ENVIRONMENTAL IMPACT ASSESSMENT REPORT

for Investment Proposal:

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

CHAPTER 3: DESCRIPTION AND ANALYSIS OF COMPONENTS AND FACTORS OF THE ENVIRONMENT AND CULTURAL HERITAGE THAT SHALL BE LARGELY AFFECTED BY THE INVESTMENT PROPOSAL AND THE INTERACTION BETWEEN THEM

3.9. HARMFUL PHYSICAL FACTORS

3.10. HEALTH AND SANITARY ASPECTS OF THE ENVIRONMENT AND RISK TO HUMAN HEALTH

3.11. RADIATION RISK TO THE POPULATION IN THE EVENT OF RADIOACTIVE RELEASES

3.12. CULTURAL HERITAGE

☒ original

☐ copy

DEVELOPED BY:	NELLY GROMKOVA – TL VERJINIA DIMITROVA – PM	VERSION:
VALIDATED BY:	TZVETANKA DIMITROVA – TQ CONTROL EXPERT	DATE:

CONTENTS

LIST OF FIGURES

LIST OF TABLES

3 DESCRIPTION AND ANALYSIS OF COMPONENTS AND FACTORS OF THE ENVIRONMENT AND CULTURAL HERITAGE THAT SHALL BE LARGELY AFFECTED BY THE INVESTMENT PROPOSAL AND THE INTERACTION BETWEEN THEM

3.9 HARMFUL PHYSICAL FACTORS

3.9.1 NOISE

The site for the construction of the new nuclear unit will be situated adjacent to or at the Kozloduy NPP site. Four alternative locations have been suggested. The on-site inspection established that at present there are no sources of noise at Sites 1, 2 and 3. Site 4 represents a built-up production and storage areas with limited diverse activity. Six nuclear power units are deployed at the Kozloduy NPP site, with units 5 and 6 still in operation, and the remaining ones have been shut down.

The sources of noise within the territory of the Kozloduy NPP are the basic and auxiliary equipment and the transport associated with the production activity. The majority of the facilities are located in confined spaces in the buildings existing at the NPP site – power units, special buildings, a RAW Processing Plant, chemical plants, circulation pump stations, nitrogen-oxygen, compressor and diesel generator stations, workshops, etc. When there is no passport data on the noise characteristics of the different sources of noise, the noise emissions of the equipment situated in the buildings can be estimated on the basis of the noise levels measured at the workplaces near the specific equipment. According to data from the 1999 EIAR on the Kozloduy NPP, the highest noise levels measured at workplaces situated near specific equipment were:

Power unit 6 (resp. 5)

- ✓ Instrumental compartment – within the range 85.5 dBA – 88.6 dBA;
- ✓ Turbine Hall (noise sources at elevation levels from 0.00 to 33.00 – turbosupply and condensation pumps, turbines, BOU filters, steam ejectors, deaerator column, main steam collector) – within the range 90.0 dBA – 114.5 dBA.

Circulation pump station – 4

- ✓ Turbine Hall – 93.8 dBA.

General stationary complex

- ✓ Carpeneter's workshop – 97.6 dBA;
- ✓ Compressor station – 90.6 dBA;
- ✓ Nitrogen-oxygen station– 86.9 dBA;

The level of the noise transferred to the environment outside the production buildings can be estimated on the basis of the noise levels measured in the buildings (at the workplaces) and the sound insulation of their external surrounding constructions. The buildings are solid, with average sound insulation of the constituent external walls (dense and glazed part) within the range 30 dB – 35 dB, which considerably reduces the noise level from the technological equipment that has passed through them and into the environment.

The major outdoor sources of noise at the NPP site are: the transformer platforms of the outdoor switchgears (400 kV, 220 kV, 110 kV), the ventilation systems of Specialised Buildings 1, 2 and 3, the pumps for the spray ponds and the internal transport.

The mode of operation of the Kozloduy NPP is around-the-clock, 24/7.

The noise regime at the plant's site was established through noise measurements under real conditions, during the development of the 1999 EIA for the Kozloduy NPP. The equivalent noise level was measured at selected locations of the site, near the major sources of noise into the environment – outdoor switchgears, WWTP, ventilation systems, transport vehicles, etc. The established noise levels were within the range 52 dBA – 97 dBA. At some locations, between the buildings and the outdoor facilities, the noise levels exceed the hygiene standards for industrial areas – 70 dBA. The results of the noise measurements were recorded in Protocol 12/08.1999 – Appendix 3.9–1. The conclusion was that the production activity at the Kozloduy NPP site is not a source of noise for the territory of the closest settlement – town of Kozloduy – due to the great distance from the site (2.6 km). The study of the noise regime was conducted in compliance with the applicable legislation at the time when the EIA Report was prepared.

New measurements to determine the noise regime at the Kozloduy NPP site were conducted in 2010 by the MEW, and specifically the Regional Laboratory of the Pleven RIEW, in accordance with the methodology for establishing the total sound power emitted to the environment by an industrial plant and establishing the noise level at the location of impact, MEW, 2007. (Protocols №618 and 621 from 13.09.2010). The measurements were conducted along two measurement contours. The first contour encompasses Electricity Production–1 (EP–1), which includes units 1÷4, while the second contour encompasses Electricity Production–2 (EP–2), which includes units 5 and 6. The contours also include the auxiliary facilities of the reactors that are major sources of noise. The protocols referred to above present the measurement contours, the positions of the **measurement points** (MPs) and the readings of the equivalent noise levels at each of them. The noise levels measured along the first contour were within the range 44.8 dBA – 62.5 dBA, distributed along the contour in the following manner:

- MP1 to MP7 (south) – between 44.8 dBA and 47.7 dBA;
- MP8 to MP14 (south) – between 48.8 dBA and 59.8 dBA;
- MP15 to MP22 (south) – between 55.3 dBA and 62.5 dBA;
- MP23 to MP29 (south) – between 48.6 dBA and 57.3 dBA;

The noise levels measured along the second contour were within the range 47.3 dBA – 66.6 dBA, distributed along the contour in the following manner:

- MP1 to MP9 (north) – between 47.3 dBA and 65.7 dBA;

- MP10 to MP15 (west) – between 62.4 dBA and 64.1 dBA;
- MP16 to MP24 (south) – between 50.1 dBA and 66.6 dBA;
- MP25 to MP30 (east) – between 59.4 dBA and 63.3 dBA;

Most values above 60 dBA were measured near outdoor noise sources – transformer platforms, pumps for spray ponds, fans. The indicated values do not exceed the limit of 70 dBA, set for production and storage areas. The same conclusion can be made for the levels of the noise reaching the more distanced boundaries of the NPP site. The calculated total sound power levels for the two contours are: **primary circuit** – 113.7 dBA, **secondary circuit** – 119.1 dBA.

The settlements situated near the Kozloduy NPP site are the following: the town of Kozloduy – 2.6 km, the village of Harlets – 3.5 km, the village of Glozhene – 4.0 km, the town of Mizia – 6.0 km, the village of Butan and the town of Oryahovo – 8.4 km.

Due to the great distances to the settlements the production activity at the Kozloduy NPP site is not a source of noise for their territories.

The Kozloduy NPP site, respectively the sites subject to the EIA, is connected to the national road network via roads **II-11** and **II-15**. The complex is not connected to the national railway network.

The noise characteristics of the traffic flows along roads II-11 and II-15 (equivalent noise level of Leq, dBA) were obtained by calculations based on data provided by the Road Infrastructure Agency on the total profile counting of transport vehicles, conducted in 2010. The calculations were made in accordance with the methodology stipulated in Regulation №6 on the parameters for noise in the environment, considering the degree of discomfort during the different hours of the day, the limit values for the parameters for noise in the environment, the methods for evaluation of the noise parameters and the adverse effects of noise on public health (MH, MEW, SG 58/2006),, and the Methodology for establishing the road transport noise for the purposes of road construction (Roads General Directorate, 1995). The equivalent noise level was established at a distance of 7.5 m from the axis of the closest traffic lane at a speed of 80 km, longitudinal slope of the road under 5% and asphalt concrete surface. The noise characteristics of the flow were established for two periods: daytime (07.00 – 23.00) and night-time (23.00 – 07.00), where the evening time period envisaged in Regulation №6 (19.00 – 23.00) was included into the daytime period, since the aforesaid Regulation stipulates parameters for the traffic flow of both of these periods – in terms of intensity (road vehicles/hour) and structure (portion of heavy vehicles and buses in %), pursuant to the above methodology of the Roads General Directorate. The resulting noise characteristics were as follows:

- Road II–11 – section Kozloduy – Lom (ДПП 205) – daytime – 63.3 dBA, night-time – 54.1 dBA; section Mizia – Kozloduy (ДПП 496) – daytime – 71.6 dBA, night-time – 62.5 dBA.
- Road II–15 – section Borovan – Mizia (ДПП 547) – daytime – 69.4 dBA, night-time – 60.8 dBA.

The traffic flows also include the buses carrying the workers to and from the Kozloduy NPP. According to data provided by the Client, they make 40 trips per day. The noise characteristics of the buses used by the NPP are: Setra 215 ND and Setra 315 ND – 74 dBA, Mercedes and Mercedes Tourismo – 76 dBA, Iveco – 74 dBA.

The limit values for the noise level of different areas and development zones are outlined in Regulation № 6 on the parameters for noise in the environment (MH, MEW, SG No. 58/2006). For residential areas, they are: daytime – 55 dBA, evening time – 50 dBA, night-time – 45 dBA, and for residential areas exposed the impact of heavy traffic: daytime – 60 dBA, evening time – 55 dBA, night-time – 50 dBA, and for industrial and storage areas – 70 dBA for daytime, evening time and night-time.

The traffic flows along the main roads in the area (II-11 and II-15) are a significant source of noise for the residential areas located near the settlements through which they pass. For travel speed of 50 km/h (within settlements), the noise characteristics will be about 3 dBA lower than the ones stated above. For the residential areas of the town of Kozloduy which are adjacent to the road, the equivalent level of traffic noise, average for the whole 24-hour period, is close to the hygiene standard of 60 dBA. In the rush hour, within the interval 7.15 – 8.15, measurements were made in front of the House of Energy, resulting in equivalent levels of traffic noise of 65 dBA, 67 dBA and 72 dBA, according to data from Protocol№12/08.08.1999 to the EIA Report on the Kozloduy NPP. The hygiene standard for a 48-hour period is exceeded by about 8 dBA at the village of Harlets and the village of Glozhene, and by about 10 dBA in the town of Mizia, where the traffic flows of the two roads pass through a single route.

3.9.2 Vibrations

There is no data about any existing technological vibrations in the environment of the Kozloduy NPP site. The 1999 EIA Report on the Kozloduy NPP concluded that the technological vibrations do not occur in the space between the installations and the environment outside the plant site, and that they are therefore only a factor for the work environment (around the turbine generators, steam ejectors, compressors, etc.). The existing design-based technological equipment is not source of vibrations to the environment. For machinery and equipment, the propagation of vibrations beyond their source is limited through the implementation of specific technical requirements during their installation: anti-vibration treatment of their baseplates and fundaments by means of rubber pads, isolating gaps filled with vibration-quenching materials, elimination of the rigid connections between vibrating areas and structural elements of the premises, etc. The vibrations at industrial sites are a factor only for the working environment.

The transport vehicles servicing the operation of the Kozloduy NPP are not sources of vibrations to the environment. They use travel along class II roads from the national road network, consistent with the category of the traffic, and as a result the vibrations from heavy vehicles subside over short distances around the road route.

3.9.3 NON-IONIZING RADIATION

Non-ionizing radiation (NIR) includes the following physical phenomena:

- ✓ Electric field, with intensity, **E** [V/m].
- ✓ Magnetic field, with magnetic induction **B** [T[1]].
- ✓ Extremely low frequency (ELF) electric and magnetic fields,; frequency from **f** > 0 Hz to **f** = 300 Hz. It is measured in the aforesaid units.
- ✓ Radio frequency (RF) electromagnetic fields (EMF). The assessment is made based on the variables for intensity of the electric field **E** [V/m] and intensity of the magnetic field **H** [A/m].
- ✓ Super-high frequencies (SHF); microwaves. The assessment is made based on the power density of the EMF – **S** [W/m^2].
- ✓ Optical radiations (ultraviolet, visible and infrared radiation). The assessment is made based on variables such as power density **S** [W/m^2];light flux **Φ** [lx[2]] etc.
- ✓ Laser radiations. The assessment is made based on the following parameters – power **P**, energy **Q**, power density **S** [W/m^2] and/or energy density **W** [J/m^2].

3.9.3.1 SOURCES OF NON-IONIZING RADIATION TO THE ENVIRONMENT

There are natural and artificial sources of NIR, and they are different for the respective frequency bands included into the NIR spectrum.

The most common emitters of NIR to the environment are the high-voltage power lines, outdoor switchgears, communication systems – radio stations transmitting at long, medium, short and ultra-short frequencies, base stations for mobile communications, radar systems, etc.

In everyday life such sources are all household appliances, electrical installations, communication systems, etc. People are also irradiated with different NIR in the electric transport vehicles, at disco clubs, in medical facilities, etc.

In this regard, NIRs can be included into the list of the so-called "universal factors," i.e. ones that are encountered everywhere, much like local climate and other similar factors.

3.9.3.2 IMPACT OF ELF FIELDS ON HUMAN HEALTH AND THE ENVIRONMENT

Non-ionizing radiation, even at high frequencies, cannot cause ionization in a biological system. However, they do cause other biological effects – for instance due to heating, influencing chemical reactions in the body, or by inducing electric currents and fields in tissues and cells.

ELF fields, apart from inducing in the human body electric currents that could lead to various adverse effects, have been included into the list of the so-called "type 2B cancerogens" – ones with "possible" cancerogenic impact. There is evidence from

---

[1] 1 Tesla (T) is the unit used to measure the density of the magnetic field.

[2] 1 lux (lx) = 1 lumen per square metre – the unit of illumination.

epidemiological studies that the presence of such fields coincides with elevated incidence of various forms of cancer and pin particular – leukaemia in children and some forms of cancer affecting the central nervous system. Such fields can also lead to electric shock upon contact with conductive parts or with solid metal surfaces situated close to power lines.

Legislative Standards

After the repeal of Regulation № 7/1992 г. (SG, issue 46 from 1992) *on the hygienic requirements for health protection for the urban environment,* there is no effective legislative document in the country that regulates the hygienic protection zone around 110, 220 and 400 kV power lines.

In our legislation there is a requirement for **easement zones** around 110, 220 and 400 kV power lines – Regulation № 16/2004 *on the easements for the energy sites of the Ministry of Energy and Energy Resources, the Ministry of Agriculture and Forestry, and the Ministry of Regional Development and Public Works*(amended in SG issue 88 from 8.10.2004), which limits the construction of buildings and facilities and the planting of high-stem vegetation within certain boundaries around the site, where the distance from the outer wires of Overhead Power Lines (OPL), at their greatest deviation to the nearest parts of the buildings and facilities, is calculated for each specific case..

The Regulation states that *„no easement zone is envisaged around the main site of an outdoor switchgear“* (OSG) due to the fact that these facilities are placed within technical enclosures that do not allow any impact of electric and magnetic fields from the OSG on the population.

The following safety band is required along OPL routes:

For routes passing through settlements and settlement formations:

For 110 – 400 kV OPLs, the horizontal distance between the outer wires, at the maximum deviation, plus:

- ✓ *8 m for 110 kV OPL – 4 m on both sides;*
- ✓ *12 m for 220 kV OPL – 6 m on both sides;*
- ✓ *18 m for 400 kV OPL – 9 m on both sides.*

The same normative act outlines exact distances for the transformer switchgear and other facilities within the work environment of outdoor switchgears (within the technical enclosure of the site).

For the protection of the **personnel operating in work areas**, if the stay of people is possible and the technology requires it, measurements on the electric and magnetic fields should be taken. The measured values can be compared to those envisaged in Regulation № 7/23.09.1999 of the Ministry of Labour and Social Policy and the Ministry of Health *"...on the minimum requirements for health and safety at work and when operating equipment"* (SG issue 88 from 8.10.1999, effective as of 09.01.2000), stipulating the maximum admissible values of electric and magnetic fields within the frequency band from 0 Hz to 60 kHz, i.e. for the fixed and variable fields (electric and magnetic – ELF), as well as for a small part of the radio frequency band.

Pursuant to this Regulation, the maximum admissible values for electric and magnetic fields are the following:

1. *For frequencies **1** – **100** Hz:*

Intensity of the electric field: 25 kV/m, density of the magnetic flux (magnetic induction): 60/**f** [mT], where **f** [Hz] is the frequency of the EMF.

2. *For frequencies **100** Hz – **4**kHz:*

Intensity of the electric field: 2.5 x 10^6 V/m, density of the magnetic flux (magnetic induction): 60/**f** [mT].

3. *For frequencies **4** kHz – **60** kHz:*

Intensity of the electric field: 625 V/m, density of the magnetic fluxes (magnetic induction): 60/**f** [mT].

Additional limitations have been stipulated for individuals with implanted cardio-stimulators, as follows:

4. For frequencies < 6 Hz: 1 mT.
5. For frequencies of 50 Hz: 0.1 mT.

The maximum admissible value for magnetic induction at a frequency of 50 Hz is 1.2 mT. For individuals with cardio-stimulators, the admissible value for magnetic induction is B = 1 mT.

Other legislative documents that must be taken into account are: Regulation № 8 from 1999, SG issue 72, *"on the rules and standards for the deployment of technical lines and facilities within settlements"* and Regulation № 9 from 2004, SG issue 72, *"on the technical operation of power plants and networks".*

Regarding settlements, they are only affected by Regulation № 9 from 1991 *"on the maximum admissible levels of electromagnetic fields within populated territories and establishing safety zones around emitting sites"* (SG issue 35 from May 3, 1991, later amended by SG issue 8 from January 22, 2002). It establishes the standards and requirements aimed at protecting the population from the adverse impact of electromagnetic fields (EMF) by means of calculating the boundaries of the safety zone around each stationary emitter situated within a settlement and the subsequent measurement of EMF values within the frequency band from 30 kHz to 30 GHz – **Table 3.9-1.**

TABLE 3.9-1: MAXIMUM ADMISSIBLE LEVELS OF INTENSITY AND POWER DENSITY OF THE EMF FLOW WITHIN POPULATED AREAS

№	Frequency range within which the emitter operates	Maximum admissible noise level
1.	from 30 to 300 kHz	25 V/m

№	Frequency range within which the emitter operates	Maximum admissible noise level
2.	from 0.3 to 3 MHz	15 V/m
3.	from 3 to 30 MHz	10 V/m
4.	from 30 to 300 MHz	3 V/m
5.	from 0.3 to 30 GHz	10 μW/cm^2

For the remaining frequency ranges, the international regulations are applied: ICNIRP (International Commission on Non-Ionizing Radiation Protection) Guidelines, 1998, 2010, and Recommendation of the European Union (Council Recommendations 1999/519/EC).

The *European Commission* in *Recommendation 1999/519/EC* adopted the following limit values for

1. **public exposure within the frequency range 0.025÷0.8 kHz (25÷800 Hz):**
   - ✓ intensity of the electric field: **E** = 250/**f** [V/m];
   - ✓ density of the magnetic flux: **B** = 5/**f**, [μT] (1Tesla = 10^4 Gauss);
   - ✓ intensity of the magnetic field: **H** = 4/**f** [A/m].
2. **industrial frequency 50 Hz; the calculated reference limit values are the following:**
   - ✓ intensity of the electric field: **E** = 5000 V/m;
   - ✓ density of the magnetic flux: **B** = 100 μT;
   - ✓ intensity of the magnetic field: **H** = 80 A/m.

Other applicable provisions are those of the Health Act from January 1, 2005, last amended by SG issue 9 frm January 28, 2011.

3.9.3.3 EMP AT THE KOZLODUY NPP SITE

The sub-sites and facilities constructed to date at the Kozloduy NPP site, which are significant in terms of possible effects of non-ionizing radiation, are the outdoor switchgears, consisting of three parts: 110 kV, 220 kV, 400 kV. The Kozloduy NPP is connected to the Electric Power System (EPS) of the Republic of Bulgaria by means of three installations, called Outdoor Switchgears (OSG), with 400 kV, 220 kV and 110 kV voltages. The connections between them are established via auto-transformers. The 400 kV installations are realized according to the "double sectioned busbar system", the 220 kV installations – according to the "double busbar system", and the 110 kV installations – according to the "double busbar system with a bypass busbar".

The main sources of ELF electric and magnetic fields (with an industrial frequency of 50 Hz) within the working environment are the Open Switchgears (OSG) of the transformer installations, the busbar systems, the circuit-breakers, and the power lines. Sources of ELF fields (mainly magnetic) can also be the turbine generators, the rectifiers, and the low-voltage power supply systems.

Sources of radio frequency and microwave (ELF) electromagnetic radiation in the Kozloduy NPP are found in:

- ✓ security systems;
- ✓ mobile connection systems;
- ✓ emergency public address systems.

The measurements on the intensity of the electric field and the magnetic induction, conducted by specialists from the National Centre for Public Health Protection in 1999 and 2001 at a frequency of 50 Hz (industrial frequency) within the working environment of the OSG demonstrated the following – **Table 3.9-2**.

TABLE 3.9-2: MEASURED INTENSITIES OF THE ELECTRIC FIELD AND THE MAGNETIC INDUCTION

	At busbars A, B, C			At transformers		
	E_{ave}	E_{max}	B_{max}	E_{ave}	E_{max}	B_{max}
	kV/m		µT	kV/m		µT
OSG 110 kV	4.96	9.26	3.67	5.97	8.92	14.3
OSG 220 kV	14.2	34.9	40.7	6.45	11.23	3.67
OSG 440 kV	17.8	29.3	18.5	15.36	30.6	no data

As evident from the presented data, the maximum admissible values for the industrial frequency electric field may only be exceeded within the working environment of individual points at OPYs with 220 and 400 kV voltages.

The values of magnetic induction are multiple times below the admissible ones and cannot create any risk to the health of the workers.

As already mentioned, outdoor switchgears are surrounded by technical enclosures and therefore it is inappropriate to discuss the effects of industrial frequency EMF on the population in the area of the outdoor switchgears, regardless of the voltage applied.

Other sources of industrial frequency EMFs are the indoor switchgears, transformers, high-voltage (over 100 kV), medium-voltage (up to 20 kV) and low-voltage (220 V) power lens. For such systems the measurements conducted in the country show that the electric field does not exceed the values **E** = 100 V/m, and the magnetic induction does not exceed **B** = 0.01 mT.

Apart from industrial frequency electric and magnetic fields, the turbines and generators within the working environment of the power plant create EMF with higher frequencies: ones harmonic to the main (industrial) frequency, as high as **f** = 1-2 kHz. These EMF are within the spectrum of low EMF frequencies and they are governed only by a national normative act on the working environment, as clarified above. The measurements conducted around such turbines show that the electric field has an intensity of **E** = 10–50 V/m, and the magnetic field reaches **B** = 0.01–0.1 mT.

Upon comparing the normative documents on the working environment, we notice that these values are within the limit values presented above. Only in close proximity to the turbines (up to 1 m) the magnetic induction can create problems to individuals with active implants.

There is no data on the emitters of RF and microwaves within the Kozloduy NPP site, which belong to public address systems, local communication systems, etc.

Within the Kozloduy NPP site and the area around it, there are the following sources of EMF belonging to third parties, emitting within the communication frequency ranges:

1. ***Digital Televisions:***

- ✓ The "Kozloduy" Television and Radio Relay Station (TRRS), ID 6250, town of Kozloduy, "Krushov Bair" area.
- ✓ The "Mizia" TRRS, ID 6255, town of Mizia, "Sreden Vrah" area.
- ✓ The "Oryahovo" TRRS, ID 6260, town of Oryahovo, region of Montana, "Hr. Ikonomov" district.
- ✓ The "Oryahovo" Television Retranslator (TVR).
- ✓ The television broadcasting station of the "NTV" (New Television) TV programme, mounted on the "Mizia" TRRS, town of Mizia.

2. ***Mobile Communication Base Stations***

Mtel:

- ✓ "Kozloduy Nova", VRC 0063, town of Kozloduy, res. district 3, bl. 12a, ent. B
- ✓ "Kozloduy 2", VRC 0002, municipality of Kozloduy, "Krushov Bair" area, №3 "Han Tervel" St.
- ✓ "Dunav", VRC 0010, village of Harlets, municipality of Kozloduy, property № 218
- ✓ "Mizia", VRC 0037, town of Mizia, "Mizia" TRRS, "Sreden Vrah" area
- ✓ "Butan", VRC 0005, village of Butan, municipality of Kozloduy, regulated landed property V-1084, district 123
- ✓ "Lovna", VRC 0030, town of Oryahovo, "Oryahovo" hunting lodge.

Globul:

- ✓ № 5520, town of Kozloduy, "Kozloduy" TRRS, "Krushov Bair" area, region of Montana
- ✓ № 5920, town of Kozloduy, regulated landed area №3050
- ✓ "№ 5524, village of Harlets, municipality of Kozloduy, Kozloduy NPP
- ✓ № 5503, town of Mizia, TRRS, "Sredni Vrah" area, region of Vratsa

- № 5903, town of Mizia, "Sredni Vrah" area, property № 276002
- № 5597, town of Oryahovo, № 29 "Aleya Na Mira" St.
- № 5921, town of Oryahovo, "Hristo Ikonomov" residential district, TRRS, municipality of Vratsa, region of Montana
- № 5521, town of Oryahovo, district 133, plot XXVI, tower Telemob 30.

BTC-EAD (with the commercial name Vivacom):

- VZ 6016, town of Kozloduy, region of Vratsa, "Krushov Bair" area, "Kozloduy" RRS
- VZ 6061, municipality of Kozloduy, region of Vratsa, district 2A , bl. 71, ent. C
- VZ 6061, town of Vratsa, № 1 "Simeon Ruskov" St.
- VZ 6168, "Kozloduy" NPP, administrative building, region of Vratsa
- VZ 6049, village of Harlets, municipality of Kozloduy, cadastre unit building
- VZ 6015, town of Mizia, region of Vratsa, "Mizia" TRRS
- VZ 6185, village of Butan,№ 41A "G. Dimitrov" St., municipality of Kozloduy
- VZ 6262, village of Butan, municipality of Kozloduy, property № V-1133, district 99
- VZ 6017, town of Oryahovo, region of Vratsa, TRRS
- VZ 6170, town of Oryahovo, № 16 "9-th of September" St., "Orbita" block

3.9.4 HEAT IMPACT ON THE DANUBE RIVER

3.9.4.1 TEMPERATURE PROFILE OF THE DANUBE RIVER

The temperature profile of the Danube River is highly relevant to the assessment of the impact of spent, warmed-up circulatory waters used for the operation of the power plant. There is evidence of increased water temperature in European rivers by 1-3°C, mainly due to climate change – increasing air temperature, and anthropogenic impact, resulting mainly from the infusion of warmed-up water, which is of local nature.

The heat exchange processes between the Danube River and the environment (without regard to the infusion of warm water from the NPP) depends on the following factors:

- The heat transmitted from the solar radiation;
- The heat expended for evaporation or condensation;
- The heat resulting from turbulent exchange with the atmosphere;
- The transfer of heat from the bottom of the river;
- The heat from liquid precipitation (rain) or its consumption for the melting of solid precipitation (snow, sleet, hail);
- The heat lost to draining or in-flowing water quantities;

- ✓ The heat received or expended for the melting of ice phenomena.

It should be noted that the participation of the individual factors in the heat balance has a different contribution, due to their spatial and temporal variations. Furthermore, all factors have a pronounced day-and-night displacement based on astronomical time.

Throughout the period of operation of the Kozloduy NPP, studies have been performed on a regular basis to determine the impact of the power plant on the temperature profile of the Danube River. During the period 1978-95, 12 research expeditions have been conducted by teams from the UACG. For the purposes of the 1999 EIA report on the Kozloduy NPP, the team that prepared the document, with the assistance of the Kozloduy NPP management, organised a research expedition along the Danube River on August 4 and 5, 1999.

The report analysed and summarised the main results of the research expeditions and the known publications on issues pertaining to the thermal characteristics and their influence on the thermal field of the Danube River.

The water temperature of the Danube River is a hydrological element/indicator, for which the ongoing monitoring began relatively late – after 1941. There are relatively few publications of studies on the temperature profile of the Danube River.

The distribution of the water temperature across the river stream depends on the total amount of water, the season and the hydraulic characteristics of the river section. The maximum temperature variations measured across the width of the river reach 0.2 – 0.4°C with the highest values occurring early in the morning. During the warm season the river is virtually isothermal along its cross-section.

At the depth of the stream, the water temperature, especially in the central part of the river bed, is equal. Infrequent differences in the 0.2 – 0.4°C range are observed in the midstream area. Due to the intensive turbulence-induced displacement and the inertia of the thermal processes in the open streams, in the event of relatively rapid changes of the ambient air temperature, the variations of the water temperature at different depths remain within the 0.2 – 0.4 C range.

The water temperature along the Bulgarian section of the Danube River decreases from Novo Selo to Silistra. Upon cooling the maximum temperature difference in the area is observed in March and reaches 0.5°C. Upon warming the maximum temperature difference between the two points reaches 1.3 °C and is observed in August. A seasonal pattern is outlined with peaks in the summer months.

The changes in the average daily water temperatures for the period 1941-1985, as well as their extremes under the natural regime of the river, without taking into account the impact of the Kozloduy NPP, have shown that in some months the average monthly temperatures tend to differ in some months by more than 3˚C, i.e. the amplitude of the variations of the monthly average water temperatures of the Danube River is compatible to the acceptable normative difference of 3˚C.

The observations on the variations of the water temperatures at different points of the Danube river, although limited, cover different days and seasons and encompass the full annual cycle. The data analysis showed that the smallest daily amplitudes of the water temperatures occur during the months April-May and October-November. Then the daily variations in the water temperature rarely exceed 0.5˚C – 1.2˚C. The biggest daily fluctuations in the water temperature occur during the coldest and the warmest months of the year (for the water) – January and August. In August the daily fluctuations in the water temperature reach 1.6˚C -2.2°C.

The analysis on the changes and fluctuations in the temperature regime of the river is based on data from the "Oryahovo" WP which is situated immediately below the NPP site. The analysis on the data for the period 1981-1985 shows that the average multi-year water temperatures vary from 1.6°C in January to 22.9°C in August, and the average annual temperature is 12.5 °C. **Table 3.9-3** shows the average multi-year temperatures for the "Oryahovo" WP[3].

TABLE 3.9-3: AVERAGE MONTHLY AND ANNUAL TEMPERATURES (°C) OF THE WATER OF THE DANUBE RIVER AT THE "ORYAHOVO" WP (BASED ON DATA FROM 2006)

month	1	2	3	4	5	6	7	8	9	10	11	12	Average
T_{av}	1.6	1.9	5.0	11.3	17.0	20.8	22.2	22.9	19.8	14.0	8.3	3.5	12.5

Table 3.9-4 presents the extreme values for the water temperature in the Bulgarian section during the period 1981 – 1985

TABLE 3.9-4: EXTREME VALUES FOR THE WATER TEMPERATURE (°C) IN THE BULGARIAN SECTION DURING THE PERIOD 1981 – 1985

month		1	2	3	4	5	6	7	8	9	10	11	12
T	min	0.0	0.0	0.0	3.1	11.2	15.7	18.1	16.2	13.7	6.7	0.8	0.0
	max	5.8	7.7	11.0	18.0	24.0	26.0	26.5	28.1	24.8	21.0	13.8	7.7
	ΔT	5.8	7.7	11.0	**14.9**	12.8	10.3	8.4	11.9	11.1	14.3	13.0	7.7

The maximum water temperature in January is 5.8°C, and the absolute maximum temperature measured in August is 28.1 °C.

The maximum monthly amplitude of the water temperature is 14.9°C, occurring in April. The analysis on the temperature profile for the period 1971-1975, in comparison to the period 1941-1970, shows that the average monthly water temperature remained unchanged. An insignificant change in the water temperature from 0.1°C to 0.3°C was

[3] Conducting studies and determining the location of the preferred site for the building of a new nuclear unit at the site of "NPP Kozloduy" EAD and the adjacent territories. A review of the research undertaken, Ref. No. REL-1000-ST-001-2, January 2013.

witnessed during the periods 1941-1980 and 1981-1985 in comparison to the previous two periods.

With regard to the maximum monthly temperatures, a more substantial elevation by about 1.7°C for the month of March is observed during the period 1941-1980 in comparison to the period 1941-1970 and by about 1°C in October during the period 1981-1985 in comparison to the period 1971-1975.

Figure 3.9-1 shows the average daily temperatures for the Lom and Oryahovo WP during the period 2002 – 2012[4].

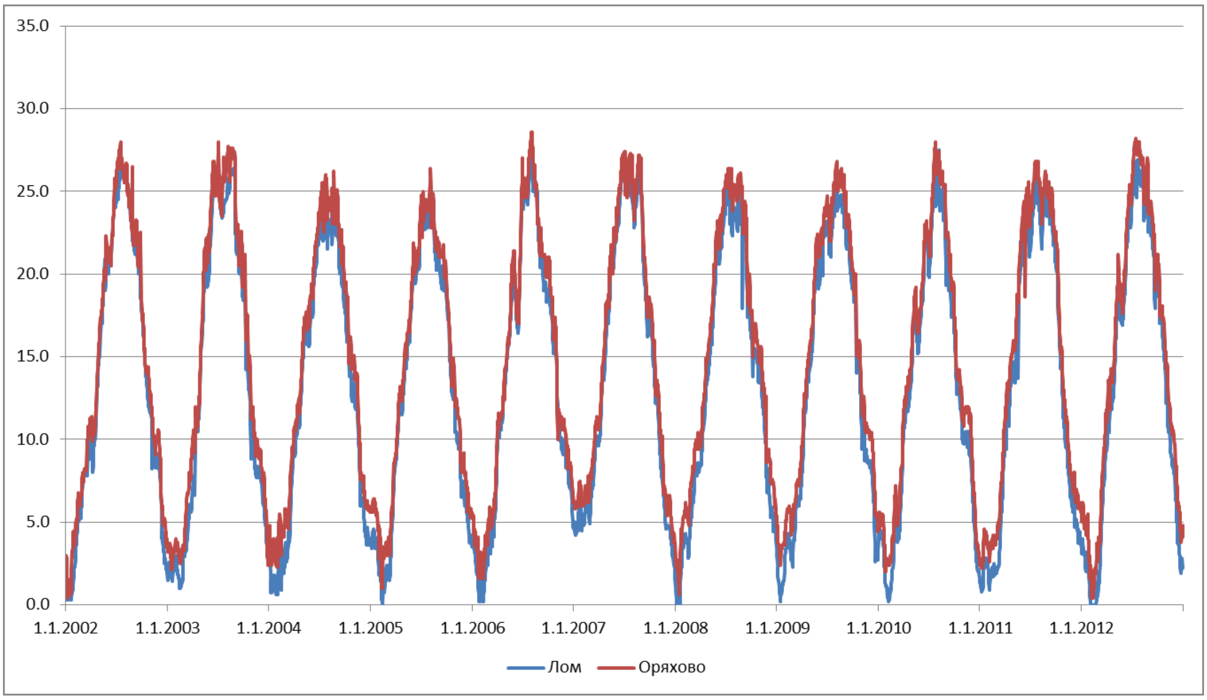

FIGURE 3.9-1: AVERAGE DAILY WATER TEMPERATURES (IN °C) AT THE ORYAHOVO AND LOM STATIONS FOR THE PERIOD 2002-2012

3.9.4.2 THERMAL POLLUTION

The change of the river's temperature profile caused by the discharging of warmed-up waters from the Kozloduy NPP is a specific form of pollution. According to the norms[5] that were applicable in Bulgaria until recently, the thermal pollution of open streams must be assessed on the basis of the minimum average monthly water volume (in a year with 95% incidence) and the natural temperature of the open stream – the average temperature in the warmest or coldest months of the year in the last 10 years. The permissible limit for the temperature rise of the open flow is 3°C for the warmest and 5°C for the coldest month of the year. The norm does not take into account the probability of combinations with water

[4] Letter № 438 from 17.03.2013 with PPP 34 from 17.03.2013 – data provided by the Executive Agency for Exploration and Maintenance of the Danube River (EAEMDR, www.appd-bg.org) to the Client.

[5] Regulation №7/1986, repealed in SG issue 22 from 05.03.2013.

quantity with 95% incidence and average water temperature for the last 10 years, and whether this temperature is representative of the natural temperature profile of the open stream.

3.9.4.2.1 Studies on the thermal pollution of the Danube River in 1991

Studies on the temperature profile of the water in the section of the Kozloduy NPP have been conducted in connection with the construction of units 5 and 6 in 1991, by a team from the UACG[6], led by prof. B. Kazakov. They also include environmental studies where a temperature profile was created for the water in the Danube River in the section between the discharge of the hot (outlet) channel and the town of Oryahovo. Due to the fact that environmental studies cannot encompass all possible combinations of changes to the factors determining the heat impact of the Kozloduy NPP on the Danube River, the results from the studies have been used to derive semi-empirical dependencies to calculate the size of the heat-influenced area for the Danube River, based on similar studies conducted by Heinz– Stefan for the conditions in the USA. These include the water quantity of the Danube River before the BPS, the water quantity taken in by the cooling system of the power plant, the temperature difference between the water borrowed and returned to the river, and the geothermal characteristics of the section of the Danube River – average width and depth. 4 dependencies have been established – two for the maximum distance from the right bank at a pre-set isotherm and length of the zone to the right bank, enclosed by that isotherm. The margin of error for these dependencies is from 3.8% to 6.5%.

The conducted studies show that:

- → the temperature of the water in the hot (outlet) channel before the discharge into the river follows a natural rise of the water temperature in the Danube River before the BPS on an hourly basis during the day, with a temperature difference of 7.5-8.5°C, during normal operational conditions;
- → the heat stratification along the river at the zone of the thermal plume only occurs up to about 700 m after the discharge of the Hot (Outlet) Channel (HC). The maximum stratification in the vertical direction (by about 4°C) is observed at about 200 m after the discharge and at about 80-100 m into the cross-section to the waterway (midstream) of the river;
- → the "thermal pollution" strain in the Danube River (with ΔT = 3°C) is then manifested at about 1700 m after the discharge of the HC, with a maximum width of about 300 m: For example, 80% of relative dispersion of water temperature in the Danube River after the merger of the HC (with a flow rate of 75 m^3/s) occurs at about 2 km downstream.

[6] NPP Kozloduy. A study of thermal pollution to the Danube River by the NPP, along with reduction measures – 1991. A scientific report by a team lead by Prof. B. Kazakov.

3.9.4.2.2 Studies on the thermal pollution of the Danube River in 1999

In order to establish some current characteristics of the thermal impact of the Kozloduy NPP on the Danube River, expeditionary studies were carried out on August 4 and 5, 1999, along the Danube from the port of the town of Kozloduy to the village of Ostrov, for the purposes of the EIA[7] conducted in 1999 by experts from the team and the National Institute of Meteorology and Hydrology under the BAS, with the cooperation of the NPP management.

The analysis on the results from these studies demonstrated that:

The thermal impact of the "Kozloduy" NPP at an average 24-hour capacity of 1380 MW on the Danube River on 04.08.1999 was relatively more pronounced than the one on 09.09.1991, when only units 3 and 6 were working, at a reduced capacity.

The results from the measurements made on 05.08.1999 showed a consistently elevated temperature by about 2°C compared to the ones that were expected based on the calculations and the ongoing monitoring conducted by the Executive Agency for Exploration and Maintenance of the Danube River (EAEMDR), based in city of Ruse. That is why these results should only be used as a guideline on the nature of the temperature change in the Danube River, in contrast to the more stringent results from 4.08.1999, which correspond well to previous studies and the ongoing monitoring. The possible reasons for these deviations could be sought in the inaccurate coordination of the motorboat along the stream, using only the navigational equipment and/or a possible systematic error in the measuring device.

The conclusion of the experts is that the results from the examination of the isotherm +3°C (a temperature field with a temperature higher by 3°C than the natural one for the Danube River) in previously conducted studies and during the conducted experiment are grounds to assume that there is concordance in the results from the different studies.

Using the established dependencies, the team made calculations in order to determine the amount of the heat-influenced area from the Danube River after the discharge of the hot channel, under average monthly water quantities and with a 95% probability. The operation of the power plant has been studied when working at 1760 MW and 3760 MW – respectively at a discharge rate from the hot channel amounting to 104 and 180 m^3/s. Calculations have been made for two isotherms: +3°C and +5°C. The results obtained show that during the operation of 4 units, with a total quantity of heated waters of 104 m^3/s, to a temperature 10°C above the temperature of the Danube River, the heat-influenced area, at a 5% probability to not exceed the value, and a temperature of + 3°C above the natural one, during the individual months of the year has a length of 2.3 to 10.6 km, i.e. it extends from ^{km}684.3 to ^{km}676.1, forming near the Bulgarian bank and having a maximum width in the zone from 100 to 185 m – **Figure 3.9-2**.

7 EIA Report on the "Kozloduy" NPP – 1999.

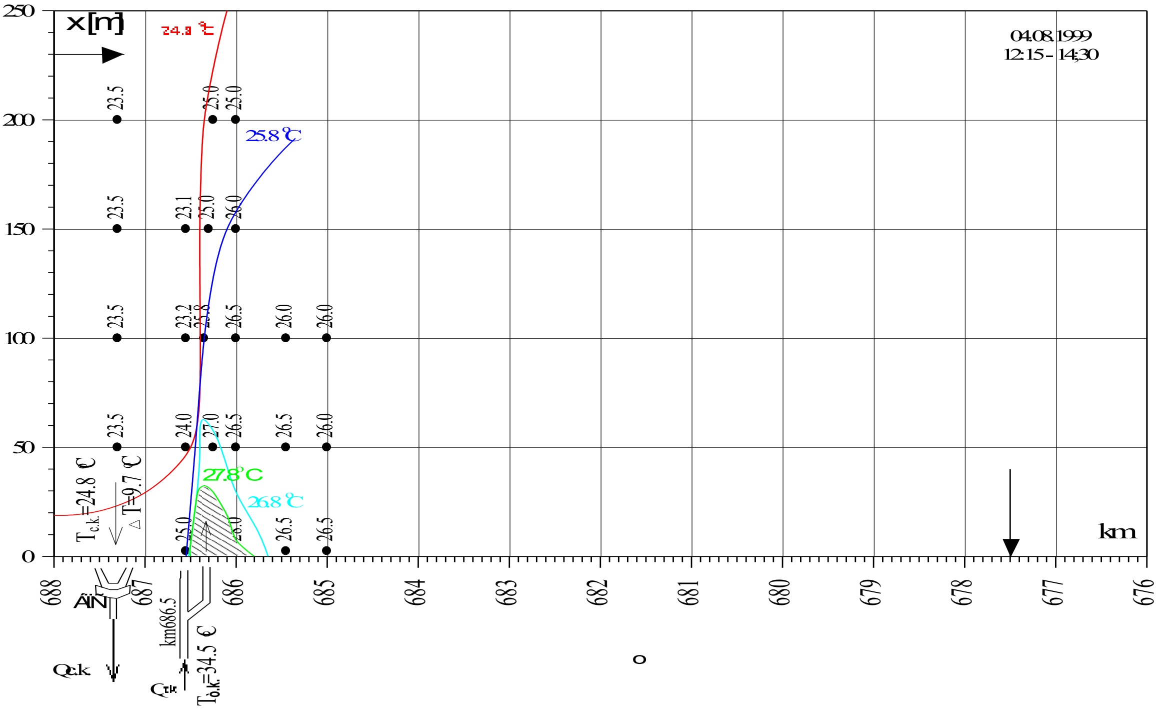

FIGURE 3.9-2: ISOTHERMAL OUTLINE AND RESULTS FROM MEASUREMENTS ON THE HEAT-INFLUENCED AREA OF THE DANUBE RIVER ON 04.08.1999

When the full capacity of the 6 units of the power plant is utilized (3760 MW), and respectively the quantity of the heated waters rises to 180 m^3/s, the length of the heat-influenced area by 3°C will vary during the individual months from 7.0 to 31 km, and have a width from 175 to 320 m. The size of the heat-influenced area is typically the largest in October. The thermal plume moves relatively quickly to the bank and at 7-7.5 km after the discharge point the difference between the temperature of the water and the thermal plume reaches 1.8C (at dissipation rate of about 80%). At a temperature difference of 0.2°C the maximum width of the plume from the bank to the waterway reaches 195 m, and the length – about 21-22 km.

Based on the results presented above, we can draw the conclusion that for inflowing water quantities up to Q_T=150 m^3/s the influence of the heat exchange between the heated waters coming from the Kozloduy NPP into the Danube River for the section from kilometre 687 (the point of discharge of the hot channel) to kilometre 678 (the port of Oryahovo) and the environment is negligible and can be ignored.

These trends are also confirmed by the data presented on Figure 3.9-3 to **Figure 3.9-6** , which shows that after the commissioning of the Kozloduy NPP a certain heat load has been observed at Oryahovo (^{km}678) as compared to Lom (^{km}743.3), not exceeding 3°C, which is within the regulatory limit.

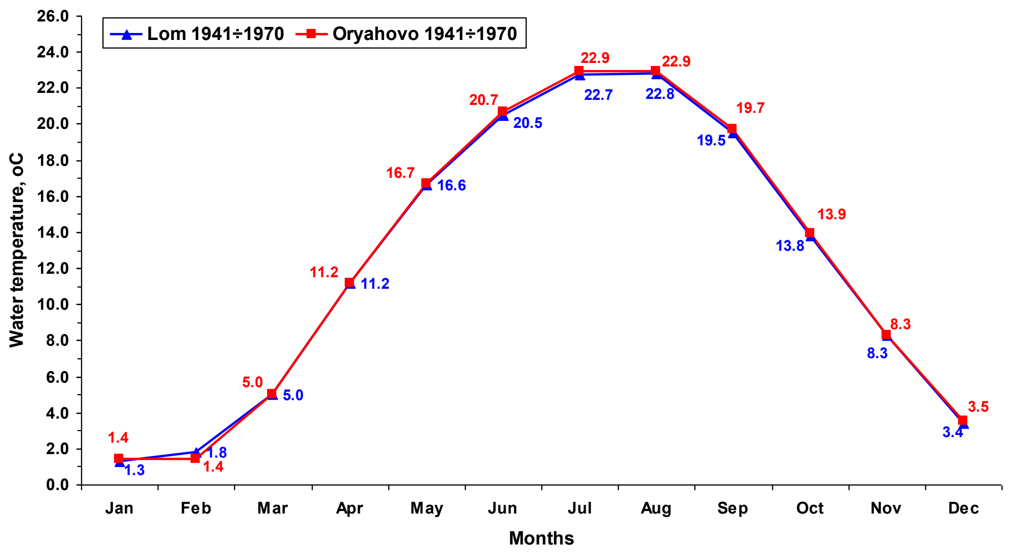

FIGURE 3.9-3: AVERAGE MONTHLY WATER TEMPERATURES (IN °C) AT THE LOM AND ORYAHOVO STATIONS FOR THE PERIOD 1941-1970 – BEFORE THE COMMISSIONING OF THE NPP.[8].

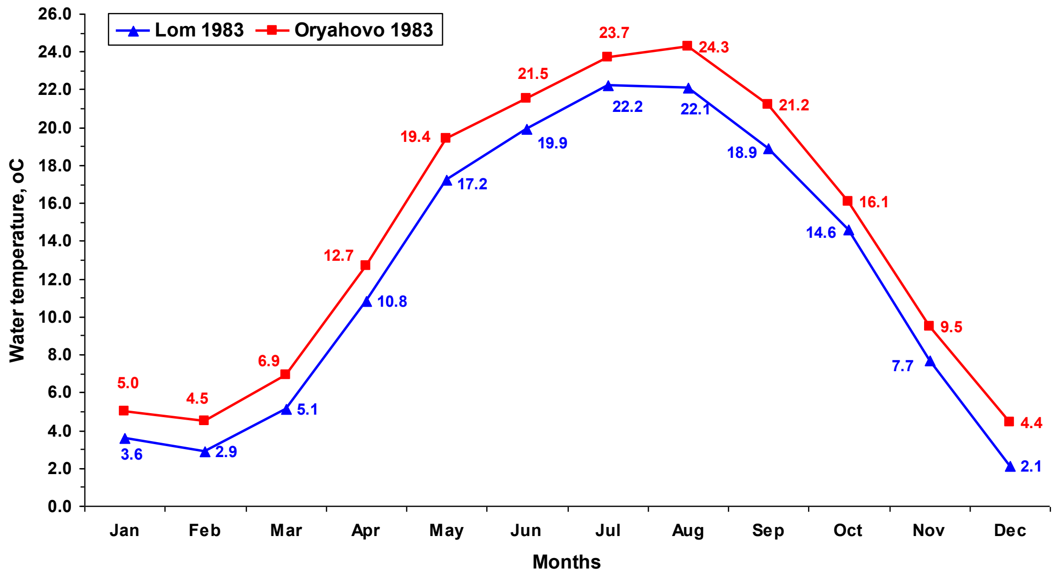

FIGURE 3.9-4: AVERAGE MONTHLY WATER TEMPERATURES (IN °C) AT THE LOM AND ORYAHOVO STATIONS FOR 1983 (A DRY YEAR) – WITH 4 UNITS IN OPERATION (1÷4)[9]

---

8 Rusev, B. K., V. T. Naydenov (ed.) 1978. Limonology of the Bulgarian section of the Danube River. BAS Publishing House, Sofia, p. 308.

9 EIA on the “Kozloduy” NPP –1999.

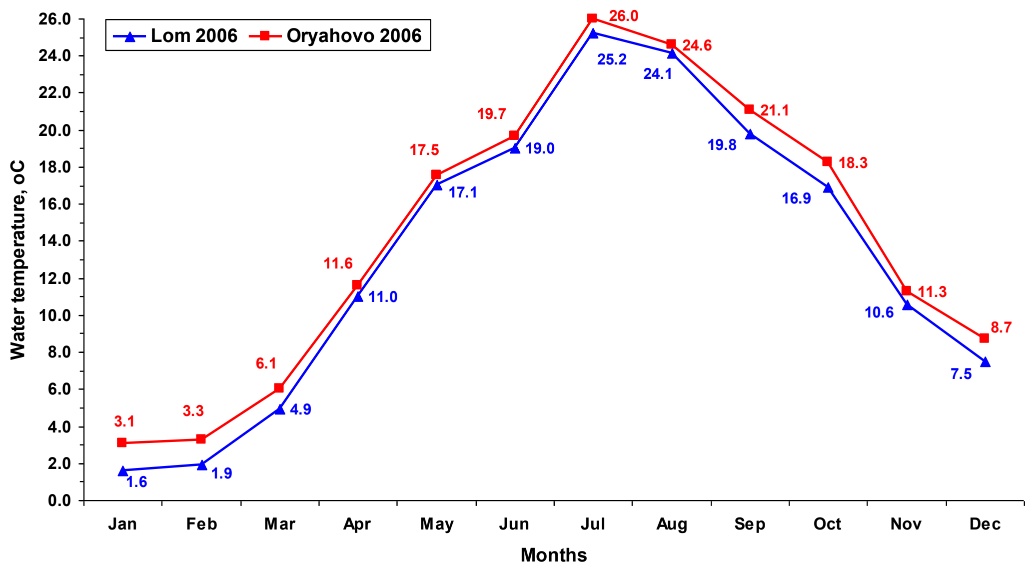

FIGURE 3.9-5: AVERAGE MONTHLY WATER TEMPERATURES (IN °C) AT THE LOM AND ORYAHOVO STATIONS FOR 2006 (A YEAR WITH VERY HIGH WATER LEVELS) – WITH 4 UNITS IN OPERATION (3, 4, 5 AND 6)[10].

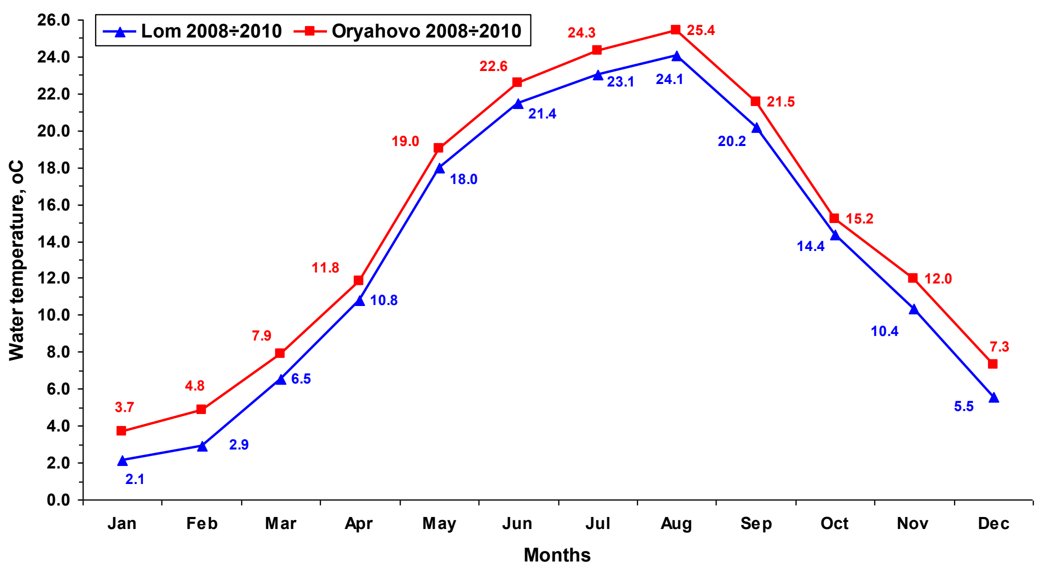

FIGURE 3.9-6: AVERAGE MONTHLY WATER TEMPERATURES (IN °C) AT THE LOM AND ORYAHOVO STATIONS FOR THE PERIOD 2008-2010 – WITH 2 UNITS IN OPERATION (5 AND 6)

Figure 3.9-3 shows the difference in the average daily temperatures measured at Lom and Oryahovo during the period 01.01.2012 – 31.12.2012. (Letter No. 438 from 17.03.2013 with PPP 34 from 17.03.2013. – data provided by the EAEMDR to the Client). We can see that when the NPP operates at 2000 MW capacity, the temperature difference rarely exceeds 2°C.

10 Letter No. 438 from 17.03.2013 with PPP 34 from 17.03.2013. – data provided by the Executive Agency for Exploration and Maintenance of the Danube River (EAEMDR, www.appd-bg.org) to the Client.

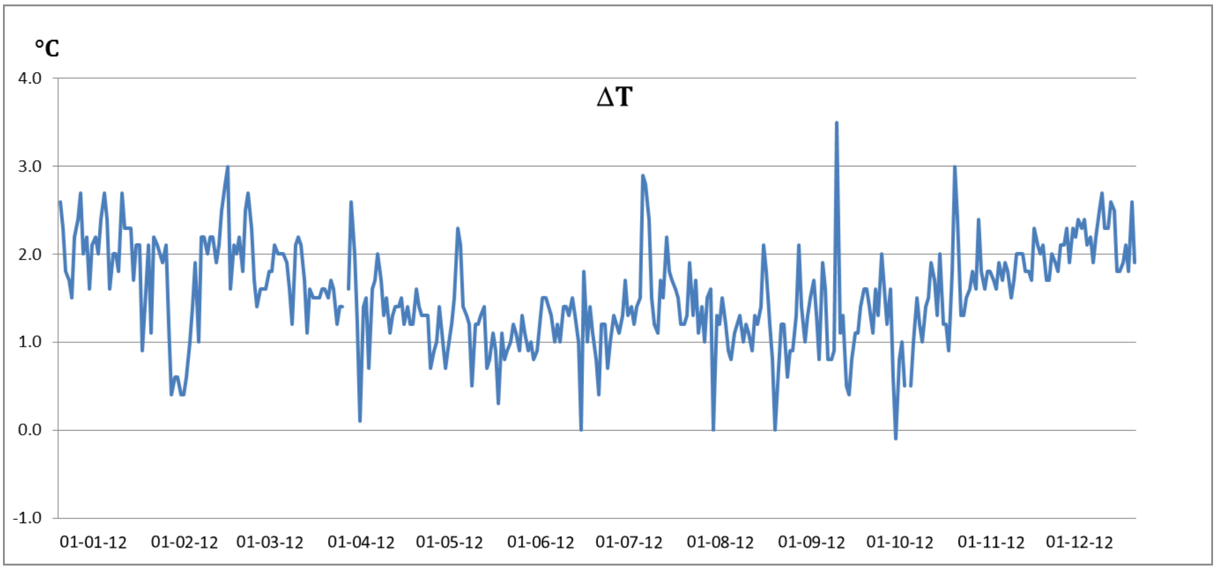

FIGURE 3.9-7: DIFFERENCE IN THE AVERAGE DAILY WATER TEMPERATURES (IN °C) AT THE ORYAHOVO AND LOM STATIONS FOR 2012

3.9.4.3 CONCLUSION

No exact quantitative estimates can be made on the basis of the data presented above, but it is included in order to illustrate the existing trends. We can see that for almost 30 years before commissioning of the NPP there was no difference between the average monthly temperatures at the two stations of Lom and Oryahovo. In 1983, when only the small units (1÷4) were in operation, the average annual temperature difference was 1.84°C, and it was a dry year. In 2006, the difference was only 0.84° C, but then the water quantity reached very high values. During the period 2008-2010, with two operating reactors, the average annual temperature difference between the two stations was 1.38°C. The differences are higher in the winter months in comparison to the summer ones, reaching 2.3°C, and that is also true for dryer years.

3.9.5 ICE FORMATION IN THE DANUBE RIVER

The ice phenomena in the Danube River depend on the air temperature and the water temperature. The temperature profile of the water of the Danube River is closely correlated to the air temperature. Changes to the water temperature in comparison with air temperature fluctuations occur with a slight delay and take place in a significantly steadier manner.

Ice phenomena in the Danube River are related to many factors – climatic, hydrological and hydraulic, and therefore their formation and development should be considered for a section of the river with a considerable length, encompassing the areas available to the NPP as well.

The Lower Danube ($^{km}931$ – $^{km}0$) offers climatic conditions that are favourable for the formation of ice phenomena. The combination of these conditions with the complex morphology of the river bed favours phenomena of complete freezing of the river, followed by a subsequent rapid rise of the water levels, creating conditions for the formation of ice build-ups.

The data on the monthly and yearly typical water temperatures show that the lowest water temperature occurs in January and February.

The freezing of the river and the formation of an ice cover is normally accompanied by the formation of ice dams and the rising the river level, called build-ups. In the section where influence of the dams is spreading, the flow velocity decreases considerably, which further impedes the passage of ice and facilitates its accumulation and the freezing of the river.

Ice build-ups (barriers of heaped ice blocks) occur mainly around groups of islands, as there are favourable conditions for deceleration of the average stream speeds in these sections. Sections where ice build-ups are typical and occur frequently are the ones at ^{km}246, ^{km}140 и ^{km}81. All three of these sections are outside the Bulgarian part of the Danube River.

Nevertheless, ice build-ups have historically also formed up in the section from ^{km}375 to ^{km}845. The points where ice build-ups can be expected are presented in **Table 3.9-5**.

TABLE 3.9-5: POINTS WHERE ICE BUILD-UPS TYPICALLY OCCUR

Vidin	(^{km}802)	Archar	(^{km}764)	Kozloduy	(^{km}702-^{km}704)
Oryahovo	(^{km}660-^{km}678)	Ostrov	(^{km}660)	Nikopol	(^{km}594-^{km}597)
Ruse	(^{km}490)	Aleko	(^{km}476)	Brashlyan Island	(^{km}454)
Tutrakan	(^{km}428)				

From the ice build-ups phenomena occurring during the period 1900-1985, the most unfavourable effects were experienced from the 1942 and 1947 build-ups.

In 1942, as a result of an ice build-up, in the area of ^{km}664- ^{km}678 the Oryahovo port was flooded (water level 929 cm). During the same year the lowest part of the town of Nikopol was flooded (^{km}597.5) as a result of an ice build-up in the area of ^{km}594.

In 1947 the biggest build-up in the Bulgarian section of the Danube River was experienced near Oryahovo. The build-up was formed near the group of islands Oreh, Ezik and Popadiya. It had a length of about 18 km and a width of about 1-2 km. It lasted for 18 days, and occurred at relatively low water levels.

Table 3.9-6 presents data on winter periods when there was the potential for ice phenomena to appear.

TABLE 3.9-6: PERIODS OF ICE BUILD-UP PHENOMENA

winter	Oryahovo	Svishtov
1899/1900	20.12.-04.02.	
1904/1905	25.01.-05.02.	
1908/1909	24.01-12.02.	

1913/1914	29.01.-24.02.	
1921/1922	04.02.-25.02	
1923/1924	26.01.-29.01.	
1927/1928	03.01.-20.01.	
1928/1929	30.01.-20.03.	
1931/1932	20.02.-16.03.	
1936/1937	-	31.01.-08.02.
1939/1940	16.01.-06.03.	16.01.-05.03.
1941/1942	26.01.-13.03.	22.01.-11.03.
1942/1943	13.01.-11.02.	12.01.-16.02.
1946/1947	10.01.-02.03.	08.01.-01.03.
1953/1954	12.01.-08.03.	06.01.-13.03.
1962/1963	01.02-06.02.	27.01.-16.02.
1963/1964*	07.01.-27.02.	22.01.-15.02.

**- after the winter of 1963/64 no ice build-ups are observed*

After 1971 there was practically no registered full-scale freezing, with the exception of one day in 1985. The estimates for the areas of the Danube River situated within the section up to Silistra are similar. There is a trend for a reduced number and duration of ice phenomena. The probable reasons for that are the anthropogenic activity and the global warming.

There is information about ice build-up phenomena in 1893 but for that year we cannot establish an exact date and relate it to data on the factors causing the build-up. For the period before 1941 there is no reliable information on annual key curves. In the course of the study we did not find documented works on the methods used before 1965 to "clean up" the data from ongoing observations on the influence of the ice phenomena.

Conclusion

In the section of the Danube River within our territory, for more than 70 years there were only 5 ice build-ups at flow rates from 4870 m^3/s to 11 910 m^3/s. The fact that the last one was in 1963 shows that after the construction of the “Zhelezni Vrata” water supply system, the probability of freezing of the Danube has decreased substantially. Events such as the "catastrophic wave" caused by the accident at "Zhelezni Vrata" I and II and the ice build-ups are of low probability and should not happen concurrently, even more so because ice lockdowns are not possible in the presence of catastrophically high water levels above 20 000 m^3/s[11]. Freezing is possible at low to medium water levels (around elevation level +25 m.), which occurs during the winter. If we assume that even at this low probability such an event is still possible, it would create water retention up to 2.5 m and the average level of 25.00 m will go up to 27.00 m. Due to these reasons, the elevation of the water level and the flooding of the “Kozloduy” NPP due to water retention caused by an ice drift is very unlikely.

[11] Determining the hydrological and hydraulic characteristics of the Danube River, related to the design, construction and operation of the Belene NPP, UACG. Part 2.2, Hydrology.

Earlier studies (St. Modev, 1991) demonstrate that the damming effect on the water levels in the BPS area during shallow waters can reach 3.60 m and during high waters – 1.50 m. The probability of damming due to ice build-ups at Oryahovo is 1 time in 10 years while the water standstills reached after damming correspond to standstills with repeat rate of 0.5, i.e. 1 time in 200 years. So far, no studies have been carried out regarding the chances of ice build-ups at higher water levels, and the probability for the occurrence of such phenomena has not been evaluated.

3.10 HEALTH AND SANITARY ASPECTS OF THE ENVIRONMENT AND RISK TO HUMAN HEALTH /EXISTING SITUATION/

The area of the Kozloduy NPP, where four alternative sites for the deployment of a new nuclear unit have been localised, is characterised by relatively favourable social and demographic conditions. One of the guiding principles for the implementation of the IP is to ensure the health and safety of the workers on site and of the people living in the vicinity.

The population that is considered to be potentially affected by the implementation of the Project is mainly the inhabitants of the settlements within a 30 km radius around the Kozloduy NPP, amounting to 65 994[12] people within the Bulgarian territory and 75 150 people[13]within the Romanian territory.

For the calculations of the collective exposure, an equal population density in all directions has been presumed – 43 people per 1 km^2. The critical group from the population, which includes settlements situated downstream along the Danube River (the town of Oryahovo, the village of Leskovets, the village of Ostrov and the village of Gorni Vadin) has been estimated at 7469 people (NSI, 2011 census).

3.10.1 HEALTH STATUS OF THE POTENTIALLY AFFECTED POPULATION

The health status is determined by many factors of the environment and the working environment, social welfare, hereditary and demographic factors. A significant role is played by some specific criteria that can lead to more direct links between environmental pollutants and changes in the health status, such as the indicators of oncological morbidity.

The purpose or the specialised study is to investigate the health status of the population of the Kozloduy municipality and the Vratsa region for a retrospective period in view of assessing the presence or absence of deterministic environmental factors.

The objectives toward this purpose were the following:

1. Investigating the health status of the population of the Kozloduy municipality via demographic indicators across a three-year retrospective period and preparing a comparative analysis against the values for the whole country.
2. Investigating the health status of the Vratsa region via the indicators of registered morbidity rate, the number of hospitalised patients and the oncological morbidity.

12 National Statistical Institute, census as of 01.02.2011.
13 A letter by the Romanian Ministry of Environment and Forests No. 3672/RP/18.10.2012.

3. Creating a summary profile of the health status of the population in the Kozloduy municipality. Developing recommendations for health and environmental monitoring.

The subject to the study is the population of the Kozloduy municipality and the population of the whole country.

Scope of the study:

A comprehensive investigation on the population of the Kozloduy municipality based on the indicators presented above, and in comparison to the entire population of the Republic of Bulgaria.

Monitoring units:

The logical monitoring unit is the inhabitants of the Kozloduy municipality. The technical monitoring unit is the environment, including the factors and parameters of the Kozloduy municipality.

3.10.1.1 INVESTIGATING THE HEALTH STATUS OF THE POPULATION OF THE KOZLODUY MUNICIPALITY VIA DEMOGRAPHIC INDICATORS AND PREPARING A COMPARATIVE ANALYSIS AGAINST THE VALUES FOR THE WHOLE COUNTRY.

The Kozloduy NPP is situated in the municipality of Kozloduy, which consists of the town of Kozloduy and the villages Harlets, Glozhene, Bhutan and Kriva Bara. The average population density, according to data by the National Statistical Institute from the census conducted on 01.02.2011 for the Kozloduy municipality, is 74.4 people/km^2. It is higher than the national average (66.35 people/km^2) and the average for the Vratsa region (51.1 people/km^2), where the Kozloduy municipality is situated. A significant part of the population of the town of Kozloduy is socially and economically connected to the Kozloduy NPP.

The demographic development of Kozloduy municipality is rather specific, yet typical of such settlements with large industrial facilities. The factors determining the specific demographics are, on the one hand, the migration of a part of the population (common in rural areas) to the big towns and cities – in this case from the villages to the town of Kozloduy, and on the other hand, the increase in the total population as a result of influx of construction workers and experts for the construction and operation of the Kozloduy NPP from the interior of the country. [14]

The 30 km zone encompasses (fully) the following municipalities: Kozloduy, Valchedram, Hayredin, Mizia and partially the following municipalities: Lom, Byala Slatina, Oryahovo, Boychinovtsi, Krivodol and Borovan, as well as a total of 19 settlements[15] in the counties of Dolj and Olt in Romania.

---

[14] Regional Health Inspectorate (RHI) – town of Vratsa, Annual Report, 2011.

[15] Current data for the territory of the Republic of Rumania – a letter of the Kozloduy NPP-NC EAD, 297/01.04.2013.

During the period 2005-2010, a progressive downward trend is observed in all settlements for a reduction in the number of inhabitants, which is associated with the negative natural growth. Only the town of Kozloduy has a positive mechanical growth, and the population has increased from 10498 to 14892 people. This is related to the jobs and career opportunities associated with the operation and maintenance of the Kozloduy NPP.

Table 3.10-1 presents the dynamics in the population size between the 1985 census and the 2011 (last) census, for the settlements within the 30 km MZ of the Kozloduy NPP.

TABLE 3.10-1: POPULATION SIZE IN THE MUNICIPALITIES WITHIN THE 30 KILOMETRE ZONE OF THE KOZLODUY NPP

Settlement	Number according to the census				Increase – number		Average annual – %	
	1985	1992	2001	2011	2011 /1985	2011 /2001	2011 /1985	2011 /2001
Dobrolevo	1420	1307	1077	865	-555	-212	-1.5	-2
Malorad	2786	2593	2380	1883	-903	-497	-1.2	-2.1
Sirakovo	414	396	330	225	-189	-105	-1.8	-3.2
Altimir	1989	1900	1525	1179	-810	-346	-1.6	-2.3
Balgarski Geran	1459	1292	1078	745	-714	-333	-1.9	-3.1
Galiche	3327	2882	2406	1976	-1351	-430	-1.6	-1.8
Tarnava	3370	3184	2875	2366	-1004	-509	-1.1	-1.8
Butan	4019	3717	3343	2918	-1101	-425	-1.1	-1.3
Glozhene	3459	3294	3150	2748	-711	-402	-0.8	-1.3
Kozloduy	12494	13632	14892	13058	564	-1834	0.2	-1.2
Kriva Bara	713	663	554	397	-316	-157	-1.7	-2.8
Harlets	2821	2633	2428	2059	-762	-369	-1	-1.5
Furen	609	579	409	251	-358	-158	-2.3	-3.9
Voyvodovo	476	411	360	264	-212	-96	-1.7	-2.7
Krushovitsa	3050	2633	2193	1712	-1338	-481	-1.7	-2.2
Lipnitsa	1421	1212	945	737	-684	-208	-1.9	-2.2
Mizia	5137	4596	4069	3252	-1885	-817	-1.4	-2
Saraevo	118	95	73	44	-74	-29	-2.4	-4
Sofronievo	3138	2540	1965	1561	-1577	-404	-1.9	-2.1
Galovo	690	535	409	277	-413	-132	-2.3	-3.2
Leskovets	1230	1089	876	656	-574	-220	-1.8	-2.5
Oryahovo	7326	6767	6107	5031	-2295	-1076	-12	-1.8
Ostrov	2740	2433	2042	1480	-1260	-562	-1.8	-2.8
Selanovtsi	6104	5245	4623	3540	-2564	-1083	-1.6	-2.3
Botevo	225	194	105	81	-144	-24	-2.5	-2.3
Barzina	598	491	399	251	-347	-148	-2.2	-3.7
Manastirishte	1934	1755	1515	1067	-867	-448	-1.7	-3
Mihaylovo	1720	1676	1378	1048	-672	-330	-1.5	-2.4
Rogozen	1877	1769	1463	1007	-870	-456	-1.8	-3.1
Hayredin	2893	2532	2125	1547	-1346	-578	-1.8	-2.7
Beli Brod	566	479	395	238	-328	-157	-2.2	-4
Lehchevo	2948	2705	2370	1797	-1151	-573	-1.5	-2.4
Botevo	180	127	107	65	-115	-42	-2.5	-3.9

Settlement	Number according to the census				Increase – number		Average annual – %	
	1985	1992	2001	2011	2011 /1985	2011 /2001	2011 /1985	2011 /2001
Bazovets	469	384	267	114	-355	-153	-2.9	-5.7
Valchedram	6481	5732	4800	3662	-2819	-1138	-1.7	-2.4
Gorni Tsibar	950	675	390	196	-754	-194	-3.1	-5
Dolni Tsibar	1498	1535	1576	1586	88	10	0.2	0.1
Zlatia	2070	1616	1289	870	-1200	-419	-2.2	-3.3
Ignatovo	532	443	358	262	-270	-96	-2	-2.7
Mokret	1768	1502	1150	803	-965	-347	-2.1	-3
Razgrad	1638	1366	1092	686	-952	-406	-2.2	-3.7
Septemvriytsi	1924	1746	1441	1149	-775	-292	-1.5	-2
Stanevo	1006	786	549	341	-665	-208	-2.5	-3.8
Total for the MZ	**101587**	**93141**	**82878**	**65994**	**-35593**	**-16884**	**-2.0**	**-2.7**

Based on data by the RHI – town of Vratsa, Annual Report, 2011, the total population under and above the employable age as of 31.12.2010 in the 4 municipalities, as well as the total mechanical growth for the same period, are presented in **Table 3.10-2.**

TABLE 3.10-2: POPULATION DISTRIBUTION BASED ON EMPLOYABLE AGE AND MECHANICAL GROWTH IN THE MUNICIPALITIES WITHIN THE 30 KILOMETRE ZONE OF THE KOZLODUY NPP

Municipalities / Population	Below the employable age	In the employable age	Above the employable age	Mechanical growth
Kozloduy	4616	14772	4443	1
Mizia	1247	4487	2895	-96
Oryahovo	2011	7177	4608	-141
Hayredin	844	2742	2664	-97

The comparative analysis shows a definite trend toward aging for the population in the municipalities Mizia, Oryahovo, Hayredin and Valchedram, and that is also valid for the whole country. The number of individuals below the employable age is considerably lower than the number of individuals above the employable age. For the municipalities of Hayredin and Valchedram the number of inhabitants in and above the employable age is approximately equal. This type of demographic age distribution makes up a clearly unfavourable profile, from the social and economic point of view.

The distribution by gender indicates a higher proportion of women in the range of 0.8% to 1.4% above the average. The gender differences in the working population have the following characteristics: the number of boys and girls below the employable age is approximately the same. The proportion of men in the employable age is higher than that of women in the employable age, but the differences are not statistically significant. The relative share of men over the employable age is significantly lower than that of women. This is associated with the known trend for higher mortality among men compared to women over 60 years of age. The leading causes for their higher mortality are mainly cardiovascular diseases.

For the Municipality of Kozloduy the number of persons under and over the employable age has a relatively more favourable distribution. Young people surpass old ones aged over 60-65 years by more than 200. The relative share of individuals in the employable age is greater. This is explained by the employment opportunities provided by the Kozloduy NPP.

Only in the Kozloduy municipality the mechanical growth is positive. This is related to the career opportunities associated with the operation and maintenance of the NPP. In comparison to it, the mechanical growth in the other municipalities is negative. This once again is related to the more unfavourable conditions to satisfy the social and economic needs of the population in the remaining municipalities in the region, in comparison to the Kozloduy municipality.

The relative share of unemployment in the municipality of Kozloduy for 2010 was 12%, with employment encompassing about 84% of the employable population. The unemployment was lower than the average for Bulgaria (16.3%) and significantly lower than the unemployment rate for the Vratsa region (24%). The data presented above supports the significance of the Kozloduy NPP for the social and economic welfare of the population in the municipality of Kozloduy and the more favourable demographic indexes in terms of population distribution by employability.

The Kozloduy municipality incorporates five settlements – Kozloduy, Harlets, Glozhene, Butan and Kriva Bara. The population within the territory of the municipality follows a downward general trend. This negative trend follows the nationwide general negative trend for population decrease.

Examining the data on the population size for the Kozloduy municipality and its distribution by gender and age we notice that the age structure is favourable and represents a "stationary to ageing type," with a broad representation of the population in an active employable age and retirement age.

TABLE 3.10-3: DISTRIBUTION OF THE POPULATION IN THE KOZLODUY MUNICIPALITY

Subject and signs		number	
Population of the Kozloduy municipality as of 31.12.2010		23970	
out of which	men	11751	(48.5%)
	women	12119	(51.5%)
	up to 18 years of age	4075	(14.1%)
	18-64 years of age	15478	(43.7%)
	over 65 years of age	9292	(32.2%)

FIGURE 3.10-1: SUMMARISED INDICATORS OF TOTAL MORTALITY, BIRTH RATE AND NATURAL POPULATION GROWTH FOR THE WHOLE COUNTRY

The birth rate for the whole country (**Figure 3.10-1**) has different parameters for the period 2005 – 2010, but it is close, and generally lower for the Kozloduy municipality **Table 3.10-4.** The mortality rate is equal to the one for the country. The natural growth, as a resultative parameter between the two primary demographic indicators – birth rate and total mortality rate, does not differ significantly between the population of the Kozloduy municipality and that of the whole country for 2010.

TABLE 3.10-4: DEMOGRAPHIC PARAMETERS FOR THE KOZLODUY MUNICIPALITY, THE VRATSA REGION AND THE WHOLE COUNTRY (2010-2012)

Year	Parameters for 1000 inhabitants	Kozloduy municipality	Republic of Bulgaria
	Demographic parameters for the country		
2010	Birth rate	6.33	9.2
	Mortality rate	14.3	14.6
	Natural growth	-5.4	-5.1
	Child mortality rate per 1000 newborns	8.3	11.1
	Demographic parameters for the Vratsa region		
2011	Birth rate	6.29	
	Mortality rate	15.52	
	Natural growth	-11.57	
	Child mortality rate per 1000 newborns	4.71	
2012	Birth rate	6.14	
	Mortality rate	15.72	
	Natural growth	-9.58	
	Child mortality rate per 1000 newborns	3.26	
	Demographic parameters for the Kozloduy municipality		
2012	Birth rate	5.09	
	Mortality rate	12.5	
	Natural growth	-7.41	

Year	Parameters for 1000 inhabitants	Kozloduy municipality	Republic of Bulgaria
	Child mortality rate per 1000 newborns	0.00	

TABLE 3.10-5: LIVE BIRTHS IN 2011 IN THE MUNICIPALITIES WITHIN THE 30 KILOMETRE ZONE OF THE KOZLODUY NPP AND VRATSA

Municipality (population)	Total	girls	boys
Vratsa	1594	819	775
Kozloduy (23970)	192	96	96
Mizia (7455)	55	36	19
Oryahovo (11392)	104	57	47
Hayredin (4935)	33	15	18

TABLE 3.10-6: DEATHS IN 2011 IN THE MUNICIPALITIES WITHIN THE 30 KILOMETRE ZONE OF THE KOZLODUY NPP AND VRATSA

Municipality	Total	women	men
Vratsa	3442	-	-
Kozloduy	311	158	153
Mizia	170	80	90
Oryahovo	284	142	154
Hayredin	159	77	72

TABLE 3.10-7: LEADING MORTALITY CLASSES, BY CAUSE, FOR THE VRATSA REGION FOR 2011 AND 2012

№	ICD -10	Number
1	Diseases affecting the circulatory organs	1903
2	Neoplasms	497
3	Diseases affecting the digestive system	98
4	Diseases affecting the endocrine system	83
5	Diseases affecting the respiratory system	64

TABLE 3.10-8: LEADING MORTALITY CLASSES, BY CAUSE, FOR THE VRATSA REGION FOR 2012

№	ICD -10	Number
1	Diseases affecting the circulatory organs	1841
2	Neoplasms	528
3	Symptoms, signs and abnormalities discovered during clinical tests	264
4	Diseases affecting the endocrine system	109
5	Diseases affecting the digestive system	108

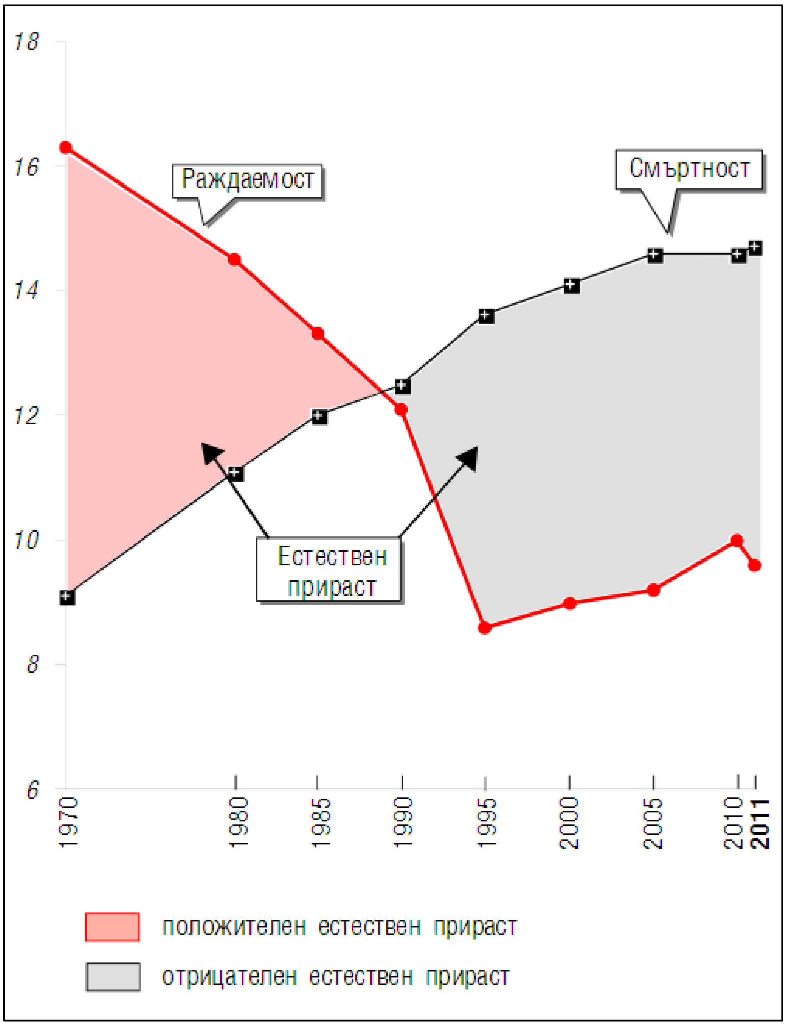

FIGURE 3.10-2: BIRTH RATE, MORTALITY RATE AND NATURAL GROWTH (FOR A POPULATION OF 1000)

There is an overall negative demographic profile for the population of the Kozloduy municipality. It is more probable that it is socially generated and not so much the result of any adverse impact caused by environmental factors. The main problem is the constant migration, incl. external – beyond the national borders, economic problems, marital and family problems, harmful habits and the socially significant diseases related to them.

The mortality rate of the population belongs to the primary health indicators, and is often used as the basis for a deeper analysis on the health of the population. The mortality rate indicator has an advantage because it is unambiguous and based on established events (death) and the measurements are final. That is why it allows us to make a good comparison between the different population groups. The detailed assessment of the various mortality indicators is therefore an unavoidable part of the assessment, even though the potential impact on mortality by the existence and operation of the NPP is unlikely. Furthermore, such an impact within the area of nuclear facilities has not been established for any place around the world.

The mortality rate is an indicator of the impact of lifestyle conditions, mostly with regard to diseases that have a relatively low duration and high mortality rate.

The evaluation of this indicator is focused on the exposition areas, and out of them particularly the one closest to the power plant, where the potential negative impact would be most likely to be manifested.

The following criteria on the potential adverse impact of the NPP are recommended:

- ✓ A higher mortality rate in the closest exposition area than in any other area;
- ✓ A higher mortality rate in the exposition areas than in the control areas;
- ✓ Occurrence of the aforesaid impact only during the period after the commissioning of the NPP;
- ✓ Parallel impact on both men and women.

None of these criteria is unequivocally confirmed under the existing situation with the Kozloduy NPP.

Not even the slightest negative impact affecting both genders in the same manner is detected. We can draw the conclusion that the proximity of the NPP has no influence on the mortality characteristics within the settlements in the vicinity.

A superficial interpretation of the aforesaid indicator may lead to erroneous conclusions about the impact category of the NPP.

The reasons for mortality are deeper and should be reviewed as a result of a complex of local, social, economic, demographic categories, habits, health and other lifestyle conditions.

We find the data on mortality caused by some classes of diseases according to ICD-10 to be informative in terms of demographics and health status – one of the indirect indicators of the health status of the population, considering the fact that the data is available for the overall region where the Kozloduy municipality is situated.

The classes of diseases that are most closely linked to environmental factors are the following:

- ✓ Class II: Neoplasms
- ✓ Class IV: Diseases of the endocrine system, digestive and metabolic disorders
- ✓ Class IX: Diseases of the circulatory organs
- ✓ Class X: Diseases of the respiratory system
- ✓ Class XI: Diseases of the digestive system
- ✓ Class XII: Diseases of the skin and the subcutaneous tissue
- ✓ Class XIV: Diseases of the urinary and reproductive system
- ✓ Class XVII: Congenial anomalies

The data on the Vratsa region are relative favourable in comparison with the averages for the country, especially considering the groups of diseases most frequently affected by environmental factors – ones affecting the cardiovascular and the respiratory systems.

Heightened values are recorded in the Vratsa region for some oncological diseases in comparison with the average indicators for the country – 18.6 %.

One of the main manifestations in the vicinity of polluting industrial facilities is the adverse impact on the functions of the respiratory and cardiovascular systems, respectively on the mortality rate resulting from these nosological units. For the last period no significant increase in the incidence of respiratory and cardiovascular diseases was registered in the region, which is a favourable fact and proves the limited effect of the aggressive factors, incl. of the environment.

3.10.1.2 STUDIES ON THE MORBIDITY RATE AMONG THE POPULATION

3.10.1.2.1 Non-radiation aspects

A detailed study was conducted on the indicator "Registration of diseases in medical treatment facilities for outpatient care in the Vratsa region" for the period 2009-2011.[16] The survey was conducted for 19 classes of diseases.

TABLE 3.10-9: LEADING CLASSES OF DISEASES IN HOSPITALISED MORBIDITY AT MPHAT EOOD, TOWN OF KOZLODUY, FOR 2009

Class №	ICD 10	Number
0-17 years		
I	Some infectious and parasitic diseases	161
X	Diseases of the respiratory system	129
XIX	Injuries, poisoning	90
XIV	Diseases of the urinary and reproductive system	54
III	Diseases of the circulatory organs	48
18-64 years		
XI	Diseases of the digestive system	442
XV	Pregnancy, childbirth, postnatal period	371
XIV	Diseases of the urinary and reproductive system	269
III	Diseases of the circulatory organs	234
XIX	Injuries, poisoning	209
over 65		
III	Diseases of the circulatory organs	342
XI	Diseases of the digestive system	244
XIX	Injuries, poisoning	88
X	Diseases of the respiratory system	85
IV	Diseases of the endocrine system	82

TABLE 3.10-10: LEADING CLASSES OF DISEASES IN HOSPITALISED MORBIDITY AT MPHAT EOOD, TOWN OF KOZLODUY, FOR 2010

Class №	ICD 10	Number

16 Regional Health Inspectorate (RHI) – town of Vratsa, Annual Reports, 2009-2011.

0-17 years		
X	Diseases of the respiratory system	215
I	Some infectious and parasitic diseases	131
XIV	Diseases of the urinary and reproductive system	41
XV	Pregnancy, childbirth, postnatal period	35
XIX	Injuries, poisoning	30
18-64 years		
XV	Pregnancy, childbirth, postnatal period	292
III	Diseases of the circulatory organs	192
XIV	Diseases of the urinary and reproductive system	184
X	Diseases of the respiratory system	180
XI	Diseases of the digestive system	124
over 65		
III	Diseases of the circulatory organs	390
X	Diseases of the respiratory system	128
IV	Diseases of the endocrine system	93
XI	Diseases of the digestive system	81
VI	Diseases of the nervous system	53

TABLE 3.10-11: LEADING CLASSES OF DISEASES IN HOSPITALISED MORBIDITY AT MPHAT EOOD, TOWN OF KOZLODUY, FOR 2011

Class №	ICD 10	Number
0-17 years		
X	Diseases of the respiratory system	246
XIV	Diseases of the urinary and reproductive system	57
XIX	Injuries, poisoning	32
XII	Diseases of the skin and the subcutaneous tissue	27
XV	Pregnancy, childbirth, postnatal period	26
18-64 years		
XV	Pregnancy, childbirth, postnatal period	442
III	Diseases of the circulatory organs	371
XIV	Diseases of the urinary and reproductive system	269
XII	Diseases of the skin and the subcutaneous tissue	234
X	Diseases of the respiratory system	209
Over 65		
III	Diseases of the circulatory organs	464
X	Diseases of the respiratory system	146
IV	Diseases of the endocrine system	118
XI	Diseases of the digestive system	86
XII	Diseases of the skin and the subcutaneous tissue	70

The analysis of the data presented above established that from the year 2009 there is an ongoing trend of increased incidence of diseases included in the leading classes of diseases, with respiratory diseases occupying the top position and being above the average for the country.

It is worth noting that in Multi-Profile Hospital for Active Treatment "St. Ivan Rilski" EOOD, town of Kozloduy, the number of patients that passed through the hospital is lower compared to other hospitals in the region and among the municipalities. We can assume that the residents of the town, most of whom majority are working at the Kozloduy NPP, are under regular medical supervision with appropriate equipment. This fact is clearly confirmed by the lower incidence of diseases of the respiratory system, compared to any other part of the population in area involved with other economic activities.

TABLE 3.10-12: PATIENTS PASSING THROUGH MEDICAL ESTABLISHMENTS FOR OUTPATIENT CARE IN THE VRATSA REGION FOR 2009

Medical establishments	Patients passing through	Incl. deceased ones
MPHAT "Hristo Botev" AD, town of Vratsa	18116	281
MPHAT EOOD, town of Oryahovo	5185	63
MPHAT "St. Ivan Rilski" EOOD, town of Kozloduy	3846	46

TABLE 3.10-13: PATIENTS PASSING THROUGH MEDICAL ESTABLISHMENTS FOR OUTPATIENT CARE IN THE VRATSA REGION FOR 2010

Medical establishments	Patients passing through	Incl. deceased ones
MPHAT "Hristo Botev" AD, town of Vratsa	16515	280
MPHAT EOOD, town of Oryahovo	4477	62
MPHAT "St. Ivan Rilski" EOOD, town of Kozloduy	2860	40

TABLE 3.10-14: PATIENTS PASSING THROUGH MEDICAL ESTABLISHMENTS FOR OUTPATIENT CARE IN THE VRATSA REGION FOR 2011

Medical establishments	Patients passing through	Incl. deceased ones
MPHAT "Hristo Botev" AD, town of Vratsa	15864	267
MPHAT EOOD, town of Oryahovo	1894	15
MPHAT "St. Ivan Rilski" EOOD, town of Kozloduy	3064	46

The retrospective review of morbidity in the Kozloduy municipality shows that 18-20 years ago higher levels of some diseases were observed among the population of the municipality, compared to the incidence in other municipalities in the Vratsa region.

However, no conclusion can be made that as the town of Kozloduy is situated close to the power plant, the higher morbidity would be due to the adverse impact of the NPP, since there is a number of other factors in effect, which must also be taken into account:

- Kozloduy offers a higher level of medical specialists, equipment and other healthcare opportunities, which improves the accessibility of ambulatory and policlinic medical care for the population and improves the diagnostic capabilities;

- The predominant part of NPP workers live in Kozloduy and the assessment needs to take into account the influence of their health status (depending to some degree on the adverse impact of exposure to industrial production facilities) on the level of overall morbidity in the town.

These considerations do not try to diminish the importance of some established alarming levels of morbidity. They should be used as a starting point for modern in-depth medical studies aimed at the full and comprehensive clarification of the health status of the population living around the Kozloduy NPP.

3.10.1.2.2 A study of the health status of the population through the indicators of cancer incidence by level and structure for a retrospective period

The data on oncological incidence has been reviewed – as summarised indicators and by location – for 2010. The tables below examine 7 classes of oncological diseases which are socially significant and at the same time are most visibly affected by the impact of environmental factors.

We take special interest in the data on the incidence of 4 classes of diseases which are socially significant for the population of Bulgaria and which are affected by the impact of environmental factors, incl. of environmental risk factors, and specifically: oncological diseases; diseases of the blood and blood forming organs; circulatory diseases; diseases of the respiratory system.

The analysis on the incidence of oncological diseases in the Vratsa municipality identified elevated levels of registered and newly diagnosed cases for 2010 in comparison to those 5-7 years ago. The comparison of this nosological unit for the Vratsa region and for the country, as well as of the average values of oncological diseases in the region, shows that they are higher than those for the country.

The specialised analyses give us reasons to believe that the elevated levels of oncological diseases in the Vratsa region, which includes the Kozloduy municipality, are most likely due to the complicated socio-economic conditions in the region, with the decisive impact of irregular and poor nutrition on the population, including the population within the 100 km zone around the Kozloduy NPP, which further dispels the possibility for the operation of the power plant to be relevant to the levels of oncological diseases in the region.

TABLE 3.10-15: REGISTERED DISEASES WITH MALIGNANT NEOPLASMS IN 2010-2012, BY LOCALITY WITHIN THE VRATSA REGION

Name and location of the neoplasm – ICD, X-th revision	Total for the country	Vratsa		
		2010	2011	2012
Total	**261382**	**8262**		
Lips, oral cavity and pharynx	8031	309		
incl. lip	4516	188		
Digestive organs	39121	1227	850	981
including:				
Esophagus	445	27		

Name and location of the neoplasm – ICD, X-th revision	Total for the country	Vratsa 2010	2011	2012
Stomach	5571	193		
Colon	16475	422		
Rectosigmoidal area, rectum				
anus and anal channel	12165	373		
Liver and intrahepatic bile				
pathways	1058	61		
Pancreas	2280	106		
Respiratory organs and chest	15933	502	333	383
including:				
Larynx	4951	142		
Trachea, bronchi and lungs	10382	337		
Bones and joint cartilage	797	35		
Melanoma and other malignant				
skin neoplasms	56319	1887	1552	1814
incl. malignant skin melanoma	3752	76		
Mesothelial and soft tissues	2760	89		
Mammary gland	46861	1247	1084	1191
incl. the mammary gland of women	46335	1228		
Female genitalia	40042	1435	1224	1362
including:				
Cervix	13988	607		
Body of the uterus	17208	559		
With an unspecified location within the uterus	281	14		
Ovary	6884	163		
Male genitalia	13842	365		
incl. prostate	10041	263		
Urinary system	16259	458	376	429
incl. bladder	11245	300		
Eye, cerebrum and other parts of				
central nervous system	3192	93		
including:				
Eye and its appendages	568	15		
Cerebrum	2252	62		
Thyroid and other endocrine glands	4481	114		
incl. thyroid gland	4302	106		
Inaccurately defined, secondary and undefined				
locations	3284	203		
Lymphatic, haematopoietic and related tissues	10460	298		
including:				
Hodgkin disease	2329	56		
Non-Hodgkin lymphoma	3131	100		
Leukemia	3858	110		
including:				
Lymphatic leukemia	2063	58		
Myeloid Leukemia	1222	34		

TABLE 3.10-16: NEWLY DIAGNOSED DISEASES IN 2010-2012, BY LOCALITY WITHIN THE VRATSA REGION

Name and location of the neoplasm – ICD, X-th revision	Total for the country	Vratsa 2010	2011	2012
Total	32067	894		
Lips, oral cavity and pharynx	797	27		
incl. lip	192	11		
Digestive organs	7506	185	162	167
including:				
Esophagus	179	5		
Stomach	1387	25		
Colon	2484	60		
Rectosigmoidal area, rectum				
anus and anal channel	1778	44		
Liver and intrahepatic bile				
pathways	442	12		
Pancreas	919	28		
Respiratory organs and chest	4093	103	105	85
including:				
Larynx	549	15		
Trachea, bronchi and lungs	3454	85		
Bones and joint cartilage	61	5		
Melanoma and other malignant			143	142
skin neoplasms	4851	141		
incl. malignant skin melanoma	442	9		
Mesothelial and soft tissues	316	5		
Mammary gland	3644	90	91	87
incl. the mammary gland of women	3589	90		
Female genitalia	3195	130	94	92
including:				
Cervix	1065	57		
Body of the uterus	1210	44		
With an unspecified location within the uterus	34	1		
Ovary	726	18		
Male genitalia	1889	52	48	57
incl. prostate	1640	48		
Urinary system	2199	61	50	64
incl. bladder	1461	40		
Eye, cerebrum and other parts of				
central nervous system	546	10		
including:				
Eye and its appendages	39	1		
Cerebrum	474	9		
Thyroid and other endocrine glands	288	3		
incl. thyroid gland	268	3		
Inaccurately defined, secondary and undefined				
locations	1292	53		
Lymphatic, haematopoietic and related tissues	1390	29		
including:				

Name and location of the neoplasm – ICD, X-th revision	Total for the country	Vratsa		
		2010	2011	2012
Hodgkin disease	137	2		
Non-Hodgkin lymphoma	456	13		
Leukemia	612	9		
including:				
Lymphatic leukemia	270	5		
Myeloid Leukemia	236	4		

As most analyses show, the impact of radiation exposure on children is different than the one on adults, which influences the overall estimate on the health status.

Within the framework of a functioning Kozloduy NPP, a study was carried out on 150 children from the area in order to identify possible local variations on the thyroid gland. The measurements were conducted in the following settlements: Kozloduy, Oryahovo, Mizia, Selanovtsi and Harlets. An assessment was made on ^{131}I content.

The final analysis of the results shows that there is no indication of the presence of artificial radionuclides in the bodies of the studied children as well as of presence of ^{131}I in their thyroid glands. There was no difference in the spectral distributions and their numerical values from the individual measurements between the 'clean' area and the area of the NPP. According to the comparison of the spectrums measured in both areas, we can say that the internal dose uptake in the tested children was due only to naturally occurring radionuclides (K-40), which normally vary among individuals according to the area and the biological characteristics of the individuals[17].

With regard to ^{131}I, inflows of radionuclides in the thyroid gland were also not found.

Conclusion:

Based on the results obtained, we can draw the conclusion that up to the point when the measurements were conducted, "NPP Kozloduy" EAD has observed the technological regime.

"NPP Kozloduy" EAD has not committed any pollution to the environment and respectively no exposure of the population to artificial radionuclides that would increase the internal exposure.

The above statements regarding the dose exposure to the studied children, the majority of whom have parents working at the NPP, allow concluding that the sanitary and throughput regime functions so well that no activity was transferred from the power plant to the homes of the employees.

[17] Independent expert assessment of the content of technogenic radionuclides in the bodies of 150 children living in the area the Kozloduy NPP, Contractual assignment by the Kozloduy NPP and the NRRPC, 2003.

3.10.2 ASSESSMENT OF THE NON-RADIOACTIVE EMISSIONS FROM THE KOZLODUY NPP

The results from the analyses on the total suspended dust and basic gaseous pollutants to atmospheric air, such as SO_2, CO, NO_2, H_2S methane and non-methane hydrocarbons, O_3 and NH_3 are significantly below the respective limit admissible values $(LAV)_{MSC}$ and LAV_{ADS}.

As a result of the transport transfer, the analysis shows elevated values of nitrogen oxides and carbon monoxide. The level of the above pollutants is lower in the atmospheric air of the village of Harlets in comparison to that of the town of Kozloduy.

For the Kozloduy area, radioactive pollutants (gaseous and aerosol emissions) are included as an indicator for an effective and safe operation of the power plant, rather than as components characterising the quality of atmospheric air. The primary sources determining the quality of atmospheric air in the area of the Kozloduy NPP and within the studied zones around it are not radioactive pollutants, but industrial ones, and specifically:

- the workshops, production facilities and diesel generator stations of the power plant;
- the motor transport servicing the power plant;
- the domestic sites in the area;
- industrial facilities within the territory and around the site.

The most significant source of air pollution in the area is the motor transport.

We can view as potential sources, mostly of dust at the local scope, the concrete plants of "Atomenenergostroyprogres," "Zavodski Stroezhi" and the "Machinery and Auto-transportation" enterprise, situated to the north of the power plant. They can cause local air pollution with dust, and less so with harmful gasses, during the production of concrete and lime solutions, etc.[18].

As a summary, we can say that in the area of the Kozloduy NPP, the town of Kozloduy and the neighbouring settlements the pollution to the atmospheric air with dust and harmful gases is insignificant.[19].

The existing monitoring studies, conducted in the years from the commissioning of the Kozloduy NPP (1974) to the present moment, have not registered any excessive radiation and non-radiation aerosol pollution within the entire work site of the NPP. The cases of pollution, especially of the air environment of the actual site, are not a factor for adverse effects on the health of the population in the settlements within the 30 km safety zone.

We should note that during the disassembly of facilities, especially in the case of nuclear units 1 and 2, we are expecting the emission of substances of non-radiation but dangerous toxicological properties.

[18] "Radiation Environmental Control" on the Kozloduy NPP – 2005 – 2010.

[19] A study by the National Radiobiology and Radiation Protection Centre (NRRPC), 2005.

3.10.3 RADIOECOLOGICAL MONITORING

The natural gamma background for the Republic of Bulgaria has been measured continuously since the mid-1980s and is within the range from 0.06 to 0.60 µSv/h.

Furthermore, the National Automated System for Continuous Monitoring of the Background Gamma Radiation of the Republic of Bulgaria has been in operation since 1997. It consists of a central control station, 9 regional stations, 26 local stations, one mobile station, a crisis centre and an emergency station. Theory perform sample selection for laboratory analysis on the presence of technogenic radionuclides in the main components of the environment – air, water, soils and vegetation. The Vratsa RHI pays particular attention to the health status of drinking water sources.

The radioecological monitoring on the Kozloduy NPP is essential for ensuring the safety of the nuclear power plant and the radiation protection of the population and the environment in the area. The goal is to provide an accurate and detailed assessment of the radiation status of the environment and to localise the potential effects from the operation of the nuclear power plant on the population and the environment in the area within the established standards.

In accordance with the Regulation on the Basic Norms of Radiation Protection (BNRP-2012), the limit of the annual effective dose from the general external and/or internal exposure of the population is set at 1 mSv/a. Based on this limit and for the purposes of radiation control, secondary limits have been set, such as limits for the annual intake, a limit on the average annual volumetric activity (LAAVA) of a particular radionuclide in the atmospheric air, drinking water, etc. **Table 3.10-17** presents data on the average admissible concentrations of some more typical radionuclides in the atmospheric air and the drinking water for the critical group of the population.

TABLE 3.10-17: LAAVA IN THE AIR AND THE DRINKING WATER FOR SOME RADIONUCLIDES, (BNRP-2012) EXPECTED EFFECTIVE DOSE 1 MSV/A

Radionuclide	LAAVA of atmospheric air, Bq/m^3	LAAVA of drinking water, Bq/l
^{3}H	6900	7600
^{54}Mn	72	120
^{60}Co	4	14
^{90}Sr	0.77	1.9
^{131}I	7.3	2.1
^{137}Cs	3.2	11

The values presented in **Table 3.10-17** only apply to the cases when one radionuclide enters the human body along one of the possible pathways. For the cases concerning the intake of a mixture of radionuclides, or those of simultaneous intake via a combination of food, air and drinking water sources, the values stated in the tables should be corrected (the formulas are available in the respective legislative documents), so that the annual dose of 1 mSv/a would not be exceeded.

Regulation №10/2002 of the Ministry of Health *on the maximum admissible radioactive pollution for the import of agricultural products following the accident at the Chernobyl Nuclear Power Plant*, SG issue 44, 2002, defines the maximum admissible radioactive pollution for the import of processed, partially processed and unprocessed agricultural products intended for human consumption and polluted with radionuclides as a result of the accident at the Chernobyl Nuclear Power Plant. **Table 3.10-18** presents the limits on the radionuclide content in agricultural products.

TABLE 3.10-18: MAXIMUM ADMISSIBLE SPECIFIC ACTIVITY FOR SOME RADIONUCLIDES IN FOODS, BQ/KG [REGULATION №10]

Radionuclide	Milk and dairy products	Other agricultural products
Total: ^{134}Cs and ^{137}Cs	370	600

Admissible standards for the drinking water are established in Regulation №9/16.03.2001 on the quality of water for drinking and domestic purposes: 1 Bq/l for the total beta-activity and 100 Bq/1 for tritium. For the waters from natural water basins, Regulation №7/08.08.1986 on the parameters and standards determining the quality of running surface water envisages an admissible total beta-activity of 0.75 Bq/1.

3.10.3.1 ATMOSPHERIC AIR

3.10.3.1.1 Background gamma radiation

In 2012 a total of 1315 measurements were made to the background gamma radiation at the control checkpoints and routes using portable dosimetric devices and the stationary thermo luminescent dosimeters. Out of them, 1039 measurements were made using portable dosimetric devices at a total of 77 checkpoints within the 100 km zone. For independent passive control of the gamma background radiation, a total of 70 thermo-luminescent dosimeters Panasonic UD-802AS were used, for a total of 276 measurements. The summarised data and results for 2012 are presented in **Table 3.10-19**.

TABLE 3.10-19: AUTOMATED CONTROL /AISRM/ ON THE RADIATION GAMMA BACKGROUND WITHIN THE 30 KM MZ, 2012, µSV/H

Radiation gamma background, registered by the AISRM in 2012, average values, µSv/h

	Local Measurement Checkpoint – Kozloduy	Local Measurement Checkpoint – Harlets	Local Measurement Checkpoint – Glozhene	Local Measuremen t Checkpoint – Butan	Local Measurement Checkpoint – Mizia
average	0.098	0.098	0.074	0.097	0.081
min-max	0.07 ÷ 0.13	0.07 ÷ 0.13	0.05 ÷ 0.11	0.06 ÷ 0.13	0.05 ÷ 0.12

The gamma background radiation at points of the NPP's fence and at the checkpoints and settlements within the 100 km zone is completely comparable with the natural background radiation – 0.05 ÷ 0.15 μSv/h.

The radiation situation in the area is stable and has not been changed by the operation of the Kozloduy NPP.

3.10.3.1.2 Aerosol activity

The main subject of control for the radiation environmental monitoring is the airborne aerosol activity. For the purposes of localising the possible environmental impact of the Kozloduy NPP on the air, a sample collection network has been set up, consisting of a total of 11 control checkpoints within the 100 km Monitoring Zone around the NPP.

Up to April of 2009 the total beta activity of aerosol samples was also examined, and after that, pursuant to an amendment to the Monitoring Programme[20], coordinated with the BNRA, it was cancelled and replaced by an intensified (two-week) gamma spectrometric analysis of the samples, by nuclide composition. For 2009 the average values of the total beta activity in long-lived aerosols for the individual checkpoints were within the range 0.50÷0.68 mBq/m³. The long-term research of this radiation parameter is presented in **Figure 3.10-3**.

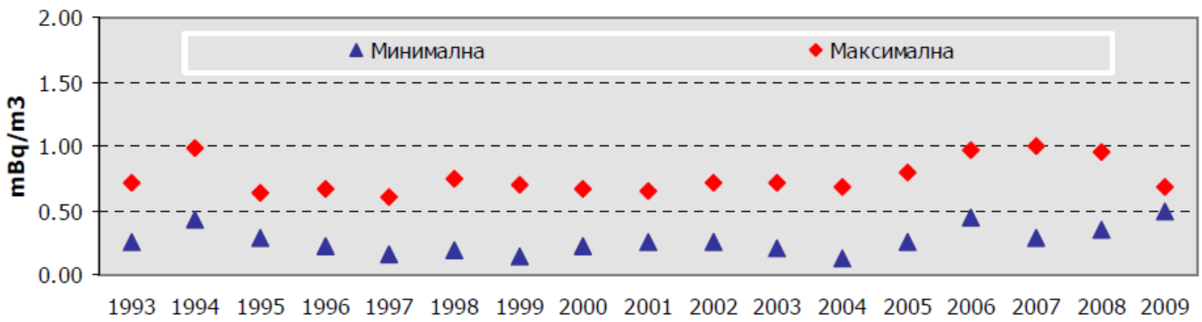

Figure 3.10-3: Average values of long-lived beta activity (mBq/m³) in aerosols from the 100 km zone of the Kozloduy NPP, 1993-2009

In 2012 a total of 259 samples have been analysed – of aerosol filters subjected to gamma spectral analyses aimed at establishing the nuclide composition.

The results for ^{137}Cs from the gamma spectrometric analyses on almost all aerosol samples in 2012 were within the Maximum Admissible Activity ranges (from 0.8 to 11 μBq/m³), on average 2.3 μBq/m³. These are characteristic values for the ground air in the area. The results provide a realistic assessment of the residual content of "Chernobyl" radiocesium in the atmosphere and demonstrate the possibility to register even the smallest changes in the radioactivity of the ground air, which are about 10^5÷10^6 times lower than the standards

[20] Radiation Environmental Monitoring Programme on the operation of the Kozloduy NPP, ID No. УБ.МОС.ПМ.262/02.

effective in the country (the average annual admissible concentration for ^{137}Cs under the BNRP-2012 is 3.2 Bq/m^3).

In 2011 the results for ^{137}Cs from the gamma spectrometric analyses on almost all aerosol samples were within the Maximum Admissible Activity ranges (from 0.8 to 10 $\mu Bq/m^3$), on average 2.8 $\mu Bq/m^3$. In 2011 an increase in aerosol activity was registered in April, as a result of the transboundary transfer of radioactively contaminated air masses from the Fukushima NPP accident. The results indicated an increase of technogenic activity within the following ranges: for ^{131}I – 31÷2240 $\mu Bq/m^3$, for ^{134}Cs – 33÷456 $\mu Bq/m^3$ and for ^{137}Cs:- 38÷637 $\mu Bq/m^3$. The data analysis categorically proves that the origin of these contaminants was the faulty Japanese NPP. All results were operationally reported to the BNRA and ALMERA-IAEA.

With the exception of the impact of the Fukushima NPP accident in 2011, the measured activities of ^{137}Cs in aerosols from all control checkpoints within the 100 km MZ of the Kozloduy NPP during the year and during previous periods were negligible, with background concentrations.

This experience demonstrated under real-world conditions the capabilities of the institutional radioecological monitoring of the Kozloduy NPP to ensure timely and reliable information in emergency situations within a transboundary scale.

3.10.3.1.3 Gaseous and aerosol releases

The monitoring on the gaseous and liquid releases from the Kozloduy NPP and their reporting is conducted in adherence to the requirements of the European legislation – Directive 96/29/Euratom and Recommendation of the European Commission 2004/2/Euratom. For the purposes of the assessment on the dose exposure of the population, the results were reassessed in a conservative manner, pursuant to sections 6 and 7 of 2004/2/Euratom.

The data on radioactive releases to the atmosphere from the ventilation stacks of the Kozloduy NPP for the last nine years are presented in **Table 3.10-20**. Considering the decommissioned power units 1÷4, as well as the fact that only units in operation are considered as sources of RNG and Iodine-131, the power plant has employed a more conservative approach in comparison to the administrative annual release limits (**Table 3.10-21**), by components for the whole site at 2000 MW operating capacity.

The limits have been set in such way that when are reached, the control level for the individual effective dose for the population –50 µSv/a – would not be exceeded.

TABLE 3.10-20: Gaseous and aerosol releases 2004-2012

Gaseous and aerosol releases	2004	2005	2006	2007	2008	2009	2010	2011	2012
RNG, TBq	71.5	27.8	6.83	1.15	0.55	0.66	6.43	9.61	0.942
LLA, GBq	0.10	0.074	0.069	0.070	0.019	0.63	0.0282	0.0164	0.0192

Gaseous and aerosol releases	2004	2005	2006	2007	2008	2009	2010	2011	2012
^{131}I, GBq	1.31	0.32	0.26	0.10	0.0011	0.0056	0.0657	0.1220	0.0019
^{3}H, TBq	-	-	-	-	-	-	0.376	0.545	0.586
^{14}C, TBq	-	-	-	-	-	-	0.519	1.010	0.710

TABLE 3.10-21: ADMINISTRATIVE ANNUAL LIMITS ON RELEASES FROM THE KOZLODUY NPP (IED<50 µSV/A)

Emission components	VS-1 Units 1 and 2	VS-2 Units 3 and 4	5VS Unit 5	6VS Unit 6	0VS 6CC-3	VS-SNFSF	NPP-total
RNG, TBq	100	2000	1400	1400	700	-	5600
LLA, GBq	3	15	12	12	5	3	50
^{131}I, GBq	3	30	13,5	13,5	5	-	65
^{3}H, TBq	10	60	60	60	60	-	250
^{14}C, TBq	1	10	9	9	9	-	38

In 2012 the total released 7.57x109 m3 gaseous and aerosol emission (**Table 3.10-20**) are multiple times below the conservatively defined limits (**Table 3.10-21**), respectively: RNG – 0.017%, LLA – 0.038%, ^{131}I – 0.0029%, ^{14}C – 1.87% и ^{3}H – 0.23%.

3.10.3.2 LIQUID RADIOACTIVE RELEASES

In 2012, a total of 45 800 m^{3} treated water was discharged into the Danube River. The percentage composition of liquid releases (without ^{3}H), as a sum total for the Kozloduy NPP and based on the gamma-spectrometric analyses, is presented in **Figure 3.10-4**.

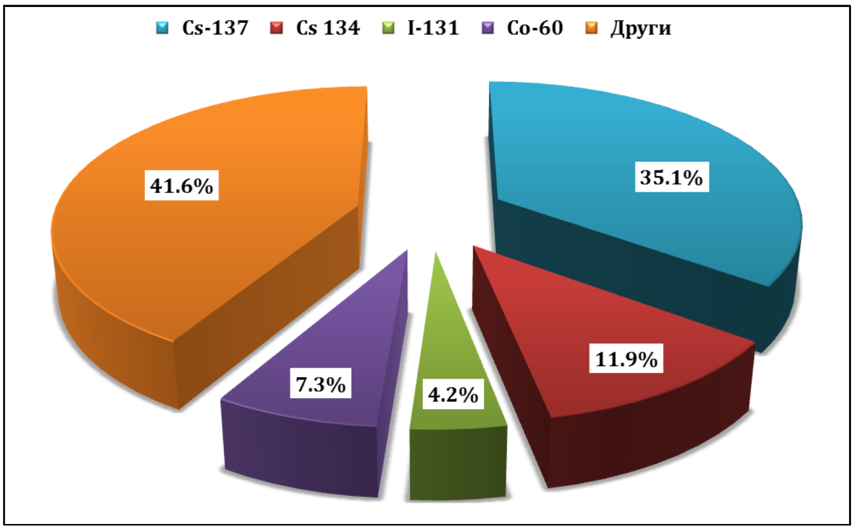

FIGURE 3.10-4: PERCENTAGE COMPOSITION OF LIQUID RELEASES FROM THE KOZLODUY NPP, 2012 AT TOTAL ACTIVITY 411 MGQ

3.10.3.3 ASSESSMENT OF THE DOSE EXPOSURE OF THE POPULATION WITHIN THE 30 KM ZONE RESULTING FROM RADIOACTIVE EMISSIONS FROM THE KOZLODUY NPP[21]

The monitoring studies of the Kozloduy NPP envisage specific individual and collective exposure doses for the population, caused by the release of radioactive substances from the NPP. This task, in its entirety, is solved via a complex of direct instrumental methods and assessment methods. The obtained results serve as the basis for the radiation protection parameters (See section **3.11**).

The values of the maximum individual effective dose to the population within the 30-km MZ of the Kozloduy NPP from the total radioactive releases for the last three years are shown in **Table 3.10-22.**

TABLE 3.10-22: DOSE EXPOSURE FOR THE POPULATION WITHIN THE 30 KM ZONE FROM GASEOUS, AEROSOL AND LIQUID RELEASES, 2010-2012.

Year	Maximum individual effective dose for the critical group, [Sv/a]		
	Gaseous and aerosol	Liquid	Total
2010	$8.02.10^{-7}$	$6.00.10^{-7}$	$1.40.10^{-6}$
2011	$2.72.10^{-6}$	$6.05.10^{-7}$	$3.33.10^{-6}$
2012	$1.33.10^{-6}$	$6.37.10^{-7}$	$1.97.10^{-6}$

Gaseous and aerosol releases

For 2012 the estimated doses to the population have been calculated in parallel using meteodata for the year and local climate data. The maximum individual effective annual dose within the 30 km zone from gaseous and aerosol releases (RNG+LLA+^{131}I+^{3}H+^{14}C) by the Kozloduy NPP has been estimated at 1.33x10^{-6} Sv/a using meteorological data. The collective effective annual dose was estimated at 2.65 x.10^{-2} man.Sv/a. The normalised annual collective effective dose to the population living within the 40-km zone due to gaseous and aerosol emissions amounts to 1.47x10^{-2} man.Sv/GW.a. Estimations by components for RNG, LLA and Iodine for the Kozloduy NPP are fully comparable with the data for a large number of PWR reactors in the world (UNSCEAR-2000, 2008).

Liquid releases

The collective dose for the population within the 30 km zone from liquid radioactive releases in 2012 was estimated at 4.7x10^{-3} man.Sv/a. The normalised collective dose per unit of produced electricity amounts to 2.61x10^{-3} man.Sv/GW.a. This exposure is only 13% of the average value for PWR reactors in the world: 2x10^{-2} man.Sv/GW.a. (UNSCEAR'2000).

The maximum individual effective dose for the 30-km zone is set at 6.37x10^{-7} Sv/a, and for a representative of the critical group of the population along the Danube River (town of Oryahovo and the villages of Leskovets, Ostrov and Gorni Vadin) it is respectively 4.49x10^{-6}

[21] Results from the radiological monitoring on the Kozloduy NPP for 2009, 2010, 2011 and 2012.

Sv/a. This exposure is negligible and is less than 0.5% of the annual limit for the effective dose of 1 mSv (BRPS-2012) and hundreds of times lower than the exposure from the natural background radiation (2.33 mSv/a). In comparison to the administrative quota on the limit exposure to the radioactive releases of the NNU under all operational states, set at 0.05 mSv/a (guidelines by the BNRA given by letter № 47-00-171/12.02.2013), the maximum calculated dose is just 9%.

The completed assessments on the dose impact of the releases from the Kozloduy NPP are completely comparable with the global practice, according to official UN data (UNSCEAR-2000). It should be noted that since then the international best practice shows a continuous improvement in the control of the releases, and respectively lower emissions and actual reporting, resulting in lower dose estimates for the population in the areas of the NPP. Since the comparison is made based on the collective dose, in the assessments of the Kozloduy NPP the relatively small population density in the area, compared with many other NPPs worldwide, also positively affects the assessment.

The low levels of radioactive releases from the Kozloduy NPP determine radiation exposure values with negligible radiation risk to the population within the area of the power plant. The additional radiation exposure of the population within the 30 km zone averages at about 500 times lower than the one received from the natural background radiation (2330 μSv). In the last 5 years, the values of the maximum individual effective dose for the population varies within the range 4÷7 μSv/a, which is below the level for clearance from regulatory control – 10 μSv/a, BRPS-2012.

The results of the radioecological monitoring conducted in 2012 and other radiation measurements from previous years provide a realistic evaluation of the negligible impact of the Kozloduy NPP on the aerosol activity in the air. In practical terms, this indicator has not been impacted by the operation of the power plant. The radiological air purity fully meets the normalised requirements and the radioactivity of the atmospheric depositions within the MZ and the 100 km zone is within normal background limits, unaffected by the operation of the Kozloduy NPP.

The results of the plant's radiation monitoring are verified annually by independent studies conducted by the MEW and the NRRPC (MH)[22].

Determining the quantitative content of technogenic radionuclides in environmental sites shows that the results are usually lower than or comparable to the lower detectable limit with modern measurement techniques and equipment. This fact determines the necessity to use model-mathematical methods for evaluation of the migration and quantitative content of radionuclides into the environment. The input data for the modelling is in the form of real data from the radiation control at the source – radioactive releases into atmosphere and hydrosphere, real meteorological and hydrological data, statistical demographic data, data on the consumption of foods produced in the area, and data on the electric power generated by the NPP during the evaluation period.

22 Reports of the NRRPC – Sofia, 2009-2010.

3.10.3.4 ASSESSMENT OF RADIOBIOLOGICAL EFFECTS AND RADIATION RISK

The population within the monitored zone of the Kozloduy NPP is considered to be 65994 people (**Table 3.10-1**).

According to statistical data by the National Statistical Institute from the Census conducted on 01.02.2011, the population within the 30 km zone around the Kozloduy NPP on the territory of the Republic of Bulgaria is 65 994 people, and on the Romanian territory – 75 150 people (based on a letter by the Romanian Ministry of Environment and Forests, № 3672/RP/18.10.2012). The following conclusions can be made for this population regarding the radiobiological effects and the radiation risk resulting from the operation of the Kozloduy NPP

The following conclusions can be made for this population regarding the radiobiological effects and the radiation risk resulting from the operation of the Kozloduy NPP in 2012.

3.10.3.4.1 Deterministic effects

There is no risk of the development of deterministic effects for the population within the 30 km zone of the Kozloduy NPP.

In recent years the values of the maximum individual effective dose to the population vary in the range 4÷7 μSv/a. The individual doses of gaseous and aerosol releases are within the range $7.18 \times 10^{-9} \div 2.72 \times 10^{-6}$ Sv.

These doses are much lower than the threshold level established by Art. 10 of the BNRP as a maximum annual effective dose, which is 1 mSv for the population.

Based on the above, we can state that **there is no risk of the development of deterministic effects** for the population within the 30 km zone of the NPP.

3.10.3.4.2 Stochastic effects

The probability of the occurrence of radiation-induced cancer for the entire population is 2.01×10^{-8}, and the probability of the occurrence of hereditary diseases is 7.32×10^{-10}., i.e. the risk of stochastic effects is negligible.

The tables below present detailed assessments for 2012 on:

- ✓ **Table 3.10-23** – risks reflecting the damage from radiation-induced cancer and hereditary diseases for the entire population and the persons of employable age;
- ✓ **Table 3.10-24**- assessments on the risk and damage to some tissues for the population as a whole;
- ✓ **Table 3.10-25 ÷ Table 3.10-27** – risks of hereditary diseases for the reproductive part of the population, estimated for two generations, when the first generation is exposed before the second one, and estimated for the first generation after the exposure.

Table 3.10-23: Risks reflecting the damage from radiation-induced cancer and hereditary diseases for the entire population and the persons of employable age

Irradiated population	Cancer	Hereditary effects	Total
entire population	2.01E-08	7.32E-10	2.09E-08
persons within employable age	1.50E-08	3.66E-10	1.54E-08

Table 3.10-24: Estimates on the risk and damage to some tissues for the population as a whole

Tissue/Organ	Nominal risk *(cases per 10 000 persons)*	Nominal risk, taking into account the death rate	Damage
esophagus	4.50E-05	4.53E-05	3.94E-05
stomach	2.37E-04	2.31E-04	2.03E-04
colon	1.95E-04	1.48E-04	1.44E-04
liver	9.00E-05	9.06E-05	7.97E-05
lungs	3.42E-04	3.39E-04	2.71E-04
bones	2.10E-05	1.53E-05	1.53E-05
skin	3.00E-03	1.20E-05	1.20E-05
mammary gland	3.36E-04	1.86E-04	2.40E-04
ovaries	3.30E-05	2.64E-05	2.96E-05
bladder	1.29E-04	7.05E-05	5.01E-05
thyroid gland	9.90E-05	2.94E-05	3.79E-05
bone marrow	1.26E-04	1.13E-04	1.84E-04
other solid ones	4.32E-04	3.31E-04	3.41E-04
gonads	6.00E-05	5.79E-05	7.64E-05
Total	**5.15E-03**	**1.50E-03**	**1.60E-03**

Table 3.10-25: Evaluation of the risk of hereditary diseases

Disease class	Two generations	First generation
	entire population average in %	entire population average in %
Mendelian diseases	2.93E-08	1.83E-08
chronic diseases	1.10E-08	1.10E-08
congenital anomalies	4.03E-08	2.93E-08
Total	**8.06E-08**	**5.86E-08**

Table 3.10-26: Evaluation of the risks of hereditary diseases for the reproductive part of the population, estimated for two generations (when the first generation is exposed before the second one)

Disease class	reproductive population	
	range in %	average in %
Mendelian diseases	4.76E-08 ÷ 9.15E-08	6.95E-08
chronic diseases	1.10E-08 ÷ 4.39E-08	2.93E-08
congenital anomalies	8.78E-08 ÷ 1.10E-07	9.88E-08
Total		**1.98E-07**

TABLE 3.10-27: EVALUATION OF THE RISKS OF HEREDITARY DISEASES FOR THE REPRODUCTIVE PART OF THE POPULATION, ESTIMATED FOR THE FIRST GENERATION AFTER THE EXPOSURE

Disease class	reproductive population	
	range in % for the introductory dose	average in % for the introductory dose
Mendelian diseases	2.75E-08 ÷ 5.49E-08	4.03E-08
chronic diseases	9.15E-09 ÷ 4.39E-08	2.56E-08
congenital anomalies	-	7.32E-08
Total		**1.39E-07**

3.10.3.5 CONCLUSION

The radioecological monitoring conducted in 2012 established a correspondence between the condition of the environment around the NPP and the legislative requirements in the area of radiation protection and environmental protection. There is no deviation from the radiation parameters above the admissible standards.

The comparison between the data from 2012 and those from previous years and those for the period before the commissioning of the power plant proves the absence of any adverse trends in the radioecological status resulting from the operation of the Kozloduy NPP. The radiation parameters are within normal ranges, with background radiation values typical for the area. The radiation situation within the 100 km zone is stable and favourable.

The scheduled measurements of the background radiation using specialised dosimeters, installed along the boundaries of the Kozloduy NPP site, show that the potency of the equivalent dose of gamma radiation varies within the ranges of the natural background radiation.

The summary of the data from the long-term monitoring of the background radiation in the area of the Kozloduy NPP shows that for the whole period of operation of the Kozloduy NPP the radiation parameters have been within normal ranges, with background values typical for the area. The radiation status within the 100 km zone is stable and favourable, with relatively small deviations after the accident with the Chernobyl NPP in comparison to other areas in the country, and without any cases of exceeded values above the typical background radiation levels for the individual areas.

The respective authorities have stated that the good results have been achieved under strict adherence to the dosimetric and radiation control and qualified implementation of technological requirements.

3.10.4 WORK ENVIRONMENT

3.10.4.1 RADIATION FACTORS OF THE WORK ENVIRONMENT

The operation of the NPP is in compliance with the purposes and principles of radiation safety, and the protection of the life and health of the people and the environment takes precedence over the economic and other factors. The authorities have established mandatory hygienic standards and requirements and sanitary rules for all matters pertaining to hygiene, radiation safety and protection, etc.

The exposure doses for the personnel have been established on the basis of long-term studies on the working conditions at nuclear power stations.

The strict regulation of radiation factors of the work environment is a necessary condition for the practice of nuclear safety and radiation protection for the NPP personnel. The main legislative document in the area of radiation protection in the Republic of Bulgaria is the Basic Norms of Radiation Protection – BNRP-2012.

The workplaces where the personnel is exposed to the impact of ionizing radiation are – premises for permanent stay of the personnel and premises where the personnel spends no more than half of the established working hours. The long-term studies on the working conditions at nuclear power stations have served as the basis for establishing the patterns and factors determining the radiation environment within production premises and the exposure doses for the personnel.

Depending on the nature of the work, the NPP premises are classified into the following categories:

- ✓ serviced premises – those where the impact of the radiation factor on the personnel is practically excluded, or it is within such normalised limits that it is possible for the personnel to spend the whole work shift there;
- ✓ semi-serviced premises – those where repairs and other activities are performed, which are related to the operation of technological equipment, temporary storage of nuclear waste, etc. In these premises the personnel stays no more than half of the working hours;
- ✓ unserviced premises – boxes, chambers and other hermetically sealed premises housing technological equipment, communications, etc. representing sources of ionizing radiation; during normal operation the presence of the personnel in these premises is prohibited;
- ✓ admissible potency of the equivalent doses for one calendar year:
- ✓ for premises for permanent stay of the personnel (serviced premises) 5 µSv/h (1700 hours);
- ✓ for premises where the personnel stays no more than half of the established working hours (semi-serviced premises) – 10 µSv/h (850 hours).

Based on the characteristics presented above, in view of maintaining control over the sources of radiation and on exposed individuals, the authorities have established controlled and supervised (monitored) zones. Within the controlled zone, under the normal operation mode, the regulations require specific measures for monitoring of the professional exposure and the radiation protection of the personnel, and in the cases of incidents – also measures for the prevention or containment of the radiation impact. The monitored zones are those outside the boundaries of the controlled zone. In them there is ongoing radiation control on the working environment, but no measures are required for the radiation protection of the personnel.

The potency of the gamma radiation dose for the different workplaces may vary within wide ranges – from 0.05 mGy/h to 85 mGy/h.

Pursuant to BNRP-2004, BNRP-2012 for the surfaces of premises for periodic stay of the personnel and the equipment situated there, the admissible radioactive contamination with beta-active radionuclides is 8000 $\beta/(cm^2\ min)$. The summary of the above data shows that:

1. The values of the background radiation are the highest in the reactor compartment, the transport corridors and some radiochemical laboratories. In some premises the level of background radiation reaches up to 1.5 mSv/h.
2. The total exposure dose for 85 % of the personnel is in the range of 1-12 mSv/year.
3. The personnel in the maintenance groups, the decontamination department and external organisations is exposed to relatively high doses.
4. The external and internal exposure of the personnel working within the monitored zone, outside the controlled zone, is comparable to the one received from the natural background radiation in the area of the power plant – around 2 mSv/year.
5. During the years of operation of the Kozloduy NPP, the parameters of the radiation environment vary considerably but do not exceed the limits defined by BNRP-2004 and BNRP-2012.

3.10.4.2 Radiation environment and exposure dose for the personnel of the Kozloduy NPP. Situational analysis

The analysis on the exposure dose to the people working at the power plant encompasses a 5-year operation period and was done based on data by the "Safety and Quality" department of the Kozloduy NPP.

Under normal operation the collective effective dose for the personnel working in EP-1 was reduced from 6634 man.mSv in 2000 to 2153 man.mSv in 2005, and for external exposure these values are 6412 man.mSv and 2070 man.mSv respectively. The contribution of radionuclides to the total exposure of the personnel is a relatively consistent value, which in terms of percentage varies within the range from 2.89% to 3.91% over the years. The control on internal exposure conducted by the NRRPC in the course of several years shows that for the majority of the examined workers the annual individual dose from incorporated radionuclides is below 1 mSv.

The average individual effective annual doses of the control contingent working in EP-1 are much lower than the national limits for professional exposure and were within the range up to 0.69 mSv in 2005.

A reduction of the dose is also observed for the maximum effective dose of professionally exposed individuals.

An inquiry into the individuals exposed to doses above 50 mSv demonstrated that in comparison to previous years, during the period 2005-2010 there is no registered exceeding of the individual annual effective dose above the annual limit for personnel exposure.

During reactor refuelling and during various repairs, the personnel of the power plant is exposed to an elevated radiation impact, which leads to a relative increase of individual exposure. The distribution of the contribution of different work operations, under normal operation mode, to the total exposure of the personnel, expressed as a percentage of the annual total dose, is the following:

- ✓ operation of the reactor and general supervision – 10.8%;
- ✓ current repairs – 52.6%;
- ✓ preventive maintenance – 3.0%;
- ✓ specialised repairs – 10.0%;
- ✓ processing of radioactive waste – 6.9%;
- ✓ refuelling – 7.7%.

The majority of the personnel exposure results from the repair works – 71.6% total.

3.10.4.3 HEALTH STATUS OF THE PERSONNEL OF THE KOZLODUY NPP

The exposure of people to ionizing radiation can cause various biological and health effects, affecting different organs, with varying severity and time of occurrence. A specific feature of radiation damage is that it may manifest itself in the exposed individuals (somatic effects) or in their offspring (hereditary or genetic effects). The somatic effects include both malignant neoplasms and non-malignant diseases.

Generally, the radiation effects are *deterministic* (non-probabilistic or non-stochastic, or threshold-based) and *stochastic* (probabilistic or non-threshold).

The ***deterministic*** effects are characterised by the presence of a limit to the exposure dose, under which the effect is not clinically manifested. If the threshold is exceeded, the severity of the damage increases with the exposure dose. The manifestation of the deterministic effects depends also on the potency of the dose, in addition to the actual exposure dose. The threshold doses for the occurrence of various deterministic effects depend on the radiation sensitivity of the tissues and organs. Deterministic or non-stochastic are some effects specific to individual organs, such as cataract (threshold dose – 0.15 Gy/y), non-malignant skin damage, suppression of bone marrow blood formation (0.4 Gy/y), damage to germ cells (0.4 Gy/y), associated with disruption of fertility. Other places where non-stochastic effects tend to get manifested are blood vessels and connective tissue, which can cause damage to various organs and systems in the human organism.

The ***stochastic*** effects are characterised with the absence of a threshold dose for their occurrence. The biological effect increases with the increase of the dose intake, and its clinical manifestation requires a latency period. This is where all genetic (hereditary) effects belong, and from the somatic ones – the radiation-induced malignant neoplasms. It is exactly carcinogenesis that primarily determines the somatic risk from chronic exposure to low doses of ionizing radiation.

The main components of the harmful impact of ionizing radiation are the following stochastic parameters:

- probability of lethal cancer (malignant);
- probability of non-lethal cancer;
- probability of severe hereditary effects and reduced life expectancy if the damage is manifested.

The following values of the so-called nominal probability factors for the occurrence of stochastic effects have been defined for people working in an environment with ionizing radiation:

- lethal cancer – 4.0×10^{-2} Sv^{-1}
- non-lethal cancer – 0.8×10^{-2} Sv^{-1}
- severe hereditary effects – 0.8×10^{-2} Sv^{-1}
- Total – 5.6×10^{-2} Sv^{-1}

The probability for increased radiation-induced damage in irradiated individuals goes up with the increase of the received individual annual dose and the overall cumulative exposure dose received during the whole period.

The health status of the power plant personnel is monitored by the Kozloduy NPP Health Centre and by teams from the NRRPC and the MH. The personnel undergoes regular preventive examinations and routine tests, as well as some specialised tests for this type of contingent. Based on a pre-defined schedule, the occupational health service examines and analyses the health status of the people working at the Kozloduy NPP for a three-year period. The sources of information are the personal medical cards (PMC) of all individuals whose results from conducted preventive examinations and tests have been registered, as well as the sick leave certificates with information on temporary disability and the respective reasons for it. The analysis on long-term disability is characterised by and based on the expert decisions of the Territorial Expert Medical Committee (TEMC) and the Medical Consultative Committee (MCC).

The characteristic of the workers of the Kozloduy NPP by gender for a retrospective period is presented in **Table 3.10-28**: .

TABLE 3.10-28: CHARACTERISATION OF THE WORKERS OF THE KOZLODUY NPP BY GENDER

Sub-sites	Total	Gender	
		M	F
2009	4674	3283	1391
2010	4484	3178	1306
2011	4251	2895	1356

The monitoring and evaluation of the health status of the workers of the power plant is the result of comprehensive preventive examinations, organised by the Kozloduy NPP Health

Centre. The examinations during the period 2009 – 2011 have attained nearly full coverage of the individuals subject to preventive examination (**Table 3.10-29**).

TABLE 3.10-29: SCOPE OF THE INDIVIDUALS SUBJECT TO PREVENTIVE EXAMINATION

Annual	Subject to preventive examination	Passed	Scope in %	Temporary sickness	In %	Number of workers with new diseases	In %	Number of workers with suspected occupational disease	Number of occupied individuals
2009	4674	4582	98.03	2333	50.91	454	9.90	-	32
2010	4484	4383	97.74	1904	43.44	428	9.76	-	33
2011	4251	4187	98.49	1417	33.84	183	4.37	-	61

It should be noted that for 2011 we observe a considerable reduction of temporary sickness, as well as the number of workers with new diseases ((009 – 454/9.90%; 2010 – 183/4.37%). The results from the analysis and evaluation of the health status with temporary disability (TD) in one-third of the individuals who experienced sickness (2009 – 2011), out of the average number of employees of the power plant, show an approximately equal level of the frequency of cases and frequency of working day losses (**Table 3.10-30** and **Table 3.10-31**).

TABLE 3.10-30: LEVEL OF INCIDENCE AND FREQUENCY OF WORKING DAY LOSSES FOR 2009-2011

Annual	Average number of employees	Sick	Relative share of the sick employees in %	Primary sick leaves	Frequency of cases in %	Lost days	Frequency of working days losses in %	Average duration
2009	4674	1772	37.91	2333	49.91	28017	599.42	12.01
2010	4484	1192	26.58	1904	42.46	26737	596.05	14.04
2011	4251	1417	33.33	2408	56.65	28747	676.24	11.93

The system for evaluation of the primary indicators of sickness with temporary disability includes a comparison with the benchmarks used up to this point, based on the Baktis-Lekarev scale, **Table 3.10-31.**

TABLE 3.10-31: EVALUATION SCHEME FOR THE PRIMARY INDICATORS OF SICKNESS WITH TEMPORARY DISABILITY

Evaluation	Frequency of cases with temporary disability per 100 workers	Frequency of calendar days with temporary disability per 100 workers
Very low	Up to 60	Up to 600
Low	61 -80	601 -800
Average	81 -100	801 -900
High	101 -120	901 -1200
Very high	over 120	over 1200

Table 3.10-32 shows the relative share of long-term sickness and frequent sickness.

TABLE 3.10-32: RELATIVE SHARE OF LONG-TERM SICKNESS AND FREQUENT SICKNESS

Year	Long-term sickness and frequent sickness		
	Relative share	Over 4	Over 30 days
2009	9.11 %	193	233
2010	7.73 %	137	210
2011	10.02 %	191	235

For the purposes of prevention of diseases with temporary disability (DTD) the respective groups with the respective quantitative assessment have been examined and systematised.

TABLE 3.10-33: COMPARATIVE TABLE AGAINST THE STANDARD FOR DTD BY NOSOLOGICAL GROUPS

Indicators	Frequency of the cases "frequency"			
Nosological groups	**2009**	**2010**	**2011**	**Standard**
1. OKGDP	5.91	6.18	9.36	21.6
2. Pneumonias	0.64	1.09	0.75	1.1
3. Other diseases of the respiratory system	4.66	4.15	5.08	0.9
4. Diseases of the eye	0.45	0.45	0.33	1.8
5. Diseases of the ear	0.98	0.80	1.43	3.4
6. Diseases of the PNS	4.2	3.2	3.92	3.4
7. Diseases of the NS, incl. neuroses	0.1	0.6	0.49	2.6
8. Hypertonic disease	1.16	1.7	1.34	2.5
9. HIBS	0.6	0.36	0.56	0.8
10. Other diseases of the cardiovascular system	0.24	0.45	0.49	1.9
11. Ulcers of the stomach and duodenum	0.3	0.07	0.14	2.7
12. Gastritis, enteritis, colitis	2.46	2.12	2.66	5.6
13. Malignant neoplasms	0.45	0.40	0.61	0.9
14. Benign neoplasms	0.71	0.67	0.99	1.5
15. Diseases of the urogenital system	2.35	2.20	2.70	3.4
16. Diseases of the female genitals	1.22	0.85	1.15	4.09
17. Diseases of the skin	1.19	0.71	1.12	2.9
18. Diseases of the musculoskeletal system	3.79	4.79	2.44	4
19. Domestic accidents	2.97	2.77	3.19	5.9
20. Occupational accidents	0.06	0.16	0.05	2.2

The leading diseases causing temporary disability for the workers of the Kozloduy NPP are the diseases of the upper respiratory tract. Attention should also be paid during subsequent preventive examinations of the employees to the diseases of the peripheral nervous system and the diseases of the musculoskeletal system. For the period 2009 – 2011 no occupational accidents have been registered.

The National Radiobiology and Radiation Protection Centre (NRRPC) has conducted studies on the risk of inducing malignant neoplasms in workers of the Kozloduy NPP, using a methodology for establishing chromosome damage (micronuclei in peripheral blood lymphocytes). It should be noted that the results from the utilization of this type of cytogenetic examination on irradiated individuals does not characterise the health status of the individual. They provide important information about the degree of mutagenic impact of the exposure and can serve for a possible risk assessment. The results from the conducted cytogenetic monitoring on 120 individuals occupied with repair operations and refuelling of reactors, with cumulative exposure doses from 250 to 690 mSv, show an elevated rate of chromosomal damage in the lymphocytes of the peripheral blood in comparison to the spontaneous rate for the country. Similar results have also been observed in some individuals with exposure below the admissible standards, working within the controlled zone.

The individuals with elevated rate of chromosomal aberrations should be subjected to special medical monitoring, due to presence of potential risk of the development of late effects, which may be manifested mainly during the retirement age.

No permanent adverse trends have been established regarding changes to the haematological indicators for the workers of the NPP which could be caused by the factors related to working within the Kozloduy NPP, which has been in operation for decades.

3.11 RADIATION RISK TO THE POPULATION IN THE EVENT OF RADIOACTIVE RELEASES FROM THE KOZLODUY NPP

3.11.1 DOSES FROM GASEOUS AND AEROSOL RELEASES

This report presents estimates of individual and collective doses to the population within 30 km zone from gaseous, aerosol and liquid radioactive releases from the Kozloduy NPP for the period 2010 ÷ 2012 (Annual Reports, Results from the radiation environmental monitoring on the Kozloduy NPP in 2010 – №11.РМ.ДОК.085, 2011 – №12.РМ.ДОК.111 and 2012 – №13.РМ.ДОК.175).

Under all operating conditions of the facilities situated at the Kozloduy NPP site, the annual individual effective dose from internal and external exposure of the population caused by the impact of liquid and gaseous releases in the environment for all units and facilities that are and will be located at the Kozloduy NPP site should not be higher than 0.25 mSv (instructions of the BNRA, presented via letter № 47-00-171/12.02.2013). For all existing facilities at the site, the established exposure quota for gaseous releases is 0.05 mSv and for liquid releases – 0.05 mSv, for a total of 0.1 mSv.

According to the Environmental Impact Assessment Report on the Dry Spent Fuel Storage Facility of the Kozloduy NPP, there is no release of radioactive material in the atmosphere and in the discharged water under normal operational conditions.

In 2010, the estimated maximum individual effective dose to the population from total gaseous and aerosol (including ^{14}C и ^{3}H) and liquid releases from the Kozloduy NPP in the environment was 1.4 μSv/a. This is only 0.06 % of the exposure from the natural background radiation in the country (2.33 mSv), 0.14% of the standard for the population (1 mSv, under the BRPS-2012) and about 1.4% of the limit (0.1 mSv/a) for exposure to radioactive releases from the facilities situated at the NPP site.

In 2011, the estimated maximum individual effective dose to the population from total gaseous and aerosol (including ^{14}C и ^{3}H) and liquid releases from the Kozloduy NPP in the environment was 3.33 μSv/a. This is only 0.14 % of the exposure from the natural background radiation in the country (2.33 mSv), and 0.33 % of the standard for the population (1 mSv, under the BRPS-2012) and about 3% of the limit (0.1 mSv/a) for exposure to radioactive releases from the facilities situated at the NPP site.

In 2012, the estimated maximum individual effective dose to the population from total gaseous and aerosol (including ^{14}C и ^{3}H) and liquid releases from the Kozloduy NPP in the environment was 1.97 μSv/a. This is only 0.08 % of the exposure from the natural background radiation in the country (2.33 mSv/a), and 0.2 % of the standard for the population (1 mSv/a, under the BRPS-2012) and about 2% of the limit (0.1 mSv/a) for exposure to radioactive releases from the facilities situated at the NPP site.

3.11.1.1 GASEOUS AND AEROSOL RELEASES TO THE ATMOSPHERE

The results from the model assessments of the exposure doses to the population within the 30 km MZ for the last three years from gaseous and aerosol releases from the Kozloduy NPP into the environment are presented in Table **3.11-1** ÷ **Table 3.11-5**, and a graphical illustration of the exposure dose from gaseous releases for 10 years (2003-2012) is presented in **Figure 3.11-1.**

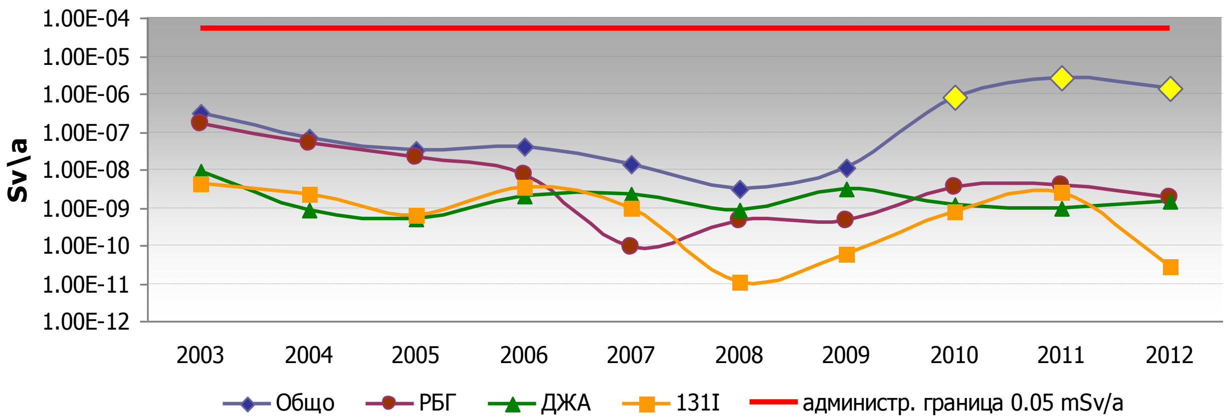

FIGURE 3.11-1. EXPOSURE DOSE WITHIN THE 30 KM ZONE FROM GASEOUS RELEASES FOR 2003-2009 (WITHOUT ^{3}H, ^{14}C) AND FOR 2010-2012 Г. (+^{3}H +^{14}C)

TABLE 3.11-1: EXPOSURE DOSE WITHIN THE 30 KM ZONE FROM GASEOUS AND AEROSOL RELEASES FOR 2010 – 2012 (RNG+LLA+^{131}I+^{3}H+^{14}C)

Year	Gaseous and aerosol releases					
	Collective dose [manSv]	Normalised collective dose [manSv/GW.a]	Individual effective dose [Sv]	Comparisons of the maximum individual dose		
				BNRP-2012 1 mSv	Quota BNRA 0.05 mSv	Background radiation 2.4 mSv
2010	$1.47.10^{-2}$	$8.44.10^{-3}$	$7.18.10^{-9}$ – $8.02.10^{-7}$	0.080%	1.61%	0.033%
2011	$3.49.10^{-2}$	$1.87.10^{-2}$	$1.22.10^{-8}$ – $2.72.10^{-6}$	0.27%	5.44%	0.11%
2012	$2.65.10^{-2}$	$1.47.10^{-2}$	$1.10.10^{-8}$ – $1.33.10^{-6}$	0.13%	2.66%	0.06%
UNSCEAR-2008		$2.2.10^{-1}$				

TABLE 3.11-2: EXPOSURE DOSE WITHIN THE 30 KM ZONE FROM RNG (RADIOACTIVE NOBLE GASES), 2010-2012

Year	RNG			
	Collective dose [manSv]	Normalised collective effective dose [manSv/GW.a]	Compared to UNSCEAR-2000 [%]	Individual effective dose External exposure – RNG [Sv]
2010	$6.82.10^{-5}$	$3.92.10^{-5}$	1.31%	$9.19.10^{-11}$ – $3,34.10^{-9}$
2011	$5.44.10^{-5}$	$2.92.10^{-5}$	0.97%	$5.31.10^{-11}$ – $3.80.10^{-9}$
2012	$4.07.10^{-5}$	$2.26.10^{-5}$	0.75%	$4.75.10^{-11}$ – $1.84.10^{-9}$
UNSCEAR-2000		$3.0.10^{-3}$		

TABLE 3.11-3: EXPOSURE DOSE WITHIN THE 30 KM ZONE FROM LLA (LONG-LIVED AEROSOLS), 2010-2012

Year	LLA			
	Collective dose [manSv]	Normalised collective effective dose [manSv/GW.a]	Compared to UNSCEAR-2000 [%]	Individual effective dose Depositions on the ground surface – LLA [Sv]
2010	$6.71.10^{-5}$	$3.85.10^{-5}$	10%	$3.36.10^{-11}$ – $1.23.10^{-9}$
2011	$4.50.10^{-5}$	$2.42.10^{-5}$	6.1%	$1.26.10^{-11}$ – $9.16.10^{-10}$
2012	$6.05.10^{-5}$	$3.36.10^{-5}$	8.4%	$3.61.10^{-11}$ – $1.40.10^{-9}$
UNSCEAR-2000		$4.0.10^{-4}$		

TABLE 3.11-4: EXPOSURE DOSE WITHIN THE 30 KM ZONE FROM ^{131}I, 2010-2012

Year	^{131}I			
	Collective dose [manSv]	Normalised collective effective dose [manSv/GW.a]	Compared to UNSCEAR-2000 [%]	Individual equivalent dose Inhalation intake ^{131}I Thyroid gland 0–1 years (max) [Sv]
2010	$2.21.10^{-5}$	$1.27.10^{-5}$	13%	$1.21.10^{-11}$ – $7.95.10^{-10}$
2011	$5.04.10^{-5}$	$2.71.10^{-5}$	27%	$2.00.10^{-11}$ – $2.59.10^{-9}$
2012	$8.45.10^{-7}$	$4.69.10^{-7}$	0.47%	$4.01.10^{-13}$ – $2.81.10^{-11}$
UNSCEAR-2000		$1.0.10^{-4}$		

TABLE 3.11-5: INDIVIDUAL AND COLLECTIVE DOSES FOR THE POPULATION FROM THE RELEASES OF ^{3}H И ^{14}C INTO THE ATMOSPHERE, 2010-2012

Radionuclide	Year	Collective dose, [manSv]	Normalised collective effective dose [manSv/GW.a]	Individual effective dose [Sv]
^{3}H	2010	$7.73.10^{-5}$	$4.44.10^{-5}$	$9.51.10^{-11}$ – $5.63.10^{-9}$
	2011	$1.38.10^{-4}$	$7.41.10^{-5}$	$1.23.10^{-10}$ – $1.43.10^{-8}$
	2012	$1.60.10^{-4}$	$8.86.10^{-5}$	$1.70.10^{-10}$ – $1.08.10^{-8}$
^{14}C	2010	$1.45.10^{-2}$	$8.33.10^{-3}$	$6.81.10^{-9}$ – $7.88.10^{-7}$
	2011	$3.46.10^{-2}$	$1.86.10^{-2}$	$1.18.10^{-8}$ – $2.69.10^{-6}$
	2012	$2.62.10^{-2}$	$1.46.10^{-2}$	$1.07.10^{-8}$ – $1.31.10^{-6}$

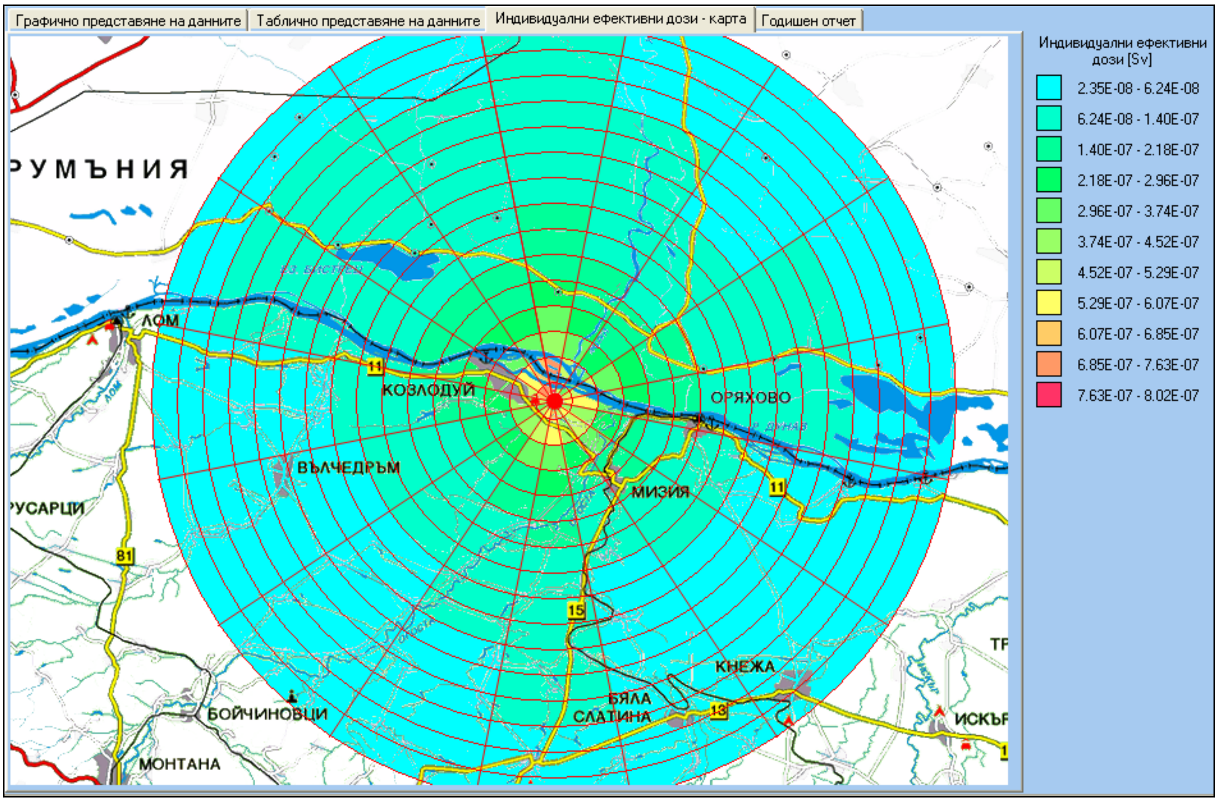

FIGURE 3.11-2: DISTRIBUTION OF THE INDIVIDUAL EFFECTIVE DOSES WITHIN THE AREA OF THE KOZLODUY NPP, 2010

Maps of the distribution of the individual effective doses within the area of the Kozloduy NPP for the period 2010-2012 are presented in **Figure 3.11-2** to **Figure 3.11-4**.

The collective annual dose for 2010 was estimated at 1.47 x 10^{-2} manSv/a. The normalised collective annual dose to the population within the 30 km zone from gaseous and aerosol emissions amounted to 8.44 x 10^{-3} manSv/GW.a.

The collective annual dose for 2011 was estimated at 3.49 x 10^{-2} manSv/a. The normalised collective annual dose to the population within the 30 km zone from gaseous and aerosol emissions amounted to 1.87 x 10^{-2} manSv/GW.a.

The collective annual dose for 2012 was estimated at 2.65 x 10^{-2} manSv/a. The normalised collective annual dose to the population within the 30 km zone from gaseous and aerosol emissions amounted to 1.47 x 10^{-2} manSv/GW.a.

Estimations by components for RNG (radioactive noble gases), LLA (long-lived aerosols) and ^{131}I (Iodine-131) for the Kozloduy NPP are fully comparable with the data for a large number of PWR reactors in the world (UNSCEAR–2000, 2008) –

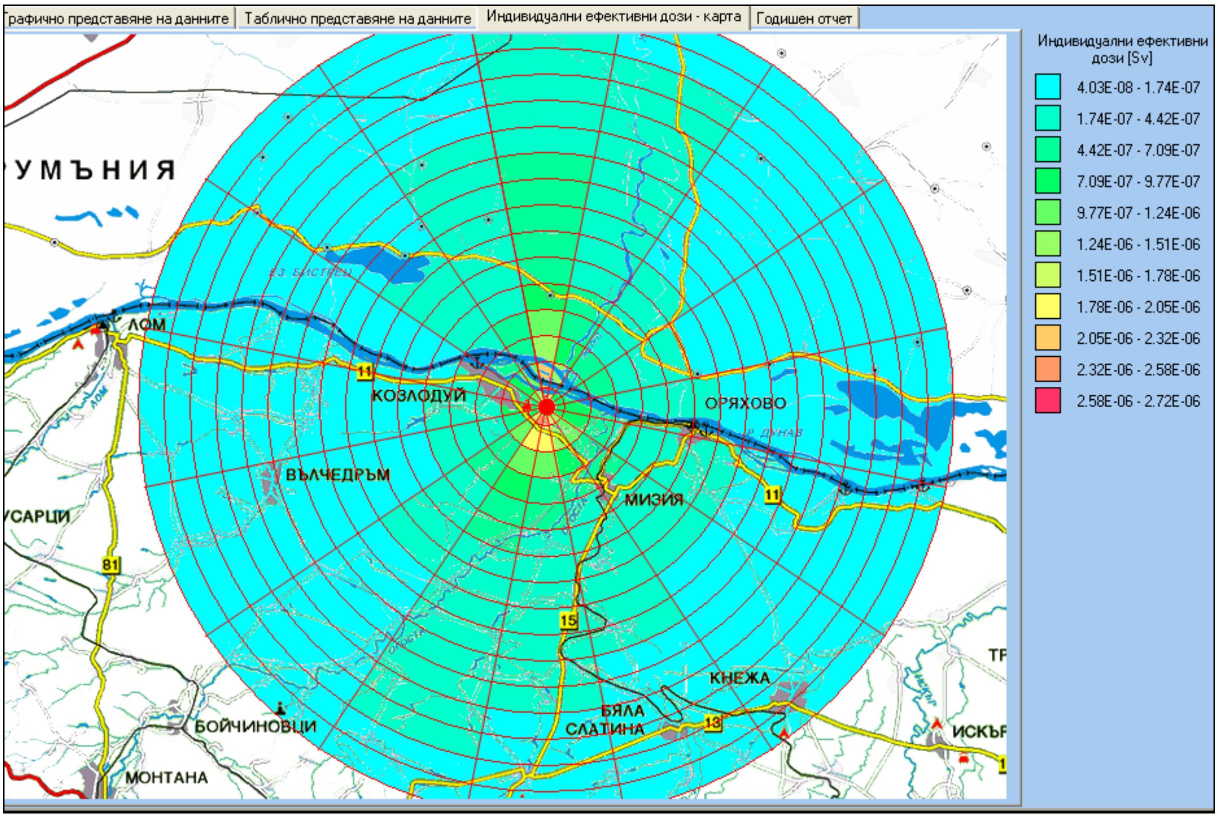

FIGURE 3.11-3: DISTRIBUTION OF THE INDIVIDUAL EFFECTIVE DOSES WITHIN THE AREA OF THE KOZLODUY NPP, 2011

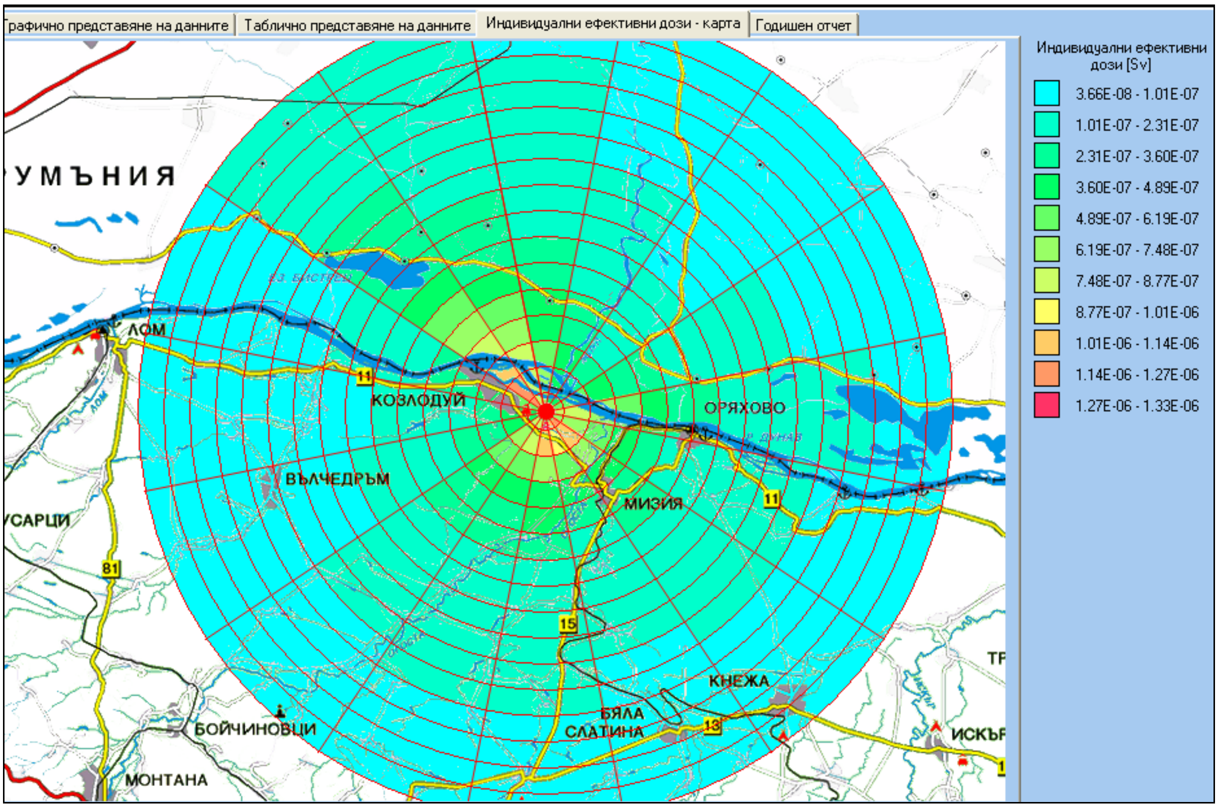

FIGURE 3.11-4: DISTRIBUTION OF THE INDIVIDUAL EFFECTIVE DOSES WITHIN THE AREA OF THE KOZLODUY NPP, 2012

3.11.1.2 LIQUID RADIOACTIVE RELEASES INTO THE DANUBE RIVER

The low values of radioactive releases with the treated water discharged from the Kozloduy NPP in 2012 and previous years determine the low levels of exposure to the population in the area. The tritium activity of 24.1 TBq released in 2012 represents respectively 13% of the admissible level and 93% of the control level for the period. This parameter has been stable during the past decade within 7 to 13% of the admissible level. The total activity (excluding tritium) of the liquid releases is 411 MBq, which is only 0.28% of the control level limit allowed by the Bulgarian NRA for the period.

The assessment of the exposure doses from liquid releases uses a model of complete mixing in the Danube River and does not distinguish between the left and the right bank. Based on this, it is claimed that the estimated doses for the respective kilometre are identical for both banks of the Danube River.

The additional exposure dose to the population from liquid radioactive releases resulting from the operation of the Kozloduy NPP in 2012 was assessed via the modelling program DARR-CM, adapted to the hydrology of the area of the Kozloduy NPP. The modelling program is based on the CREAM methodology adopted by the European Union (EU), using a conservative estimate of the exposure dose for the critical population group. The results of the exposure dose assessments for a three-year period are presented in **Table 3.11-6**.

TABLE 3.11-6: EXPOSURE DOSE WITHIN THE 30 KM ZONE FROM LIQUID RELEASES, 2010-2012

Year	Liquid releases				
	Collective dose [man.Sv]	Normalised collective effective dose [man.Sv/GW.a]		Individual effective dose	
		^3H	without ^3H	Max. for the 30 km zone [Sv]	Critical group [Sv/a]
2010	$4.43.10^{-3}$	$2.54.10^{-3}$	$4.62.10^{-6}$	$6.00.10^{-7}$	$4.23.10^{-6}$
2011	$4.47.10^{-3}$	$2.40.10^{-3}$	$5.11.10^{-6}$	$6.05.10^{-7}$	$4.26.10^{-6}$
2012	$4.70.10^{-3}$	$2.61.10^{-3}$	$7.88.10^{-6}$	$6.37.10^{-7}$	$4.49.10^{-6}$
	UNSCEAR-2000	$1.4.10^{-2}$	$6.0.10^{-3}$		

The results from the received assessments on the maximum individual effective dose within the 30 km zone and the critical group from the population living along the Danube River are graphically presented in **Figure 3.11-5.**

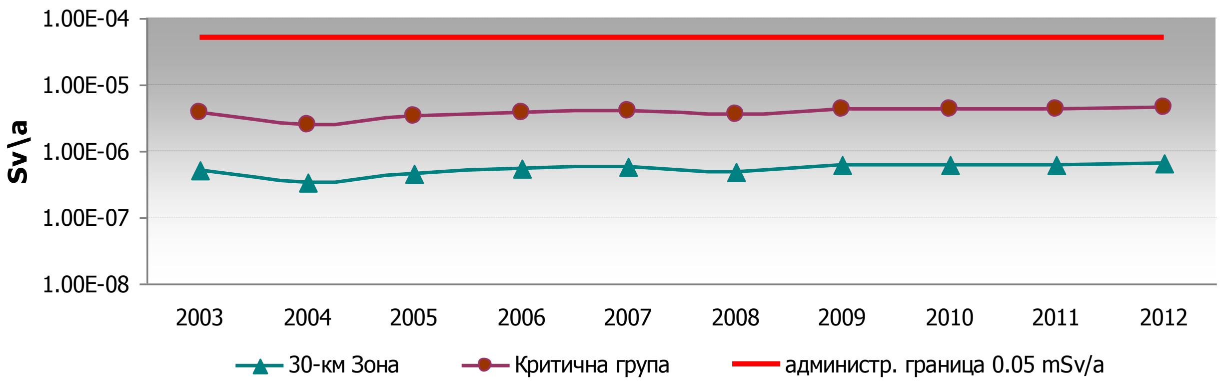

FIGURE 3.11-5. EXPOSURE DOSE WITHIN THE 30 KM ZONE FROM LIQUID RELEASES, 2003-2012

The collective dose for the population within the 30 km zone form liquid radioactive releases in 2012 was estimated at $4.7x10^{-3}$ man.Sv/a. The normalised collective dose per unit of produced electricity amounted to $2.61x.10^{-3}$ man.Sv/GW.a. This exposure is only 13% of the average value for PWR reactors in the world: $2x10^{-2}$ man.Sv/GW.a. (UNSCEAR'2008).

The maximum individual effective dose for the 30 km zone is set at $6.37x10^{-7}$ Sv/a, and for a representative of the critical group of the population living along the Danube River (the town of Oryahovo and the villages of Leskovets, Ostrov and Gorni Vadin – with population of 7469 people [23]) it is respectively $4.49x10^{-6}$ Sv/a. This exposure is negligible and represents less than 0.5% of the annual limit for the effective dose, amounting to 1 mSv (BRPS-2012) and hundreds of times lower than the exposure from natural background

[23] National Statistical Institute, census conducted on 01.02.2011.

radiation (2.33 mSv/a). Compared to the administrative quota for doses of liquid releases – 0.05 mSv/a, the maximum dose is approximately 9%.

3.11.2 ASSESSMENT OF RADIOBIOLOGICAL EFFECTS AND RADIATION RISK

The values for the maximum individual effective dose to the population within the 30 km zone of the Kozloduy NPP, from the total radioactive releases for the last three years, are shown in **Table 3.11-7**.

TABLE 3.11-7: MAXIMUM EXPOSURE DOSE TO THE POPULATION WITHIN THE 30 KM ZONE FROM GASEOUS, AEROSOL AND LIQUID RELEASES, 2010-2012

Year	Maximum individual effective dose, [Sv/a]		
	Gaseous and aerosol	Liquid	Total
2010	$8.02.10^{-7}$	$6.00.10^{-7}$	$1.40.10^{-6}$
2011	$2.72.10^{-6}$	$6.05.10^{-7}$	$3.33.10^{-6}$
2012	$1.33.10^{-6}$	$6.37.10^{-7}$	$1.97.10^{-6}$

The estimates for the dose impact of the releases from the Kozloduy NPP are fully comparable with the global practice, according to official data of the United Nations (UNSCEAR-2000, 2008). It should be noted that since then the international best practice shows a continuous improvement in the control of the releases, and respectively lower emissions and actual reporting, resulting in lower dose estimates for the population in the areas of the NPP.

The low levels of radioactive releases from the Kozloduy NPP determine radiation exposure values with negligible radiation risk to the population within the area of the power plant. The additional radiation exposure of the population within the 30 km zone for one year averages at about 400 times lower than the one received from the natural background radiation (2330 μSv/a). In recent years, the maximum values of the individual effective dose to the population varies in the range of 1÷4 μSv/a, which is below the level for clearance from regulatory control – 10 μSv/a, BRPS-2012.

3.12 CULTURAL HERITAGE

In terms of administrative and territorial zoning, the NPP and the proposed new sites are in the lands of the modern town of Kozloduy. The town does not have its own museum structure containing records of immovable cultural values (ICV) or archeological artifacts. The nearest specialised museum facility (Museum of history with archeological collection) is in the town of Oryahovo.

The institution responsible for observation, registration and investigation of ICV is the Vratsa Regional Museum of History.

3.12.1 REGISTER OF IMMOVABLE CULTURAL VALUABLES IN THE AREA OF NOWADAYS KOZLODUY

The Register of immovable cultural values (IVC) kept by the National Institute of Immovable Cultural Heritage (NIICH) (formerly National Institute of Cultural Monuments) includes 2 historic sites (locality Kozloduyski Bryag and Mateev Geran) and 2 archeological sites (ancient fortress Augustae in locality Chetate and ancient fortress Regianum in locality Magura Piatra). The Automated Information System "Archeological map of Bulgaria" (AIS-AMB)[24] contains registration cards of 18 sites within the territory of the municipality. Most of them are in the lands of v. Hurlets, located east of the delta of Ogosta river and related with a Roman camp and the Roman polis of Augustae[25] - **Figure 3.12-4**. The system also contains descriptions of 4 other sites situated in the western part of the town's lands.

The Main Inventory of Vratsa Regional Museum of History (MI-VRMH) carries 23 findings of different ages discovered in the area of nowadays Kozloduy[26]:

Inv. no.	Description	Place of discovery
B504	Exagia – square plate of cast bronze. Dimensions: 12x13x3.5mm. Weight 3.9951 g. Very well preserved.	Discovered during Site Survey, Regianum, Kozloduy.
B505	Exagia – square plate of cast bronze. On the face – IV and three dots above and under the number. Dimensions: 13x12x3.5 mm. Weight 4.1814 g. Well preserved.	Discovered at Regianum, Kozloduy.
B560	Columna Miliarnia made of dense white marble. During discovery the column was split in three parts lengthwise. The front side with part of the inscription and the middle part with the last letters in the lines are preserved. The back and top part of the column are missing. The inscription is in ten lines. Preserved height 1.44 m, diameter – 0.40 m. Height of the letters – up to 0.07 m. The Columna Miliarnia was installed in 117 at the time of Emperor Hadrian.	Discover 2.5 km east of Kozloduy – the ancient Regianum.
B569	Exagia – square plate of cast lead. The back is flat. There are six engraved circles on the front side. The walls of the exagia are concaved. Dimensions: 17x18 mm, thickness 10 mm.	Discovered in the ancient Regianum near Kozloduy.
B620	Bronze weight. Square plate. On the face: N = 1 nomisma, the symbol is sunken, the upper part of the vertical hastas ends in concave dots, four dots under and four dots above the slash. Dimensions: 14x13 mm, thickness 3 mm. Weight 4.2 g.	Discovered in the ancient Regianum near Kozloduy.
B621	Bronze weight. Square plate. On the face: N = 1 nomisma, the symbol is sunken, the upper part of the vertical hastas end in concave dots, the ends of the vertical hastas are marked with concave dots, three dots under and one dots above the slash. Dimensions: 12 x13 mm, thickness 3 mm, weight 4 g.	Discovered in the ancient Regianum near Kozloduy.

[24] http://naim-bas.com/akb/

[25] Declared as "popular antiquity" as early as in 1927 (State Gazette 69/1927) and "architectural reservation of national relevance" (Decision of the Bureau of the Council of Ministers no. 14 of 25.06.1984).

[26] Inventory of Vratsa Regional Museum of History.

Inv. no.	Description	Place of discovery
B622	Bronze weight. Square plate. On the face: N = 1 nomisma. The symbol is sunken, there are three concave dots under and three concave dots above the slash. Dimensions: 13x14 mm, дебел. 3 mm. Weight 3.5 g.	Discovered in the ancient Regianum near Kozloduy.
B650	Joggled bronze fibula. A small rounded plate above the narrowing part of the bow, with a hole for the axle of the spring with the upper limb. Now missing. Rounded curve of the bow, the leg is bent upwards and beveled. The needle holder is a rectangular plate. Dimensions: length 3.4 cm, height 1.2 cm	Discovered in the area of the ancient Regianum near Kozloduy.
B656	Joggled bronze fibula. Rounded bow with massive semi-ring above the cylinder, which was accommodating the spring and the iron axle. The leg is short, beveled. The needle holder is a rectangular plate. Dimensions: length 3.4 cm height 2.2 cm.	Discovered in the area of the ancient Regianum near Kozloduy.
B664	Fibula, strongly profiled, of cast bronze. One-piece, with rectangular plate on top of the funnel-shaped bow. A round wire is drawn above the plate, and wound to form the spring (half of it is missing) with the upper limb, held by a hook. The leg is separated from the bow by three biconical semi-rings. The leg is slightly elongated and ends in a bud. The needle holder is a trapeze plate. Dimensions: length 5.3 cm, height 2.2 cm.	Discovered in the area of the ancient Regianum near Kozloduy.
B686	One-piece fibula of cast bronze. A round wire had been drawn from the widening part of the bow and wound to form the spring, now missing. The transition between the bow and the leg is a triple biconical ring. The leg is short and the needle holder is a trapeze plate. Dimensions: length 4.6 cm, height 1.6 cm.	Discovered in the area of the ancient Regianum near Kozloduy.
B687	One-piece fibula of cast bronze. A round wire is drawn from the end of the bow and wound to form the spring (now missing) with the upper limb. The transition between the bow and the leg is a triple biconical ring. The needle holder is a trapeze plate. Dimensions: length 3.9cm, height 1.4 cm.	Discovered in the area of the ancient Regianum near Kozloduy.
B688	One-piece fibula of cast bronze. A round wire is drawn from the end of the bow to form the spring with the upper limb. The half of spring with the needle are missing. The transition between the bow and the leg is a biconical ring. The short leg ends in a small ball. The needle holder is a trapeze plate. Dimensions: length 3.9cm, height 1.7 cm.	Discovered in the area of the ancient Regianum near Kozloduy.
G289	A pot made of clay with some quartz inclusions. Egg-shaped, with mouth bent to the outside. Under the mouth there is an engraved waveform line, and half of the body is decorated with wide straight	Discovered in 1987 during Site Survey in locality Uhoto (Kazana) near Kozloduy in the profile of the bank of the Danube in the remains of

Inv. no.	Description	Place of discovery
	lines. The colour is red-brown with grey-black spots from later scorching. Dimensions: height 28cm, diameter: mouth – 23.5cm, body – 28cm, bottom 15.3 cm.	a medieval village. Some carbonized grain was found in the pot.
G292	A pot made on potter's wheel of clay and some quartz inclusions, of red-brown colour after baking. Later scorched to obtain grey colour. Has egg-shaped form with low neck and mouth rim bent to the outside. Nearly the entire external surface is decorated in engraved horizontal lines. There is a small sheaf on the shoulders and a single wave-from engraved line on the neck. Dimensions: height: 17.4cm, mouth diameter 13cm, bottom diameter 9 cm. Restored with gypsum.	Discovered in locality Kilera 5 km west of Kozloduy. Nikolay Pachev of the same town gave it Assoc. Prof. St. Angelova of Sofia University, and she passed it on to the museum (1988). Early Middle Ages.
G471	Nozzle of blacksmith's furnace, made of clay with small quartz inclusions, red-brown colour after backings, later smoked at some places. Has a cylindrical shape, and longitudinal opening with smooth walls. The outer surface is rough with traces of smoothing work lengthwise. Slight expansion in one of the ends. Dimensions: length 86 mm, diameter 30-31 mm, diameter of the opening 14 mm.	Discovered during drilling explorations in 1987 in the lands of Kozloduy, locality Kilera, borehole I, at depth 0.40 m, together with ancient Bulgarian pottery. Received inv. no. 10/2.07. 1987.
G472	Knucklebone (astragalus), probably of lamb, of yellowish colour. At some places the surface is worn from long-time use as a sanding tool. Dimensions: 14x16x27 mm. Well preserved.	Discovered during drilling explorations in 1987 in Kozloduy, near the House of the Power Industry Worker, in borehole B, together with fragments of ancient Bulgarian pottery.
255	Silver coin, Philip II, barbarian imitation. Face – head of Zeus, barbarized, to the right. Back - little horse, to the right.	Forms part of collective discovery, Kozloduy, 1962. Donated by Penyu Nikolov, teacher of history at the local secondary school.
444	Clay vessel with high handle (handle is broken) and beveled mouth. The bottom is rounded and concaved. Grey-brown colour, decorated with canelures and symmetrical buds (one is broken). Dimensions: height 16cm, diameter 12 cm. Bronze Age.	Kozloduy, during excavation works for irrigation plant Asparuhov val, 1962. Donated by the site foreman Angel Kirchev.
A445	Node of spinning spindle made of clay, brown colour, punched in the middle, flattened spherical shape. Bronze Age. Dimensions: diameter 5.5 cm.	Kozloduy, during excavation works for irrigation plant Asparuhov val, 1962. Donated by the site foreman Angel Kirchev.
A666	Clay cup with high handle and slightly beveled mouth. The lower part is widened and the bottom is round and concaved. The decoration consists of oblique canelures and buckles. Dimensions: height 11cm, diameter 16 cm.	Discovered together with 444 during excavations for pressurized pipeline on the bank of the Danube during the construction of irrigation plant Asparuhov val, 1962. Donated by workers at the site.
A667	Burial urn made of clay, with spherical shape, high mouth neck and one handle. The decoration consists of engraved ornament filled with white	During excavations for pressurized pipeline on the bank of the Danube during the construction of irrigation

Inv. no.	Description	Place of discovery
	paste and three buckles. End of the Bronze Age. Dimensions: height 30cm, diameter 25cm, mouth diameter 10 cm.	plant Asparuhov val, 1962. Donated by workers at the site.

Various archaeological artefacts marked as originating from the "lands of Kozloduy"are kept as part of the collection of Secondary Comprehensive School St. Cyril and Methodius in the town, and in the academic museum at the Department of Archaeology in Sofia University St. Kl. Ohridski. In the inventories and the collections there are no records of archaeological findings or sites discovered or registered during the construction of the present NPP[27].

The territory of the present NPP has never been subject to any research and archaeological monitoring during construction works and subsequent reconstructions, extensions, installation of utilities, etc.

Under various circumstances, the lands of the town have been researched by archaeological expeditions and archaeological drilling works: in 1985 and 1986 under the mentorship of Assoc. Prof. Stefka Angelova (Sofia University St. Kliment of Ohrid) and Assoc. Prof. Ivan Panayotov, Ph.D (National Institute and Museum of Archaeology, Bulgarian Academy of Sciences) as part of the education archaeology students[28]. Part of the results is published in various scientific magazines[29]. Details of archaeological sites and individual findings are also contained in the archive of Nikolay Pachev, a long-time local teacher and ethnographer[30]. The results from the long-time research work of Borgan Nikolov from the Vratsa District Museum of History (now Vratsa Regional Museum of History) are reflected in many of his publications addressed to the academic and general audience[31].

In the meaning of the *Cultural Heritage Act* (CHA) all archaeological sites are regarded as ICV "of national relevance" (Art. 146, paragraph 3) until their boundaries and regimes are defined in accordance with the procedures laid down in the CHA.

---

[27] Archive of Vratsa Regional Museum of History.

[28] Archive of Site Survey by I. Panayotov and S. Angelova in 1985 and 1986.

[29] I. Panayotov, С. Александров. Of the Magura- Cotofeni culture in Bulgarian lands, Archeology, XXX, 1988, no. 2, 1-14; I. Panayotov, V. Dinchev, S. Alexandrov. Archeological survey of Kozloduy. Manuscript; S. Angelova, R. Koleva. Of certain specificities of Early Slavic pottery from Northwest Bulgaria. – В: Contributions to Bulgarian archeology, I, 1992, 173-179; S. Angelova, R. Koleva. Early Slavic pottery from Kozloduy. – Yearbook of Sofia University, Faculty of History, Department of Archeology, vol. I, 1994, 129-147.

[30] Archive of the ethnographer Nikolay Pachev.

[31] B. Nikolov. Bronze Age settlements and necropoles in Vratsa district. – Archeology, VI, 1964, 2, 69-78.

B. Nikolov. Archeological monuments in Vratsa district. – Proceedings of Archeological institute, 1967, vol. XXX, 216-223. B. Nikolov. Between Iskar and Ogosta, Vratsa, 1996.

3.12.2 DETAILS OF ARCHAEOLOGICAL SITES IN AND AROUND THE TOWN OF KOZLODUY

1. **Locality Kilera** (Mitrevi ozya), 1.5 km westward of the port – prehistoric (early Bronze Age, Cotofenu culture), ancient and medieval village. Abundant household pottery on the surface, copper jewelry – intact or fragments as well as coins dated I-IV AD[32].
2. **Locality Chukata** (500 m south of Kilera) – evidence of antique village. Also there is evidence of early Bonze Age village (Cotofeni culture) as seen from the typical tool discovered (axe-hammer)[33].
3. **Locality Kalifera,** next to the western side of Chukata – large ancient and medieval village, clues of medieval necropolis with incineration of bodies, bronze coins of IX-X century. Evidence of inhabitance in the early Bronze Age (Cotofeni culture)[34].
4. **Locality Vrachanska funia** – east of locality Kalifera; typical breakthrough in the high terrace above the river: evidence of late ancient necropolis with burial of bodies[35].
5. **Locality Chetate** – late ancient (IV-VI c.) fortress. Situated approx. 6 km west of the present town. Declared as architectural and building monument of Ancient and Middle Ages of "local" relevance[36].
6. **Town of Kozloduy – centre** (approx. 200 m southwest of the Bus Station) – site of late Bronze Age (Baley-Orsoia culture), necropolis probably destroyed during present-time construction works, there are reports of clay idols[37].
7. **Town of Kozloduy, House of the Power Industry Worker** – late Roman necropolis (IV c.), masonry graves with rich inventory discovered[38];
8. **Town of Kozloduy (westward of the House of the Power Industry Worker, former yard of Baliev family)** – necropolis with incineration of bodies – early Middle Ages (VII-VIII c.), early medieval village (IX c.-?)[39].

---

[32] D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985. no. 96; I. Panayotov, S. Alexandrov. Of the Magura- Cotofeni culture in Bulgarian lands. – Archeology, XXX, 1988, no. 2, 1-14. S. Angelova, R. Koleva. Of certain specificities of Early Slavic pottery from Northwest Bulgaria. – B: Contributions to Bulgarian archeology, I, 1992, 173-179. B. Nikolov. Between Iskar and Ogosta, Vratsa. 1996.

[33] D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985, №97; I. Panayotov, S. Alexandrov. Of the Magura- Cotofeni culture in Bulgarian lands. – Archeology, XXX, 1988, no. 2, 1-2, Card of specimen 2.

[34] Archive of Nikolay Pachev; D. Dimitrova. Archeological monuments in Vratsa District. София. 1985, 28; I. Panayotov, S. Alexandrov. Of the Magura- Cotofeni culture in Bulgarian lands. – Archeology, XXX, 1988, no. 2, 1-2, Card of specimen 2; S. Angelova, R. Koleva. Early Slavic pottery from Kozloduy. – Yearbook of Sofia University, Faculty of History, Department of Archeology, vol. I, 1994, 129-147.

[35] Archive of Nikolay Pachev; D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985, no. 98.

[36] State Gazatte no. 90/ 1965; D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985, 28; B. Nikolov. Between Iskar and Ogosta, Vratsa. 1996,149.

[37] Archive of Nikolay Pachev; I. Panayotov, V. Dinchev, S. Alexandrov. Archeological survey of Kozloduy. Manuscript.

[38] Archive of Nikolay Pachev; Archive of Vratsa Regional Museum of History; B. Nikolov. Between Iskar and Ogosta, Vratsa.

[39] Archive of Nikolay Pachev; S. Angelova, R. Koleva. Of certain specificities of Early Slavic pottery from Northwest Bulgaria. – B: Contributions to Bulgarian archeology, I, 1992, 173-179; S. Angelova, R. Koleva. Early Slavic pottery from Kozloduy. – Yearbook of Sofia University, Faculty of History, Department of Archeology, vol. I, 1994, 129-147.

9. **Town of Kozloduy, locality Uhoto - Kazana.** Early Bronze Age village (Cotofeni culture) and early medieval village[40].

10. **Locality Zlatnata** (500 m east-southeast of the town boundary)- remains of life in several ages: late Iron Age (VI-I c. BC), Roman (II-IV c. AD); early and advanced Middle Ages (VII-XI c.). Evidence of necropolis with burial of bodies. Registered remains of manufacturing activities – processing of iron and non-ferrous metals[41].

3.12.3 DETAILS OF ARCHAEOLOGICAL SITES BETWEEN KOZLODUY, DANUBE RIVER AND THE PRESENT NPP SITE

Regianum (Regianum) is road post and polis (fortified settlement) in province Dacia Ripensis (Coastal Dacia) in the town of Kozloduy, municipality of Kozloduy, Vratsa District, situated 2 km east of the present town in locality Magura Piatra (Stone Mound) – a well-known elevation, elongated in west-east direction, on the first non-floodable terrace of the Danube. It is designated as immovable cultural value by publication in the State Gazette (no. 90/1965) and has a status of monument of "national relevance". Boundaries and regimes of the site are not defined. No archaeological surveys have been carried out. The site is part of the Roman Empire's fortified Danube border and *Via Danubica*. The first description was provided by Karel Škorpil: fortification of rectangular (square) shape and walls approximately 70 m in length and up to 2.8 meters in depth, with a widened area of approx. 40 x 20 meters in the southwest part. Everywhere around the wall there were buildings/structures contemporaneous with the fortification.[42] Prof. Boris Gergov believes that it originated as a road post (mansion) at *Via Danubica* already in I c. AD. In II c. it probably evolved into a civilian village, probably the centre of the district between Ogosta and Tsibaritsa River[43]. A few golden coins of Emperor Domitian and others from the second half of III c. were found in 1940.[44] In the 1930's and 1950's as the present town was expanding in eastern direction, there were discoveries of tombs and masonry graves with burial gifts: ceramic and glass vessel, bronze jewellery (including a unique gold-plated fibula with portrait of Constantine the Great and his sons), coins from III and IV c. AD[45]. According to unconfirmed reports, graves (skeletons) without other facilities south and east of the fortress were destroyed during farming activities and during the building of

---

[40] Archive of Nikolay Pachev; Archive of Site Survey by I. Panayotov and S. Angelova in 1985 and 1986; S. Angelova, R. Koleva. Of certain specificities of Early Slavic pottery from Northwest Bulgaria. – B: Contributions to Bulgarian archeology, I, 1992, 173-179; I. Panayotov, S. Alexandrov. Of the Magura-Cotofeni culture in Bulgarian lands. – Archeology, XXX, 1988, no. 2, 14, map of specimen 2; S. Angelova, R. Koleva. Early Slavic pottery from Kozloduy. – Yearbook of Sofia University, Faculty of History, Department of Archeology, vol. I, 1994, 129-147.

[41] Archive of Nikolay Pachev; D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985, no.99;

[42] K. Škorpil. Of some roads in Eastern Bulgaria – Proceedings of the Russian Imperial Institute of Archeology in Constantinople, T. H. 1905.

[43] B. Gerov. Romantism between the Danube and the Balkan mountain. From Augustus to Hadrian. Part I. – Yearbook of Sofia University, Faculty of History and Philosophy, vol. XLV, 1948/1949, 90.

[44] T. Gerasimov. Collective findings of coins in 1940, Proceedings of the Bulgarian Institute of Archeology, vol. XIV, 1940-1942, 283.

[45] D. Tsonchev, Kozloduy - Proceedings of the Bulgarian Institute of Archeology, vol. VIII, 1934, 450. T. Ivanov. – Archeology, 1972, no. 4, 16).

field roads[46]. Well known is Columna Miliarna (byroad column) with the name of the fortress – Regianum[47]. At present the site is severely compromised with holes dug by treasure hunters.

Roman road connecting Regianum (at Kozloduy) and Augustae (at Hurlets)[48].

Locality Selishte (approx. 300 m south and southeast of Magura Piatra and approx. 500 m. from the former yards of the Cooperative Farm) – remains of open-type Roman village and probably necropolis from the late Bronze Age[49].

Tumuli – well expressed burial mounds are situated south and southeast of the present NPP site (and shown with points of the national system on maps in scale 1:25,000); their local names being: Maguralui Krastoy (106 m), Maguralui Sharbanoy (97.4 m) – on maps 1:5 000 (locality Mogilite), Golyamata mogial (89.8 m), Presechenata mogila (or Kopanata mogila - 87.7 m). Northeast of the present site is the mound Gurlishte (33.2 m). These were registered by archaeologists during their surveys of area, D. Dimitrova and B. Nikolov[50] *(map showing the locations of the mounds is attached).*

Locality Otara (from the Romanian word for "border") – located next to the northern side of the hot channel – evidence of open-type (unfortified) prehistoric villages (probably from the Bronze Age) and from the early Middle Ages[51].

On the bank of Mali Dunav (Kozloduiski rakav) – evidence of Neolithic settlement has been localized east of the present town – vessels with engraved and embossed decoration, one of them was sent to the Popular Museum in Sofia (inventory no. 41), and flint plates[52].

3.12.4 THE TERRAIN OF THE POTENTIAL NNU SITES

Large mounds of sand – dunes (with local toponyms *Golemia* and *Srednia gred* or *grid*) formed as a result of riverbed changes during the various geologic and historic ages, are situated north and northeast of the NPP site and the present bed of Danube river. Early Middle Ages pottery (VIII-IX c.) has been found on their surface during farming activities in present days[53].

The gathered evidence from archive sources, scientific publications and collections allow the conclusion that the lands of nowadays Kozloduy are relatively intense in objects of

---

[46] D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985, No. 99; B. Nikolov. Between Iskar and Ogosta, Vratsa. 1996, 148-149;

[47] B. Nikolov. Between Iskar and Ogosta, Vratsa. 1996, 149;

[48] B. Gerov. Romantism between the Danube and the Balkan mountain. From Augustus to Hadrian. Part I. – Yearbook of Sofia University, Faculty of History and Philosophy, vol. XLV, 1948/1949, 90; D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985, no. 100.

[49] Archive of Nikolay Pachev; B. Nikolov. Between Iskar and Ogosta, Vratsa. 1996, 148-149; I. Panayotov, V. Dinchev, S. Alexandrov. Archeological survey of Kozloduy. Manuscript.

[50] D. Dimitrova. Archeological monuments in Vratsa District. Sofia. 1985, 18-19; B. Nikolov. Between Iskar and Ogosta, Vratsa. 1996.

[51] Archive of Nikolay Pachev; Archive of Site Survey by I. Panayotov and S. Angelova in 1985 and 1986.

[52] V. Mikov. Prehistoric villages and discoveries in Bulgaria. Sofia. 1933.

[53] Archive of Nikolay Pachev; Archive of Site Survey by I. Panayotov and S. Angelova in 1985 and 1986; S. Angelova, R. Koleva. Early Slavic pottery from Kozloduy. – Yearbook of Sofia University, Faculty of History, Department of Archeology, vol. I, 1994, 129-147.

cultural and historic heritage of wide chronological scope – Neolith (8 – 5 millenniums BC), early and late Bronze Age (3200 – 1300/1200 BC), the Roman period (I-IV c. AD), the late Antiquity period (IV-VI c.) and the early Middle Ages (VII-XI c.). From the information about these objects it can be deduced that objects unknown to date can be affected by new construction works carried on presently intact surfaces and original relieves.

3.12.4.1 SITE 1

The southeast side (enclosed between the channel and the asphalt-surfaced bypass round) represents untrimmed areas with surfaces heavily overgrown in grass, thorns and shrubs. Visual inspection of the contemporary surface in daytime is absolutely excluded, there is zero chance for archaeological observation. The present altitude of the terrain is 24.9 and 26.3. It is much lower than the site of the existing NPP and probably this is reason for the swamps seen at several places. The lands north of the channel are farmed – used for growing winter crops and alfalfa, and the terrain visibly elevates by 3 to 5 meters. The chances for direct observation are significantly better and a detailed walk-over (survey) may give clues as concerns the presence of archaeological artefacts. Two mounds up to 2 meters above the surrounding terrain can be seen under the high-voltage overhead power line north of Site 1 (500 to 600 meters away). These mounds are not within the boundaries of Site 1. The first one displays clear signs of excavation works – **Figure 3.12-1**. One the other mound there is triangulation mark no. 14, its altitude above sea level is 33.17 and it is not farmed – **Figure 3.12-2**.

FIGURE 3.12-1: MOUND 1

FIGURE 3.12-2: MOUND 2

3.12.4.2 SITE 2

The western part of the site is occupied by a yards of the former State-owned Agricultural Farm (according to the annotation in scale 1:5000), and is now managed by GBS – Energoremontstroy. The original surface of this part is heavily compromised with pads, aboveground structures of concrete, monolithic and semi-monolithic buildings. The eastern side of the site is arable and used for growing winter crops. Most of the terrain is flat (elevation above sea level 35.2-35.8), while the the south displacement is significant (up to level 49 horizontal). The arable areas offer good opportunities for observation of the contemporary surface.

3.12.4.3 SITE 3

The southeast part of the site is right on the northern side of the asphalt-surfaced bypass road of the existing NPP (enclosed from the north by water supply channel). The present surface is strongly compromised with embankments (depots) of earth, building waste, etc. Observations for registration of immovable cultural values (archaeological sites) are not possible in this part. The western part of the site is occupied with agricultural lands (arable, used for growing winter crops). The possibilities for observation during walk-over (survey) are very good. In terms of relief, these are slightly elevated mounds (up to 4-5 meters high and typically oriented in west-east direction), probably formed due to changes of Danube riverbed. Probably they form part of an old non-floodable (or partially floodable) terrace above the bed of the river. The long-time cultivation (including with heavy machines) has partially modified the relief. The erection of huge lattice towers for the high-voltage overhead power lines has also contributed to the modification. There is visual link with localities Magura Piatra and Selishte (**Figure 3.12-3**), which are quite far from the Kozloduy NPP site and accordingly from Site 3. Based on the topographic situation, it can be assumed that the site is crossed by *Via Danubica*, which used to connect Regianum with Augustae (**Figure 3.12-4**). The tumuli situated in an in-line arrangement in north-south direction, located south of the present NPP site and in parallel to Sites 1 and 2 (south and southeast of the existing NPP site) are entirely commensurate with the Roman practice to build necropolis alongside roads (**Figure 3.12-5**).

FIGURE 3.12-3 POSITION OF MAGURA PIATRA

3.12.4.4 SITE 4

This site is entirely within the present boundaries of the NPP. The original surface is irreversibly damaged by the construction of contemporary facilities.

FIGURE 3.12-4: POSITIONS OF THE ROMAN FORTRESES REGIANA AND AUGUSTAE

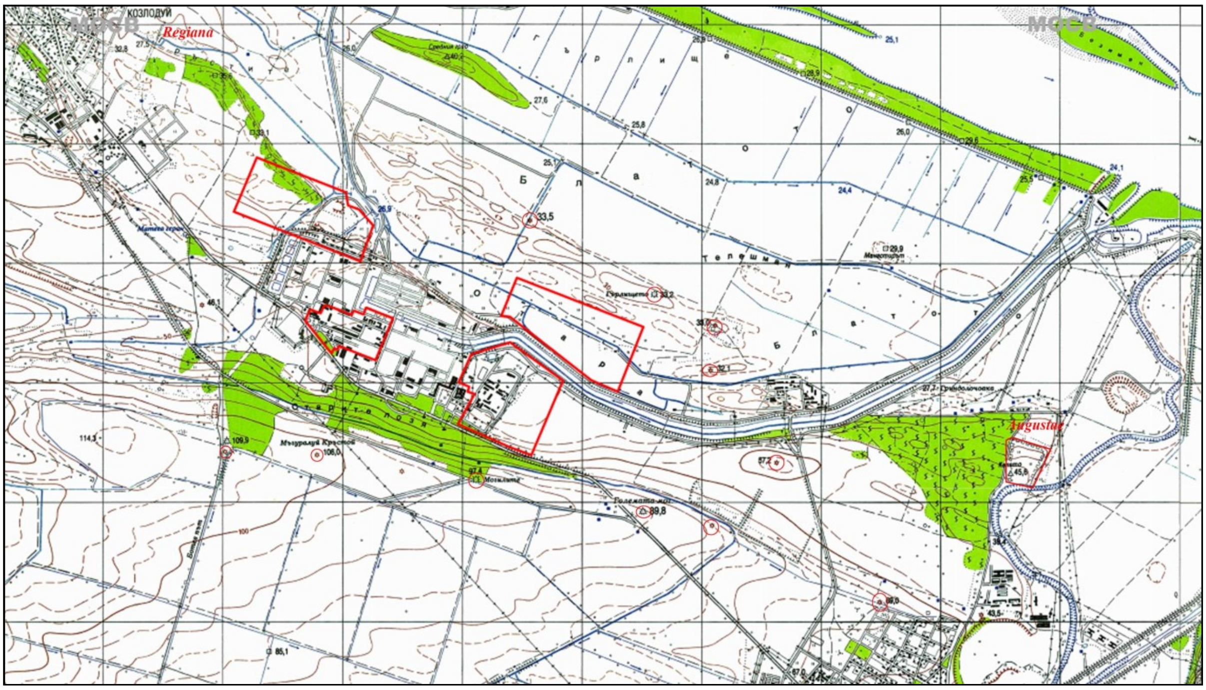

FIGURE 3.12-5: TUMULUS AROUND THE PROPOSED NNU SITES AT KOZLODUY NPP