+01	2,6E+01	1,6E+01		
B2	Tihange	3		4,1E+01	2,4E+01	2,3E+01	5,2E+01	2,4E+01	2,0E+01		
CH1	Beznau	2	1,1E+02	9,1E+01	2,5E+01	2,2E+01	2,4E+01	1,7E+01	4,1E+01	1,5E+01	
CH2	Goesgen	1	2,8E-02	1,3E-02	5,5E-02	2,2E-02	3,4E-02	1,0E-02	3,8E-02	3,8E-02	
D1	Biblis A	1		9,9E-02	2,8E-01	1,6E-01	2,4E-02	1,0E-01	2,9E-02		
D1	Biblis B	1		3,9E-01	5,1E-01	5,7E-01	5,0E-01	2,4E-01	2,0E+00		
D2	Brokdorf	1		0,0E+00	0,0E+00	5,2E-02	2,6E-02	2,3E-02	1,3E-02		
D4	Grafenrheinfeld	1		3,2E-02	1,7E-02	1,7E-02	1,1E-02	3,1E-02	6,2E-02		
D5	Grohnde/Emmerthal	1		3,9E-03	4,6E-02	1,3E-01	1,1E-01	4,5E-02	2,3E-02		
D9	Lingen/Emsland	1		6,0E-04	7,4E-04	2,1E-04	9,8E-06	0,0E+00	9,4E-06		
D10	Mülheim-Kärlich	1		1,4E-01	1,5E-01	3,6E-02	8,9E-03	1,2E-02	1,1E-01		
D11	Neckarwestheim 1	1		7,1E-03	1,5E-03	4,6E-03	4,7E-03	2,6E-03	5,3E-03		
D11	Neckarwestheim 2	1		1,4E-02	1,4E-02	2,2E-02	9,9E-02	2,3E-02	4,9E-02		
D12	Obrigheim	1		1,1E-01	2,4E-01	5,2E-01	3,6E-01	2,3E-01	6,8E-01		
D13	Philippsburg 2	1		6,1E-01	9,1E-01	4,3E-01	2,9E-01	4,3E-01	8,3E-01		
D15	Stade	1		3,2E-01	4,9E-02	3,7E-01	1,7E-01	1,3E-01	5,0E-02		
D16	Rodenkirchen/Unterweser	1		2,3E-01	1,1E-01	1,6E-01	2,0E-01	1,2E-01	6,1E-02		
E1	Almaraz	2				4,3E+01	1,4E+01	1,3E+01	1,1E+01	1,2E+01	1,2E+01
E2	José Cabrera	1				2,3E-01	1,9E-01	2,0E-01	8,5E-02	4,5E-01	3,2E-01
E3	Trillo	1				6,9E-01	7,6E-01	1,3E+00	5,6E-01	7,8E-01	6,6E-01
F1	Belleville	2				4,0E+00	6,1E+00	3,3E+00	2,3E+00	3,3E+00	
F2	Blayais	4				1,4E+01	4,9E+00	2,2E+00	1,8E+00	1,7E+00	
F3	Cattenom	4				7,0E+00	3,8E+00	2,3E+00	1,9E+00	2,0E+00	
F4	Chinon	4				1,4E+01	1,0E+01	3,2E+00	2,2E+00	9,2E-01	
F5	Chooz	1				2,0E+01	4,6E+00	3,7E+00	3,4E+00	2,4E+00	
F6	Dampierre	4				9,0E+00	7,0E+00	7,9E+00	5,2E+00	6,1E+00	
F7	Fessenheim	2				2,1E+00	2,7E+00	6,1E+00	2,9E+00	1,9E+00	
F8	Flamanville	2				3,4E+00	2,0E+00	2,9E+00	2,8E+00	2,2E+00	
F9	Golfech	2				4,7E+00	1,7E+00	2,8E+00	8,3E-01	1,5E+00	
F10	Gravelines	6				1,8E+01	1,4E+01	5,8E+00	5,8E+00	4,0E+00	
F11	Nogent	2				3,0E+00	3,0E+00	3,2E+00	1,9E+00	1,7E+00	
F12	Paluel	4				8,9E+00	4,6E+00	6,5E+00	6,7E+00	6,8E+00	
F13	Penly	2				1,8E+00	1,6E+00	1,7E+00	1,6E+00	1,3E+00	
F14	St-Laurent	2				2,2E+00	2,0E+00	3,0E+00	1,6E+00	1,9E+00	
GB11	Sizewell B	1				1,7E+01	2,0E+01	2,1E+01	1,8E+01		
NL1	Borssele	1		6,0E-01	6,2E-01	6,1E-01	5,2E-01	1,3E+00	5,2E-01		
S2	Ringhals 2-4	3		9,1E+01	9,8E+01	6,9E+01	4,8E+01	4,7E+01	4,1E+01		
	Sum per year					3,3E+02	2,5E+02	2,1E+02	1,9E+02	6,6E+01	
	min per year										
	Average per year					8,8E+00	6,7E+00	5,6E+00	5,2E+00		
	max per year										
	Average 1995-1998										

16 Data from UNSCEAR 2000 and OSPAR for 1998 for the two Belgian reactors.

Table 4: Normalised radioactive discharges of other radionuclides than tritium from pressurised water reactors (PWR)

OSPAR Ref. No	Installation/facility	No of units	Normalised liquid discharges - other radionuclides than tritium (GBq/GWa)								
			1992	1993	1994	1995	1996	1997	1998	1999	2000
B1	Doel[17]	4		1,0E+01	4,1E+00	2,0E+01	8,5E+00	1,2E+01	6,5E+00		
B2	Tihange	3		1,7E+01	9,6E+00	9,0E+00	2,3E+01	9,8E+00	7,6E+00		
CH1	Beznau	2	2,0E+02	1,7E+02	3,8E+01	3,5E+01	3,9E+01	2,6E+01	6,1E+01	2,6E+01	
CH2	Goesgen	1	3,3E-02	1,5E-02	6,4E-02	2,5E-02	3,8E-02	1,1E-02	4,2E-02	4,4E-02	
D1	Biblis A	1		9,9E-02	3,1E-01	5,2E-01	4,9E-02	1,0E-01	2,4E-02		
D1	Biblis B	1		4,3E-01	5,2E-01	6,0E-01	5,2E-01	2,3E-01	2,0E+00		
D2	Brokdorf	1		0,0E+00	0,0E+00	4,4E-02	2,0E-02	1,7E-02	2,7E-02		
D4	Grafenrheinfeld	1		3,0E-02	1,5E-02	1,4E-02	9,6E-03	2,5E-02	5,6E-02		
D5	Grohnde/Emmerthal	1		3,0E-03	3,7E-02	1,0E-01	8,7E-02	3,1E-02	1,7E-02		
D9	Lingen/Emsland	1		4,8E-04	5,8E-04	1,7E-04	7,7E-06	0,0E+00	7,2E-06		
D10	Mülheim-Kärlich[18]	1									
D11	Neckarwestheim 1	1		1,0E-02	1,9E-03	6,3E-03	6,3E-03	3,4E-03	7,3E-03		
D11	Neckarwestheim 2	1		1,2E-02	1,1E-02	1,7E-02	7,6E-02	1,9E-02	3,8E-02		
D12	Obrigheim	1		3,5E-01	7,6E-01	2,0E+00	1,1E+00	6,9E-01	2,0E+00		
D13	Philippsburg 2	1		4,8E-01	7,4E-01	3,4E-01	2,2E-01	3,2E-01	6,4E-01		
D15	Stade	1		5,9E-01	7,6E-02	7,0E-01	2,8E-01	2,2E-01	8,1E-02		
D16	Rodenkirchen/Unterweser	1		1,8E-01	1,2E-01	1,7E-01	1,7E-01	1,0E-01	7,7E-02		
E1	Almaraz	2				2,8E+01	9,6E+00	8,8E+00	6,9E+00	7,1E+00	7,1E+00
E2	José Cabrera	1				5,8E+00	1,7E+00	2,2E+00	6,7E-01	3,5E+00	2,6E+00
E3	Trillo	1				8,0E-01	8,7E-01	1,5E+00	7,4E-01	1,0E+00	7,0E-01
F1	Belleville[19]	2				2,2E+00	3,7E+00	1,6E+00			
F2	Blayais	4				4,9E+00	1,6E+00	7,4E-01			
F3	Cattenom	4				1,9E+00	9,3E-01	5,7E-01			
F4	Chinon	4				4,9E+00	3,6E+00	1,1E+00			
F5	Chooz	1						3,7E+00			
F6	Dampierre	4				3,6E+00	2,6E+00	3,2E+00			
F7	Fessenheim	2				1,7E+00	1,9E+00	4,6E+00			
F8	Flamanville	2				1,8E+00	9,7E-01	1,6E+00			
F9	Golfech	2				2,8E+00	8,3E-01	1,4E+00			
F10	Gravelines	6				4,2E+00	3,4E+00	1,4E+00			
F11	Nogent	2				1,8E+00	1,6E+00	1,6E+00			
F12	Paluel	4				2,4E+00	1,4E+00	1,7E+00			
F13	Penly	2				9,2E-01	7,3E-01	9,0E-01			
F14	St-Laurent	2				2,0E+00	1,5E+00	2,4E+00			
GB11	Sizewell B	1				2,8E+01	2,1E+01	2,2E+01	1,6E+01		
NL1	Borssele	1		1,6E+00	1,6E+00	1,6E+00	1,3E+00	5,3E+00	1,2E+00		
S2	Ringhals 2-4	3		5,1E+01	4,4E+01	3,5E+01	2,2E+01	2,1E+01	1,9E+01		
	Sum per year										
	min per year					1,5E-04	7,7E-06	0,0E+00	7,2E-06		
	Average per year			1,4E+01	5,6E+00	5,8E+00	4,4E+00	3,8E+00	5,6E+00	7,6E+00	3,4E+00
	max per year					3,5E+01	3,9E+01	2,6E+01	6,1E+01		
	Average 1995-1998					4,9E+00					
	UNSCEAR min			3,5E+00	4,1E+00	3,2E+00	3,2E+00	1,4E+00			
	UNSCEAR average/year			1,1E+01	1,3E+01	1,0E+01	1,0E+01	4,5E+00			
	UNSCEAR max			3,5E+01	4,1E+01	3,2E+01	3,2E+01	1,4E+01			
	UNSCEAR average 1995-97					8,2E+00					

17 Data from UNSCEAR 2000 and OSPAR for 1998 for the two Belgian reactors.

18 No electricity generation.

19 Energy production from UNSCEAR 2000 (except for 1998) for all French reactors.

Table 5: Normalised discharges for PWRs during the 2nd and 3rd implementation rounds

	Normalised discharges tritium (TBq/GWa)	
	2nd round (1991-1994)	**3rd round (1995-1998)[20]**
minimum value	3,1	0,02
average för the period	13,9	16,2
maximum value	43,4	45,9
UNSCEAR low	6,6	5,91
UNSCEAR[21]	21	18,7
UNSCEAR high	66	59,1

	Normalised discharges other radionuclides than tritium (GBq/GWa)	
	2nd round (1991-1994)	**3rd round (1995-1998)[22]**
minimum value	0,00048	0
average för the period	20,8	4,9
maximum value	1600	61
UNSCEAR low	5	2,6
UNSCEAR[23]	16	8,2
UNSCEAR high	51	25,9

[20] UNSCEAR value for 1995-1997.

[21] UNSCEAR value corrected for 1991-1994 (earlier 25 in the 2nd implementation report).

[22] UNSCEAR value for 1995-1997.

[23] UNSCEAR value corrected for 1991-1994 (earlier 45 in the 2nd implementation report).

Table 6: Radioactive discharges of tritium from boiling water reactors (BWR)

OSPAR Ref. No	**Installation/facility**	**No of units**	**Liquid discharges - tritium (TBq/year)**							
			1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
CH3	Leibstadt	1	0,95	0,62	0,57	0,47	0,71	1,10	0,59	0,70
CH4	Muehleberg	1	0,20	0,30	0,20	0,34	0,29	0,32	0,43	0,17
D3	Brunsbuttel	1		0,07	0,02	0,12	0,35	0,24	0,28	
D8	Krummel/Geesthacht	1		0,61	0,13	0,58	0,68	0,47	0,42	
D13	Philippsburg 1	1		0,76	0,47	0,57	0,54	0,49	0,52	
D17	Wurgassen/Beverungen[24]	1		0,44	0,33	0,04	0,04	0,01	0,01	
NL2	Doodewaard[25]	1		0,16	0,09	0,03	0,02	0,02		
S1	Barsebäck 1+2	2		0,58	0,53	0,55	1,10	0,76	0,49	
S2	Ringhals 1	1		0,50	0,86	0,83	0,79	0,49	0,55	
	Sum per year					3,53	4,52	3,90	3,29	
	min per year					0,03	0,02	0,01	0,01	
	Average per year					0,39	0,50	0,43	0,41	
	max per year					0,83	1,10	1,10	0,59	
	Average 1995-1998									

Table 7: Normalised radioactive discharges of tritium from boiling water reactors (BWR)

OSPAR Ref. No	**Installation/facility**	**No of units**	**Normalised liquid discharges - tritium (TBq per GWa)**							
			1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
CH3	Leibstadt	1	1,10	0,74	0,71	0,53	0,81	1,24	0,64	0,74
CH4	Muehleberg	1	0,71	1,03	0,67	1,13	0,97	1,10	1,43	0,55
D3	Brunsbuttel	1				0,34	0,62	0,39	0,59	
D8	Krummel/Geesthacht	1		0,78	0,44	0,53	0,69	0,43	0,76	
D13	Philippsburg 1	1		1,37	0,60	0,76	0,65	0,64	0,63	
D17	Wurgassen/Beverungen[26]	1		0,93	0,82					
NL2	Doodewaard[27]	1		3,30	1,90	0,57	0,49	1,40		
S1	Barsebäck 1+2	2		0,85	0,57	0,63	1,22	0,87	0,52	
S2	Ringhals 1	1		1,10	1,40	1,29	1,07	1,92	0,86	
	Sum per year									
	min per year					0,34	0,49	0,39	0,52	
	Average per year		0,91	1,26	0,89	0,72	0,81	1,00	0,77	0,64
	max per year					1,29	1,22	1,92	1,43	
	Average 1995-1998					0,83				
	UNSCEAR min		0,30	0,29	0,36	0,27	0,30	0,26		
	UNSCEAR average/year		0,95	0,93	1,14	0,85	0,95	0,82		
	UNSCEAR max		3,00	2,94	3,60	2,69	3,00	2,59		
	UNSCEAR average 1995-97					0,87				

24 Shut down in 1995.

25 Shut down in 1997.

26 Shut down in 1995.

27 Shut down in 1997.

Table 8: Radioactive discharges of other radionuclides than tritium from boiling water reactors (BWR)

OSPAR Ref. No	Installation/facility	No of units	Liquid discharges - other radionuclides than tritium (GBq/year)							
			1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
CH3	Leibstadt	1	2,83	1,14	1,96	1,31	0,34	0,44	0,49	0,11
CH4	Muehleberg	1	16,90	3,98	2,49	10,10	11,00	21,80	46,30	19,40
D3	Brunsbuttel	1		0,09	0,02	0,06	0,11	0,04	0,25	
D8	Krummel/Geesthacht	1		0,01	0,03	0,02	0,01	0,00	0,01	
D13	Philippsburg 1	1		0,53	0,42	0,26	0,84	0,92	0,46	
D17	Wurgassen/Beverungen[28]	1		0,41	1,00	0,12	0,11	0,10	0,17	
NL2	Doodewaard[29]	1		4,50	5,53	7,83	6,83	2,43		
S1	Barsebäck 1+2	2		26,10	26,60	57,80	194,00	58,30	35,60	
S2	Ringhals 1	1		118,00	246,00	69,60	48,40	153,00	52,40	
	Sum per year					147,10	261,64	237,02	135,68	
	min per year					0,02	0,01	0,00	0,01	
	Average per year		9,87	17,20	31,56	16,34	29,07	26,34	16,96	9,76
	max per year					69,60	194,00	153,00	52,40	
	Average 1995-1998									

Table 9: Normalised radioactive discharges of radionuclides other than tritium from boiling water reactors (BWR)

OSPAR Ref. No	Installation/facility	No of units	Normalised liquid discharges - other radionuclides than tritium (GBq per GWa)							
			1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
CH3	Leibstadt	1	3,29	1,36	2,45	1,49	0,38	0,49	0,53	0,12
CH4	Muehleberg	1	60,36	13,72	8,30	33,67	36,67	75,17	154,33	62,58
D3	Brunsbuttel	1				0,16	0,20	0,06	0,53	
D8	Krummel/Geesthacht	1		0,02	0,08	0,02	0,01	0,00	0,02	
D13	Philippsburg 1	1		0,96	0,54	0,34	1,01	1,20	0,56	
D17	Wurgassen/Beverungen[30]	1		0,87	2,48					
NL2	Doodewaard[31]	1		91,18	116,25	172,86	150,75	186,77		
S1	Barsebäck 1+2	2		38,36	28,73	65,93	214,85	66,93	37,48	
S2	Ringhals 1	1		258,61	399,88	107,59	65,32	599,41	81,94	
	Sum per year									
	min per year					0,02	0,01	0,00	0,02	
	Average per year		31,82	50,64	69,84	47,76	58,65	116,26	39,34	31,35
	max per year					172,86	214,85	599,41	154,33	
	Average 1995-1998					65,5				
	UNSCEAR min		12,97	12,66	12,34	3,80	3,80	3,16		
	UNSCEAR average/year		41,00	40,00	39,00	12,00	12,00	10,00		
	UNSCEAR max		129,56	126,40	123,24	37,92	37,92	31,60		
	UNSCEAR average 1995-97					11,33				

28 Shut down in 1995.

29 Shut down in 1997.

30 Shut down in 1995.

31 Shut down in 1997.

Table 10: Normalised discharges for BWRs during the 2nd and 3rd implementation rounds

	Normalised discharges tritium (TBq/GWa)	
	2nd round (1991-1994)	**3rd round (1995-1998)[32]**
minimum	0,44	0,34
average för the period	1,29	0,83
maximum	5,26	1,92
minimum	0,3	0,29
UNSCEAR[33]	0,96	0,87
maximum	3,0	2,88

	Normalised discharges other radionuclides than tritium (GBq/GWa)	
	2nd round (1991-1994)	**3rd round (1995-1998)[34]**
minimum	0,011	0,003
average för the period	64,9	65,5
maximum	386	599
minimum	13,3	3,6
UNSCEAR[35]	42	11,3
maximum	133	35,7

32 UNSCEAR value for 1995-1997.

33 UNSCEAR value corrected for 1991-1994 (earlier 0,79 in 2nd implementation report).

34 UNSCEAR value for 1995-1997.

35 UNSCEAR value corrected for 1991-1994 (earlier 36 in 2nd implementation report).

Table 11: Radioactive discharges of tritium from gas cooled reactors (Magnox and AGR) 1993-1998

OSPAR Ref. No	Installation/facility	No of units	Liquid discharges - tritium (TBq/year)					
			1993	1994	1995	1996	1997	1998
	Magnox							
GB1	Berkeley[36]	2	0,265	0,029	0,04	0,037	0,055	0,034
GB2	Bradwell	2	3,028	2,2	2,1	1,36	1,46	1,793
GB4	Chapelcross	4	0,5	0,49	0,5	0,37	0,2	0,22
GB5	Dungeness A	2	4,43	0,17	0,23	1,38	0,14	0,42
GB8	Hinkley Point A	2	0,78	0,71	0,76	0,76	0,81	0,68
GB9	Hunterston A [37]	2	0,36	0,2	0,041	0,023	0,01	0,007
GB10	Oldbury	2	0,23	0,26	0,23	0,19	0,18	0,17
GB11	Sizewell A	2	2,8	3,6	6,7	1,13	5,06	2,9
GB13	Trawsfynydd [38]	2	0,075	0,122	0,232	0,103	0,298	0,063
GB14	Wylfa	2	5,9	7	7,6	9,88	7,02	9,64
	sum per year		18,368	14,781	18,433	15,233	15,233	15,927
	min per year		0,265	0,029	0,04	0,023	0,01	0,007
	Average per year		2,0	1,6	2,0	1,7	1,7	1,8
	max per year		5,9	7	7,6	9,88	7,02	9,64
	AGR							
GB5	Dungeness B	2	270	240	15	250	250	170
GB6	Hartlepool	2	350	290	240	350	370	330
GB7	Heysham 1	2	400	380	250	340	460	400
GB7	Heysham 2	2	460	360	330	380	350	310
GB8	Hinkley Point B	2	390	340	430	320	390	390
GB9	Hunterston B	2	360	420	450	420	410	440
GB12	Torness	2	235	220	270	300	320	350
	sum per year		2465	2250	1985	2360	2550	2390
	min per year		235	220	15	250	250	170
	Average per year		352	321	284	337	364	341
	max per year		460	420	450	420	460	440

36 Energy generation ceased 1989.

37 Energy generation ceased 1989/90.

38 Energy generation ceased 1991.

Table 12: Normalised radioactive discharges of tritium from gas cooled reactors (Magnox and AGR) 1993-1998

OSPAR Ref. No	**Installation/facility**	**No of units**	**Normalised liquid discharges - tritium (TBq/GWa)**					
			1993	**1994**	**1995**	**1996**	**1997**	**1998**
	Magnox							
GB1	Berkeley[39]	2						
GB2	Bradwell	2	16,14	10,60	11,91	7,87	10,73	9,21
GB4	Chapelcross	4	2,34	2,26	2,32	1,70	1,10	1,15
GB5	Dungeness A	2	11,34	0,42	0,60	4,41	0,35	1,06
GB8	Hinkley Point A	2	2,00	1,90	1,88	2,47	2,06	1,92
GB9	Hunterston A [40]	2						
GB10	Oldbury	2	0,56	0,65	0,59	0,50	0,45	0,44
GB11	Sizewell A	2	8,12	9,36	20,85	25,32	25,47	21,26
GB13	Trawsfynydd [41]	2						
GB14	Wylfa	2	7,18	10,14	9,94	12,15	8,18	11,97
	sum per year							
	min per year		0,56	0,42	0,59	0,50	0,35	0,44
	Average per year		6,81	5,05	6,87	7,77	6,91	6,71
	max per year		16,14	10,60	20,85	25,35	25,47	21,26
	Average 1995-1998				7,07			
	AGR							
GB5	Dungeness B	2	411	424	88	363	412	355
GB6	Hartlepool	2	354	318	290	347	376	357
GB7	Heysham 1	2	441	403	358	393	458	383
GB7	Heysham 2	2	452	365	299	374	352	301
GB8	Hinkley Point B	2	398	332	405	353	403	409
GB9	Hunterston B	2	434	432	463	452	420	411
GB12	Torness	2	268	246	271	275	306	325
	sum per year							
	min per year		268	246	88	275	306	301
	Average per year		394	360	310	365	390	363
	max per year		452	432	463	452	458	411
	Average 1995-1998				357,15			

39 Energy generation ceased 1989.

40 Energy generation ceased 1989/90.

41 Energy generation ceased 1991.

Table 13: Radioactive discharges of other radionuclides than tritium from gas cooled reactors (Magnox and AGR) 1993-1998

OSPAR Ref. No	Installation/facility	No of units	Liquid discharges - other radionuclides (GBq/year)					
			1993	1994	1995	1996	1997	1998
	Magnox							
GB1	Berkeley[42]	2	380	143	133	49	71	87
GB2	Bradwell	2	598	727	813	753	853	679
GB4	Chapelcross	4	270	310	160	110	40	40
GB5	Dungeness A	2	1030	730	810	835	782	1094
GB8	Hinkley Point A	2	690	730	990	615	704	730
GB9	Hunterston A [43]	2	290	210	150	141	165	242
GB10	Oldbury	2	506	395	358	362	272	243
GB11	Sizewell A	2	274	292	394	589	233	221
GB13	Trawsfynydd [44]	2	41	24	24	21	18	34
GB14	Wylfa	2	68	54	53	61	46	70
	sum per year		4147	3615	3885	3536	3184	3440
	min per year		41	24	24	21	18	34
	Average per year		415	361	389	354	318	344
	max per year		1030	730	990	835	853	1094
	AGR (incl S-35)							
GB5	Dungeness B	2	669	611	49	339	387	217
GB6	Hartlepool	2	782	460	358	921	811	336
GB7	Heysham 1	2	614	569	118	229	468	250
GB7	Heysham 2	2	73	128	65	48	61	52
GB8	Hinkley Point B	2	1715	1421	1316	809	886	600
GB9	Hunterston B	2	2134	1532	1723	1506	1405	2412
GB12	Torness	2	29	20	44	46	81	52
	sum per year		6017	4741	3672	3897	4098	3920
	min per year		29	20	44	46	81	52
	Average per year		891	688	604	593	619	617
	max per year		2134	1532	1723	1506	1405	2412
	AGR (excl S-35)							
GB5	Dungeness B	2	19	51	28	19	27	17
GB6	Hartlepool	2	52	10	8	21	11	6
GB7	Heysham 1	2	24	9	8	9	8	10
GB7	Heysham 2	2	23	44	10	12	12	18
GB8	Hinkley Point B	2	15	21	16	9	16	20
GB9	Hunterston B	2	34	32	23	6	5	12
GB12	Torness	2	9	1	2	2	4	4
	sum per year		158	117	67	58	56	70
	min per year		9	1	2	2	4	4
	Average per year		25	24	13	11	12	13
	max per year		52	51	28	19	27	20

[42] Energy generation ceased 1989.

[43] Energy generation ceased 1989/90.

[44] Energy generation ceased in 1991.

Table 14: Normalised radioactive discharges of other radionuclides than tritium from gas cooled reactors (Magnox and AGR) 1993-1998

OSPAR Ref. No	Installation/facility	No of units	Normalised liquid discharges - other radionuclides (GBq per GWa)					
			1993	1994	1995	1996	1997	1998
	Magnox							
GB1	Berkeley[45]	2						
GB2	Bradwell	2	3188	3503	4610	4357	6269	3489
GB4	Chapelcross	4	1266	1429	741	506	220	210
GB5	Dungeness A	2	2636	1796	2119	2667	1931	2755
GB8	Hinkley Point A	2	1767	1954	2455	2001	1788	2059
GB9	Hunterston A [46]	2						
GB10	Oldbury	2	1237	986	919	949	676	623
GB11	Sizewell A	2	794	759	1226	13196	1173	1620
GB13	Trawsfynydd [47]	2						
GB14	Wylfa	2	83	78	69	75	54	87
	min per year		83	78	69	75	54	87
	Average per year		1567	1501	1734	3393	1730	1549
	max per year		3188	3503	4610	13196	6269	3489
	Average 1995-1998				2102			
	AGR (incl S-35)							
GB5	Dungeness B	2	1019	1079	286	491	638	454
GB6	Hartlepool	2	790	505	432	913	823	364
GB7	Heysham 1	2	677	603	168	264	466	240
GB7	Heysham 2	2	72	130	58	47	61	51
GB8	Hinkley Point B	2	1749	1388	1240	894	916	630
GB9	Hunterston B	2	2571	1577	1774	1621	1438	2252
GB12	Torness	2	34	23	44	42	78	48
	min per year		34	23	44	42	61	48
	Average per year		988	758	572	610	631	577
	max per year		2571	1577	1774	1621	1438	2252
	Average 1995-1998				598			
	AGR (excl S-35)							
GB5	Dungeness B	2	29	90	162	27	44	36
GB6	Hartlepool	2	53	11	10	20	11	6
GB7	Heysham 1	2	26	9	11	10	8	10
GB7	Heysham 2	2	23	44	9	11	12	18
GB8	Hinkley Point B	2	16	21	15	10	16	21
GB9	Hunterston B	2	41	33	24	7	5	11
GB12	Torness	2	11	2	2	2	4	4
	min per year							
	Average per year		28	30	33	12	14	15
	max per year							
	Average 1995-1998				19			

45 Energy generation ceased 1989.

46 Energy generation ceased 1989/90.

47 Energy generation ceased in 1991.

Table 15: Radioactive discharges of tritium from the reprocessing facilities in La Hague (1994-1999) and Sellafield (1993-1998)

OSPAR Reference number	Installation/facility	*Liquid discharges* *Tritium* (TBq/year)						
		1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
F15	La Hague (absolute)		8,10E+03	9,60E+03	1,10E+04	1,20E+04	1,10E+04	1,30E+04
GB15	Sellafield (absolute)	2,30E+03	1,70E+03	2,70E+03	3,00E+03	2,60E+03	2,30E+03	
		Normalised liquid discharges *Tritium* (TBq per tonne uranium reprocessed)						
		1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
F15	La Hague (normalised)		6,34E+00	6,16E+00	6,24E+00	7,13E+00	6,43E+00	8,26E+00
GB15	Sellafield (normalised)	1,41E+00	1,43E+00	1,54E+00	2,48E+00	2,62E+00	1,84E+00	
			La Hague		**Sellafield**			
	minimum		6,16E+00		1,54E+00			
	average for the data provided		6,49E+00		2,12E+00			
	maximum		7,13E+00		2,62E+00			

Table 16: Radioactive discharges of total beta from the reprocessing facilities in La Hague (1994-1999) and Sellafield (1993-1998)

OSPAR Reference number	Installation/facility	*Liquid discharges* *Total Beta* *TBq/year*						
		1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
F15	La Hague (absolute)		7,00E+01	5,30E+01	2,90E+01	2,70E+01	2,70E+01	1,60E+01
GB15	Sellafield (absolute)	9,70E+01	1,30E+02	1,90E+02	1,40E+02	1,40E+02	8,60E+01	
		Normalised liquid discharges *Total Beta* (TBq per tonne uranium reprocessed)						
		1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
F15	La Hague (normalised)		5,49E-02	3,40E-02	1,72E-02	1,62E-02	1,65E-02	1,02E-02
GB15	Sellafield (normalised)	5,90E-02	1,10E-01	1,10E-01	1,20E-01	1,40E-01	6,90E-02	
			La Hague		**Sellafield**			
	minimum		1,62E-02		6,90E-02			
	average 1995-1998		2,10E-02		1,10E-01			
	maximum		3,40E-02		1,40E-01			

Table 17: Radioactive discharges of total alpha from the reprocessing facilities in La Hague (1994-1999) and Sellafield (1993-1998)

OSPAR Reference No.	Installation/facility	*Liquid discharges* *Total Alpha* *TBq/year*						
		1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
F15	La Hague (absolute)		9,70E-02	7,00E-02	4,60E-02	4,80E-02	4,70E-02	4,00E-02
GB15	Sellafield (absolute)	2,60E+00	1,00E+00	4,00E-01	2,70E-01	1,80E-01	1,70E-01	
		Normalised liquid discharges *Total Alpha* **(TBq per tonne uranium reprocessed)**						
		1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
F15	La Hague (normalised)		7,60E-05	4,49E-05	2,74E-05	2,87E-05	2,88E-05	2,56E-05
GB15	Sellafield (normalised)	1,60E-03	8,40E-04	2,30E-04	2,20E-04	1,80E-04	1,40E-04	
			La Hague		**Sellafield**			
	minimum		2,74E-05		1,40E-04			
	average 1995-1998		3,25E-05		1,93E-04			
	maximum		4,49E-05		2,30E-04			

Table 18: Radioactive discharges from fuel production facilities

OSPAR Ref. No	Installation/facility	Liquid discharges - tritium (GBq/year)							
		1993	1994	1995	1996	1997	1998	1999	2000
GB16	Springfields								
GB17	Capenhurst	900	100	270	540	290	150		
		Liquid discharges – total alpha (Springfields), total U-alpha (Capenhurst) (TBq/year)							
GB16	Springfields	7,70E-02	1,60E-01	1,20E-01	1,20E-01	1,20E-01	2,00E-01		
GB17	Capenhurst	1,60E-03	1,10E-03	1,80E-03	1,40E-03	6,00E-04	1,30E-03		
		Normalised liquid discharges – total alpha (TBq per tonne)							
GB16	Springfields	2,70E-05	3,70E-05	2,70E-05	2,00E-05	2,00E-05	3,30E-05		
GB17	Capenhurst								
		Liquid discharges - Total beta (TBq)							
GB16	Springfields	6,30E+01	1,10E+02	1,10E+02	1,50E+02	1,40E+02	1,50E+02		
GB17	Capenhurst								
		Normalised liquid discharges - Total beta (TBq/tonne)							
GB16	Springfields	2,20E-02	2,60E-02	2,40E-02	2,40E-02	2,40E-02	2,50E-02		
GB17	Capenhurst								
		Liquid discharges - Total alpha (Bq/year)							
D19	Gronau	3,10E+04	3,80E+03	1,50E+04	1,10E+04	3,30E+03	8,50E+03		
D20	Hanau	9,20E+08	8,30E+08	3,10E+08	1,30E+08	1,80E+08	2,30E+08		
D9	Lingen	ND	ND	ND	ND	ND	ND		
E4	Juzbado			2,22E+07	3,65E+07	1,80E+07	2,03E+07	1,24E+07	3,54E+07
NL3	Almelo	1,11E+06	1,96E+06	1,62E+06	3,30E+06	2,66E+06	1,74E+06		
		Normalised liquid discharges - Total alpha (Bq/tonne produced/processed)							
D19	Gronau	3,20E+01	3,60E+00	1,10E+01	7,50E+00	2,10E+00	4,80E+00		
D20	Hanau[48]	3,10E+06	3,80E+06	1,20E+06	1,60E+06				
D9	Lingen								
E4	Juzbado			8,92E+04	1,33E+05	5,82E+04	8,42E+04	5,96E+04	1,55E+05
NL3	Almelo	8,20E+02	1,40E+03	1,10E+03	2,20E+03	1,80E+03	1,20E+03		

48 Production of uranium fuel elements finished in 1996.

Table 19: Radioactive discharges of tritium from research and development facilities

OSPAR Ref. No	Installation/facility	Note	Liquid discharges - tritium (TBq/year)						
			1993	1994	1995	1996	1997	1998	1999
B3	Mol	49							
CH5	Paul Scherrer Institute	50	2,60E-02	2,80E-02	1,50E-01	8,10E-03	1,80E-02	8,70E-03	7,00E-03
D8	Geesthacht	51	8,30E-04	7,90E-03	1,10E-02	1,10E-02	3,10E-03	3,70E-03	
D18	Karlsruhe	52	1,20E+01	4,40E+01	1,40E+01	6,30E+00	5,90E+00	2,50E+00	
D22	HMI Berlin	53	3,60E-04	1,50E-03	1,50E-03	1,80E-03	9,40E-03	1,30E-03	
D23	Jülich	54	2,20E-01	5,90E-01	2,50E-01	4,60E-01	1,20E+00	9,50E-01	
D24	Rossendorf	55	3,40E-03	6,10E-03	4,10E-02	2,20E-03	2,30E-04	3,40E-02	
DK1	Risø	56	8,50E-02	2,90E-01	5,00E-02	4,79E-01	2,78E-01	9,90E-02	7,70E-02
GB18	Dounreay	57	1,03E+00	3,22E+00	1,09E+00	2,03E+00	8,20E-01	4,50E-01	
GB19	Harwell	58	4,80E-01	5,10E-01	6,20E-02	5,10E-02	3,00E-02	8,80E-02	
GB20	Winfrith	59	7,40E+01	5,70E+01	7,70E-01	1,59E+00	3,90E+00	3,42E+00	
N 1	Halden	60		3,3E-01	4,3E-01	3,7E-01	3,4E-01	8,9E-01	6,7E-01
N2	Kjeller	61		3,27E-01	3,06E-01	7,23E-01	1,10E-02	1,52E-01	8,50E-02
NL4	Delft	62							
NL5	Petten	63	2,30E-01	3,20E-01	2,65E-01	2,46E-01	2,77E-01	3,75E-01	
P1	INETI/ SACAVEM	64							

49 No data.

50 3 reactors.

51 2 reactors.

52 3 reactors.

53 1 reactors.

54 3 reactors.

55 Reactors closed down.

56 1 reactor (shut down in October 2000).

57 No reactors since March 1994, cessation of fuel reprocessing after October 1996.

58 All reactors closed down prior to 1993.

59 All reactors closed down.

60 1 reactor.

61 1 reactor.

62 1 reactor, (data not possible to interpret!) discharges from other facilities included.

63 2 reactors, (discharges incl isotope production, Mo-99 production).

64 1 reactor, no data.

Table 20: Radioactive discharges of other radionuclides than tritium from research and development facilities

OSPAR Ref. No	Installation/facility	Note	Liquid discharges - other radionuclides (GBq/year)						
			1993	1994	1995	1996	1997	1998	1999
B3	Mol	65							
CH5	Paul Scherrer Institute	66	6,50E-01	3,00E-01	1,90E-01	1,30E-01	1,90E-01	2,10E-01	8,80E-01
D8	Geesthacht	67	2,90E-02	4,00E-02	8,90E-02	1,30E-01	5,50E-02	9,00E-02	
D18	Karlsruhe	68	6,60E-01	1,90E+00	1,20E-01	5,40E-02	1,00E-01	1,20E+00	
D22	HMI Berlin	69	4,40E-04	7,30E-04	6,80E-04	5,00E-04	0,00E+00	6,10E-04	
D23	Jülich	70	1,10E+00	8,40E-01	7,10E-01	5,00E-01	3,80E-01	2,30E-01	
D24	Rossendorf	71	3,90E-02	3,80E-02	1,30E-02	6,50E-03	2,20E-03	7,70E-03	
DK1	Risø	72							
GB18	Dounreay	73	7,95E+03	8,97E+03	6,98E+03	6,28E+03	9,52E+02	5,84E+02	
GB19	Harwell	74	2,00E+00	4,70E+00	3,60E+00	1,80E+00	1,00E+00	3,00E+00	
GB20	Winfrith	75	5,00E+01	6,00E+01	3,00E+01	2,40E+01	3,40E+01	8,00E+00	
N 1	Halden	76		2,19E+00	1,64E+00	1,00E+00	1,34E+00	1,07E+00	1,33E+00
N2	Kjeller	77		5,66E-01	1,32E+00	3,34E+00	1,07E+00	1,02E+00	1,74E+00
NL4	Delft	78	16,8E-03	12,8E-03	20,3E-03	13,6E-03	8,4E-03	14,0E-03	
NL5	Petten	79	1,30E+02	5,7E+01	1,20E+02	1,59E+02	4,41E+01	6,15E+01	
P1	INETI/ SACAVEM	80	0,64E+00	0,94E+00	0,84E+00	0,43E+00	0,52E+00	0,66E+00	1,16E+00

65 No data.

66 3 reactors.

67 2 reactors.

68 3 reactors.

69 1 reactors.

70 3 reactors.

71 Reactors closed down.

72 1 reactor (shut down in October 2000).

73 No reactors since March 1994, cessation of fuel reprocessing after October 1996.

74 All reactors closed down prior to 1993.

75 All reactors closed down.

76 1 reactor.

77 1 reactor.

78 1 reactor, (discharges from other facilities incl).

79 2 reactors, (discharges including isotope production, Mo-99 production).

80 1 reactor.

Table 21: Doses to the critical groups around PWRs

OSPAR Ref. No	Installation/facility	No. of units	Radiation doses to critical groups (microSv/year)								
			1992	1993	1994	1995	1996	1997	1998	1999	2000
	PWR										
B1	Doel[81]	4									
B2	Tihange	3									
CH1	Beznau	2	<1	<1	<1	<1	<q1	<1	<1	<1	
CH2	Goesgen	1	<1	<1	<1	<1	<1	<1	<1	<1	
D1	Biblis A	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D1	Biblis B	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D2	Brokdorf	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D4	Grafenrheinfeld	1		0,2	0,14	0,18	0,22	0,22	0,21		
D5	Grohnde/Emmerthal	1		0,1	0,12	0,11	0,14	<0,1	0,15		
D9	Lingen/Emsland	1		0,4	0,3	0,26	0,6	0,63	0,39		
D10	Mülheim-Kärlich	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D11	Neckarwestheim 1	1		0,2	0,2	0,23	0,2	0,23	0,16		
D11	Neckarwestheim 2	1		0,2	0,3	0,34	0,3	0,31	0,26		
D12	Obrigheim	1		0,2	0,2	0,21	0,2	0,2	0,29		
D13	Philippsburg 2	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D15	Stade	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D16	Rodenkirchen/Unterweser	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
E1	Almaraz	2				3,86	3,77	4,51	4,08	4,78	4,79
E2	José Cabrera	1				0,68	0,78	1,35	0,39	0,80	0,66
E3	Trillo	1				2,85	1,84	3,29	1,99	2,61	2,24
F1	Belleville[82]	2									
F2	Blayais	4									
F3	Cattenom	4									
F4	Chinon	4									
F5	Chooz	1									
F6	Dampierre	4									
F7	Fessenheim	2									
F8	Flamanville	2									
F9	Golfech	2									
F10	Gravelines	6									
F11	Nogent	2									
F12	Paluel	4									
F13	Penly	2									
F14	St-Laurent	2									
NL1	Borssele	1		3,1E-05	3,8E-05	3,3E-05	2,7E-05	7,0E-05	2,4E-05		
GB11	Sizewell B[83]	1									
S2	Ringhals 2-4[84]	3		1,2	0,55	0,24	0,15	0,4	0,2		
	Average					0,81	0,75	1,01	0,74		

[81] No dose data for Belgian reactors.

[82] No dose data for French reactors.

[83] Included in Sizewell A.

[84] Incl Ringhals 1 (BWR).

Table 22: Doses to the critical groups around BWRs, Magnox reactors and AGRs

OSPAR Ref. No	Installation/facility	No. of units	Radiation doses to critical group (microSv/year)								
			1992	1993	1994	1995	1996	1997	1998	1999	2000
	BWR										
CH3	Leibstadt	1	<1	<1	<1	<1	<1	<1	<1	<1	
CH4	Muehleberg	1	<1	<1	<1	<1	<1	<1	<1	<1	
D3	Brunsbuttel	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D8	Krummel/Geesthacht	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D13	Philippsburg 1	1		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D17	Wurgassen/Beverungen	1		0,1	0,15	0,1	<0,1	0,12	0,1		
NL2	Doodewaard	1		3,9E-04	4,7E-04	6,0E-04	6,4E-04	2,8E-04			
S1	Barsebäck 1+2	2		0,13	0,06	0,13	0,22	0,08	0,05		
S2	Ringhals 1[85]	1									
	Average			0,077	0,070	0,077	0,074	0,067	0,075		
	GCR Magnox[86]										
GB1	Berkeley[87]	2		6	<5	10	8	13	9		
GB2	Bradwell	2		10	10	11	10	12	11		
GB4	Chapelcross	4		40	30	26	32	29	27		
GB5	Dungeness A	2		5	<5	<8	6	8	14		
GB8	Hinkley Point A	2		8	7	8	6	13	13		
GB9	Hunterston A[88]	2		10	10	18	23	27	25		
GB10	Oldbury[89]	2									
GB11	Sizewell A	2		<5	<5	<5	<5	<5	<5		
GB13	Trawsfynydd[90]	2		80	30	35	43	23	23		
GB14	Wylfa	2		10	9	5	6	6	10		
	Average			21,1	16	16,1	16,8	16,4	16,5		
	GCR AGR										
GB5	Dungeness B[91]	2									
GB6	Hartlepool	2		5	5	5	5	5	5		
GB7	Heysham 1[92]	2		140	80	73	82	73	74		
GB7	Heysham 2[93]	2									
GB8	Hinkley Point B[94]	2									
GB9	Hunterston B[95]	2									
GB12	Torness	2		<5	<5	<5	<5	8	6		

85 Dose incl. in Ringhals 2-4 (PWRs).

86 All coastal sites are affected to varying degrees by the Sellafield discharges.

87 Energy generation ceased in 1989.

88 Energy generation ceased in 1989/90.

89 Dose incl. in Berkeley.

90 Energy generation ceased in 1991.

91 Dose incl. in Dungeness A.

92 Mostly due to Sellafield discharges.

93 Dose incl in Heysham 1.

94 Dose incl in Hinkley Point A.

95 Dose incl in Hunterston A.

Table 23: Doses to the critical groups around fuel reprocessing plants, fuel production plants and research reactors

OSPAR Ref. No	Installation/facility	Radiation doses to critical group (microSv/year)								
		1992	1993	1994	1995	1996	1997	1998	1999	2000
	Reprocessing									
	La Hague			5,7	4,42	4,05	4,22	4,5	3,72	
	Sellafield[96]		100	80	120	140	100	150		
	Fuel production									
GB16	Springfields[97]		260	140	91	140	130	150		
GB17	Capenhurst		<5	<5	<5	<5	<5	<5		
D19	Gronau		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D20	Hanau		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D9	Lingen		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
E4	Juzbado [98]									
NL3	Almelo		<0,04	<0,04	<0,04	<0,04	<0,04	<0,04		
	Research reactors									
B3	Mol [99]									
CH5	Paul Scherrer Institute	<1	<1	<1	<1	<1	<1	<1	<1	
D8	Geesthacht		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D18	Karlsruhe		27	96	28	14	12	17		
D22	HMI Berlin		<0,1	<0,1	<0,1	<0,1	<0,1	<0,1		
D23	Jülich		2	2	2	2	3	2		
D24	Rossendorf		12	11	11	5	3	12		
DK1	Risø[100]									
GB18	Dounreay		20	30	30	22	20	8		
GB19	Harwell [101]		10	9	17	9	14	17		
GB20	Winfrith		<5	<5	<5	<5	<5	<5		
N 1	Halden			0,19	0,11	0,04	0,06	0,05	0,08	
N2	Kjeller[102]			0,12	0,23	0,71	0,06	0,24	0,53	
NL4	Delft		<0,009	<0,009	<0,009	<0,009	<0,009	<0,009		
NL5	Petten				0,006	0,002	0,0015	0,0008		
	Average		14,2	21,2	11,0	6,6	6,5	7,0		

96 Includes discharges from Windscale.

97 Mostly due to historic Sellafield discharges.

98 No dose data.

99 No dose data.

100 No dose data.

101 There is no marine critical group, external radiation from activity in sediments on tne banks of Thames.

102 Dose from limnic environment.