
Report on Information about, and the Assessment of, the Application of BAT in Nuclear Facilities

Netherlands' Report on the Implementation of PARCOM Recommendation 91/4 on radioactive discharges[1]

OSPAR Commission
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[1] This report has been put together by H Eleveld and PJM Kwakman by order and for the account of the Ministry of Housing, Spatial Planning and the Environment, within the framework of project M/861020/01, Policy Support Ionising Radiation , RIVM, P.O. Box 1, 3720 BA Bilthoven.

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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1 Introduction and general information

The 2004 meeting of the OSPAR working group on Radioactive Substances in La Rochelle (France) established draft guidelines for the submission of information about, and the assessment of, the application of BAT in nuclear facilities.

In order to meet the requirements of the guidelines for the Netherlands the requested information is given in this report. In this chapter general information on i.e. national implementation of BAT/BEP, discharge limits and monitoring programmes is provided. The subsequent chapters deal with both nuclear power plants, the nuclear enrichment plant, two research reactors and the waste treatment plant.

The annexes A and C to this report provide additional information on the location of the nuclear installations and specific sampling locations of the national monitoring programme (Annex A) and the environmental impact (Annex C). Figures which show the discharges and emissions normalized to the limits and annual electric output can be found in Annex B.

1.1 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 tendency 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.

The provisions for radiation protection in the Act are based on the 3 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 are not explicitly referred to in the Nuclear Energy Act. BAT/BEP in terms of the OSPAR Convention are implemented in the Dutch national regulation by the ALARA principle.

1.2 Dose limits/constraints for nuclear installations

The dose limit for members of the public is 1 mSv per year. This limit is cumulative for all sources an individual is exposed to. In the Netherlands a member of the public may be exposed to 10 sources at most. Consequently, a location limit of 0,1 mSv/a is applied for single sources. Therefore, a nuclear power plant, as a single source, is not allowed to expose members of the public to more than 0,1 mSv/a, due to normal operation. There are no specific dose constraints for nuclear installations.

A nuclear installation has to meet risk criteria. To prevent such hazards the cumulative risk of death from all sources together is confined to a maximum permissible level of 10^{-5} a year. For a single source the individual risk should not exceed a maximum permissible level of 10^{-6} a year. This refers not only to the risk of dying immediately after an accident, but also includes delayed mortality due to stochastic effects (late 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 damage does not always offer sufficient safeguards against severe disruptions to society. To control such losses the concept of group risk is used. In order to avoid large-scale disruptions to society the probability of an accident in which at least 10 or more suffer ‘acute’ death is restricted to a level of 10^{-5} a year. ‘Acute’ death means death within a few weeks and the cause of death should be directly attributable to the accident. Accidents with larger consequences will cause disruptions which are disproportional larger. Therefore a limitative factor will be applied which increases quadratically to take account of larger groups. When the number of fatalities increases with a factor n, the probability should decrease 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} a year.

Nuclear installations have to demonstrate compliance with the risk criteria by means of a safety report.

1.3 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 are given per group of nuclides: beta/gamma emitters (excluding tritium), alpha emitters and tritium[2].

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.

1.4 Monitoring programmes of environmental concentrations of radionuclides

RIZA, Institute for Inland Water Management and Waste Water Treatment, monitors the activity concentrations of radionuclides in inland waters and RIKZ, National Institute for Coastal and Marine Management, monitors the activity concentrations in the marine environment. The environmental monitoring program consists of measuring water samples and suspended particles. The frequency of sampling is variable per year per nuclide and per location. For each of the alpha, rest beta and tritium activity measurements an average sampling frequency of 12 times per year per location is kept. ^{226}Ra activity is measured with an average sampling frequency of 4 times per year per location. RIZA monitors the activity concentrations at 12 locations. RIKZ monitors the activity concentrations at 7 locations.

1.5 Environmental norms and standards (other than dose standards for humans, e.g. standards for drinking water)

A WHO guideline [WHO93] prescribes the following norms for drinking water, which is adopted in the Netherlands:

- total alpha activity concentration: <0,1 Bq/l
- rest beta activity concentration: <1 Bq/l

The norms for drinking water quality are according to EU regulation [EU98]:

- total indicative dose: <0,1 mSv
- tritium activity concentration: <100 Bq/l

National target levels of activity of radionuclides in the environment are defined for inland water [TPW98]:

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

1.6 National authority responsible for supervision etc. 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.

1.7 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 Nuclear Safety Service and RIVM, the National Institute of Public Health and the Environment, for quality control of the measurements of the radioactivity of the wastewater and air.

[2] Only in case of nuclear power plants a discharge limit for tritium discharges is given.

2 The nuclear power plant in Borssele

2.1 Site characteristics

2.1.1 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)".

2.1.2 Type of facility

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

2.1.3 Year for commissioning/licensing/decommissioning

The reactor was commissioned and licensed in 1973. The license is modified in September 2004 in order to facilitate NPP Borssele to employ 4,4%wt (maximum) enriched ^{235}U (was $4,0\%_{wt}$) and a maximum average nuclear fuel element burning to 68 MWday/kgU.

2.1.4 Location

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

2.1.5 Receiving waters and catchment area

The cooling-water is received from the estuary of the Scheldt river discharging into the North Sea, which is also the catchment area of the reactor.

2.1.6 Production

The reactor has a steady thermal power capacity of 1366 MW(th) and an electrical power capacity of 485 MW(e).

Table 2.1. The annual electric output of net produced electricity for the last six years

	GWh	GWa	Reference
1998	3593	0,410	[KCB98]
1999	3603	0,411	[KCB04]
2000	3699	0,422	[KCB04]
2001	3747	0,428	[OSP01]
2002	3687	0,421	[KCB04]
2003	3788	0,432	[KCB04]

2.1.7 Other relevant information

There is no other relevant information.

2.2 Discharges

2.2.1 Systems to reduce discharges

Batchwise treatment of liquid waste is applied (in annually 3.10^3 m^3). 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 dependent on the activity concentration and composition of samples from a tank. At this point the ALARA principle is applied. 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 pellets.

For this installation other measures or more extensive application of measures to reduce discharges are considered not to be feasible economically.

2.2.2 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.

2.2.3 Annual liquid discharges

Table 2.2. Liquid discharges of gamma and beta emitters of the Borssele NPP, excluding tritium (in TBq/GWa)

	1998* [KCB98]	**1999** [KCB99]	**2000** [KCB00]	**2001** [KCB01]	**2002** [KCB02]	**2003** [KCB03]
Cr-51	1,4E-04	3,9E-05	7,6E-05	4,4E-05	1,2E-05	1,7E-05
Mn-54	1,4E-05	7,8E-06	3,3E-06	2,0E-05	5,8E-06	2,6E-06
Fe-55	8,5E-05	9,9E-05	1,0E-04	3,3E-04	1,3E-04	5,2E-05
Co-58	1,4E-04	5,7E-05	6,2E-05	9,4E-05	1,4E-05	1,5E-05
Co-60	2,9E-04	2,5E-04	2,8E-04	2,9E-04	1,6E-04	9,0E-05
Ni-63	7,0E-05	8,9E-05	8,7E-05	2,0E-04	8,3E-05	5,8E-05
Zr-95	2,5E-05	5,1E-06	7,8E-06	4,5E-05	6,7E-06	2,1E-06
Nb-95	4,7E-05	1,5E-05	2,4E-05	8,0E-05	1,4E-05	2,9E-06
Ag-110m	2,4E-05	2,0E-05	1,5E-05	5,6E-05	1,8E-05	8,9E-06
Te-123m	2,2E-06	0,0E+00	0,0E+00	2,5E-07	0,0E+00	3,0E-07
Sb-124	9,5E-06	1,2E-06	1,6E-05	8,5E-06	2,3E-06	1,5E-06
I-131	1,9E-04	3,3E-06	2,5E-05	8,2E-05	7,2E-05	1,6E-07
Cs-134	1,7E-06	1,5E-05	1,4E-05	2,2E-05	1,4E-05	8,7E-06
Cs-137	1,9E-05	4,8E-05	3,7E-05	4,6E-05	2,5E-05	2,0E-05

NI = no information

***the data are slightly different from those reported in [OSP00] due to rounding differences.

Table 2.3. Liquid discharges of H-3 of Borssele NPP (in TBq/GWa)

	1998* [KCB98]	**1999** [KCB99]	**2000** [KCB00]	**2001** [KCB01]	**2002** [KCB02]	**2003** [KCB03]
H-3	1,8E+01	1,5E+01	1,8E+01	1,5E+01	1,8E+01	1,8E+01

* the reported liquid discharge of tritium in 1998 differs from the value in OSPAR 2000 report [OSP00].

Table 2.4. Liquid discharges of alpha emitters of Borssele NPP (in TBq/GWa)

	1998 [KCB98]	**1999** [KCB99]	**2000** [KCB00]	**2001** [KCB01]	**2002** [KCB02]	**2003** [KCB03]
Alpha	7,3E-07	<DL	1,4E-07	<DL	1,7E-07	<DL

<DL= below detection limit

COMPARISON WITH SIMILAR REACTORS

UNSCEAR [UNS00] 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.

2.2.4 Emissions to air relevant for the marine compartment

Table 2.5. Emissions to air of Borssele NPP (in TBq/GWa)

	1998* **[KCB98]**	**1999** **[KCB99]**	**2000** **[KCB00]**	**2001** **[KCB01]**	**2002** **[KCB02]**	**2003** **[KCB03]**
H-3	8,1E-01	5,4E-01	7,1E-01	6,5E-01	6,2E-01	4,5E-01
C-14	2,1E-01	1,7E-01	2,1E-01	2,7E-01	2,9E-01	3,2E-01

*the reported emission of tritium in 1998 differs from the value in OSPAR 2000 report [OSP00].

Emissions of ^{129}I to air are not measured.

2.2.5 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 IEAE 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].

2.2.6 Site specific target discharge data

Site internal target discharges are defined. For 2003 these targets are:

Emissions to air:

- noble gasses < 0,5% of discharge limit
- iodine-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

2.2.7 Relevant information not covered by previous sections

Table 2.6. The discharge limits of the Borssele NPP (in TBq)

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 the limits and to the annual electric output.

There is a downward trend regarding the liquid discharges of beta/gamma emitters, these discharges decreased from 0,22% of the discharge limit in 1998 to 0,07% in 2003. The tritium discharges remain at a constant level, whereas the tritium emissions to air show a decrease from 16% of the emission limit in 1998 to 9,7% in 2003.

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

The C-14 emissions to air show an increase, also relative to the emission limit. This increase is basically attributed to the improved C-14 measurement technique.

2.3 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.

2.4 Radiation doses to the public

2.4.1 Individual effective dose

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

The individual effective dose via the marine exposure pathway for the critical group, defined in section 2.4.3 is estimated using the methodology described in 2.4.5 and the site specific factors given in 2.4.6.

Table 2.7. Effective dose per year caused by liquid discharges of the Borssele NPP (in µSv)

	1998*	1999	2000	2001	2002	2003
E (in µSv)	1,4E-05	9,1E-06	1,1E-05	1,5E-05	8,5E-06	4,8E-06

*This dose estimated for 1998 differs from the reported value in the OSPAR 2000 report [OSP00].

2.4.2 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.

2.4.3 Critical group definition

In the Netherlands the critical group is called the reference group [PRAM99b]. The reference group is the (hypothetical) homogeneous group from 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 adults are considered, in accordance with the Dutch regulation guidelines.

Reference behavior is the behavior, given a certain contamination in the environment, that leads to the highest dose. This behavior contains all habits of living: working, eating and etcetera. 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.

2.4.4 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.

2.4.5 Methodology to estimate doses

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

2.4.6 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 [NRG99a] on the basis of using the methodology of Van Hienen et al. [VROM90] and using the DCC's of ICRP 72 [ICRP96].

Table 2.8. 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

The radionuclide Te-123m has not been taken into account due to omission of these radionuclides in the methodology of Van Hienen. 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 2.2.4.

2.4.7 Site specific target annual effective dose

Site internal targets for the annual effective dose have been defined. For example, for 2000 an effective dose target of 5,5 nSv per year as a consequence of all discharges (gaseous and liquid) is defined.

2.4.8 Quality assurance system for dose estimates

A quality assurance system is applied. Dose estimates have a low priority due to the expected minor dose consequences.

2.4.9 Relevant information not covered by previous sections

The previous sections cover all relevant information.

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

Since 1998 a downward trend can be observed regarding the dose estimates due to liquid discharges.

2.5 Summary evaluation

According to the Revised Guidelines 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 both parameters show such a downward trend, with the exception of emissions of carbon-14 to air. This increase is basically attributed to the improved C-14 measurement technique. So, according to these BAT/BEP indicators, BAT/BEP has been applied for the Borssele NPP.

Also, in the Netherlands compliance with the ALARA principle is considered to meet the requirements of BAT/BEP in terms of the OSPAR Convention. At present, the NPP in Borssele is considered to comply with the ALARA principle. Furthermore, the discharges are low compared to the discharge limits in the license and 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 [UNS00].

The conclusion is that the NPP in Borssele has applied BAT/BEP.

3 The nuclear power plant in Dodewaard

3.1 Site characteristics

3.1.1 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”.

3.1.2 Type of facility

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

3.1.3 Year for commissioning/licensing/decommissioning

The reactor was commissioned and licensed in 1968. The reactor was shut down in 1997. The fuel elements are already conveyed to a nuclear fuel reprocessing plant by April 2003. In 2002 a permit was granted to GKN to realize a condition of a Safe Enclosure of the NPP, before the NPP is dismantled.

3.1.4 Location

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

3.1.5 Receiving water and catchment area

The cooling-water is received from the estuary of the Waal river, which is also the catchment area of the reactor.

3.1.6 Production

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

3.1.7 Other relevant information

There is no other relevant information.

3.2 Discharges

3.2.1 Systems to reduce discharges

Batchwise treatment of liquid waste is applied (in total about 3000 m^3 per year). The following techniques are applied, dependent on the analysis of the water samples, to reduce the discharges [KCD94, KCD99]. Consequently, at this point 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 dependent 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.

3.2.2 Efficiency of systems

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

3.2.3 Annual liquid discharges

Table 3.2. Liquid discharges of Dodewaard NPP (in GBq, i.e. not normalized)

	1998 [IMH99]	1999 [OSP99]	2000 [GKN00]	2001 [GKN01]	2002 [GKN02]	2003 [GKN03]
Beta/gamma	1,2E+00	3,9E+00	6,8E-01	8,2E-01	7,9E-01	0,8E+00
Alpha	1,8E-04	N.D.	2,0E-04	1,5E-04	9,0E-05	< 1,0E-06

Table 3.3. Liquid discharges of H-3 of Dodewaard NPP (in GBq, i.e. not normalized)

	1998 [IMH99]	1999 [OSP99]	2000 [GKN00]	2001 [GKN01]	2002 [GKN02]	2003 [GKN03]
H-3	1,1E+00	2,9E+00	1,4E+00	2,5E-01	2,7E-01	1,0E+02

COMPARISON WITH SIMILAR REACTORS

The discharges of the reactor can not be compared to other reactors in the world, as it is in preparation for Safe Enclosure.

3.2.4 Emissions to air relevant for the marine compartment

Table 3.4. Emissions to air of Dodewaard NPP (in GBq, i.e. not normalized)

	1998 [IMH99]	1999 [OSP99]	2000 [GKN00]	2001 [GKN01]	2002 [GKN02]	2003 *
H-3	3,0E+00	3,7E+00	1,5E+00	6,8E-01	5,1E-01	8,E-01
C-14	5,3E-01	5,7E-01	4,6E-01	4,8E-01	3,4E-01	3,E-01

* The H-3 emission to air in 2004 is estimated based on one measurement in that year. The C-14 emission to air is estimated based on the detection limit.

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 IEAE 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

No target discharge data have been defined.

3.2.7 Relevant information not covered by previous sections

Table 3.5. Discharge limits of Dodewaard NPP (in TBq)

Total gamma and rest beta emitters	0,1
Tritium	2
total alpha emitters	0,00005

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

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

Except for the discharges of tritium to water in 2003, the discharges to water and emissions to air show downward trends.

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 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 3.4.6.

Table 3.6. Effective dose per year caused by liquid discharges of the Dodewaard NPP (in μSv)

	1998	1999	2000	2001	2002	2003
E (in μSv)	1,4E-04	4,5E-04	7,7E-05	9,4E-05	9,0E-05	7,2E-05

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.

3.4.3 Critical group definition

In the Netherlands the critical group is called the reference group. The definition of the reference group is given in section 2.4.3.

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 methodology to estimate the dose is based on models presented 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 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 3.7. Site specific factors of the Dodewaard NPP

Nuclide	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

3.4.7 Site specific target annual effective dose

No specific target annual effective dose has been defined.

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 Relevant information not covered by previous sections

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

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

No downward trends can be observed regarding the dose estimates. However, the estimated dose for the critical group due to discharges to water is less than 0,001 μSv per year. Furthermore, the discharges of the radionuclides are already low when compared to the licensed discharge limits (section 3.2.9).

3.5 Summary evaluation

According to the Revised Guidelines an indication that BAT/BEP has been applied, is a downward trend in the liquid discharges [RAD04]. Except for the liquid discharge of tritium, the annual discharges and emissions of the nuclear power plant in Dodewaard show a downward trend. However, the question whether or not BAT/BEP has been applied, is not only a matter of downward trends.

In the Netherlands compliance with the ALARA principle is considered to meet the requirements of BAT/BEP in terms of the OSPAR Convention. At present, the NPP in Dodewaard is considered to comply with the ALARA principle.

The discharges are low compared to the discharge limits in the license.

The conclusion is that the NPP in Dodewaard has applied BAT/BEP.

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 is 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 Overijssel, see map in Annex 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. Wastewater is treated in the municipal sewage treatment plant.

4.1.6 Production

The licensed production capacity amounts 2800 tSW/yr (tSW stands for tons of Separative Work).

Table 4.1. The fuel enrichment production (in tSW/yr)

	tSW/y	reference
1998	1450	[IMH99]
1999	1415	[UREN04a]
2000	1440	[UREN04a]
2001	1528	[UREN04a]
2002	1682	[UREN04a]
2003	1964	[UREN04a]

4.1.7 Other relevant information

There is no other relevant information.

4.2 Discharges

4.2.1 Systems to reduce discharges

The following techniques and end of pipe measures are applied, dependent on the analysis of the water samples, to reduce the discharges [UREN93]. At this point the ALARA principle is applied:

- distillation is utilized dependent 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 4.2. Liquid discharges of Almelo facility (in TBq/tSW)

	1998 [UREN98]	1999 [UREN99]	2000 [UREN00]	2001 [UREN01]	2002 [UREN02]	2003 [UREN03]
total alpha	1,2E-09	1,2E-09	2,3E-09	1,8E-09	2,7E-09	1,8E-09
beta/gamma	6,9E-09	7,1E-09	7,8E-09	4,7E-09	3,2E-09	2,2E-09

4.2.4 Emissions to air relevant for the marine compartment

The emissions to air are not relevant to the marine compartment. The plant is not located in the direct neighborhood of a sea or lake.

4.2.5 Quality assurance of retention systems/data management

The environment protection is guaranteed by a quality assurance system. The enrichment division has 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 4.3. Discharge limits of Almelo facility (in TBq) until February 2004

Gamma and beta emitters	0,0002
Total alpha emitters	0,00002

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

Table 4.3. Discharge limits of Almelo facility (in Re) from February 2004

Alpha, beta and gamma emitters	130

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

No downward trends can be observed regarding the discharges of radionuclides. However, according to the license, the discharges of the fuel enrichment plant are less than 24% of the discharge limit with respect to discharges of gamma and beta emitters and less than 7% of the discharge limit for alpha emitters.

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 Annex 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), subsequently pass the lake IJsselmeer which flows into the Waddensea and North Sea.

The maximum contribution to the annual dose due to discharges and emissions of the fuel enrichment plant is estimated to be less than 1 μSv [UREN04b].

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 2.4.3.

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 RIVM modelling.

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 Relevant information not covered by previous sections

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

4.4.10 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 Revised Guidelines an indication that BAT/BEP has been applied, is a downward trend in the liquid discharges [RAD04]. No downward trends can be observed regarding the discharges of radionuclides.

However, the question whether or not BAT/BEP has been applied, is not only a matter of downward trends.

In the Netherlands compliance with the ALARA principle is considered 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 conclusion is that the fuel enrichment plant in Almelo has applied BAT/BEP.

5 The research facility in Petten

5.1 Site characteristics

5.1.1 Name of site

The facility consists of two research reactors. Also research laboratories and auxiliary industry like Malinckrodt specialized in production of medically applied isotopes and the Mo-99-Production facility will contribute to the discharges from the site. The site is referred to as “Onderzoek 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 Community. 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 are commissioned and licensed in 1960.

5.1.4 Location

The reactors are located in Petten, in the Province Noord-Holland (see map in Annex A).

5.1.5 Receiving water and catchment area

The North Sea functions as receiving water for and catchment area of the facility.

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 Malinckrodt 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 litre 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 reduction achieved is described 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 Malinckrodt, 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 5.1. Liquid discharges of Petten site (in GBq: i.e. not normalized)

Nuclide	**1998 [OSP00]**	**1999 [NRG99b]**	**2000 [NRG00]**	**2001 [NRG01]**	**2002 [NRG02]**	**2003 [NRG03]**
H-3	3,8E+02	2,9E+02	2,8E+02	2,3E+02	2,1E+02	4,1E+02
Na-22	3,9E-02	2,3E-02	8,1E-02	5,3E-02	5,4E-02	4,9E-02
Cr-51	4,0E-03	NI	2,7E-03	6,0E-03	NI	3,6E-02
Mn-54	4,0E-02	2,4E-01	4,3E-02	1,0E-02	9,1E-03	8,3E-02
Co-57	NI	1,2E-04	NI	NI	NI	NI
Co-58	1,6E-02	7,3E-02	1,5E-02	7,0E-03	2,4E-02	4,6E-02
Co-60	6,3E-01	3,0E+00	6,0E-01	1,8E-01	4,2E-01	1,5E+00
Zn-65	1,7E-01	3,2E-01	2,5E-01	2,2E-01	1,3E-01	2,8E-01
Mo-99	4,5E+00	1,2E+00	1,8E-01	1,0E+01	9,4E+00	3,4E+01
Ru-103	2,5E-02	8,0E-03	3,8E-03	NI	7,0E-03	1,2E-02
Cd-109	5,0E-03	3,5E-01	1,2E-01	NI	NI	2,7E-01
Sb-124	1,3E-01	2,7E-01	2,9E-01	3,4E-01	1,9E-01	4,9E-01
Sb-125	8,6E-01	5,9E-01	7,5E-01	NI	5,4E-01	5,8E-01
I-131	5,0E+00	6,0E+00	6,3E+00	2,9E+00	2,1E+00	2,4E-01
Cs-134	4,2E-01	2,3E+00	5,3E+00	7,1E+00	8,0E+00	1,7E+00
Cs-137	1,1E+00	4,0E+00	1,2E+01	2,0E+01	1,5E+01	5,2E+00
W-181	8,7E-01	1,7E-01	2,4E-01	1,2E-01	8,3E-02	NI
W-188	1,8E-01	1,2E-02	2,6E-02	5,0E-03	NI	1,4E-02
Re-186	1,3E-02	1,2E-02	NI	NI	1,6E-01	3,1E-02
Tl-202	5,0E-03	NI	NI	2,0E-03	2,0E-03	3,2E-02
Alpha	2,0E-03	6,2E-04	6,2E-04	7,0E-03	9,0E-04	1,8E-03
Beta	6,2E+01	5,9E+01	7,8E+01	9,1E+01	8,1E+01	4,1E+01

NI = no information

5.2.4 Emissions to air relevant for the marine compartment

Table 5.2. Tritium emissions to air from all facilities combined on the Petten site in TBq (mainly from HFR)

	1998 [OSP00]	**1999 [NRG99b]**	**2000 [NRG00]**	**2001 [NRG01]**	**2002 [NRG02]**	**2003 [NRG03]**
H-3	1,1	0,8	0,9	0,8	0,3	0,9

Emissions of C-14 and I-129 are 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 the other 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.

Table 5.3. Discharge limit of 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 Annex C.

5.4 Radiation doses to the public

5.4.1 Individual effective dose

Using the data in 5.2.3 a dose assessment can be performed. The individual dose effective dose is calculated from the discharged activity and the site specific dose conversion coefficients as given in 5.4.6. The results are given in Table 5.4.

Table 5.4. Effective dose per year caused by the liquid discharges of the Petten site (in μSv)

	1998	**1999**	**2000**	**2001**	**2002**	**2003**
E (in μSv)	7E-04	3E-03	3E-03	4E-03	3E-03	2E-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 2.4.3.

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 pathways are treated to estimate a maximum individual dose.

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

Table 5.5. Site specific factors to estimate the dose to critical group members from discharges to water. These factors published by Van Hienen et al. [VROM90].

Nuclide	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 main BAT/BEP indicator (dose to public) shows no significant reduction. However, the doses are already extremely low during these years.

5.5 Summary evaluation

According to the Revised Guidelines 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 and therefore has applied BAT/BEP.

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 Interfaculty Reactor Institute, Delft University of Technology. The common **name** of the reactor is the HOR: “Hoger Onderwijs Reactor”.

6.1.2 Type of facility

The reactor **type** is a swimming pool reactor.

6.1.3 Year for commissioning/licensing

The research reactor is commissioned and licensed in 1963.

6.1.4 Location

The reactor is located in Delft, in the province Zuid-Holland (see map in Annex 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 Den Haag. Radionuclides, which pass the sewage treatment plant, proceed to the North Sea.

6.1.6 Production

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

6.1.7 Other relevant information

There is no other relevant information.

6.2 Discharges

6.2.1 Systems to reduce discharges

The following processes and end of pipe measures are applied:

- collection of all waste water batchwise;
- minimize dilution of waste water and mixing batches of different contamination level;
- contamination is reduced as far as reasonable achievable;
- batch wise 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 resin 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 presented as a total of the IRI Complex, also including research laboratories, as the discharges cannot easily be separated. Therefore, the actual discharges of the HOR will be substantially lower than the reported data.

Table 6.1. Liquid discharges of Delft facility (in GBq: i.e. <u>not</u> normalized)

nuclide	1998 [OSP00]	1999 [OSP99]	2000 [IRI00]	2001 [IRI01]	2002 [IRI02]	2003 [IRI03]
alpha	< 0,005	< 0,004	< 0,4E-03	< 0,3 E-3	< 0,24E-03	< 0,36E-3
beta	1,1E-02	1,1E-02	9,6E-03	6,5E-03	6,4E-03	1,1E-02
gamma	3,0E-03	< 3,4E-03	< 3,8E-03	< 2,7E-03	< 2,6E-03	< 2,5E-03

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 5.2.8 a definition of Re_{ing} is given).

Table 6.2. Discharge limit of Delft facility (in Re_{ing}'s)

	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 Annex 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 Waddensea.

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

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 Relevant information not covered by previous sections

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

6.4.10 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 Revised Guidelines 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 compliance with the ALARA principle is considered to meet the requirements of BAT/BEP in terms of the OSPAR Convention. 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 conclusion is that the research facility in Delft has applied BAT/BEP.

7 Waste treatment plant 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”.

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 Zeeland.

7.1.5 Receiving water and catchment area

COVRA does not use any cooling water.

7.1.6 Production

It is a waste treatment plant.

7.1.7 Other relevant information

There is no other relevant information.

7.2 Discharges

7.2.1 Systems to reduce discharges

COVRA applies $FeCl_3$ flocculation for the sedimentation of some ions. In the table 7.1 the so-called "slip-through" factors are given after waste water treatment by COVRA.

7.2.2 Efficiency of systems

The efficiency of the waste water treatment system is given in Table 7.1. For each nuclide in this Table the activity concentration after the $FeCl_3$ treatment is divided by the activity concentration before. A "slip-through" factor of 0,3 therefore means a waste water cleaning efficiency of 70%.

Table 7.1. Slip-trough factors for the waste water treatment system

Radionuclide	1999	2000	2001	2002	2003
Co-60	0,3	0,3	0,1	0,2	0,2
Cs-137	0,7	0,6	0,6	0,6	0,7
I-125	0,4	0,1	-	-	0,3
H-3	1	0,8	0,9	0,8	0,8
C-14	1	0,3	0,5	0,3	0,3
Alpha's	-	0,2	0,1	0,1	0,1
Gross gamma	-	0,5	0,4	0,5	0,4

7.2.3 Annual liquid discharges

Table 7.2. Liquid discharges of COVRA (in GBq: i.e. not normalized)

	1998 [COV98]	1999 [COV99]	2000 [COV00]	2001 [COV01	2002 [COV02]	2003 [COV03]
H-3	1,0E+02	1,0E+03	6,6E+01	2,2E+01	5,4E+01	5,9E+01
C-14	1,5E+00	9,0E-01	1,3E+00	2,3E-01	1,4E-01	2,0E-01
gross-alpha	1,4E-04	1,0E-03	9,0E-04	5,2E-04	1,1E-03	1,2E-04
rest-beta	1,4E-01	2,5E-01	5,0E-01	2,2E-01	3,6E-01	3,2E-01
gamma	3,0E-01	5,7E-01	5,0E-01	2,2E-01	3,3E-01	4,4E-01

7.2.4 Emissions to air relevant for the marine compartment

Table 7.3. Emissions to air of COVRA (in GBq: i.e. not normalized)

	1998 [COV98]	1999 [COV99]	2000 [COV00]	2001 [COV01]	2002 [COV02]	2003 [COV03]
H-3	2,6E+01	2,4E+01	5,0E+01	7,9E+00	3,5E+01	1,9E+01
C-14	2,9E+00	2,7E+00	9,3E-01	8,8E-01	3,9E+00	2,1E+00
gross-alpha	1,0E-05	<1,0E-04*	3,5E-05	3,7E-05	1,5E-05	1,7E-05
rest-beta	3,1E-05	<3,9E-03*	1,5E-04	3,1E-04	3,3E-04	3,1E-03
gamma	9,0E-03	5,0E-04	8,0E-06	1,2E-03	9,2E-04	NI

*based on 84.10^5 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.

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 7.2. Discharge limit of COVRA (in Re_{ing}'s).

	Re_{ing}
all radionuclides	2460

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 Annex 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 Scheldt river, 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 2.4.3. The methodology is described in 2.4.5 and the site specific factors given in 2.4.6.

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 one is referred to section 2.4.3.

7.4.4 Considered exposure pathways

The considered exposure pathways are defined in section 2.4.4.

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 one is referred to section 2.4.6.

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 Relevant information not covered by previous sections

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

7.4.10 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 Revised 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 compliance with the ALARA principle is considered to meet the requirements of BAT/BEP in terms of the OSPAR Convention. 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 conclusion is that COVRA has applied BAT/BEP.

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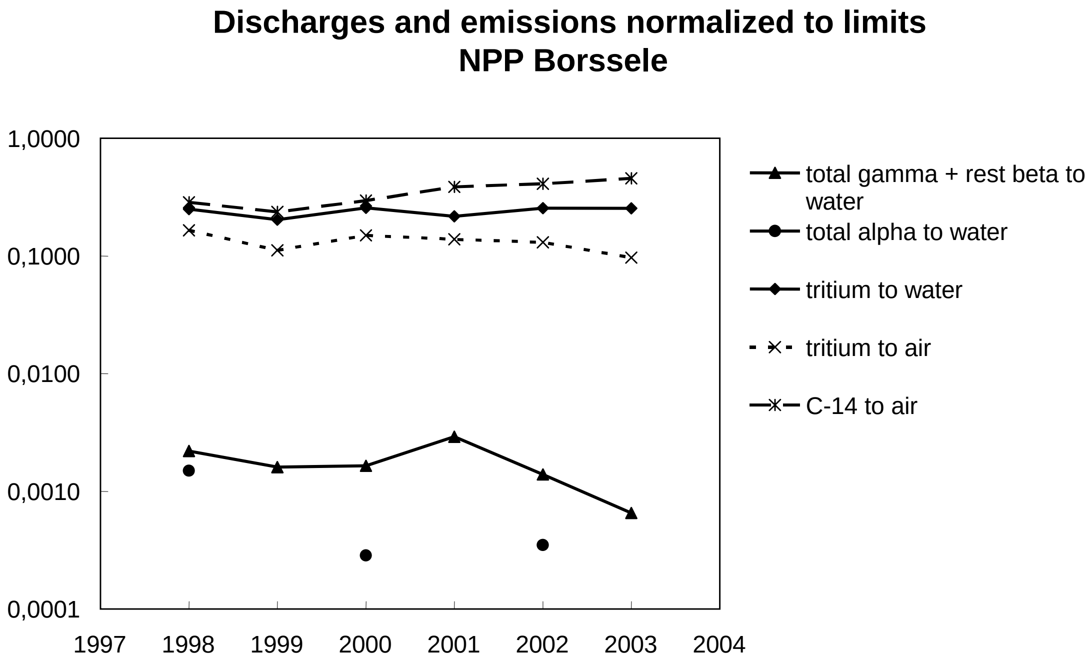
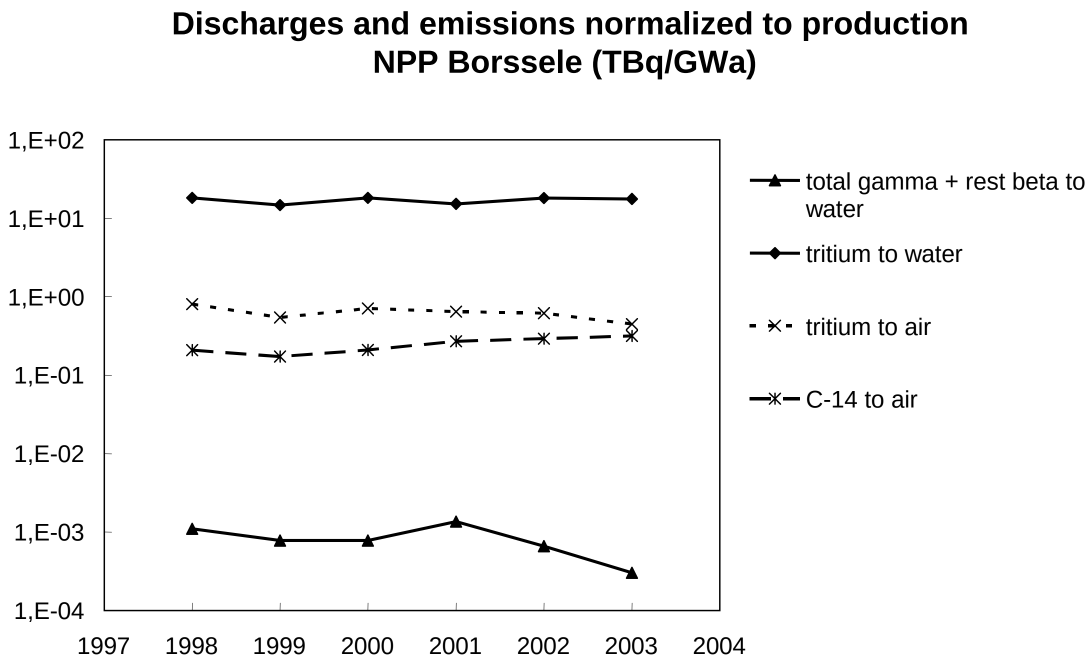
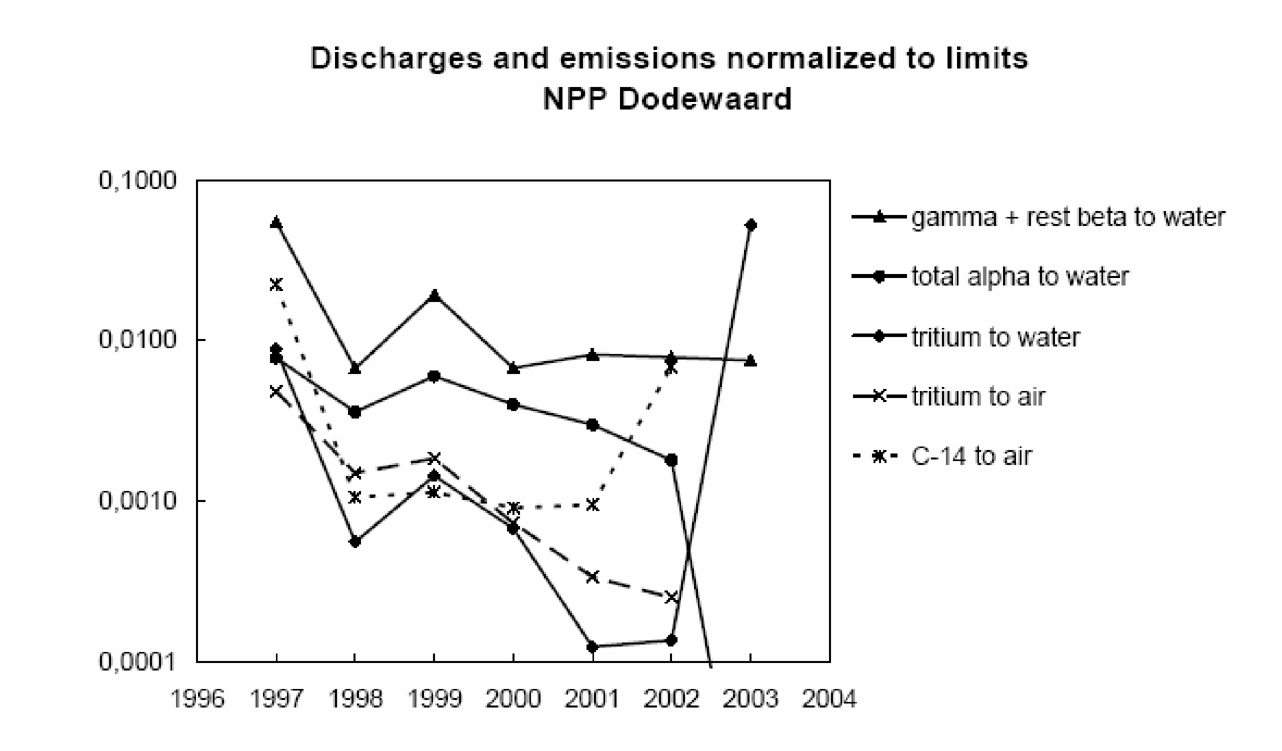
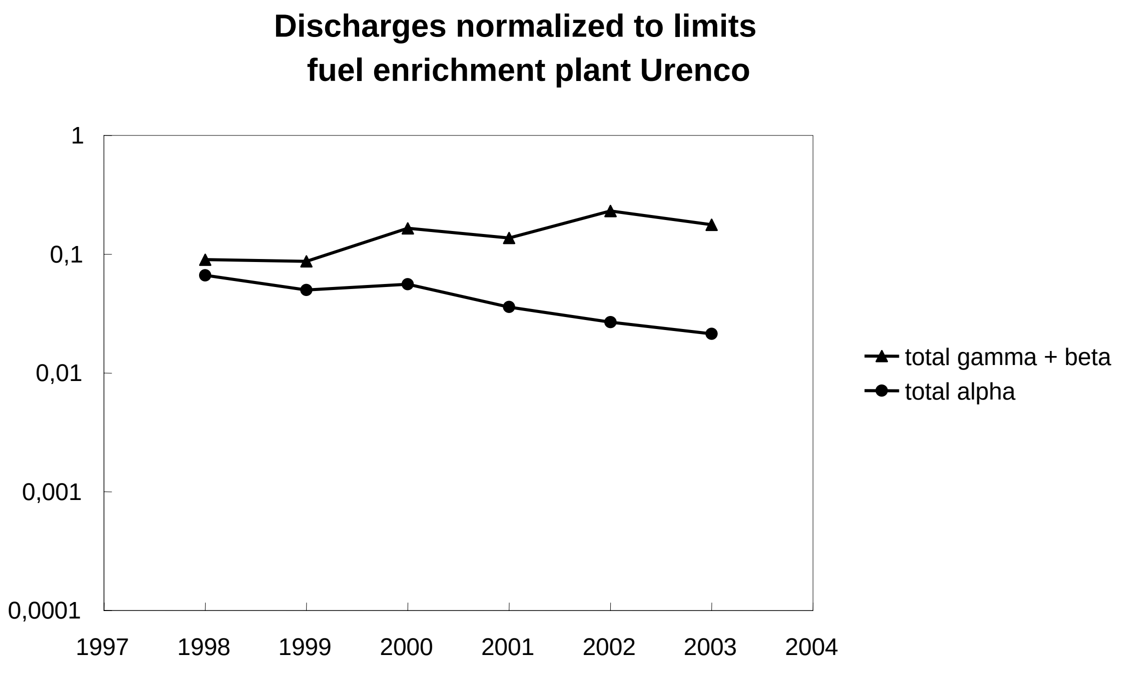
Annex A: Location nuclear installations in the Netherlands

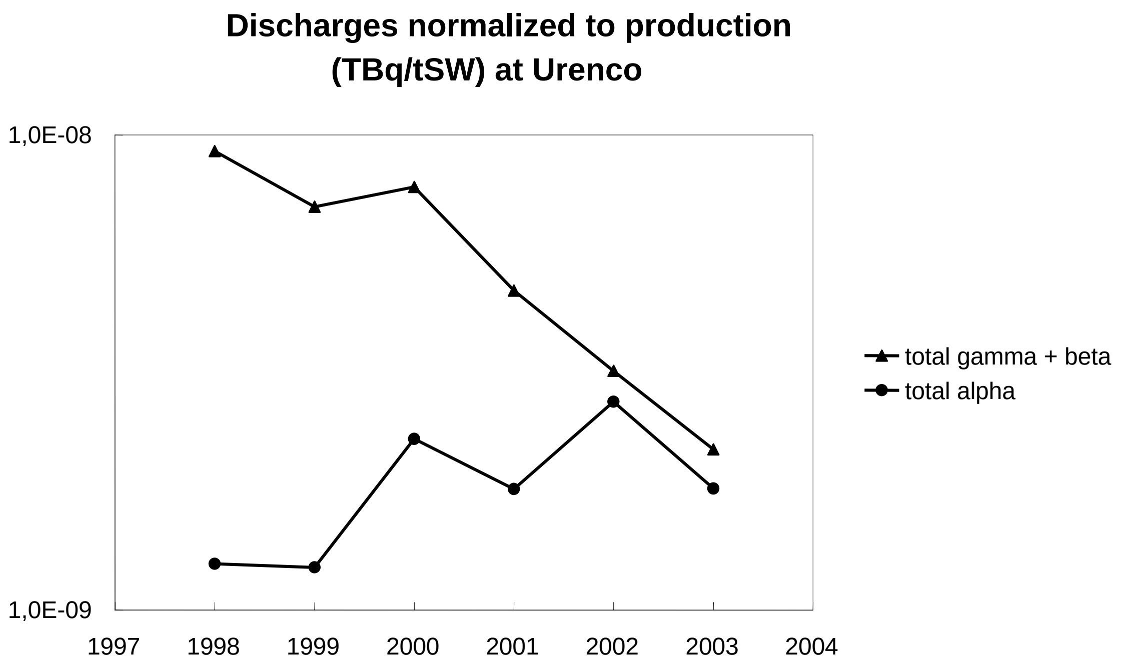
Annex B: Normalized discharges






Discharges and emissions normalized to limits
NPP Dodewaard
0,1000
0,0100
0,0010
0,0001
1996
1997
1998
1999
2000
2001
2002
2003
2004
gamma + rest beta to water
total alpha to water
tritium to water
tritium to air
C-14 to air


Discharges normalized to limits
fuel enrichment plant Urenco
1
0,1
0,01
0,001
0,0001
1997
1998
1999
2000
2001
2002
2003
2004
total gamma + beta
total alpha


Discharges normalized to production (TBq/tSW) at Urenco
1,0E-08
1,0E-09
1997
1998
1999
2000
2001
2002
2003
2004
total gamma + beta
total alpha

Annex C: environmental impact

It is not expected that the environmental monitoring data can be associated to a unique discharge source. Discharges of Dutch and foreign nuclear installations lead to an increase of the activity concentrations in the environment. For that reason the sections on the environmental impact are left out of the main text and can be found in this annex.

1 Concentrations of radionuclides in samples

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

Table C.1. Alpha activity concentration (in Bq.m^{-3})

	Dantzig gat	Eijsden ponton	Vrouwe zand	Haring-vlietslui	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	4,7E+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

Table C.2. Rest beta activity concentration (in Bq.m^{-3})

	Dantzig gat	Eijsden ponton	Vrouwe zand	Haring-vlietslui	Lobith ponton	Maas-sluis	Mars-diep noord	Sas van Gent	Wester-scheldt
1998[3]	NI	1,3E+02	2,5E+02	1,9E+02	2,1E+02	6,0E+02	9,4E+03	9,5E+02	9,8E+03
1999	9,7E+03	1,4E+02	2,1E+02	1,5E+02	1,9E+02	4,7E+02	9,0E+03	1,1E+03	9,4E+03
2000	9,7E+03	1,2E+02	2,2E+02	1,6E+02	1,8E+02	6,2E+02	9,3E+03	8,0E+02	9,1E+03
2001	9,0E+03	1,3E+02	2,0E+02	1,6E+02	1,8E+02	4,0E+02	8,9E+03	5,7E+02	9,1E+03
2002	8,9E+03	1,4E+02	1,9E+02	1,5E+02	1,6E+02	3,6E+02	8,9E+03	7,7E+02	9,3E+03
2003	9,4E+03	1,5E+02	2,1E+02	1,8E+02	1,8E+02	1,1E+03	9,6E+03	1,2E+03	9,7E+03

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

	Dantzig gat	Eijsden ponton	Vrouwe zand	Haring-vliet-sluis	Lobith ponton	Maas-sluis	Mars-diep noord	Sas van Gent	Wester-scheldt
1998[3]	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

[3] Some data are different from those reported in OSPAR 2000 report [OSP00], which must possibly be ascribed to different sources.

Table C.4. ^{226}Ra activity concentration (in Bq.m^{-3})

	Dantzig gat	Eijsden ponton	Vrouwe zand	Haring-vliet-sluis	Lobith ponton	Maas-sluis	Mars-diep noord	Sas van Gent	Wester-scheldt
1998	NI	7,0E+00	NI	NI	9,0E+00	1,6E+01	7,0E+00	1,3E+01	9,0E+00
1999	6,0E+00	5,5E+00	NI	NI	7,5E+00	8,0E+00	6,0E+00	1,1E+01	9,0E+00
2000	6,0E+00	4,0E+00	NI	NI	5,0E+00	7,0E+00	6,0E+00	7,0E+00	6,0E+00
2001	5,0E+00	2,5E+00	NI	NI	3,5E+00	4,0E+00	3,5E+00	5,5E+00	4,5E+00
2002	4,0E+00	3,0E+00	NI	NI	4,0E+00	5,0E+00	4,0E+00	7,0E+00	5,0E+00
2003	4,0E+00	4,0E+00	NI	NI	5,0E+00	4,0E+00	3,5E+00	7,0E+00	5,0E+00

2 Nuclide libraries

The reported activity concentrations are total alpha, total and rest beta, tritium, Pb-210/Po-210, Sr-90 en Ra-226.

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.

3 Environmental monitoring program

The environmental monitoring program consists of measuring water samples and floating substances. 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. ^{226}Ra activity is measured with an average sampling frequency of 4 times per year per location.

4 National target levels of radioactive substances

National target levels of activity of radionuclides in the environment are defined for inland water as given in section 1.5. Comparing the 90th percentile of the measured data, not given in this report, with the target levels is the test.

Table C.5. National target levels (in Bq.m^{-3}) [TPW98]

Total alpha	1,0E+02
Rest beta	2,0E+02
Tritium	1,0E+04

5 Quality assurance of systems for environmental monitoring

The methodology of environmental monitoring of gamma emitting nuclides is according to NEN 5623 [NEN99], a Dutch quality assurance standard. Beta and alpha emitters are monitored according to KTA 1504 [KTA94].

6 Relevant information not covered by previous sections

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

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

Only in some occasions of measured concentration of alpha emitters the national target level is exceeded. The measured concentrations can not be associated with a native discharge source. Furthermore, in one occasion the sampling location, where activity concentrations are measured which exceed the target level, is downstream in a river that flows into the Netherlands.

8 Summary evaluation

The results of the national environmental monitoring program show that in some occasions the target level of the total alpha concentration is exceeded. The measured activity concentrations can not identify a unique nuclear discharge source.