Radioactive Substances Series

Liquid Discharges from Nuclear Installations in 2001

OSPAR Commission
2003

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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contents

EXECUTIVE SUMMARY

This annual report includes the data of 2001 on liquid radioactive discharges from nuclear installations and covers the longer period 1989-2001. On this basis, an assessment has been made for the discharges from nuclear power stations, nuclear fuel reprocessing plants, nuclear fuel fabrication and enrichment plants, and research and development facilities. It covers total alpha, tritium and total beta activity excluding tritium in TBq/y for each nuclear installation sector and the ratio as a percentage of the total discharge from all installations. To facilitate comparison of the discharges year by year temporal trends are shown for total alpha, tritium and total beta excluding tritium for the period 1989-2001.

There is a downward trend of the total alpha activity discharged from all nuclear installations over the 13-year period. While in broad agreement with the long-term trend, discharges of alpha activity in 2001 were higher than in 2000, largely as a result of higher total alpha releases from the reprocessing plant at Sellafield. Further significant contributors to the summed discharges are from the fuel fabrication plant at Springfields and the reprocessing plant at La Hague. Discharges from research and development facilities have been reduced.

The tritium releases from all installations also decreased from 1999 to 2001 which is mainly due to the discharges from La Hague. The reprocessing plants in La Hague and Sellafield contribute in aggregate to 77,5% of the overall discharges. Discharges of tritium from nuclear power stations and research and development facilities remain effectively constant with no pronounced variations over the period 1996-2001.

The sum of total beta activity excluding tritium from all nuclear installations has fallen significantly over the period 1989-2001. However, the downward trend of recent years was not continued in 2001. When compared to 2000, the overall increase in 2001 was mainly the result of a rise in discharges from the reprocessing plant in Sellafield and the nuclear fuel plant in Springfields, although this was partly offset by a decrease in total beta activity from La Hague. The high total beta discharges from Sellafield are mainly attributable to the radionuclide technetium-99.

RÉCAPITULATIF

Le présent rapport annuel comprend les données de 2001 des rejets radioactifs liquides des installations nucléaires, et couvre une longue période, puisqu'elle s'étend de 1989 à 2001. Sur cette base, les rejets des centrales nucléaires, des usines de retraitement du combustible nucléaire, des installations de fabrication et d'enrichissement du combustible nucléaire, ainsi que des équipements de recherche et développement ont été évalués. Cette évaluation porte sur l'activité alpha totale, le tritium et l'activité bêta totale exprimées en TBq/an pour chacun des secteurs des installations nucléaires, ainsi que le ratio correspondant, en pourcentage du total des rejets de l'ensemble des installations. Pour faciliter la comparaison des rejets d'une année à l'autre, les tendances chronologiques d'alpha total, du tritium et de bêta total sont mises en évidence, à l'exclusion du tritium pendant la période de 1989 à 2001.

On constate une tendance à la baisse de l'activité alpha total rejeté par toutes les installations nucléaires sur la période de 13 ans en cause. Tout en étant en harmonie avec la tendance sur le long terme, les rejets d'activité alpha en 2001 se sont avérées plus importants qu'en 2000, en grande partie en raison de l'augmentation des émissions d'alpha total de l'usine de retraitement de Sellafield. Les autres contributeurs importants à la somme des rejets sont l'usine de fabrication de combustible de Springfields et l'usine de retraitement de La Hague. Les rejets des équipements de recherche et de développement ont baissé.

Les rejets de tritium de toutes les installations ont également baissé de 1999 à 2001, diminution essentiellement due aux rejets de l'usine de La Hague. Regroupées, les usines de retraitement de La Hague et de Sellafield représentent 77,5 % de l'ensemble des rejets. Les rejets de tritium des centrales nucléaires et des équipements de recherche et développement sont restés constants, sans fluctuations prononcées sur la période de 1996 à 2001.

A l'exclusion du tritium, la somme d'activité bêta total de toutes les installations nucléaires a significativement baissé de 1989 à 2001. Toutefois, la tendance à la baisse qui s'est manifestée ces dernières années ne s'est pas maintenue en 2001. Par rapport à 2000, l'augmentation globale survenue en 2001 résulte pour l'essentiel d'une augmentation des rejets de l'usine de retraitement de Sellafield et de l'usine de combustible nucléaire de Springfields, même si cette augmentation a été en partie compensée par une baisse de l'activité bêta total de La Hague. Les rejets de bêta total de Sellafield sont surtout imputables au radionucléide technétium 99.

1. INTRODUCTION

1.1 Programmes and measures

Since the mid 1980s, liquid discharges of radioactive substances from nuclear installations have been addressed under the former Paris Convention (PARCOM) and under the OSPAR Convention. The following relevant measures[1] are applicable under the OSPAR Convention:

- PARCOM Recommendation 88/4 on Nuclear Reprocessing Plants;
- PARCOM Recommendation 91/4 on Radioactive Discharges[2];
- PARCOM Recommendation 93/5 Concerning Increases in Radioactive Discharges from Nuclear Reprocessing Plants;
- PARCOM Recommendation 94/8 Concerning Environmental Impact Resulting from Discharges of Radioactive Discharges[3];
- PARCOM Recommendation 94/9 Concerning the Management of Spent Nuclear Fuel[4].
- OSPAR Decision 2000/1 on Substantial Reductions and Elimination of Discharges, Emissions and Losses of Radioactive Discharges, with Special Emphasis on Nuclear Reprocessing;
- OSPAR Decision 2001/1 on the Review of Authorisations for Discharges or Releases of Radioactive Substances from Nuclear Reprocessing Activities.

In 1998, the Ministerial meeting of the OSPAR Commission adopted the OSPAR Strategy with regard to Radioactive Substances which was revised at the Ministerial meeting in 2003 to update it (reference number: 2003-21). In 2000, the OSPAR Commission adopted, and in 2001 revised, the Programme for the More Detailed Implementation of the OSPAR with regard to Radioactive Substances (reference number: 2001-13). National reports submitted in 2002 and 2003 under this more detailed programme also contain information on liquid discharges from nuclear installations including, where available, forecasts on how these discharges would develop in order to move towards a situation by the year 2020 whereby discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero. Regular reporting is therefore required in order to review progress towards this target (see also the 2003 Progress Report on the More Detailed Implementation of the

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1 All measures referred to in this chapter can be downloaded from the OSPAR website www.ospar.org (under "measures").

2 The implementation of this Recommendation requires an assessment to be carried out as to whether BAT is being applied in nuclear installations. Contracting Parties submit national reports that also contain discharge data on a regular basis thereby using the Guidelines for the submission of information about, and the assessment of, the application of BAT in nulear facilities (reference number: 1999-11). A summary report of the second round of implementation reporting on PARCOM Recommendation was published for the first time by the OSPAR Commission in 1999. A summary report of the third round is being published by the Commission in 2003.

3 Assessments of the effect and relative contributions of remobilised historical discharges and current discharges of radioactive substances, including wastes, on the marine environment have been published in the Quality Status Report 2000 published by the OSPAR Commission in 2000 (ISBN 0 946956 52 9) and in the MARINA II Report published by the European Commission; see website: http://europa.eu.int/comm/environment/radprot/.

4 At the request of the OSPAR Commission in this Recommendation, the OECD Nuclear Energy Agency published in 2000 a comparative study on Radiological Impacts of Spent Nuclear Fuel Management Options (ISBN 92 64 17657 8).

OSPAR Strategy with regard to Radioactive Substances approved by the Ministerial meeting of the OSPAR Commission in 2003).

1.2 Annual reporting

In 1985, Contracting Parties to the former Paris Convention initiated reporting on liquid discharges from nuclear installations. These data were submitted by Contracting Parties and compiled by the Secretariat and, following examination by the relevant subsidiary bodies, published by the Commission in the form of annual reports; at first as part of the Commission's general annual report, and from 1991 onwards in annual reports on discharges from nuclear sectors. From 1998 onwards, the annual reports (starting with 1996 data) also contain an assessment of liquid discharges including a description of the trends from 1989 until the date of this report. The Commission also published in 1998 a summary of the report on sources, inputs and temporal trends of radioactive discharges from nuclear installations for the years 1989 to 1995 (ISBN 0 946955 85 9).

Over time, reporting requirements and formats for data collection were regularly reviewed and updated in the light of ongoing work under the Commission as regards nuclear installations. With a view to harmonising the way in which data and information are being established and reported, the Programmes and Measures Committee (PRAM) of the OSPAR Commission adopted in 1996 the current reporting formats and procedures (reference number: 1996-2), which sets out the requirements for data and information to be provided by Contracting Parties.

1.3 Parameters monitored and reported

The tables in this annual report contain data on total alpha, total beta, tritium and individual radionuclides. The assessment in chapter 2 and the figures 1, 2 and 3 show trends in discharges of total alpha activity, total beta activity and tritium.

Total alpha and total beta values are useful as they will encompass the contribution to the overall activity from a wide range of radionuclides which, individually, would be difficult to measure or could be below detection limits. However, total alpha and total beta values provide limited information about the potential harm as such information should be based on the characteristics of individual radionuclides. Tritium is reported separately.

Total alpha represents the measured radioactivity of alpha particles that are composed of two protons and two neutrons. These particles are emitted as a result of the decay of certain radionuclides, the so-called α-emitters. On average, the total liquid discharges of α-emitters from all nuclear sites represent mainly Pu-239 and Am-241 and, to a lesser extent, Th-230, Pu-238 and some other nuclides.[5]

Total beta represents the measured radioactivity of beta particles that are similar to electrons, except they originate from (processes within) the atomic nucleus. These particles are emitted as a result of the decay of other radionuclides, the so-called β-emitters. On average, the total liquid discharges of β-emitters from all nuclear sites represent mainly Ru-106, Sr-90, Pu-241, Cs-137, Tc-99 and, to a lesser extent, some other nuclides. The breakdown for β-emitters in liquid discharges from nuclear power plants comprises Cs-137 (39%), S-35 (20%), Sr-90 (11%), Co-60 (5%) and (for about 20%) other radionuclides. Total beta in this report excludes tritium.

Tritium (^{3}H) is an isotope of hydrogen that emits low-energy radiation in the form of beta particles. Tritium is discharged from most nuclear power plants, reprocessing plants and some research and development facilities.

5 For abbreviations of radionuclides see chapter 3.

2. ASSESSMENT OF THE LIQUID RADIOACTIVE DISCHARGES FROM NUCLEAR INSTALLATIONS IN 2001

The liquid radioactive discharges from nuclear installations in 2001 and for the period 1989 - 2000 are summarised in Table 1. The OSPAR Annual Reports for 1989 - 2000 on Liquid Discharges from Nuclear Installations form the basis for this assessment. Reported discharges from nuclear power stations, nuclear fuel reprocessing plants, nuclear fuel fabrication and enrichment plants and research and development facilities have been taken into account. Table 1 gives total alpha activity, tritium and total beta activity excluding tritium in TBq/y for each nuclear installation sector and the ratio as a percentage of the total discharge from all installations. To facilitate comparison of the discharges year by year, Figures 1 to 3 show temporal trends of total alpha, tritium and total beta excluding tritium for the period 1989 to 2001.

Both Table 1 and Figure 1 show a downward trend of the total alpha activity discharged from all nuclear installations over the 13-year period. While in broad agreement with the long-time trend, discharges of alpha activity in 2001 were higher than in 2000. The reason for this rise to 0,41 TBq/y is largely a result of higher total alpha releases from the reprocessing plant at Sellafield, United Kingdom (2000: 0,12 TBq, 2001: 0,2 TBq). Further significant contributors to the summed discharges are from the fuel fabrication plant at Springfields (0,16 TBq) and the reprocessing plant at La Hague (0,05 TBq). Discharges from research and development facilities have been reduced in 2001 to 0,0016 TBq from the range 0,01 - 0,13 TBq over the period 1991 - 98.

Figure 2 presents the discharges of tritium, in terms of activity. The tritium releases from all installations decreased from 18 870 TBq in 1999 to 15 759 TBq for 2001. This decrease is mainly due to recent decreases in discharges from La Hague (1999: 12 900 TBq, 2000: 11 000 TBq, 2001: 9 650 TBq). The reprocessing plants in La Hague and Sellafield contribute in aggregate**,** approximately 77,5% of the overall discharges. Discharges of tritium from nuclear power stations and research and development facilities remain relatively constant with no pronounced variations over the time period 1996 – 2001.

Figure 3 shows, that the sum of total beta activity excluding tritium from all nuclear installations has fallen significantly over the past 13 years, from 930 TBq (1989), 365 TBq (1995) down to 265 TBq (1998) and 171 TBq (2000). But, the downward trend of recent years was not continued in the last year. When compared to 2000, the overall increase in 2001 was mainly the result of a rise in discharges from the reprocessing plant in Sellafield (2000: 98 TBq, 2001: 141 TBq) and the nuclear fuel plant in Springfields (2000: 71 TBq, 2001: 85 TBq), although this was partly offset by a decrease in the total beta activity discharged from La Hague (2000: 21 TBq, 2001: 18 TBq). The high total beta discharges from Sellafield are mainly attributable to the radionuclide technetium-99 (2000: 44 TBq, 2001: 79 TBq).

2. EVALUATION DES REJETS RADIOACTIFS LIQUIDES DES INSTALLATIONS NUCLEAIRES EN L'AN 2001

Les rejets radioactifs liquides des installations nucléaires en l'an 2001 ainsi que pendant la période allant de 1989 à 2000 sont résumés au tableau 1. Les rapports annuels OSPAR concernant la période de 1989 à l'an 2000, sur les rejets liquides des installations nucléaires, constituent la base de cette évaluation. Les rejets notifiés des centrales nucléaires, des usines de retraitement du combustible nucléaire, des équipements de fabrication du combustible nucléaire et des équipements d'enrichissement ainsi que des installations de recherche et de développement ont été pris en compte. Le tableau 1 indique l'activité alpha totale, le tritium et l'activité bêta totale sans le tritium, exprimés en TBq/an pour chacun des secteurs nucléaires, ainsi que le ratio, en pourcentage, de l'ensemble des rejets de la totalité des installations. Pour faciliter la comparaison des rejets d'une année à l'autre, les figures 1 à 3 illustrent les tendances chronologiques d'alpha totale, du tritium et de bêta totale sans le tritium pendant la période de 1989 à 2001.

Le tableau 1 et la figure 1 mettent en évidence une tendance à la baisse de l'activité alpha totale rejetée par toutes les installations nucléaires sur la période de 13 ans. Tout en étant en harmonie avec la tendance sur le long terme, les rejets d'activité en 2001 se sont avérés plus importants qu'en 2000. Cette augmentation, de 0,41 TBq/an, est due en grande partie à l'augmentation des émissions d'activité alpha totale de l'usine de fabrication de combustible nucléaire de Springfields au Royaume-Uni (2000 : 0,12 TBq, 2001 : 0,2 TBq). Les autres contributeurs les plus importants à la somme des rejets sont l'usine de fabrication de combustible de Springfields (0,16 TBq) et l'usine de retraitement de Sellafield (0,05 TBq). Les rejets des équipements de recherche et de développement ont baissé en l'an 2001 pour n'être plus que de 0,0016 TBq, alors qu'ils se situaient dans une fourchette de 0,01 à 0,13 TBq pendant la période de 1991 à 1998.

La figure 2 illustre les rejets de tritium en termes d'activité. Les émissions de tritium de toutes les installations ont baissé puisqu'ils sont passés de 18 870 TBq en 1999 à 15 759 TBq/an en l'an 2001. Cette diminution est pour l'essentiel due à la baisse des rejets de La Hague (1999 : 12 900 TBq, 2000 : 11 000 TBq, 2001 : 9 650 TBq). Après regroupement, la contribution des usines de retraitement de La Hague et de Sellafield représente environ 77,5 % de l'ensemble des rejets. Les rejets de tritium des centrales nucléaires et des installations de recherche et de développement ne présentent aucune tendance prononcée sur la période allant de 1996 à l'an 2001.

La figure 3 montre que la somme de l'activité bêta totale, à l'exclusion du tritium, rejetée par l'ensemble des installations nucléaires, a baissé significativement les 13 dernières années, puiqu'elle est passée de 930 TBq (1989), à 365 TBq (1995) puis à 265 TBq (1998) et à 171 TBq (2000). Toutefois, la tendance à la baisse qui s'est manifestée ces dernières années ne s'est pas maintenue l'année dernière. Par rapport à 2000, l'augmentation globale survenue en 2001 résulte pour l'essentiel d'une augmentation des rejets de l'usine de retraitement de Sellafield (2000 : 98 TBq, 2001 : 141 TBq) et de l'usine de combustible nucléaire de Springfields (2000 : 71 TBq, 2001 : 85 TBq), même si cette augmentation a été en partie compensée par une baisse de l'activité bêta total de La Hague (2000 : 21 TBq, 2001 : 18 TBq). Les rejets de bêta total de Sellafiled sont surtout imputables au radionucléide technétium 99 (2000 : 44 TBq, 2001 : 79 TBq).

Table 1 Summary of Liquid Radioactive Discharges of Nuclear Installations, 1989 - 2001

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
TOTAL ALPHA													
All Nuclear Installations (TBq)	3,14	2,43	2,43	1,83	2,88	1,36	0,68	0,57	0,38	0,43	0,42	0,33	0,41
Reprocessing Plants (TBq)	2,7	2,2	2,2	1,7	2,7	1,1	0,47	0,32	0,23	0,22	0,17	0,16	0,25
% of all installations	86,0	90,6	90,6	93,0	93,7	80,9	69,1	56,1	60,5	51,2	41,6	47,7	59,9
Nuclear Power Plants (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-
% of all installations	-	-	-	-	-	-	-	-	-	-	-	-	-
Nuclear Fuel Fabrication (TBq)	0,41	0,21	0,15	0,10	0,08	0,16	0,12	0,12	0,12	0,20	0,24	0,17	0,16
% of all installations	13,1	8,6	6,2	5,4	2,8	11,8	17,6	21,1	31,6	46,5	57,7	51,7	39,7
Research & Development Facilities (TBq)	0,03	0,02	0,03	0,03	0,1	0,1	0,09	0,13	0,03	0,01	0,003	0,0019	0,0016
% of all installations	0,9	0,8	1,2	1,6	3,5	7,3	13,3	22,8	7,9	2,3	0,7	0,6	0,4
TRITIUM													
All Nuclear Installations (TBq)	8036	7224	8797	7658	10902	12931	15040	16779	17991	16240	18871	16548	15759
Reprocessing Plants (TBq)	5814	4959	6513	4969	7460	9770	12310	13500	14500	12800	15420	13300	12221
% of all installations	72,4	68,6	74,0	64,9	68,4	75,6	81,9	80,5	80,6	78,8	82,1	80,4	77,5
Nuclear Power Plants (TBq)	2161	2164	2252	2665	3354	3044	2713	3264	3440	3430	3335	3241	3543
% of all installations	26,9	30,0	25,6	34,8	30,8	23,3	18	19,5	19,1	21,1	17,8	19,6	22,5
Nuclear Fuel Fabrication (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-
% of all installations	-	-	-	-	-	-	-	-	-	-	-	-	-
Research & Development Facilities (TBq)	61	101	32	23,7	87,9	117,5	16,7	15	16	14	16	7	5,8
% of all installations	0,7	1,4	0,4	0,3	0,8	0,9	0,1	0,0	0,1	0,1	0,1	0,04	0,04
TOTAL BETA (OTHER RADIO-NUCLIDES EXCLUDING TRITIUM)													
All Nuclear Installations (TBq)	930	491	227	269	252	321	365	332	315	265	256	173	231
Reprocessing Plants (TBq)	690	384	178	134	170	195	243	169	167	112	126	98	141
% of all installations	74,2	78,3	78,4	49,8	67,4	60,8	66,5	50,9	53,0	42,4	49,1	57,5	61,2
Nuclear Power Plants (TBq)	7,6	10,3	3,8	8,8	11,1	2,8	3,4	5,2	7,4	2,0	2,0	3,0	4,2
% of all installations	0,8	2,1	1,7	3,3	4,4	0,9	0,9	1,6	2,3	0,8	0,7	1,7	1,8
Nuclear Fuel Fabrication (TBq)	114	92	38,9	120	63	114	112	150	140	150	128	71	85
% of all installations	12,2	18,7	17,1	44,6	25	35,5	30,7	45,1	44,4	56,6	50,0	41,6	36,8
Research & Development Facilities (TBq)	119	4,5	6,3	6,6	8,2	9,1	7,0	8,1	1	0,66	0,36	0,30	0,46
% of all installations	12,8	0,9	2,8	2,4	3,2	2,8	1,9	2,4	0,3	0,2	0,1	0,2	0,2

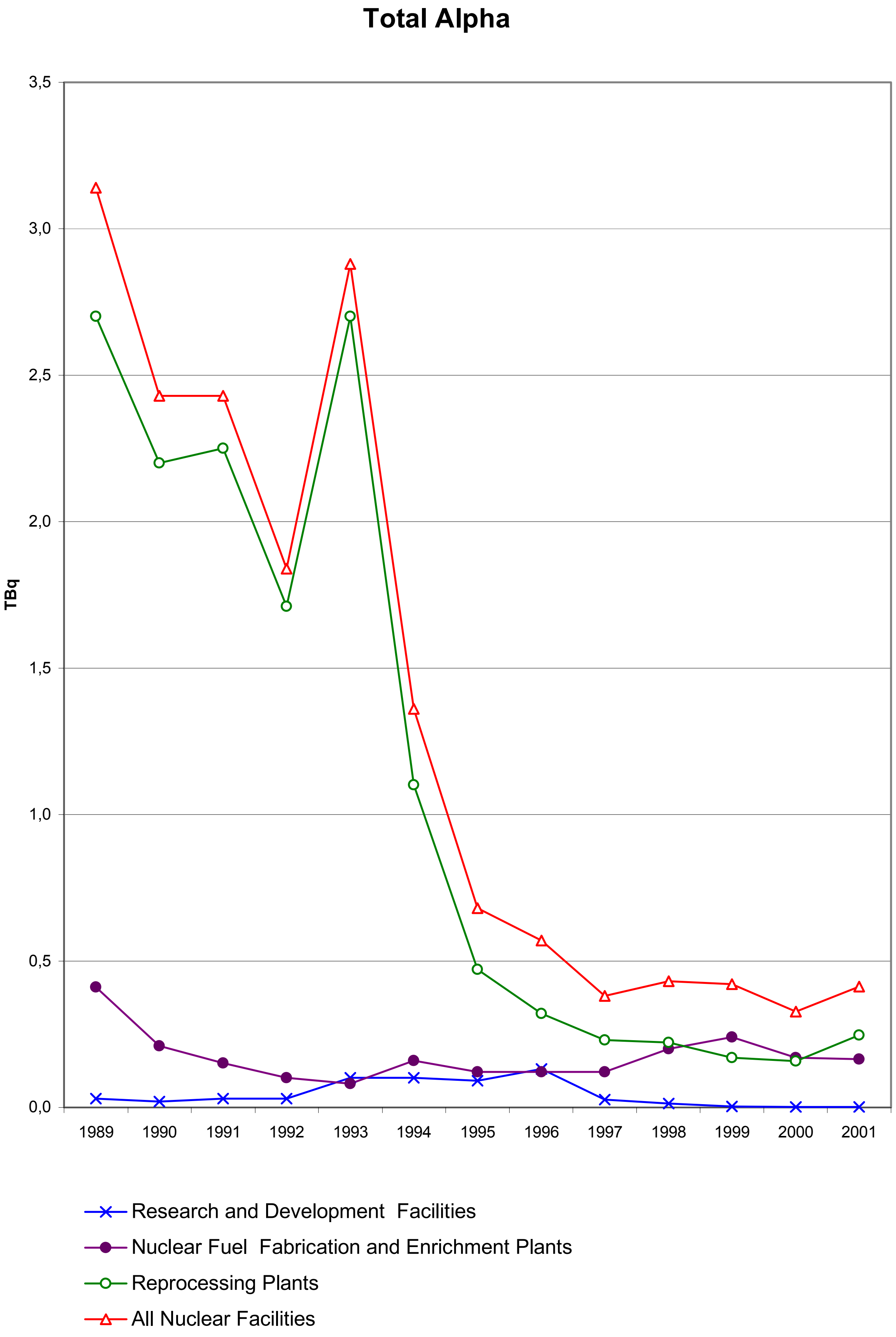


Figure 1 Annual releases of Total Alpha in liquid discharges from all nuclear installations of Contracting Parties to the OSPAR Convention, 1989 - 2001

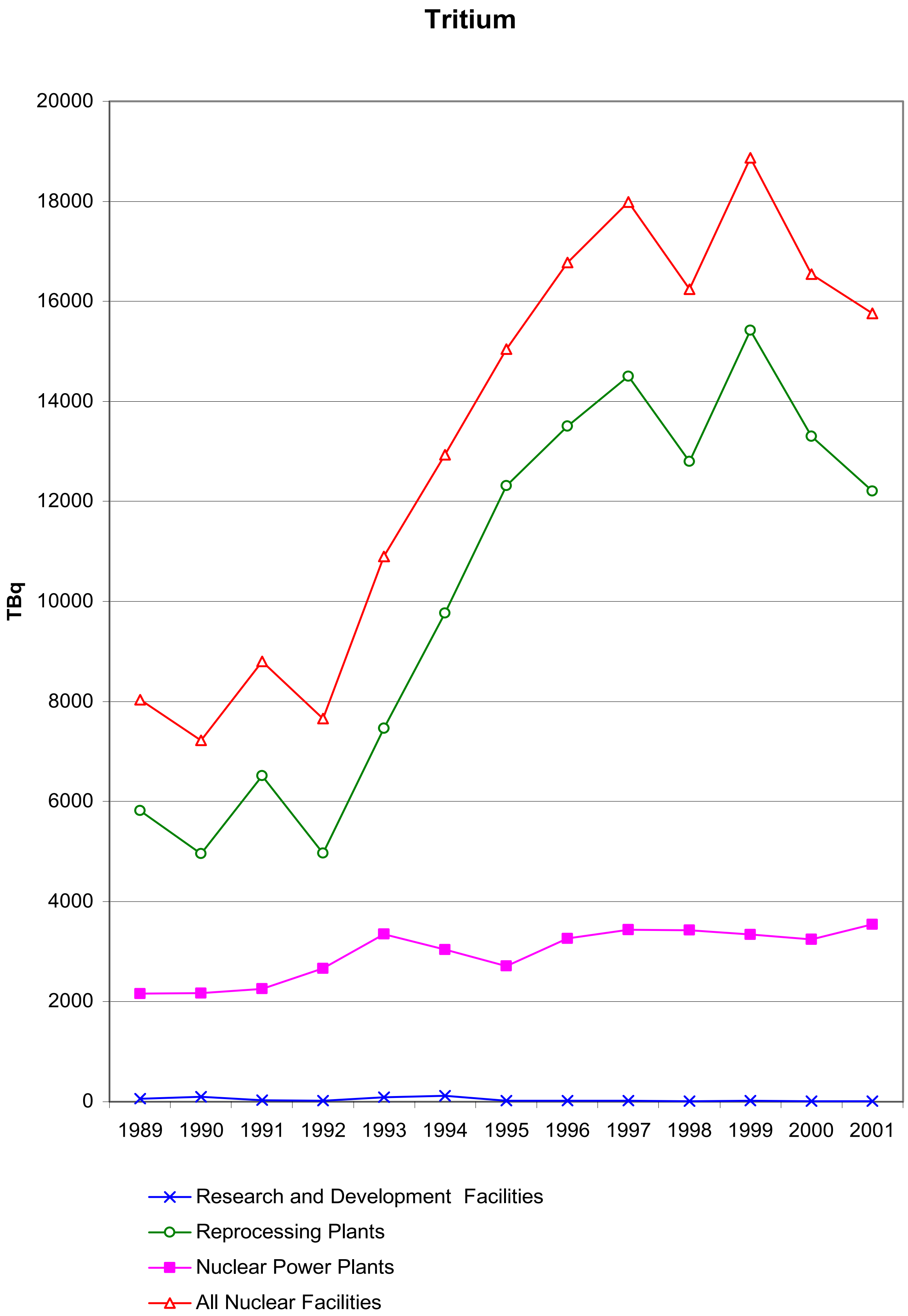
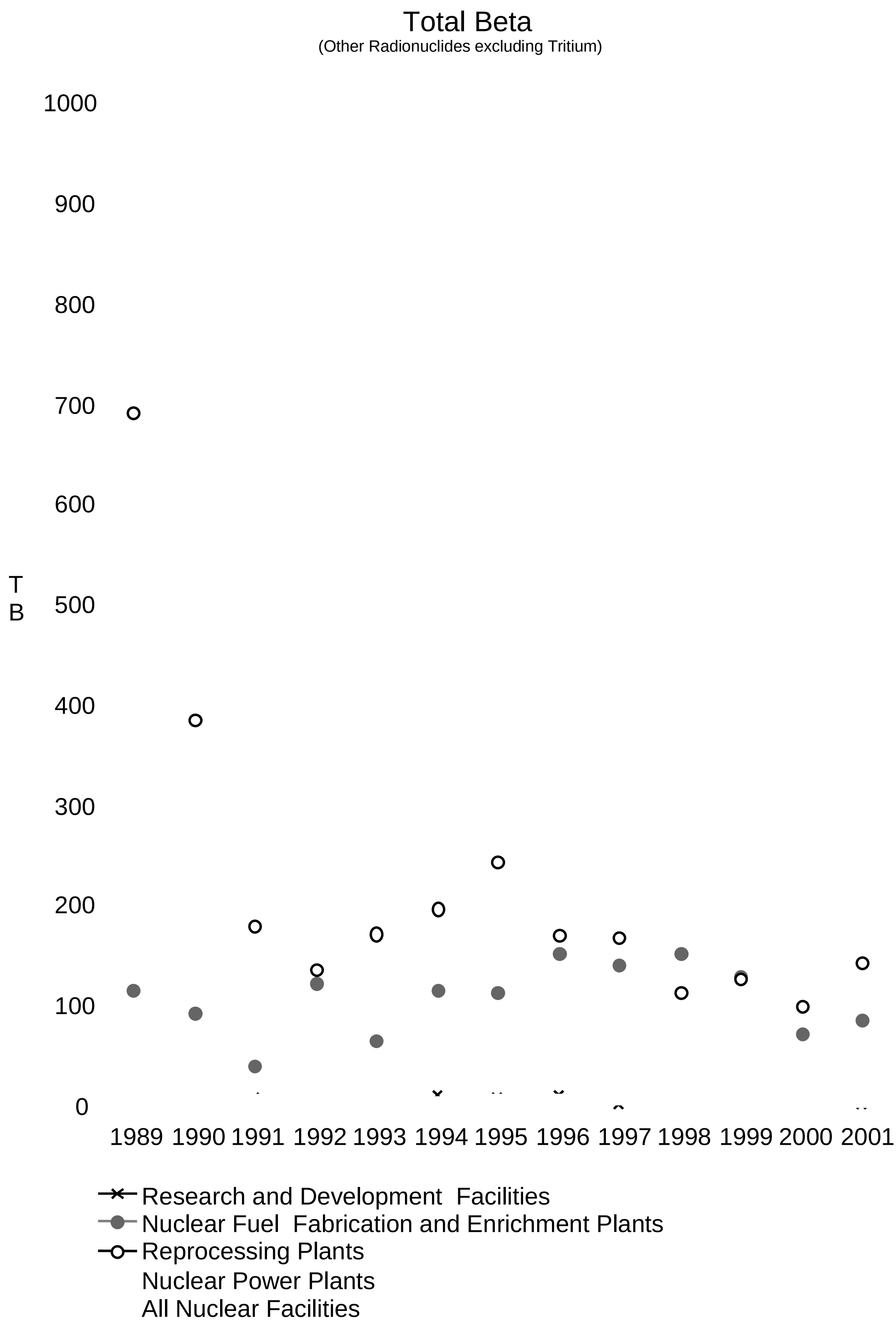


Figure 2: Annual releases of Tritium in liquid discharges from all nuclear installations of Contracting Parties to the OSPAR Convention, 1989 - 2001


Total Beta
(Other Radionuclides excluding Tritium)
1000
900
800
700
600
500
400
300
200
100
0
T
B
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
Research and Development Facilities
Nuclear Fuel Fabrication and Enrichment Plants
Reprocessing Plants
Nuclear Power Plants
All Nuclear Facilities

3. 2001 DATA AND INFORMATION

In this part of the report, data and information about liquid discharges from nuclear installations draining into the OSPAR maritime area is presented for each Contracting Party as follows:

Table 2: Nuclear Power Stations;

Table 3: Nuclear Fuel reprocessing Plants;

Table 4: Nuclear Fuel Fabrication and Enrichment Plants;

Table 5: Research and Development Facilities.

Further detailed information with respect to individual plants is presented in endnotes after the entire set of tables.

The column headings and abbreviations (e.g. for plants) used in the tables correspond to the reporting requirements set out in the current formats. The following abbreviations are used in the tables:

AGR: Advanced Gas Cooled Reactor;

GCR: Gas Cooled Reactor;

UNGG: Natural Uranium Gas Graphite (French equivalent for GCR);

PWR: Pressurised Water Reactor;

THTR: Thorium High Temperature Reactor;

BWR: Boiling Water Reactor;

NA: Not applicable;

NI: No information;

ND: Not detectable.

All data on discharge limits and releases of radionuclides have been entered in the tables using continental decimal system. The data values are expressed in scientific number format, e.g. 0,0009 as 9,0E-04.

The abbreviations used in the tables for radionuclides are the following:

Ag:	Silver	Gd:	Gadolinium	Rh:	Rhodium
Am:	Americum	I:	Iodine	Ru:	Ruthenium
Ba:	Barium	Mn:	Manganese	S:	Sulphur
Be:	Beryllium	Na:	Sodium	Sb:	Antimony
C:	Carbon	Nb:	Niobium	Se:	Selenium
Ce:	Cerium	Ni:	Nickel	Sr:	Strontium
Cm:	Curium	Np:	Neptunium	Tc:	Technetium
Co:	Cobalt	Pm:	Promethium	Th:	Thorium
Cr:	Chromium	Pr:	Praseodymium	U:	Uranium
Cs:	Caesium	Pu:	Plutonium	Y:	Yttrium
Eu:	Europium	Ra:	Radium	Zn:	Zinc
Fe:	Iron	Rb:	Rubidium	Zr:	Zirconium

3.1 Locations of nuclear installations

The following map gives an overview of the locations of the type of installations below:

Country / Code	Name installation	Type	Discharging into
Belgium			
B1	Doel	NPS	Schelde
B2	Tihange	NPS	Meuse
B3	Mol	RDF	River Mol-Neet
Denmark			
DK1	Risø	RDF	Kattegat through Roskilde Fjord
France			
F1	Belleville	NPS	Loire
F2	Cattenom	NPS	Mosel
F3	Chinon	NPS	Loire
F4	Chooz	NPS	Meuse
F5	Civaux	NPS	Vienne
F6	Dampierre en-Burly	NPS	Loire
F7	Fessenheim	NPS	Rhine
F8	Flamanville	NPS	Channel
F9	Fontenay-aux- Roses	RDF	Seine
F10	Golfech	NPS	Garonne
F11	Gravelines	NPS	North Sea
F12	Le Blayais	NPS	Gironde Estuary
F13	La Hague	NFRP	English Channel
F14	Nogent-sur-Seine	NPS	Seine
F15	Paluel	NPS	Channel
F16	Penly	NPS	Channel
F17	Saclay	RDF	Etang de Saclay
F18	Saint Laurent		Loire
Germany			
D1	Biblis A/Biblis B	NPS	Rhine
D2	Brokdorf	NPS	Elbe
D3	Brunsbüttel	NPS	Elbe
D4	Grafenrheinfeld	NPS	Main
D5	Grohnde/Emmerthal	NPS	Weser
D6	Hamm-Uentrop	NPS	Lippe
D7	Kahl	NPS	Main
D8	Krümmel/Geesthacht	NPS	Elbe
D8	Geesthacht	RDF	Elbe
D9	Lingen/Emsland	NPS	Ems
D9	Lingen	NFFEP	Ems - via municipal sewer system
D10	Mülheim-Kärlich	NPS	Rhine
D11	Neckar- westheim 1/Neckar-wesheim 2	NPS	Neckar
D12	Obrigheim	NPS	Neckar
D13	Philippsburg KKP1/ Philippsburg KKP2	NPS	Rhine
D14	Rheinsberg	NPS	Havel
D15	Stade	NPS	Elbe
D16	Rodenkirchen-Unterweser	NPS	Weser
D17	Würgassen/Beverungen	NPS	Weser

Country / Code	**Name installation**	**Type**	**Discharging into**
D18	Karlsruhe	RDF	Rhine
D19	Gronau	NFFEP	Vechte, IJsselmeer
D20	Hanau	NFFEP	Main - via municipal sewer system
D21	Karlstein	NFFEP	Main - via municipal sewer system
D22	HMI Berlin	RDF	Havel
D23	Jülich	RDF	Rur
D24	Rossendorf	RDF	Elbe
The Netherlands			
NL1	Borssele	NPS	Scheldt Estuary
NL2	Doodewaard	NPS	Waal
NL3	Almelo	NFFEP	Municipal sewer system
NL4	Delft	RDF	Sewage system
NL5	Petten	RDF	North Sea
Norway			
N1	Halden	RDF	River Tista (Skagerrak)
N2	Kjeller	RDF	River Nitelva (Skagerrak)
Portugal			
P1	Campus de Sacavém	RDF	Tagus River
Spain			
E1	Almaraz	NPS	Tagus
E2	José Cabrera	NPS	Tagus
E3	Trillo	NPS	Tagus
E4	Juzbado	NFFEP	River Tormes - Duero
Sweden			
S1	Barsebäck	NPS	Öresund
S2	Ringhals 1-4	NPS	Kattegat
Switzerland			
CH1	Beznau	NPS	Aare
CH2	Gösgen	NPS	Aare
CH3	Leibstadt	NPS	Rhine
CH4	Mühleberg	NPS	Aare
CH5	Paul Scherrer Institute	RDF	Aare
United Kingdom			
GB1	Berkeley	NPS	Severn Estuary
GB2	Bradwell	NPS	North Sea
GB3	Calder Hall	NPS	Irish Sea
GB4	Chapelcross	NPS	Solway Firth
GB5	Dungeness A/Dungeness B	NPS	English Channel
GB6	Hartlepool	NPS	North Sea
GB7	Heysham 1 / Heysham 2	NPS	Morecambe Bay
GB8	Hinkley Point A/Hinkley Point B	NPS	Severn Estuary
GB9	Hunterston A/Hunterston B	NPS	Firth of Clyde
GB10	Oldbury	NPS	Severn Estuary
GB11	Sizewell A/Sizewell B	NPS	North Sea
GB12	Torness	NPS	North Sea
GB13	Trawsfynydd	NPS	Trawsfynydd lake
GB14	Wylfa	NPS	Irish Sea
GB15	Sellafield	NFRP	Irish Sea

Country / Code	Name installation	Type	Discharging into
GB16	Capenhurst	NFFEP	Irish Sea via Rivacre Brook and Mersey Estuary
GB17	Springfields	NFFEP	Irish Sea via River Ribble
GB18	Dounreay	RDF	Pentland Firth
GB19	Harwell	RDF	River Thames
GB20	Winfrith	RDF	Weymouth Bay (English Channel)

NPS: Nuclear Power Stations
RDF: Research and Development Facilities
NFRP: Nuclear Fuel Reprocessing Plants
NFFEP: Nuclear Fuel Fabrication and Enrichment Plants

Map of nuclear installations

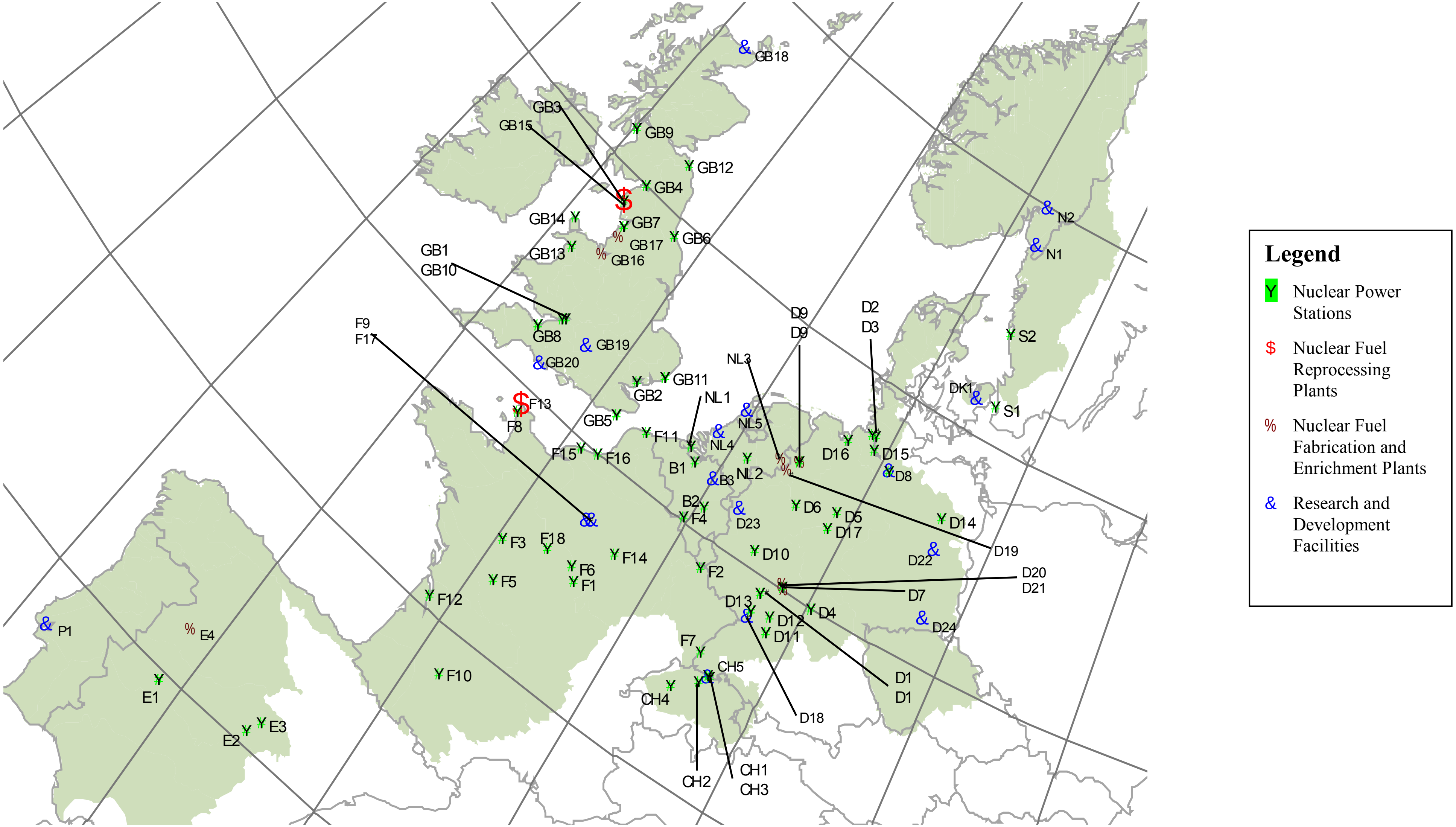


Table 2 Nuclear Power Stations

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capacity MW (e) 2001	Net Electrical Out-put MW (e) a 2001	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2001 (TBq)		Specific radionuclides												
						Tritium	other (2) radio-nuclides	gross (2) α-activity	gross (2) β-activity	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144
	Belgium																			
B1	Doel	Schelde	4 PWR	390 / 390	1. 392,5	1,0E+02	1,5E+00													
				900 / 1000	2. 392,5	3,8E+01	6,7E-03	0,0E+00	2,3E-05	8,4E-04	9,5E-04	0,0E+00	2,3E-05	0,0E+00	0,0E+00	6,3E-05	2,1E-03	0,0E+00	2,7E-03	0,0E+00
					3. 1006									0,0E+00						
					4. 985															
B2	Tihange	Meuse	3 PWR	900 / 900	1. 962	1,5E+02	8,9E-01	2,0E-03												
				1000	2. 960	4,1E+01	3,3E-02	1,2E-07	0,0E+00	2,1E-02	5,3E-03	0,0E+00	0,0E+00	2,6E-04	0,0E+00	3,6E-04	4,5E-04	9,6E-05	4,2E-04	0,0E+00
					3. 1015									7,5E-04						
	France (3)																			
F1	Belleville	Loire	2 PWR	2600		6,0E+01	4,3E-01													
						4,9E+01	1,0E-02			4,3E-04	3,5E-04					6,8E-05	2,2E-04	4,4E-05	5,9E-05	
F2	Cattenom	Mosel	4 PWR	5200		1,6E+02	2,2E+00													
						1,1E+02	1,0E-03			4,5E-04	1,7E-04					5,0E-05	3,5E-05	1,5E-05	7,2E-05	
F3	Chinon	Loire	4 PWR	3600		1,1E+02	1,5E+00													
						3,9E+01	1,4E-03			1,2E-04	1,4E-04					7,3E-04	2,4E-05	3,8E-05	7,3E-05	
F4	Chooz (4)	Meuse	2 PWR	2900		8,0E+01	2,2E-01													
						3,9E+01	7,0E-04			2,3E-04	4,0E-05					3,4E-04		8,0E-06	1,5E-05	
F5	Civaux	Vienne	2 PWR	2900		8,0E+01	2,2E-01													
						1,6E+01	1,7E-03			7,7E-04	2,4E-05					7,6E-04		1,2E-05	1,4E-05	
F6	Dampierre-en-Burly	Loire	4 PWR	3600		1,1E+02	1,5E+00													
						3,5E+01	2,2E-03			7,2E-04	6,8E-04					3,0E-04	6,4E-05	2,2E-05	2,2E-04	
F7	Fessenheim	Rhine	2 PWR	1800		7,5E+01	9,3E-01													
						2,3E+01	1,3E-03			3,9E-04	7,6E-05					5,1E-04		3,8E-05	5,4E-05	
F8	Flamanville	North Sea (Channel)	2 PWR	2600		6,0E+01	4,3E-01													
						5,8E+01	1,3E-02			3,7E-04	3,9E-04					1,2E-04	5,6E-05	1,5E-05	2,6E-05	
F10	Golfech (5)	Garonne	2 PWR	2600		8,0E+01	1,1E+00													
						4,9E+01	6,0E-04			2,5E-04	1,4E-04					8,0E-06		3,5E-05	9,7E-05	
F11	Gravelines	North Sea	6 PWR	5400		1,7E+02	2,2E+00													
						5,3E+01	5,9E-03			2,8E-03	8,9E-04					1,0E-03	5,7E-04	1,6E-05	9,1E-05	
F12	Le Blayais	Gironde Estuary	4 PWR	3600		1,1E+02	1,5E+00													
						4,7E+01	2,4E-03			7,2E-04	1,7E-04					9,4E-04		1,6E-05	2,7E-05	
F14	Nogent-sur-Seine	Seine	2 PWR	2600		8,0E+01	1,1E+00													
						5,3E+01	1,8E-03			4,7E-04	7,2E-04					2,7E-04	4,2E-05	2,2E-05	9,2E-05	
F15	Paluel	North Sea (Channel)	4 PWR	5200		1,2E+02	8,5E-01													
						1,0E+02	8,1E-02			2,7E-03	1,8E-03					6,3E-04	8,5E-04	8,0E-05	3,4E-04	
F16	Penly	Channel	2 PWR	2600		8,0E+01	1,1E+00													
						4,5E+01	1,1E-03			4,0E-04	2,7E-04					1,8E-05	3,1E-05	8,6E-04	1,8E-04	

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capacity MW (e) 2001	Net Electrical Out-put MW (e) a 2001	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2001 (TBq)														
								Specific radionuclides												
						Tritium	other (2) radio-nuclides	gross (2) α-activity	gross (2) β-activity	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144
F18	Saint	Loire	2 PWR	1800		4,5E+01	3,3E-01													
	Laurent (6)					2,6E+01	2,1E-02			6,0E-04	2,8E-04					2,5E-04	2,0E-05	1,7E-05	3,9E-05	
	Federal Republic of Germany																			
D1	Biblis A	Rhine	1 PWR	1225		3,0E+01	1,1E-01													
						7,7E+00	9,6E-05			1,2E-06	3,7E-05				1,2E-06	3,0E-07	3,4E-06	1,5E-07	1,2E-06	
D1	Biblis B	Rhine	1 PWR	1300		3,0E+01	1,1E-01													
						1,1E+01	2,6E-04			2,2E-06	1,4E-04					7,5E-07	7,7E-06	3,3E-06	1,2E-05	
D2	Brokdorf	Elbe	1 PWR	1440		3,5E+01	5,5E-02													
						2,0E+01	1,4E-05				6,5E-07						1,1E-07	1,4E-06	6,8E-06	
D3	Brunsbüttel	Elbe	1 BWR	806		3,7E+01	1,9E-01													
						3,1E-01	2,8E-04			1,0E-05	7,9E-05	1,5E-05	2,9E-07	2,3E-07			1,3E-08	2,3E-08	2,5E-05	
D4	Grafenrheinfeld	Main	1 PWR	1345		4,1E+01	5,5E-02													
						1,6E+01	2,9E-05			1,9E-07	1,7E-05			6,5E-07		2,6E-07		6,8E-08	8,3E-08	
D5	Grohnde/	Weser	1 PWR	1430		4,8E+01	5,5E-02													
	Emmerthal					1,3E+01	1,4E-05			4,2E-07	2,8E-06					8,4E-07			1,3E-07	
D6	Hamm-	Lippe	1 THTR	296	(7)	3,7E+01	1,9E-02													
	Uentrop																			
D7	Kahl	Main	1 BWR	16	(8)	1,5E-01	4,4E-02													
						2,9E-04	1,2E-05				6,2E-06		4,2E-08						2,8E-06	
D8	Krümmel/	Elbe	1 BWR	1316		1,9E+01	5,0E-02													
	Geesthacht					4,3E-01	2,6E-05				9,3E-06	3,8E-06								
D9	Lingen/	Ems	1 PWR	1363		3,5E+01	3,7E-02													
	Emsland					1,8E+01	1,4E-07			6,5E-08	2,6E-08			2,0E-08						
D9	Lingen	Ems	1 BWR	268	(9)	2,5E-02	2,5E-05													
						2,4E-04	4,1E-06	6,2E-08			1,4E-06								1,6E-06	
D10	Mülheim-	Rhine	1 PWR	1302	(8)	5,0E+01	6,0E-02													
	Kärlich					5,3E-03	1,1E-05				8,3E-06									
D11	Neckar-	Neckar	1 PWR	840		1,9E+01	1,9E-02													
	westheim 1					9,5E+00	1,4E-06	2,6E-07			5,1E-07		6,2E-08							
D11	Neckar-	Neckar	1 PWR	1365		7,0E+01	6,0E-02													
	westheim 2					9,5E+00	5,7E-07				1,9E-07			2,7E-07					1,1E-07	
D12	Obrigheim	Neckar	1 PWR	357		1,9E+01	1,9E-01													
						5,4E+00	1,1E-04	4,3E-08		2,0E-05	2,8E-05		1,9E-07			1,4E-05		4,2E-06	7,7E-06	
D13	Philippsburg	Rhine	1 BWR	926		1,9E+01	1,5E-01													
	KKP1					6,5E-01	1,3E-04			4,0E-06	6,3E-05	2,5E-05						2,4E-07	7,9E-06	
D13	Philippsburg	Rhine	1 PWR	1424		4,8E+01	1,5E-01													
	KKP2					1,3E+01	4,9E-04			8,5E-06	8,1E-05	1,8E-05		1,4E-06		7,9E-06	7,2E-06	3,0E-05	1,6E-04	
D14	Rheinsberg	Havel	1 PWR	70	(10)	2,0E+00	2,0E-03													
							5,5E-06	5,8E-08			1,0E-06		1,8E-07						1,0E-06	

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capacity MW (e) 2001	Net Electrical Out-put MW (e) a 2001	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2001 (TBq)														
								Specific radionuclides												
						Tritium	other (2) radio-nuclides	gross (2) α-activity	gross (2) β-activity	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144
D15	Stade	Elbe	1 PWR	672		4,8E+01	1,9E-01													
						5,1E+00	4,7E-05			3,1E-06	3,7E-05		2,5E-08	1,5E-07		6,8E-06	7,2E-06		6,5E-06	
D16	Rodenkirchen-	Weser	1 PWR	1350		3,5E+01	7,4E-02													
	Unterweser					1,6E+01	1,0E-04				2,9E-05					1,9E-07	1,2E-05	2,0E-06	1,2E-05	
D17	Würgassen	Weser	1 BWR	640	(11)	1,0E+01	6,0E-02													
	/Beverungen					8,0E-04	5,1E-05				1,4E-06		1,7E-07						1,5E-05	
	The Netherlands																			
NL1	Borssele	Scheldt	1 PWR	485	427	3,0E+01	0,2 (11a)	2,0E-05												
		Estuary				6,5E+00	5,8E-04	NI	NI	4,0E-05	1,2E-04	NI	NI	5,3E-05	NI	2,4E-05	NI	9,0E-06	2,0E-05	1,0E-06
NL2	Doodewaard	Waal	1 BWR	58	(11b)	2,0E+00	0,1 (11c)													
						2,5E-07	8,2E-07	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	Ni	NI	NI
	Spain																			
E1	Almaraz	Tagus	2 PWR	1956	1798	(12)	(12,13)													
						4,9E+01	9,0E-03	ND	NI	7,0E-04	1,7E-03	ND	ND	1,3E-04	ND	9,4E-04	8,8E-04	2,3E-04	1,1E-03	ND
E2	José	Tagus	1 PWR	160	121	(12)	(12,13)													
	Cabrera					4,5E+00	1,0E-04	ND	NI	3,1E-05	1,7E-05	ND	3,1E-06	ND	ND	ND	ND	ND	7,0E-06	ND
E3	Trillo	Tagus	1 PWR	1066	903	(12)	(12,13)													
						2,0E+01	1,0E-03	ND	NI	3,5E-05	3,4E-04	ND	ND	3,2E-05	ND	1,9E-04	2,3E-05	2,7E-05	2,8E-04	ND
	Sweden																			
S1	Barsebäck	Öresund	BWR	600		(15)	(16, 16a)													
	(14)					3,2E-01	4,9E-02			3,1E-03	3,1E-02	4,1E-04	1,6E-06	4,4E-04	ND	1,7E-04	5,6E-04	1,1E-03	7,0E-03	ND
S2	Ringhals 1-4	Kattegat	BWR	835		(15)	(16, 16b)													
						6,7E-01	2,0E-02			8,8E-04	1,7E-02	6,3E-06	2,4E-06	1,2E-04	ND	1,3E-04	9,8E-05	5,3E-06	4,9E-04	ND
			PWR	875		(15)	(16, 16c)													
						1,1E+01	1,2E-02			3,8E-04	4,6E-04	2,8E-06	8,5E-07	5,9E-05	ND	6,9E-04	9,1E-04	7,9E-06	3,8E-05	2,8E-06
			PWR	915		(15)	(16, 16d)													
						9,2E+00	2,4E-02			1,8E-02	1,6E-03	3,4E-05	ND	9,1E-04	ND	4,6E-04	1,4E-04	ND	3,6E-05	6,4E-06
			PWR	915		(15)	(16, 16e)													
						4,6E+00	1,3E-02			1,1E-02	6,8E-04	6,3E-06	2,0E-06	1,6E-04	ND	4,0E-05	9,6E-05	2,1E-05	3,2E-05	4,9E-07
	Switzerland																			
CH1	Beznau	Aare	2 PWR	380/380	353/293	7,0E+01	4,0E-01													
						1,1E+01	2,5E-02			2,0E-02	1,6E-03		2,2E-05	4,9E-05		1,8E-04	6,8E-04	2,3E-04	8,7E-04	6,6E-07
CH2	Gösgen	Aare	1 PWR	1015	899	7,0E+01	2,0E-01													
						1,2E+01	4,2E-06	2,8E-08			1,1E-06			1,8E-07		1,3E-06			8,2E-08	
CH3	Leibstadt	Rhine	1 BWR	1200	1038	2,0E+01	4,0E-01													
						1,1E+00	2,5E-04	6,5E-07		3,2E-06	1,3E-04							2,8E-05	4,0E-05	

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capacity MW (e) 2001	Net Electrical Out-put MW (e) a 2001	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2001 (TBq)														
								Specific radionuclides												
						Tritium	other (2) radio-nuclides	gross (2) α-activity	gross (2) β-activity	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144
CH4	Mühleberg	Aare	1 BWR	372	316	2,0E+01	4,0E-01													
						2,0E-01	1,1E-02			3,8E-04	5,1E-03	8,6E-04	6,3E-06	8,1E-06				6,9E-05	3,2E-03	
	United Kingdom																			
GB1	Berkeley	Severn	2 GCR	0	(17)	8,0E+00	4,0E-01												2,0E-01	
	(17)	Estuary				7,4E-04	3,9E-03												2,3E-03	
GB2	Bradwell	North Sea	2 GCR	245	184	3,0E+01	1,0E+00												7,5E-01	
					MWa	1,8E+00	3,1E-01												4,7E-01	
GB3	Calder Hall	Irish Sea	4 GCR	198	8		(18)													
					MWa		(18)													
GB4	Chapelcross	Solway Firth	4 GCR	192	1278693	5,5E+00		1,0E-01	2,5E+01											
					MWh	1,7E-01		7,3E-05	2,6E-02											
GB5	Dungeness A	English	2 GCR	440	288	3,5E+01	1,4E+00												1,2E+00	
	(19)	Channel			MWa	2,4E+00	2,1E-01												1,1E-01	
GB5	Dungeness B	English	2 AGR	1110	674	6,5E+02	2,5E-01				3,0E-02									
	(19)	Channel			MWa	3,6E+02	2,7E-02				2,4E-03									
GB6	Hartlepool	North Sea	2 AGR	1210	1017	1,2E+03	3,0E-01				3,0E-02									
	(20)				MWa	3,9E+02	8,4E-03				2,0E-03									
GB7	Heysham 1	Morecambe	2 AGR	1150	958	1,2E+03	3,0E-01				3,0E-02									
	(21)	Bay			MWa	4,0E+02	2,1E-02				7,9E-04									
GB7	Heysham 2	Morecambe	2 AGR	1250	1031	1,2E+03	3,0E-01				3,0E-02									
	(22)	Bay			MWa	3,3E+02	1,6E-02				2,3E-04									
GB8	Hinkley Point A	Severn	2 GCR	0	(23)	2,5E+01	1,0E+00												1,5E+00	
	(23)	Estuary				1,1E+00	1,5E-01												4,3E-01	
GB8	Hinkley Point B	Severn	2 AGR	1220	1047	6,2E+02	2,4E-01				3,3E-02									
	(24)	Estuary			MWa	4,2E+02	1,9E-02				4,5E-04									
GB9	Hunterston A	Firth of	2 CGR	0	(25)	7,0E-01	1,0 (Pu-241)	4,0E-02	6,0E-01											
		Clyde				4,1E-03	8,3E-04	1,4E-04	2,5E-02											
GB9	Hunterston B	Firth of	2 AGR	1150	7,38	8,0E+02	10 (S-35)	1,0E-03	4,5E-01		3,0E-02									
		Clyde			TWh	4,8E+02	2,3E+00	6,1E-05	5,8E-03		4,1E-04									
GB10	Oldbury	Severn	2 GCR	434	390	2,5E+01	1,3E+00												7,0E-01	
		Estuary			MWa	3,4E-01	3,2E-01												4,8E-01	
GB11	Sizewell A	North Sea	2 GCR	420	339	3,5E+01	7,0E-01												1,0E+00	
					MWa	2,0E+00	3,2E-01												7,6E-01	
GB11	Sizewell B	North Sea	1 PWR	1175	1050	8,0E+01	2,0E-01													
					MWa	6,4E+01	5,3E-02													
GB12	Torness	North Sea	2 AGR	1264		8,0E+02	10 (S-35)	1,0E-03	4,5E-01		3,0E-02									
GB13	Trawsfynydd	Trawsfynydd	2 GCR	0	(26)	1,2E+01	7,2E-01						8,0E-02						5,0E-02	
		lake				2,9E-02	1,8E-03						9,2E-04						1,9E-03	
GB14	Wylfa	Irish Sea	2 GCR	950	537	4,0E+01	1,5E-01													
					MWa	6,4E+00	5,5E-02													

Table 3 Nuclear Fuel Reprocessing Plants

Location (Map Ref.)	La Hague (F 13)		Sellafield (GB 15)	
Discharges to	English Channel		Irish Sea	
Type of Fuel Reprocessed Capacity (t/y)	PWR + BWR NI NI		Magnox, AGR, LWR 1750 te/yr Magnox 1200 te/yr U oxide (28)	
Radionuclide	Discharge Limit in TBq per annum (27)	TBq released per annum	Discharge Limit in TBq per annum (29, 30)	TBq released in 2001 (30)
Tritium	3,7E+04	9,7E+03	2,5E+04	2,6E+03
Total-α	1,7E+00	5,1E-02	1,0E+00	2,0E-01
Total-β	1,7E+03	1,8E+01	4,0E+02	1,2E+02
C 14		7,2E+00	2,1E+01	9,5E+00
S 35				
Mn 54		9,2E-03		
Fe 55				
Co 57		1,3E-04		
Co 58		2,3E-04		
Co 60		3,6E-01	1,3E+01	1,2E+00
Ni 63		8,0E-02		
Zn 65		4,1E-05		
Sr 89		ND		
Sr 90		3,6E-01	4,8E+01	2,6E+01
(Sr 90 + Cs 137)	2,2E+02	1,9E+00		
(Zr + Nb 95)		ND	9,0E+00	2,7E-01
Tc 99		2,5E-01	9,0E+01	7,9E+01
Ru 103		ND		
Ru 106			6,3E+01	3,9E+00
(Ru + Rh) 106		1,7E+01		
Ag 110m		ND		
Sb 124		ND		
Sb 125		3,8E-01		
I 129		1,2E+00	1,6E+00	6,3E-01
Cs 134		4,0E-02	6,6E+00	4,8E-01
Cs 137		1,5E+00	7,5E+01	9,6E+00
Ce 144			8,0E+00	7,9E-01
(Ce + Pr) 144		1,5E-05		
Pm 147		ND		
Eu 152		ND		
Eu 154		8,6E-04		
Eu 155		1,9E-05		
Np 237		8,6E-04		
Plutonium-a		1,2E-02	7,0E-01	1,6E-01
Pu 241		2,1E-01	2,7E+01	4,6E+00
Am 241		2,1E-02	3,0E-01	3,8E-02
Cm 242		1,6E-05		
Cm 243+244		2,2E-03		
Uranium (kg)			2,0E+03	3,9E+02

Table 4 Nuclear Fuel Fabrication and Enrichment Plants

Map Ref.	Country/ site	Discharges to	Type of Fuel	Capacity (t/y)	Production	Activity	Discharge limit in TBq per annum	TBq released in 2001
	Federal Republic of Germany							
D9	Lingen	Ems - via municipal sewer system	LWR	400		Uranium	350g uranium	not detectable
D19	Gronau	Vechte, IJsselmeer	Uranium enrichment	760		total - α	7,4E-07	1,0E-08
D20	Hanau	Main - via municipal sewer system	PWR, MOX	1350		total - α	1,5E-02	1,4E-04
	Netherlands							
NL3	Almelo	Municipal sewer system	Uranium enrichment	2500	1483	total - α	2,0E-05	2,7E-06
						β– & γ– emitting radionuc.	2,0E-04	1,5E-05
	Spain							
E4	Juzbado	River Tormes - Duero	PWR, BWR	500	260	total - α	1,2E-02	2,5E-05
	United Kingdom							
GB16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment	NI		Uranium - α	2,0E-02	1,5E-03
						Uranium daughters	2,0E-02	2,2E-03
						other - α	3,0E-03	2,1E-05
						Tc 99	1,0E-01	1,3E-03
GB17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication	10000 te/yr as UOC		total - α	4,0E+00	1,6E-01
						total - β	2,4E+02	8,5E+01
						Tc 99	6,0E-01	1,8E-02
						Th 230	2,0E+00	6,9E-02
						Th 232	2,0E-01	4,7E-03
						Uranium α	1,5E-01	4,8E-02
						Np 237	4,0E-02	3,0E-04

Table 5 Research and Development Facilities

Map Ref.	Country/ site	Discharges to	Reactors Number & Type	Installed Capacity	Radionuclides	Discharge limit in TBq per annum	TBq released per annum in 2001
	Belgium						
B3	Mol	River Mol-Neet	1	40 MW (th)	weighted activity	2,0E+00	5,8E-03
	France						
F9	Fontenay-aux-Roses	Seine	Centre de recherches du Commissariat à l'énergie atomique		Alpha	1,0E-03	3,0E-06
					Bêta (autre que tritium)	4,0E-02	1,3E-05
					Tritium	2,0E-01	3,3E-04
F17	Saclay	Etang de Saclay	Centre de recherches du Commissariat à l'énergie atomique		Alpha	7,4E-04	<1,65E-04
					Bêta (autre que tritium)	3,7E-02	1,5E-03
					Tritium	7,8E+00	1,2E-01
	Denmark						
DK1	Risø	Kattegat through Roskilde Fjord		None	Tritium	(30)	1,5E-01
					gross β	(31)	1,3E-04
	Federal Republic of Germany						
D8	Geesthacht	Elbe	1	5 MW	Tritium	5,6E-02	7,8E-03
					other radionuclides	1,9E-02	1,2E-04
D18	Karlsruhe	Rhine	No reactors	None	Tritium	1,5E+02	6,9E-01
					other radionuclides	3,2E-01	1,9E-05
D22	HMI Berlin	Havel	1	10 MW	Tritium	-	5,8E-04
					other radionuclides	-	2,8E-07
D23	Jülich	Rur	1	23 MW	Tritium	1,1E+01	4,4E-01
					other radionuclides	7,6E-03	2,8E-04
D24	Rossendorf	Elbe	No reactors	None	Tritium	4,0E-01	1,1E-02
					other radionuclides	2,3E-04	4,1E-06
	Portugal						
P1	Campus de Sacavém	Tagus River	1 Research Swimming Pool Reactor	1 MW	total - β	4,0E-02	8,1E-01
	Netherlands						
NL4	Delft (32)	Sewage system	1	6 MW (th)	α - emitting radionuclides		<0,3E-06
					β – emitting radionuclides		6,5E-06
					γ – emitting radionuclides		<2,7E-06
					total	20gew RE,ing(33)	
NL5	Petten (34)	North Sea	1 HFR for material testing	60 MW (th)	Tritium		2,3E-02
					α - emitting radionuclides		7,0E-06
			1 LFR	30 MW (th)	β/γ – emitting radionuclides		1,3E-01
					total	2000gew RE,ing(33)	
	Norway						
N1	Halden (35)	River Tista (Skagerrak)	1 BWR D2O as moderator	25 MW	Tritium	4,0E+02	2,4E-01
					Cr 51	4,0E+00	2,9E-04
					Mn 54	4,0E-03	7,0E-06
					Co 58	3,0E-01	4,9E-05
					Co 60	8,0E-02	4,4E-04
					Nb 95	8,0E-02	4,0E-05
					Zr 95	8,0E-02	1,6E-05
					Sb 124	5,0E-02	-
					Cs 134	1,0E-02	2,0E-06
					Cs 137	1,0E-02	5,8E-05
					I-131	4,0E-03	4,3E-08
					Sb-125	1,5E-02	1,3E-04

Table 5, cont. Research and Development Facilities

Ref	Country site	Discharges to	Reactors Number & Type	Installed Capacity	Radionuclides	Discharge limit in TBq per annum	TBq released per annum in 2001
N2	Kjeller (35)	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled Research Reactor	2 MW	Tritium	4,8E+02	1,5E+00
					S 35	8,0E-02	0,0E+00
					Co 60	1,1E-03	7,4E-05
					Zn 65	1,7E-03	3,8E-06
					Sr 90	4,8E-03	1,2E-06
					I 125	2,5E-02	3,1E-04
					I 131	1,3E-02	1,1E-04
					Cs 134	1,5E-04	2,5E-06
					Cs 137	2,7E-04	2,6E-05
					Gd 153		-
					Pu 239	2,0E-02	4,1E-08
	Switzerland						
CH5	Paul Scherrer Institute	Aare	1 research reactor, 1 hot laboratory	zero power	Tritium	2,0E+01	1,3E-01
					other radionuclides	2,0E-01	1,2E-04
					β- and γ- emitting radionuclides		
					Be 7		1,2E-07
					Na 22		4,3E-07
					S 35		1,8E-05
					Mn 54		1,9E-08
					Co 57		7,5E-09
					Co 58		9,5E-09
					Co 60		9,6E-06
					Zn 65		2,3E-08
					Sr 90		4,4E-05
					I 125		2,9E-05
					I 131		1,8E-06
					Cs 134		5,9E-07
					Cs 137		1,8E-05
					Eu 154		9,8E-08
					α - emitting radionuclides		
					U 234/238		4,8E-07
					Pu 238/Am 242		2,0E-07
					Pu 239/240		3,8E-08
	United Kingdom						
GB18	Dounreay (36)	Pentland Firth	No reactors	None	α - emitting radionuclides (excluding Cm 242)	2,7E-01	1,4E-03
					β - emitting radionuclides (excluding Tritium)	4,9E+01	3,1E-01
					Tritium	3,1E+01	9,7E-02
					Co 60	4,6E-01	7,4E-04
					Sr 90	7,7E+00	1,6E-01
					Zr 95 + Nb 95	4,0E-01	6,4E-04
					Ru 106	4,1E+00	1,5E-03
					Ag 110m	1,3E-01	2,4E-04
					Cs 137	2,3E+01	1,5E-02
					Ce 144	4,2E-01	1,0E-03
					Pu 241	2,3E+00	7,4E-04
					Cm 242	4,0E-02	5,1E-07

Table 5 Research and Development Facilities

Map Ref.	Country/ site	Discharges to	Reactors Number & Type	Installed Capacity	Radionuclides	Discharge limit in TBq per annum	TBq released per annum in 2001
GB19	Harwell	River Thames	No reactors	None	total - α	1,0E-03	1,2E-05
					total - β	2,0E-02	6,1E-04
					Tritium	4,0E+00	1,6E-02
					Co 60	7,0E-03	9,4E-06
					Cs 137	7,0E-03	6,3E-05
GB20	Winfrith	Weymouth Bay (English Channel)	No reactors	None	total - α	3,0E-01	1,6E-04
					Tritium	6,5E+02	2,4E+00
					Co 60	1,0E+01	1,3E-03
					Zn 65	6,0E+00	2,4E-04
					others	8,0E+01	1,3E-02

4. FOOTNOTES TO TABLES 2-5

(1) Discharge limits are given in row above the actual releases.

(2) Where the value indicated corresponds to the sum of individually assessed nuclides, please indicate the nuclides included.

For Belgium:

ß-Activity for Tihange: Sr-89, Sr-90. ß-Activity for Doel: Sr-89, Sr-90. Other radionuclides for Tihange: Na-24, Cr-51, Mn54, Co-57, Co-58, Co-60, Fe-59, Zn-65, Zr-95, Nb-95, Mo-99, Tc99m, Ru-103, Ru-106, Ag-110m, Sb-122, Te-123m, Sb-124, Sb-125, I-131, Cs-134, Cs-136, Cs-137, Ba-140, La-140, Ce-141, Ce-144. Other radionuclides for Doel: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, Zr-95, Nb-95, Ru-103, Ru-106, Ag-110m, Te-123m, Sb-124, Sb-125, I-131, Cs-134, Cs-137, Ba-140, La-140, Ce-141, Ce-144.

(3) French statement, cf. Appendix.

(4) Chooz A ceased to operate on 30.10.1992, Chooz B1 was connected to the grid on 30.8.1996.

(5) Second reactor was connected to the grid on 28.5.1993.

(6) Ceased to operate on 27.5.1992.

(7) Shut down in 1988.

(8) Shut down in 1986.

(9) Shut down in 1977.

(10) Shut down in 1990.

(11) Shut down in 1994.

(11a) Total β- and γ-activity excluding Tritium. In 2001 for Borssele the detected radionuclides were: Co-58; Co-60; Zr-95/Nb-95; Ag-110m; Cs-134; Cs-137; Ce-144.

(11b) Dodewaard shut down 26 March 1997.

(11c) Total β- and γ-activity excluding Tritium. For the year 2001 no specific nuclides were indicated for Dodewaard.

(12) Each facility has to comply with an authorised total effective dose equivalent limit of 100 µSv/y (ALARA dose limit), which is distributed between liquid and gaseous effluents in accordance with the criteria established in the Offsite Dose Calculation Manual. The relation between discharges and dose is calculated according to a methodology developed in the above document, based on the USNRC-Regulatory Guide 1.109 methodology with dose conversion factors for internal exposition taken from the NRPS-GS7 publication, using local or national parameters.

(13) Total β- and γ-activity excluding Tritium and dissolved gases.

(14) Discharges into the Øresund (HELCOM area adjacent to the OSPAR Maritime Area). Data provided for information only.

(15) Discharges from Swedish nuclear facilities are regulated on the basis of dose to critical group. The annual effective dose to individuals of the critical group shall during normal operation not exceed 0,1 mSv. The 2001 discharges to the marine environment from the Ringhals and Barsebäck Nuclear Power Plants correspond to annual effective doses of 0,06 µSv and 0,16 µSv, respectively.

(16) Total α-, β-, and γ-activity excluding Tritium.

(16a) In 2001 the detected radionuclides for Barsebäck were: Cr-51, Mn-54, Fe-59, Co-58, Co-60, Zn-65, Sr-90, Nb-95, Zr-95, Ag-110m, Sn-113, Sb-124, Sb-125, Cs-134, Cs-137, La-140, Pu-239, Am-241, Cm-244.

(16b) For Ringhals unit 1 the detected radionuclides were: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, As-76, Sr-90, Nb-95, Zr-95, Ag-110m, Sn-113, Sb-124, Sb-125, Cs-134, Cs-137, Ba-140 La-140, Pu-238/Am-241, Pu-239/Pu-240, Am-241,Cm-242, Cm-244, I-131.

(16c) For Ringhals unit 2 the detected radionuclides were: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, Sr-90, Nb-95, Zr-95, Ag-110m, Sn-113, Sb-122, Sb-124, Sb-125, Cs-134, Cs-137, Ce-144, Pu-238/Am-241, Pu-239/Pu-240, Am-241, Cm-242, Cm-244.

(16d) For Ringhals unit 3 the detected radionuclides were: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, Sr-89, Nb-95, Zr-95, Ag-110m, Sn-113, Sb-124, Sb-125, Te-132, Cs-137, Ce-144, Pu-238/Am-241, Pu-239/Pu-240, Am-241, Cm-242, Cm-244.

(16e) For Ringhals unit 4 the detected radionuclides were: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, Sr-90, Nb-95, Zr-95, Zr-97, Ag-110m, Sn-113, Sb-124, Sb-125, Cs-134, Cs-136, Cs-137, Ce-144, Pu-238/Am-241, Pu-239/Pu-240, Am-241, Cm-242, Cm-244, I-131.

(17) Shut down in 1989, reactors decommissioned. Combined discharge data for Berkeley Power Station and Technology Centre.

(18) Discharges from Calder Hall power station are included in the data for Sellafield (cf. Table 3).

(19) New authorised discharge limits came into effect on 1 July 1994. Dungeness B also discharges sulphur-35 in a liquid form. The discharge limits and values for 2001 for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and are as follows: limit 2 TBq; discharge 0,58 TBq.

(20) Hartlepool also discharges sulphur-35 in a liquid form. The discharge limits and values for 2001 for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and are as follows: limit 3 TBq; discharge 1,72 TBq.

(21) Heysham 1 also discharges sulphur-35 in a liquid form. The discharge limits and values for 2001 for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and are as follows: limit 2,8 TBq; discharge 0,179 TBq.

(22) Heysham 2 also discharges sulphur-35 in a liquid form. The discharge limits and values for 2001 for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and are as follows: limit 2,3 TBq; discharge 0,0558 TBq.

(23) Hinkley A is permanently shut down.

(24) Hinkley B also discharges sulphur-35 in a liquid form. The discharge limits and values for 2001 for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and are as follows: limit 5 TBq; discharge 0,483 TBq.

(25) Shut down in 1990, reactors decommissioned.

(26) Shut down in 1991, reactors decommissioned.

(27) Discharges of the Centre de Stockage de la Manche (low and intermediate level waste disposal site) are included in the La Hague discharges.

(27a) The reprocessing of uranium oxide fuel began in 1994.

(28) New authorisation for discharges from Sellafield came into force on 17 January 1994. There was a variation to the liquid (sea pipelines) and gaseous (THORP stacks) authorisations for Sellafield from 1 January 2000. The values of the liquid discharge limits for tritium and iodine-129 vary depending on the annual mass throughput of uranium in THORP (Thermal Oxide Reprocessing Plant), which was 573 tonnes in 2001.

(29) Discharges from Calder Hall Nuclear Power Station are included in the discharges from Sellafield.

(30) Reporting obligation at discharge 10 times above average level.

(31) The discharge limit is 0,4 Bq/ml gross-β in the sewage from the plant. The average sewage discharge is 77,5x 10^9 ml per annum. The discharge limit per annum can thus be calculated to 0,03 TBq gross-β.

(32) The data represent the total emissions/discharges from the Interfaculty Research Institute (IRI) complex, including the IRI-Higher Research Reactor (HOR) and different laboratories (it is not

possible to make a distinction between the various sources). The discharges from the IRI-HOR are substantially lower than the values reported. At the end of 1996 the permit regarding discharges to sewage were changed into a maximum value of 20 weighted Re,ing per year.

(33) Depending on the half life of the individual radionuclides, 1 weighted Re,ing corresponds with the following amounts of radioactivity expressed in ICRP-61 Annual Limit Intake (ALI) -units:

0,5	ALI	for	t ½	>	250 year			
5	ALI	for	250 year	>	t ½	>	25	year
50	ALI	for	25 year	>	t ½	>	15	days
500	ALI	for	15 days	>	t ½	>	7,5	days
5 000	ALI	for	7,5 days	>	t ½	>	5	days
50 000	ALI	for	5 days	>	t ½			

(34) The data represent the total emissions/discharges from the Petten complex. This will lead to a substantial overestimate of the discharges of the two reactors (it is not possible to distinct the discharges from each separate reactor). In all cases concentrations of α-emitters were lower than the detection limit, which is used for load calculations. The discharge limits for Petten have been changed into 2000 weighted Re,ing per year.

(35) Annual discharge data of gaseous effluents are also available.

(36) The prototype fast reactor was shut down on 31 March 1994 and there is to be no further fuel reprocessing at Dounreay.

APPENDIX

RADIOACTIVE EFFLUENT AND THE PRODUCTION OF ELECTRICITY

Explanatory text to footnote 5 (submitted by France)

There is no simple relationship between the production of electricity and discharges of radioactive effluent other than tritium. This is because the amounts of effluent discharged depend on many factors: the condition of fuel cladding (first barrier), the processing carried out in the various existing plants, the operational mode of the reactor (load-following or providing basic power) and, above all, the volume of work carried out during shutdowns for refuelling.

Moreover, electricity is produced according to a programme fixed station by station at national level, and deliberate shutdowns, either during stand-by periods or for work to be carried out, are fixed by national criteria: the end of a natural cycle, arrangements for maintenance depending on the availability of teams of workers, constraints of the national grid and the demand for electricity.

It is easy to understand that a unit can operate over a calendar year and can produce a lot of power if it has been refuelled at the end of the previous year and if it is made to extend its cycle. In this case, the production of effluent will be minimised (no work is carried out). On the other hand, a unit shutdown for a long time (decennial shut-down, typically) will show an increase in the production of effluent and a decrease in the power supplied. During the next year, these two scenarios may be reversed. There is therefore good reason not to attempt a comparison of one site with another over short periods (= 10 years) as regards the quantity of radioactive effluent (other than tritium) discharged for a given amount of electrical energy produced.