CONSORTIUM

DICON-ACCIONA ING.

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

for Investment Proposal:

BUILDING A NEW NUCLEAR UNIT OF THE LATEST GENERATION AT THE KOZLODUY NPP SITE

CHAPTER 5: CUMULATIVE IMPACTS

☒ original

☐ copy

PREPARED BY:	NELLY GROMKOVA - TL VERJINIA DIMITROVA – PM	VERSION: 03
VALIDATED BY:	TZVETANKA DIMITROVA – TQ CONTROL EXPERT	DATE: AUGUST 2013

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

5 CUMULATIVE IMPACTS

The main objective of the assessment of the cumulative impacts, as part of the EIA, is to provide an analysis and assessment of the potential cumulative impacts of the implementation of the investment proposal and the operation of other (existing and future) equipment at the Kozloduy NPP site and outside of the limits thereof that could arise from the summation of the impacts of the implementation of the New Nuclear Unit (NNU) and the operation of Units 5 and 6 of the NPP with higher thermal power of 104 %, Depot for dry storage of spent nuclear fuel (DDSSNF), Depot for storing spent fuel under water (DSSFUW); all activities for decommissioning of units 1 ÷ 4 (Workshop for size reduction and deactivation); operation of the Plasma Incineration Facility (PIF) and the National depot for storage of radioactive waste (NDSRW).

To achieve this objective **the scope of the assessment of the cumulative impacts** includes the analysis of the potential cumulative impacts regarding:

- → Each of the assessed sites, presented separately;
- → Each component (factor) of the environment – separately and combined;
- → All identified and studied past, present and future actions at the Kozloduy NPP site and within the 30 km radius zone.

APPROACH

The approach applied to the assessment of the cumulative impacts is based on the common methodological framework presented in **Table 5.1-1.**

TABLE 5.1-1: METHODOLOGICAL FRAMEWORK FOR ASSESSMENT OF CUMULATIVE IMPACTS

Main stages of the cumulative impact assessment	Cumulative impact assessment for the different stages
Stage 1: Determination of the scope of the cumulative impact assessment	• Identification of the environmental components and factors that could be affected by the possible cumulative impacts; • Identification of projects that are existing, approved or in the process of approval and/or development; • Identification of the potential impacts of the identified objects.
Stage 2: Analysis of the cumulative impacts and determination of the significance thereof	• Assessment of the cumulative impacts on individual environmental components/factors the environment of all identified projects that are existing, approved or in the process of approval

Main stages of the cumulative impact assessment	Cumulative impact assessment for the different stages
	and/or development; • Assessment of the significance of the possible cumulative impacts.
Stage 3: Definition of measures to reduce, limit or prevent potential cumulative impacts	• Recommendations for specific applicable measures to reduce, limit, or prevent cumulative impacts.
Stage 4: Determination of the need for further action	• Identification of the need to expand the scope of monitoring.

The specific approaches implemented for the assessment of the cumulative impacts of the construction of a new nuclear power capacity include:

Stage 1: Determination of the scope of the cumulative impact assessment

The following approaches are implemented during this stage:

- → *identification of the environmental components and factors* that could be affected by the possible cumulative impacts of the IP;
- → *identification of projects that are existing, approved or in the process of approval and/or development,* including identification of all the projects that have spatial, functional, technical, logistical and other similar associations with the IP on the Kozloduy NPP territory as well as within the 30 km Emergency Protective Measures Zone (EPMZ);
- → *identification of the potential impacts of the identified objects on each environmental component/factor.* This assessment will be based on an analysis of:
  - ✓ location and characteristics of projects that are existing, approved or in the process of approval and/or development (occupied territory, production process and technology, operation mode, contaminants, etc.);
  - ✓ main and supporting infrastructure (roads, railways, waterways, etc.);
  - ✓ lifetime and status of sites – research, construction, commissioning, latest plans for modernization or expansion, decommissioning, etc.;
  - ✓ permits for operation modes.

Sources of information for identification of potential impacts on sites are as follows:

- ✓ spatial development plans, local and regional development plans;
- ✓ written consultations held with the legal entities of the sites, representatives of regulatory bodies, local authorities, etc.;
- ✓ expert assessments, reports, findings and other information.

Stage 2: Analysis of the cumulative impacts and determination of the significance thereof

During this stage an assessment has been carried out of the potential cumulative impacts of projects that are existing, approved or in the process of approval and/or development on the environmental components/factors and this analysis includes:

- → cumulative impacts – the total effect of different impacts on each environmental component/factor;
- → overlaying of impacts:
  - ✓ accumulation of the **same** impacts which results in a new significant impact,
  - ✓ accumulation of **different** impacts, which can result in a new significant impact,
- → effects over time – an assessment of possible impacts that could arise at various stages during the site implementation (construction, operation and decommissioning) and which may result in a new significant impact.

The assessment of the cumulative impacts and their significance will be made taking into account the level of impact on environmental components/factors.

5.1 MAGNITUDE OF CUMULATIVE EFFECTS

The magnitude of the impact is expressed by using a matrix approach – **Table 5.1-1**.

For the assessment of the cumulative impact a 5-point scale for the importance of the impact is applied and it is defined in three main groups:

- → the red colour designates the impacts with high significance (i.e. unacceptably high impact);
- → the green colour designates the impacts with moderate significance (i.e. impacts that affect the respective component/factor, but are not damaging thereto. For these impacts measures will be proposed to reduce, limit or prevent cumulative impacts;

→ the yellow colour designates impacts with low impacts. For these impacts measures will also be proposed to reduce, limit or prevent cumulative impacts.

TABLE 5.1-1: ASSESSMENT MATRIX FOR CUMULATIVE IMPACT OF THE CONSTRUCTION OF A NEW NUCLEAR CAPACITY ON THE KOZLODUY NPP SITE

SIGNIFICANCE of the impacts	DEGREE OF IMPACT				
	Very low (VL)	Low (L)	Moderate (M)	High (H)	Very high (VH)
Very low (1)					
Low (2)					
Moderate (3)					
High (4)					
Very high (5)					

Stage 3: Definition of measures to reduce, limit or prevent potential cumulative impacts

This stage of the cumulative impact assessment of the IP refers to the provision of measures and ways to prevent potential impacts, and if this is not possible, measures are provided to reduce and/or limit possible cumulative impacts.

In determining the measures an iterative approach was applied including:

→ assessment based on the characteristics of the IP and all identified projects that are existing, approved or in the process of approval and/or development;

→ assessment of residual impacts after the implementation of the proposed measures.

Stage 4: Determination of the need for further action

The need to expand the scope of the monitoring was identified during this stage based on the results and conclusions from previous stages.

5.2 CUMULATIVE IMPACTS REGARDING THE ATMOSPHERIC AIR COMPONENT

Regarding the emissions of air pollutants, cumulative impacts are expected from gas emissions from transportation activities associated with the project on the national and municipal road network – supply of complete construction elements (modules), machinery and equipment, including bulk construction materials and soil, parts, transportation of staff, etc. related to the construction works.

Assessment of the levels of emissions from vehicles is made using the methodology of the **EMEP/EEA air pollutant emission inventory guidebook-2009** for the main pollutants from cargo transport vehicles (*20 t tip-lorry* – **1.A.3.b.ii**). Transportation emissions during the construction of the project are described in Section **4.1.1.1.1.2**: **Transportation activity** and emissions from average daily annual intensity of estimates for traffic for 2015 at the census points of the Road Infrastructure Agency for Road II -11 of the national road network in additional census point ACP -205 in the Kozloduy-Lom section and ACP-496 in the Misia Kozloduy section close to the area of the plant[1] are given in Section **3.1.2.5: Emissions from traffic for the second class road II- 11.**

The cumulative impact of transportation activities related to the project and the average daily intensity of traffic is presented in **Table 5.2-1.**

TABLE 5.2-1: CUMULATIVE IMPACT OF CARGO TRAFFIC FOR THE PROJECT AT THE CENSUS POINTS OF THE ROAD INFRASTRUCTURE AGENCY FOR A PERIOD OF 24 HOURS.

Транспортен трафик	CO	NMVOC	NO_X	N_2O	NH3	Pb	PM_{10}	Ideno Pyrene	B(k)F	B(b)F	B(a)P	CO_2	SO_2	C_6H_6
пункт ДПП-496	0.5%	0.9%	3.8%	0.2%	0.1%	1.7%	2.4%	1.2%	4.2%	3.1%	1.0%	1.2%	0.5%	0.9%
пункт ДПП-205	3.2%	6.3%	23.0%	1.5%	0.7%	10.8%	13.0%	7.9%	28.1%	20.6%	6.1%	7.8%	3.1%	6.3%

Traffic; counting point CP -496; counting point CP -205

Table 5.2-1 presents a comparison between the emission load (kg/km) from **regular traffic** on the roads of the national road network which will be used for the project and for **transportation**, supply of complete construction elements (modules), machinery and equipment, including bulk construction materials and soil, parts, transportation of staff, etc. related to the construction works.

The maximum cumulative load in these locations is 28.1 % for B(k)F, but the levels of these emissions are much lower then the corresponding catalytic units of vehicles in the relevant EURO standard.

The expected cumulative load on the second class road II- 11 of the national road network is negligible.

The measures to further mitigate the cumulative impacts on air quality due to gas emissions from transportation activities associated with the project requires precise analysis and planning of the traffic of construction vehicles which shall be included in the Construction Works Methodology (CWM) and in the final plan for the organization of the transportation scheme. These documents shall include and shall comply with the following:

- powdered material shall be transported covered;
- coordination of the transportation scheme with the local municipalities and town-councils;
- limiting of the traffic through populated areas. If this is not possible, the following shall be provided:

[1] *Annex 8 – INPUT DATA – Letter No. ЦИ-0167-0158 dated 04.02.2013.*

  - ✓ quick and free passage through the populated areas at a normal speed (without the need to stop and speed limit reduction), which shall ensure a stable temperature operation of the engine, resulting in much lower levels of pollutant emissions ;
  - ✓ engines shall not operate on an idle mode in populated areas.
- → the provided vehicles shall comply with the EURO V standards for heavy trucks and with the EURO 5 for cars;
- → traffic of oversized cargo trucks for delivery of complete construction elements (modules), machinery and equipment shall be during the hours of the day, when the national road network traffic is low, which shall ensure free passage (without causing traffic jams).

5.3 CUMULATIVE IMPACT REGARDING THE WATER COMPONENT

5.3.1 SURFACE WATER

The possible cumulative effect of the operation of the New investment proposal for NNU shall be studied in view of its impact on the receiver – the Danube River for medium and minimum water levels of the river. Pollution values for the Danube River were taken from the monitoring point of at the village of Novo Selo, right river bank (2011). These show the pollutants which enter the river in our area. There is no point of the National environment monitoring system (NEMS) located directly before the NPP in the section of the river which we are reviewing, therefore we will use the point near the village of Novo Selo. Quality of the river water is determined using data provided by DRWMBD[2] for 2011. These data will be added to the data from the self-monitoring of the existing NPP for 2011 and from the NNU. Data regarding water levels is provided by the Executive Agency for Exploration and Maintenance of the Danube River (EAEMDR)-Ruse[3].

In order to describe the cumulative impact, the pollution load is calculated for the Danube River before discharges of the NPP water and after the discharge of the NNU water and the existing NPP for all existing and operating on-site emitters of wastewater and the NDSRW.

The calculation of pollution load is carried out using the following formula:

$T = C \times Q \times 10^{-3}$, where:

- C – average pollutant concentration in [mg/dm^3],
- Q – water quantity in [m^3/d],
- T – pollution loads in [kg/d].

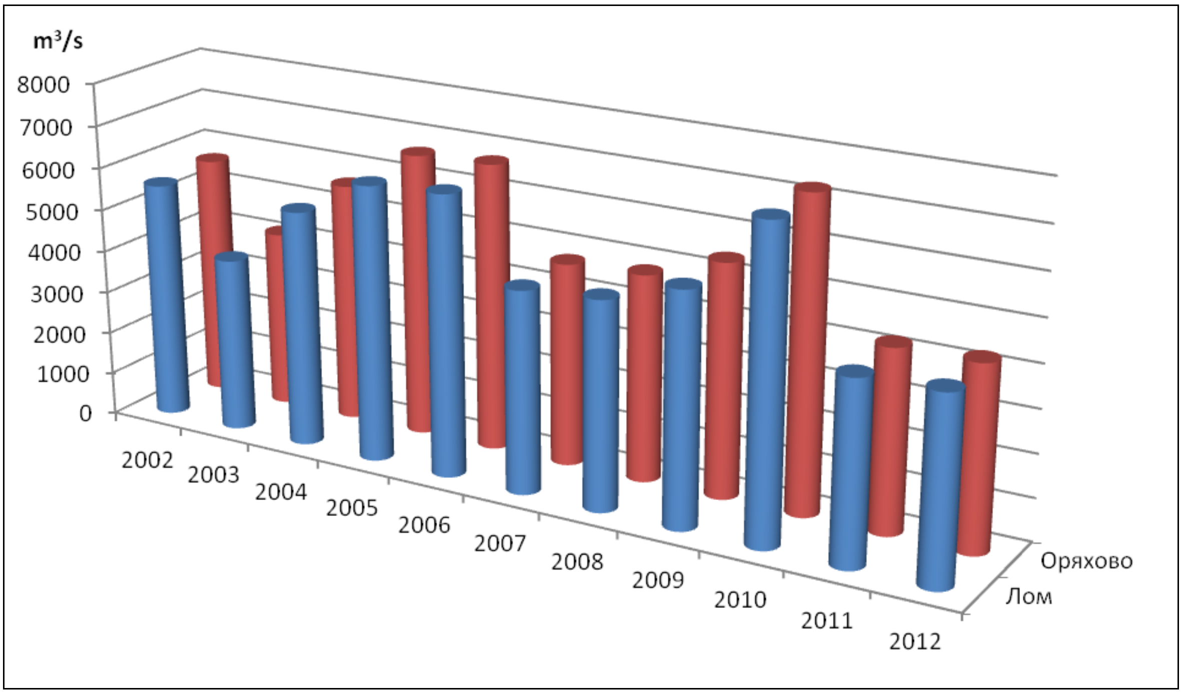
---

[2] Letter, Outgoing Ref. No. 453 dated 23.05.2013 and Protocol for handing over No. 36 dated 23.05.2013; DRWMBD – Danube Region Waters Management Basin Directorate

[3] Letter, Ref. No. 438 dated 17.05.2013 and Protocol for handing over No. 34 dated 17.05.2013; EAEMDR – Ruse – Executive Agency for Exploration and Maintenance of the Danube River – Ruse

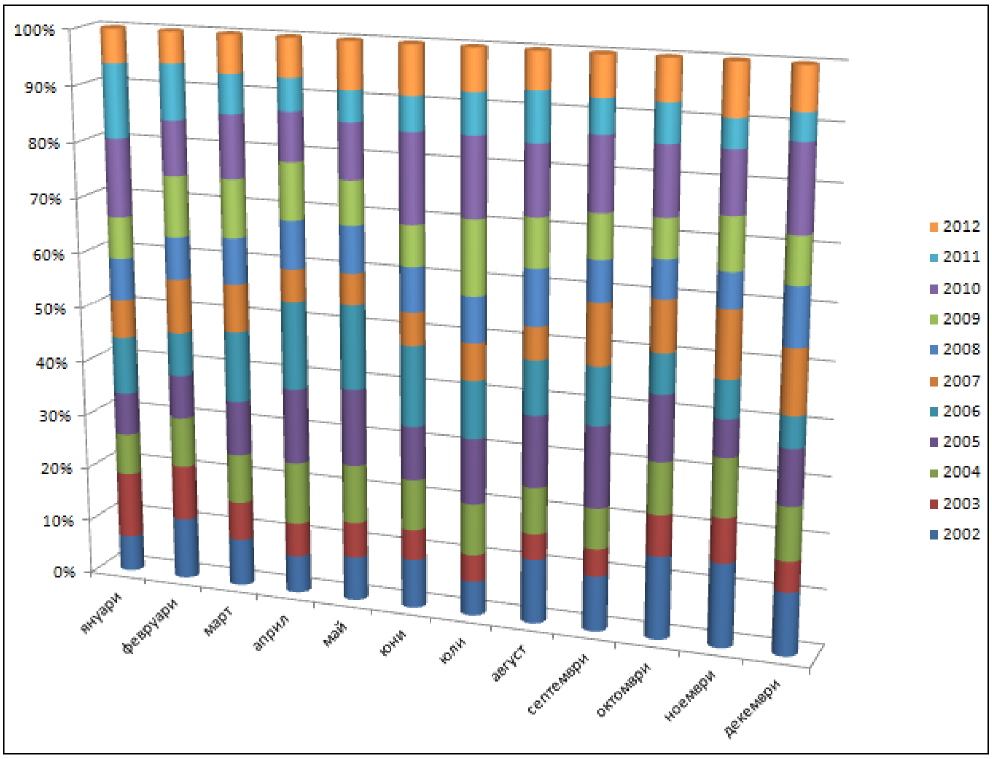
Figure 5.3-1 illustrates the average annual water quantity in the Danube River for the period 2002 to 2012 according to data from EAEMDR – Ruse.

Figure 5.3-2 and **Figure 5.3-3** below present other main characteristics of the Danube River in the reviewed section which is affected by the project.



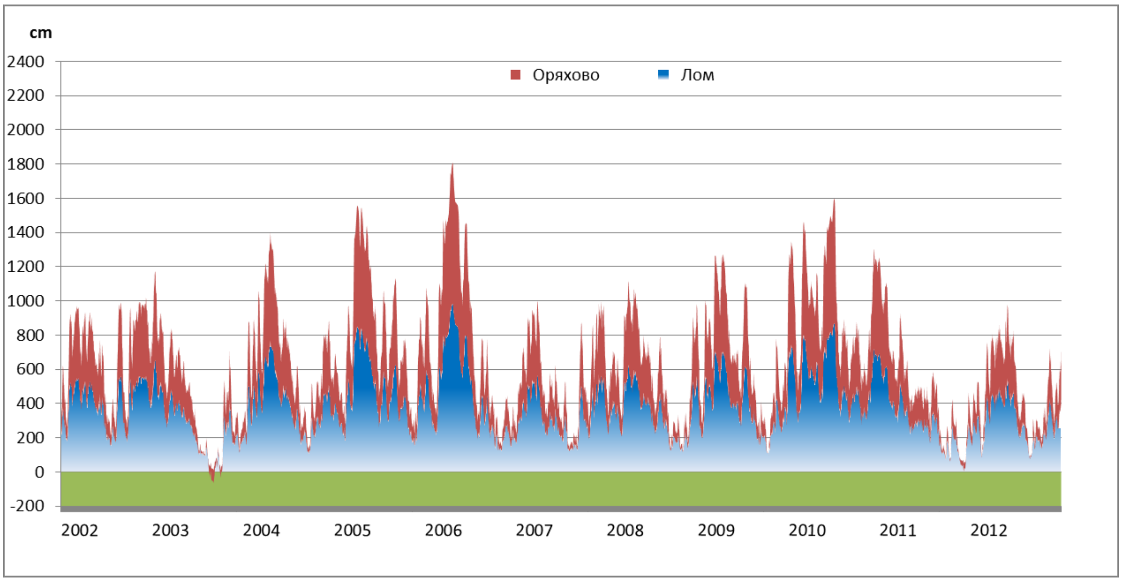
Oryahovo; Lom;

FIGURE 5.3-1: ANNUAL AVERAGE WATER QUANTITY AT THE TOWN OF LOM AND THE TOWN OF ORYAHOVO – DATA FROM EAEMDR – ROUSE



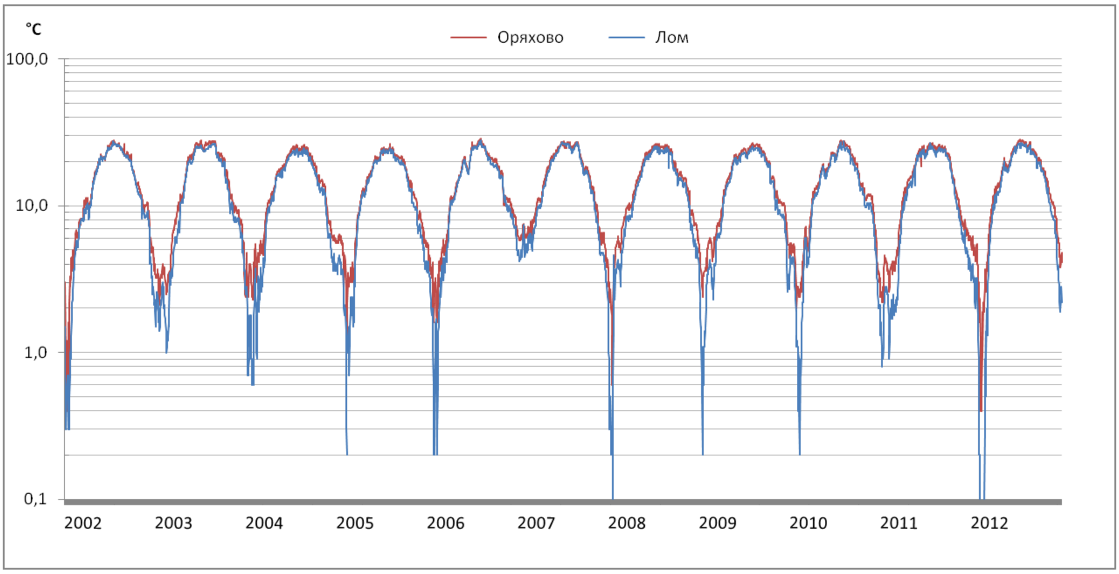
January; February; March; April; June; July; August; September; October; November; December.

FIGURE 5.3-2: AVERAGE MONTHLY QUANTITY IN M³/S FOR 2002-2012. DATA FROM EAEMDR – RUSE



Oryahovo; Lom;

FIGURE 5.3-3: WATER SURFACE ELEVATION (IN CM) ON THE DANUBE RIVER 2002-2012 DATA FROM EAEMDR – RUSE



Oryahovo; Lom;

FIGURE 5.3-4: WATER TEMPERATURE OF THE DANUBE RIVER 2002-2012
DATA FROM EAEMDR – RUSE

Figure 5.3-1 shows that the years 2005, 2006 and especially 2010 are characterized by high water quantity flow.

Figure 5.3-2 shows the monthly distributions of water quantities in the period 2002 ÷ 2012. Again, the years 2005, 2006 and 2010 stand out and the percentage of the monthly flow during the months of high waters (April-June) that has passed through the section from the town of Lom to the town of Oryahovo is the highest.

Figure 5.3-3 shows water surface elevations during the period. The maximum values for the characteristic years 2005, 2006, 2010 are clearly expressed, as well as a low minimum in mid-2003.

Figure 5.3-4 represents a graph of the movement of the water temperature in the Bulgarian section of the river between the towns of Lom and Oryahovo. You can see the almost complete concurrence of the two temperature lines, resulting in a minimal difference in water temperature at the town of Oryahovo as impact caused by the NPP. This difference is considerably less than that specified by the competent authority in the permit for discharge.

For subsequent calculations, the experts chose to use the data of water quantities and pollutants from 2011 of the last three years as an year without major variations of the flow of the river.

Table 5.3-1 presents the daily pollution loads in the Danube River at the Novo Selo Point, right bank (before NPP) at the minimum and average water quantity in the river.

Information regarding the pollution of the Danube River was taken from the monitoring point of Novo Selo, right bank, for 2011 according to data from the NEMS provided by DRWMBD.

TABLE 5.3-1: DAILY POLLUTION LOADS IN THE DANUBE RIVER BEFORE THE NPP

Indicator	Unit	For average water quantity 4251m³/s	For minimum water quantity 1665m³/s
BOD_5	kg/d	1 322 231	517 882
COD	kg/d	5 546 025	2 172 226
Zinc	kg/d	3 603 070	1 411 227
Detergents	kg/d	40 769	15 968
Manganese (total)	kg/d	3 673	1 439
Sulphate ions	kg/d	17 629 747	6 905 088
Nitrates	kg/d	712 536	279 081
Nitrites	kg/d	9 917	3 884
Nitrogen (ammonium)	kg/d	70 519	27 620
Iron (total)	kg/d	48 849	19 133
Petrolium products	kg/d	73 457	28 771
Total phosphorus	kg/d	55 460	21 722
Total nitrogen	kg/d	1 336 922	523 636
Boron	kg/d		
Qav. d.	m³/d	**367 286 400**	**143 856 000**

The following nuclear facilities are located at the Kozloduy NPP site:

- power units 1 ÷ 4 – shut down/no nuclear fuel (NF)/ in order to be decommissioned – discharge of household-faecal and industrial wastewater into the Danube River via the Main Drainage Canal (MDC);
- nuclear power units 5 and 6 – commercial operation – discharge of all types of wastewater from the operation via MDC HC-1 and HC-2 in the Danube River;
- depots for spent fuel (DSF under water, DSF) – no discharge of wastewater into the Danube River;
- dry storage of spent nuclear fuel (DSSNF) – no discharge of wastewater into the Danube River;
- facilities for the State Enterprise Radioactive Waste (SERAW) – discharge of household-faecal and industrial wastewater into the sewerage of the NPP;

Implementation of the following facilities is ongoing:

- Workshop for size reduction and deactivation (WSRD);
- Plasma Melting Facility (PIF);

- Wastewater will be discharged from the NDSRW, which is located near the Kozloduy NPP site. Water is in small quantities and is discharge through the sewerage of the NPP in MDC (according to the NDSRW EIA).

Table 5.3-2 shows the existing pollution loads for Kozloduy NPP flowing into the Danube River from different discharging facilities. The calculation included $Q_{av.d.}$, average daily water quantity, for each of the streams.

TABLE 5.3-2: EXISTING POLLUTION LOADS FOR THE OPERATION OF THE KOZLODUY NPP

Indicator	Unit	Stream 1	Stream 3	Stream 4	HC 1	HC 2	Total
BOD_5	kg/d	7.191	21.182	0.019	15 060.68	4 255.89	19 344.96
COD	kg/d	29.948	72.685	0.068	52 712.39	12 016.63	62 831.72
Zinc	kg/d	0.007	0.116		11.59	2.78	14.39
Detergents	kg/d	0.186	0.363				0.55
Manganese (total)	kg/d	0.019	0.042				0.06
Sulphate ions	kg/d	9.315	0.052				9.37
Nitrates	kg/d						
Nitrites	kg/d						
Nitrogen (ammonium)	kg/d						
Iron (total)	kg/d	0.006	0.156		289.63	97.36	387.15
Petroleum products	kg/d	0.838	1.298	0.001	115.85	76.49	194.48
Total phosphorus	kg/d	0.503	0.935	0.004			1.44
Total nitrogen	kg/d	5.216	10.384	0.008			11 716.60
Boron	kg/d	1.584	4.309		1 515.99	1 515.99	1 521.88
Qav. d.	m^3/d	**1 863.01**	**5 191.78**	**2.74**	**5 792 569.86**	**1 390 813.70**	**7 190 441.10**

Note: The data used is from the self-monitoring of the NPP. It is necessary to emphasize that it is based on on-the spot values reported from the sampling. **Values exceeding the norm for the Individual Emission Limitations (IEL) determined in accordance with the regulatory requirements** have not been identified during the monitoring or in the control samples taken by the competent authorities.

TABLE 5.3-3: EXPECTED POLLUTION LOADS FOR THE AVERAGE WATER QUANTITY OF THE DANUBE RIVER RESULTING FROM THE JOINT OPERATION OF THE EXISTING UNITS OF THE KOZLODUY NPP, NNU (WITH AP-1000 REACTOR) AND THE NDSRW

Indicator	Unit	Pollution loads				
		Danube River before the NPP	From the NNU	From the existing NPP	From the NDSRW	Danube River after the NPP total
BOD_5	kg/d	1 322 231	8 986	19 344.97	1.3	1 350 563
COD	kg/d	5 546 025	31 450	64 831.72		5 642 309
Zinc	kg/d	3 603 070	7	14.39		3 603 101
Detergents	kg/d	40 769		0.55		40 769

Indicator	Unit	Pollution loads: Danube River before the NPP	From the NNU	From the existing NPP	From the NDSRW	Danube River after the NPP total
Manganese (total)	kg/d	3 673		0.06		3 673
Sulphate ions	kg/d	17 629 747		9.37		17 629 757
Nitrates	kg/d	712 536				712 536
Nitrites	kg/d	9 917				9 917
Nitrogen (ammonium)	kg/d	70 519				70 519
Iron (total)	kg/d	48 849	173	387.15		49 409
Petroleum products	kg/d	73 457	172	194.48		73 824
Total phosphorus	kg/d	55 460		1.44	0.04	55 462
Total nitrogen	kg/d	1 336 922	7 258	11 716.6	0.18	1 355 897
Boron	kg/d		3 456	1 521.88		4 978
Qav. d.	m^3/d	**367 286 400**	**3 456 000**	**7 190 441**	**6**	**377 932 847**

The pollution loads of the river are calculated using the average water quantity for 2011, $Q_{av.}$ = 4251 m^3/s and the indicators of pollution for the Danube River at the village of Novo Selo, right bank, according to data from NEMS – **Table 5.3-1**.

The existing pollution loads resulting from the operation of the Kozloduy NPP are taken from **Table 5.3-2.**

The pollution loads from the NNU are used for an analogue of the AP-1000 reactor – **Table 4.2-7** in **Section 4.2.1.2** of the EIAR. The pollution loads from the NDSRW are taken from the EIA for NDSRW[4].

TABLE 5.3-4: EXPECTED POLLUTION LOADS FOR MINIMUM WATER QUANTITY IN THE DANUBE RIVER FROM THE JOINT OPERATION OF THE EXISTING UNITS OF THE KOZLODUY NPP, NNU (WITH AP-1000 REACTOR) AND THE NDSRW

Indicator	Unit	Pollution loads: Danube River before the NPP	From the NNU	From the existing NPP	From the NDSRW	Danube River after the NPP total
BOD_5	kg/d	517 882	8 986	19 344.97	1,3	546 214
COD	kg/d	217 2226	31 450	64 831.72		2 268 510
Zinc	kg/d	1 411 227	7	14.39		1 411 248
Detergents	kg/d	15 968		0.55		15 969
Manganese (total)	kg/d	1 439		0.06		1 439
Sulphate ions	kg/d	6 505 088		9.37		6 905 097
Nitrates	kg/d	279 081				279 081
Nitrites	kg/d	3 884				3 884
Nitrogen (ammonium)	kg/d	27 620				27 620

[4] EIAR for NDSRW-2011

Indicator	Unit	Pollution loads				
		Danube River before the NPP	From the NNU	From the existing NPP	From the NDSRW	Danube River after the NPP total
Iron (total)	kg/d	19 133	173	387.15		19 693
Petroleum products	kg/d	27 771	172	194.48		29 137
Total phosphorus	kg/d	21 722		1.44	0,04	21 723
Total nitrogen	kg/d	523 636	7 258	11 716,6	0,18	542 611
Boron	kg/d		3 456	1 521,88		4 978
Qav. d.	m^3/d	**143 856 000**	**3 456 000**	**7 190 441**	**6**	**154 502447**

The pollution loads of the river are calculated for the minimum water quantity for 2011, $Q_{min.}$ = 1665 m^3/s and the indicators of pollution of the Danube River at the village of Novo Selo, right bank, according to data from NEMS. The pollution loads of NNU and NDSRW are as shown on **Table 5.3-3**.

The existing pollution loads resulting from the operation of the Kozloduy NPP are taken from **Table 5.3-2.**

TABLE 5.3-5: EXPECTED POLLUTION LOADS FOR AVERAGE WATER QUANTITY IN THE DANUBE RIVER FROM THE JOINT OPERATION OF THE EXISTING UNITS OF THE KOZLODUY NPP, NNU (WITH AES-92 OR AES-2006 REACTOR) AND THE NDSRW

Indicator	Unit	Pollution loads				
		Danube River before the NPP	From the NNU	From the existing NPP	From the NDSRW	Danube River after the NPP total
BOD_5	kg/d	1 322 231	13 435	19 344.97	1.3	1 355 012
COD	kg/d	5 546 025	47 022	64 831.72		5 657 881
Zinc	kg/d	3 603 070	10	14.39		3 603 104
Detergents	kg/d	40 769		0.55		40 769
Manganese (total)	kg/d	3 673		0.06		3 673
Sulphate ions	kg/d	17 629 747		9.37		17 629 757
Nitrates	kg/d	712 536				712 536
Nitrites	kg/d	9 917				9 917
Nitrogen (ammonium)	kg/d	70 519				70 519
Iron (total)	kg/d	48 849	258	387.15		49 494
Petroleum products	kg/d	73 457	<258	194.48		73 910
Total phosphorus	kg/d	55 460		1.44	0.04	55 462
Total nitrogen	kg/d	1 336 922	10 851	11 716.6	0.18	1 359 490
Boron	kg/d		5 167	1 521.88		6 689
Qav. d.	m^3/d	**367 286 400**	**5 185 000**	**7 190 441**	**6**	**379 661 847**

The pollution loads of the river are calculated for the average water quantity for 2011, $Q_{av.}$ = 4251 m³/s and the indicators of pollution of the Danube River at the village of Novo Selo, right bank, according to data from NEMS.

The existing pollution loads resulting from the operation of the Kozloduy NPP are calculated on the basis of pollutants from the self-monitoring of Kozloduy NPP for 2011 – **Table 5.3-1**.

The pollution loads from the NNU are used for an analogue of the AES-92 reactor (Hybrid) or AES-2006 – **Table 4.2-5** in **Section 4.2.1.2** of the EIAR. The pollution loads from the NDSRW are taken from the EIA for NDSRW.

TABLE 5.3-6: EXPECTED POLLUTION LOADS FOR MINIMUM WATER QUANTITY IN THE DANUBE RIVER FROM THE JOINT OPERATION OF THE EXISTING UNITS OF THE KOZLODUY NPP, NNU (WITH AES-92 OR AES-2006 REACTOR) AND THE NDSRW

Indicator	Unit	Pollution loads				
		Danube River before the NPP	From the NNU	From the existing NPP	From the NDSRW	Danube River after the NPP total
BOD 5	kg/d	517 882	13 435	19 344.97	1.3	550 663
COD	kg/d	217 2226	47 022	64 831.72		2 284 082
Zinc	kg/d	1 411 227	10	14.39		1 411 251
Detergents	kg/d	15 968		0.55		15 969
Manganese (total)	kg/d	1 439		0.06		1 439
Sulphate ions	kg/d	6 505 088		9.37		6 605 097
Nitrates	kg/d	279 081				279 081
Nitrites	kg/d	3 884				3 884
Nitrogen (ammonium)	kg/d	27 620				27 620
Iron (total)	kg/d	19 133	258	387.15		19 778
Petrolium products	kg/d	27 771	<258	194.48		29 223
Total phosphorus	kg/d	21 722		1.44	0.04	21 723
Total nitrogen	kg/d	523 636	10 851	11 716.6	0.18	546 204
Boron	kg/d		5 167	1 521.88		6 689
Qav. d.	m³/d	**143 856 000**	**5 185 000**	**7 190 441**	**6**	**156 231 447**

The pollution loads of the river are calculated for the minimum water quantity for 2011, $Q_{min.}$ = 1665 m³/s and the indicators of pollution of the Danube River at the village of Novo Selo, right bank, according to data from NEMS. The remaining pollution loads are as shown in **Table 5.3-5.**

CONCLUSION

The pollution load of the river, as shown on **Table 5.3-1,** provides information on the state of the river at a single point, which is in close proximity to the section, reviewed in this EIAR. The monitoring of NEMS shows that a significant number of the examined indicators for the river belong to the higher category than the one determined under Regulation

No. 7/1986, repealed with State Gazette, issue No. 22 from 05.03.2013. The urban wastewater collectors of the town of Vidin, the town of Lom and the town of Kozloduy are discharged after this point since there are still no town wastewater treatment plants /TWWTPs/.

The presented results of the expected pollution loads in the tables above illustrate the significant change in the quantity of pollution loads in the Danube river after discharging any waste water from the plant.

As noted, the self and control monitoring of wastewater from the NPP **does not** indicate pollutation – the values are higher than the specified IEL, but they introduce an additional load which is negligible when considering the large amount of discharged water and the large water quantity for the water intake point, including the minimum flow.

However, this minimal additional load resulting from the work of the existing Kozloduy NPP blocks at the site, the SERAW sites, the future NDSRW, and from the site for the new investment proposal for NNU, taken together may be determine as having a negligible impact considering the qualitative and quantitative status of the water intake point.

It should be taken into account that all wastewater from the NNU will pass through modern purification facilities having high purification impact, and these are not expected to have indicator values above those specified in IEL.

A minimal impact resulting from the new nuclear unit may be estimated for the Danube River water status on the basis of the above preconditions.

5.3.2 GROUNDWATER

The NNU construction, regardless on which of the selected alternative sites, will not result in an increase in the level of groundwater.

There is no expected cumulative impact resulting from the NNU construction regarding the migration of radionuclides throughout groundwater.

5.4 CUMULATIVE IMPACT REGARDING THE EARTH AND SOIL COMPONENT

5.4.1 NNON-RADIATION ASPECT

Investment proposals the implementation of which is related to earthworks requires the availability of contact areas such as time and place of the construction and transport schemes and schedules. These will be temporary (during the construction period) and will lead to further secondary soil compaction, erosion (from water and wind), technogenic pollution by petroleum products and soil pollution by construction and household waste. The territorial scope of the cumulative impact is expected to be local and within the limits of the service strip of the construction site.

The degree of cumulative impact is expected to be insignificant.

5.4.2 RADIATION ASPECT

The following criteria has been used in terms of soil for the assessment of cumulative impacts:

→ in case of emergency the limit for Cesium-137 emissions in the atmosphere, which does not require long-term restrictions on the use of the soil and water in the monitored area, is 30 TBq. Combined emission of other radionuclides, different from the isotopes of Cesium, should not cause long-term, starting 3 months after a failure, risk resulting from the Cesium emission within the specified limit.

→ The frequency of large radioactive emission into the environment, when it is necessary to take emergency protective measures for the population, should not be greater than 1.10^{-6} events per nuclear power plant for one year.

Based on the analysis of the radiological monitoring of the impact of the Kozloduy NPP under normal operation on the radiation of the soil, as well as the monitoring of EEA-Vratsa, it can be estimated that the activity of NNU, under normal operation, would not lead to statistically significant changes in the radiation status of the soil[5], [6].

However, the following are subject of analysis and assessment:

- ✓ soil within the sites under assessment for the construction of NNU;
- ✓ disturbances and changes as a result of the investment proposal implementation;
- ✓ taking measures to prevent ongoing disturbances and changes;
- ✓ need of annual radiological monitoring of soils;
- ✓ annual monitoring, tracking the impact of soil on other environment elements, such as groundwater, vegetation or aerial pollution;
- ✓ soil cleaning measures in case of emergency situations;
- ✓ description of soil condition for equipment from decommissioning.

In relation to the negligent values and localised scope of the possible cumulative impacts at the stage of EIA preparation, there are no specific mitigation measures recommended to address the potential cumulative impacts regarding the earth and soil component.

5.5 CUMULATIVE IMPACT REGARDING THE GEOLOGICAL ENVIRONMENT COMPONENT

There are no conditions for the occurrence of cumulative impacts in terms of geological and hydro geological conditions in the area of the alternative sites for the NNU.

---

[5] Report on the Results of the radioecological monitoring of the Kozloduy NPP – 2012.

[6] EEA – Vratsa, Protocols of radioecological monitoring of soil for 2012.

The construction of the NNU will not be accompanied by ground subsidence. No interaction is expected with the transmitted ground tension during the construction of the foundations of the site specified for the NNU.

Continuous geodetic monitoring and periodic inspections of structures are carried out. If necessary, repairs shall be carried out in order to ensure the operability (including seismic inspections) of structures. This provides grounds to state that there is no cumulative impact up to the design seismic level.

5.6 CUMULATIVE IMPACTS REGARDING THE LANDSCAPE COMPONENT

There is no expected cumulative impact.

5.7 CUMULATIVE IMPACTS REGARDING THE BIODIVERSITY

5.7.1 AQUATIC INVERTEBRATES AND FISH

The impact on aquatic invertebrates and fish having the greatest negative effect is the thermal load on the Danube River, as well as the impact on aquatic invasive species, and to a lesser extent, the water transport, organic pollution load and inert ingredients of the Danube River and the Ogosta River, etc.

Site 1

There is no expected cumulative impact on aquatic invertebrates and fish.

Site 2

There is no expected cumulative impact on aquatic invertebrates and fish.

Site 3

There is no expected cumulative impact on aquatic invertebrates and fish.

Site 4

There is no expected cumulative impact on aquatic invertebrates and fish.

5.7.1.1 30 KM ZONE

There are expected cumulative impacts to aquatic invertebrates and fish. These are as follows:

5.7.1.1.1 Overlapping of impacts of the same nature.

5.7.1.1.1.1 Overlapping of thermal impact

The most significant impact on aquatic invertebrates and fish is expected to be the increase of the temperature of the water of the Danube River from the discharge of the cooling canal during the operation of the NNU. Previous studies and data show that both for the operation of four and two reactors there is a significant temperature difference between the discharged water and the water of the Danube River. Research conducted by the

University for Architecture, Construction and Geodesy (UACG) (1991) on the zone under thermal influence of the discharge of the hot canal (during normal operation of the 4 reactors) shows a high degree of thermal load. The water temperature in the canal itself is 7.5-8.5˚C above the natural temperature and the width of the thermal load area is up to 130 m and up to about 1700 m downstream. Later studies (1999) show that the area under thermal influence (constant increase by more than 3˚C) reaches the section from river km 684.3 to km 676.1 (depending on the season) and has a maximum width of 100 m to 185 m towards the Bulgarian coast. According to data from the EAEMDR for the period 2002-2006, the annual average temperature difference between the two stations – in the town of Lom and the town of Oryahovo is 1.23°C. In the period 2008-2010 (with two reactors in operation) the annual average temperature difference between the two stations is 1.38°C and for the period 2007-2012 – 1.43°C. Difference values are higher during the winter months in comparison with the summer months, reaching 2.3°C and the same is true for the years with low water level. Furthermore, the comparison of the two periods 2002-2006 with 4 reactors in operation and for the period 2007-2012 with 2 reactors in operation shows that the differences do not depend on the number of reactors in operation and that they are even higher during the second period. Increased water temperature impacts the Bulgarian shore up to 9 km downstream of the Danube River. Increased water temperature will impact directly on aquatic invertebrates and fish, and indirectly by stimulating the development of other aquatic invasive species. The strongest direct adverse impact will be on the cryophilic species e.g. Spined loach (*Cobitis taenia*), Common zingel (*Zingel zingel*), Danube streber (*Zingel streber*) and others.

5.7.1.1.1.2 Overlapping of impacts of invasive water species

Currently, a total of 3 alien species of mussels, 2 types of crabs and 13 species of fish are found or are expected to enter the Bulgarian section of the Danube River. The most aggressive invasive alien species have entered since 2001, Quagga Mussel (*D. Bugensis*), Chinese Corbicula (*C. Fluminea*), Chinese Pond Mussel (*A. Woodiana*), Chinese Mitten Crab (*E. Sinensis*), Chinese Sleeper (*Percottus Glenii*), etc. The majority of alien species are already naturalized and have stable populations, reaching large numbers, especially the mussels and some fish. The factors of the environment and the stability of local populations play a critical role in stabilizing the populations of other alien species. Available data and the results of field studies also show that all invasive mussels species and the majority of fish are found in the 30 km zone of the Kozloduy NPP. During the construction and operation of the NNU, it is expected to have favourable conditions for the development of already existing or the entry of new invasive alien species in the area mainly due to the thermal pollution and the increased navigational activity. This can lead to an increase in the impact thereof on the development of new impact on aquatic invertebrates and fish.

5.7.1.1.1.3 Overlapping of impact from navigation

Currently the Kozloduy NPP is serviced by maritime transport in relation to the supply of fuel for the power plants, etc. There is also regular water transport of passenger and cargo ships maintained along the Danube River. Mostly during the construction works, but also during the operation of the NNU it is expected that the water traffic will increase due to the need for supply of construction materials and fuels. This may result in causing anxiety in aquatic invertebrates and fish, or even greater negative impact mostly on larvae and juvenile fish.

5.7.1.1.2 Overlapping of different impacts

5.7.1.1.2.1 Thermal energy load and impact of invasive species

Thermal load will create very favourable conditions for the development of many invasive species. Most of them are thermophilic and the increased temperature of the heated waters in the area of the wastewater discharge for the NPP will be favourable for the development thereof – leading to activation of metabolic processes, increase of feeding activity, accelerated growth and increased biomass, creating favourable conditions and accelerating reproductive processes. Furthermore the increased temperature can attract new, more thermophilic invasive species. This will result the impact thereof (increased filtration and overgrowth of mussels, strong competition and predation in fish) and there may be long-term adverse consequences for aquatic invertebrates, fish, and for the whole structure and functioning of aquatic ecosystems.

5.7.1.1.2.2 Impact of invasive alien species and navigation

It is assumed that the transfer of larvae or adult individuals by means of ships (via ballast water, containers, baggage, etc.) and their subsequent introduction into the port area is one of the primary mechanisms for the spreading of aquatic invasive species (Panov *et al.* 2009). We assume that this is one of the main reasons for the spreading of many invasive species in the Bulgarian section of the Danube River. The existing 30 km zone for navigation which will be higher during the construction and operation of the NNU would increase the risk of transfer of invasive aquatic invertebrates species and fish species – on the one hand, they can cause introduction of new invasive species, and on the other – spreading of already stable species. An increase in the number of invasive species may be expected, as well as in the quantity thereof – number of transferred specimens, larvae and eggs.

5.7.1.2 IMPACT IN TIME

It is assumed that during the first stages of the NNU implementation (construction, commissioning) there will be no significant cumulative impact. Impact is expected only during the operation of the completed facilities in terms of thermal pollution in the long run. Occurring climate changes in water temperature (by 1-3 degrees over the last century, according to some studies, EEA 2008[7], 2010[8]), combined with the additional thermal load

[7] EEA (European Environment Agency), 2008. Impacts of Europe's changing climate — 2008 indicator-based assessment. Joint EEA-JRC-WHO report; EEA Report No 4/2008, JRC Reference Report No JRC47756, 246 pp.

will provide increased adverse effects on aquatic ecosystems: change in the number of species, entry and spreading of invasive species, acceleration of the biological cycles, changes in the food chain, increasing in the share of hydrobionts at the expense of stenothermal species(Kernan et al., 2010). In the long term, these processes will further deteriorate due to the fact that climate change will cause a further increase in the temperature of surface waters in Europe by about 2°C by 2070 (according to EEA 2008).

5.7.2 MEASURES FOR REDUCTION, LIMITING OR PREVENTION OF POSSIBLE CUMULATIVE IMPACTS

- Implementation of regular monitoring on the ecological situation of the Danube River in the NPP area.
  - Expected effect: control on the quality of water and taking timely action in case of detection of pollution.
- Implementation of monitoring of alien aquatic invasive species in the NPP port area during the construction of the NNU.
  - Expected effect: identification of alien aquatic invasive species immediately after their introduction and if necessary proposal of measures for the extermination thereof as well as preventive and control measures for reducing the cumulative effect of navigation.
- Implementation of regular monitoring of alien aquatic invasive species in the Danube River of the NPP area during the operation of the NNU.
  - Expected effect: identification of alien aquatic invasive species immediately after their introduction and if necessary proposal of measures for the extermination thereof as well as prevention and control measures for reducing the risk of introduction of new alien aquatic invasive species and the impact on the ones that are already introduced in the zone, and to reduce the cumulative effect with thermal load of the water.
- Regular mechanical cleaning of the hot canals especially in the event of blossoming, growth, formation of mussel clusters, etc.
  - Expected effect: destruction of newly introduced aquatic invasive species and control in order to reduce their impact on the ones that have already stable populations.
- Ensure that the ships carrying fuel are cleaned before they enter the area of the hot canals – clean the growth, use of anti-growth coating for the ship bottom and ensuring that bilge waters are discharged in dedicated containers (no discharge in the Danube River or in the canals).

[8] EEA (European Environment Agency), 2010. Climate change, impacts and vulnerability in Europe 2012: An indicator-based report. EEA Report No 12/2012, 300 pp.

- Expected effect: Prevention of the introduction and spreading of new aquatic invasive species.

5.8 CUMULATIVE IMPACTS REGARDING GENERATED WASTE

5.8.1 NON-RADIOACTIVE WASTE

A comparative analysis was carried out regarding the waste in order to assess the cumulative effect of the generated waste and the expected waste from the new nuclear capacity.

There is expected increase in the different types of radioactive waste

- ✓ During the construction period of 5 years – surplus soil are to be expected only at Site 2, approximately 180 thousand m^3 for the entire construction period. The majority of non-hazardous non-radioactive waste will be utilised accordingly.
- ✓ During the operation period – different types of non-radioactive waste is expected to increase until the period of operation of the remaining reactors at the site.
- ✓ During the decommissioning period there is no expected cumulative effect.

5.8.2 RADIOACTIVE WASTE

A comparative analysis was carried out in order to assess the expected cumulative effect regarding the expected radioactive waste (RAW) resulting from the investment project implementation and the existing flows of generated waste.

Currently, the following nuclear facilities are in operation at the Kozloduy NPP:

1. Estimated quantities of RAW from the operation of Units 5 and 6 are about 25 m^3 metal RAW and 550 m^3 non-metal RAW;
2. Estimated quantities of RAW from the operation of the Depot for storing spent fuel under water is expected to generate approximately 0.2m^3 metal RAW and about 12 m^3 of non-metal RAW;
3. Facilities for RAW management operated by the Specialised Enterprise RAW-Kozloduy – the objective of the of Central Enterprise RAW is to reduce the volume of RAW and conditioning it. The secondary generated RAW in the workshop such as clothing, tools, etc., shall be processed in CERAW. The NPP site has facilities for the temporary storage of RAW with variable volumes. There is no RAW generated at the sites. The site of the Kozloduy NPP has available the following facilities managed by SE RAW:
   - → Storage facility for conditioned RAW – onground reinforced concrete structure providing the necessary engineering barriers between the stored RAW and the environment and the personnel. Its capacity is 1920 concrete containers with conditioned RAW;

→ Lime Site which includes the following sub-sites:

- Trench depot – designed for temporary storage of solid RAW 2-I and 2-II category and servicing all nuclear facilities of the Kozloduy NPP. The depot is located near the surface, made of reinforced concrete and of bunker type. It is divided into forty cells with upper hatch, each with dimensions of 2.7 x 5.9 x 96.0 m and a volume of 96.5 m^3. Working conditions – ambient temperature, atmospheric pressure.

- Depot for storage of processed solid RAW – designed for temporary storage of processed solid RAW 2-I and 2-II category of all nuclear facilities at the Kozloduy NPP. site. The facility is a building, made of reinforced concrete slab structure with a reception transport corridor. Processed solid RAW shall be stored in metal pallets, arranged in three rows one above the other. The useful volume of the depot is 1130 m^3.

- Sites (No. 1 and No. 2) for storage of solid RAW in reinforced concrete containers – designed for temporary storage of processed solid RAW 2-I and 2-II category, packed in reinforced concrete containers. It services all the nuclear facilities at the Kozloduy NPP. The sites have a capacity to accommodate about 2000 concrete containers. The walls of the reinforced concrete container provide biological protection so that the equivalent dose of gamma radiation from the RAW does not exceed 2 mSv/h at any point on its external surface and 0.1 mSv/h at 1 m distance from the surface.

- Depot for storage of solid RAW in large volume containers – designed for temporary storage of low-activity solid RAW 2-I category. The depot services all the nuclear facilities of Kozloduy NPP. The site has a capacity to accommodate 14 large volume containers (large volume container with side door with external dimensions 5.8x2.2x2.4 m and useful volume of 30 m^3).

4. Estimated quantities of RAW from the decommissioning of 1 ÷ 4 are 5532 tons of metal RAW and about 12590 tons non-metal RAW such as concrete, insulation and insulation of cables, and according to the strategy for managing SRF and RAW, these amounts will be generated and processed by 2030, which means an average of about 1,100 t per year.

New nuclear facilities scheduled for commissioning at the Kozloduy NPP site:

1. New nuclear capacity of the most contemporary generation has been designed according to the requirements of EUR, which require generation of no more than 50 m^3 solid RAW (about 1000MW electric power) per year, which depending on the selected alternative for new nuclear capacity means conditioned RAW between 180 m^3 and 250 m^3 per year.

2. Facility for plasma incineration of low and medium activity RAW (category 2a) with a high coefficient of volume reduction – no generation of secondary RAW other than clothing.
3. Depot for dry storage of spent nuclear fuel – no generation of secondary RAW other than clothing.
4. The Radiana site is located near the Kozloduy NPP, where the national depot for the disposal of low and medium radioactive RAW will be constructed, which also does not generate secondary RAW other than clothing.

From the above it is clear that the main generator of RAW over the next 16 years will be due to the decommissioning of units 1 ÷ 4. After removal of the sources of ionizing radiation from the units, the other large generator of RAW will be units 5 and 6. Due to the specifics of Russian projects of previous generations to keep the accumulated waste of units until the decommissioning thereof, within the limits of units 5 and 6, and at special unit 3, there is accumulated RAW from previous years. This approach for the RAW management at the site has the objective to achieve gradual extraction and processing of the accumulated RAW from the operation of the units, which means larger quantities for processing. From the above we can conclude **that the flow of RAW generated by NNU is** negligible compared to existing flows. This will be true to the decommissioning of units 5 and 6 which means that the contribution of the RAW generated by the NNU to the cumulative effect is negligible until that NNU will be the only nuclear facility at the site.

5.9 CUMULATIVE IMPACT REGARDING THE HAZARDOUS PHYSICAL FACTOR COMPONENT

5.9.1 NOISE

During the various stages of implementing the investment project, a cumulative impact is expected from the adding of noise from freight transport and that of the existing traffic flows along the traffic routes – national roads II- 11 and II- 15, and this will result in raising the noise characteristics during the day. The expected increase in traffic noise levels in urban areas during **the preparation** of the respective alternative site is as follows: for the town of Kozloduy – from 9.5 to 14.0 dBA, for the village of Harlets and the village of Glozhene – from 3.5 to 7.0 dBA, for the town of Mizia – from 2.5 to 5.5 dBA; **during the construction** of the site for: the town of Kozloduy – by 5.5 dBA, the village of Harlets and the village of Glozhene – by 1.5 dBA, the town of Mizia – by 1.0 dBA; **during the operation** of the site for: the town of Kozloduy, a 1.5 dBA, and for the others (village of Harlets, village of Glozhene, village of Mizia) with virtually no change (about 0.3 dBA).

There is expected cumulative impact from the addition of noise from the construction equipment for the site preparation and the construction of the new nuclear capacity and the transportation service, and that from the production activity of Kozloduy NPP, which will take place at the plant site.

Change in the noise regime formed by the existing technological activity of Kozloduy NPP is expected resulting from the operation of the new nuclear capacity, which will occur on the overlapping parts of the existing NPP site and that of the NNU: the site of EP – 2 and site 3, the site of EP-1 and site 2, as well as close to the common borders of site 4 with EP-1 and EP-2. There is no significant change expected for the selection of Site 1, which is the farthest from the active production areas EP-1 and EP-2. The noise regime change will depend on the location of the noise sources at the site of the new capacity. The expected maximum increase in the noise level in those areas, as a result of the accumulation is 3 dBA. The most significant change is expected in the selection of site 4, and the smallest for the selection of Site 1.

5.9.2 NON-IONISING RADIATION

5.9.2.1 DETERMINATION OF THE SCOPE FOR THE CUMULATIVE IMPACT ASSESSMENT

One of the factors which can be discussed in terms of a cumulative impact are the super low frequency (SLF) electric and magnetic fields. Possible cumulative impact can be expected only for employees of open distribution devices (ODD) and closed distribution devices (CDD) in the course of their professional practice.

So far, there is no evidence of a cumulative impact of these fields on human health, but it should be taken into account that the personnel in the ODD and CDD is exposed to electric and magnetic fields with different values continuously during the working shift.

In addition, there is no proven effect for the *electromagnetic hypersensitivity*, but in some countries there are preventive measures taken for persons with a higher sensitivity to the effects of electric current.

In this case we can not expect cumulative impact of the SLF fields for the personnel of the ODD and CDD, but workers must be examined in terms of preclinical manifestations of impact thereof.

As regards to the impact of SLF fields on the population – there is no expected cumulative impact.

This applies to each of the planned sites, regardless of which alternative will be implemented. The reason for this is that, regardless of the site selected for implementation, the same power facilities will be constructed for conversion and distribution of electric power. Each construction requires installation of ODD and CDD, and high voltage power lines that carry electricity to the consumers.

Cumulative impact cannot be expected with the existing ODD and CDD in the Kozloduy NPP due to the fact that electromagnetic fields do not spread beyond the technical protections of the site and therefore cannot cause a cumulative impact.

Implementation of the investment plan for capacity expansion in Kozloduy NPP cannot have a cumulative impact on the NIR regarding the permits issued by the Regional

Environment and Water Inspectorate of the town of Montana, for building sites in the 30 km zone around the site as well as in the area of emergency protective measures.

Cumulative impacts cannot be expected also for the expansion of the site of digital television and wireless communications, which are constructed near the site.

5.9.2.2 ANALYSIS OF CUMULATIVE IMPACTS AND DETERMINATION OF THE SIGNIFICANCE THEREOF

The analysis of the cumulative impacts of projects that are existing, approved or in the process of approval and/or development on the NIR environment show the following:

There is no expected superposition of the effects of various EMF – with industrial frequency, radio frequency and others with newly constructed sources – ODD, CDD, high voltage power lines.

It cannot be expected to have a cumulative impact from the NIR emissions with other factors of the environment, since the effect is negligible and also there is no synergy with any other environmental factors such as ionizing radiation.

Accordingly, it can be said that there is no accumulation of both the same effects, and of other effects which may lead to a new significant impact.

5.9.3 VALUE OF CUMULATIVE IMPACT

According to **Table 5.1-1,** for NIR it can be assumed that the significance of the impact is very low for the population and low to medium – for employees in the ODD and CDD. Therefore, according to the table impact falls within the yellow colour areas with **very low impact** on the population and within the yellow and green colour areas- **with low impact** on the employees.

5.9.3.1 DETERMINATION OF MEASURES FOR REDUCING, LIMITING OR PREVENTION OF POSSIBLE CUMULATIVE IMPACTS

There is no need to take certain measures to reduce, limit or prevent potential cumulative impacts, since NIR is not expected to cause such impacts.

The only recommendation that can be made to employers in the ODD and CDD is to comply with the requirements for mandatory preliminary and periodic medical examinations of employees at the site, as required by Regulation No. 3 of 28.02.1987 for the mandatory preliminary and periodic medical examinations of workers, promulgated in Stage Gazette issue No. 16 of 27.02.1987, amended. and supplemented in issue No. 65 of 9.08.1991, issue No. 102 of 13.12.1994.

5.9.3.2 DETERMINATION OF THE NEED FOR FURTHER ACTIONS

There is no need to take further actions to protect from NIR both for the population and for the personnel serving the ODD and CDD.

5.10 CUMULATIVE IMPACT REGARDING THE COMPONENT FOR THE HEALTH AND HYGIENE ASPECT FOR THE ENVIRONMENT AND THE RISK FOR HUMAN HEALTH

The assessment of the cumulative impacts for health risk on the population in the protected zones around the Kozloduy NPP during the construction, operation and decommissioning of the new nuclear capacity is based on the information gathered to identify the hazards, the determination of the dose-effect and dose-response to chemical, physical and physiological factors of the environment.

The recommendations of international organizations and the methodology for assessing the health risk (WHO, 1994, WHO/UNEP/ILO, 2001) have been used. The European indicators for assessing the impact of the environment on human health have been taken into consideration.

Any potential negative impact on the environment and public health, including taking into account the synergistic effects of the background radiation is within the permissible norms according to the regulations.

The contribution of the new nuclear capacity to the background radiation in the vicinity of the town of Kozloduy due to external radiation is small. The cumulative environmental impacts will be **negligible**.

5.11 CUMULATIVE IMPACT REGARDING THE RADIATION RISK FOR THE POPULATION IN CASE OF RADIOACTIVE DISCHARGES

In order to assess the cumulative impact, an analysis was carried out for the dose loading of the population within the 30 km zone of the Kozloduy NPP of gas-aerosol and liquid radioactive discharges into the environment under all operating modes: of the existing facilities at the NPP site (units 5 and 6, SFS, DDSSNF); the facilities of SE RAW-Kozloduy and the future activities regarding: the decommissioning of units 1 ÷ 4, including the Workshop for size reduction and deactivation (WSRD); the plasma incineration facility (PIF); the NDSRW – Radiana site and the NNU.

According to the Report on the assessment of the impact on the environment of the NDSRW there is no release of radioactive material into the atmosphere and the discharged water under all operating modes.

The assessment of risk to the population and the radioactive discharge include:

- ✓ assessment of individual and collective doses to the population;
- ✓ assessment of the radiobiological effects and the radiation risk.

Assessment of external and internal exposure of the population in the area consider the following ways of influence:

- ✓ external exposure from radioactive cloud;
- ✓ external exposure resulting from the deposition on the ground;

- internal exposure by inhalation;
- internal exposure from the consumption of radioactively contaminated food.

The assessment of external and internal exposure of the population in the region of the NNU to liquid discharges takes into account the following ways of influence:

- during stay in the water of the Danube River – external exposure during swimming and travelling by boat;
- contact with coastal sediment of the Danube River – external exposure from bottom sediments and stay on the beach;
- ingestion of products (fish) from the water of the Danube River – internal exposure due to consumption of fish;
- during stay on the territory irrigated by water from the Danube River – external exposure.;
- ingestion of plant products irrigated with water from the Danube River (fruits, vegetables, etc.) – internal exposure;
- ingestion of meat and milk from animals that use drinking water from the Danube River – internal exposure;
- ingestion of meat and milk from animals using fodder, irrigated with water from the Danube – internal exposure;
- consumption of drinking water – internal exposure.

The assessment of radiation risk is within the following range:

1. Risk of radiation-induced cancer for the general population and for those in active employment age;
2. Risk for hereditary diseases in the general population and for those in active employment age;
3. Risks and damage to certain tissues for the general population;
4. Risks of inherited diseases for the first generation and for the two following generations;
5. Risks of inherited diseases of the reproductive part of the population evaluated for two generations under irradiation of the first generation before the second;
6. Risks of inherited diseases of the reproductive part of the population, estimated for the first generation after exposure.

5.11.1 GAS-AEROSOL DISCHARGE DOSES

5.11.1.1 INPUT DATA

Input data include radioactive discharge into the atmosphere, meteorological data, statistical demographic data, and consumption habits.

- ✓ Demographic data and data on consumption and habits:
  - Bulgarian territory: Annual Report, Results of radiation monitoring of the environment for Kozloduy NPP in 2012, No. 11.РМ.ДОК.085;
  - Romanian territory: Letter from the Romanian Ministry of Environment and Forests, No. 3672/RP/18.10.2012.

According to statistical data from the National Statistical Institute of the census of 01.02.2011 the population within the 30 km zone around the Kozloduy NPP in the territory of the Republic of Bulgaria is 65994 people. The comparison with the statistics from 2007 show a 10 % higher population – 72,416 people. By gender the population has the following structure: men – 48.6 %, women – 51.4 %. In the researched area there is 37.7 % of urbanization, which is much lower than the national average of 70.7 %.

The distribution by age groups in the region is as follows: 0-14 years of age – 14.2 %, 15-60 years of age – 54.3 % and over 60 years of age – 31.5 %. For purposes of dose assessment a more detailed age distribution is used.

A population density of 43 people per 1 km^2 evenly distributed in all directions was used for the calculation of the collective doses. The critical group population along the Danube River has been identified for the town of Oryahovo, the village of Leskovets, the village of Ostrov and the village of Gorni Vadin) and has been estimated at 7469 people (NSI, last census in 2011).

Statistics on the production and consumption of basic food products in the region have been used. The data are mainly plant foods, foliar vegetables, meat and milk.

- ✓ Micrometeorological data for the period from 2001 to 2012 from:
  - Annual Report, Results of radiation monitoring of the environment for Kozloduy NPP in 2012, No. 11.РМ.ДОК.085;
- ✓ Air emissions:
  - Annual Report, Results of radiation monitoring of the environment for Kozloduy NPP in 2012, No. 11.РМ.ДОК.085.

The paper reports discharges from the following facilities at the site: VT-1, VT-2 5VT-1 5VT-2 6VT-1 6VT-2, OVT and VT-DSSF. Considering the decommissioned units 1 ÷ 4, and the fact that the sources for emission of RWB and Iodine-131 are the units in operation, the report uses a more conservative approach for comparison with the administrative ranges of annual discharges for the whole site by components with operation of 2000 MW.

- Annual averages throughout the decommissioning, EIA for the decommissioning of units 1 4, П16Д08Ред01.6_ДОВОС – Chapter 11.

Average annual values throughout the decommissioning of units 1 ÷ 4 are provided for long-lived aerosols (LLA): 20 MBq. This value includes emissions from planned projects: workshop for size reduction and decontamination of materials. The distribution of the radionuclide composition and the activity in aerosol discharges is under the annual limits and the control levels of total activity of liquid and gaseous discharges from units 1 ÷ 4 in the process of decommissioning.

TABLE 5.11-1: DISTRIBUTION OF THE RADIONUCLIDE COMPOSITION AND ACTIVITIES IN THE AEROSOL DISCHARGES THROUGHOUT THE WHOLE PERIOD FOR DECOMMISSIONING OF UNITS 1÷4

Radionuclide	VT-1	VT-1	VT-2	VT-2
	%	A, MBq	%	A, MBq
Co-60	46	4.6	50	5.0
Sr-90	0.5	0.05	0.3	0.03
Cs-134	0	0	0.5	0.05
Cs-137	53	5.3	49	4.9
Pu-239, 240	0.2	0.02	0.1	0.01
Am-241	0.3	0.03	0.1	0.01
TOTAL: 20 MBq		10		10

- Report for input data for EIA for PIF, IBERDROLA, ID No. I-650-RP-0009.

Annual averages during normal operation of the plasma incineration facility (PIF) for long-lived aerosols (LLA): 6 MBq.

The distribution of the radionuclide composition and activity in aerosol discharges is given in the following table:

TABLE 5.11-2: DISTRIBUTION OF THE RADIONUCLIDE COMPOSITION AND ACTIVITIES IN THE AEROSOL DISCHARGES

Radionuclide	BT-2
	A, MBq
Mn-54	0.362
Co-58	0.181
Fe-59	0.0603
Co-60	3.44
Nb-95	0.0603
Ag-110m	0.362
Cs-134	0.362
Cs-137	1.21
TOTAL:	6.04 MBq

- data for emissions in the air from the NNU;

TABLE 5.11-3: RADIONUCLIDE IN THE GAS AND AEROSOL DISCHARGES FOR ALL OPERATION MODES, BQ/YEAR

Nuclide	Westinghouse AP-1000	AES BBEP-1000/B466
H – 3	1.3E+13	3.9E+3
C – 14	2.7E+11	3.0E+2
Ar-41	1.3E+12	
Kr-83m		1.0E+3
Kr-85m	1.3E+12	3.6E+3
Kr-85	1.5E+14	3.6E+2
Kr-87	5.6E+11	1.9E+3
Kr-88	1.7E+12	7.0E+3
Xe-131m	6.7E+13	3.1E+2
Xe-133m	3.2E+12	1.4E+3
Xe-133	1.7E+14	4.7E+4
Xe-135m	2.6E+11	
Xe-135	1.2E+13	2.5E+4
Xe-138	2.2E+11	3.5E+2
I – 131	4.4E+09	3.4E+8
I – 132		7.5E+8
I – 133	1.5E+10	9.0E+8
I – 134		1.9E+8
I – 135		6.1E+8
Cr – 51	2.3E+07	6.3E+3
Mn – 54	1.6E+07	8.7E+3
Co – 57	3.0E+06	
Fe – 59	2.9E+06	
Co – 58	8.5E+08	
Co – 60	3.2E+08	1.0E+5
Sr – 89	1.1E+08	9.8E+5
Sr – 90	4.4E+07	2.1E+3
Zr – 95	3.7E+07	
Nb – 95	9.3E+07	
Ru – 103	3.0E+06	
Ru – 106	2.9E+07	
Sb – 125	2.3E+07	
Cs – 134	8.5E+07	4.7E-2
Cs – 136	3.2E+06	
Cs – 137	1.3E+8	5.9E-2
Ce – 141	1.6E+06	

- requirements described in EUR – European Utility Requirements for LWR Nuclear Power Plants.

Limits of radioactive emissions in accordance with EUR for all operating modes are as follows:

- for radioactive noble gases – 50 TBq;

- for long-lived aerosols and halogens – 1 GBq.

Reference values are set for a reactor based on 1500 MWe electric power. These limits are adopted to determine a conservative assessment for the environmental impact of new nuclear capacity and the actual releases from the various models of reactors are expected to be much lower.

The following values for the NNU are taken for the assessment of the normalized annual collective doses: AP 1000 – 1200 MWe, AEC BBEP -1000/V466 – 1000 MWe as per EUR – 1500 MWe capacity and 90 %.

To assess the radiation exposure of the population within the 30 km zone of gaseous discharges a modelling program LEDA-SM, *SHIELD Normal operation* was used and adapted to the geographical and meteorological characteristics of the area of the Kozloduy NPP. This methodology takes into account both external and domestic impact of radioactive discharges and estimated annual individual effective dose, equivalent annual individual dose and the dose to the critical group, but also the collective dose to the population by age groups. The program is based on the CREAM methodology (Consequences of Releases to the Environment Assessment Methodology) adopted by the European Union (EU) – Radiation Protection 72 – Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment.

The applied modelling programs for assessment of the individual and collective effective doses to the population from the radioactive emissions into the environment are verified and validated.

Estimates of the individual and collective doses to the population within the 30 km zone of gaseous discharges from the Kozloduy NPP for 2012 are presented in **Table 5.11-4**.

TABLE 5.11-4: DOSE LOADING IN THE 30-KM ZONE DUE TO THE GAS-AEROSOL DISCHARGES FOR 2012 FROM THE KOZLODUY NPP

	Collective dose [manSv]	Individual effective dose [Sv]
Total (RBG+LLA+^{131}I+^{3}H+^{14}C)	$2.65.10^{-2}$	$1.10.10^{-8}$ – $1.33.10^{-6}$
RBG	$4.07.10^{-5}$	$4.75.10^{-11}$ – $1.84.10^{-9}$
Sediment over the earth surface- LLA	$6.05.10^{-5}$	$3.61.10^{-11}$ – $1.40.10^{-9}$
Inhalation intake ^{131}I	$8.45.10^{-7}$	$4.01.10^{-13}$ – $2.81.10^{-11}$
^{3}H	$1.60.10^{-4}$	$1.70.10^{-10}$ – $1.08.10^{-8}$
^{14}C	$2.62.10^{-2}$	$1.07.10^{-8}$ – $1.31.10^{-6}$

5.11.1.2 RESULTS

Estimates of the individual doses to the population within the 30 km zone of gaseous emissions from the decommissioning process (DP) of units 1 ÷ 4 are presented in **Table 5.11-5.** The collective annual dose is assessed at $8.86.10^{-5}$ manSv/a.

TABLE 5.11-5: DOSE LOADING IN THE 30-KM ZONE DUE TO THE GAS-AEROSOL DISCHARGES FROM DP OF UNITS 1÷4

Maximum dose LLA (external), Sv/a	Maximum dose ^3H, Sv/a	Maximum dose ^{14}C, Sv/a	Maximum dose total, Sv/a
$5.58x10^{-11}$ – $1.37x10^{-9}$	-	-	$1.47x10^{-10}$ – $2.46.10^{-9}$
$1.37x10^{-9}$	-	-	$2.46x10^{-9}$

Estimates of the individual dose to the population within the 30 km zone of gaseous emissions from the operation of the plasma incineration facility (PIF) are presented in **Table 5.11-6**.

The collective annual dose is assessed at $1.98.10^{-5}$ manSv/a.

TABLE 5.11-6: DOSE LOADING IN THE 30-KM ZONE DUE TO THE GAS-AEROSOL DISCHARGES FROM THE PIF OPERATION

Maximum dose LLA (external), Sv	Maximum dose ^3H, Sv/a	Maximum dose ^{14}C, Sv/a	Maximum dose total, Sv/a
$1.46x10^{-11}$ – $3.60x10^{-10}$	-	-	$3.36x10^{-11}$ – $5.47x10^{-10}$
$3.60x10^{-10}$	-	-	$5.47x10^{-10}$

Estimates of the individual and collective doses to the population within the 30 km zone of gaseous emissions from the NNU are presented in **Table 5.11-7**.

TABLE 5.11-7: DOSE LOADING IN THE 30-KM ZONE DUE TO THE GAS-AEROSOL DISCHARGES FROM THE NNU

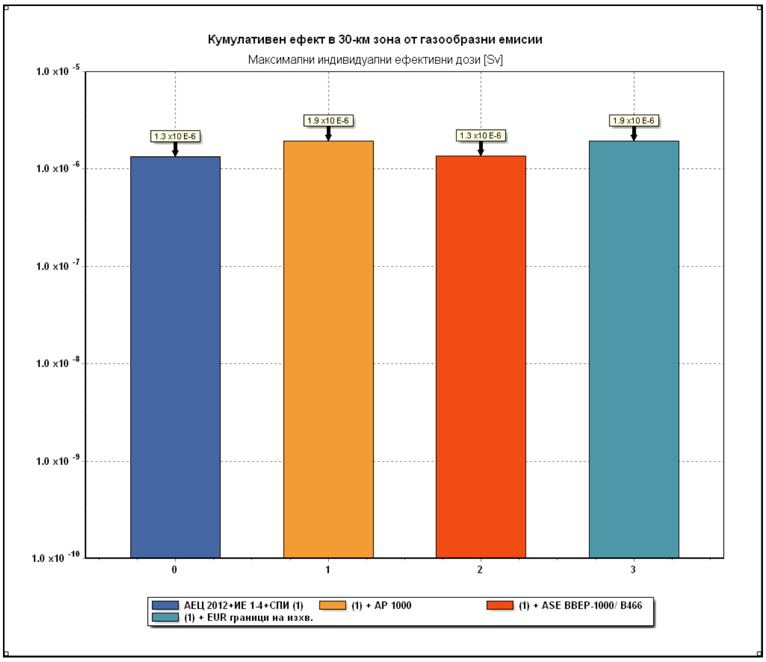
NNU	Collective effective dose [manSv]	Individual effective dose [Sv]
AP 1000	$1.93.10^{-2}$	$3.10.10^{-8}$ – $5.99.10^{-7}$
AES BBEP-1000/ B466	$1.59.10^{-4}$	$1.93.10^{-10}$ – $1.79.10^{-8}$
EUR limits of emissions	$2.49.10^{-2}$	$2.46.10^{-8}$ - $6.13.10^{-7}$

The cumulative impact of various sources of gaseous discharge is presented in **Table 5.11-8** and **Figure 5.11-1** and **Figure 5.11-2**.

TABLE 5.11-8: CUMULATIVE IMPACT IN THE 30-KM ZONE FOR GAS-AEROSOL DISCHARGES

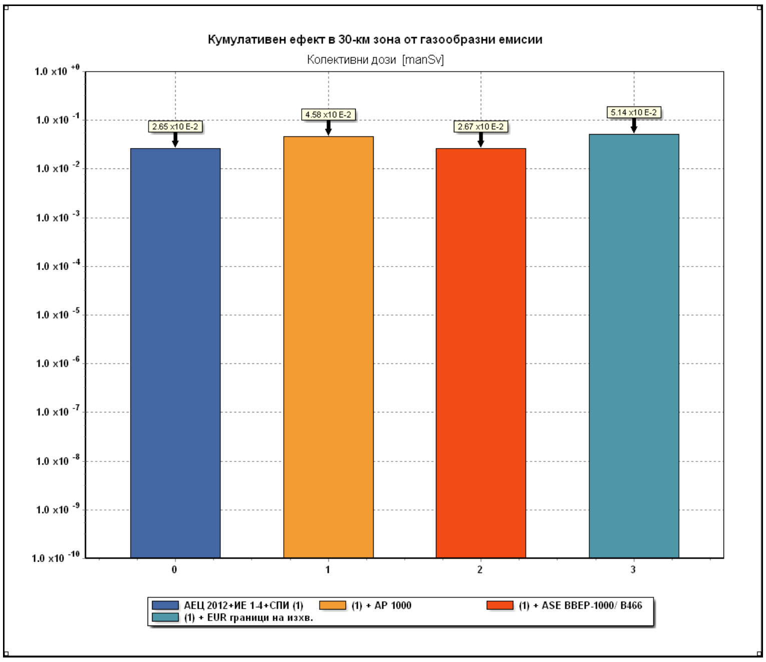
Source description	Collective dose [manSv]	Individual effective dose [Sv]

Source description	Collective dose [manSv]	Individual effective dose [Sv]
Kozloduy NPP 2012 + DP1-4 + PIF	$2.65.10^{-2}$	$1.10.10^{-8}$ – $1.33.10^{-6}$
Kozloduy NPP 2012 + DP1-4 + PIF + AP 1000	$4.58.10^{-2}$	$4.20.10^{-8}$ – $1.93.10^{-6}$
Kozloduy NPP 2012 + DP1-4 + PIF + AES BBEP-1000/ B466	$2.67.10^{-2}$	$1.12.10^{-8}$ – $1.35.10^{-6}$
Kozloduy NPP 2012 + DP1-4 + PIF + EUR limits of discharge	$5.14.10^{-2}$	$3.56.10^{-8}$ – $1.94.10^{-6}$



Cumulative impact in the 30-km zone for gas-aerosol emissions; Maximum individual effective doses (Sv); NPP 2012 + DP1-4 + PIF (1); EUR limits of discharge

FIGURE 5.11-1: MAXIMUM INDIVIDUAL EFFECTIVE DOSES (SV) FROM THE GAS-AEROSOL DISCHARGES



Cumulative impact in the 30-km zone for gas-aerosol emissions; Collective doses (manSv); NPP 2012 + DP1-4 + PIF (1); EUR limits of discharge

FIGURE 5.11-2: COLLECTIVE DOSES (MANSV) FROM THE GAS-AEROSOL DISCHARGES

5.11.2 DOSES FROM LIQUID DISCHARGES

5.11.2.1 INPUT DATA

- ✓ Demographic data and data on consumption and habits:
  - Bulgarian territory: Annual Report, Results of radiation monitoring of the environment for Kozloduy NPP in 2012, No. 11.РМ.ДОК.085;
  - Romanian territory: Letter from the Romanian Ministry of Environment and Forests, No. 3672/RP/18.10.2012.
- ✓ Hydrological data:
  - Annual Report, Results of radiation monitoring of the environment for Kozloduy NPP in 2012, No. 11.РМ.ДОК.085;
- ✓ Emissions in water:
  - ✓ Annual Report, Results of radiation monitoring of the environment for Kozloduy NPP in 2012, No. 11.РМ.ДОК.085.

The paper reports discharges from the following facilities at site: CC-1, CC-2 and CC-3.

- Annual averages throughout the decommissioning, EIA for the decommissioning of units 1 4, П16Д08Ред01.6_ДОВОС – Chapter 11.
  - – Nuclides(without H-3): 120 MBq.

– Tritium (H-3): 50 GBq.

These figures include emissions from the above-mentioned projects: workshop for size reduction and decontamination of materials and all activities for the decommissioning of units 1 ÷ 4.

✓ Distribution of radionuclide composition and activity in liquid discharges (without H-3) is under the annual limits and control levels of total activity of liquid and gaseous discharges from units 1 ÷ 4 in the process of decommissioning.

TABLE 5.11-9: DISTRIBUTION OF RADIONUCLIDES AND ACTIVITIES IN THE LIQUID DISCHARGES

Radionuclide	CC-1	CC-1	CC-2	CC-2
	%	A, GBq	%	A, GBq
Co-60	2	1.2	2	1.2
Cs-134	1	0.6	1	0.6
Cs-137	93	55.8	93	55.8
Sr-90	0.5	0.3	0.5	0.3
Pu-239, 240	0	0	0	0
Am-241	0	0	0	0
Ni-63	3	1.8	3	1.8
Fe-55	0.5	0.3	0.5	0.3
Total: 120 MBq		60		60

- data for liquid discharges from the NNU.

TABLE 5.11-10: RADIONUCLIDES IN THE LIQUID DISCHARGES FOR ALL OPERATION MODES, BQ/YEAR

Nuclide	Westinghouse AP 1000
Te-131m	3.33E+06
Te-131	1.11E+06
I-131	5.23E+08
Te-132	8.88E+06
I-132	6.07E+07
I-133	2.48E+08
I-134	3.00E+07
Cs-134	3.67E+08
I-135	1.84E+08
Cs-136	2.33E+07
Cs-137	4.93E+08
Ba-137m	4.61E+08
Ba-140	2.04E+08
La-140	2.75E+08
Ce-141	3.33E+06
Ce-143	7.03E+06

Nuclide	Westinghouse AP 1000
Pr-143	4.81E+06
Ce-144	1.17E+08
Pr-144	1.17E+08
All other	7.40E+05
H-3	3.74E+13

For AES BBEP-1000/V466: the volume of emissions from discharge water into the environment may be about 8.5.1012 Bq/year of tritium[9].

- requirements set out in European Utility Requirements for LWR Nuclear Power Plants

The limits for liquid radioactive emissions comply with EUR for all operating conditions and are as follows:

✓ Liquid except for Tritium 10 GBq.

These reference values are determined on the basis of 1500 MWe. These limits are adopted to determine a conservative assessment for the environmental impact of new nuclear capacity and the actual releases from the various models of reactors are expected to be much lower.

The following values for the NNU are taken for the assessment of the normalized annual collective doses: AP 1000 – 1200 MWe, AEC BBEP-1000/V466 – 1000 MWe with discharge within the limits of the radioactive emission in the hydrosphere, as per EUR – 1500 MWe capacity and 90 %.

To assess the radiation exposure of the population within the 30 km zone of gaseous discharges a modelling program DARR-CM was used and adapted to the hydrology of the area of the Kozloduy NPP in order to perform conservative assessment of the dose exposure for the critical group of the population. The program is based on the CREAM methodology (Consequences of Releases to the Environment Assessment Methodology) adopted by the European Union (EU) – Radiation Protection 72 – Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment.

The applied modelling programs for assessment of the individual and collective effective doses to the population from the radioactive emissions into the environment are verified and validated.

Estimates of the individual doses to the population within the 30 km zone of liquid discharges from the Kozloduy NPP for 2012 are presented in **Table 5.11-11**.

[9] Accordimg to client's letter No. 828/13.08.2013

TABLE 5.11-11: DOSE LOADING FROM LIQUID DISCHARGES FROM KOZLODUY NPP FOR 2012

Population	Individual effective dose without ^{3}H, Sv/a	Individual effective dose ^{3}H, Sv/a	Individual effective dose total, Sv/a
30 km zone	$6.81.10^{-12}$ – $8.73.10^{-10}$	$3.41.10^{-7}$ – $6.37.10^{-7}$	$3.42.10^{-7}$ – $6.37.10^{-7}$
Critical group	$4.22.10^{-9}$	$4.48.10^{-6}$	$4.49.10^{-6}$

The collective dose assessment along the Danube River is presented in **Table 5.11-12**.

TABLE 5.11-12: COLLECTIVE DOSES FROM LIQUID DISCHARGES FROM KOZLODUY NPP FOR 2012

Collective dose without ^{3}H, manSv/a	Collective dose ^{3}H, manSv/a	Collective dose total, manSv/a
$7.88.10^{-6}$	$4.69.10^{-3}$	$4.47.10^{-3}$

5.11.2.2 RESULTS

In assessing doses from liquid discharges a model of complete mixing was used for the Danube River and there is no difference made for the left and right bank. On this basis it is argued that estimates of doses for the respective kilometre on both banks of the Danube River are identical.

The critical population group includes *residential areas* along the Danube River – the town of Oryahovo, the village of Leskovets, the village of Ostrov, the village of Gorni Vadin.

Normalized collective dose per unit of electricity totalled $2.61.10^{-3}$ man.Sv/GW.a. The data are fully comparable with data for a large number of PWR reactors in the world (UNSCEAR-2000, 2008).

Estimates of individual doses to the population within the 30 km zone of liquid discharges from decommissioning of units 1 ÷ 4 are presented in **Table 5.11-13.**

TABLE 5.11-13: DOSE LOADING OF LIQUID DISCHARGES FROM DP OF UNITS 1÷4

Population	Maximum dose without ^{3}H, Sv/a	Maximum dose ^{3}H, Sv/a	Maximum dose total, Sv/a
30 km zone	$3.56.10^{-12}$ – $5.50.10^{-10}$	$7.07.10^{-10}$ – $1.32.10^{-9}$	$8.30.10^{-10}$ – $1.48.10^{-9}$
Critical group	$2.31.10^{-9}$	$9.30.10^{-9}$	$1.16.10^{-8}$

Collective doses along the Danube River are presented in **Table 5.11-14**.

TABLE 5.11-14: COLLECTIVE DOSES OF LIQUID DISCHARGES FROM DP OF UNITS 1÷4

Collective dose without ^{3}H, manSv/a	Collective dose ^{3}H, manSv/a	Collective dose total, manSv/a
$5.01.10^{-6}$	$9.73.10^{-6}$	$1.47.10^{-5}$

Estimates of individual doses to the population within the 30 km zone of liquid discharges NNU are presented in **Table 5.11-15**.

TABLE 5.11-15: DOSE LOADING OF LIQUID DISCHARGES FROM THE NNU

NNU	Individual effective dose, [Sv]					
	For the population in the 30 km zone			For the critical group		
	^{3}H	without ^{3}H	Total	^{3}H	without ^{3}H	Total
EUR limits of discharge	$1.64.10^{-7}$ - $3.07.10^{-7}$	$1.67.10^{-10}$ - $2.13.10^{-8}$	$1.71.10^{-7}$ - $3.07.10^{-7}$	$2.16.10^{-6}$	$1.03.10^{-7}$	$2.26.10^{-6}$
AP-1000	$5.29.10^{-7}$ - $9.89.10^{-7}$	$1.03.10^{-10}$ - $4.23.10^{-9}$	$5.32.10^{-7}$ - $9.89.10^{-7}$	$6.95.10^{-6}$	$1.93.10^{-8}$	$6.97.10^{-6}$
AES BBEP-1000/B466	$1.2.10^{-7}$- $2.25.10^{-7}$	No available data	$1.2.10^{-7}$- $2.25.10^{-7}$	$1.58.10^{-6}$	No available data	**$1.58.10^{-6}$**

Collective doses along the Danube River from liquid discharges NNU are presented in **Table 5.11-16**.

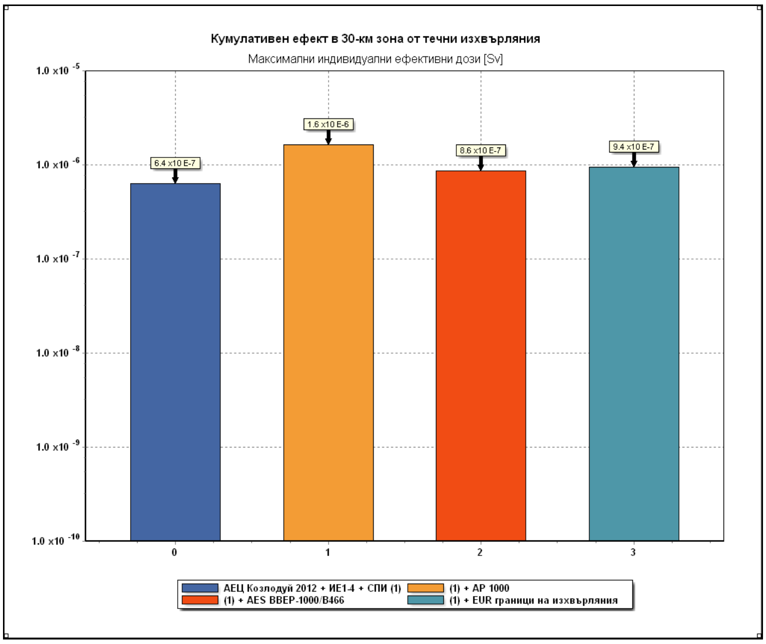
TABLE 5.11-16: COLLECTIVE DOSES OF LIQUID DISCHARGES FROM THE NNU

NNU	Collective dose without ^{3}H, manSv/a	Collective dose ^{3}H, manSv/a	Collective dose total, manSv/a
EUR limits of discharge	$1.92.10^{-4}$	$2.26.10^{-3}$	$2.45.10^{-3}$
AP-1000	$3.86.\ 10^{-5}$	$7.28.10^{-3}$	$7.32.\ 10^{-3}$
AES BBEP-1000/B466	No available data	$1.65.10^{-3}$	$1.65.10^{-3}$

TABLE 5.11-17: CUMULATIVE IMPACT IN THE 30-KM ZONE FROM LIQUID DISCHARGES

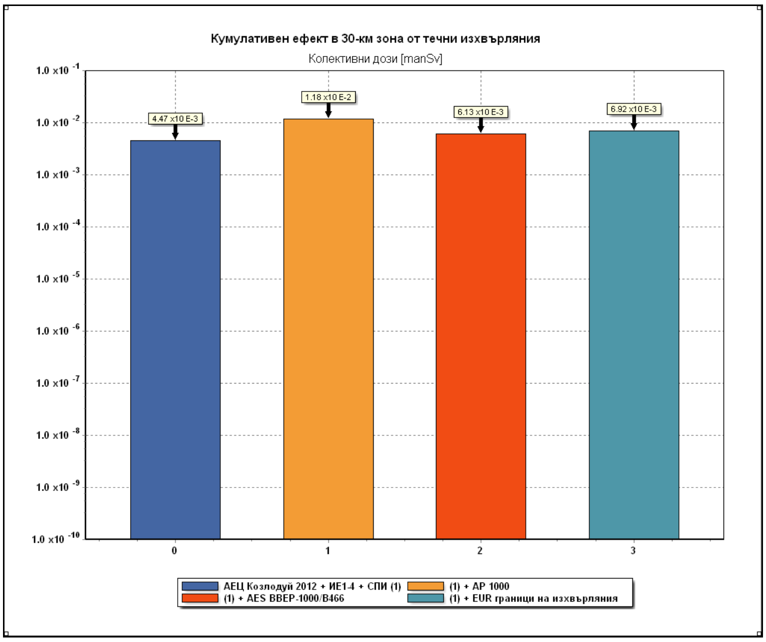
Source description	Collective effective dose [manSv]	Individual effective dose [Sv]
Kozloduy NPP 2012 + DP1-4	$4.47.10^{-3}$	$3.42.10^{-7}$ – $6.37.10^{-7}$
Kozloduy NPP 2012 + DP1-4 + AP 1000	$1.18.10^{-2}$	$7.74.10^{-7}$ – $1.63.10^{-6}$
Kozloduy NPP 2012 + DP1-4 + EUR limits of discharge	$6.92.10^{-3}$	$5.13.10^{-7}$ – $9.44.10^{-7}$
Kozloduy NPP 2012 + DP1-4 + AES BBEP-1000/B466	$6.12.10^{-3}$	$4.62.10^{-7}$ – $8.62.10^{-7}$

The cumulative impact of all the sources of liquid discharges is shown in **Table 5.11-17** and **Figure 5.11-3** and **Figure 5.11-4**.



Cumulative impact in the 30-km zone for liquid discharges; Maximum individual effective doses (Sv); NPP 2012 + DP1-4 + PIF (1); EUR limits of discharge

FIGURE 5.11-3: MAXIMUM INDIVIDUAL EFFECTIVE DOSES (SV) FROM LIQUID DISCHARGES



Cumulative impact in the 30-km zone for liquid discharges; Collective doses (manSv); NPP 2012 + DP1-4 + PIF (1); EUR limits of discharge

FIGURE 5.11-4: COLLECTIVE DOSES (MANSV) FROM LIQUID DISCHARGES

The maximum annual effective dose to the population within the 30 km zone of Kozloduy NPP due only aerosol discharges under all operating modes of the existing and new nuclear power capacities was estimated to be 1.94 μSv/a. This is only 0.08 % of the radiation from the natural background radiation in the country (2.33 mSv/a) and 0.2 % of the norm for the population (1 mSv/a), Basic Norm for Radiation Protection (BNRP)-2012.

The maximum annual effective dose to the population within the 30 km zone of Kozloduy NPP originating only from liquid discharges under all operating modes of the existing and the new nuclear power capacities was estimated to be 1.63 μSv/a. This radiation is negligible and is below 0.16 % of the annual limit on the effective dose of 1 mSv (BNRP-2012) and hundreds of times lower than the exposure from the natural background radiation (2.33 mSv/a).

TABLE 5.11-18: CUMULATIVE IMPACT IN THE 30-KM ZONE FROM GAS-AEROSOL LIQUID EMISSIONS

Source description	Maximum individual effective dose from gas-aerosol discharges	Maximum individual effective dose from liquid discharges	Maximum individual effective dose total
	[Sv]		
Kozloduy NPP 2012 + DP1-4 + PIF + AP-1000	1.93E-06	1.63E-06	3.56E-06
Kozloduy NPP 2012 + DP1-4 + PIF + AES BBEP-1000/ B466	1.35E-06	8.62E-07	2.21E-06
Kozloduy NPP 2012 + DP1-4 + PIF + EUR limits of discharge	1.94E-06	9.44E-07	2.88E-06

The estimates for the dose effect of the Kozloduy NPP discharges are fully comparable with the world practice as specified in the official data of the United Nations (UNSCEAR-2000, 2008).

In accordance with the guidelines of the NRA by letter No. 47-00-171/12.02.2013 under all operating modes of the Kozloduy NPP, the annual individual effective dose from internal and external exposure of the population, caused by the impact of liquid and gaseous discharges to the environment for all units and facilities located and to be located at the site of Kozloduy NPP should not be higher than 0.25 mSv. The maximum annual effective dose to the population within the 30 km zone of Kozloduy NPP (cumulative impact) due to liquid and gaseous emissions to the environment was estimated to be 3.56 μSv/a, which is much lower than the quota of 250 μSv/a and the norm for the population is 1 mSv/a (BNRP-2012), which is below the clearance level 10 μSv/a (BNRP-2012). The obtained additional dose loading is about 500 times lower than the natural background radiation (2.33 mSv).

5.11.3 ASSESSMENT OF RADIOBIOLOGICAL IMPACT AND RADIATION RISK FOR REFERENCE INDIVIDUAL

5.11.3.1 MODELS AND SOFTWARE FOR ASSESSMENT OF THE RADIOBIOLOGICAL IMPACT AND RADIATION RISK FOR REFERENCE INDIVIDUAL

Assessment of the radiobiological impacts and the radiation risk for a reference individual in case of radioactive discharges from the nuclear plant is carried out using the Program HeConEmpPop (Health consequences for employees and population). The modelling program formalizes the methodology for assessing the radiobiological impact and the radiation risk, according to ICRP Publication 103, The 2007 Recommendations of the International Commission on Radiological Protection.

The modelling programs used to evaluate the individual and collective effective dose to the population from the radioactive discharges into the environment are verified and validated.

5.11.3.2 RESULTS

The estimates of the cumulative dose impact of the existing and the new nuclear power capacities are fully comparable with the global practice, according to the official data of the United Nations (UNSCEAR-2000, 2008).

According to statistical data from the National Statistical Institute of the census of 01.02.2011 the population within the 30 km zone around the Kozloduy NPP in the territory of the Republic of Bulgaria is 65994 people, while on Romanian territory is 75 150 people. The following conclusions may be considered for the population regarding the effects of radiobiology and radiation risk due to the cumulative impact of the existing and new nuclear power capacities:

Deterministic impacts

There is no risk of deterministic effects on the population in the 30 km zone of Kozloduy NPP.

Individual doses of gas-aerosol discharges in accumulation with all nuclear facilities and NNU are within the norm 1.35.10-6 ÷ 1.94.10-6 Sv (See **Table 5.11-8**).

These doses are much lower than the threshold specified in Art. 10 BNRP limit for annual effective dose, which is 1 mSv per capita.

On that basis, it is argued that there is no risk of deterministic effects for the population within the 30 km zone of the NPP.

Stohastic impacts

Risk of stochastic effects is negligible.

Likelihood of radiation-induced cancer in the whole population is therefore: 1.06h10^{-7} for the existing nuclear plants + AP-1000; 7.43x10^{-8} for existing nuclear plants + AES BBEP-1000/V466 and 1.07x10^{-7} for the existing nuclear facilities + EUR limit discharges, and the likelihood of hereditary diseases is therefore: 3.86x10^{-9} for the existing nuclear plants + AP-1000; 2.7x10-9 for the existing nuclear plants + AES BBEP-1000/V466 and 3.88x10^{-9} for existing nuclear plants + EUR limits discharges.

The tables below provide detailed assessments of the cumulative radiobiological effects and radiation risk from the existing and new nuclear power capacities:

- **Table 5.11-19** – Risks taking into account the damage from radiation-induced cancer and hereditary diseases for the general population and for those of active employment age;
- **Table 5.11-20** – Risks and damage to some tissues for the population as a whole;
- **Table 5.11-21** ÷ **Table 5.11-23** – Risks of inherited diseases of the reproductive part of the population evaluated for two generations with exposure of one generation after another and assessment for the first generation after exposure.

TABLE 5.11-19: RISKS ACCOUNTING FOR THE DAMAGES FROM RADIATION INDUCED CANCER AND HEREDITARY ILLNESSES FOR THE WHOLE POPULATION AND THE PERSONS WITHIN ACTIVE EMPLOYMENT AGE

NNU	Cancer		Hereditary effects		Total	
	Whole population	Persons in active employment age	Whole population	Persons in active employment age	Whole population	Persons in active employment age
Kozloduy NPP 2012 + DP1-4 + PIF + **EUR limits of discharge**	1.07E-7	7.95E-8	3.88E-9	1.94E-9	1.11E-7	8.15E-8
Kozloduy NPP 2012 + DP1-	1.06E-7	7.91E-8	3.86E-9	1.93E-9	1.10E-7	8.11E-8

4 + PIF + **AP 1000**						
Kozloduy NPP 2012 + DP1-4 + PIF + **AES BBEP-1000/ B466**	7.43E-8	5.57E-8	2.70E-9	1.35E-9	7.70E-8	5.67E-8

TABLE 5.11-20: ASSESSMENT OF THE RISK AND DAMAGES FOR SOME TISSUES FOR THE POPULATION AS A WHOLE

Tissue/Organ	Nominal risk (cases per 10 000 persons)	Nominal risk accounting for the lethal outcome case	Damage
	Kozloduy NPP 2012 + DP1-4 + PIF **+ *EUR limits of discharge***		
oesophagus	2.91E-05	2.93E-05	2.55E-05
stomach	1.53E-04	1.49E-04	1.31E-04
colon	1.26E-04	9.58E-05	9.30E-05
liver	5.82E-05	5.86E-05	5.16E-05
lungs	2.21E-04	2.19E-04	1.75E-04
bones	1.36E-05	9.89E-06	9.89E-06
skin	1.94E-03	7.76E-06	7.76E-06
mammary gland	2.17E-04	1.20E-04	1.55E-04
ovaries	2.13E-05	1.71E-05	1.91E-05
bladder	8.34E-05	4.56E-05	3.24E-05
thyroid gland	6.40E-05	1.90E-05	2.45E-05
marrow	8.15E-05	7.31E-05	1.19E-04
other solids	2.79E-04	2.14E-04	2.20E-04
gonads	3.88E-05	3.74E-05	4.94E-05
Total	**3.33E-03**	**1.10E-03**	**1.11E-03**
	Kozloduy NPP 2012 + DP1-4 + PIF **+ *AP-1000***		
oesophagus	2.90E-05	2.91E-05	2.54E-05
stomach	1.52E-04	1.49E-04	1.31E-04
colon	1.25E-04	9.53E-05	9.25E-05
liver	5.79E-05	5.83E-05	5.13E-05
lungs	2.20E-04	2.18E-04	1.74E-04
bones	1.35E-05	9.84E-06	9.84E-06
skin	1.93E-03	7.72E-06	7.72E-06
mammary gland	2.16E-04	1.19E-04	1.54E-04
ovaries	2.12E-05	1.70E-05	1.90E-05
bladder	8.30E-05	4.54E-05	3.22E-05
thyroid gland	6.37E-05	1.89E-05	2.44E-05
marrow	8.11E-05	7.28E-05	1.19E-04
other solids	2.78E-04	2.13E-04	2.19E-04
gonads	3.86E-05	3.72E-05	4.92E-05
Total	**3.31E-03**	**1.09E-03**	**1.11E-03**

Tissue/Organ	Nominal risk (cases per 10 000 persons)	Nominal risk accounting for the lethal outcome case	Damage
*Kozloduy NPP 2012 + DP1-4 + PIF + **AES BBEP-1000/ B466***			
oesophagus	2.03E-05	2.04E-05	1.77E-05
stomach	1.07E-04	1.04E-04	9.15E-05
colon	8.78E-05	6.67E-05	6.47E-05
liver	4.05E-05	4.08E-05	3.59E-05
lungs	1.54E-04	1.52E-04	1.22E-04
bones	9.45E-06	6.88E-06	6.88E-06
skin	1.35E-03	5.40E-06	5.40E-06
mammary gland	1.51E-04	8.36E-05	1.08E-04
ovaries	1.49E-05	1.19E-05	1.33E-05
bladder	5.81E-05	3.17E-05	2.25E-05
thyroid gland	4.45E-05	1.32E-05	1.71E-05
marrow	5.67E-05	5.09E-05	8.30E-05
other solids	1.94E-04	1.49E-04	1.53E-04
gonads	2.70E-05	2.61E-05	3.44E-05
Total	**2.32E-03**	**7.63E-04**	**7.75E-04**

TABLE 5.11-21: ASSESSMENT OF THE RISK OF HEREDITARY ILLNESSES

Class of illness	Two generations			Firs generation		
	For the whole population, average in %			For the whole population, average in %		
	Kozloduy NPP 2012 + DP 1-4 + PIF + **EUR limits of disch.**	Kozloduy NPP 2012 + DP 1-4 + PIF + **AP 1000**	Kozloduy NPP 2012 + DP 1-4 + PIF + **AES BBEP-1000/B466**	Kozloduy NPP 2012 + DP 1-4 + PIF **+ EUR limits of disch.**	Kozloduy NPP 2012 + DP 1-4 + PIF + **AP 1000**	Kozloduy NPP 2012 + DP 1-4 + PIF + **AES BBEP-1000/B466**
Illnesses caused by chemical elements	1.55E-07	1.08E-07	1.43E-09	9.70E-08	6.75E-08	8.95E-10
Chronic illnesses	5.82E-08	4.05E-08	5.37E-10	5.82E-08	4.05E-08	5.37E-10
Congenital anomalies	2.13E-07	1.49E-07	1.97E-09	1.55E-07	1.08E-07	1.43E-09
Total	**4.26E-07**	**2.98E-07**	**3.94E-09**	**3.10E-07**	**2.16E-07**	**2.86E-09**

TABLE 5.11-22: ASSESSMENT OF THE RISKS OF HEREDITARY ILLNESSES FOR THE REPRODUCTIVE PART OF THE POPULATION, ASSESSED FOR TWO GENERATIONS (RADIATION FOR ONE GENERATION AFTER THE OTHER)

Class of illness	Reproductive population	
	Range in %	Average in %

Kozloduy NPP 2012 + DP1-4 + PIF + **EUR limits of disch.**		
Illnesses caused by chemical elements	2.522E-07 – 4.85E-07	3.69E-07
Chronic illnesses	5.82E-08 – 2.328E-07	1.55E-07
Congenital anomalies	4.656E-07 – 5.82E-07	5.24E-07
	Total	**1.05E-06**
Kozloduy NPP 2012 + DP1-4 + PIF **+ AP 1000**		
Illnesses caused by chemical elements	1.755E-07 – 3.375E-07	2.57E-07
Chronic illnesses	4.05E-08 – 1.62E-07	1.08E-07
Congenital anomalies	3.24E-07 – 4.05E-07	3.65E-07
	Total	**7.30E-07**
Kozloduy NPP 2012 + DP1-4 + PIF + **AES BBEP-1000/B466**		
Illnesses caused by chemical elements	2.327E-09 – 4.475E-09	3.40E-09
Chronic illnesses	5.37E-10 – 2.148E-09	1.43E-09
Congenital anomalies	4.296E-09 – 5.37E-09	4.83E-09
	Total	**9.66E-09**

TABLE 5.11-23: ASSESSMENT OF THE RISKS OF HEREDITARY ILLNESSES FOR THE REPRODUCTIVE PART OF THE POPULATION, ASSESSED FOR FIRST GENERATIONS AFTER THE RADIATION

Class of illness	Reproductive population	
	Range in %	**Average in %**
Kozloduy NPP 2012 + DP1-4 + PIF + **EUR limits of disch.**		
Illnesses caused by chemical elements	1.455E-07 – 2.91E-07	2.13E-07
Chronic illnesses	4.85E-08 – 2.328E-07	1.36E-07
Congenital anomalies	---	3.88E-07
	Total	**7.37E-07**
Kozloduy NPP 2012 + DP1-4 + PIF + **AP-1000**		
Illnesses caused by chemical elements	1.013E-07 – 2.025E-07	1.49E-07
Chronic illnesses	3.375E-08 – 1.62E-07	9.45E-08
Congenital anomalies	---	2.70E-07
	Total	**5.14E-07**
Kozloduy NPP 2012 + DP1-4 + PIF + **AES BBEP-1000/B466**		
Illnesses caused by chemical elements	1.343E-09 – 2.685E-09	1.97E-09
Chronic illnesses	4.475E-10 – 2.148E-09	1.25E-09
Congenital anomalies	---	3.58E-09
	Total	**6.80E-09**

5.12 CUMULATIVE IMPACTS REGARDING THE CULTURAL HERITAGE COMPONENT

There is no expected potential for cumulative impacts with respect to the component for cultural heritage.

5.13 MATRIX FOR CUMULATIVE IMPACTS

Within the 30 km zone around the Kozloduy NPP and alternative sites for the implementation of AI have been identified both existing and future implementation of other investment proposals, which are expected cumulative impact of NNU.

Table 5.13-1 below presents a summary matrix of the identified cumulative impacts – cumulative effects resulting from the superimposition of the effects of the activities on the implementation of the IP.

TABLE 5.13-1: MATRIX FOR CUMULATIVE IMPACTS

Activities for the implementation of the IP – construction, operation and decommissioning	Environment components for which there is expected cumulative impact								
IP activities, which may generate cumulative impacts:	**Atmospheric air**	**Surface waters**	**Groundwater**	**Soils**	**RAW**	**Biological diversity**	**Thermal impact**	**Health and hygiene aspects**	**Radiation risk**
From transportation during the construction, operation and decommissioning (DP)		x	x	x	x	x	x	x	
Discharge of wastewater during operation and DP	x		x	x	x	x	x	x	x
Discharge of cooling water during operation	x	x	x	x	x	x		x	x
RAW generation during operation and DP DP	x	x	x	x		x	x		
Gas-aerosol discharge during operation									
Liquid discharges during operation									
Combined cumulative impacts with other investment projects: decommissioning of units 1÷4, PIF and NDSRW at the Kozloduy NPP site									
Discharge of wastewater	x		x	x	x	x	x	x	x
RAW generation	x	x	x	x		x	x		
Gas-aerosol discharge									
Liquid discharges									

Key:	Changes of the environment component:
	Negative cumulative impacts of high significance
	Negative cumulative impact of moderate significance
	Negative cumulative impact of low significance
x	No cumulative impacts
	Positive cumulative impact