Belarusian NPP Post-project Analysis

PROGRAM

Minsk

2014

TERMS AND DEFINITIONS:

IMPACT means any effect caused by a proposed activity on the environment, including human health and safety, flora, fauna, soil, air, water, climate, landscapes and historical monuments or other physical structures, or interactions among these factors; it also includes effects on cultural heritage or socio-economic conditions resulted from changes in these factors.

BEYOND DESIGN BASIS ACCIDENT is an accident resulted from the initiating events not considered for the design basis accidents, or accompanied with additional (as compared to design basis accidents) failures of safety systems beyond the single failure, or implementation of wrong decisions of personnel.

NPP ABNORMAL OPERATION is a disturbance in the NPP operation accompanied by deviation from specified operating limits and conditions. At the same time, other designed limits and conditions can be violated, including the safe operating limits.

NORMAL OPERATION is the NPP operation within the designed operating limits and conditions.

1. INTRODUCTION

The following team participated in the development of the *Belarusian NPP Post-Project Analysis Draft Program*:

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The goal of this activity is to prepare, based on the international documents and normative documents of the Republic of Belarus in the area of environmental protection, the scientifically grounded practical instruction, which implementation will allow the competent authorities and public of the concerned parties to make independent assessment of transboundary impacts of the Belarusian NPP.

When developing this document, the authors were guided by the provisions of the Articles 7, 8, 9 and Appendices V, VI of the UN ECE Convention on Environmental Impact Assessment in a Transboundary Context (hereinafter referred to as the Espoo Convention).

The documents used for this draft plan preparation are as follows:

- Preliminary Safety Assessment Report. Chapter 1. NPP General Description, 2013;

- Belarusian NPP EIA Report (as of 06 July, 2010), 2010;

- Conclusion No.98 of the State Ecological Expertize by the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus on the Belarusian NPP Project Documentation, approved by V.V. Kulik, the First Deputy Minister on October 23, 2013;

and other normative documents listed in References.

2. GENERAL PROVISIONS

The Belarusian NPP post-project analysis program is implemented by the Republic of Belarus in cooperation with the Affected parties in accordance with the Espoo Convention, Article 7.

The grounds for this program implementation are the relevant writing requests submitted by Affected parties:

Austria, BMLFYW-YW.1.4.2/0032-V/1/2011, dated 29 April, 2011;

Latvia, Letter No. 1/3781, dated 04 April, 2011;

Poland, Letter No. DOOS-tos.442.11.2011 JA, dated 05 February, 2014;

Ukraine, Discussion Protocol, dated 29 June, 2010, Lutsk City;

Lithuania, Findings and Recommendations of the Implementation Committee Related to the Submission by Lithuania with Regard to Belarus (EIA/IC/S/4), V. Recommendations, Paragraph 74.(i),(j).

The post-project analysis is the mechanism available for the Affected parties to control the Belarusian NPP project implementation. The post-project analysis includes:

- monitoring whether conditions specified in the project are met and measures aimed at mitigating the environmental impact are effective;
- analysis of impacts for the purpose of implementation of appropriate measures and elimination of uncertainties;
- verification of forecast correctness and use of gained experience for similar works in the future.

The post-project analysis is carried out for normal operation mode and for abnormal operation mode as described in the project.

In accordance with the Espoo Convention, Article 2, Paragraph 8, the post-project analysis shall not affect the matters being within the scope of national laws, regulations, administrative provisions or accepted legal practices protecting information the supply of which would be prejudicial to industrial and commercial secrecy or national security.

If the risk of a beyond design basis accident exists or if such an accident occurs, the post-project analysis shall be carried out by the Republic of Belarus and concerned Parties within the scope of bilateral agreements:

the Agreement between the Government of the Republic of Belarus and the Government of the Russian Federation on Cooperation in the Field of Nuclear safety, in force since 4 July, 2013;

the Agreement between the Ministry of Emergency Situations of the Republic of Belarus and the State Nuclear Regulatory Inspectorate of Ukraine, planned for signing;

the Treaty between the Government of the Republic of Belarus and the Government of the Republic of Poland, 26 October, 1994, on Prompt Notification about Nuclear Accidents and Cooperation in the Field of Radiation Safety;

the Proposal on conclusion of the Intergovernmental Treaty between the Government of the Republic of Belarus and the Government of the Republic of Latvia on Prompt Notification about Nuclear Accidents, Information Exchange and Cooperation in the Field of Nuclear Safety and Radiation Protection (the proposals were sent to Latvia in 2011);

the Proposal on conclusion of the Intergovernmental Treaty between the Government of the Republic of Belarus and the Government of the Republic of Lithuania on Prompt Notification about Nuclear Accidents, Information Exchange and Cooperation in the Field of Nuclear Safety and Radiation Protection (the proposals were sent to Lithuania in 2011).

In accordance with the Espoo Convention, Article 6, the final decision with regard to the Belarusian NPP project is the Edict of the President of the Republic of Belarus, 2 November, 2013, No. 499, *On Construction of the Belarusian NPP*; therefore, the EIA Report discussion procedure in a transboundary context within the scope of the Espoo Convention is completed, and this Belarusian NPP post-project analysis draft program is the next step in the subsequent EIA procedure that will accompany the project throughout the life cycle.

3. ANALYSIS OBJECT: CHARACTERISTICS

3.1. Belarusian NPP: basic data

The Belarusian NPP is a NPP with two reactor units; the reactor system B-491 is used. See Table 1 for the NPP reactor unit specifications [1].

Table 1 – NPP reactor unit with the VVER-1200 reactor: specifications

	Characteristic description	Characteristic value
1	Reactor unit structure	Integrated unit
2	Service life (years): reactor unit reactor system	 50 60
3	Reactor unit power (MW): electrical (gross power), for guaranteed conditions thermal	 1194 3200
4	Reactor unit’s heating power (MW)	46.6

5	Installed capacity utilization factor	0.9
6	Auxiliary electric power consumption, including consumption for the circulating water supply and site-related consumption (%)	7.0
7	Unscheduled automatic reactor shutdowns (per year)	<0.5
8	Average annual scheduled shutdowns (reactor refueling, scheduled maintenance, preventive maintenance) (days)	≤25
9	Operating personnel for the first reactor unit (persons/MW)	0.66
10	Fuel assemblies in the core (pieces)	163
11	Fuel assemblies with the control and protection system's regulating elements (pieces)	121
12	Maximum burn-up fraction, average by fuel assemblies (MW·day / kg U)	60
13	Fuel lifetime (years)	4
14	Refueling interval (months)	12
15	Coolant parameters: first circuit: core inlet temperature (°C) core outlet temperature (°C) coolant warming at the core (°C) coolant consumption through the reactor (m^3/hour) core outlet pressure (MPa) second circuit: steam pressure at the steam generator outlet (MPa) steam generator capacity (tons/hour) feed water temperature (°C) steam humidity at the steam generator outlet (%)	 298.2 328.9 30.7 86000 16.2 7.0 1602±21 225±5 ≤0.2
16	Turbine unit	К-1200-6.8/50
17	Turbine unit design	2 low pressure cylinders + high pressure cylinder + 2 low pressure cylinders

18	Regenerative heating circuit	4 low pressure heaters + motor + 2 high pressure heaters
19	Main feed pumps number and type	Tentatively: 5 submersible electric pumps (electric drive)
20	Generator	T3B-1200-2
21	Generator cooling type	Complete water cooling
22	Circulating water supply system for the turbine unit	Circulating system with evaporative cooling towers
23	Technical water supply for systems critical in terms of safety	Circulating system with spray ponds
24	Safety equipment (structure): active safety systems (emergency core cool-down system, heat removal from reactors etc.) emergency electric power supply system supplementary equipment for the beyond design basis accident management (system for passive heat removal by steam generators, system for passive heat removal from the containment etc.)	4×100 % (4x50%) 4×100 % 4×33 %, 1×100 %

25	Double containment for the reactor building	
	Outer protective containment (reinforced concrete)	
	inner diameter (m)	50.0
	dome top height (m)	70.2
	thickness, cylindrical part / dome (m)	0.8/0.6
	Inner tight containment (reinforced concrete)	
	inner diameter (m)	44.0
	dome top height (m)	67.6
	thickness, cylindrical part / dome (m)	1.2/1.0
	design excessive pressure (MPa)	0.4
	design temperature (°C)	150
	emergency system for air cleaning in the inter-containment space removes radioactive leakages, with the cleaning characteristics as follows (or better):	
	elemental iodine (%)	99.9
	organic iodine (%)	99
	aerosols (%)	99.99

3.2. Siting

The Belarusian NPP (see Figure 1) is in the north-west part of the Republic of Belarus, in the center of Ostrovets District, Grodno Region.

http://www.fishtour.by/search/?cmd=search&search_text=%E0%FD%F1&search_type=3

Figure 1 – Belarusian NPP construction site location

The distance from the site center to the borders of neighboring states:

Republic of Lithuania: 25 km;

Republic of Latvia: 110 km;

Republic of Poland: 200 km.

The NPP site boundaries are as follows: north, R-45 Republican motor road *Polotsk – Glubokoye – Lithuanian border (Kotlovka)*; east, N-6210 local motor road *Mikhalishki – Gervyaty - Izobelino*; south and west, Voleikuny and Goza settlements (respectively).

The double-track railroad, *Ukrainean border – Gomel – Minsk – Lithuanian border*, is 30 km south from the Belarusian NPP site.

3.3. Natural initiating events in the Belarusian NPP area and at the site, taken into consideration in the project

See Table 2 [1] for the description of natural initiating events in the Belarusian NPP area and at the site to be taken into consideration in the project for the purpose of emergency situation response planning (SP 11-103-97).

Table 2 – Summary of natural initiating events in the Belarusian NPP area and at the site to be taken into consideration in the project for the purpose of emergency situation response planning

No.	Processes, events and factors	Parameters considered in the project backgrounds	Parameter amounts or impact characteristics	Frequency	NPP site affected or not (or hazard degree)
1	Hydrometeorological processes and events				
1.1	Flood	Maximum flow rates and levels in the river Viliya - Mikhalishki	Highest recorded level: 125.32 m (Baltic elevation system), 131.00 m (Baltic elevation system). Maximum flow rate: 4420 m^3/s	1958; 0.01 % occurrence 0.01 % occurrence	Not affected
1.2	Ice events on watercourses	a) Ice thickness b) Ice phase periods	Average: 40…50 cm Max: 0.77 m Ice formation Ice clearance	88 days 117 days 30.12 31.03	Not affected
1.3	Variations of water resources: extremely low flow, abnormal water level drop	Minimum flow Minimum water level, maximum variation amplitude for many years	17.5 (daily, in winter) 118.62 м (Baltic elevation system) 6.5 m	97 %	
1.4	Tornado	a) Design intensity class,	2.58		Hazard degree: I

	In accordance with RD-022-01, the territory of Belarus is in the zone A: higher risk of tornados	Fujita (F) scale b) Annual probability c) Tornado wall rotation (maximum horizontal speed) d) Tornado advance speed e) Pressure difference between the rotating funnel center and periphery	 $30 \cdot 10^{-4}$ 72 m/s 18 m/s 64 GPa		
1.5	Wind, hurricane (hurricane, V>32 m/s, Beaufort scale). The NPP area is classified as the wind area I, the rated wind pressure is 0.23 kPa	a) Maximum wind speed (V). Vmax for the NPP area (covered by observations) b) Strong wind, V > 15 m/s	 Vave.annual = 3.7 m/s Vmax = 12 m/s Vmax = 20 m/s Vmax = 24 m/s Vmax = 54 m/s (gust) Vmax = 30 m/s	 year year 20 years 50 years 10000 years 1969 < 1 days/year	II
1.6	Precipitations	a) Atmospheric precipitations, precipitation depth Recorded maximum	Average: 650-750 mm/year 322 mm/month	Average time: 1200 hours August July	Not affected

		Recorded minimum One-day maximum b) Fogs Average number of days Maximum c) Sandstorms	 0 101 mm 70 days/year 117 days/year no	May	
1.7	Extreme snowfalls and snowdrifts	a) Snow cover thickness: Average Maximum Minimum b) Snow cover existence period c) Snow cover pressure	 40 cm 77 cm 10 cm 111-120 days 1.2 kPa/m^2	7-14.12 -13.04	Not affected
1.8	Air temperature	a) Maximum and minimum temperatures Average annual Maximum (abs.) Minimum (abs.)	 +5.2 - +5.4^{o}C +34.6 -39.8		
1.9	Icing	Ice wall thickness (10 m over the ground surface)	Once in 5 years 5 mm		
1.10	Lightning strikes	Lightning days average maximum	 22 days/year 38 days/year		
2	Design seismic	Design earthquake (DE)			

	impacts	intensity Maximum design earthquake (MDE) intensity Maximum accelerations (50% occurrence): MDE, horizontal component MDE, vertical component DE, horizontal component Maximum vertical acceleration	6 (MSK-64 scale) 7 (MSK-64 scale) 67.22 cm/s^2 (0.069g) 44.81 cm/s^2 (0.046g) 54.29 cm/s^2 (0.055g) Assumed to be 2/3 of the maximum horizontal acceleration		

4. ECOLOGICAL STANDARDIZATION: RADIATION

4.1. Standards

Ecological standards are normative technical documents specifying some ecological requirements. This term is applied to maximum permissible concentrations (MPS) of pollutants in the environment (air, water, soil) and maximum permissible levels (MPL) of harmful physical impacts affecting the environment. See [2] for basic provisions of the system of standards; this system is the complex of interrelated documents. Environment quality standardization is one of key provisions stipulated by the Law of the Republic of Belarus *On Environment Protection* [3].

The environment quality is the set of parameters of environmental ecological systems' condition ensuring uninterruptable and continuous adequate processes of substance and energy exchange within the nature and between the nature and humans, as well as the conditions for life reproduction. The factors ensuring the environment quality are, inter alia, the properties of the nature itself, such as self-regulation and self-cleaning of substances harmful for it.

The following sets of norms are used to control the environment quality:

- sanitary and hygienic norms;
- industrial and economic norms;
- integrated norms.

4.2. Sanitary and hygienic norms (radiation impacts not considered)

The purpose of sanitary and hygienic standardization is to develop the scientifically reasonable criteria of safety (or harmfulness), in terms of human health, of the human habitat factors and life activity conditions. This scope of standardization covers the environmental, industrial and housing aspects of human life. For these purposes, the threshold impact concept is one of key principles of standardization.

The backgrounds used to set the numerical values of maximum permissible concentrations (MPC) are as follows:

- the concentration is recognized to be permissible if it does not result, directly or indirectly, in harmful or unpleasant impacts for a human and his or her workability, well-being and mood;
- any addiction to a harmful substance is impermissible;
- the impact affecting humans shall be assessed in accordance with effects for the most sensitive human organs, with two- or three-times margin;

- the human organism response must be assessed in accordance with the objectively measured data.

Air environment. The biological impact mode, reflex-related (organoleptic) and resorptive (toxic), is used as a background for assessment of harmfulness in air environment.

Several types of MPC are in use for air environment:

- MPC of harmful substances in working zone air ($MPC_{working\ zone}$);
- MPC of the same substances in the atmospheric air ($MPC_{atmospheric\ air}$).

$MPC_{working\ zone}$ is subject to occupational monitoring, so, it is beyond the scope of the monitoring system.

If air contains several (*n*) harmful substances having similar effects (i.e. the substances impacting an organism in a cumulative harmful way), their concentration must meet the condition as follows:

$$(C_1/MPC_1) + (C_2/MPC_2) + \ldots + (C_n/MPC_n) \leq 1$$

See [4] for $MPC_{atmospheric\ air}$ values.

Aquatic environment. The MPC of a substance in aquatic environment is the concentration of the particular harmful substance that, if exceeded, makes water unusable for respective type of water use. The types of water use are as follows:

- for domestic and drinking purposes;
- for sanitary purposes;
- for fishery.

When surface waters are assessed within the scope of the National Environment Monitoring System, the strictest MPC norms are applied for water bodies used for fishery. Quality of surface water in the river Viliya shall be assessed in accordance with these norms. To set the norms for concentration of harmful substances in water, three major criteria must be taken into consideration:

- general sanitary mode of the water body;
- organoleptic properties;
- human health.

See [5] for MPCs applied for drinking water; [6], for water bodies used for domestic and drinking purposes as well as for cultural and sanitary purposes; [7], for water bodies used for fishery.

Soils (land plots). Maximum permissible concentration of a substance in soil is the maximum concentration of the particular harmful substance that does not result in direct or indirect impacts affecting the environments being in contact with soil, human health and soil capability to clean itself and to maintain vegetation, i.e. growth and development of plants.

In accordance with the ways of migration of chemicals from soils, the following MPC types are considered:

- translocation MPC, characterizing the transfer of substances from soil, through the roots of plants, into herbage and fruits;
- airborne migration MPC, characterizing the transfer of substances from soil into the atmosphere;
- waterborne migration MPC, characterizing the transfer of substances from soil into ground waters and water sources;
- general sanitary MPC, characterizing the impacts of substances affecting the soil self-cleaning capability and microbiocenosis.

If there are no valid MPCs, provisional permissible concentrations (PPC_{soil}) may be specified. The following formula is used to calculate provisional permissible concentrations:

$$PPC_{soil} = 1.23 + 0.48 \times \lg MPC_{foodstuffs}$$

See [4] for MPCs applied for harmful substances in soils.

4.3. Sanitary norms and rules for radiation safety

In accordance with the Sanitary Norms and Rules [8] being in force in the Republic of Belarus, three types of radiation exposure situations are considered:

- planned exposure situation;
- emergency exposure situation;
- existing exposure situation.

Annual radiation intake limits and permissible average annual volumetric activities are calculated in accordance with the limit exposure doses, 20 mSv/year for personnel and 1 mSv/year for population, and are specified in separate hygienic normative documents approved by the Ministry of Public Health of the Republic of Belarus [9, 10].

The average risk factor used to set the limit exposure doses for personnel and population is assumed to be 5×10^{-2} Sv^{-1}.

For the mode of normal operation of ionizing radiation sources, the limit annual exposure doses are set in accordance with the individual lifetime risk: for personnel, 1.0×10^{-3}; for population, 5.0×10^{-5}.

The negligible risk level separates the risk optimization zone and the unconditionally permissible risk zone; this level is 10^{-6}.

For the mode of normal operation, free of deviations from such operation, the norms specified in [11] are used for surface water quality assessment.

5. CONDITIONS LISTED IN THE PERMISSION [12]

5.1. Process water supply system

The circulating process water supply system shall be used at the NPP:

- the primary cooling water system (PA) that shall deliver cooling water and remove heat to the chimney-type evaporative cooling towers from the turbine condensers;
- the auxiliary cooling water system (PC) that shall remove heat to the cooling towers from the intermediate cooling circuit used for nonessential services and from the chilling machines’ condensers;
- the cooling system for essential services (PE) that shall remove heat to the spray ponds from the systems located in the safety building.

During normal operation, the total water flow rate in the PA system (i.e. water flow through the cooling towers) for two reactor units is 300000 m^3/hour. The design of water catchers accepted for the cooling towers is capable to reduce the carryover of droplets to 0.002% of the total flow rate at the cooling tower. The annual average water loss resulting from evaporation and carryover in the cooling towers shall not exceed 4630 m^3/hour (for two reactor units).

The annual average total amount of regular fresh water makeup shall not exceed 2.54 m^3/second (for two reactor units).

The river Viliya is assumed to be the primary source to make up the consumptive water use.

5.2. Effective use of water resources

For the purposes of effective use of water resources, waste water originating from the NPP site is predominantly reused. The reused water includes treated waste water as follows:

- sanitary waste water from the free-access zone;
- process waste water and runoff rain water;
- process waste water contaminated with petroleum products;
- non-radioactive sanitary waste water from the controlled-access zone.

Treated waste water is used as makeup water for the circulating process water supply system.

Due to the treated water reuse, water consumption from external sources is reduced by 2270 m^3/day (not including runoff rain water use).

In accordance with the project, container-type modular water treatment facilities shall be used to purify the sanitary waste water from the free-access zone. These facilities shall provide mechanical and biological treatment as well as disinfection.

The project also provides for the system of facilities to treat process waste water, runoff rain water and waste water contaminated with petroleum products.

5.3. Radioactive emissions and discharges

To avoid population exposure exceeding the limit for population exposure resulting from industrial sources, the population exposure quota specified for the NPP is 100 μSv/year, including 50 μSv/year resulting from gas and aerosol emissions and 50 μSv/year resulting from liquid discharges [13]. This quota is specified for the total exposure impacting the population from all sources of radioactive gas and aerosol emissions into atmospheric air and liquid discharges into surface waters, for the NPP in total, irrespective of the number of reactor units at the NPP site. For normal NPP operation, the quotas for population exposure from radiation factors (emissions and discharges) are specified in the Hygienic Standard.

Maximum permissible emissions and discharges of radioactive substances are the upper limits for gas and aerosol emissions and for liquid discharges of radioactive nuclides into the environment when the NPP is operated in the normal mode.

The minimum significant exposure dose, 10 μSv/year, is assumed to be the lower exposure dose limit for the purposes of population protection against radiation when the NPP is operated in the normal mode.

See Table 3 [13] for annual permissible emissions (Bq/year) of the most significant radioactive nuclides.

Table 3 – Annual permissible emission of radioactive nuclides into the atmosphere, for the NPP with VVER reactors

Radioactive nuclide	Permissible emission
Inert radioactive gases	690 TBq
^{131}I	18 GBq
^{60}Co	7.4 GBq
^{134}Cs	0.9 GBq
^{137}Cs	2.0 GBq

Technical solutions and organizational arrangements are applied for treatment of sanitary waste water to prevent radionuclides from penetration into the environment with treated sanitary waste water.

The controlled-access zone's sanitary sewerage system receives sanitary waste water from water closets and shower rooms. Waste water from the special laundry and sanitary checkpoints is delivered to the special sewerage system tanks. After radiation measurements, this water is discharged to the controlled-access zone's sanitary water treatment facilities. However, if the level of activity found in waste water exceeds the permissible level, water is removed for special treatment.

6. IMPACT TYPE ANALYSIS

6.1. Norms of maximum permissible levels (MPL) for physical impacts

Thermal impact. The most significant type of environmental physical impact produced by the NPP is thermal impact. The thermal pollution MPL for the river Viliya is limited in accordance with [7]. Water temperature must not be raised by more than 5°C above the natural temperature of a water body, with the resulting temperature not exceeding 20°C in summer and 5°C in winter for water bodies being the habitats for *Salmonidae* and *Coregonidae* fish species.

Radiation impact. The limits for annual intake with air and food, the permissible average annual volumetric activity for inhaled air and the response levels in case of intake of radioactive nuclides with water are specified in [13] for population. The permissible concentrations of radioactive nuclides in foodstuffs and drinking water, valid in Belarus, are specified in [11].

The maximum permissible emission norm (MPE) is the permissible weight of substance emission per time unit (grams per second or tons per year), resulting (taking into consideration the expected development of nearby industrial enterprises and substance dispersion in the atmosphere) in surface concentration not exceeding the substance MPC for population, flora and fauna.

6.2. Water intake impact forecast

The forecast of water intake for the NPP from the river Viliya demonstrates that, for two reactor units:

– in case of water flow in the river approximately equal to its mean annual flow estimated for many years, water intake shall not be greater than 2.2% of the water flow in the river;

– in case of a year with low water, and water flow rates in Viliya approximately equal to the minimum average monthly rates in summer, autumn and winter low-water periods, the consumptive water intake shall not be greater than 6% of the river flow rate.

After water intake from the river Viliya for the NPP operation processes, with the above-listed hydrological conditions, water flow rate in Viliya shall not be less than 24.12 m^3/second, i.e. it shall remain higher than the minimum flow rate necessary for the aquatic ecological system existing in the river.

The estimated water consumption for the NPP utilities and drinking purposes (including hot water supply) is 1315 m^3/day.

The estimated water consumption for the NPP processes (not including the makeup water for the circulating water supply system) is about 876.4 m^3/day (process water).

6.3. Thermal impact

6.3.1. Cooling towers [12]

The thermal impact on the environment results from use of evaporative cooling tower and spray ponds in the circulation water cooling system.

The thermal environmental emission from one VVER-1200 reactor unit is about 2000 Gcal/hour. The total overheat of the steam-air mixture is about 30°C (as compared with the ambient atmosphere). Water and droplet carryover from the cooling tower nozzle results in precipitations at the leeward side. The additional amount of precipitations falling on the soil, as a result of emissions from cooling towers, is about 0.3 mm/year or less than 0.05% of the natural level of precipitations. Intensity of precipitations and the area affected by them depends on the wind speed and direction. When the wind is weak or moderate, the intensity of precipitations near the cooling tower becomes maximum but sharply drops at a distance. At 1…3 km, only weak precipitations or their traces are observed, and there is practically no thermal impact.

The calculations were carried out for two VVER-1000 reactor units (similar to those used at the NPP) for summer and winter climatic characteristics.

In summer, the estimated maximum additional water vapor content resulting from the cooling towers' emissions is about 135.7 mg/m^3; it is about 22 times less than the background vapor content, and it cannot impact any moisture-related atmospheric processes (such as dew, fog or mist).

In winter, the maximum water vapor concentration is 120.71 7 mg/m^3; it cannot significantly impact any moisture-related processes, such as aerial conductor icing. Under real conditions, maximum water vapor concentration in winter will be much less because the evaporated water consumption rate is about 3 times less than in summer mode.

The cooling tower's flare impacts the distribution of gas and aerosol emissions from the NPP resulting in their more intensive vertical dispersion when they are distributed near the flare. However, at 5 km from the cooling tower, there is practically no flare-related effects; for longer distances, reduction of gas and aerosol release impact on the off-site territory is observed.

6.3.2. Waste water discharge [12]

As a result of waste water discharge into the river Viliya, water temperature in the reference cross-section in the warmest month during the summer period (July) will be 1.1°C higher than the initial water temperature in Viliya, and it is estimated to be +23.0°C; in the warmest month during the winter period (October), it will be 0.9°C higher than the initial water temperature in Viliya, and it is estimated to be +7.8°C.

Also, water temperature in the reference cross-section of the river Viliya in August is estimated to be +21.0°C.

In accordance with the requirements specified in [7], water temperature in water bodies used for preservation and reproduction of *Salmonidae* and *Acipenseriformes* fish species shall not be raised by more than 5°C above the natural temperature of a water body, with the resulting temperature not exceeding 20°C in summer and 5°C in winter.

The total growth of water temperature in the reference cross-section of Viliya (500 m downstream from the Belarusian NPP waste water discharge location) in July and October results from background temperatures in the river (21.9°C in July and 6.9°C in October); these background temperatures are higher than those specified in the Decision of the Ministry of Natural Resources and Environmental Protection and the Ministry of Public Health of the Republic of Belarus No.43/42, 08 May, 2008 (20°C in summer, 5°C in winter).

In accordance with the requirement of the Ministry of Natural Resources and Environmental Protection and taking into consideration the concern declared by Lithuania within the scope of discussions with regard to the EIA Report, the measures as follows are provided for in the project documents for the Belarusian NPP construction: for the most unfavorable period (in terms of thermal impacts), the supplementary facility shall be used to cool waste water discharged from the NPP. This facility is an open pool with the nozzles used to spray water over the tank surface for cooling (similar to the technique used in spray ponds). The pool dimensions are 31 x 172 m, the depth is 3 m.

Due to this after-cooling facility, the discharge water temperature can be reduced, before discharge into Viliya, to 20°C in July and August and to 5°C in October; as a result, it will meet the quality requirements for relevant seasons specified for water bodies used for fishery. In July and October, discharged water temperature will be even lower than the natural water temperature in Viliya.

6.4. Pollution impact

6.4.1. Atmospheric air [12]

The NPP's environmental impact include atmospheric emissions from the starting and standby boiler plant, diesel generator plants, vehicles, gas electric welding works, exhausts from chemical laboratories etc.

The primary fuel for the boiler plant is natural gas. Diesel fuel is used as emergency fuel.

For diesel fuel storage, three vertical ground tanks shall be built, 300 m^3 each (one tank shall be used as a standby unit).

As for the time of commissioning and adjustment procedures, the boiler plant shall operate 24 hours a day.

In accordance with the boiler plant design, four LOOS 825 L steam boilers (manufactured by *LOOS International*, Germany) shall be installed, providing 40 tons of steam per hour.

The designed boiler plant's total maximum heat generation capacity is 104.376 kW (89.763 Gcal/hour). In accordance with the design, the emissions from the boiler plant shall be within the limits stipulated in [14].

The consumption of the primary fuel at the boiler plant is as follows:

- maximum hourly consumption: 12444 m^3/hour;
- annual consumption: 46332.72 thousand m^3/year.

The pollutants originating from natural gas burning in the boiler plant are as follows: nitrogen dioxide, nitrogen oxide, carbon oxide, benzpyrene, benzapyrene.

When the boiler plant consumes the emergency (diesel) fuel, more pollutants appear: black carbon (soot) and sulfur dioxide.

To remove the combustion gas, each boiler is provided with an individual chimney. The chimneys' opening diameter is 1.1 m. The height of chimneys is 45 m (from the ground).

As per the design, the total atmospheric emission from all designed stationary facilities shall not exceed 93.77 tons/year (including the emissions from the boiler station during the commissioning and adjustment procedures).

The standardized atmospheric pollution calculation software, *Ecolog PRO* (v.3.0), designed by *Integral* Company (Russian Federation), was used to calculate the surface concentrations of pollutants in an atmospheric air.

Calculation results demonstrate that the surface concentrations of pollutants at the site boundary shall not exceed 0.1 of the MPC.

6.4.2. Discharge into surface water [12]

To reduce concentrations of chemicals and other (suspended) substances in the discharged waste water to the levels meeting the maximum permissible concentrations, the design provides for partial removal of waste water from the water conditioning facilities into the sludge disposal sites; this water shall be later returned to the water conditioning circuit.

See Table 4 [15] for concentrations of the most significant chemicals in the reference cross-section.

Table 4 – Major pollutants concentration

Characteristic	Concentration (mg/dm^3), $C_{measured}$		MPC (mg/dm^3)	Capacity, MPC-$C_{measured}$
	Summer	Winter		
Solid residue (mineralization)	334.9	318.4	1000	673
Suspended materials	6.7	7.4	0.25 from the background	
pH	8.0-8.5	8.0-8.5	6.5-8.5	
Calcium	70.98	73.72	180.0	107.65
Sodium	80.5	92.5	120.0	33.50
Petroleum products	0.01	0.02	0.05	0.035
Sulfates	68.6	79.3	100	26.05
Chlorides	130.6	148.5	300	160.45

The waste water discharge into the river Viliya is implemented as a dispersing release.

6.5. Radiation impact

To avoid population exposure exceeding the limit for population exposure resulting from industrial sources, the population exposure quota specified for the NPP is 100 μSv/year [13].

The minimum significant exposure dose, 10 μSv/year, is assumed to be the lower exposure dose limit for the purposes of population protection against radiation when the NPP is operated in the normal mode.

See Table 3 (Section 5.3) for annual permissible emissions of the most significant radioactive nuclides.

6.6. Transboundary impact forecast

The analysis of natural conditions in the Belarusian NPP siting area demonstrates that:

- the major transboundary watercourse is the river Viliya (Nyaris), used to provide the Belarusian NPP with water for the process purposes and, also, to discharge the blowdown and process waters from the Belarusian NPP;

- the maximum water level drop in the river Viliya transboundary cross-section, with two reactor units, can be up to 5 cm, if the water flow in the river is approximately equal to its mean annual flow estimated for many years, or up to 6 cm, if the water flow is minimum;

- the forecast for Viliya speed parameters during the Belarusian NPP operation demonstrates that the mean flow speed downstream the water intake facility will slightly drop (by 0.04 m/s max), and the flow speed drop in the transboundary river section will be insignificant.

- the wind direction repetition data collected for many years demonstrate that western and northern winds prevail in the Belarusian NPP site area;

- the research results demonstrate that no conditions can be observed at the major part of the 30-km zone for initiation and transit of underground water in Dnieper-Sozh and Berezina Dnieper aquifer complexes and in the combined pre-quaternary aquifer complex from Belarus towards Lithuania;

- analysis of migration of radioactive substances from site-related and local sources demonstrated that penetration of radioactive pollution into the river network in the 30-km zone is practically impossible, and that the impact zone of a local source (if it is in the NPP site) will be restricted within the areas where ground water seeps towards the day surface.

See Table 5 for the summary characteristic of possible Belarusian NPP impacts affecting the neighboring states.

Table 5 – Belarusian NPP: Possible impacts

Country	Distance (km)	Impact ways		
		Surface water	Ground water	Surface water
Lithuania	25	yes	no	yes
Poland	200	no	no	yes
Latvia	110	no	no	yes
Russia	200	no	no	yes
Ukraine	318	no	no	yes

In accordance with the Espoo Convention, Appendix II, relevant forecasting models (see Table 6) were used to forecast possible environmental impacts of the Belarusian NPP.

Table 6 – Mathematical models used

Object	Model used
Atmospheric air	Automated system for radiation situation analysis and forecast, RECASS NT (Radioecoiogical Analysis Support System), recommended by the Federal Service for Hydrometeorology and Environmental Monitoring of Russia (Roshydromet), Federal Information Analytical Center (*GU NPO Taifun* State Institution – Scientific and Production Association).
Surface water Thermal pollution Chemical pollution	 Frolov-Rodziller method and Roshydromet recommendations, MIKE 21 software. Frolov-Rodziller formula; Karaushev method was used to calculate the turbulence diffusivity coefficient (D).
Ground waters	Unified generalized multi-chamber model of mixed cell (MULTIBOX).
Agricultural products	Compartmental mathematical models based on the system analysis method.
Population	INTERRAS software (The International Radiological Assessment System). EMISSION SOURCE – DOSE model (ST-DOSE - Source Term To Dose).

The comprehensive assessment was carried out, using modern modeling techniques; the results demonstrate that, both during normal operation and in case of abnormal operation, the Belarusian NPP will not produce transboundary impacts affecting the territories of neighboring states.

7. RADIATION ECOLOGICAL MONITORING PROGRAM WITHIN THE SCOPE OF THE POST-PROJECT ANALYSIS: GENERAL

7.1. Ecological monitoring: atmospheric air, surface water, ground water, soils (lands)

The environmental ecological monitoring purposes are as follows:

– find the levels and trends of pollution affecting atmospheric air, water, components of terrestrial and aquatic ecosystems;

– find the contribution of emissions and discharges from the NPP in pollution of environmental components.

The environment pollution sources may include radioactive waste storages, boiler plants, other industrial facilities, household waste storages, motor vehicles, fertilizers washed by water from surfaces of agricultural lands located in drainage basins of water bodies etc.

The objects of monitoring include atmospheric air, surface water, ground water, soils (land plots), flora and fauna.

The atmospheric air condition observation intervals shall be chosen, taking into consideration the nature and intensity of human-induced impacts affecting the atmospheric air; as a rule, these observations shall be carried out 4 times a day. Snow cover condition observations (including snow sampling and measurements of necessary meteorological parameters) shall be carried out once a year, during the period when maximum total amount of water has been accumulated in the snow cover (as a rule, at the end of February).

The atmospheric air condition observation shall cover the parameters as follows: concentration of solid particles (dust and aerosol not differentiated in terms of components), sulphur dioxide, carbon oxide, nitrogen dioxide, phenol, ammonia, volatile organic compounds, lead, cadmium, meteorological parameters (such as air temperature, atmospheric pressure, relative humidity, wind speed and direction), weather condition.

The analysis of snow cover samples shall include the most significant salts (sulphates, nitrates, chlorides, hydrogen carbonates, ammonium nitrogen, and cations of potassium, calcium, magnesium and sodium) and heavy metals (lead, cadmium); also, specific electrical conductivity and pH shall be measured.

Hydrochemical observations at watercourses shall be carried out seven times a year, in accordance with periods of major hydrological phases: during high-water period (rise, peak and decline); at the time of maximum and minimum water flow rate during the summer low-water period; in autumn, prior to freezing; during the winter low-water period. Observations for heavy metal concentration monitoring shall be carried out four times a year.

The monitoring program shall include observations covering the parameters of physical properties of water and gas content in it (temperature, clarity, pH, suspension concentrations, dissolved oxygen concentration, specific electrical conductivity), most significant ions and mineralization (chlorides, sulphates, hydrogen carbonates, magnesium, calcium, sodium, potassium,, mineralization in terms of dry residue, water hardness), organic substances ($BOD_{5,}$ COD_{cr}, petroleum products, anionic synthetic surfactants, phenols), biogenic substances (ammonium expressed as N, nitrates expressed as N, nitrites expressed as N, total nitrogen expressed in terms of Kjeldahl method, phosphates expressed in terms of P and as total phosphorus), heavy metals (total iron, manganese, copper, zinc, nickel, total chromium, lead, cadmium).

Samples for measurements of these pollutants' concentrations in the aquatic environment shall be taken from discharge channels of industrial facilities and from rivers in drainage basins. A continuous observation station shall be arranged to monitor the background condition of a water body; this station shall be located in a point not affected directly by factors impacting water quality, such as discharges from industrial or agricultural facilities, water course inflows, dredging operations etc.

At transboundary monitoring stations, surface water chemical pollution observations shall be carried out in accordance with the list of substances for which, if their threshold concentrations in water are exceeded, prompt information exchange is required in accordance with the international obligations of the Republic of Belarus.

See Table 7 for the list of parameters subject to monitoring at transboundary cross-sections.

Table 7 – Parameters and their threshold values for water at transboundary cross-sections of rivers in the Republic of Belarus for which, if they are exceeded, prompt information exchange shall be carried out in accordance with the international cooperation obligations

Parameters		Units of measurement	Content thresholds
Water physical properties and gas concentration parameters	pH	–	< 6-9 >
	Dissolved oxygen	mgO_2/dm^3	< 2.0
Organic substances	BOD_5	mgO_2/dm^3	23
	COD_{Cr}	mgO_2/dm^3	100
	Petroleum products	mg/dm^3	0.7
	Anionic synthetic surfactants	mg/dm^3	1.0
	Phenols (total)	$\mu g/dm^3$	10
Biogenic substances in water	Ammonium nitrogen	mg/dm^3	3.9
	Nitrate nitrogen	mg/dm^3	12.0
	Nitrite nitrogen	mg/dm^3	0.2
	Phosphate phosphorus	mg/dm^3	1.0
	Total phosphorus	mg/dm^3	1.5

Elements (total concentration in non-filtered sample)	Copper	μg/dm^3	50
	Zink	μg/dm^3	1000
	Nickel	μg/dm^3	50
	Chromium	μg/dm^3	50
	Lead	μg/dm^3	100
	Cadmium	μg/dm^3	10
	Mercury	μg/dm^3	5.0
Radioactive nuclides	Cesium-137	Bq/dm^3	10
	Strontium-90	Bq/dm^3	0.37

Soil sample analysis shall cover pH, concentrations of heavy metals (manganese, copper, zinc, nickel, lead, cadmium), sulphates, nitrates, petroleum products.

7.2. Radiation monitoring: atmospheric air, surface water, ground water, soils (lands)

Radiation monitoring shall result in acquisition of information necessary to:

assess the contribution of gas and aerosol emissions from the Belarusian NPP into the exposure doses for population;

assess the contribution of water discharges from the Belarusian NPP into the exposure doses for population;

reveal the areas of maximum impacts resulting from radioactive nuclide emissions and discharges making the major contribution into the pollution of environment components;

reveal the long-term trends of environment pollution resulting from the Belarusian NPP operation;

reveal the external and internal exposure doses for population and the radiation-related risk for population resulting from the environment pollution.

Within the scope of radiation monitoring covering atmospheric air, surface water, ground water, soils (lands), components of terrestrial ecosystems (including agricultural ones), forest ecosystems and aquatic ecosystems, the activities shall include observations, measurements in laboratories, and information collection, systemized arrangement and analysis with regard to the environment pollution.

Models verified by the environment monitoring in the particular region shall be used to analyze the dispersion of radioactive nuclide emissions and discharges into the environment. This information shall be stored, analyzed, presented and updated in accordance with applicable requirements.

Equipment and procedures used for radiation monitoring of the environment surrounding the NPP shall be adequate to control the environment components in order to identify both low (background) concentrations of radioactive nuclides, corresponding to the global fallouts, and extremely high concentrations resulting from accidents.

The environmental radiation monitoring objects are as follows:

atmospheric air (natural fallouts from the atmospheric layer near the ground surface, radioactive aerosols, atmospheric precipitations), surface waters and bottom sediments in water bodies, ground water, drinking water, soil (lands);

components of agricultural and forest ecosystems (such as perennial herbs, needles of conifers, moss, mushrooms, berries, forest litter, arable and virgin lands);

components of aquatic ecosystems in rivers and lakes within the observation zone.

The scope of radioactive nuclides to be analyzed in the environment components shall be in accordance with the range of radioactive nuclides existing in the NPP emissions and discharges, both for normal and abnormal operation (^{14}C, ^{3}H, radioactive inert gases, $^{137,134}Cs$, ^{60}Co, ^{54}Mn, ^{131}I, $^{89,90}Sr$), artificial radioactive nuclides existing in depositing components of ecosystems after accident at radiation-related facilities (^{137}Cs, ^{90}Sr, $^{239,240}Pu$), and radioactive nuclides being the components of the natural radiation background (^{40}K, ^{210}Pb, ^{232}Th, ^{226}Ra etc.).

7.3. Biological monitoring

The biological monitoring includes observations covering the condition of biological systems at various levels, from populations of indicator species to biocenoses, in terms of trends of their structural and functional characteristics.

The biological monitoring goal is to assess and forecast the changes in the condition of terrestrial and aquatic ecosystems.

For terrestrial ecosystems, monitoring is based on comprehensive field surveys covering their condition, including the current condition and trends characterizing the changes in agrocenoses, soil cover, vegetation (phytocenoses) and fauna, measurements of concentrations of radioactive nuclides, heavy metals and other possible pollutants in components of terrestrial ecosystems.

Surveys shall be carried out during three years at the chosen continuous observation stations and reference areas in order to prepare finally the observation procedures and the scope of parameters to be monitored. During the first three years, observations covering the hydrobiological parameters of water bodies shall be arranged and carried out at hydrochemical parameter observation stations. Also, observations shall be arranged to monitor the parameters of bottom sediments in water bodies. Morphological characteristics, NPP waste water impacts, and data characterizing the water usage system and other related scopes of economic activities shall be taken into consideration in order to select the locations for continuous observation stations.

Hydrobiological monitoring shall cover the quantitative characteristics of aquatic biocenoses (phytoplankton, zooplankton, bacterial plankton, benthos, periphyton, macrophytes, fish fauna), characteristics of hydrobionts in terms of migration, sanitary and hygienic condition of water bodies.

Bottom sediment samples shall be taken layer by layer to assess their current chemical composition and variations of this composition. The samples shall be analyzed for artificial and natural radioactive nuclides and heavy metals. Samples of suspensions and bottom sediments shall be taken once in 4-5 years.

To describe the composition of the surface layer and the bottom sediment profile in mechanical terms, the measured parameters shall cover grain-size characteristics, skeleton volume weight, natural humidity, density and thickness of layers comprising the bottom sediments. Concentrations of suspensions for various hydrometeorological conditions, distribution of suspensions throughout the water depth and the water area, and their variation within a year or season shall be found in order to assess the rates of sedimentation and deposit accumulation processes in water.

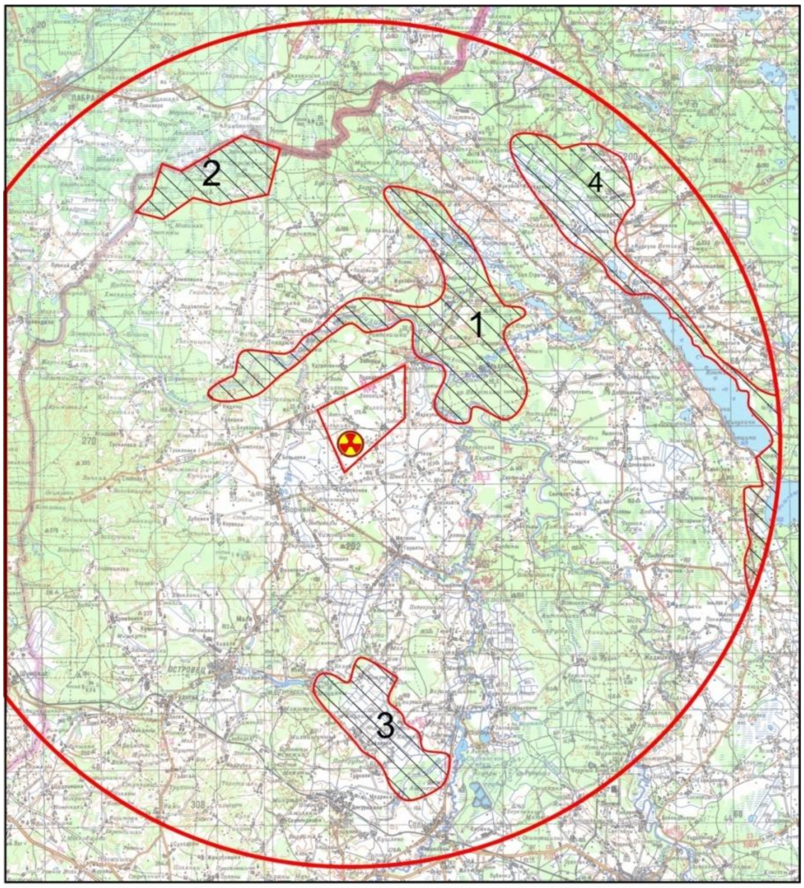
In accordance with the results of observations carried out during the first three years after the NPP commissioning, final observation procedures and the scope of parameters to be monitored (the parameters characterizing the condition of natural environments, components of terrestrial and aquatic ecosystems) shall be prepared.

In addition to these activities within the scope of ecological monitoring of terrestrial and aquatic ecosystems, observations covering the amounts and trends of ground water pollution by radioactive nuclides and chemicals shall be carried out in the NPP site area.

8. CONTINUOUS OBSERVATION STATIONS

8.1. Most vulnerable critical areas

It seems reasonable to carry out the environmental monitoring in the most vulnerable areas in terms of radiation-related ecology. For these purposes, within the Belarusian NPP observation zone, the areas were outlined where the migration of radionuclides (^{90}Sr and ^{137}Cs) is especially high, and protection against chemical pollution is minimal. See Figure 2 for locations of typical critical areas most vulnerable in case of accidental emissions during the NPP operation.



Symbols

1, 2, 3, 4 — Areas with maximum rates of migration through the soil profile for 137C and 90Sr, and maximum probability of ground water pollution

Figure 2 – Map depicting the selected typical areas most vulnerable in terms of a set of natural factors

Area No.1 is in the floodplain of the river Viliya, near Malye Sviryanki, Muzhily, Ryten, Matskely villages, 10 km from the Ostrovets NPP site. Peaty boggy soils and sod-podzol soils (with thin podzol layer) prevail; subsoil consists of medium-grain sand. The ground water level depth is 0.5 m.

Area No.2 is at the Lithuanian border, near Vornyany and Klenovka villages, 20 km from the Ostrovets NPP site. Sod-podzol soils (with thin podzol layer) prevail; subsoil consists of fine-grain sand. The ground water level depth is 1.0 m.

Area No.3 is in the area that was formerly covered by a bog; later, it was reclaimed. The area is near Dailidki, Yuzulino and Klochki villages, 10 km from the Ostrovets NPP site. Peaty boggy soils and sod-podzol soils (with thin to moderate podzol layer) prevail; subsoil consists of fine-grain sand. The ground water level depth is 0.2…0.5 m.

Area No.4 is in the ameliorated territory, in the valley of the river Sruna, where this river inflows into the river Stracha, near Olshevo, Strachinki, Kareishi villages, 25 km from the Ostrovets NPP site. Sod-podzol soils (with thin podzol layer) prevail; subsoil consists of fine-grain sand. The ground water level depth is 0.7 m.

8.2. Water body hydrology continuous observation stations

The river Viliya has been studied quite well. Now, gauging stations are in operation near Steshitsy large village, Mikhalishki settlement and Vileika town. Mikhalishki gauging stations is near the NPP site; this station is in use for observations since 1946. Water level and flow rate measurements and observations of ice conditions and thermal characteristics are carried out at all stations.

Two gauging stations are in operation at the river Oshmyanka: Soly (since 1953) and Velikiye Yatsyny (since 1955) gauging stations. Also, observations of water flow, thermal characteristics, ice-related events and ice thickness are carried out. Water samples for chemical composition analysis are taken at Oshmyanka - Velikiye Yatsyny gauging station seven times a year.

Also, to provide complete hydrological information, several more gauging stations and hydrological stations are planned to be arranged at rivers Viliya (Muzhily settlement), Stracha (Olkhovka settlement), Gozovka (Goza settlement), Polpe (Chekhi and Markuny settlements); they shall be used for hydrological monitoring observations, including water levels, water temperatures, ice-related events, turbidity, and water flow rate measurements with calculations of daily discharge. To meet the post-project analysis requirements, the complete range of hydrological, hydrochemical and radiation-related observations must be carried out in the transboundary section of the river Viliya, Bystritsa settlement.

8.3. Weather parameters observation stations

Oshmyany weather station, in operation since 1962 as a complete Grade 2 station (in accordance with the classification used by the World Meteorological Organization), is 44 km south from the NPP site area. Lyntupy weather station, in operation since 1945 as a complete Grade 2 station, is 170 km east from the NPP site area.

To study the conditions at the Belarusian NPP site in terms of microclimate, the automatic weather station shall be installed in Valeikuny or Chekhi settlement; this station will be used to measure air temperature and humidity, wind direction and speed, precipitations and atmospheric pressure in the real-time mode. To make the pollutant transfer forecasts more accurate (including those for radioactive pollutants, for various distances and heights), the remote measurement equipment intended to measure meteorological parameters (wind speed and direction, first of all) shall be installed in the NPP observation zone.

8.4. Continuous observation stations siting

See Table 8 for the list of radiation ecological monitoring stations.

Observations of environment components pollution shall be regular and shall be carried out throughout the complete NPP lifecycle.

Table 8 – Radiation ecological monitoring stations

Location	Monitoring object											Control type	
	Soil	Surface water	Ground water	Precipitations	Aerosols	Agricultural products	Bottom sediments in water bodies	Landscapes	Flora	Fauna	Aquatic ecosystems	Chemical pollution	Radioactive contamination
Mikhalishki	+	+		+	+	+	+	+	+	+	+	+	+
Gervyaty	+	+				+	+	+	+	+	+	+	+
Goza	+	+				+	+					+	+
Chekhi	+	+		+	+		+						+
Vornyaty						+					+	+	+
Podoltsy						+						+	+
Valeikuny			+			+						+	+
Shulniki			+			+						+	+
Bystritsa	+	+				+	+				+	+	+
Ostrovets	+	+		+	+	+	+				+	+	+
Oshmyany				+	+	+						+	+
Svir		+				+	+				+	+	+
Malye Sviryanki							+					+	+
Dovnarishki			+									+	+
Sviryanki			+									+	+
Markuny		+	+					+	+	+		+	+
Litvyany								+	+	+		+	+
Bolshye Sviryany								+				+	+
Novaya Ves								+	+	+		+	+
Novye Filimony								+	+	+		+	+

Vishnevskoe Lake											+	+	+
Sarochanskaya Lakes Group											+	+	+
NPP site	+	+	+	+	+							+	+

8.5. Radiation monitoring and control stations

8.5.1. Automated radiation situation control system

Observance of norms and rules with regard to radiation safety must be controlled at a territory where population can be impacted by internal or external radiation exposure.

The automated radiation situation control system (ASKRO system) is designed to ensure radiation safety of population and environment in the NPP site area during normal NPP operation and in case of emergencies. The system collects and processes the gamma-radiation dose rate data and meteorological data necessary to control observance of population safety norms with regard to radiation in accordance with applicable norms and legislation. The ASKRO continuously controls radiation in the environment and informs the general public about the current radiation situation at the NPP and in the neighboring areas.

Now, the automatic dose rate measurement station is in operation in Trokeniki transboundary settlement.

The factors that shall be taken into consideration for selection of locations for automatic dose rate measurement stations shall include social and economic factors (such as population density, availability of access ways and electric energy sources, conditions for protection of automatic measurement stations against damage) and meteorological conditions in the NPP site area estimated in accordance with the data resulting from many years of observation.

Information display boards shall be installed in the locations where the equipment of automatic measurement stations is mounted; these boards shall be used to display current radiation background in local points. Also, large-size display board shall be installed in Ostrovets for the same purposes.

8.5.2. Radiation monitoring observation stations

The NPP is a nuclear facility, hazardous in terms of radiation. Taking into consideration that the NPP attracts special interest as a source of radioactive pollution of environment, the project of the radiation monitoring system has been prepared, covering the 30-km zone near the NPP. See Table 9 for the proposed list of observation stations, parameters to be controlled and related observation procedures.

Таблица 9 – Proposed list of observation stations, parameters under control and observation procedures

Env. component	Monitoring points	Monitoring objects	Parameters to be monitored	Observation interval	
				NPP construction	NPP operation
Air	Mikhalishki	precipitations	Σβ, γ	once in 10 days*	daily
		aerosols		the same	the same
	Chekhi	the same	the same	the same	the same
	Ostrovets	the same	the same	the same	the same
	Oshmyany	the same	the same	the same	the same
Water	River Viliya (Bystritsa village)	water	γ, ^{90}Sr, Σβ	once a year	4 times a year
		bottom sediments	γ, ^{90}Sr	once a year	once a year
		aquatic vegetation	γ, ^{90}Sr	-	once a year
	River Viliya (Mikhalishki village)	water	γ, ^{90}Sr, Σβ	once in 3 years	4 times a year
		bottom sediments	γ, ^{90}Sr	once in 3 years	4 times a year
		aquatic vegetation	γ, ^{90}Sr	-	once a year
		water in wells	γ, ^{90}Sr	once in 3 years	4 times a year
			^{3}H	the same	the same
	River Polpe (Chekhi, Markuny villages)	water	γ, ^{90}Sr, Σβ	once in 3 years	4 times a year
		bottom sediments	γ, ^{90}Sr	once in 3 years	4 times a year
		aquatic vegetation	γ, ^{90}Sr	-	once a year
		water in wells	γ, ^{90}Sr	once in 3 years	4 times a year
			^{3}H	-	the same
	River Gozovka (Goza village)	water	γ, ^{90}Sr, Σβ	once in 3 years	4 times a year
		bottom sediments	γ, ^{90}Sr	once in 3 years	4 times a year
		aquatic vegetation	γ, ^{90}Sr	-	once a year
		water in wells	γ, ^{90}Sr	once in 3 years	4 times a year
			^{3}H	-	the same
	River Losha (Gervyaty village)	water	γ, ^{90}Sr, Σβ	once in 3 years	4 times a year
		bottom sediments	γ, ^{90}Sr	once in 3 years	once a year

		water in wells	γ, ^{90}Sr	once in 3 years	4 times a year
			^{3}H	-	the same
	River Losha (Ostrovets town)	water	γ, ^{90}Sr, $\Sigma\beta$	once in 3 years	4 times a year
		bottom sediments	γ, ^{90}Sr	once in 3 years	once a year
	Lake Svir (Svir village)	water	γ, ^{90}Sr, $\Sigma\beta$	once in 3 years	4 times a year
		bottom sediments	γ, ^{90}Sr	once in 3 years	once a year
Soil	Mikhalishki	Radioactive dust	^{137}Cs, ^{90}Sr	once in 3 years	once a year
	Gervyaty	the same	the same	the same	the same
	Goza	the same	the same	the same	the same
	Chekhi	the same	the same	the same	the same
	Bystritsa	the same	the same	the same	the same
	Ostrovets	the same	the same	the same	the same

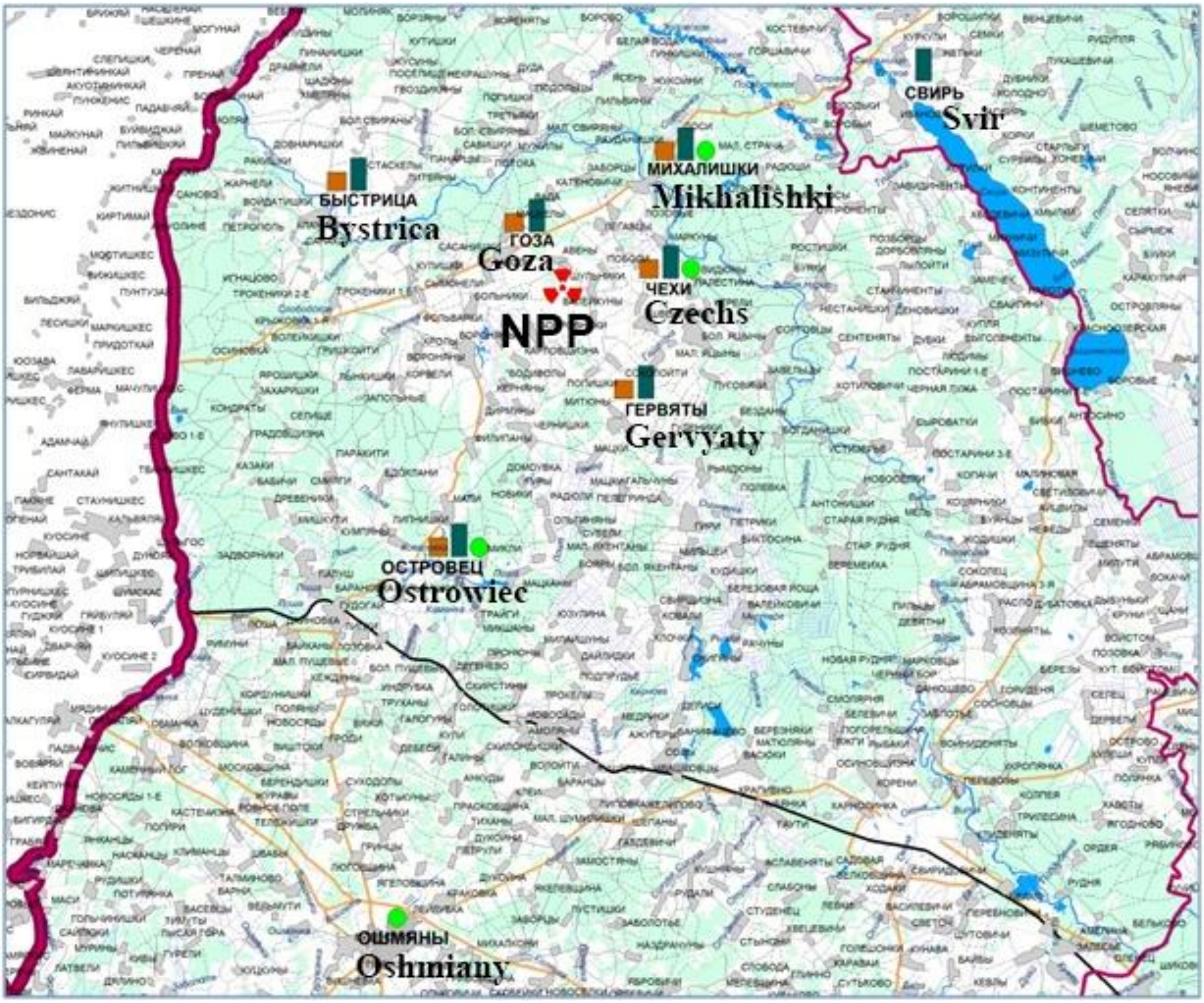
* Measurements shall be launched one year before the NPP commissioning

Symbols:

$\Sigma\beta$ - total beta activity; γ - radioactive nuclides emitting gamma radiation.

Activities for collection of samples of radioactive aerosols and natural atmospheric fallouts at fixed observation stations should be launched one year before the NPP commissioning, in order to collect data describing the background radioactive pollution of the atmospheric air typical for the NPP site area, including seasonal variations of the total beta activity and concentration of radioactive nuclides emitting gamma radiation in air. The observation stations for atmospheric air radiation monitoring shall be commissioned stage by stage, in accordance with the NPP reactor units' commissioning schedule.

See Figure 4 for the map depicting the locations of radiation monitoring observation stations in the NPP observation zone.



Observation stations for surface water radiation monitoring

Observation stations for soil radiation monitoring

Observation stations for atmospheric air radiation monitoring

Figure 4 – Observation stations for radiation monitoring in the NPP observation zone (draft siting map)

9. RESEARCH METHODS, PROCEDURES AND EQUIPMENT: GENERAL INFORMATION

9.1. Organization implementing the activities for analysis of pollution of environmental components: General information

The analysis of chemical and radioactive pollution of environmental components is carried out in the Republican Center for Radiation Control and Monitoring (hereinafter referred to as RCRCM). The quality management system, meeting the requirements listed in STB ISO/IEC 17025, is in force in this organization.

The quality control system used by the RCRCM is capable to control regularly the instrumentation calibration, to control regularly the test procedures and to control the stability of test results. Control charts are used for the purposes of statistical control covering the stability of test results; these charts are appropriate tools to control and maintain the uncertainties of measurements within the required level, and to control and maintain the intralaboratory precision in terms of repeatability and reproducibility within the required level.

The RCRCM regularly confirms its technical competence by participation in interlaboratory verification procedures, including those organized by the Belarusian certification authority and international verification procedures.

9.2. Devices and equipment for detection of radioactivity in environment components

See Table 10 for the list of devices and equipment applicable for detection of radioactivity in environment components.

Gamma-spectrometers, ADCAM-100, NOMAD, DAVIDSON (manufactured by ORTEC, USA), with GEM or GMX detectors made of ultrapure germanium, can be used for measurements. These gamma-spectrometers must be certified for the range of recorded emissions 50…3000 keV, with the basic relative error less than ±10% in terms of the efficiency detection (for the confidence level 0.95). Samples, prepared for gamma spectrometry analysis, shall be put into measuring vessels (Marinelli vessels, 1000 ml, 100 ml cup). Measuring vessels shall be placed on the detectors; the detectors shall be in the protective casing made of lead, the wall thickness shall be 100 mm. Measurements shall be carried out and results shall be processed in accordance with valid procedures and standards [15, 16]; GAMMAVISION-32 software shall be used for these purposes.

The procedure used for measurements carried out by the gamma-spectrometer shall be appropriate to measure the activity of radioactive nuclides in samples with the relative error within 10…25%.

If the activity of ^{90}Sr and plutonium isotopes must be measured in environment components, the radiochemical method must be used in accordance with procedures and standards specified in [17, 18].

Table 10 – Instrumentation recommended for radioactive nuclide content measurements

Instrumentation or equipment description	Specifications (range and error)
Atomic absorption spectrophotometer	Range: (190÷380), (380÷865) nm; sensitivity for Sr: 55 μg/litre; error: 10%
Alpha-beta-radiometer	Beta-radiation: range: 0.1÷3000 Bq; sensitivity: (0.117÷0.161) pulses/(Bq·s); error: 15%. Alpha-radiation: range: (0.01÷1000) Bq; sensitivity: 0.265 pulses/(Bq·s); error: 15%
Beta-radiometer	Beta-radiation range: 13-1300 Bq; sensitivity: 0.11±0.02 s^{-1} Bq^{-1}; error: 25 %
Electronic analytical balance	Range: (0.01÷210) g; resolution: 0.1 mg
Electronic analytical balance	Range: (0.5÷510) g; resolution: 10 mg
Gamma spectrometer	Gamma-radiation range: 40-3000 keV; error: 20%
Gamma spectrometer	Gamma-radiation range: 50-3000 keV; error: 30%
Dose meter - radiometer	Ambient dose rate (X-ray and gamma-radiation): range: (0.1÷10.0) mSv/hour; error: 20%. Beta-particle stream density: range: (10÷10^4) particles/minute×s^2; error: 20%
Muffle furnace	Range: 10-1100°C; error: 4°C

Procedures described in [19] are applicable for ^{238}U concentration measurements. This document specifies radiochemical and radiometric procedures for the radiochemical method as applied for detection of uranium radioactive nuclides emitting alpha-particles. These procedures are applicable for samples of soils, rocks, water body bottom sediments, vegetation components and aerosol filters.

The minimum detectable activity of uranium radionuclides shall be 0.005 Bq/sample, with the alpha-particles counting efficiency 30%, for the measurement time 20,000 s or longer, with the minimum permissible radiochemical uranium yield 20%. For radiochemical uranium yield 60%, the minimum detectable activity of uranium radioactive nuclides is 0.002 Bq/sample.

10. INFORMATION FOR DISCUSSION WITHIN THE SCOPE OF THE POST-PROJECT ANALYSIS

Measured concentrations of pollutants and radioactive contamination in environment components under control shall be compared against the standardized pollution levels in order to check whether the Belarusian NPP operation conditions listed in permission documents are met.

For these purposes, annual *Belarusian NPP Ecological Safety Reports* shall be submitted to the Affected parties. These reports shall be prepared in accordance with the results of implementation of the radiation ecological environment monitoring program. The report sections shall be as follows:

1. Belarusian NPP: General description;

2. Belarusian NPP: Ecological policy and radiation safety policy;

3. Belarusian NPP: Major activities;

4. Basic documents regulating the activities for nature protection with regard to the Belarusian NPP an the activities for implementation of the radiation ecological environment monitoring;

5. Ecological management and quality management system;

6. System for technical solidity and independence of laboratory control in accordance with ISO/IEC 17025;

7. Industrial ecological control;

8. Environmental impacts:

- water intake from water sources;
- discharges into open water bodies;
- emissions into atmospheric air;
- wastes;
- polluted territories and reclamation;

8. Ecological policy implementation in the reporting year;

9. Information and educational activities with regard to the radiation ecological monitoring.

The results of the post-project analysis will be regularly published at the web sites of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus, *BelAES* Republican Unitary Enterprise and other organizations. Also, information describing the ecological situation in the Republic of Belarus in terms of radiation is available at the web site of the Republican Center for Radiation Control and Monitoring.

Affected Parties may participate in joint expeditions in the area of the transboundary cross-section of the river Viliya (Belarus – Lithuania), in discussions on the issues of ecological management and quality management systems and other questions stipulated within the scope of existing bilateral agreements in accordance with Appendix VI of the Espoo Convention.

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