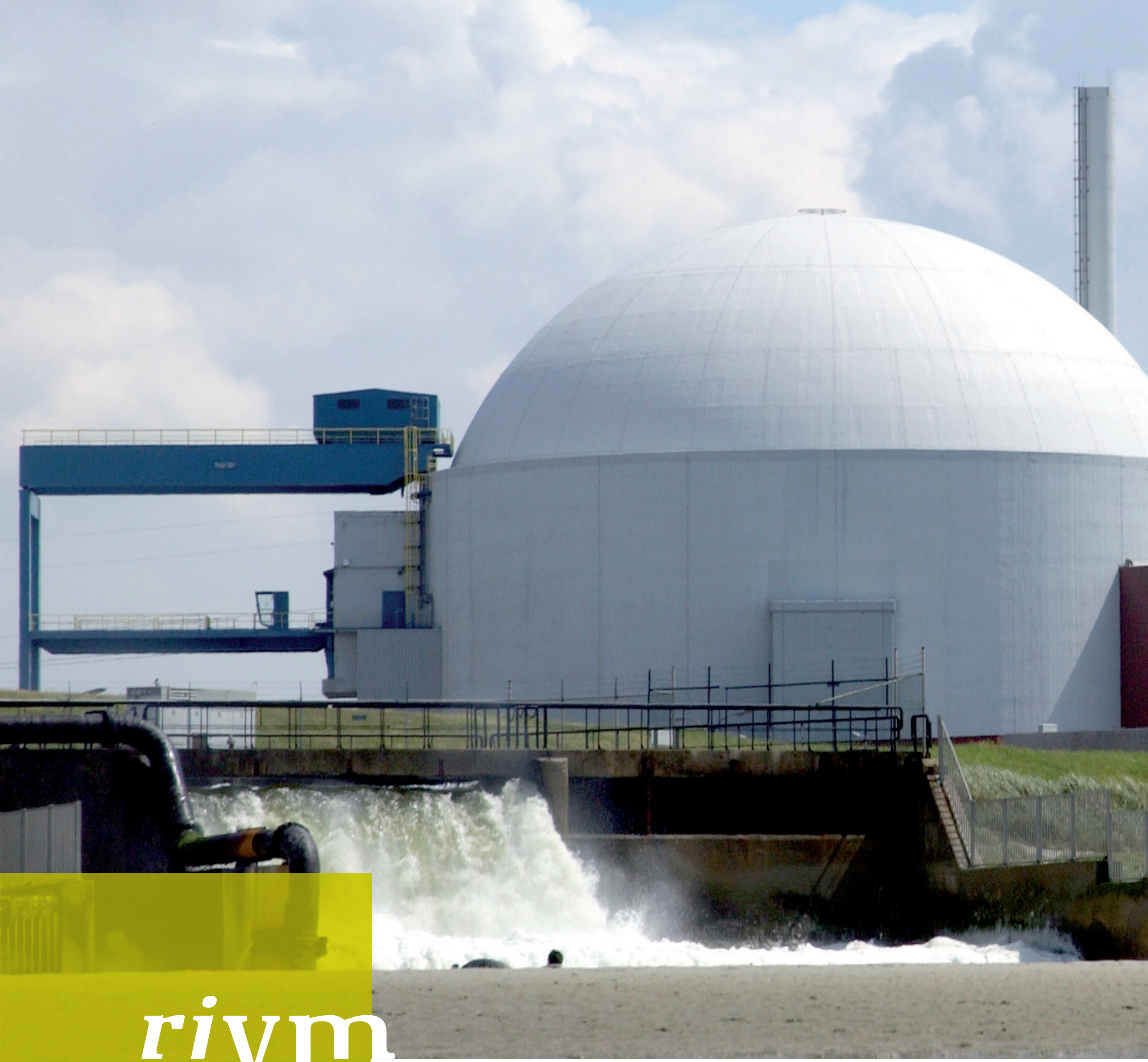

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Report 610790005/2009

C.P. Tanzi | P.J.M. Kwakman

Report on implementation of PARCOM Recommendation 91/4 on radioactive discharges by the Netherlands

OSPAR: nuclear installations

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Abstract

Report on implementation of PARCOM Recommendation 91/4 on radioactive discharges by the Netherlands
OSPAR: nuclear installations

This report presents the discharges of radioactive substances to sea by nuclear installations in the Netherlands between 1998 and 2007. The techniques used to reduce these discharges are also described. This report fulfills the recommendation of the OSPAR Convention to report regularly on these discharges and techniques.

The Netherlands has ratified the OSPAR Convention, which entered into force in 1998. The aim of the OSPAR Convention is to prevent and eliminate pollution and to protect the marine environment of the North-East Atlantic (including the North Sea) against the adverse effects of human activities. The agreement is to prevent pollution as much as possible and to terminate discharges where possible.

The highest radiation dose resulting from the discharges to sea has been assessed for each of the nuclear installations. Each dose is less than one thousandth of the average radiation dose for individuals in the Netherlands.

Key words:
OSPAR, radioactive substances, nuclear power plant, nuclear installation, discharges, water, marine environment, North Sea, the Netherlands

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Rapport in het kort

Rapport over de aanvulling van PARCOM Aanbeveling 91/4 over radioactieve lozingen door Nederland
OSPAR: nucleaire installaties

Dit rapport beschrijft de lozing van radioactieve stoffen naar de zee door nucleaire installaties in Nederland tussen 1998 en 2007. Ook staan de technieken beschreven die worden toegepast om die lozingen te beperken. Het rapport geeft daarmee invulling aan de aanbevelingen uit het OSPAR-verdrag om regelmatig verslag uit te brengen over die lozingen en technieken.

Nederland heeft het OSPAR-verdrag, dat sinds 1998 van kracht is, ondertekend. De doelstelling van het verdrag is om maatregelen te nemen die het zeegebied (het noordoostelijke deel van de Atlantische Oceaan inclusief Noordzee) beschermen tegen de nadelige gevolgen van menselijke activiteiten. Daartoe is afgesproken verontreiniging zoveel mogelijk te voorkomen en lozingen waar mogelijk te beëindigen.

Voor elk van de nucleaire installaties is een schatting gemaakt van de maximale dosis als gevolg van de waterlozingen. Deze dosis is minder dan één duizendste van de gemiddelde stralingsdosis die mensen in Nederland oplopen.

Trefwoorden:
OSPAR, radioactieve stoffen, lozingen, water, mariene milieu, kerncentrale, nucleaire installatie, Noordzee, Nederland

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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. This is the report of the Netherlands for the fifth round of implementation reporting (2008-2011). The information is submitted according to the OSPAR 'Guidelines for the submission of information about, and assessment of, the application of BAT in nuclear facilities'.

The information presented in this report is in accordance with the OSPAR guidelines 2004-03 and includes indicators that BAT/BEP (Best Environmental Practices) have been applied in all nuclear installations in the Netherlands: the only operational nuclear power plant in the Netherlands, the nuclear fuel enrichment plant, two locations with research reactors, the waste treatment plant, and the nuclear power plant Dodewaard which has ceased operations in 1997, and is presently in the state of Safe Enclosure.

1 Introduction

PARCOM Recommendation 91/4 states that contracting parties agree 'to respect the relevant Recommendations of the competent international organisations and to apply the Best Available Technology (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. Contracting Parties shall present a statement on progress made in applying such technology every four years in accordance with the guidelines annexed to this recommendation'.

After the third round of implementation reporting on PARCOM Recommendation 91/4, the OSPAR Radioactive Substance Committee compiled revised guidelines at its 2004 meeting in La Rochelle (France) for the submission of information about, and the assessment of, the application of BAT in nuclear facilities. This document has been elaborated according to these guidelines.

This document reviews the situation in the Netherlands over the period 1998-2007, and is part of the fifth round of implementation reporting.
A previous report (OSPAR document 2005/238 [OSP05]), which contains information from report RIVM/LSO 561/04, covered the years 1998-2003.

In this report general information on the national implementation of BAT/BEP (Best Environmental Practices), discharge limits and monitoring programmes is provided.
Chapters 2 to 7 deal with the only operational nuclear power plant in the Netherlands, the nuclear fuel enrichment plant, two locations of research reactors, and the nuclear waste treatment plant.
For completeness, information is also reported on the nuclear power plant Dodewaard which has ceased operations in 1997. This nuclear power plant is in decommissioning and no radionuclides are discharged to water since July 2005.

Appendix A to this report provides additional information on the location of the nuclear installations and specific sampling locations of the national monitoring programme. Figures showing the discharges and emissions normalized to the granted limits and annual production figures can be found in Appendix B. The environmental impact is illustrated in Appendix C. In Appendix D the specific references for the discharge data are given for each year and for each installation.

Information on the radiological discharges of nuclear (and non nuclear) industries are collected by the National Institute for Public Health and the Environment (RIVM) and reported to the Ministry of Housing, Spatial Planning and the Environment. Information on emissions to the environment is made available on the internet at www.rivm.nl/brs [RIVM08].

2 General information

2.1 Implementation of BAT/BEP in terms of the OSPAR Convention in national legislation/regulation

In the Netherlands, the basic legislation governing nuclear activities is contained in the Nuclear Energy Act. The character and aim of the Nuclear Energy Act is to stimulate the safe application of nuclear energy and radioactive techniques, as well as to give rules for protection against the risks of such applications. The Act lays down the basic rules in the nuclear field, makes provision for radiation protection, designates the different competent authorities and outlines their responsibilities. Responsibility for nuclear installations is not centralized, but shared by several Ministers who consult each other and issue regulations jointly, as required, in accordance with the area of competence.

There have not been any relevant changes in legislation since the previous report [OSP05]. This section largely reflects the information contained in that report.

The provisions for radiation protection in the Act are based on the three principles of radiation protection: justification, optimization and dose limits. Optimization is applied by the ALARA concept: exposure to ionizing radiation should be kept As Low As Reasonably Achievable, economic and social factors taken into account. The terms BAT/BEP (Best Available Techniques and Best Environmental Practices) are not explicitly referred to in the Nuclear Energy Act. BAT/BEP, as defined in terms of the OSPAR Convention, are implemented in the Dutch national regulation by means of the ALARA principle.

2.2 Dose limits/constraints for nuclear installations

The dose limit for members of the public is 1 mSv per year (1 mSv/y). This limit is cumulative for all sources an individual is exposed to. The assumption is that a member of the public will be exposed to at most 10 sources. Consequently, a location limit of 0.1 mSv/y is set for individual sources. As there are no specific dose constraints for nuclear installations, a nuclear power plant is not allowed to expose members of the public to more than 0.1 mSv/y, due to normal operation.

A nuclear installation has to meet given regulatory risk criteria. These are defined such that the cumulative risk of death from all sources together is set to a maximum permissible level of 10^{-5} per year. For a single source, the individual risk should not exceed a maximum permissible level of 10^{-6} per year. This refers not only to the risk of dying immediately after an accident, but also includes delayed mortality due to stochastic effects (delayed deaths). Delayed fatalities of this type are ascribed to the year in which the accident takes place.
However, for the prevention of major accidents, the use of limits to restrict the probability of damage to human health does not always offer sufficient safeguards against severe disruptions to society. The concept of group risk is used in order to account for such damage. In order to avoid large-scale disruptions to society the probability of an accident in which at least 10 individuals or more suffer ‘acute’ death is restricted to a level of 10^{-5} per year. ‘Acute’ death means death within a few weeks, where the cause of death should be directly attributable to the accident. Accidents with larger

consequences will cause disruptions which are disproportionally larger. Therefore a limitative factor will be applied. This factor increases quadratically in order to take into account larger groups. When the number of fatalities increases with a factor n, the probability should decrease by a factor n^2. The probability of an accident occurring in which at least 100 people are killed immediately, or die within several weeks of the accident, is therefore limited to 10^{-7} per year.
Nuclear installations have to demonstrate compliance with these risk criteria by means of a safety report.

2.3 Discharge limits

The nuclear installations are licensed to discharge a limited amount of radionuclides. The amount of radionuclides that can be disposed by a nuclear installation differs per installation. In case of discharges to surface water, discharge limits can be given per group of nuclides: beta/gamma emitters (excluding tritium), alpha emitters and tritium. Only in case of nuclear power plants, and for the nuclear waste treatment plant, a discharge limit for tritium discharges is given.

In the licenses of the research facilities the discharge limits are given in Re_{ing}, radiotoxicity equivalent for ingestion. The radiotoxicity equivalent for ingestion is defined by the Ministry of Housing, Spatial Planning and the Environment as the radioactivity that, if completely ingested at the discharge source, would cause an effective dose of 1 Sv to reference man.

2.4 Monitoring programmes of environmental concentrations of radionuclides

Rijkswaterstaat, Centre for Water Management[1], monitors the activity concentrations of radionuclides in inland waters and the marine environment. The environmental monitoring programme 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 12 times per year per location is kept. Ra-226, Sr-90, Sr-89, Po-210 and gamma (Cs-137, etc.) activity is measured with a sampling frequency between 4 and 13 times per year per location. The Centre for Water Management monitors the activity concentrations at 10 locations in inland waters and at 11 locations at sea.

Environmental norms and standards
The norms for drinking water quality are according to EU regulation [EU98]:
- total alpha activity concentration: < 0.1 Bq/l
- rest beta activity concentration: < 1 Bq/l
- tritium activity concentration: <100 Bq/l
- total indicative dose: < 0.1 mSv/a

[1] Before 2008 these tasks were carried out by RIZA, National Institute for Inland Water Management and Waste Water Treatment, and RIKZ, National Institute for Coastal and Marine Management.

where total alpha activity excludes radon but includes short-lived radon daughters, and 'rest beta' is total beta activity excluding K-40, H-3 and short-lived radon daughters.

National target levels of activity of radionuclides in the environment, which are partly based on background levels, are defined for inland waters [TPW98] (see also Appendix C):

- total alpha activity concentration: 0.1 Bq/l
- rest beta activity concentration: 0.2 Bq/l
- tritium activity concentration: 10 Bq/l

2.5 National authority responsible for supervision of discharges

The Nuclear Safety Service ('Kernfysische Dienst', KFD) of the Inspectorate for the Environment is the national authority responsible for supervision of discharges of radionuclides into air and water.

2.6 Nature of inspection and surveillance programmes

The nuclear installations are inspected on an ad hoc basis several times per year by the KFD. Once per year the installations are visited by the KFD and RIVM, the National Institute for Public Health and the Environment, for quality control of the measurements of the radioactivity in waste water and air.

3 The nuclear power plant in Borssele

3.1 Site characteristics

3.1.1 Name of site

The nuclear energy reactor in Borssele is owned by the electricity production company EPZ, 'N.V. Elektriciteits-Productiemaatschappij Zuid-Nederland'. The common name of the installation is 'Kernenergiecentrale Borssele' (KCB).

3.1.2 Type of facility

The reactor facility is a Pressurized Water Reactor (PWR), built by Kraftwerkunion (KWU).

3.1.3 Year for commissioning/licensing/decommissioning

The reactor was commissioned and licensed in 1973. The license was modified in September 2004 in order to allow NPP Borssele to employ 4.4%wt (maximum) enriched U-235 (it was previously 4.0%wt), and to burn a nuclear fuel element up to a maximum of 68 MWd/kgU (pin average).

3.1.4 Location

The nuclear reactor is located at Borssele in the province of Zeeland (see map in Annex A).

3.1.5 Receiving waters and catchment area

The reactor is cooled by water from the estuary of the river Scheldt, which flows out into the North Sea. Radioactive liquid effluents are also discharged into the river Scheldt.

3.1.6 Production

The reactor has a steady thermal power capacity of 1366 MW (th) and an electrical power capacity of 485 MW (e) net output. The net output has increased, following a turbine upgrade, by 35 MW (e) at the end of 2006: in the previous report [OSP05] the gross output is quoted.

Table 1 Annual electric output of net produced electricity over the last ten years.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
GWh	3593	3603	3699	3747	3687	3788	3604	3772	3270	3994
GWa	0.410	0.411	0.422	0.428	0.421	0.432	0.411	0.431	0.373	0.455

3.2 Discharges

3.2.1 Systems to reduce discharges

Batchwise treatment of liquid waste is applied (with a maximum of 3 10^3 m^3 annually). The following techniques are applied to reduce the discharges [KCB93]:

- ion exchange techniques are applied in order to reduce the contamination of primary cooling water due to corrosion. The used saturated resin is transported to the storage tank. From the storage tank it is removed to the solid waste system.
- distillation is utilized, depending on the activity concentration and composition of samples from a tank. The ALARA principle is applied in this process. The distillation extract is removed to the solid waste system.
- filtration of sludge can be used when it is required. Filter residue is transported to the solid waste system.
- immobilization by cementation of distillation extract.
- storage and decay if possible.
- addition of chemicals preventing corrosion in the primary cooling system.
- monitoring/surveillance of leakage of fuel pins.

Other measures to reduce discharges, or a more extensive application of existing measures, are considered not to be economically feasible for this installation.

3.2.2 Efficiency of systems

The efficiency of the distillation step, except for tritium, is about a factor 10^4 [KCB93]. The tritium discharges are not reduced by the distillation step. Information on the efficiency of other systems is not available.

3.2.3 Annual liquid discharges

Table 2 Liquid discharges of gamma and beta emitters of the Borssele NPP, excluding tritium (in TBq/GWa).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Cr-51	1.4E-04	3.9E-05	7.6E-05	4.4E-05	1.2E-05	1.7E-05	3.7E-05	1.4E-06	4.3E-05	2.2E-06
Mn-54	1.4E-05	7.8E-06	3.3E-06	2.0E-05	5.8E-06	2.6E-06	6.7E-06	3.0E-06	4.4E-06	2.0E-06
Fe-55	8.5E-05	9.9E-05	1.0E-04	3.3E-04	1.3E-04	5.2E-05	1.2E-04	6.7E-05	2.3E-04	8.9E-05
Co-58	1.4E-04	5.7E-05	6.2E-05	9.4E-05	1.4E-05	1.5E-05	3.5E-05	5.4E-06	3.6E-05	6.0E-06
Co-60	2.9E-04	2.5E-04	2.8E-04	2.9E-04	1.6E-04	9.0E-05	2.2E-04	1.5E-04	3.2E-04	1.4E-04
Ni-63	7.0E-05	8.9E-05	8.7E-05	2.0E-04	8.3E-05	5.8E-05	9.1E-05	8.5E-05	1.4E-04	1.7E-04
Zr-95	2.5E-05	5.1E-06	7.8E-06	4.5E-05	6.7E-06	2.1E-06	9.7E-06	2.6E-06	3.7E-05	2.3E-05
Nb-95	4.7E-05	1.5E-05	2.4E-05	8.0E-05	1.4E-05	2.9E-06	1.8E-05	5.9E-06	5.4E-05	3.7E-05
Ag-110m	2.4E-05	2.0E-05	1.5E-05	5.6E-05	1.8E-05	8.9E-06	1.8E-05	7.1E-06	9.7E-06	5.8E-06
Te-123m	2.2E-06	< DL	< DL	2.5E-07	< DL	3.0E-07	1.4E-06	7.9E-08	9.0E-07	2.2E-07
Sb-124	9.5E-06	1.2E-06	1.6E-05	8.5E-06	2.3E-06	1.5E-06	1.8E-05	1.9E-06	4.6E-06	1.3E-06
I-131	1.9E-04	3.3E-06	2.5E-05	8.2E-05	7.2E-05	1.6E-07	1.5E-05	1.6E-06	8.4E-05	1.4E-05
Cs-134	1.7E-06	1.5E-05	1.4E-05	2.2E-05	1.4E-05	8.7E-06	1.9E-05	7.2E-06	2.9E-05	6.0E-06
Cs-137	1.9E-05	4.8E-05	3.7E-05	4.6E-05	2.5E-05	2.0E-05	4.7E-05	2.2E-05	7.2E-05	2.6E-05

<DL is below detection level

Table 3 Liquid discharges of H-3 of Borssele NPP (in TBq/GWa).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
H-3	18	15	18	15	18	18	18	13	24	13

Table 4 Liquid discharges of alpha emitters of Borssele NPP (in TBq/GWa).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
alpha	7.3E-07	<DL	1.4E-07	<DL	1.7E-07	<DL	<DL	<DL	1.3E-06	2.0E-07

<DL= below detection limit

Comparison with similar reactors

UNSCEAR [UNSC00] reports for the years 1995-1999 an average value of 19 TBq/GWa of H-3 in liquid discharges for PWR's in the world. The reported discharges of tritium in liquid effluents of the PWR reactor Borssele are equal or below this value, except for 2006. In this year a long production stop was necessary for the so called 'Turbine project', when the old turbine was replaced with a modern, more efficient one.

3.2.4 Emissions to air relevant for the marine compartment

Table 5 Emissions to air of Borssele NPP (in TBq/GWa).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
H-3	8.1E-01	5.4E-01	7.1E-01	6.5E-01	6.2E-01	4.5E-01	4.7E-01	5.0E-01	7.3E-01	5.7E-01
C-14	2.1E-01	1.7E-01	2.1E-01	2.7E-01	2.9E-01	3.2E-01	2.3E-01	2.0E-01	3.1E-01	3.1E-01

Emissions of I-129 to air are not measured.

3.2.5 Quality assurance of retention systems/data management

The quality assurance system of the power plant is based on IAEA Basic safety principles [IAE88] and Safety Culture [IAE91]. The Dutch nuclear safety guidelines, NVR's, are based on IAEA Safety Guide Safety Series. Quality assurance of retention systems and data management is ensured by NVR2.2.11 'Operational Management of radioactive effluents and wastes arising in nuclear power plants', based on [IAE86].

3.2.6 Site specific target discharge data

Site specific target discharges are defined as ratios to the discharge limits which have been defined, see Table 6. For 2003 these targets are:

Emissions to air:
- noble gases < 0.5% of discharge limit
- I-131 < 0.2% of discharge limit
- tritium < 26% of discharge limit

Liquid discharges:
- beta/gamma emitters < 0.2% of discharge limit
- tritium < 20% of discharge limit

For tritium, the target value is consistently exceeded, with a peak of 29% of the limit in 2006.

Table 6 The discharge limits for liquid discharges per year of the Borssele NPP (in TBq).

	Discharge limit
Total gamma and rest beta emitters	0.2
Tritium	30
Total alpha emitters	0.0002

In Annex B figures are given which show the discharges normalized to these limits and to the annual electric output.
The liquid discharges of beta/gamma emitters vary between 0.07 % and 0.23 % of the discharge limit. The tritium discharge in waste water remains at a constant level, just as the tritium emissions to air.

3.2.7 Relevant information not covered by previous sections

The previous sections cover all relevant information.

3.2.8 Explanations for lack of data or failure to meet BAT/BEP indicators

Due to the technical nature of a pressurized water reactor, H-3 and C-14 emissions are inevitable. It is technologically almost impossible to reduce these emissions. Therefore, the behaviour of the H-3 and C-14 discharges from 1998 onwards do not show a downward trend, but remain relatively constant.

3.3 Environmental impact

In general, discharges of all sources lead to an increase of the activity concentrations. Nevertheless, it is not expected that the environmental monitoring data can be associated to a unique discharge source. Information for this section can be found in Annex C.

3.4 Radiation doses to the public

3.4.1 Individual effective dose

The liquid discharges are discharged directly into the estuary of the river Scheldt, which flows into the North Sea.

The individual effective dose via the marine exposure pathway for the critical group, defined later in section 3.4.3, is estimated using the methodology described in section 3.4.5 and the site specific factors given in section 3.4.6.

Table 7 Effective dose per year caused by liquid discharges of the Borssele NPP (in μSv)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
E (μSv)	1.4E-05	9.2E-06	1.1E-05	1.6E-05	8.8E-06	5.0E-06	9.2E-06	6.1E-06	1.3E-05	6.8E-06

3.4.2 Total exposures (including those from historic discharges)

The total exposure including those from historic discharges is not estimated due to fact that the estimated individual effective dose is already low compared to the dose limit for members of the public in case of normal operation.

3.4.3 Critical group definition

In the Netherlands the critical group is called the reference group [PRAM99]. The reference group is the (hypothetical) homogeneous group of the population for which the individual dose due to the source is the highest. A group of persons is homogeneous when uniform behavior parameters are applicable and when the individual exposures within the group are more or less equal.

For dose estimates, the reference group is composed by adults, in accordance with the Dutch regulation guidelines.

Reference behaviour is, in this contest, that behaviour which maximizes the dose, given a certain contamination in the environment. This behaviour includes all living habits such as working and eating. To determine reference behaviour only realistic assumptions have to be taken into account. For instance, yearly consumption of the reference group includes:

- drinking water,
- fish,
- milk and dairy products,
- meat and meat products,
- vegetables.

When the discharge authorizations are being reassessed, the reference group will be reconsidered.

For more information on the definition of critical group in the Netherlands, see [ZUUR02].

3.4.4 Considered exposure pathways

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.

3.4.5 Methodology to estimate doses

The estimates of the doses are based on the models by Van Hienen et al. [VROM90] and actual discharge data.

3.4.6 Site specific factors to estimate the dose

Site specific factors to estimate the dose to the critical group from discharges to water have been calculated for the most relevant radionuclides by NRG [NRG99], see Table 8. The calculation is based on the methodology of Van Hienen et al. [VROM90] and using the DCC's of ICRP 72 [ICRP96].

The radionuclide Te-123m has not been taken into account due to omission of this radionuclide in the methodology of Van Hienen et al. [VROM90]. Using the methodology of [MER93a], it can be calculated that the total dose due to Te-123m is less than 1% of the dose to the critical group from discharges to water of all radionuclides listed in section 3.2.3.

Table 8 Site specific factors of the Borssele NPP.

Nuclide	Factor ($Sv.a^{-1}$ per $Bq.s^{-1}$)
H-3	7.7E-18
Cr-51	6.6E-14
Mn-54	2.7E-12
Fe-55	5.3E-13
Co-58	2.9E-13
Co-60	1.7E-12
Ni-63	6.8E-14
Zr-95	7.6E-13
Nb-95	1.5E-13
Ag-110m	8.4E-13
Sb-124	3.2E-13
I-131	1.5E-12
Cs-134	8.0E-13
Cs-137	5.6E-13

3.4.7 Site specific target annual effective dose

The site internal target for the annual effective dose for the reference group has been set at 8 nSv/y. The realisation is around 5.5 nSv per year, as a consequence of all discharges (gaseous and liquid).

3.4.8 Quality assurance system for dose estimates

The dose estimates have a low priority due to the expected minor dose consequences; therefore a quality assurance system is not considered to be appropriate.

3.4.9 Explanations for lack of data or failure to meet BAT/BEP indicators

A downward trend in the dose estimates due to liquid discharges can be observed. More important, the calculated dose is less than 2 10^{-5} microSv/a.

3.5 Summary evaluation

According to the OSPAR guidelines 2004-03, an indication that BAT/BEP has been applied is a downward trend in the liquid discharges and dose estimates [RAD04]. In the case of the NPP in Borssele the emissions to air and water, normalized to the production in GWa, have been reduced where technologically possible. No downward trends are however apparent, although the emissions remain constant at a relatively low level. The calculated dose is consistently below 2 10^{-5} microSv/a over the years. It follows that, according to these indicators, BAT/BEP has been applied in NPP Borssele.

Moreover, in the Netherlands, compliance with the ALARA principle is considered sufficient evidence that the requirements of BAT/BEP in terms of the OSPAR Convention have been met. At present, the NPP in Borssele is judged to be compliant with the ALARA principle. Furthermore, the discharges are low compared to the licensed discharge limits in the license and largely fulfill the site internal

discharge targets. The normalized tritium discharges are equal or less than the reference data for the same type of reactor in the UNSCEAR report [UNSC00].
The information presented above is in accordance with the OSPAR guidelines 2004-03 [RAD04] and includes indicators that BAT/BEP has been applied in NPP in Borssele.

4 The fuel enrichment plant in Almelo

4.1 Site characteristics

4.1.1 Name of site

The multinational consortium URENCO owns the fuel enrichment plant in Almelo. The common name of the installation is 'URENCO'.

4.1.2 Type of facility

The type of the facility is a fuel enrichment plant.

4.1.3 Year for commissioning/licensing

The first installation was commissioned in 1970, followed by gradual extension with additional production facilities.

4.1.4 Location

The fuel enrichment plant is located in Almelo, in the province of Overijssel, see map in Appendix A.

4.1.5 Receiving water and catchment area

The installation does not make use of surface water or ground water for cooling purposes. Cooling water systems are of a closed circuit type. Waste water is treated in the municipal sewage treatment plant.

4.1.6 Production

The licensed production capacity was increased from 2800 tSW/yr to 3500 tSW/y in 2005, to 3700 tSW/y in 2006 and 4500 tSW/y in 2007 (tSW stands for tons of Separative Work).

Table 9 The fuel enrichment production (in tSW/yr).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
tSW/y	1450	1415	1440	1528	1682	1964	2352	2737	3210	3554

4.2 Discharges

4.2.1 Systems to reduce discharges

The following techniques and end of pipe measures are applied, depending on the results of the analysis of the water samples, to reduce the discharges [UREN93]. In all these processes the ALARA principle is applied:

- distillation is utilized, depending on the activity concentration and composition of samples from collection tanks. The distillation extract is removed to the solid waste system. The distillate is, after routine checks on activity, discharged to the public sewer system.
- precipitation/sedimentation of wash water from cylinder decontamination. The sediment, natriumdiuranate, is filtrated and deposited into special vessels which are transported. The recovered uranium can then be reused in another nuclear fuel fabrication plant.
- storage and decay for short lived nuclides.

4.2.2 Efficiency of systems

No information is available on the efficiency of the waste water treatment systems.

4.2.3 Annual liquid discharges

Table 10 Liquid discharges of Almelo facility (in TBq/tSW).

	1998[2]	1999	2000	2001	2002	2003	2004	2005	2006	2007
total alpha	1.2E-09	1.2E-09	2.3E-09	1.8E-09	2.7E-09	1.8E-09	8.8E-10	1.1E-09	6.8E-10	1.7E-10
beta/gamma	9.2E-09	7.1E-09	7.8E-09	4.7E-09	3.2E-09	2.2E-09	7.9E-10	7.6E-10	2.1E-09	6.4E-10

4.2.4 Emissions to air relevant for the marine compartment

The emissions to air are not relevant to the marine compartment due to the involatile nature of uranium. The plant is not located in the direct neighbourhood of a sea or lake.

4.2.5 Quality assurance of retention systems/data management

The protection of the environment is guaranteed by a quality assurance system. The enrichment division holds an ISO 14001 certificate since 1997.

4.2.6 Site specific target discharge data

No target discharge data has been defined.

4.2.7 Relevant information not covered by previous sections

Table 11 Discharge limits to water per year of the URENCO Almelo facility (in TBq) until October 2005.

Gamma and beta emitters	0.0002
Total alpha emitters	0.00002

Table 12 Discharge limits to water per year of the URENCO Almelo facility (in Re) from October 2005.

Alpha, beta and gamma emitters	1.7[3]

[2] In the previous report [OSP05] the beta/gamma discharge of 1998 was reported as 6.9E-9 TBq/tSW in the corresponding table, while this same value of 9.2E-9 TBq/tSW was plotted in the figures of Annex B.

[3] In the corresponding section of the previous report [OSP05] the limit of discharges to air (130 Re), which is not relevant, was mistakenly reported.

See section 2.3 for the definition of Re (radiotoxicity equivalent). Here no correction for radioactive decay is carried out.
In Appendix B a figure shows the discharges normalized to the limits.
By the end of 2005 the separation plant SP3 was shut down. Meanwhile, the separation plant SP5, containing state-of-the-art separation technology, was expanded to reach its maximum separation capacity, which is over half of the enrichment capacity of the Almelo site. As the discharges from SP5 to air and water are much lower than those from SP3, the total discharges show a clear downward trend.

4.2.8 Explanations for lack of data and success in meeting BAT/BEP indicators

The downward trend of total discharges shows that BAT/BEP indicators are met. This is due to the application of BAT/BEP to a new separation plant, while the older separation plant has been shut down.

4.3 Environmental impact

In general, discharges of all sources lead to an increase of the activity concentrations. Nevertheless, it is not expected that the environmental monitoring data can be associated to a unique discharge source. Information for this section can be found in Appendix C.

4.4 Radiation doses to the public

4.4.1 Individual effective dose

The liquid discharges are discharged directly into the municipal sewage system. Radionuclides that pass the municipal sewage treatment plant will proceed to the river IJssel (a branch of the river Rhine), and subsequently to the lake IJsselmeer, which flows into the Waddensea and the North Sea.

The maximum contribution to the annual dose due to discharges and emissions of the fuel enrichment plant is estimated to be far less than 1 μSv [UREN07].

4.4.2 Total exposures (including those from historic discharges)

The total exposure including those from historic discharges is not estimated due to fact that the estimated individual effective dose is already low compared to the dose limit for members of the public.

4.4.3 Critical group definition

In the Netherlands the critical group is called the reference group. The definition of the reference group is given in section 3.4.3.

4.4.4 Considered exposure pathways

The considered exposure pathways are consumption of fish from the lake IJsselmeer, ingestion of drinking water and ingestion via deposition to surface water from emissions to air.

4.4.5 Methodology to estimate doses

The applied methodology to estimate the dose in [MER93b] is based on modelling by RIVM.

4.4.6 Site specific factors to estimate the dose

Site specific factors are not given in [MER93b].

4.4.7 Site specific target annual effective dose

No specific target annual effective dose has been defined.

4.4.8 Quality assurance system for dose estimates

The dose estimates have a low priority due to the expected minor dose consequences; therefore a quality assurance system is not considered to be appropriate.

4.4.9 Explanations for lack of data or failure to meet BAT/BEP indicators

Since no dose estimates are carried out, BAT/BEP indicators with respect to the radiation dose to the public can not be evaluated.

4.5 Summary evaluation

According to the OSPAR guidelines 2004-03, an indication that BAT/BEP has been applied is a downward trend in the liquid discharges [RAD04]. A downward trend can be observed in the discharges of radionuclides. This is mainly due to do the closing of separation plant SP3 and the expansion of the modern separation plant SP5.

Moreover, in the Netherlands, compliance with the ALARA principle is deemed sufficient to meet the requirements of BAT/BEP in terms of the OSPAR Convention. At present, the fuel enrichment plant in Almelo is considered to comply with the ALARA principle.
The discharges are low compared to the discharge limits in the license. Also, the estimated dose for the critical group due to liquid discharges is very low, less than 1 μSv/year.
The information presented above is in accordance with the OSPAR guidelines 2004-03 and includes indicators that BAT/BEP has been applied in the fuel enrichment plant in Almelo.

5 The research facility in Petten

5.1 Site characteristics

5.1.1 Name of site

The facility consists of two research reactors. In addition, research laboratories and auxiliary industry like Tyco-Mallinckrodt, a Covidien company, specialized in the production of radioisotopes for nuclear pharmaceuticals, and the Mo-99-production facility, will contribute to the discharges from the site. The site is referred to as 'Onderzoeks Locatie Petten' or the 'Petten site'.

The two research reactors have the names 'Hoge Flux Reactor' (HFR) and 'Lage Flux Reactor' (LFR).

5.1.2 Type of facility

The HFR is a research reactor and is owned by the European Commission. The reactor type is a swimming pool reactor.

The LFR is a research reactor owned and operated by NRG (Nuclear Research and consultancy Group). The reactor type is an argonaut low flux reactor.

5.1.3 Year for commissioning/licensing

The research reactors were commissioned and licensed in 1960.

5.1.4 Location

The reactors are located in Petten, in the province of Noord-Holland (see map in Appendix A).

5.1.5 Receiving water and catchment area

The North Sea is the receiving water for the facility. The catchment area of the facility might be defined as the dunes overlooking the sea on which the Petten facility is built.

5.1.6 Production

The installed capacity for the HFR is 50 MW (th). The installed capacity for the LFR is 30 kW (th).

5.1.7 Other relevant information

Waste water is collected and treated in a specially designed waste water treatment building. Direct connections exist from HFR and Tyco-Mallinckrodt to this building. Waste water from remaining buildings is transported by truck to the waste water treatment facility.

5.2 Discharges

5.2.1 Systems to reduce discharges

Installations for water treatment are available which are necessary for the separation of liquid waste in a radioactive and a non-radioactive fraction [VR00]. For example:

- sedimentation basins
- membrane filtration-units
- centrifugation of sludges
- sludge drying units

Processes at the site for waste water treatment are:

- collection and storage of samples, treatment of waste water before discharge to sea. In case of emergencies, the storage tanks may serve as backup collection basin
- addition of flocculation chemicals, and chemicals for pH adjustment
- separation of radioactive particles in waste water by using the principles of sedimentation, centrifugation and membrane filtration
- processing liquid waste by removing and drying sediments and sludges
- transportation of dried sludges and sediments in 100 liter barrels to the decontamination building
- preparation for transportation to COVRA for radioactive waste storage.

5.2.2 Efficiency of systems

The efficiency of the ceramic membrane filters for removal of (undissolved) radionuclides lies between 10 and 100. The dose achieved is described in section 5.4.1.

5.2.3 Annual liquid discharges

The liquid discharges of HFR and LFR are presented as a total of the Petten site, also including research laboratories and auxiliary industry like Tyco-Mallinckrodt, as the discharges cannot easily be separated. Therefore, the presented data will be an overestimation of the actual discharges of the HFR and LFR.

Table 13 Liquid discharges of Petten site (in GBq: i.e. not normalized).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
H-3	3.8E+02	2.9E+02	2.8E+02	2.3E+02	2.1E+02	4.1E+02	2.5E+02	2.6E+02	3.4E+02	2.7E+02
Na-22	3.9E-02	2.3E-02	8.1E-02	5.3E-02	5.4E-02	4.9E-02	3.8E-02	6.2E-02	5.2E-02	5.1E-02
Cr-51	4.0E-03	NI	2.7E-03	6.0E-03	NI	3.6E-02	1.4E-01	NI	5.3E-02	7.8E-02
Mn-54	4.0E-02	2.4E-01	4.3E-02	1.0E-02	9.1E-03	8.3E-02	1.3E-02	7.3E-02	1.6E-02	8.2E-02
Co-57	NI	1.2E-04	NI	NI	NI	NI	NI	4.3E-04	1.4E-03	1.8E-02
Co-58	1.6E-02	7.3E-02	1.5E-02	7.0E-03	2.4E-02	4.6E-02	1.3E-02	5.1E-02	1.3E-02	5.2E-02
Co-60	6.3E-01	3.0E+00	6.0E-01	1.8E-01	4.2E-01	1.5E+00	7.6E-01	1.2E+00	4.8E-01	1.2E+00
Zn-65	1.7E-01	3.2E-01	2.5E-01	2.2E-01	1.3E-01	2.8E-01	6.5E-01	2.4E-01	1.3E-01	5.0E-01
Mo-99	4.5E+00	1.2E+00	1.8E-01	1.0E+01	9.4E+00	3.4E+01	1.0E+01	1.8E+00	1.5E+00	3.0E+00
Ru-103	2.5E-02	8.0E-03	3.8E-03	NI	7.0E-03	1.2E-02	7.3E-03	1.2E-02	4.2E-03	5.5E-03
Cd-109	5.0E-03	3.5E-01	1.2E-01	NI	NI	2.7E-01	1.1E-01	8.8E-02	4.6E-01	2.1E+01
Sb-124	1.3E-01	2.7E-01	2.9E-01	3.4E-01	1.9E-01	4.9E-01	7.0E-01	6.9E-01	7.5E-01	4.1E-01

Sb-125	8.6E-01	5.9E-01	7.5E-01	NI	5.4E-01	5.8E-01	5.6E-01	4.6E-01	3.7E-01	3.1E-01
I-131	5.0E+00	6.0E+00	6.3E+00	2.9E+00	2.1E+00	2.4E-01	2.6E-01	3.5E-01	4.9E-01	4.6E-01
Cs-134	4.2E-01	2.3E+00	5.3E+00	7.1E+00	8.0E+00	1.7E+00	4.9E-01	1.4E+00	4.6E-01	5.5E-01
Cs-137	1.1E+00	4.0E+00	1.2E+01	2.0E+01	1.5E+01	5.2E+00	2.3E+00	3.1E+00	1.3E+00	1.4E+00
W-181	8.7E-01	1.7E-01	2.4E-01	1.2E-01	8.3E-02	NI	NI	NI	7.3E-02	1.3E-01
W-188	1.8E-01	1.2E-02	2.6E-02	5.0E-03	NI	1.4E-02	6.3E-02	6.6E-03	6.7E-03	2.5E-02
Re-186	1.3E-02	1.2E-02	NI	NI	1.6E-01	3.1E-02	5.6E-02	1.9E-02	NI	NI
Tl-202	5.0E-03	NI	NI	2.0E-03	2.0E-03	3.2E-02	7.4E-02	2.1E-03	NI	1.4E-03
alpha	2.0E-03	6.2E-04	6.2E-04	7.0E-03	9.0E-04	1.8E-03	5.2E-02	3.7E-03	8.9E-03	2.4E-03
beta	6.2E+01	5.9E+01	7.8E+01	9.1E+01	8.1E+01	4.1E+01	6.7E+01	7.6E+01	5.5E+01	9.8E+01

NI = no information

Information on emissions of C-14 and I-129 is not available.

5.2.4 Emissions to air relevant for the marine compartment

Table 14 Tritium emissions to air from all facilities combined on the Petten site (in TBq: i.e. not normalized).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
H-3	1.1	0.8	0.9	0.8	0.3	0.9	0.6	0.5	0.3	0.3

Information on emissions of C-14 and I-129 is not available.

5.2.5 Quality assurance of retention systems/data management

ECN and NRG both have an integrated ISO 9001 management system. In this system all aspects involving environmental protection are integrated with other quality aspects.

5.2.6 Site specific target discharge data

No target discharge data has been defined.

5.2.7 Relevant information not covered by previous sections

In the license of the Petten complex the discharge limits are given in Re_{ing}, radiotoxicity equivalent for ingestion. The radiotoxicity equivalent for ingestion is defined by the Ministry of Housing, Spatial Planning and the Environment as the radioactivity that if completely ingested at the discharge source, would cause an effective committed dose of 1 Sv for reference man, see section 2.3.

Table 15 Discharge limit per year of the Petten site (in Re_{ing}'s).

	Re_{ing}
all radionuclides	2000

5.2.8 Explanations for lack of data or failure to meet BAT/BEP indicators

There is no downward trend in the discharges to the North Sea.

5.3 Environmental impact

In general, discharges of all sources lead to an increase of the activity concentrations. Nevertheless, it is not expected that the environmental monitoring data can be associated to a unique discharge source. Information for this section can be found in Appendix C.

5.4 Radiation doses to the public

5.4.1 Individual effective dose

On the basis of the discharge data in section 5.2.3, a dose assessment can be performed. The individual effective dose is calculated from the discharged activity and the site specific dose conversion coefficients which are given in section 5.4.6. The results are given in Table 16.

Table 16 Effective dose per year caused by the liquid discharges of the Petten site (in μSv).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
E (μSv)	7E-04	3E-03	3E-03	4E-03	3E-03	2E-03	1E-03	1E-03	8E-04	9E-03

5.4.2 Total exposures (including those from historic discharges)

The total exposure including those from historic discharges is not estimated due to fact that the estimated individual effective dose is already low compared to the dose limit for members of the public in case of normal operation.

5.4.3 Critical group definition

In the Netherlands the critical group is called the reference group. The definition of the reference group is given in section 3.4.3.

5.4.4 Considered exposure pathways

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 parameters chosen for the dose assessment are such that a maximum individual dose is estimated.

5.4.5 Methodology to estimate doses

The methodology to estimate the dose is based on models presented by Van Hienen et al. [VROM90].

5.4.6 Site specific factors to estimate the dose

The site specific factors of Table 17, published by Van Hienen et al. [VROM90], are used to estimate the dose to critical group members from discharges to water.

Table 17 Site specific factors to estimate the dose from discharges to water.

	Factor ($Sv.a^{-1}$ per $Bq.s^{-1}$)
H-3	4.0E-17
Cr-51	1.6E-14
Mn-54	7.4E-13
Co-57	7.9E-13
Co-58	2.2E-12
Co-60	1.8E-11
Zn-65	1.9E-11
Zr-95	7.4E-13
Ag-110m	4.8E-12
Cd-109	1.2E-11
Sb-124	2.4E-12
Sb-125	7.6E-13
I-131	1.6E-13
Cs-134	5.0E-12
Cs-137	3.5E-12

5.4.7 Site specific target annual effective dose

No specific target annual effective dose has been defined.

5.4.8 Quality assurance system for dose estimates

The dose estimates have a low priority due to the expected minor dose consequences; therefore a quality assurance system is not considered to be appropriate.

5.4.9 Relevant information not covered by previous sections

There is no relevant information not covered by the previous sections.

5.4.10 Explanations for lack of data or failure to meet BAT/BEP indicators

The BAT/BEP indicator of average annual effective dose to public shows no significant reduction. However, the doses are less than 10 nSv per year during the period 1998-2007.

5.5 Summary evaluation

According to the OSPAR guidelines 2004-03, an indication that BAT/BEP has been applied is a downward trend in the liquid discharges [RAD04]. The annual liquid discharges of the Petten site do not show such a downward trend, but vary from year to year. The effective dose due to the liquid discharges shows the same trend. Also the estimated dose for the critical group due to liquid discharges is very low, much less than 1 μSv/year.

In the Netherlands, the requirements of BAT/BEP in terms of the OSPAR Convention are met when the ALARA principle is applied. At present the Petten site is considered to comply with the ALARA principle.
The information presented above is in accordance with the OSPAR guidelines 2004-03 [RAD04] and includes indicators that BAT/BEP has been applied in the Petten site.

6 The research facility in Delft

6.1 Site characteristics

6.1.1 Name of site

The research reactor in Delft is owned by the Reactor Institute Delft (RID), formerly Interfaculty Reactor Institute. It is part of the Applied Sciences faculty of the Delft University of Technology. The common name of the reactor is the HOR: 'Hoger Onderwijs Reactor', reactor for higher education.

6.1.2 Type of facility

The reactor type is a swimming pool reactor.

6.1.3 Year for commissioning/licensing

The research reactor was commissioned and licensed in 1963.

6.1.4 Location

The reactor is located in Delft, in the province of Zuid-Holland (see map in Appendix A).

6.1.5 Receiving water and catchment area

Liquid waste is discharged into the municipal sewage system and treated in the sewage treatment plant of the city of Den Haag (The Hague). Radionuclides, which are not captured by the sewage treatment plant, proceed to the North Sea.

6.1.6 Production

The installed capacity for the HOR is 2 MW (th).

6.2 Discharges

6.2.1 Systems to reduce discharges

The following processes and end of pipe measures are applied:

- batchwise collection of all waste water
- minimize dilution of waste water and mixing batches of different contamination level
- contamination is reduced as far as reasonable achievable
- batchwise distillation of waste water, exceeding the reference level of 37 kBq beta/gamma-emitters per m^3
- ion exchange techniques are continuously applied to reduce the contamination of the primary cooling water. The used saturated resins are removed to the solid waste system
- storage and decay if possible
- monitoring/surveillance of leakage of fuel pellets.

Furthermore, the waste water is treated in a municipal sewage treatment plant. This leads to substantial reduction of the load of radioactive material to surface waters.

6.2.2 Efficiency of systems

No information is available on the efficiency of the waste water treatment system.

6.2.3 Annual liquid discharges

The liquid discharges of the HOR are part of the reported total discharges of the RID Complex, which includes research laboratories. As the specific origin of the discharges cannot be easily ascertained, it follows that the actual discharges of the HOR will be lower than the reported data.

Table 18 Liquid discharges of Delft facility (in GBq: i.e. not normalized).

nuclide	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
alpha	< 0.5E-3*	< 0.4E-3*	< 0.4E-3	< 0.3E-3	< 0.24E-03	< 0.36E-3	< 0.17E-03	< 0.33E-03	< 0.20E-03	< 0.59E-03
beta	1.1E-02	1.1E-02	9.6E-03	6.5E-03	6.4E-03	1.1E-02	5.98E-03	1.03E-02	7.97E-03	4.67E-03
gamma	3.0E-03	< 3.4E-03	< 3.8E-03	< 2.7E-03	< 2.6E-03	< 2.5E-03	< 2.93E-3	< 3.51E-3	< 3.53E-03	< 2.89E-03

*this detection limit has been reported a factor ten higher in [OSP05] due to a typing error

6.2.4 Emissions to air relevant for the marine compartment

No information is available on emissions to air relevant to the marine compartment.

6.2.5 Quality assurance of retention systems/data management

No information is available on quality assurance of retention systems or data management.

6.2.6 Site specific target discharge data

No target discharge data has been defined.

6.2.7 Relevant information not covered by previous sections

In the license of the research facility in Delft the discharge limits are given in weighted Re_{ing}, radiotoxicity equivalent for ingestion (in section 2.3 a definition of Re_{ing} is given).

Table 19 Discharge limit of the Delft reactor facility (in Re_{ing}).

	Re_{ing}
all radionuclides	20

6.2.8 Explanations for lack of data or failure to meet BAT/BEP indicators

No downward trends can be observed regarding the discharges of radionuclides.

6.3 Environmental impact

In general, discharges of all sources lead to an increase of the activity concentrations. Nevertheless, it is not expected that the environmental monitoring data can be associated to a unique discharge source. Information for this section can be found in Appendix C.

6.4 Radiation doses to the public

6.4.1 Individual effective dose

The liquid discharges are discharged directly into the municipal sewage system. Radionuclides that pass the municipal sewage treatment plant would proceed to the North Sea.

The maximum individual dose will be far below 0.009 µSv per year [VROM90], which is the critical group dose for people living in the vicinity of the reactor and who are directly exposed to the atmospheric emissions.

6.4.2 Total exposures (including those from historic discharges)

The total exposure including those from historic discharges is not estimated due to fact that the estimated individual effective dose is already low compared to the dose limit for members of the public in case of normal operation.

6.4.3 Critical group definition

If any influence of the HOR on the marine environment can be expected at all, it will originate from deposition of the atmospheric emissions. The associated critical pathway in that case would be consumption of marine food especially from the Wadden Sea.

6.4.4 Considered exposure pathways

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 pathways are treated to estimate a maximum individual dose.

6.4.5 Methodology to estimate doses

The estimates of the doses are based on the models by Van Hienen et al. [VROM90] and actual discharge data.

6.4.6 Site specific factors to estimate the dose

As stated in section 6.4.1 the contribution to the dose due to discharges and emissions of the research reactor is very low. Therefore, no site specific factors to estimate the dose are given.

6.4.7 Site specific target annual effective dose

No specific target annual effective dose has been defined.

6.4.8 Quality assurance system for dose estimates

The dose estimates have a low priority due to the expected minor dose consequences; therefore a quality assurance system is not considered to be appropriate.

6.4.9 Explanations for lack of data or failure to meet BAT/BEP indicators

Since no dose estimates for each year are carried out, BAT/BEP indicators with respect to the radiation dose to the public can not be evaluated.

6.5 Summary evaluation

According to the OSPAR guidelines 2004-03, an indication that BAT/BEP has been applied is a downward trend in the liquid discharges [RAD04]. The annual liquid discharges of the research facility in Delft do not show such a downward trend but vary from year to year. However, the question whether or not BAT/BEP has been applied, is not only a matter of downward trends.

In the Netherlands, the requirements of BAT/BEP in terms of the OSPAR Convention are met when the ALARA principle is applied. At present, the research facility in Delft is considered to comply with the ALARA principle.
The discharges are low compared to the discharge limits in the license. Also the estimated dose for the critical group due to liquid discharges is very low, less than 0.009 μSv/year.
The information presented above is in accordance with the OSPAR guidelines 2004-03 [RAD04] and includes indicators that BAT/BEP has been applied in the research facility in Delft.

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7 Waste treatment lant COVRA in Vlissingen

7.1 Site characteristics

7.1.1 Name of site

The waste treatment plant in Vlissingen is owned by COVRA N.V. The common name of the site is COVRA: 'Centrale Organisatie Voor Radioactief Afval', Central Organisation for Nuclear Waste.

7.1.2 Type of facility

The facility treats waste from e.g. hospitals, the research reactors in Petten and Delft and radionuclide laboratories. Also, COVRA stores solid waste from e.g. NPP Borssele.

7.1.3 Year for commissioning/licensing

The waste treatment plant is commissioned and licensed for the location in Vlissingen in 1989.

7.1.4 Location

The waste treatment plant is located in Vlissingen, in the province of Zeeland (see map in Appendix A).

7.1.5 Receiving water and catchment area

COVRA uses rainwater as cooling water. For this purpose, rainwater is collected in a basin. The cooling water is eventually released, via the same basin, to the inland harbour Kaloothaven, which runs into the river Scheldt. No contamination of the cooling water takes place.

The release of wastewater of the water purification system takes place on the river Scheldt via the outlet channel of NPP Borssele.

7.1.6 Production

COVRA is a waste treatment plant, and it is difficult to express its production in a standardized way.

7.2 Discharges

7.2.1 Systems to reduce discharges

The following processes are applied (see Table 20 for the 'slip-through' factors after treatment):

- biological purification
- electrochemistry
- chemical purification based on flocculation
- centrifugal separation
- filtration
- the sediment is dried by means of induction and processed as solid waste

7.2.2 Efficiency of systems

The efficiency of the waste water treatment system is given in Table 20. For each nuclide in this table the activity concentration after the treatment is divided by the activity concentration before. A 'slip-through' factor of 0.3 therefore means a waste water cleaning efficiency of 70%.
A report of 2006 [VL06] shows that BAT/BEP are applied to the waste water treatment systems.

Table 20 Slip-through factors for the waste water treatment system.

nuclide	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Co-60	-	0.3	0.3	0.1	0.2	0.2	0.2	0.4	0.3	0.2
Cs-137	-	0.7	0.6	0.6	0.6	0.7	0.7	0.8	1.0	0.8
I-125	-	0.4	0.1	-	-	0.3	0.3	0.1	0	0
H-3	-	1	0.8	0.9	0.8	0.8	0.8	0.9	1.0	0.9
C-14	-	1	0.3	0.5	0.3	0.3	0.3	0.7	0.5	1.0
Alpha	-	-	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Gross γ		-	0.5	0.4	0.5	0.4	0.2	0.6	0.8	0.8

7.2.3 Annual liquid discharges

Table 21 Liquid discharges of COVRA (in GBq: i.e. not normalized).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
H-3	1.0E+02	1.0E+03	6.6E+01	2.2E+01	5.4E+01	5.9E+01	2.5E+01	9.4E+00	1.0E+00	6.0E-01
C-14	1.5E+00	9.0E-01	1.3E+00	2.3E-01	1.4E-01	2.0E-01	7.6E-02	5.6E+00	9.0E-02	2.5E-02
gross-alpha	1.4E-04	1.0E-03	9.0E-04	5.2E-04	1.1E-03	1.9E-04*	3.0E-04	2.7E-04	3.8E-04	2.6E-03
rest-β	1.4E-01	2.5E-01	5.0E-01	2.2E-01	3.6E-01	3.2E-01	3.5E-01	1.1E+00	6.7E-01	5.0E-02
gamma	3.0E-01	5.7E-01	5.0E-01	2.2E-01	3.3E-01	4.4E-01	5.0E-01	1.1E+00	7.2E-01	5.2E-02

*the alpha discharge for 2003 was wrongly reported as 1.2E-4 GBq in the previous report [OSP05]

7.2.4 Emissions to air relevant for the marine compartment

Table 22 Emissions to air of COVRA (in GBq: i.e. not normalized).

	1998	1999	2000	2001**	2002**	2003**	2004	2005	2006	2007
H-3	2.6E+01	2.4E+01	5.0E+01	8.0E+00	3.5E+01	1.9E+01	1.3E+01	2.5E+00	1.1E+00	3.8E+02
C-14	2.9E+00	2.7E+00	9.3E-01	7.4E-01	4.6E+00	2.4E+00	3.0E-01	3.0E-01	2.9E-01	7.6E-01
gross-alpha	1.0E-05	<1.0E-04*	3.5E-05	3.7E-05	1.5E-05	1.7E-05	9.7E-06	1.9E-05	1.9E-05	9.8E-06
rest-β	3.1E-05	<3.9E-03*	1.5E-04	3.1E-04	3.3E-04	3.1E-03	1.6E-03	3.7E-04	5.3E-04	1.4E-04
gamma	9.0E-03	5.0E-04	8.0E-06	1.2E-03	9.2E-04	NI	8.1E-03	2.9E-03	2.6E-03	9.5E-04

NI – no information available
*the minimum detectable level is based on a volume of 8.4 10^6 m^3/week and a minimum detectable activity of 2.4.10^{-4} Bq/m^3 (alpha) and 8.9.10^{-3} Bq/m^3 (beta). In 2000 the method was adjusted such that the detection limit was lowered about ten-fold.
** the emissions of H-3 and C-14 from 2001 onwards are from J. Welbergen, priv. comm, 2 nov. 2008. While the sum of the activities of H-3 and C-14 for the years 2001 to 2003 is consistent with the previous report [OSP05], the activities of the single nuclides are somewhat different.

7.2.5 Quality assurance of retention systems/data management

No information is available on quality assurance of retention systems or data management.

7.2.6 Site specific target discharge data

No target discharge data has been defined.

7.2.7 Relevant information not covered by previous sections

Table 23 Yearly discharge limits of COVRA

	Discharge limits	
H-3	1	TBq
C-14	1	TBq
rest beta/gamma	100	GBq
alpha emitters	40	MBq

7.2.8 Explanations for lack of data or failure to meet BAT/BEP indicators

No downward trends can be observed regarding the discharges of radionuclides.

7.3 Environmental impact

In general, discharges of all sources lead to an increase of the activity concentrations. Nevertheless, it is not expected that the environmental monitoring data can be associated to a unique discharge source. Information for this section can be found in Appendix C.

7.4 Radiation doses to the public

7.4.1 Individual effective dose

The liquid discharges are discharged directly into the estuary of the river Scheldt, which flows into the North Sea.

With respect to the liquid discharges the site of COVRA can be well compared to the NPP Borssele. For the individual effective dose via the marine exposure pathway for the critical group this is defined in section 3.4.3. The methodology is described in section 3.4.5 and the site specific factors given in section 3.4.6.

The maximum individual dose will be far below 0.001 μSv per year, which is the critical group dose for people living in the vicinity of the reactor. A maximum individual dose can be estimated by assuming that all gamma-emitting radionuclides are Co-60. This radionuclide is dominant for NPP Borssele with respect to the effective dose.

7.4.2 Total exposures (including those from historic discharges)

The total exposure including those from historic discharges is not estimated due to fact that the estimated individual effective dose is already low compared to the dose limit for members of the public in case of normal operation.

7.4.3 Critical group definition

For the critical group definition see section 3.4.3.

7.4.4 Considered exposure pathways

The considered exposure pathways are defined in section 3.4.4.

7.4.5 Methodology to estimate doses

The methodology to estimate the dose is based on models presented by Van Hienen et al. [VROM90].

7.4.6 Site specific factors to estimate the dose

For the site specific factors see section 3.4.6 (the sites of COVRA and Borssele are located within a few kilometers of each other).

7.4.7 Site specific target annual effective dose

No specific target annual effective dose has been defined.

7.4.8 Quality assurance system for dose estimates

The dose estimates have a low priority due to the expected minor dose consequences; therefore a quality assurance system is not considered to be appropriate.

7.4.9 Explanations for lack of data or failure to meet BAT/BEP indicators

Since no dose estimates for each year are carried out, BAT/BEP indicators with respect to the radiation dose to the public can not be evaluated.

7.5 Summary evaluation

According to the guidelines, an indication that BAT/BEP has been applied is a downward trend in the liquid discharges [RAD04]. The annual liquid discharges of COVRA do not show such a downward trend but vary from year to year. However, the question whether or not BAT/BEP has been applied, is not only a matter of downward trends.

In the Netherlands, the requirements of BAT/BEP in terms of the OSPAR Convention are met when the ALARA principle is applied. At present, COVRA is considered to comply with the ALARA principle.
The discharges are low compared to the discharge limits in the license. Also the estimated dose for the critical group due to liquid discharges is very low, much less than 0.001 µSv/year.
The information presented above is in accordance with the OSPAR guidelines 2004-03 [RAD04] and includes indicators that BAT/BEP has been applied in the research facility in the COVRA facility.

8 The nuclear power plant in Dodewaard (in decommissioning)

8.1 Site characteristics

8.1.1 Name of site

The nuclear energy reactor in Dodewaard is owned by the Gemeenschappelijke Kernenergiecentrale Nederland (GKN). The common name of the installation is ‘Kerncentrale Dodewaard’.

8.1.2 Type of facility

The reactor facility was a General Electric (Mark I) Boiling Water Reactor.

8.1.3 Year for commissioning/licensing/decommissioning

The reactor was commissioned and licensed in 1968. The reactor was shut down in 1997. In April 2003 the last fuel elements were transported to a nuclear fuel reprocessing plant. In 2002 a permit was granted to GKN to realize a condition of Safe Enclosure of the NPP, before the NPP is dismantled. This state of Safe Enclosure was realized on the 1st of July 2005.

8.1.4 Location

The reactor is located at Dodewaard in the province of Gelderland (see map in Appendix A).

8.1.5 Receiving water and catchment area

The cooling water was received from the estuary of the river Waal. The river Waal was also the catchment area of the reactor, and of the cleaning operations subsequent to the transport of fuel elements in 2003. The license for operating the Safe Enclosure came into power on July 1st, 2005. No discharges to water are licensed, and none take place, since that date.

8.1.6 Production

The reactor, when in operation, had a steady thermal power capacity of 183 MW (th) per year and an electrical power capacity of 58 MW (e).

8.2 Discharges

8.2.1 Systems to reduce discharges

Batchwise treatment of liquid waste is applied. Depending on the water samples the following techniques are applied to reduce the discharges [KCD94, KCD99]. Subsequently, the ALARA principle is applied.

- ion exchange techniques are applied in order to reduce the contamination of waste water. The used saturated resin is transported to the storage tank. From the storage tank it is removed to the solid waste system
- evaporation is utilized, depending on the activity concentration and composition of samples from a tank. The evaporation extract is removed to the solid waste system
- filtration of sludge can be used when it is required. Filter residue is transported to the solid waste system
- sedimentation is applied and the sediment is transported to the solid waste system.
- immobilization by cementation of evaporation extract
- storage and decay if possible
- addition of chemicals preventing corrosion in the cooling water systems.

For this installation other measures or more extensive application of measures to further reduce discharges are considered to be in conflict with the ALARA principle.

From June 2005 onwards no liquid discharges have taken place.

8.2.2 Efficiency of systems

No information is available on the efficiency of the waste water treatment systems.

8.2.3 Annual liquid discharges

Starting from June 2005, no liquid discharges to water have taken place.

Table 24 Liquid discharges of Dodewaard NPP (in GBq, i.e. not normalized).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
alpha	<1.8E-04	<3.0E-04	<2.0E-04	<1.5E-04	<9.0E-05	<2.3E-07	<MDL	<MDL	0	0
beta/ gamma	1.2E+00	3.9E+00	6.8E-01	8.2E-01	7.9E-01	7.5E-01	2.4E+00	1.8E-03	0	0

MDL is the (unknown) minimum detectable level

The alpha discharges to water in Table 24, between 1998 and 2005, have always been lower than the minimum detectable level. In the previous report [OSP05] the minimum detectable level has been reported as the actual discharge for 1998, 2000, 2001 and 2002.

Table 25 Liquid discharges of H-3 of Dodewaard NPP (in GBq, i.e. not normalized).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
H-3	1.1E+00	2.9E+00	1.4E+00	2.5E-01	2.7E-01	1.0E+02	4.1E+00	2.3E-04	0	0

The discharges of the reactor can not be compared to other nuclear power reactors in the world, because it is in decommissioning phase. In July 2005 the state of Safe Enclosure was realized. In the state of Safe Enclosure the emissions decrease to zero for liquid discharges and for activity concentration of H-3 and C-14 in ventilation air.

8.2.4 Emissions to air relevant for the marine compartment

Since the final transport of the last spent fuel elements to a reprocessing facility in 2003, there are no longer emissions to air.

Table 26 Emissions to air of Dodewaard NPP (in GBq, i.e. not normalized).

	1998	1999	2000	2001	2002	2003*	2004*	2005*	2006	2007
H-3	3.0E+00	3.7E+00	1.5E+00	6.8E-01	5.1E-01	<8.E-01	<3.5E+00	<1.5E-01	0	0
C-14	5.3E-01	5.7E-01	4.6E-01	4.8E-01	3.4E-01	<3.E-01	<1.5E-01	<2.1E-02	0	0

* The estimate of the H-3 emission to air in 2003-2005 is based on a single measurement in that year. The estimate of the C-14 emission to air is based on the detection limit.

8.2.5 Quality assurance of retention systems/data management

The quality assurance system of the power plant is based on IAEA Basic safety principles [IAE88] and Safety Culture [IAE91]. The Dutch nuclear safety guidelines, NVR's, are based on IAEA Safety Guide Safety Series.
Quality assurance of retention systems and data management is ensured by NVR 2.2.11 "Operational Management of radioactive effluents and wastes arising in nuclear power plants", based on [IAE86].

8.2.6 Site specific target discharge data

No target discharge data have been defined. The discharges have, as expected, decreased to zero since the start of the Safe Enclosure period on 1st July 2005.

8.2.7 Relevant information not covered by previous sections

Table 27 Discharge limits to water of Dodewaard NPP (in TBq). Valid until 30th June 2005.

	Discharge limits
Total gamma and rest beta emitters	0.1
H-3	2
total alpha emitters	0.00005

In Appendix B a figure is given which shows the discharges normalized to the limits.

8.2.8 Explanations for lack of data or failure to meet BAT/BEP indicators

From 2004, the discharges to water and emissions to air show downward trends. From 1st July 2005 these discharges are zero.

8.3 Environmental impact

In general, discharges of all sources lead to an increase of the activity concentrations. Nevertheless, it is not expected that the environmental monitoring data can be associated to a unique discharge source. Information for this section can be found in Appendix C.

8.4 Radiation doses to the public

8.4.1 Individual effective dose

The liquid discharges were, until the realization of the state of Safe Enclosure in July 2005, discharged directly into the river Waal, which flows into the North Sea.
The effective dose via the marine exposure pathway for the critical group, defined in section 3.4.3 is estimated using the methodology described in 3.4.5 and the site specific factors given in section 8.4.6.

Table 28 Effective dose per year caused by liquid discharges of the Dodewaard NPP (in μSv).

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
E (μSv)	1.4E-04	4.5E-04	7.7E-05	9.4E-05	9.0E-05	7.2E-05	2.7E-04	2.0E-07	0	0

8.4.2 Total exposures (including those from historic discharges)

The total exposure including those from historic discharges is not estimated due to fact that the estimated individual effective dose is already low compared to the dose limit for members of the public.

8.4.3 Critical group definition

In the Netherlands the critical group is called the reference group. The definition of the reference group is given in section 3.4.3.

8.4.4 Considered exposure pathways

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.

8.4.5 Methodology to estimate doses

The methodology to estimate the dose is based on models presented by Van Hienen et al. [VROM90] and actual discharge data.

8.4.6 Site specific factors to estimate the dose

Site specific factors to estimate the dose to critical group members from discharges to water have been published by Van Hienen et al. [VROM90] and corrected using the DCC's of EURATOM 96/29 [EU96].

Table 29 Site specific factors of the Dodewaard NPP

Radionuclide	Factor ($Sv.a^{-1}$ per $Bq.s^{-1}$)
H-3	2.3E-17
Cr-51	5.3E-15
Mn-54	4.3E-13
Co-58	7.3E-13
Co-60	4.2E-12
Zn-65	1.3E-11
Sr-89	4.7E-15
Sr-90	7.0E-14
Nb-95	2.4E-14
Ag-110m	3.2E-12
Sb-124	9.3E-13
Sb-125	5.5E-13
I-131	5.8E-14
Cs-134	2.4E-12
Cs-137	1.7E-12
Ba-140	5.3E-13

8.4.7 Site specific target annual effective dose

No specific target annual effective dose has been defined.

8.4.8 Quality assurance system for dose estimates

The dose estimates have a low priority due to the expected minor dose consequences; therefore a quality assurance system is not considered to be appropriate.

8.4.9 Explanations for lack of data or failure to meet BAT/BEP indicators

Since 2005, when the plant entered the state of Safe Enclosure, discharges to water have ceased. Moreover, discharges to air have reduced to the point that they can no longer be detected in ventilation air. This is the explanation for lack of data. Before 2005, the estimated dose for the critical group due to discharges to water is less than 0.001 μSv per year. Furthermore, these discharges were already low when compared to the licensed discharge limits (section 8.2.7).

8.5 Summary evaluation

According to the OSPAR guidelines, an indication that BAT/BEP has been applied is a downward trend in the liquid discharges [RAD04]. The annual discharges and emissions of the nuclear power plant in Dodewaard show a strong downward trend. The last discharge of waste water took place in the first half of 2005. From July 2005 onwards, the plant is in a state of Safe Enclosure. Liquid discharges no longer take place and neither H-3 nor C-14 can be measured in ventilation air.
The information presented above is in accordance with the OSPAR guidelines 2004-03 [RAD04] and includes indicators that BAT/BEP has been applied in NPP Dodewaard in its decommissioning phase.

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Appendix A Locations of sites

Location of nuclear sites in the Netherlands, including the Dodewaard Nuclear Power Plant, which is in Safe Enclosure since July 2005.

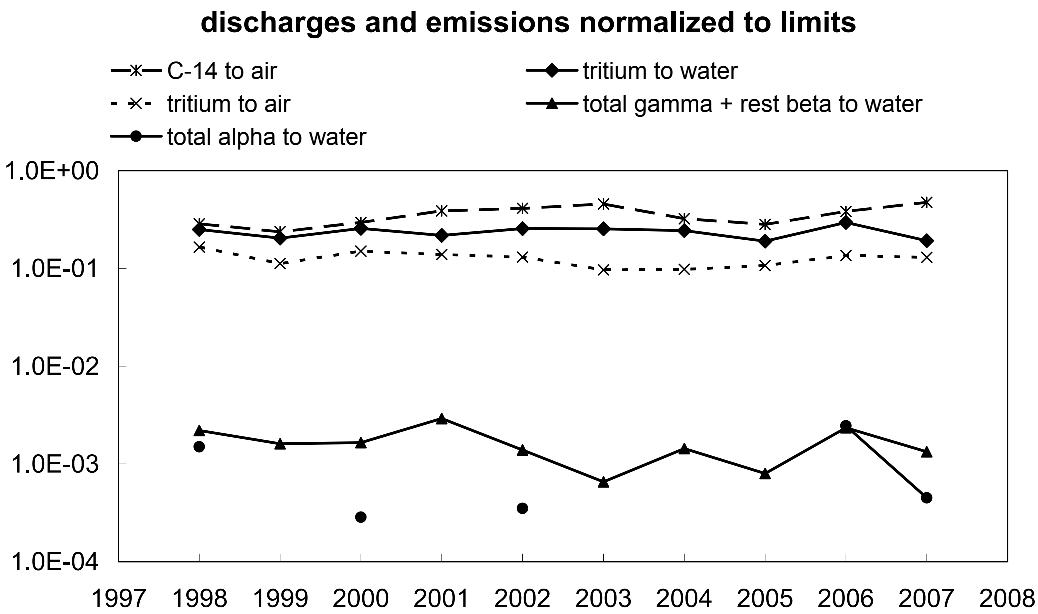
Map of Nuclear Facilities

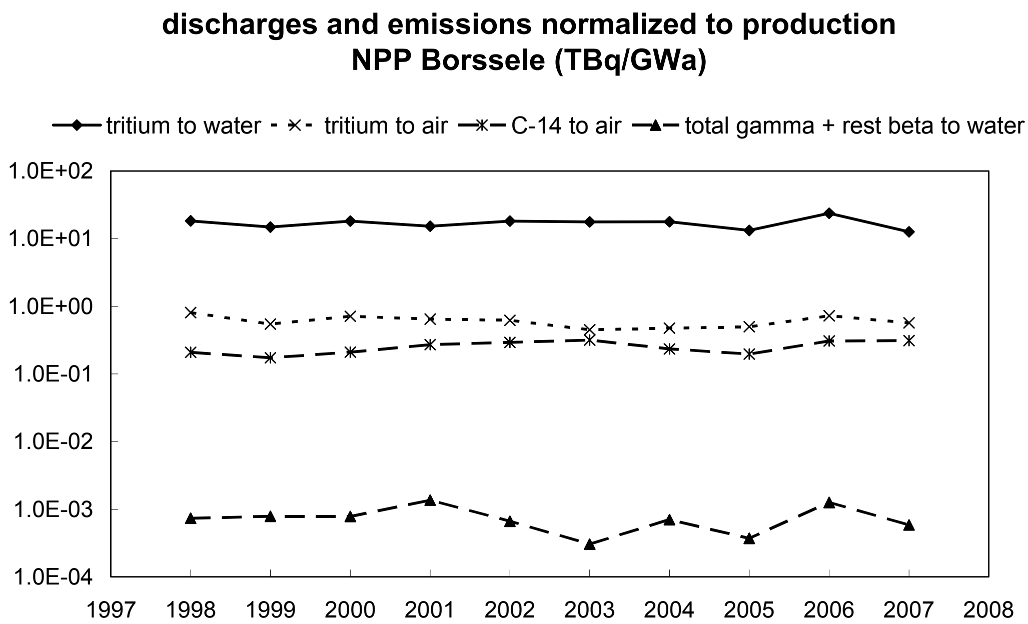
Map of sampling locations

Appendix B Normalized discharges

The normalized discharges of the Nuclear Power Plants and of the fuel enrichment facility are shown here.

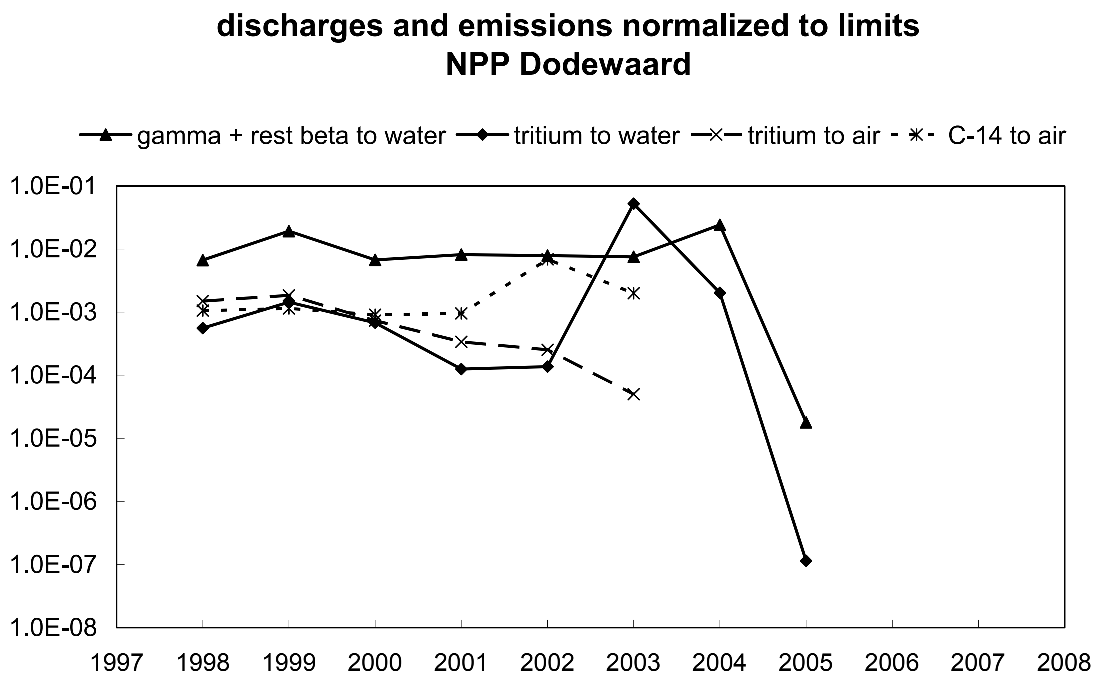
NPP Borssele





NPP Dodewaard (now in decommissioning)

The alpha discharges to water from NPP Dodewaard, now in decommissioning, have been below the minimum detection level for the period in question, and are therefore not plotted here (and neither should they have been plotted as discharges in the corresponding figure of the previous report, OSPAR document 2005/238 [OSP05]).
No discharges to water take place since July 1st, 2005, when the license for operating in Safe Enclosure came into power.



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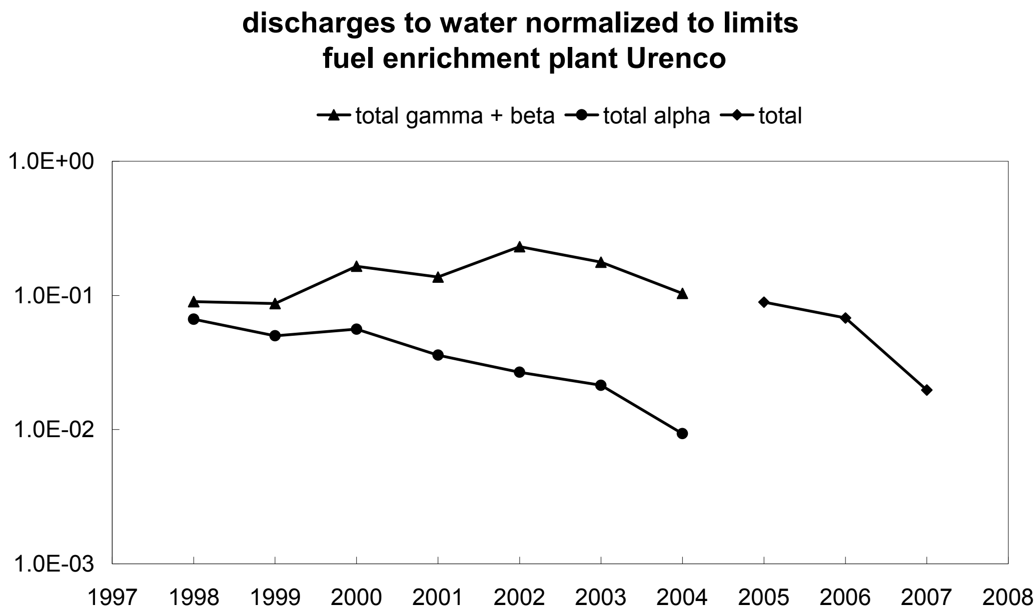
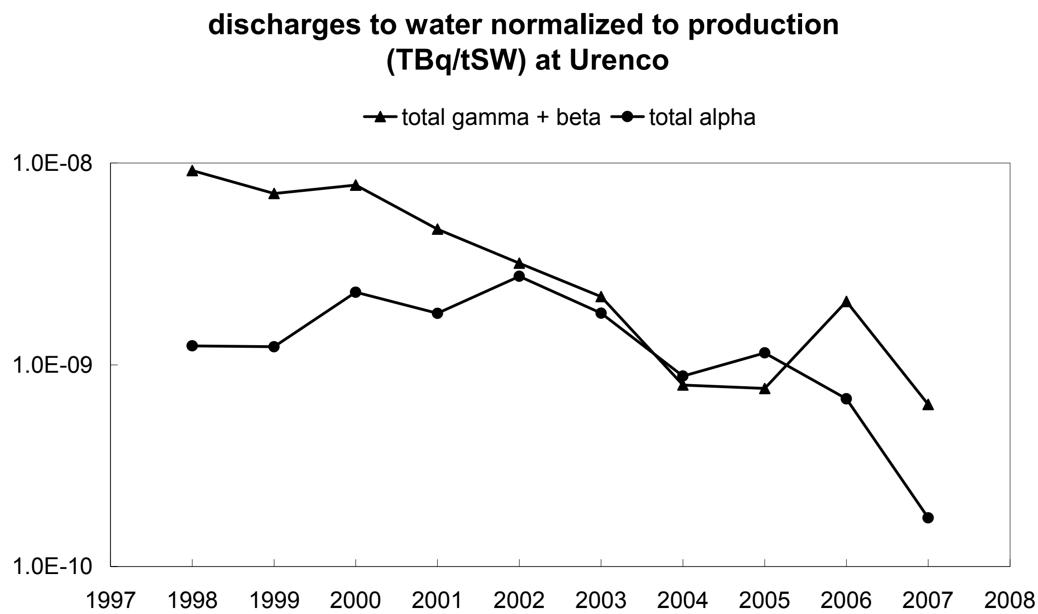
Fuel enrichment facility URENCO





Appendix C Environmental impact

Although discharges of Dutch and foreign nuclear installations lead to an increase of the activity concentrations in the environment, it cannot be expected that the environmental monitoring data are associated to a unique discharge source. For this reason the environmental impact is presented in this appendix and not in the main text.

Concentrations of radionuclides in samples

Activity concentrations are frequently measured in environmental samples from specific locations in waters of the Netherlands, see map in Appendix A. The median value for the measured activity concentrations in a year is given. The data are extracted from http://www.waterbase.nl.

Table 30 Alpha activity concentration (in Bq.m^{-3})

	Dantzig gat	Eijsden ponton	Vrouwe-zand	Haring-vlietsluis	Lobith ponton	Maas-sluis	Mars-diep noord	Sas van Gent	Wester-scheldt
1998	NI	3.8E+01	4.6E+01	5.3E+01	7.1E+01	1.2E+02	4.2E+02	8.7E+01	4.5E+02
1999	6.1E+02	5.0E+01	5.0E+01	5.1E+01	7.8E+01	1.0E+02	5.1E+02	1.5E+02	6.6E+02
2000	3.0E+02	3.1E+01	5.2E+01	3.7E+01	5.6E+01	4.8E+01	2.1E+02	4.9E+01	2.0E+02
2001	5.4E+02	3.9E+01	4.0E+01	4.4E+01	6.0E+01	8.5E+01	3.6E+02	7.1E+01	4.0E+02
2002	4.2E+02*	3.7E+01	3.6E+01	4.6E+01	6.0E+01	8.3E+01	3.6E+02	7.5E+01	3.2E+02
2003	5.2E+02	2.5E+01	3.4E+01	3.3E+01	4.6E+01	9.8E+01	3.4E+02	1.0E+02	4.8E+02
2004	4.4E+02	3.8E+01	4.6E+01	3.7E+01	5.3E+01	8.8E+01	3.3E+02	1.2E+02	5.1E+02
2005	5.4E+02	3.8E+01	3.3E+01	3.4E+01	5.9E+01	1.0E+02	7.0E+02	1.2E+02	7.0E+02
2006	8.0E+02	3.7E+01	4.7E+01	3.9E+01	5.9E+01	1.2E+02	7.3E+02	1.3E+02	6.1E+02
2007	3.6E+02	4.4E+01	4.1E+01	3.8E+01	5.5E+01	9.2E+01	4.4E+02	9.3E+02	4.1E+02

* Erroneously reported as 4.7E+02 in the previous report (OSPAR document 2005/238 [OSP05])
NI: No Information

Table 31 Rest beta activity concentration (in Bq.m^{-3})

	Dantzig gat	Eijsden ponton	Vrouwe-zand	Haring-vlietsluis	Lobith ponton	Maas-sluis	Mars-diep noord	Sas van Gent	Wester-scheldt
1998	NI	3.2E+01	2.7E+01	2.7E+01	3.8E+01	4.8E+01	8.1E+01	2.9E+01	8.6E+01
1999	9.4E+01	2.5E+01	3.1E+01	2.1E+01	4.2E+01	5.7E+01	4.8E+01	2.9E+01	6.2E+01
2000	1.2E+02	1.7E+01	3.6E+01	1.9E+01	3.6E+01	3.6E+01	4.5E+01	2.3E+01	6.4E+01
2001	1.3E+02	2.2E+01	3.2E+01	2.9E+01	4.6E+01	7.4E+01	6.2E+01	4.1E+01	8.9E+01
2002	1.4E+02	2.0E+01	2.0E+01	1.8E+01	3.0E+01	7.3E+01	8.7E+01	4.6E+01	1.1E+02
2003	1.1E+02	1.3E+01	1.8E+01	8.0E+00	2.9E+01	2.5E+01	4.3E+01	3.0E+01	6.8E+01
2004	1.4E+02	1.7E+01	2.2E+01	1.3E+01	2.5E+01	5.2E+01	5.9E+01	3.2E+01	7.8E+01
2005	1.5E+02	1.8E+01	3.8E+01	8.0E+00	3.5E+01	4.2E+01	5.0E+01	2.8E+01	7.5E+01
2006	1.0E+02	3.4E+01	3.1E+01	1.5E+01	4.3E+01	4.1E+01	6.3E+01	2.3E+01	6.8E+01
2007	1.3E+02	2.7E+01	2.6E+01	1.5E+01	3.0E+01	5.4E+01	8.1E+01	3.1E+01	5.8E+01

In the previous report (OSPAR document 2005/238 [OSP05]), total beta activity has been erroneously reported as ‘rest beta’ in the corresponding Table C.2 of Annex C (while the values in the corresponding table in RAD 00/4/5-E for the years 1988-1998 are indeed ‘rest beta’, with only small occasional differences in the reported activity for 1998).

Table 32 Tritium activity concentration (in Bq.m^{-3})

	Dantzig gat	Eijsden ponton	Vrouwe-zand	Haring-vlietsluis	Lobith ponton	Maas-sluis	Mars-diep noord	Sas van Gent	Wester-scheldt
1998	NI	2.8E+03	3.4E+03	5.5E+03	4.6E+03	4.7E+03	4.3E+03	1.7E+03	5.4E+03
1999	3.5E+03	2.4E+04	3.6E+03	5.3E+03	4.6E+03	5.1E+03	5.2E+03	2.0E+03	5.4E+03
2000	3.7E+03	3.4E+03	2.5E+03	6.1E+03	4.3E+03	5.1E+03	5.5E+03	1.5E+03	5.2E+03
2001	2.4E+03	3.5E+03	2.6E+03	3.3E+03	3.4E+03	3.7E+03	2.6E+03	1.1E+03	3.9E+03
2002	2.7E+03	1.5E+04	2.7E+03	4.1E+03	3.3E+03	4.4E+03	3.1E+03	1.7E+03	4.5E+03
2003	3.7E+03	2.0E+04	3.7E+03	5.3E+03	5.1E+03	6.0E+03	3.5E+03	2.0E+03	5.2E+03
2004	4.7E+03	1.2E+04	3.2E+03	5.0E+03	4.1E+03	5.5E+03	4.7E+03	1.7E+03	6.5E+03
2005	4.8E+03	9.2E+03	3.3E+03	4.6E+03	4.8E+03	4.7E+03	4.9E+03	1.4E+03	6.2E+03
2006	5.2E+03	1.5E+04	4.2E+03	4.1E+03	5.9E+03	4.2E+03	5.4E+03	1.3E+03	6.6E+03
2007	3.7E+03	1.5E+04	3.2E+03	4.2E+03	3.3E+03	4.1E+03	3.4E+03	5.6E+02	4.8E+03

NI: No Information

Table 33 Ra-226 activity concentration (in Bq.m^{-3}).

	Dantzig gat	Eijsden ponton	Vrouwe-zand	Haring-vlietsluis	Lobith ponton	Maas-sluis	Mars-diep noord	Sas van Gent	Wester-scheldt
1998	NI	7E+00	NI	NI	9E+00	2E+01	7E+00	1.3E+01	9E+00
1999	6E+00	6E+00	NI	NI	8E+00	8E+00	6E+00	1.1E+01	9E+00
2000	6E+00	4E+00	NI	NI	5E+00	7E+00	6E+00	7.0E+00	6E+00
2001	5E+00	3E+00	NI	NI	4E+00	4E+00	4E+00	5.5E+00	5E+00
2002	5E+00	3E+00	NI	NI	4E+00	5E+00	4E+00	7.0E+00	5E+00
2003	4E+00	4E+00	NI	NI	5E+00	4E+00	4E+00	7.0E+00	5E+00
2004	4E+00	4E+00	NI	NI	4E+00	4E+00	3E+00	8.0E+00	6E+00
2005	4E+00	4E+00	NI	NI	4E+00	4E+00	3E+00	7.0E+00	5E+00
2006	3E+00	3E+00	NI	NI	4E+00	5E+00	4E+00	6.0E+00	5E+00
2007	4E+00	2E+00	NI	NI	3E+00	4E+00	3E+00	6.0E+00	5E+00

NI: No Information

Nuclide libraries

The reported activity concentrations are total alpha, total and rest beta, H-3, Pb-210/Po-210, Sr-90 and Ra-226. Rest beta is the total beta activity excluding K-40, H-3 and short-lived radon daughters.

The nuclide library of Genie 2000, a product of Canberra, is used to identify gamma emitting radionuclides in environmental samples. However, only Co-58, Co-60, Cs-134, Cs-137, I-131 and Mn-54, are reported, if the radionuclides are detected.

Environmental monitoring program

The environmental monitoring programme 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 12 times per year per location is kept. Ra-226, Sr-90, Sr-89, Po-210 and gamma (Cs-137, etc.) activity is measured with a sampling frequency between 4 and 13 times per year per location. The Rijkswaterstaat Centre for

Water Management monitors the activity concentrations at 10 locations in inland waters and at 11 locations at sea.

National target levels of radioactive substances

National target levels of activity of radionuclides in the environment are defined for inland waters, as mentioned in section 2.4. Compliance is assessed by comparing the 90th percentile of the measured data, which is not given in this report, with the target levels.

Table 34 National target levels (in Bq.m^{-3}) [TPW98].

Total alpha	1.0E+02
Rest beta	2.0E+02
Tritium	1.0E+04

Quality assurance of systems for environmental monitoring

The methodology of environmental monitoring is according to NEN 5622[4], NEN 5623[5], and NEN 6421[6] for the determination of alpha, gamma and beta activities respectively. NEN is a Dutch quality assurance standard. Beta and alpha emitters are monitored according to KTA 1504[7].

Relevant information not covered by previous sections

There is no relevant information not covered by the previous sections.

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[5] NEN5623: Radioactivity measurements - Determination of the activity of gamma ray emitting nuclides in a counting sample by semiconductor gammaspectrometry. Date of most recent version: 2002.

[6] NEN6421: Water - Determination of volumic gross-beta activity and volumic rest-beta activity of non-volatile compounds. Date of most recent version: 2006.

[7] Kerntechnischer Asschuss (KTA 1504) Überwachung der Ableitung radioaktiver Stoffe mit wasser. Kerntechnischer Ausschuss 1504, Fassung 6/94. Carl Heymans Verlag KG, Luxemburger Strasse 449, 50939 Köln, Germany. 1994 (in German).

Appendix D References for yearly discharges

The references for the yearly discharges of each installation are given here.

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