MINISTRY OF ENERGY OF THE REPUBLIC OF BELARUS

BELNIPIENERGOPROM
DESIGN SCIENTIFIC AND RESEARCH REPUBLICAN UNITARY ENTERPRISE

VALIDATION OF INVESTMENTS IN THE NUCLEAR POWER PLANT CONSTRUCTION IN THE REPUBLIC OF BELARUS

BOOK 11

ENVIRONMENTAL IMPACT ASSESSMENT

1588-ПЗ-ОИ4

PART 8

EIA REPORT

Part 8.3. NPP environmental impact assessment

EXPLANATORY NOTE

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14 COMPREHENSIVE ASSESSMENT OF THE NPP ENVIRONMENTAL IMPACT DURING ITS LIFE CYCLE

14.1 Introduction

The ecological concepts of the nuclear power engineering are based on the analysis of the summary information about the environment protection in the NPP site area, about the behavior of contaminating substances from NPPs in the environment and about the ecosystems' responses to the impacts related to the NPP operation. These concepts are as follows:

- **NPP is a system** that includes the NPP itself, its auxiliary and construction-related organizations and enterprises, and the town (or settlement) for the NPP personnel includint its utilities enterprises and organizations;

- **NPP is a source** of four types of impacts affecting the quality of life of the population and the natural environment. These impacts are as follows: radioactive, chemical, thermal and urbanization-related;

- **when the NPP operates normally**, the population and environment are absolutely protected against the NPP radiation impacts; however, in case of any deviations from normal operation, the radiation impact can become the most significant;

- when the NPP operates normally, **the most significant impact** on the water ecosystem is its thermal impact, i.e. discharge of excessive heat, produced by the NPP, to the water pools;

- **the main types of impact** on the terrestrial ecosystems include the impacts related to construction works, region urbanization and, maybe, chemical impact;

- **in the NPP area**, groups of population, biogeocenosis, landscapes, species of plants and animals exist for which the NPP impacts are critical;

- **in the NPP area**, there are no synergetic or protection effects of the impact. However, the contaminants cumulation effect may appear, and, because the trends of these contaminants' consequences are similar, these consequences may add to each other.

It's obvious that for assessment of admissibility of additional antropogenic impacts (loads) it is necessary to know, what they may be both during the NPP construction and during its operation. The most reliable information about this may be data from the literature about the loads, accompanying the construction and operation of the similar NPPs. At assessment of the possibility to use this information one shall come from the fact that the future NPP is certainly the source of small impact both on the natural objects and on the individuals from the population. To perform such assessment, the EIA procedure is implemented. The purpose of this procedure is to obtain support from the public, local authorities, specialists and scientists for the proposal to construct the NPP in the region. This is not easy: this task must be implemented at high professional level, and the critical comments and proposals, made by the participants of the consideration with regard to the NPP environmental safety, must be taken into account during the preparation of subsequent validating materials and environmental requirements for the NPP project and operation.

14.2 Assessment of the expected impact of the geological environment upon the NPP facilities and the NPP impact upon the geological environment

The degree of stability of the geological environment and its properties predetermine the possibility of the geological environment impact on the NPP facilities, i.e. the NPP operation safety. In turn, the NPP may render antropogenic impact upon the geological environment; under the particular combination of antropogenic loads, this impact may be either negative, if the geological environment is insufficiently stabile (vulnerable), or positive, i.e. increase the geological environment stability.

Possible impact of the geological environment on the NPP facilities results from existence and combination of the natural geological factors and the factors resulting from combinations of natural and antropogenic effects; these factors render external impact upon the NPP facilities and shall be considered as external natural factors. The level of the external natural factor impact on the stability of buildings and other facilities depends on the characteristics and stability of the geological environment. Under the impact of antropogenic factors, some external natural factors can change; these changes may result in deterioration or improvement of the geological environment characteristics in active area, where the foundations of the NPP facilities are laid down.

The inherent characteristics of the geological environment within the 30-km area around the NPP, and the external natural factors related to this area, cannot affect the NPP facilities.

In Table 121, the external natural factors of the geological environment, the level of available information about these factors, and the possibilities of their changes under the impact of antropogenic effect and consequences of these changes are listed and analyzed.

In general, the geological environment of the NPP site is characterized by sufficient stability, and in this connection it does not render negative impact upon operation of the NPP construction elements.

During the NPP construction and operation, the geological environment will be affected by different factors, among which it is necessary to note the following:

- redistribution of the loads during vertical earth-moving works on the site, permanent loads on soils from the weight of buildings and facilities, and dynamic loads resulting from operation of machines, mechanisms and, the most important, of turbogenerator;
- changes of hydrogeological conditions, change of the soil durability and deformation characteristics as a result of moistening.

For the main factors, determining the impact of the NPP on the geological environment during the accident-free operation, possible negative consequences and remedy measures, see Table 121.

On the NPP site, the conditions exist for the development of the surface impoundment in case of antropogenic leaks or in case of any obstacles for the surface flow. Impoundment is conditioned by the depositions of relatively compressed moraine sandy loams with a large number of layers and lenses of sand; these deposits are near the surface. Sands have various granulometric composition and filtration properties. Distribution and thickness of lenses varies greatly, and no rules or trends are known with regard to them. In this connection impoundment may be local, can cover the area of separate facilities or the site totally.

The risk of impoundment resulting from raising the level of the first aquifer is low, subject to preservation of the unchangeable mode of flow for Vilya, Gozovka, Oshmyanka rivers.

Table 121 - External natural geological and natural antropogenic factors and their changes under an antropogenic impact of the NPP (within the NPP site)

External natural factors	Available information	changing of external natural factors under antropogenic impact		external natural factors, affecting safety
		possibility	consequences	
1 Seismic activity	+	-	-	+
2 Tectonic characteristics				
2.1 Tectonically active ruptures	+	n o		
2.2 Severely dislocated rocks, complicated by disruptive faults and displacements	n o			
2.3 Mud volcanism	n o			
3 Geomorphologic conditions				
3.1 Number of geomorphological elements	+	-	-	-
3.2 Terrain ruggedness	+	+	Conditions improved	-
3.3 Surface slopes	+	+	Conditions improved	-
3.4 Steep slopes 3.5 Ravines, lakes 3.6 Boggy areas	n o n o n o			
4 Unfavourable physical geological processes				
4.1 Karst-type processes (chasms, surface subsidences)	n o			
4.2 Suffosion karst type processes (soils decompaction)	n o			
4.3 Antropogenic karst	n o			
4.4 Erosion	n o			
4.5 Gravitation-related processes on slopes (screes, landslips, mud flows, landslides, heavings, folded deformations)	n o			
4.6 Ravine formation	n o			
4.7 Boggy areas	n o			
5 Geological structures				
5.1 Soil bedding conditions	+	-	-	-
5.2 Lythologic components of foundation soils	+	-	-	-
6 Soil characteristics and properties				
6.1 Engineering geological elements of quarterly soils				

Table 121 (continued)

External natural factors	Available information	changing of external natural factors under antropogenic impact		external natural factors, affecting safety
		possibility	consequences	
6.1.1 Degree of homogeneity in terms of genesis	+	-	-	-
6.1.2 Degree of homogeneity in terms of age	+	-	-	-
6.1.3 Degree of homogeneity in terms of lythologic components				
6.1.4 Degree of homogeneity in terms of bedding in layout and in depth				
6.1.5 Strength			Soil properties can change as a result of saturation with water	
6.1.6 Deformation properties				
6.1.7 dynamic properties	-	+	dilution	+
6.1.8 filtration properties	+	-	-	-
6.2 Specific soils				
6.2.1 weak, susceptible to subsidence, swelling, saline and other	n o			
6.2.2 having karst natute	n o			
7 Measures for technical amelioration of soils	Not required (in accordance with the available information)			
8 Hydrogeological conditions				
8.1 number of aquifers	+	+	change of hydro-geological conditions and formation of the antropogenic aquifer is possible	-
8.2 level of ground waters	+	+		-
8.3 ground water motion direction and velocity	+	-	-	-
8.4 hydraulic connection with surface waters	+	-	-	-
8.5 underground waters discharge area	+	-	-	-
8.6 underground waters supply area	+	-	-	-
8.7 temperature of underground waters	+	+	Temperature rise and change of chemical composition	-
8.8 chemical composition and aggressive properties	+	+		+
8.9 Protection of the aquifers	+	-	-	-
9 Site impoundment				
9.1 upthrust spreading at high waters	+	-	-	-

Table 121 (continued)

<table>
<tr><th rowspan="2">External natural factors</th><th rowspan="2">Available information</th><th colspan="2">changing of external natural factors

under antropogenic impact</th><th rowspan="2">external natural factors, affecting safety</th></tr>
<tr><th>possibility</th><th>consequences</th></tr>
<tr><td>9.2 leakage from water carrying communications</td><td>+</td><td>+</td><td rowspan="2">change of hydro geological conditions and impoundment</td><td>-</td></tr>
<tr><td>9.3 infiltration of atmospheric precipitations</td><td>+</td><td>+</td><td>-</td></tr>
<tr><td>9.4 potential risk of impoundment</td><td>+</td><td>+</td><td>exist</td><td>-</td></tr>
<tr><td>10 Antropogenic factors</td><td colspan="4"></td></tr>
<tr><td>10.1 underworked territories</td><td colspan="4">n o</td></tr>
<tr><td>10.2 oil and gas extraction sites</td><td colspan="4">n o</td></tr>
<tr><td>10.3 water-bearing hydrotechnical facilities</td><td colspan="4">n o</td></tr>
<tr><td>10.4 construction of water reservoir for cooling</td><td colspan="4">n o</td></tr>
<tr><td>10.5 presense of water extraction for underground waters close under the NPP site</td><td colspan="4">n o</td></tr>
<tr><td colspan="5">Notes: The notation used in this table is as follows:
a) column 2: + sufficient information is available about the external natural factors, - information about the external natural factors is not sufficient;
b) column 3: + changes of external natural factors are possible, - changes of external natural factors are impossible;
c) column 4: - no consequences;
d) column 5: + external natural factors affect the safety, - external natural factors do not affect the safety;
e) no: external natural factors at the NPP site are not revealed.</td></tr>
</table>

14.3 Assessment of the impact within the period of the NPP construction

The NPP construction comprises in itself different stages: earthworks, construction of the unit(s), works for installation and mounting of the equipment, starting- and-adjustment works, commissioning etc. As the result of conducting the works at the present stages there will be inevitably created non- radiation waste in the form of building rubbish, waste packing materials, sanitary waste of the working personnel, sewers, polluted with oil products and so on.

At the first stage of the Belarusian NPP construction, the large-scale earthmoving works shall be carried out. The depth of the construction site for the Belarusian NPP will be 8…16 meters. The extracted ground will be removed to the soil storage area, located near the site. The amount of the excavated soil will be within 850 000 m^3 for one unit of the NPP, and 1 400 000 m^3 for two units. Certain amount of the excavated soil will be returned to the construction site of the Belarusian NPP, but the rest of the soil will remain for temporary storage at the damp for ground.

Within the process of the territory preparation, removal of the soil masses, and at the storages for inert materials, the atmosphere dust pollution processes take place. However, these processes are local and short-time by their nature, and, subject to applicable measures dust pollution suppression, eventually, they do not bring changes to the condition of the environment.

The enterprises of the construction base for production of concrete, concrete solution, assemblies from reinforced concrete are also the source of dust pollution.

Dust suppression is implemented by the cyclone-dust separator installations, filters in the systems of pneumatic transport and suction apparatus, installation of ventilated local covers in the places for trasnferring the fillers, moistening of opened storehouses for fillers and roads during the summer time.

The enterprises for making metal constructions and piping equipment (including the painting, corrosion protection and chemical protection works) are the pollution sources: they emit welding aerosols, manganese oxides, vapors of solvents, acids and alkali. For reduction of harmful materials concentration on the workplaces and of emission into the atmosphere, local ventilation and, if required, cleaning of the emission to the level of maximum permissible concentration is provided.

The asphalt-concrete plant is the source of emission with the burned out oil products and dust. Reduction of emission with these materials is achieved by installation of cyclone-dust separators, high temperature fireboxes for full incineration of technological fuel and a smokestack, providing necessary height and dilution of the emission.

The enterprises of the motor transport, building machines and mechanisms emit, basically, carbon oxide, oxides of nitrogen and sulphur, aerosols of lead, hydrocarbons and other materials.

Reduction of the emission is reached to account of the optimum scheme for motion of the transport and machines, by regulation of the engines for achievement of normative emission factors.

All the before-mentioned objects, polluting the atmosphere, are located within the construction base and site and their impact, including noise, are not beyond the scope of the territory stipulated for construction of the NPP and do not exceed permissible values.

The main harmful materials, being emitted into the atmosphere, are as follows:

- nitrogen dioxide;
- benzene;
- carbon oxide;
- phenol;
- formaldehyde;
- dust, and others.

Maximum contents of harmful admixtures in the point of the emission according to similar construction sites will form approximately:

- 0.45 MPC for phenol + formaldehyde;
- 0.5 MPC for nitrogen dioxide + carbon + formaldehyde.

Other materials concentrations are much lower than the MPC.

The irretrievable consumption of water for the necessities of the construction is minimal. For treatment of the sewages there are provided reservoirs and pits – settling basins, local treatment construction elements. After treatment the sewers enter into the system of circulating water supply.

Maximum intensity of the motor vehicles and mechanism motion is not more than 40 - 60 machines per hour. The noise level outside the site and at a distance from automobile roads will not exceed the permissible value, 60 dBA.

The stage for assembling the equipment is connected with formation of considerable volume of hard waste products, usually consisting of building and domestic waste. For the types and expected amounts of waste materials at this stage, see Table 122 [13].

Table 122 - Types and amounts of general wastes during the construction

<table>
<tr><th>Type of waste</th><th>1 reactor</th><th>2 reactor</th></tr>
<tr><td>Paper</td><td rowspan="11">Total amount:

14500 t from them

1000-2000 t are not subject to recycling (the lower limit)

Approximate maximum amount of waste: 385 t/ month</td><td rowspan="11">Total amount:

27000 t from them

2000-4000 t are not subject to recycling (the lower limit)

Approximate maximum amount of waste: 740 t/ month</td></tr>
<tr><td>Glass</td></tr>
<tr><td>Package wastes</td></tr>
<tr><td>Metal scrap</td></tr>
<tr><td>Electronic equipment waste</td></tr>
<tr><td>Spent tyres</td></tr>
<tr><td>Decommissioned transport</td></tr>
<tr><td>Sewage sediments</td></tr>
<tr><td>Sediment of concrete</td></tr>
<tr><td>Lead batteries</td></tr>
<tr><td>Polluted soil</td></tr>
</table>

The exact amount, characteristics and the volumes of waste materials can be determined after the project of the NPP has been chosen, the architectural project of the Belarusian NPP has been developed, and the suppliers of the equipment for the NPP have been selected.

Considering that the period of construction will be 6-8 years, the maximum amount of hard waste materials will appear near the end of the first year and during the second year of construction; then, it will slowly and constantly decrease [13].

During the period of the NPP construction, the negative impact on the environment appears inevitably. However, the water ecosystems will be not the impact of the construction works practically will not be rendered since all water reservoirs and water streams are removed from the construction site by a significant distance. The nearest river to the site, Viliya, runs at a distance of 6 km. Provided that the construction project includes water treatment facilities and systems for circulating water supply, minimizing discharge of the sewages into the water environment, dust suppression during the construction works and other nature preservation measures, the process of the NPP construction must not result in any observable negative impact on the water ecosystems.

An integral part of the nuclear plant construction is thecconstruction of electric power lines. When choosing their routes, the ecological value of natural complexes in the region must be taken into consideration. It should be noted that the considered region includes natural complexes, having considerable and general national importance for conservation of biological and landscape variety. They are included into the national environmental network created in the territory of Belarus.

Within the borders of 30-km area, there are all elements of national environmental network of Belarus - environmental kernels, environmental corridors and buffer areas. The national park "Narochanskiy", with the reserve area of national importance, "Sorochanskiye lakes", is the environmental kernel of the European level. The lands adjoining these objects form a buffer area for the environmental kernel.

The operation of the environmental corridor is provided by the forests situated along the river Viliya and its feeder, the Oshmyanka river. They connect the environmental kernel, being situated on the Belarusian side, with natural complexes of the Lithuanian Republic.

Taking into consideration the need to preserve the wholeness of the elements of the national environmental network, located within the 30-km area, the choice of the routes for the electric power lines from the NPP there must be conducted in such manner, so as not to allow fragmentation of large natural complexes, being the component parts of the environmental network.

As a whole, the stage of the NPP construction stands as the most significant from the standpoint of the impact rendered to the natural environment. Herewith the main changes for the landscape will occur only at the construction site and in the neighborhood. They will not cause any essential disadvantageous ecological consequences since the landscapes, which will be subjected to changes, have no high ecological value. For natural ecosystems, which are located at a distance from the site, the danger is presented not by the construction works, but by the routes of the electric power lines. They must not pass through the natural complexes being significant for conservation of biological and landscape diversity.

Within the territory, adjoining to the site and along the automobile roads, there will increase chemical pollution of the atmospheric air, soil and water. However, subject to appropriate nature preservation actions, it will not present high intensity and will not render the negative impact upon the natural ecosystems. To the most risk of contamination there will be subjected small rivers Gozovka and Polpa. For them there must be realized water preservation measures.

The NPP construction and operation will result in growth of populaton in the region. This will result in growth of recreational loads on the natural ecosystems. Possibly there will take place rubbish accumulation, digression of vegetation, increasing of forest fire danger. For prevention of the disadvantageous changes for the ecosystems, additional recreation facilities with appropriate equipment may be necessary near the places of residence and labor activity of the people. Also, the measures for more strict control over observance of the stipulated mode for nature operation may be necessary.

14.4 NPP influence on the environment

14.4.1 Site impoundment forecasts

The calculation of possible impoundment is executed according to the scheme of unlimited water carrying layer for the event of the additional infiltration arrival from the round system of the sources with constant intensity within the time, under the following conditions (see Table 123):

- the radius of the round system of the antropogenic feeding source (r_0) is equal to the radius of the circle, being equivalent by the area to the accommodation site of one NPP reactor, its area being 0.56 km^2, and is 422 m;
- the calculated time for the NPP operation is assumed to be 5, 25, 60 years;
- the average (effective) power of waterless end-moraine deposits is 2.65 m (at $W_{min} = 6.8 \cdot 10^{-4}$ m/day) and 20.0 m (at $W_{max} = 5.12 \cdot 10^{-3}$ m/day);

- the border of spreading of the antropogenic aquifer dome, R(t), is defined by fitting using the equation as follows:

$$\frac{R^2(t)-r_0^{\ 2}}{2}-2\frac{R(t)r_0}{R^2(t)-r_0^{\ 2}}\ln\frac{R(t)}{r_0}=2{,}24r_0t\sqrt{WK_\phi}\ . \quad (1)$$

- the maximum rise of the antropogenic aquifer dome (Δh) is calculated as follows:

$$\Delta h^2=\frac{W}{K_\phi}\cdot 2\frac{r_0^{\ 2}}{R^2(t)-r_0^{\ 2}}\left[R^2(t)\ln\frac{R(t)}{r_0}-\frac{R^2(t)-r_0^{\ 2}}{2}\right]+\frac{W}{2K_\phi}(r^2-r_0^{\ 2})\ , \quad (2)$$

where r is the distance from the centre of the circular site, where the antropogenic infiltration exists, to the point where the water level rise is defined (other parameters remains the same);

- the maximum possible rise of the level of the antropogenic aquifer in the centre of the circular site is calculated for $r = r_0$.

Table 123 - Value of the rise for the antropogenic aquifer level according to the results of preliminary calculation

NPP operation period, years	Intensity of antropogenic infiltration feeding, W_{min} = 6.8·10^{-4} m/day		Intensity of antropogenic infiltration feeding, W_{max} = 5.12·10^{-3} m/day	
	R(t), m	Δ*h*, m	*R(t)*, m	Δ*h*, m
5.0	585	2.99	790	11.3
25.0	975	4.9	1500	17.6
60.0	1440	6.9	2300	20.8

Maximum rise of the antropogenic aquifer spreading dome, within the considered period (60 years) for operation of one Belarusian NPP reactor, will be from 6.9 to 20.8 m. The antropogenic aquifer spreading dome radius may be from 1.44 to 2.3 km.

The results of the forecast analytical calculations are preliminary; they shall be determined more exactly at the subsequent stages of survey, including the mathematical modeling.

14.4.2 Water consumption and water outlet for the Belarusian NPP

At development of preliminary Belarusian NPP EIA it was admitted that the whole volume of water, required for production water-supply at the Belarusian NPP being calculated as 1.27 m^3/sec per one energy unit (2.54 m^3/sec per two energy units) will be completely used - irretrievable water consumption corresponds to the water taking out.

After revision of decisions made before the project with usage of the data received from the JSC "Atomenergoproekt" (Saint-Petersburg) on the grounds of balance for water consumption and water outlet at the Belarusian NPP with provision for irretrievable water consumption (see Table 124) it is received that the necessary need for production of water-supply for the Belarusian NPP per one energy unit depending on the time of the year form from 0.95 m^3/sec in winter to 1.39 m^3/sec in summer (1.8-2.78 m^3/sec per two energy units). At that the amounts of water outlet for the worked out technical sewages form per one energy unit from 0.48 m^3/sec in winter – to 0.69 m^3/sec in summer (0,96-1,38 m^3/sec per two energy units).

Table 124 - General specifications for production (technical) water-supply and outlet of technical sewages at the Belarusian NPP

Name	Months												average	Max
	1	2	3	4	5	6	7	8	9	10	11	12		
Water consumption (one energy unit), m^3/ hour														
Total per one energy unit	**3431**	**3447**	**3719**	**4182**	**4643**	**4876**	**5013**	**4955**	**4642**	**4258**	**3889**	**3594**	**4221**	**5013**
Total per two energy units	**6862**	**6894**	**7438**	**8364**	**9286**	**9752**	**10026**	**9910**	**9284**	**8516**	**7778**	**7188**	**8442**	**10026**
Water sewage (one energy unit), m^3/hour														
Blowing through the water supply reverse system with c cooling towers	1572	1587	1707	1917	2127	2247	2322	2277	2157	1962	1785	1647	**1942**	**2322**
Mineralized waters from a water preparing installation	88	88	88	88	88	88	88	88	88	88	88	88	**88**	**88**
Slam waters from a water preparing installation	65	65	65	65	65	65	65	65	65	65	65	65	**65**	**65**
Total one energy unit	**1725**	**1740**	**1860**	**2070**	**2280**	**2400**	**2475**	**2430**	**2310**	**2115**	**1938**	**1800**	**2095**	**2475**
Total two energy units	**3450**	**3480**	**3720**	**4140**	**4560**	**4800**	**4950**	**4860**	**4620**	**4230**	**3876**	**3600**	**4190**	**4950**
Irretrievable water consumption (one energy unit), m^3/hour														
Filling of losses in river waters by means of the cooling tower	1503	1504	1656	1904	2150	2260	2320	2308	2118	1934	1746	1591	**1858**	**2320**
Feeding of tanks with production and counter fire stock of water	21	21	21	21	21	21	21	21	21	21	21	21	**21**	**21**
Feeding after removal of salt from the spraying pools	92	92	92	97	102	105	107	106	103	98	94	92	**98**	**107**
Feeding after removal of salt from the NPP contours	90	90	90	90	90	90	90	90	90	90	90	90	**90**	**90**
Total per one energy unit	**1706**	**1707**	**1859**	**2112**	**2363**	**2476**	**2538**	**2525**	**2332**	**2143**	**1951**	**1794**	**2126**	**2538**
Total per two energy units	**3412**	**3414**	**3718**	**4224**	**4726**	**4952**	**5076**	**5050**	**4664**	**4286**	**3902**	**3588**	**4251**	**5076**

The main technical and economic factors and composition of objects within the standard production base for construction of the NPP with reactors of the WWER type in a part of the systems for water supply and water outlet are the following:

- the extent of the water pipe for production water-supply – equals to 10000 m
- the extent of the domestic and drinking pipe – up to 7000 m;
- the extent of the water pipes for domestic and home sewerage, p.m – up to 6500 m;
- the expenditure of water:
- drinking water - 1050 m^3/day;

- technical (at construction of the NPP) – up to 800 m^3/day;
- technical (at operation of the NPP): per one energy unit – 0.95 -1.39 m^3/sec (82.08 – 120.1 thousand m^3/day), for two energy units – 1.9 – 2.78 m^3/sec (164, 16 - 240.2 thousand m^3/day);
- repeatedly -used from treatment constructions of the domestic, production-downpour and sewers, containing oil products: per one energy unit - 41 m^3/hour (984 m^3/day); per two energy units - 82 m^3/hour (1968 m^3/day);
- the technical sewages: per one energy unit – 0.48 – 0.69 m^3/sec (41.47-59.62 thousand m^3/day), per two energy units – 0.96-1.38 m^3/sec (82.94 – 119.24 thousand m^3/day);
- domestic sewages - 1050 m^3/day
- irretrievable water consumption: per one energy unit – 0.47-0.70 m^3/sec (41.61-60.48 thousand m^3/day), per two energy units – 0.94 -1.40 m^3/sec (81.22-120.96 thousand m^3/day).

14.4.3 Short specification of the impact rendered to the surface waters

The main type of the impact rendered by the NPP to the on surface waters after commissioning is changing of hydrological mode for water objects - the sources of production water-supply at the NPP. To account of constant taking out of water there is changing the level and the speed mode in the river Viliya – the main source of the production water-supply at the Belarusian NPP.

In relationship with technical sewages pouring down into the river Viliya in the volume for two energy units up to 87.67 million m^3/year with the temperature being up to 37°C there may occur heat contamination of the river, as well as its chemical pollution.

In relationship with pouring down the treated domestic sewages there may occur changing of the water quality in the surface water object-receivers for the rectified sewages (the total amount of domestic sewages for the NPP of the given type per two energy unit may be up to 0.383 million m^3/year). Herewith for minimization of the negative impact rendered by the sewages created at the Belarusian NPP to the surface waters will be used by the system for water treatment.

The source of the fluid non-radiation discharges formation are production processes, connected with usage of water (the production sewers); economic-home and rain sewers; the amounts of water at blowing through the closed (circulating) system for supply with technical waters. Domestic sewers from site of the NPP, construction base, located within the area of the NPP, living village of the NPP and construction base, located beyond the area of the NPP along the self-flowing networks enter into the corresponding pumping stations for pumping over and hereinafter through the pressure pipe line are delivered to treatment constructions. The treatment constructions for domestic sewers are projected for complete bio logical rectification of sewers. The rectified sewers through the pipe line are conducted into nearest water reservoir.

The rain waters from the water collecting territory of the administrative building by self flowing networks are collected into the existing pumping station for pumping over of rain sewages possessing capacity up to 100 m^3/hour with the help of reservoir being an interfacing element with capacity up to 60 m^3 and then they are pumped over into the self-flowing networks of the rain sewerage for the integrated auxiliary facility area. At that the amounts of repeatedly used, extracted from rectifying constructions, domestic, production and downpour sewers, containing oil products per two energy unitoв, constitute 0.72 million m^3/year.

Rain waters from the water collecting territory of the integrated auxiliary facility area and the energy units after weakly intensive rains and the polluted part of the sewer from intensive rains through the separator camera move into the pumping station for pumping over the rain sewages having capacity up to 100 m^3/hour with the help of reservoir being an interfacing element and having capacity up to 60 m^3 and hereinafter – for clarification into slime collector. The remaining portion of the rain sewer after the separation camera along the self-flowing collector enters into the leading channel of the main cooling system. The annual volume of rain sewers, delivered into the water reservoir, constitute 66 thousand m^3/year.

Rain waters from the water collection territory of the energy units No 1 and No 2, and rectifying constructions of the "dirty area" by self-flowing networks are delivered into the collector and are conducted into the leading channel of the main cooling system.

To the type of the Belarusian NPP impact on the surface water pertains possible radio nuclear contamination of water object, connected with discharge of radioactive materials from the station within the limits of permissible discharges. After radiation check up, realized by the sensors ASRTK in control tanks, and by analysis of the samples, performed in the radio-chemical laboratory, counter-balance waters of the station are thrown from the controllable access area. On necessity the water from the control tanks enters for repeated rectification into the system for treatment of fluid radioactive materials (the trapping waters). Rectification of trapping waters is produced within the evaporation installation. As the result of treatment for trapping waters there is received clean condensate, repeatedly used in the cycle of the NPP operation, and the concentrate of the salts (the deep blue remainder), being the liquid radioactive remainder.

One of the most essential types of the NPP impact on the surface water is their emergency radio nuclear contamination.

In the event when the remainder of the water in the cooling towers (up to 3.785 million m^3/year) will enter back into river, the given factor is also an additional source of the impact on surface waters, since in accompaniment to the indissoluble hard particles this water will contain the chemicals, added for prevention of corrosion and littering in the cooling towers. Usually for these aims there are used sulphur-acid inhibitors on the basis of chrome.

The source of the impact rendered to the microclimate change may be evaporation in the cooling towers. Consumption of water through evaporation in the cooling towers for providing the requirements of cooling approaches to 15.14 million m^3/year. Evaporation of water in such amounts may cause formation of mist or ice crust within local scale - this effect is inherent to any station, where there are used the cooling towers.

14.4.4 Forecast of the impact rendered by the Belarusian NPP on the surface waters

14.4.4.1 Flow characteristics

The forecast made for the impact of the Belarusian NPP rendered to the specifications of the flow is based on the maximum volume of the irretrievable water consumption of the station, which for two energy unitов constitutes 120.96 thousand m^3/day (1.4 m^3/sec) - when extracting for production water supply up to 240.2 thousand m^3/day (2.78 m^3/sec) and flowing down the technical sewages up to 119.24 thousand m^3/day (1.38 m^3/sec). Flow characteristics of the river Viliya after water taking are compared with minimum features, required for its ecological operation. The main ecological restriction is the claim about preservation in the river after tapping of the minimum possible consumption (MPC) not less than 75 % from minimum average monthly consumption of water being 95 % of supply within winter or summer lowest water level (whatever is lower), which under any hydrological condition after tapping must be not less than 22.73 m^3/sec [147.148].

The forecast of the impact rendered by tapping water for necessities of the NPP from the river Viliya shows that at accommodation of two energy units and at expenditure of water in the river, close to average annual, irretrievable water consumption will not more, than 2.2 % from consumption of water in the river. Under condition of a year bearing little water and expenditure of water in the river being close to minimum average daily of summer-autumn and winter lowest water level being 95 % exceedance probability, per two energy units - not more, than 4.6 %. Under conditions of a year bearing very little water and at expenditure of water in the river being close to minimum average daily of summer-autumn and winter lowest water level with 97 % exceedance probability per two energy units - not more, than 6% from consumption of water in the river.

14.4.4.2 Level and speed modes

The forecast about the changes for the level and speed modes in the river Viliya at accommodation of the surface water extractor and under tapping of water for two energy units of the NPP is executed with use of the mathematical model for uneven motion of water [149] and the reference hydrological and morphometric information about cross-sections of the river Viliya, received in the course of the field experimental studies. The present forecast is executed for different hydrological conditions: at expenditure of water in the river, close to average annual, minimum average monthly and average daily having 97% exceedance probability within the period of summer-autumn lowest water level (See Tables 125.126). The forecast example of changing the level and speed modes for the most disadvantageous event (under minimum average daily expenditure having 97% exceedance probability) is shown in Figures 88.89.

Maximum reduction level within the area of the river Viliya below the place for accommodation of water extractor and tapping of the technical sewages may constitute per two energy units and average annual expenditure of water up to 3 cm (up to 1 cm within transborder range -TR), under minimum expenditure – up to 7 cm (up to 5 cm in TR). Maximum reduction of the level within the area between water extraction and tapping of the sewages (2.7 km) at average annual expenditure of water will constitute up to 4 cm, under minimum expenditure - up to 9 cm. The specified water level reduction within the area between the water extraction and tapping will not result in any essential negative impact on conditions for transit type of fish, since within this area there are no inflows. Also within the specified area there are no water extractions and tapping of water, which stipulates the absence of negative impact of the water level reduction in the river on the water usage specifications.

The forecast for the speed mode of the river Viliya at accommodation of the Belarusian NPP has shown minute reduction of the current average velocities (maximum – by 0.04 m/sec) within the area of the river below accommodation of water extraction and unessential change for transborder range. Accommodation of water extraction will render small impact on the speed mode above accommodation of the water extraction - maximum increase of the current average velocities will constitute 0.02 m/sec per two energy units within the area up to 1.5 km upstream of the river.

Table 125 - Generalization of the forecast for changing the level mode in the river Viliya at accommodation of the surface water extraction for the Belarusian NPP water supply within the area "settlement Malye Sviryanki - settlement Muzhily"

Hydrological conditions/ specifications of the change	At average perennial expenditure of water	At minimum average monthly expenditure by summer-autumn lowest water level	At minimum average daily expenditure by summer-autumn lowest water level
The depth in the river under natural conditions (maximum within transverse river sections),m	2.4 – 3.4	1.7-2.6	1.6-2.3
maximum disposition within the area, having the length 2.7 km (lower than the water extraction till tapping of technical sewage waters from the NPP), m/sec	0,04	0,07	0,09
maximum disposition within the rest of the areas, to the border (lower than tapping of technical sewage waters), m	0,03	0,05	0,07
Within the transborder range, m	0,01	0,04	0,05

Table 126 - Generalized forecast for changing the speed mode of the river Viliya at accommodation of the surface water extraction for Belarusian NPP water supply within the area of the “settlement Malye Sviryanki - settlement Muzhily"

Hydrological conditions/ specifications changing	At average perennial expenditure of the water	At minimum average monthly expenditure by summer- autumn lowerest water level	At minimum average daily expenditure by summer-autumn lowerest water level
Average velocities of the flow (естественные conditions)	0,5-0,7	0,4-0,6	0,35-0,55
maximum change within the area lower than the water extraction, m/sec	-0,03	-0,04	-0,04
maximum change within the area above the water extraction, m/sec	+0,01	+0,03	+0,03
в transborder range, m/sec	-0,005	-0,01	-0,015

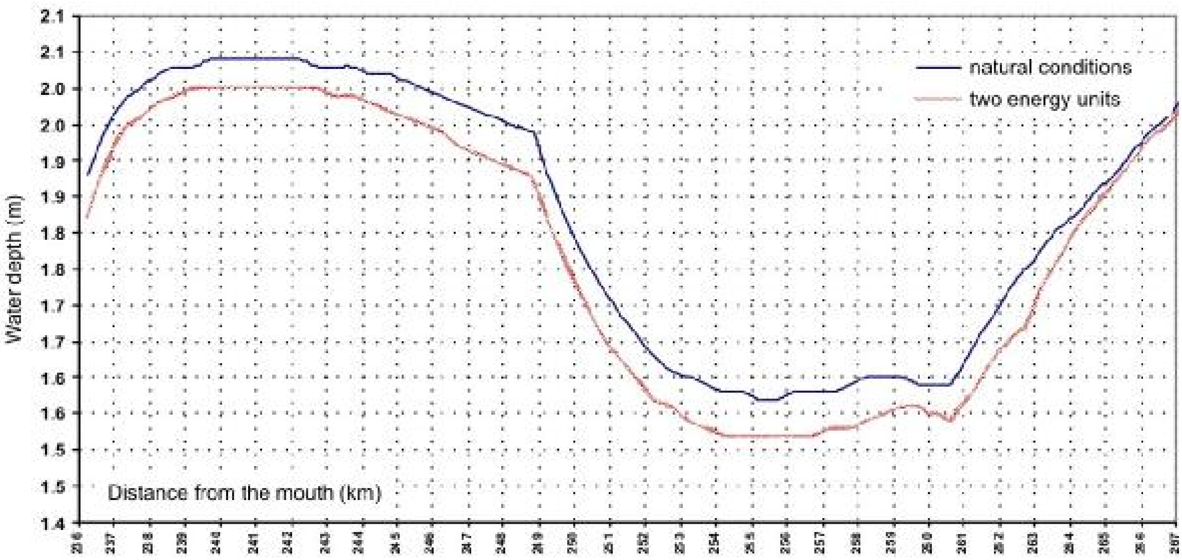


Figure 88 – The results of forecast for changes of the level mode (the stream depth) in the river Viliya in case of water supply facility construc tion, for water flow rates near the minimum average daily quantities during the summer and autumn low water level period (97 % exceedance probability)

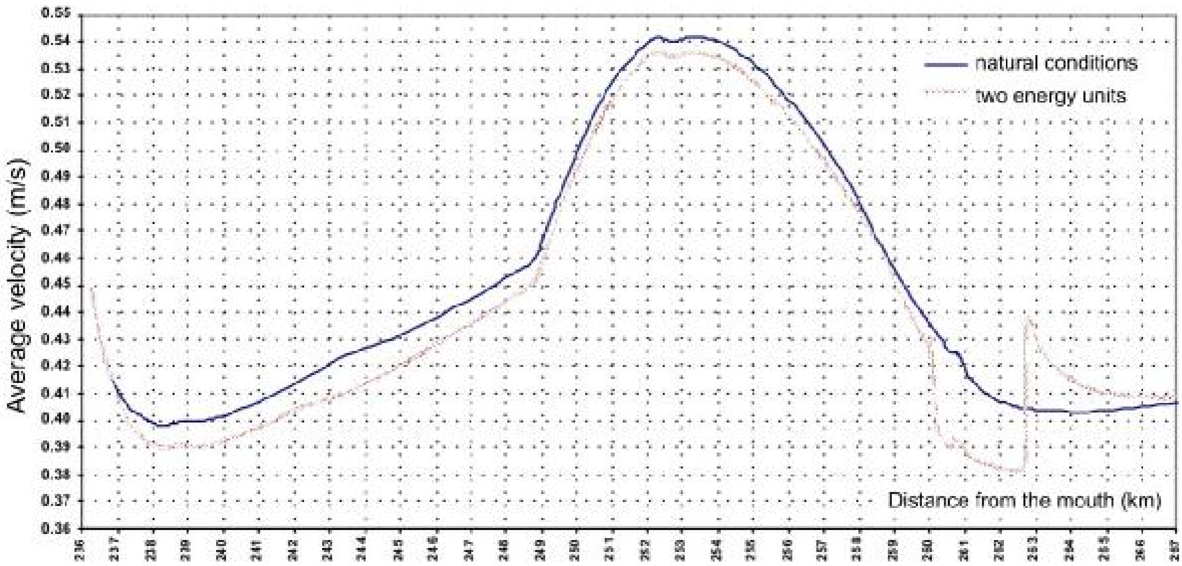


Figure 89 - The results of forecast for changes of the velocity mode for the river Viliya in case of water supply facility construction, for water flow rates near the minimum average daily quantities during the summer and autumn low water level period (97% exceedance probability)

14.4.4.3 Water balance factors

The water resources and the need for water from the standpoint of development and accommodation of production facilities are closely interconnected. The main means of control over the present condition of water resources and planning operation of water for the nearest period and for different prospects are water operation balances. Water operation balances present by themselves the material of calculation, enabling to compare the need for water with the water resources, available on given territory, and are intended for assessment of presence and the degree of use for water resource, planning and decision making for the problems of water use and protection (See the article 92 of the Water Code of the Republic of Belarus). The order for development and registration of water operation balances is stipulated by the technical code TKP 17.06-03-2008.

For more complete assessment of the condition for water supply and for determination of the impact rendered by one or several large water users to the on water facility there is used a variety of the accounting balances, standing for comparing the disposable water resource with the actual extraction of water. Such type of the balance is used for determination of the possibilities for operation of water resource in the river of Viliya for steady water supply needed for operation of the NPP. The algorithms for scheduling the balances of all types are based on algorithms for scheduling the balances belonging to two main types: the accounted and the reported ones.

The available water resources are considered as an inflow in the calculated water operation balances.

The consumption part of accounted balances includes the quotas for the volumes of extracted water, specified by the permits, issued for special water usage. During practical activity for regulation of water operation the quotas for the volumes of extracted water are similar for conditions of the average according to water filling year and the year having 75 % of the supply. But for conditions of the river flow having 90 and 95 % of the supply these quotas may be decreased by introduction of the corresponding corrective factors.

For calculation of water operation balances in common event there is used the following basic equation (in the units of the water volume per the accounted time interval):

$$W_о=W_{вс}+W_е-MW_е+W_{изм}+W_{вх}+W_{рр}-MW_{вх}+W_{пд}-W_{UЕб}-W_{пу}+MW_{сбр}-W_{пер}-W_{тр}+W_{сбр} \quad (3)$$

where $W_о$ - is water operation balance: excess (+) or deficit (-) of the river water resource within the area or in a pool;

$W_{вс}$ - is arrival of water from the above mentioned area within the river network;

$W_е$ – is the river flow down, forming within the area under the natural conditions;

$MW_е$ - are natural losses of the river flow down along the length of the river;

$W_{изм}$ - the changes, which have taken place in the river flow down created within the area (in the pool) under the impact of economic activity on the water collecting area (plough and drainage of the lands, agricultural and forest melioration, fight with erosion, mountain works, urbanizing the territory);

$W_{вх}$ – disposal (+) or filling (-) of water reservoirs and ponds within the area;

$W_{рр}$ - change of water spare stock in the river network at the expense of the influx and flow down fluctuations occurring within the area;

$MW_{вх}$ - losses of water, related with processes in the water reservoirs (additional evaporation, filtering into the coast and bed, for new objects - filling of a dead volume);

$W_{пд}$ - supply of water to the area from other pools or regions (through channel and pipe lines);

$W_{вх}$ – disposal (+) or filling (-) of water reservoirs and ponds within the area;

$W_{рр}$ - change of water spare stock in the river network at the expense of the influx and flow down fluctuations occurring within the area;

$MW_{вх}$ - losses of water, related with processes in the water reservoirs (additional evaporation, filtering into the coast and bed, for new objects - filling of a dead volume);

$W_{пд}$ - supply of water to the area from other pools or regions (through channel and pipe lines);

$W_{UЕб}$ - extraction of water from the river;

$W_{пу}$ - reduction of the river flow down, caused by extraction of the underground waters;

$W_{сбр}$ - arrival of drainage, revocable, mine and other kinds of water into the river network within the area along opened channels and closed collectors or pipe lines;

$MW_{сбр}$ – throwing down of collected and drainage waters into the river network by the underground path;

$W_{пер}$ - transfer of water into other pools (areas);

$W_{тр}$ - necessary transit flowing down (complex tapping) in the locking range for satisfaction of the water user’s requirements within the riverbed river and below along the river flow.

In the absence of reliable reference data separate constituent elements of water operation balance are not taken into account. At present for conditions of the Republic of Belarus this simplification may be applied for the values $W_{изм}$ and $W_{рр}$, as well as for $MW_{сбр}$.

The condition (the sign) water operation balance is defined with provision for accounted supply aimed to satisfy the requirements in water (according to the number of steady years, made in percent)

The criterion to satisfy the requirements of water users is the accounted supply according to the number of steady years ($P_{чбл}$), calculated in percent on the formula:

$$P_{чбл} = \frac{N-m}{N+1} * 100\% \qquad (4)$$

where N - is the length of the perennial accounting row, taken as the prototype of the future water mode, in years;

m - is the number of steady years (having deficit of water at least in one interval of the year).

The supply according to the number of steady years shows the probability of the fact, that the need for water on the part of the water users will be preserved in full amounts in $P_{чбл}$ years (from 100 years).

The state of the water operation balance is determined by comparison of the received supply with the prescribed value.

For water transport it is reasonable to use the factor of satisfaction according to the amount of the steady months (decades) of the perennial accounting period, which enables to evaluate the relative length of steady time intervals. The supply satisfaction according to the length of the steady time intervals is defined by the formula:

$$P_{чбл} = \frac{M}{N * n} * 100\% \qquad (5)$$

where M - is total length of steady time intervals within the accounted row;

n - total length of considered periods within the year.

For scheduling of water operation balance of the river Viliya there is used information of the Department for hydrometeorology about the measured water tapping within the range of the settlement Mikhalishki.

The flow of the river Viliya has suffered significant changes since 1976 after construction of Vileysky water reservoir and from the beginning of the Vileysky-Minsky water system operation. For the reason of analysis over homogeneity of the flow rows the whole period of observations over flow with two hydrological posts was divided into 2 parts (before creation of the water reservoir and after it). For each of them there were determined the main hydrological specifications, brought together into Table 127.

The received data are indicative of significant divergence of the accounted hydrological specifications, determined for the period before construction of Vileysky water reservoir and after it. At that the impact of the water stock reservoir rendered to the flow within the range of the settlement Mikhalishki turns out to be much lower, in the consequence of significant lateral inflow between the ranges of Vileika and Mikhalishki.

Table 127 - Comparative specification of the accounted values for the flow within different time periods

Factor	1949- 1975 million m^3	1977-2007 million m^3	Value of divergence, million m^3	% divergence
The river Viliya - Vileika				
Average perennial volume of the flow	883.0	655.9	227.1	26
Maximum volume of the flow	1277.2	1088.0	189.2	15
Minimal volume of the flow	567.7	444.6	123.0	22
The river Viliya – Mikhalishki				
	1945-1975	1976-2007		
Average perennial volume of the flow	2163	1895	268	12
Maximum volume of the flow	3154	2655	499	16
Minimal volume of the flow	1492	1321	171	11

The accounted hydro graphs for the necessary supply to make analysis of water operation balance are chosen on empirical curve of supply within the period after filling Vileysky water stock reservoir.

The value of the established to the present time impact of economic activity on the water collection rendered to the water mode, that the studies have shown, is found within the accuracy of calculation, and that is why when scheduling the balances is ignored [150].

In all events of scheduling the balance there are taken into account either the attracted underground waters, being unbound with the river flow hydraulically, or used underground waters, influencing on river flow. In quantitative attitude they are characterized by the data of statistical report making.

Within the area of Vilya below the Vileysky water stock reservoir there are not any other water stock reservoirs. The main parameters of the ponds, located within the water collector [151], are shown in Table 128.

Table 128 – Specifications of ponds within the pool of the river Viliya

Small			Average			Large			Total		
quantity	area, hectares	volume, thousand. m^3	quantity	area, hectares	volume, thousand. m^3	quantity	area, hectares	volume, thousand. m^3	quantity	area, hectares	volume, thousand. m^3
66	301.2	2325.7	30	489.6	7376.8	4	159.2	4734.8	100	950.0	14437.3

Excessive adjustment of the river flow within the considered area is small, which enables to realize only its partial perennial redistribution. In necessary events the modes of the ponds operation may be taken into calculation according to the rules of seasonal regulation for the flow. At calculation of the balance for the year having little water with 95 % of the supply they were not taken into account. At calculation of the balance for the year having little water with 97 % of the supply there is provided additional arrival of water at the expense of the flow regulation in the volume of 1.85 million m^3 per one month.

Determination of the needs for water was executed by discovery according to statistical reporting data about operation of water according to the form "1-Water (Minpriroda)" of modern quota for the water consumption and water sewage by water users, located within the pool of Viliya above the supposed accommodation of the surface water extraction by the NPP, determination of sanitary and ecological tapping, additional losses during evaporation from the surfaces of ponds and water stock reservoirs, as well as in assessment of the perspective needs for water.

The basic level for assessment of modern conditions for water consumption is accepted the year of 2007. The conducted analysis of materials and their comparison with retrospective factors allows to make a conclusion that they with sufficient degree of accuracy characterize the modern condition for water consumption and water sewage within the considered region [152].

On the grounds of these data into calculation of the balance at a modern level there is put the value of the water extraction in the volume of 104.5 million m^3 from the surface natural water sources and 32.76 million m^3 from the underground sources.

The losses during additional evaporation are taken in the volume of 1.3 million m^3 per annum with 97 % of the supply and 0.73 million m^3 per annum with 95 % of the supply.

Minimum necessary tapping is accepted from the calculation in the volume of 75 % from the minimum average monthly consumption of water with 95 % supply (22.72 m^3/sec) which corresponds to the ecological minimum for conservation of the river as self-repairing element of the environment.

The balances are calculated as follows:

- for the years having the accounted supply for the flow with 50 %, 75 % and 95 %, as well as for the years having little water with 95 % and 97 % supplies per monthly value;
- according to the calendar daily rows of the flow.

The performed analysis of the received results according to all accounted years is indicative of thy fact, that removing the flow from the river bed at present does not exceed 124 million m^3 per annum which constitutes less 10 % from annual flow with 97 % supply above the settlement Mikhalishki. Consequently, any observable impact upon changing the drain mode of the river may not be rendered. The growth of irretrievable extraction, planned for perspective, will not surpass 10 % of the flow and 95 % of the supply, which is also found within inaccuracy of determination for the hydrological values. So water operation balances per the years with 50 % and 75 % from the accounted supply according to the flow are not shown here.

Check up of the whole calendar hydrological row is indicative of the fact, that as a whole the perennial transit tapping is fixed in all members of the hydrological row or is practically steady (with the supply p>97 %). The analysis executed over the calendar row in daily register (See Table 129) enables to calculate the accounted supply according to the number of steady years ($P_{чбл}$):

a) for the NPP with two energy units in operation, when the number of years with faults, connected with dissatisfaction of the transit flow, at least per one day constitutes 20:

$$P_{чбп} = \frac{62-16}{63} * 100\% = 73,0 \ \% \ (6)$$

At that the supply according to duration of steady time intervals is defined by the formula:

a) in the event of the NPP two blocks operation, when the total duration of faulty period per one year constitutes 64 days:

$$P_{пр} = \frac{22566}{62*365} * 100\% = 99,7 \ \% \ (7)$$

It must be noted that the results of calculation for the water operation balance and analysis of the periods, having little water, during which there may be violated ecological restrictions in the river Viliya with provision for production water-supply of the NPP according to the calendar row, consisting 62 years (since 1946 to 2007 year), have shown that under extraction of water for two energy units duration of the deficit periods may constitute at the average three days with average deficit of water being 296.4 thousand m^3.

The exceptions constitute particularly waterless years of 1950 and 1992, when the number of deficit days constituted accordingly for two energy units - up to 19 days with maximum deficit of water being 1656.3 thousand m^3. Herewith the additional extraction of water from the river during the specified period has formed not more, than by 1 m^3/sec under the remaining in the river consumption after taking away 21.73 m^3/sec (71.7% from the minimum permissible consumption instead of 75%).

In Tables 130 and 131 there are shown the results of water operation balance, calculated according to the represented specifications of the flow for the year having 95 % and 97 % of the supply as a whole and in monthly consideration for the following conditions:

- the level of the water operation in the year of 2007 (the line 3);
- the need for satisfaction of the requirements in water in the events of operation for the two blocks of the designed NPP (the line 3.5).

Perennial reliability of water supply to the consumers is calculated according to the results of compiling the water operation balances according to monthly intervals. The result of water operation balance, received for the year having 95 % of the supply for the flow, is indicative of thy fact, that with 100 % warranty the requirements of the economy and ecology, including requirements for delivery of water for operation of the NPP 2 blocks, will be fully satisfied.

Per annum having 97 % of supplies on flow in the event of necessity for extraction of water for the two NPP units the water operation balance during individual periods of specifically waterless year may turn out to be tense. During individual months of the year it will be difficult to bear the ecological tapping in the required volume. Its maximum reduction within individual months may constitute form 6-8%.

Analysis of the water operation balance, executed for waterless years having 95 % and 97 % supply per the year as a whole, is indicative of thy fact, that the water operation balance of the river is positive and provides both as all utilitarian necessities for extraction of the river water, and so preservation in the river of sufficient water volume for ecological aims at accommodation of two energy units when providing the required level of Vileysky water stock reservoir and without breach of operation for Vileysky-Minsky water system.

Taking into consideration transbordering nature of the river Viliya, there was executed calculation of the additional lateral influx within the area of the river from the settlement Mikhalishki up to the border with Lithuania. The data are indicative of the fact that increase of consumption at the expense of the flow, created at the area, constitutes per the year being an average one for water delivery 5.4 m^3/sec, per annum with 95 % of supply for the flow of 3.9 %, but per annum with 97 % of supply – 3.6 m^3/sec. Herewith, the minimum daily flow increases by 1.3 m^3/sec in winter and by 2 m^3/sec in summer.

Table 129 - Analysis of waterless periods, during which there may be violated ecological restrictions in the river of Viliya with provision for production water-supply of the NPP during extraction of water for two energy units

Number of days in the row	year	Deficit of water, m^3
1	1946	2592
1	1948	184032
19	1950	1656288
1	1961	54432
2	1961	143424
2	1965	506304
2	1972	177984
1	1976	45792
1	1976	28512
4	1976	286848
2	1980	65664
1	1983	11232
1	1985	11232
1	1988	80352
16	1992	1207872
4	1992	416448
1	1999	11232
2	2002	350784
1	2003	477792
1	2006	209952

Generalization of the calculation results of the water operation balances for the river of Viliya have shown that at accommodation of two energy units of the Belarusian NPP under the general positive balance (sufficiency of water resources) the need in use of Vileysky water stock reservoir for possible covering of water deficit for its production water supply may appear only in very waterless years (for two energy unit with supply of 97 % and more) with approximate maximum volume up to 1.66 million m^3 and reduction of the level in water stock reservoir under its exhaustion being no more than by 10 cm from the normal pressure level.

Table 130 - Water operation balance for the area of the river Viliya

Items of the balance	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	the year
1 Available water resourses													
1.1 The calculated delivery of water to the area	34	33.9	70.8	49	46.9	36.3	36.7	44.8	29.3	33.8	35.2	36.4	487.1
1.2 Conditionally recovered sewage, created within the area	74.8	79.6	114	105	82	52.6	47.2	54.7	56.7	55.5	63.7	61.9	847.7
1.3 Water sewage (tapping into the water carrying pools)	1.5	1.5	1.5	1.7	1.9	1.95	2	1.9	1.77	1.5	1.5	1.5	20.22
1.4 Adjustment of sewage													
TOTAL	110.3	115	186.3	155.7	130.8	90.85	85.9	101.4	87.77	90.8	100.4	99.8	1355.02
2 Expendable part													
2.1 Extraction of water from the underground sources, hydraulically connected with the river	1.5	1.5	1.52	1.66	1.77	1.78	1.8	1.8	1.7	1.67	1.5	1.5	19.7
2.2 Extraction of water from the surface sources	8	8	8.2	8.6	8.7	8.8	10.1	10.1	8.9	8.6	8.5	8	104.5
2.3 Total additional evaporation c from the surface of water stock reservoirs and ponds	0	0	0	0	0	0.13	0.2	0.303	0.1	0	0	0	0.733
2.4 Ecological tapping	60.8	54.9	60.9	58.9	60.9	58.9	60.9	60.9	58.9	60.9	58.9	60.9	716.7
TOTAL	70.3	64.4	70.62	69.16	71.37	69.61	73	73.103	69.6	71.17	68.9	70.4	841.63
3 Balance	40	50.6	115.68	86.54	59.43	21.24	12.9	28.297	18.17	19.63	31.5	29.4	513.39
3.5 Irretrievable water consumption for two blocks of the NPP	2.54	2.29	2.76	3.04	3.52	3.57	3.78	3.76	3.36	3.19	2.81	2.67	37.28
3.6 Balance with taking into account operation of two NPP units	37.46	48.31	112.92	83.50	55.91	17.67	9.12	24.54	14.81	16.44	28.69	26.73	476.11
3.7 Delivery of water for the lower lying area	98.26	103.21	173.82	142.40	116.81	76.57	70.02	85.44	73.71	77.34	87.59	87.63	1192.81

Table 131 - Water operation balance for the area of the river Viliya (the year having 97 % water sufficiency), million m^3

Items of the balance	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	the year
1 Available water resourses													
1.1 The calculated delivery of water to the area	30.6	30.51	63.72	44.1	42.21	32.67	33.03	40.32	26.37	30.42	31.65	32.7	438.3
1.2 Conditionally recovered sewage, created within the area	37.26	38.72	99.4	204.78	68.43	61.64	55.87	47.94	43.2	63.88	53.25	51.83	826.2
1.3 Water sewage (tapping into the water carrying objects)	1.5	1.5	1.5	1.7	1.9	1.95	2	1.9	1.77	1.5	1.5	1.5	20.22
1.4 Adjustment of the sewage				-1.85					1.85				
TOTAL	69.36	70.73	164.62	248.73	112.54	96.26	90.9	90.16	73.19	95.8	86.4	86.03	1284.72
2 Expandable part													
2.1 Extraction of waters from the under-ground sources, hydraulically connected with the river	1.5	1.5	1.52	1.66	1.77	1.78	1.8	1.8	1.7	1.67	1.5	1.5	19.7
2.2 Extraction of waters from the surface sources	8	8	8.2	8.6	8.7	8.8	10.1	10.1	8.9	8.6	8.5	8	104.5
2.3 Total additional evaporation from the surface water stock reservoirs and ponds	0	0	0	-0.35	-0.29	0.13	0.6	0.53	0.42	0.26	0	0	1.3
2.4 Ecological tapping	60.8	54.9	60.9	58.9	60.9	58.9	60.9	60.9	58.9	60.9	58.9	60.9	716.7
TOTAL	70.3	64.4	70.62	68.81	71.08	69.61	73.4	73.33	69.92	71.43	68.9	70.4	842.20
3 Balance	-0.94	6.33	94.00	179.92	41.46	26.65	17.50	16.83	3.27	24.37	17.50	15.63	442.52
3.5 Irretrievable water consumption for two blocks of the NPP	2.54	2.29	2.76	3.04	3.52	3.57	3.78	3.76	3.36	3.19	2.81	2.67	37.28
3.6 Balance with taking into account opera-tion of two bloc of the ks NPP	-3.48	4.04	91.24	176.88	37.94	23.08	13.72	13.07	-0.09	21.18	14.69	12.96	405.24
3.7 Delivery of water to the lower lying area	57.32	58.94	152.14	235.78	98.84	81.98	74.62	73.97	58.81	82.08	73.59	73.86	1121.94

14.4.4.4 Forecast of heat contamination for the Viliya river

In relationship with discharge of the technical sewages from the Belarusian NPP into the river of Viliya in volume up to 1.38 m^3/sec, which according to the data from the JSC "SANKT-PETERSBURG Atomenergoproekt" will have the temperature at the outlet from the water conduct into the river of Viliya equal to 37 °C, as well as will contain various polluting materials - very important becomes the question about assessment of possible heat and chemical contamination of the river.

According to Appendix 1 to the Resolution of the Ministry of natural resources and protection for the environment of the Republic of Belarus and the Ministry of Public Health of the Republic of Belarus from the 8-th of May, 2007 No 43/42 "About some problems of the water quality standardization in fish growing water objects " the temperature of water must not increase in contrast with natural temperature of the water object more than by 5°C with the general increasing of the temperature no more than up to 20 °C in summer time and no more than by 5 °C in winter for the water objects, where dwell (salmon and sig)species of fish, and no more than up to 28°C in summer and 8 °C in winter in the rest of events.

According to the specified nature protection requirements there are executed calculations of possible heat contamination of the river Viliya below the place for discharge of the technical sewages with provision for execution of criterion about not exceeding the temperature of water in the river: in summer time no more than 28 °C; for salmon type of fish - no more than 20°C ; in winter - no more than 8°C for 2 energy units for various hydrological conditions (at average perennial and minimum average daily expenditure of water, 97% exceedance probability). The calculations are executed under maximum discharge of the technical sewages with use of the Frolov - Rodziller method and recommendations from Rosgidromet [153]. Herewith there were used the results of generalization for the observed data above the warming-up mode in the river of Viliya. At calculations made for the summer conditions there was taken maximum registered average monthly temperature of the water (1 % exceedance probability) – 23.8 °C ; at calculations executed for salmon sort of fish there was taken the average temperature of the water for the period of the spawning (the months April-May), which constitutes 13.5 °C ; at calculations executed for the winter time conditions - the minimum temperature of the water – 2.0 °C.

In the calculation there were taken into account actual morphometric and hydrological specifications of the river, including curvature of the river, as well as transverse and longitudinal dispersion. In the result of the calculations there was defined the distance up to the control range of practically full mixing of the river and sewage waters, as well as sharing the temperature of the water within the area of mixing the river and sewage waters at the specified area of water and assessment of the areas having heat contamination. In the generalized manner the results of calculation are provided in Table 132. The detailed results of the calculation are provided in Figures 90, 91.

Forecast for temperature pollution in the river Viliya after tapping of the technical sewage waters from the Belarusian NPP with temperature of 37 ^{o}C showed temperature pollution of the river Viliya:

–within the area up to 0.6 km at the period of spring-autumn and up to 1.1 km during winter period at expenditure of water in the river, close to average perennial;

–within the area up to 7 km at the period of spring-autumn and up to 13 km during winter period at minimum average daily expenditure of waters in the riverб 97 % exceedance probability (conditions of heavy lack of water).

In consequence with considerable temperature pollution of the river Viliya as the as a result of tapping of technical sewage waters from the Belarusian NPP for execution of nature protection requirements till tapping of technical sewage waters into the river of Viliya there are recommended engineering constructions for their cooling: at summer period –up to 25 °C, in winter – up to 10 °C. In this event the forecast for the area having heat pollution is estimated not more than 500 m (in average 100-150 m), which corresponds to the requirements for the quality of waters for fish growing water objects located lower than tapping down of sewage waters.

According to Item 7 of “Instructions about the order of stipulation for qualification standards permissible for tapping of chemical and other materials into water objects”, confirmed by the Resolution of the Ministry for natural resources and protection of the environment in the Republics of Belarus 29.04.2008, No 43 - "during tapping of polluting materials from the sewage waters into fish growing water streams the standards for the quality of water streams must be provided within the whole water object or its area, beginning from the control range, located at a distance not further 500 meters lower than the tapping down of sewage waters".

Table 132 – Generalization of results at the expense of possible heat pollution in the river Viliya after tapping of technical sewage waters from the Belarusian NPP at accommodation of two energy units

Hydrological conditions of the river Viliya lower the water extraction for the Belarusian NPP	Expediture of water, m^3/sec	Width of the river Viliya, m	Average depth of the river Viliya, m	Maximum depth of the river Viliya, m	Average velocity of the flow, m/sec	Distance to the control range (KC), km	Temperature of water in control range (after complete mixing) and length of the area with temperature pollution in the river Viliya by execution of criteria:					
							<28 °C in summer time		<20 °C for salmon		<8 °C in winter time	
							t-KC, °C	L, km	t-KC, °C	L, km	t-KC, °C	L, km
At average perennial expediture of water	65.78	65.17	1.75	2.57	0.58	29.5	24.07	**0.45**	14.0	**0.60**	2.8	**1.10**

Table 132 (continued)

Hydrological conditions of the river Viliya lower the water extraction for the Belarusian NPP	Expediture of water, m^3/sec	Width of the river Viliya, m	Average depth of the river Viliya, m	Maximum depth of the river Viliya, m	Average velocity of the flow, m/sec	Distance to the control range (KC), km	Temperature of water in control range (after complete mixing) and length of the area with temperature pollution in the river Viliya by execution of criteria:					
							<28 °C in summer time		<20 °C for salmon		<8 °C in winter time	
							t-KC, °C	L, km	t-KC, °C	L, km	t-KC, °C	L, km
At minimum average daily expediture of water (97 % exceedance probability) by summer-autumn lowest water level	21.25	57.38	0.91	1.55	0.41	33.2	24.07	**5.00**	14.0	**7.00**	-	**-**
At minimum average daily expediture of water (97 % exceedance probability) by winter lowest water level	16.55	56.81	0.79	1.43	0.36	31.0	-	-	-	-	4.3	**13.0**

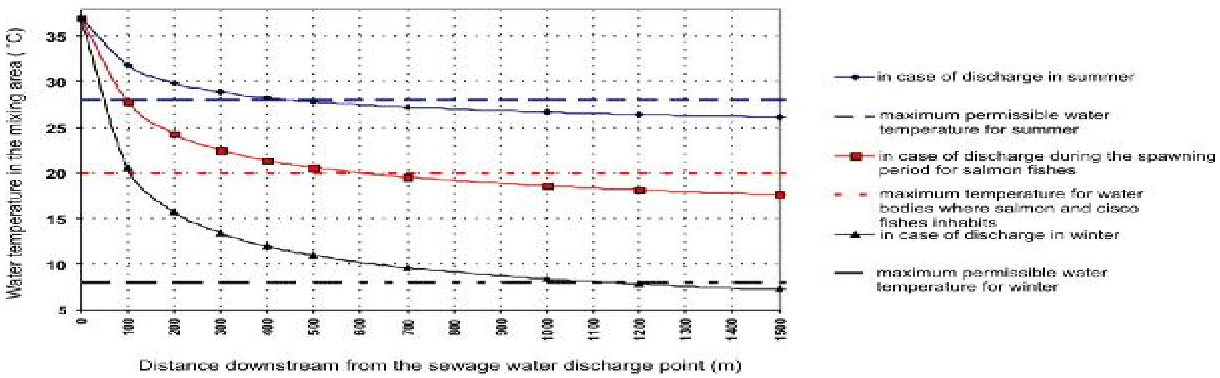


Figure 90 - Temperature mode of the river Viliya within the area of mixing the river waters and technical sewage waters from the Belarusian NPP, for average perennial flow rates in the river and for 37°C temperature of technical sewage waters, for two energy units

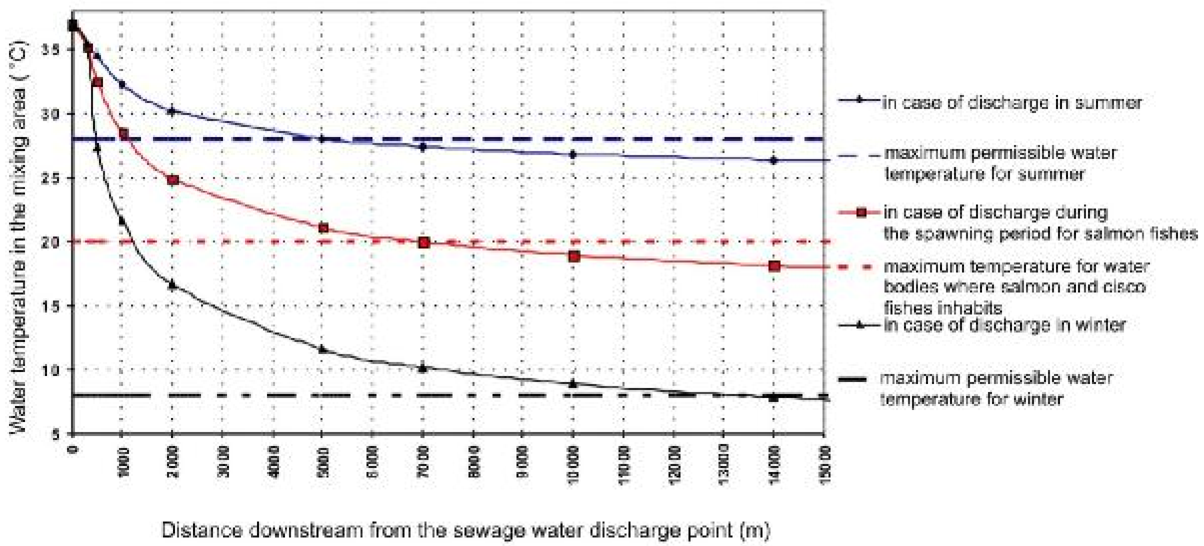


Figure 91 - Temperature mode of the river Viliya within the area of mixing the river waters and technical sewage waters from the Belarusian NPP, for minimum average daily water flow rates in the river (97 % exceedance probability), very low water, and for 37°C temperature of technical sewage waters, for two energy units

14.4.4.5 Forecast for changing the quality of water

Technical sewage waters

In volumes, of thrown down technical sewage waters into the river of Viliya, there will be kept polluting materials. According to data from JSC "SANKT-PETERSBURG Atomenergoproekt" the technical sewage waters according to such factors, as zinc, phosphates, will exceed maximum permissible concentration for the fish growing purpose by 4 times.

The main parameters, influencing upon diluting and spreading of the sewage waters, are: water mode of the river Viliya, volume of tapping the sewage waters, morphologic metric contents of the riverbed and flood plains of the river Viliya. Also it is possible to take into account the fact that the water floods, taking the sewage waters, may be in different hydrological conditions during the year. For determination of the distances for mixing sewage waters with waters of the river Viliya there is used the formula Frolov-Rodziller, the factor of turbulent diffusion D was calculated by the method of A.V. Karaushev with provision for unevenness of distribution by the depth of the river Viliya within the considered area [153]. The distance to the range of complete mixing (100 %) theoretically is equal to infinity, that is why for practical aims there is used the notion “range for guaranteed mixing”. As such range at calculation of the distances for mixing there was taken γ =0.8.

At that the expenditure area for practically complete mixing the river and sewage waters (80 %) constitutes: under expenditure of waters, close to the average perennial – 18.4 km, under minimum average daily expenditure (97 % exceedance probability) within conditions of heavy lack of water – 29.6 km. Forecast for diluting the river and technical sewage waters of the Belarusian NPP at accommodation of two energy units by average perennial and minimum average daily expenditure (97 % exceedance probability) is shown in Figure 92.

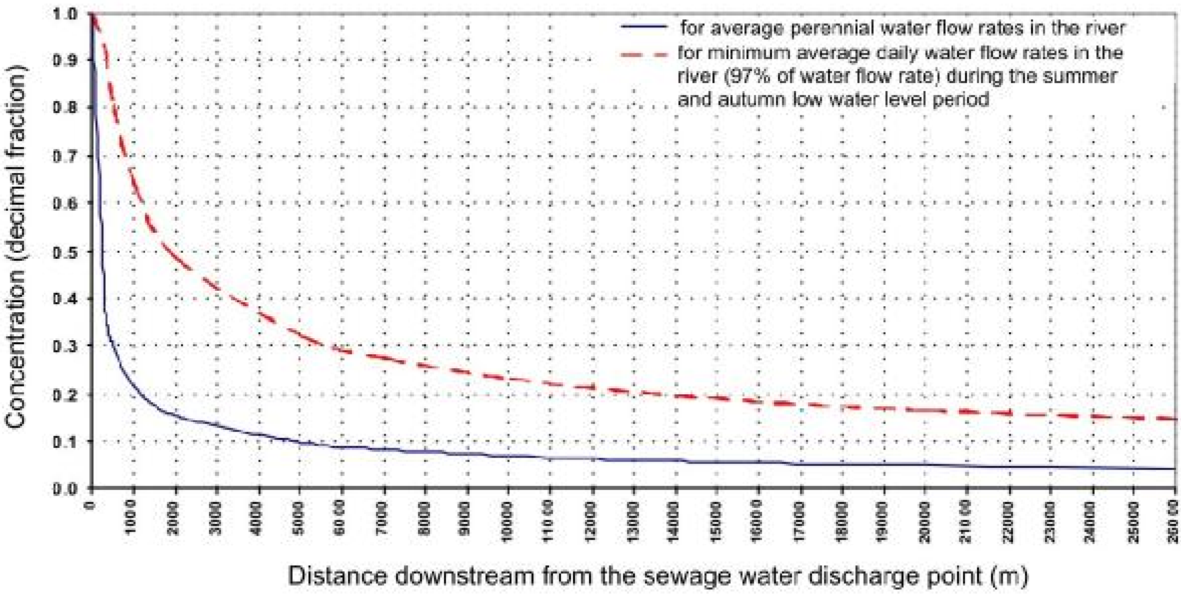


Figure 92 - Change of maximum concentration of pollutants within the area of mixing the river waters and technical sewage waters from the Belarusian NPP (dilution rate) at the length between the discharge point and the control point

In Tables 133, 134 (with bold italics are there shown the points of exceeding for maximum permitted concentration as the background concentrations in the river of Viliya there are accepted the data from expeditionary investigations for the corresponding hydrological modes. The forecast for changing the quality of the river Viliya was executed under condition of tapping in it technical sewage waters with concentration of polluting materials and according to the data of JSC "SANKT-PETERSBURG Atomenergoproekt". According to these data, the technical sewage waters on such factors, as zinc and phosphates will exceed maximum permitted concentration for fish growing purpose by 4 times. According to the analyzed materials the quality of technical sewage waters also more then by three times exceed the maximum permitted concentration. The forecast for changing concentration of the polluting materials within the area for mixing the river and technical sewage waters is shown K). On the rest of factors the quality specifications for the sewage waters are located within the limits of the maximum permissible concentration.

That is why additional rectification of technical sewage waters is expedient not more than up to the maximum permissible concentration of fish growing purpose on condition of minimization their negative impact on the quality of the river Viliya. In the event of executing recommendations for additional rectification of technical sewage waters from the Belarusian NPP there will not occur chemical pollution of the river Viliya and there not will be rendered any negative (including, transborder) impact.

Table 133 – Forecast for changing concentration of the polluting materials in the river Viliya after tapping in it sewage waters from the Belarusian NPP at expenditure of water in the river, close to the average perennial values

Name of the factor	Maximum permitted concentration for fish growing purpose	Concentration of polluting materials in the river	Concentration of polluting materials at the tapping point of sewage waters	Change of concentration for polluting materials in the river Viliya within the area of mixing the river and и technical sewage waters at a distance from their tapping place, m				
				500	1000	2000	3000	Control range 18400
Suspended materials, mg/l	0.25	3.960	***11.700***	***5.914***	***5.356***	***4.952***	***4.772***	***4.289***
Mineralizing, mg/l	1000	262.3	697	372.060	340.701	318.023	307.877	280.757
Calcium Ca^{2+} (mg/dm^3)	180	61.23	119.1	75.842	71.667	68.648	67.297	63.687
Magnesium Mg^{2+} (mg/dm^3)	40	15.75	32.58	20.000	18.785	17.907	17.515	16.465
Sodium Na^{2+} (mg/dm^3)	120	6.65	11.28	7.819	7.485	7.244	7.135	6.847
Potassium. K^+ (mg/dm^3)	50	2.65	4.74	3.178	3.027	2.918	2.869	2.739
Iron total (mg/dm^3)	0.1	***0.15***	***0.064***	***0.128***	***0.134***	***0.139***	***0.141***	***0.146***
Manganese Mn^{2+} (mg/dm^3)	0.01	***0.049***	***0.028***	***0.044***	***0.045***	***0.046***	***0.047***	***0.048***
Aluminum Al^{3+} (mg/dm^3)	0.04	0.028	***0.049***	0.033	0.032	0.031	0.030	0.029
Zinc Zn^{2+} (mg/dm^3)	0.01	***0.011***	***0.0264***	***0.015***	***0.014***	***0.013***	***0.013***	***0.012***
Phosphates PO_4^{3-} (mg/dm^3)	0.066	***0.097***	***0.238***	***0.133***	***0.122***	***0.115***	***0.112***	***0.103***
Chlorides Cl - (mg/dm^3)	300	13.78	25.9	16.840	15.966	15.334	15.051	14.295
Sulphates SO_4^{2-} (mg/dm^3)	100	25.88	45.7	30.884	29.455	28.421	27.958	26.722
Hydrocarbonates (mg-ekv/dm^3)		224.74	432	277.072	262.121	251.308	246.470	233.540
Silicon SiO_3^{2-} (mg/dm^3)		6.44	15.3	8.677	8.038	7.576	7.369	6.816
Ammonium NH_4^- (mg/dm^3)	0.39	0.153	0.161	0.155	0.154	0.154	0.154	0.153

Table 133 (continued)

Name of the factor	Maximum permitted concentration for fish growing purpose	Concentration of polluting materials in the river	Concentration of polluting materials at the tapping point of sewage waters	Change of concentration for polluting materials in the river Viliya within the area of mixing the river and и technical sewage waters at a distance from their tapping place, m				
				500	1000	2000	3000	Control range 18400
Nitrates NO_3^- (mg/dm^3)	40	4.29	1.88	3.681	3.855	3.981	4.037	4.188
Nitrites NO_2^- (mg/dm^3)	0.08	0.041	0.0177	0.035	0.037	0.038	0.039	0.040
Oil products	0.05	0.0094	0.016	0.011	0.011	0.010	0.010	0.010
Synthetic surface-active materials	0.5	0.025	0.0037	0.020	0.021	0.022	0.023	0.024

Table 134 – Forecast for changing concentration of polluting materials in the river of Viliya after tapping in it of sewage waters from the Belarusian NPP at expenditure of water in the river, being close to the minimal average daily expenditure (97% exceedance probability)

Name of the factor	Maximum permitted concentration for fish growing purpose	Concentration of polluting materials in the river	Concentration polluting materials at tapping point of sewage waters	Change of concentration for polluting materials in the river Viliya within the area of mixing the river and и technical sewage waters at a distance from their tapping place, m				
				500	1000	5000	10000	Control range 29600
Suspended materials, mg/l	0.25	0.800	***11.700***	***9.617***	***7.795***	***4.313***	***3.326***	***2.285***
Mineralizing, mg/l	1000	257	697	612.920	539.364	398.804	358.948	316.929
Calcium Ca^{2+} (mg/dm^3)	180	59.25	119.1	107.663	97.658	78.539	73.117	67.402
Magnesium Mg^{2+} (mg/dm^3)	40	16.04	32.58	29.419	26.654	21.371	19.872	18.293
Sodium Na^{2+} (mg/dm^3)	120	6.78	11.28	10.420	9.668	8.230	7.823	7.393
Potassium. K^+ (mg/dm^3)	50	2.25	4.74	4.264	3.848	3.052	2.827	2.589
Iron total (mg/dm^3)	0.1	***0.312***	***0.064***	***0.111***	***0.153***	***0.232***	***0.255***	***0.278***
Manganese Mn^{2+} (mg/dm^3)	0.01	***0.138***	***0.028***	***0.049***	***0.067***	***0.103***	***0.113***	***0.123***

Table 134 (continued)

Name of the factor	Maximum permitted concentration for fish growing purpose	Concentration of polluting materials in the river	Concentration polluting materials at tapping point of sewage waters	Change of concentration for polluting materials in the river Viliya within the area of mixing the river and и technical sewage waters at a distance from their tapping place, m				
				500	1000	5000	10000	Control range 29600
Aluminum Al^{3+} (mg/dm^3)	0.04	0.03	***0.049***	***0.045***	***0.042***	0.036	0.034	0.033
Zinc Zn^{2+} (mg/dm^3)	0.01	***0.011***	***0.0264***	***0.023***	***0.021***	***0.016***	***0.015***	***0.013***
Phosphates PO_4^{3-} (mg/dm^3)	0.066	***0.097***	***0.238***	***0.211***	***0.187***	***0.142***	***0.130***	***0.116***
Chlorides Cl - (mg/dm^3)	300	12.54	25.9	23.347	21.114	16.846	15.636	14.360
Sulphates SO_4^{2-} (mg/dm^3)	100	22.33	45.7	41.234	37.327	29.862	27.745	25.513
Hydrocarbonates (mg-ekv/dm^3)		223	432	392.062	357.123	290.357	271.425	251.466
Silicon SiO_3^{2-} (mg/dm^3)		9.72	15.3	14.234	13.301	11.518	11.013	10.480
Ammonium NH_4^- (mg/dm^3)	0.39	0.04	0.161	0.138	0.118	0.079	0.068	0.056
Nitrates NO_3^- (mg/dm^3)	40	1.3	1.88	1.769	1.672	1.487	1.434	1.379
Nitrites NO_2^- (mg/dm^3)	0.08	0.026	0.0177	0.019	0.021	0.023	0.024	0.025
Oil products	0.05	0.0085	0.016	0.015	0.013	0.011	0.010	0.010
Synthetic surface-active materials	0.5	0.021	0.0037	0.007	0.010	0.015	0.017	0.019

Public-domestic sewage waters and rain waters

In the course of construction of the NPP there will be formed public-domestic sewage waters in the volume up to 1050 m^3/day [154].

In the course of operation of the NPP the average daily expenditure of public-domestic sewage, delivered into the rectification constructions of the NPP with WWER-1200 (two energy units), constitutes 910.9 m^3/day [155]. Cleaned sewage waters will be directed into the nearest water object - into the river Polpa.

The volumes of tapping for expenditure waters up to 0.01-0.021 m^3/day at accommodation of two energy units in the manner of additional inflow into the river Polpa will render unessential impact to the hydrological feature of the river Viliya and will not bring about additional impoundment

As the background concentrations in the river of Polpa there may be taken the expeditionary data. Exceeding of standards for fish growing in water objects in the river of Polpa there exists only for iron general, manganese and copper (which is explained by their natural origin) and on bio-chemical consumption of oxygen.

Forecast for changing the quality of the river Polpa under tapping in it of public-domestic sewage waters from the Belarusian NPP under condition of their rectification up to 1 maximum permissible concentration (the most disadvantage variant) according to the corresponding chemical materials is provided in Table 135.

Table 135 – Forecast for changing polluting materials in the river of Polpa after tapping in it sewage waters from the NPP

Parameter	Rise at construction of the NPP in shares of maximum permissible concentration p/x	Rise at operation of the NPP in shares of maximum permissible concentration p/x
Sulphates (mg/dm^3)	0.78	0.85
Chlorides, (mg/dm^3)	0.85	0.92
Calcium, (mg/dm^3)	0.52	0.56
Magnesium, (mg/dm^3)	0.46	0.50
Sodium, (mg/dm^3)	0.85	0.92
Potassium, (mg/dm^3)	0.83	0.90
Ammonium, (mg/dm^3)	0.39	0.42
Nitrites, (mg/dm^3)	0.30	0.32
Nitrates, (mg/dm^3)	0.80	0.86
Phosphates, (mg/dm^3)	0.23	0.25
Oil products, (mg/dm^3)	0.80	0.87
BOC_5, mg O_2/ dm^3	-0.14*	-0.15*

* The “-“ sign means improvement of the quality for water (subject to the required treatment)

Obviously, what such increase of concentration in waters of water streams, falling into the river of Viliya, will not result in any essential deterioration for the quality of waters in the river of Viliya.

Rain waters from water collecting territory of the administrative building through self-flowing networks are collected in the existing pumping station for moving the rain sewage waters with production capacity of 100 m^3/hour by means of reservoir - interfacing installation having capacity 60 m^3 and then are pumped into self-flowing networks for rain canalyzation of the region united auxiliary building.

Intensity of precipitations constitutes 105 d m^3/sec from 1 hectare, the average perennial quantity of precipitations constitutes 641 mm, including within a warm period - 449 ms, within a cold period - 192 mm.

Rain waters from the water collecting territory of the region of the united auxiliary building and energy units due to non- intensive rains and polluted part of the sewage from intensive rains through separation camera move into the pumping station for transfer of the rain sewage waters with production capacity of 100 m^3/hour with reservoir-interfacing installation having capacity of 60 m^3 and hereinafter – for clarification into a slam collector. The test part of the rain sewage after the separation camera through the self-flowing collector enters into the supply channel of the main cooling system.

The rain waters from the water collecting territory of the energy units No 1 and No 2, and rectifying installations within the "dirty area" through self-flowing networks are collected into the collector and are directed into the supply channel of the main cooling system.

The rain sewage of the area will move into the slam collector and into the water object.

The perennial volume of the rain sewage, directed into the slam collector, constitutes 80 thousand m^3/ year.

The perennial volume of the rain sewage, directed into the water object, constitutes 66 thousand m^3/ year. Since on territory of the area there is excluded possibility for pollution of the determined rain sewages, then their quality will not be worse, than those, received from the natural surface of the land, which also with provision for their small volume will not render negative impact to the on water object.

14.4.5 Preliminary forecast for probability of biological hindrances in the system of water consumption and water sewage of the NPP

Any technological decisions, connected with provision of industrial objects with technical waters, certainly face with the problem of biological hindrances and damages. The biological hindrances and damages appear in consequence of natural process of hard substratum sunk in water, become populated with alive organisms (hydrobioitic objects). Any surfaces, having constant contact with waters, are subject to population of living organisms:

- walls of water extraction channels;
- pumping equipment;
- locking armature;
- equipment of cooling towers and others.

Because as a result of biological accumulation there speeds up the process of corrosion for metals and destruction for protection coverings, decreases reception capacity and hydraulical properties of water conducts, decrease warmth exchanging properties of cooling and heating equipment. In the event of taking off the accumulated layer from the substrate, there occurs contamination of the pumping equipment, locking armature, nozzles of the water-sprinkling machines which may bring about to the systems breakage.

The main sources for alive organisms, participating in mud accumulation of surfaces, are natural inhabitants water reservoirs, from which there is extracted water for technical necessities. So aspectual composition of mud accumulation and its nature will be defined aspectual composition of living beings dwelling in the water reservoir – from the source of water supply. Besides the fact, that to the process of mud accumulation the essential impact is rendered from the particularities for operation of that or other element of the equipment, the degree of rectification for the water, feeding the system, velocity of the stream, temperature, season of the year and others.

Biological accumulation in dependance from qualitative composition is divided into micro- and macro accumulation.

In creation of micro accumulation (the biological films) participate bacterias, water plants, mushrooms and protozoa. Formed by them community possesses the form of slime with different coloration (from light, transparent till black) having thickness up to 30-40 mm. Velocity of micro accumulation powerfully depends from the temperature of water, velocities of the flow, contentses of organic materials and oxygen. In average, on shaping of a fine layer (several millimeters) of film is spent 1-4 weeks.

Exactly with the development of micro accumulation there are connected rapid corrosion of metal sand destruction of protective covering in water conducts and of the cooling equipment, particularly if the source of the water supply are surface water reservoirs.

Overgrowing is created at the expense of sedimentation on the surface substrates of distributing forms of macro organisms, their growing and duplication. In fresh water in the process of macro accumulation there are participating mainly thread water plants and multicellular invertebrates. The invertebrates are the main source of hindrances in the systems of technical water supply. Exactly, at the expense of development of multicellular invertebrates there occurs the main mass of breakages in the systems of technical water supply and terminates the operation of the equipment in the systems of water supply for the power station. Taxonomic composition of invertebrates is enough varied. In accumulation there are met sponges, hydroides, warms, insects, shellfishes, crustacean beings.

Amongst all enumerated groups of organisms the highest hindrances are causes by accumulation of sponges and shellfishes.

Sponges (Porifera). Sponges - immovable colonial multicellular organisms, being rather strongfiltrators. Their body has mineral (lime or silica) skeleton or organic skeyears (from spongine). For fastening the colonies it is necessary to have hard substratum, therefore them are referred to specific peritophonic forms. In fresh waters there are dwelling approximately 50 types of sponge. In Europe there are commonly spread usual *Spongilla lacustris, S. frangillis, Ephydidatia mulleri*. Different types of sponge according to their morphologies and ecologies are close. For efficient filtration feeding the sponges prefer the place of dwelling with sufficient water exchange. In individual events they may form rather powerful accumulation. For instance, in water reservoirs of Uchinsky water stock reservoir there is noted the sponge biomass constituting more than 600 g/m^2, in accumulation round stones in the river of Yu. Bug there are noted colonies with the biomass of 1.5 kg/m^2. The sponges multiply through a sexless way, liberating small fragments of the body or accumulating the cells required for development. The cells required for development, which are produced by freshwater sponges, are covered with strong hard shell from spongine and spicules, enabling them to spend winter time. At sexy duplication there is formed a maggot - being covered with fragellums. Within a short period of time before sedimentation on the substratum it spends plankton lifestyle. The sponges possess high ability for regeneration. The body is capable to restore even from one cell.

The sponge is discovered in the river of Viliya.Within 30-km area around the Belarusian NPP/ The most quantitative development of sponge was registered within the water extraction construction of the cardboard factory (the river of Stracha). Concrete walls of the buildings in August, 2009 were covered with a layer of sponge having thickness of 2-3 cm.

Two-folded shellfishes (Bivalvia). One of the largeest organisms for fresh water accumulation. Exactly development of two-folded shellfish is the main reason, leading to a full stop of operation of the equipment in the systems of water supply and cooling for electric stations.

The most widely spread type in accumulation are representatives of species Pisidium, Sphaerium, Dreissena, Unionidae.

From all types of two-folded shellfish the most high degree of developments is noted for Dreissena (*Dreissena polymorpha*). So, the biomass of Dreissena on concrete facing of water extraction channel of the Chernobyl NPP reached 30 kg/m^2. Dreissena – is a rather large shellfish, the length of the shell usually constitutes 30-50 mm; life time - 6-19 years. Thanks to the ability of Dreissena firmly fasten to a substratum, there is possible to find its settlings in the systems with big velocity of the water stream, where other organisms are not capable to remain. Such strong fastening is reached at the expense of the bissus threads, produced by bissus gland of the shellfish. Their toughness exceeds toughness of steel of the corresponding diameter. Dreissena multiplies under temperature of water above 11 ^oC by means of way throwing into water of eggs - trohophors in thick quantity. The female Dreissena under optimum conditions is capable to produce above 70 000 eggs, which are thrown out in portions during a warm period of the year. Trohofors change into veligers (the maggots) sizing 60-70 mcm. Veligery liberally sail in the water and by its stream may be distributed on the whole system of water supply and water sewage. When the veliger reaches 225-250 mcm, it begins to settle on hard surface and to lead the attached lifestyle. In summer period the year quantity of velogers in water pools, for instance, water stock reservoirs, reaches 0.1-2.0 million species/m^3 of water. Within a cool period of the year Dreissena at any stage of the development, not having time to finish its conversion, as if it "is preserved", all the processes stop, but at springtime with warm temperatures up to before 11 ^oC Dreissena renew its development. Dreissena gets its food by the way of filtering water. 90 % of the food constitutes detritus. The mass development and distribution of Dreissena promote not only particularities of its biology, but also conditions of external environment. Optimal for sedimentation and development are the following conditions:

- constant contents of oxygen in water is not lower 8 mg/l;
- pH 7-9; permanganate oxidability 5-15 mg O_2/l; velocity of the water flow 0.5-0.8 m/sec;
- temperature 18-25 ^oC.

Intensity of mud accumulation for different surfaces depends on the position of the washed plane in the space. Most powerfully become overgrown with Dreissena lower horizontal planes.

Dreissena negatively withstands high temperatures, the temperature of survival - 0-36 ^oC. Under 45 ^oC Dreissena dies within several minutes. Under the temperature above 30 ^oC *Dreissena* is in an depressed condition. In this event is possible changing of the two-folded shellfish population, particularly in the areas of maximum heating, with other types of shellfish, being stable to the temperature influences. One of such types is *Sinanodonta woodian*. So, in the tapping channel of the Patnovskoy TES, where the temperature exceeds 30 ^oC the biomass of *Sinanodonta woodian* constituted 43 kg/m^2, reaching in individual places 50-70 kg/ m^2 [156].

The shells of two-folded shellfish, either as abdominal, present by itself good substratum for overgrowing with other organism. Thanks to thick colonies of two-folded vastly increases heterogenous capability of the substrate and the area of its surface which creates good conditions for further growing of macro growing.

In August, 2009 in the river of Viliya (the range of Tartak) *Dreissena* is discovered in composition of peritophone of macrophytes in the amount of 27 species/m^2 at the bottom. In spite of the so low quantitative development for *Dreissena* in water reservoir for technical water supply, at delivering its distribution forms into the system of cooling, there may be created powerful layer of *Dreissena* accumulation practically on all types of hard surfaces. For instance, at examination of concrete walls of the pumping station at the South-Ukrainian NPP there was revealed that they are completely covered with powerful layer of *Dreissena*, which biomass reaches up to 5 kg/m^2 and more. All metallic surfaces of the cameras in circulating pumps at Krivorozhsky TPS are populated with *Dreissena* having the biomass equal to 9 kg/m^2 [157].

Moss-grown (Bryozoa). The module-type, colonial animals; each colony consists of separate species (the zooides), which number may reach to a million. The colonies are formed at the expense of sexless duplication (gemmation) of the person-founder. Fabrics of each zooide get in contact with fabrics of its directneighbours. In fresh water are wide-spread basically representatives of the class *Phylactolaemata: species of Fredericella, Pumatella, Hyalinella, Pectinatella, Australiella, Cristatella and others.* Nearly all attaching forms. The form of the moss-grown colonies is very varying and has a complex spatial orientation. Moreover to the size and the form of the colonies big impact is rendered by factors of environment and dwelling. The amounts vary within broad limits: from the size of zooides equal to shares of millimeter up to colonies in several meters. In the greatest amounts the moss-grown species develop in the systems with raised temperature of the water. Mass development is noted under the temperature of 36-38 ^oC. In the cameras of oil coolers at Krivorozhsky Combined Power Plant there is discovered moss-grown species with biomass up to 18 kg/m^2. Together with two-folded shellfish, the moss-grown species are the main organisms for overgrowing in fresh waters. In the river of Viliya the moss-grown species are constantly met in qualitative samples.

Aside from the biological mud accumulation the greater danger for water extraction systems may stand *metaphyton*, formed in the waters source of the water supply. With current of the water the *metaphyton* fragments may be delivered into the system of water supply and be one more source of technical disturbances.

14.4.6 Impact of the NPP normal operation on the structure and functions of water ecosystems

During construction. In the period for construction of the NPP inevitably there arises negative impact on the environment. However on the water ecosystems the impact rendered from construction works practically will not have any consequences since all water reservoirs and water streams are removed from the construction area at considerable distance. The exception constitutes only the river of Gozovka, running in close proximity to the borders construction area. In respect to this water stream there must be undertaken special measures for protection from the impact of the construction works. As a whole, under condition that the projected construction will foresee rectification installations and the system for circulating water supply, the minimizing discharge waters into the hydrographical network, dust suppression during execution of construction works and other nature protection measures, the process of the NPP construction must not make considerable negative impact on the water ecosystems.

Under standard mode of operation. At the first stage of works for assessment of the impact from the NPP on biological components of water ecosystems and the processes of quality waters creation there was expected that the system of water supply and water sewage will operate in closed cycle without massaged tapping of perfected waters into the river of Viliya.

Calculations have shown that under average perennial expenditure of water in the river of Viliya being 50 m^3/sec, the volume of sewage waters constitutes in total 0,2 % from the perennial volume of the river sewage. Thence it follows that, negative impact of the NPP on the ecosystems of the river Viliya will be minimal, local and weakly expressed.

However, the calculations, coming from the elaborated water balance, executed by the JSC "SANKT-PETERSBURG Atomenergoproekt", it follows that tapping of perfected technical sewage waters constitutes per 1 energy unit from 0.48 m^3/sec in winter time up to 0.69 m^3/sec in summer time (0.96-1.38 m^3/sec per two energy units). Herewith the sewage water, in spite of preliminary rectification, will contain considerable quantities of biogenic elements, salts of metals, oil products, synthetic surface active materials, and other ingredients, rendering active impact to the biological components of waters ecosystems. According to the data of JSC "SANKT-PETERSBURG Atomenergoproekt", the technical sewage waters on such factors as zinc, phosphates, will exceed the maximum permissible concentration for fish growing purpose up to 4 times, but the temperature of the sewage waters, thrown into the river Viliya will change from 27.1 ^{0}C in winter time up to 38 ^{0}C in summer time.

It is absolutely obvious that under such parameters the designed tapping of the sewage waters for operation of the NPP presents the serious threat for biological communities and ecosystems of the river Viliya in total.

The calculations, executed by the Central Research Institute of Comprehensive Use of Water Resources, have persuasively shown, that on significant areas of the river Viliya there will be tracked considerable temperature pollution, under which existence and normal distribution of the row of rare and disappearing species of fish, put in the Red book of the Republic Belarus, becomes impossible. However the threat for the ecosystems of the river Viliya comprises not only this fact.

At present the river Viliya presents by itself highly populated water stream with the level of gross primary product above 7g S/m^3 per day, and the concentration of chlorophyll in waters up to 90 mg/ m^3, sharply standing out on the level of trophy on the background of other water streams and water pools within the 30 kilometer area of the NPP. Delivery, together with drainage waters, of large amounts of main trophic elements (compounds of phosphorus and nitrogen) on the background of thermal pollution, certainly, will bring about the further rise the trophic level. Negative consequences of this process are well known. It is possible uniquely to forecast sharp increasing the biomass of the phytoplankton, thanks to the perennial mass duplication of bluish-green water plants, causing "bloom" of the water, thus worsening its quality and conditions for life of hydro biotic inhabitants, producing toxins, dangerous not only for hydro biotic inhabitants, but also for human body. Self trophic ability is accompanied with the breach of the structure of trophic relationship of hydro biotic inhabitants, worsening of biologic variety in plankton and benthos communities which leads to loss genetic fund, reduction in abilities of the ecosystems in the river Viliya to homoeostasis and self regulation. Entering with the drainage waters salts of toxic heavy metals, for instance, chromium, may break the production – destruction balance in organic materials, which may bring about surplus accumulation of the biomass, further decomposition of which will impact on the quality of water and sanitary condition of the river Viliya.

Thereby, the planned mode for discharge waters into the river Viliya is inadmissible. It is necessary in the system of water sewage to provide additional engineering constructions, providing diminishing of the temperature and additional rectification of the sewage waters. The level of cooling and of hydro biotic inhabitants must provide in the river Viliya within the area of tapping for the sewage waters, delivery of self trophic and polluting materials on level of the maximum permissible concentrations for the water objects pertaining to the first category of fish growing purpose.

The lake ecosystems are located on sufficient removal from the area of the NPP and will not be a subject to direct impact of fluid sewage tapping. Within the 30-km area around the Belarusian NPP the share of pollution for the soils with radionuclides from the emission under normal operation of the two energy units to the natural pollution is neglected small and it changes from 2.0 $\cdot 10^{-3}$ % (after the first year for operation) up to 2.3 $\cdot 10^{-2}$ % (after operation constituting sixty years). The share of radionuclides, which from the composition of the sewage of the water collection will move over to water ecosystems, will be lower. Thence it follows that under operation of the NPP in stationary mode the danger of radiation pollution in water ecosystems, significantly exceeding the background level, is small and neglected.

The real threat for the river and lake ecosystems will present increased antropogenic (recreation) load. In connection with commissioning of the NPP the number of population in Ostrovets will increase approximately by 30000 persons, which will inevitably bring about growth of antropogenic press not only on the water ecosystems, but also on the natural complex as a whole. However this impact may be compensated by nature protection measures.

14.5 Radiation impact

14.5.1 Specification of radioactive emissions and discharges under normal operation

For ensuring radiation safety for the personnel, population and environment by the project NPP-2006 it is provided a complex of technical and arrangement decisions, which realizing is directed at observance of the following principle:

- the irradiation for the personnel within all modes for operation of the NPP must not exceed the corresponding main limits of doses, installed by NRB -2000 (Belarus), NRB -99 (Russia);
- the irradiation for the population must not exceed the corresponding main limits of doses, installed by the Legislature of the Republic of Belarus "About radiation safety for the population", NRB -2000. NRB -99;
- by the project there was realized the concept of deeply introduced protection, founded on using the system physical barriers on the way of spreading ionizing radiations and radioactive materials in the environment and the system of technical and arrangement measures for protection barriers and preservation of their efficiency;
- maintenance of the irradiation for the personnel and the number of irradiated persons on possible low and attainable level with taking into account of economic and social factors (the ALARA principle).

The source of the radiation impact from the NPP are radioactive tapping and emissions. The permissible emissions and permissible sewages under normal operation for the NPP are stipulated by SP AES-03 [45] in accordance with the quota for the population irradiation equal to 10 μSv annually for each of way of the impact.

With provision for technically achieved level of safety for the NPP in the mode of normal operation (when actual emissions and tapping sewage of the NPP create on each way for the impact of the irradiation dose for the persons from the population not more than 10 μSv / year) the radiation risk for the population under operation of the NPP is unconditionally acceptable ($<10^{-6}$ per year $^{-1}$). In this connection by the Rules there is specified a emission of the following radionuclides: inert radioactive gases (IRG), iodine 131, cobalt – 60, cesium - 134 and 137 (See Table 31). The impact of the radioactive emission and tapping sewages in the mode of normal operation of the NPP on the environment is minimum. So in 2008 the gas aerosol emissions and fluid sewage tapping of all the NPP were far less than the specified permissible values (permissible emissions and permissible sewages), and they have created, in addition to the background irradiation for the population, the doses from natural sources of irradiation (2.2 mSv) not more than:

- 0.1 μSv at the NPP with reactors WWER - 1000;
- 0.5 μSv at the NPP with reactors WWER - 440;
- 2.0 μSv at the NPP with reactors RBMK - 1000.

Thereby, the level of radiation impact from the NPP on the population and the environment in 2008 has not exceeded 0.1 % from the doses, created by natural sources of irradiation, and does not change the level of natural radiation in the region of the NPP site. The emissions even at the level of 100 % from possible permissible are unconditionally acceptable and do not create the detectable by the instruments of radiation control change of the radiation situation in of the regions of the NPP site. The actual emissions from the NPP are optimized, and their further closing is not economically justified. The purpose of the NPP for the forthcoming period for provision of the radiation safety and the population – is preservation of the achieved emission and discharge into the environment. The brought above data allow to assert the environmental purity for the nuclear plants.

14.5.2 Radiation impact on agricultural ecosystems under normal operation

14.5.2.1 General principles of forecast calculations for contents of radionuclides in agricultural ecosystems

Forecast calculations for contents of ^{137}Cs and ^{90}Sr in composition agro-ecosystems was executed on the base of commonly adopted in the radiation ecology of content mathematical models, in which the investigation system is shown in the manner of individual sections (for instance, 0-30 cm layer of soil, >30 cm the layer of soil, the elevated part harvest, the underground part harvest), between which there occurs carrying radionuclides with commonly adopted admissions and restrictions [158 - 162]. At that the dynamics of carrying the radionuclides is described by the system of the differential first-order equations. The parameters of the carrying are accepted in accordance with the modern scientific data achieved in the field of agricultural radio ecology[158.161.162].

The forecast calculations are executed for standard and emergency fallouts for the most wide-spread types of the agricultural products: grain of the cereals (the rye, wheat, barley and oats), root- and tuber crop (the beet and potatoes), sheet verdure (the salads), grass of natural fodder crops within the peat grounds, as well as milk and beef, got under growing on provender, produced on peat grounds.

Under standard fallouts there was expected to receive delivery ^{137}Cs with intensity of 0.001 Bk $\cdot m^{-2} \cdot c^{-1}$ (1.16×10^{-8} Bk $\cdot m^{-2} \cdot c^{-1}$) and ^{131}I - with intensity of 0.01 Bk $\cdot m^{-2} \cdot c^{-1}$ (1.16×10^{-7} Bk $\cdot m^{-2} \cdot c^{-1}$). In view of the low value for standard emission of ^{90}Sr - not more than (1×10^{-13} Bk $\cdot m^{-2} \cdot c^{-1}$) its pollution was neglected. It was considered, that root delivery into plants takes place with constant and comparatively high velocity [158, 162].

For emergency fallouts the forecast calculations of the contents for ^{137}Cs, ^{131}I and ^{90}Sr were executed in the first vegetation period, characterizing with the surface pollution of plants at the moment of maximum development for the elevated phytomass and the following vegetation periods, when the root way of delivery for radionuclides into agricultural plants is the most significant [162].

Under the forecasted radiation pollution in the first vegetation period there is used the most conservative approach, providing maximum degree of holding aerial fallouts by the elevated phytomass of the plants (up to 70 % with the green mass and up to 5 % - with the grain) having the period of half rectification up to 15 days [159].

Under the forecasted assessment of the radiation pollution in the following vegetation season there was used conservative approach under which there were considered 95 % of probability for non-rising of the calculated values under real radioactive pollution. For this there are used constants for carrying, corresponding to the soils with minimal contents of fraudulent potassium and pH_{KCl}. The calculations of pollution with ^{137}Cs in the fodder crops and products the animals breeding (milk and beef), was used the most conservative approach, expecting use of grasses at natural pasture and hayfield on peat grounds with maximum factor of transition for radionuclides in the system "ground-plant" in contrast with the ground from the mineral rows. At assessment of pollution with ^{90}Sr there was expected that the herbs are produced on soddy-podzol sandy grounds with high acidity of salt extraction.

Special importance was paid at assessment of correspondence of the calculated levels for contents of the radionuclides in products of agriculture to the real observed values according to the data, published in scientific literature [163 - 167]. The forecast of calculated factors for transition of radionuclides in the investigated types of the agricultural products correspond to those, practically observed, received on the grounds of measures for radio-ecologic monitoring in Eastern Europe, and on the grounds of designed models it is possible to realize the forecasted values with sufficient degree of reliability and uncertainty being not more than 50 %.

The calculations were executed with using normalized conditions (per 1 $Bk \cdot m^{-2}$) and with using concrete scenarios for development of the undesigned and maximum designed emergences.

The assessment of pollution for the agricultural products on the territory Lithuania was executed coming from the distance from the NPP to state border in west, north-west and north directions (being beside 20 km).

The criteria for decision making about restriction consumption by the types of agricultural products in the first year after emergency, in accordance with the NRB -2000 [168], is contents of radionuclides. Under non-excess for the level A, corresponding to the specific activity of ^{137}Cs and ^{131}I 1000 $Bk \cdot kg^{-1}$, and ^{90}Sr - 100 $Bk \cdot kg^{-1}$, there is no need to in using protection measures. If contents of the radionuclides in the species of agricultural products exceeds the level B (>1000 $Bk \cdot kg^{-1}$ for ^{90}Sr and above 10000 $Bk \cdot kg^{-1}$ for ^{137}Cs and ^{131}I) it is necessary to limit consumption by species of agricultural products with exceeding of the determined standard. Under specific activity of the radionuclides in species of agricultural products with exceeding the level A, but more low in contrast with the level B, the decision on its use is taken separately in each concrete event in dependency from the forecast of doses for the internal irradiation.

In the following year after emergency emission and under standard fallouts the content of the s radionuclides in species of the agricultural product is specified according to the acting in the Republic of Belarus possible level for contents of the ^{137}Cs and ^{90}Sr in food-stuffs, agricultural raw material and provender: for grain on food purposes - 90 $Bk \cdot kg^{-1}$ on ^{137}Cs and 11 $Bk \cdot kg^{-1}$ on ^{90}Sr, for milk - 100 $Bk \cdot kg^{-1}$ on ^{137}Cs and 3.7 $\cdot kg^{-1}$ on ^{90}Sr, for root- and tuber crop - 80 $Bk \cdot kg^{-1}$ on ^{137}Cs and 3.7 $Bk \cdot kg^{-1}$ on ^{90}Sr, for rubbed natural provender beside the fodder for production of raw milk

- 165 Bk ·kg^{-1} on ^{137}Cs and 37 Bk ·kg^{-1} on ^{90}Sr, for beef - 500 Bk ·kg^{-1} on ^{137}Cs and 37 Bk ·kg^{-1} on ^{90}Sr

14.5.2.2 Forecast for contents of radionuclides in case of standard radioactive fallouts

The forecasted calculations are indicative of extremely low delivery of radionuclides into the environment in consequence of standard radioactive fallouts during operation of the Belarusian NPP (See Figure 93). Even under condition of constant precipitation of ^{137}Cs on the same territory during the total period for operation the maximum surface activity in the 0-30 cm layer will not exceed 12 Bk·м$^{-2}$, which will constitute not more than 1 % in contrast with the existing level.

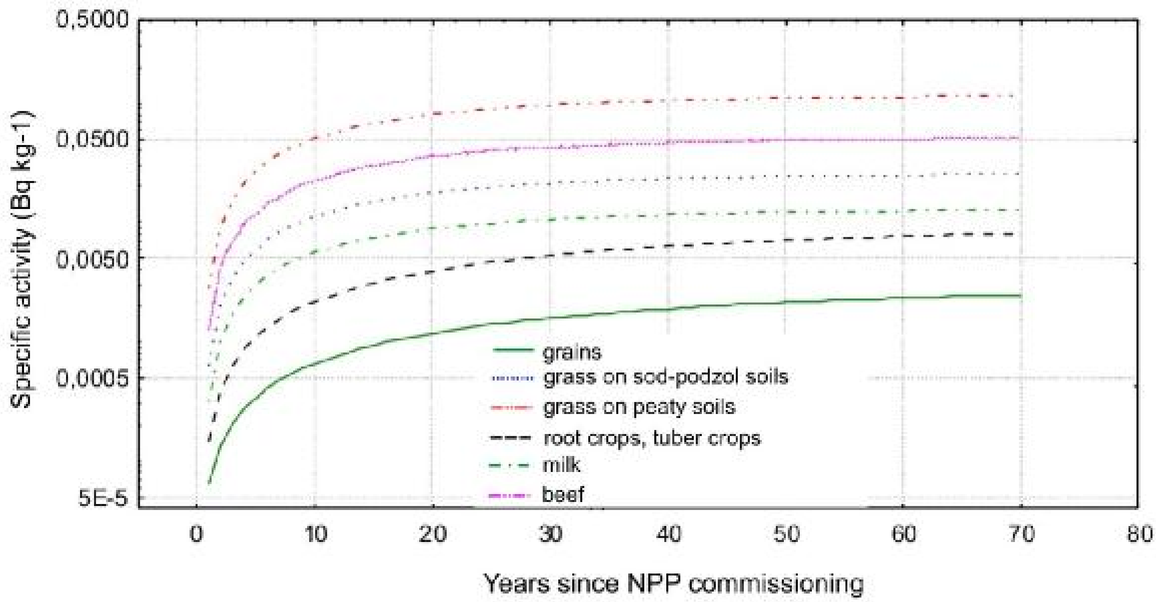


Figure 93 – Forecast for specific activity of ^{137}Cs in agricultural products at standard fallouts from the NPP (0.001 Bq ×m^{-2}×day^{-1})

Activity of ^{90}Sr in standard precipitations is extremely low (several Bq pert one day) so its contribution into pollution of soil is neglected small.

The data of the calculation executed coming from conservative suggestion about constant sedimentation on the same territory, it is obvious that real values at account of the wind rose will approximately be by an on order higher.

Additional contents of the radionuclides in the investigated species of agricultural products are forecasted on very low level and constitute at the order of 10^{-4}-10^{-2} Bq·kg^{-1}. From the investigated products some higher values (10^{-2} Bq·kg^{-1}) will exist in beef and milk (previously total, during usage of the provender, produced on peat soils), the herb from natural pasture. In herbs, produced on peat soils, the specific activity may constitute the value 0.1 Bq·kg^{-1}, however this is nearly by 100 times less in contrast with the existing level of contents for radionuclides. The minimum values (10^{-4} Bq·kg^{-1}) of the forecast calculations were executed for grain, root- and tuber crop. The comparable values for specific activities are forecasted for ^{131}I, and the contents for ^{90}Sr is expected at extremely low level - ~10^{-6} Bq·kg^{-1}.

Thereby, long operation of the NPP will bring about extremely low exceeding of contents ^{137}Cs in the products of agriculture.

14.5.2.3 Impact of ionizing irradiation on agricultural plants and animals

The forecast calculations for dose loads on the representatives of the bio population in agro-ecosystems were executed coming from the model calculations for precipitation of the radiation materials on the surface of soil in consequence with the standard and emergency fallouts by means of Gauss models for spreading the admixtures in the atmosphere. Herewith there were used conservative parameters of the models, allowing to calculate greatly unfavorable variants of radiation pollution and determining creation of the most levels of pollution and of doses for ionizing irradiation. Such approach is broadly used under modeling the consequences of radiation emergences. The received results testify about the absence of radiation-induced effects under standard emissions of the Belarusian NPP. Under daily emission the forecast calculations testify creation of very low doses: not more than 0.05 μSv for γ- and β- - irradiations from the cloud radiation fallouts and not more than 10^{-4} nSv · hour^{-1} on γ-irradiation from radionuclides, fallen down on the ground which is greatly lower than the natural radiation background.

14.5.3 Emergency emissions

The incidents and emergency at nuclear plants may be subdivided into categories, with use of the international scale INES [169]. The categories 0-7 show the nature and the importance of the events at the NPP. The categories 1-3 mark the incidents, which reduce safety, but do not lead to emission of radioactivity, accompanied with significant exceeding level of doses for the population (not more than the order of one tenth share being maximum for the perennial dose). The categories 4-7 pertain to various types of emergences. The category 4 ("emergency without considerable risk outside the borders of the area") corresponds to the defined designed emergency. The categories 5-7 – is an emergency with serious damage for fuel. In the process of evolution development for the NPP there was raised environmental safety in the NPP (See Figure 94).

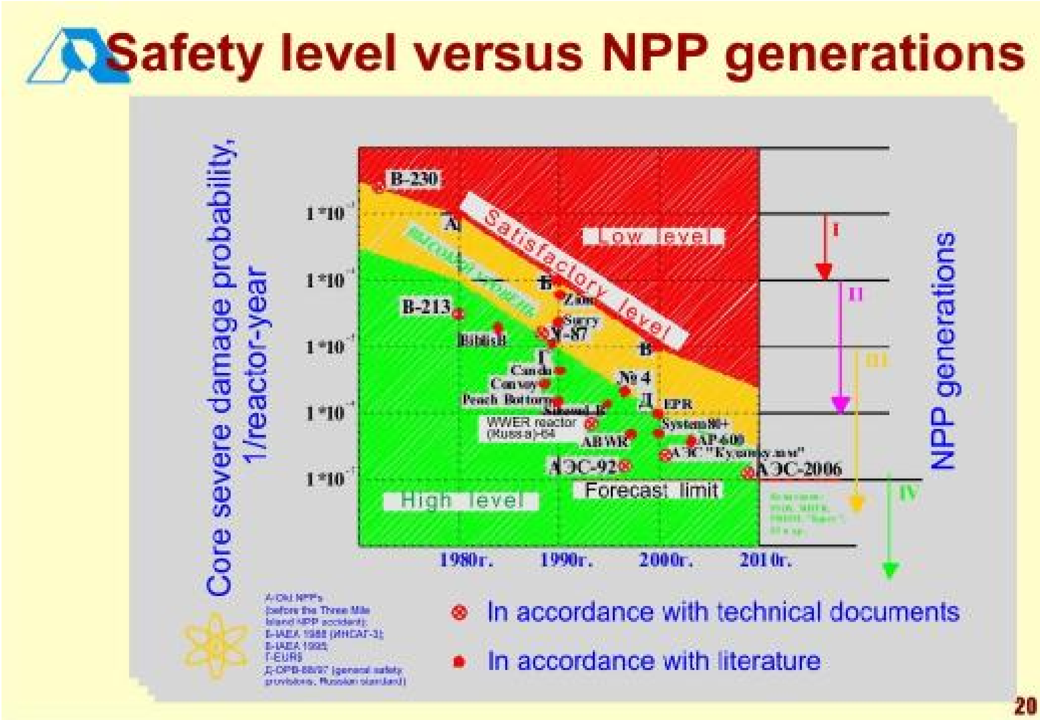


Figure 94 – NPP evolution development [170]

In accordance with the requirements being in force in Russia, OPB--88/97 [56], and corresponding international requirements EUR [43] in the project NPP-2006 are considered the designed and beyond design basis accident, including heavy emergency with melting of the fuel.

As the main quantitative criteria, characterizing the level of safety, there stands the values for probability of serious damage in active area and at most possible emergence emission of the main dose forming radionuclides in the environment under heavy accidents beyond the design basis (maximum emergency emission).

The prescribed probabilistic factors, specified by the operation organization for the energy unit NPP-2006 [171]:

- the probability of emergences at the energy unit with serious damage in the active area of the reactor up to the level 10^{-6} 1/year per one reactor and the greater emission over the limits of the area, for which it is necessary to undertake quick countermeasures outside the area, the level being 10^{-7} 1/ year per reactor;

- of restriction maximum emergency emission of the main dose creating nuclides into the environment under heavy beyond design basis accident with probability being 10^{-7} 1/ year per reactor of the level 100 TBq for ^{137}Cs.

- calculations for maximum emergency emission of the main of dose forming nuclides into the environment under heavy beyond design basis accident with probability being 10^{-7} 1/ year per reactor, up to the level, under which:

- there is excluded the need of introduction urgent measures, including both obligatory evacuation, and long transfer of the population outside the borders of the area; the calculations of the area radius for planning obligatory evacuation of the population does not exceed 800 m from the reactor department;

- obligatory introduction of protection measures for the population (the coverture, iodine preventive maintenance) is limited by the area not more than 3 km from the block.

Installed for the energy unit of the type NPP-2006 the doses limits and target probabilistic factors completely respond to the requirements in the acting Russian standard documents, recommendations and the standards of safety IAEA, International consulting group on nucleus safety (INSAG1 - INSAG12) and requirements of the European operation organizations laid for the projects of nuclear plants of the new generation having reactors of the type PWR [43]. In Table 136 there are shown for comparison the target factors for radiation and nuclear safety of energy units with higher safety for different projects of the NPP and requirements for them.

Table 136 – Factors of the radiation and nuclear safety for the NPP

Criteria	EUR [43] INSAG-3 [173]	Russian Federation norms [56.34]	Project of NPP-2006 [171]	Project of USA-APWR [172]
Quotas for irradiation of the population from emissions (sewage discharges) during normal operation of the NPP, μSv/ year	No limit	50(50) [34]	10(10)	-
Quotas for irradiation of the population from emissions and sewage discharges during normal operation of the NPP, taking into consideration the breaches of normal operation of the NPP, μSv/year	100	No limit	100	100
Effective dose for the population at design accidents, mSv/event		No limit		
- with frequency more than 10^{-4} 1/ year	1		1	1
- with frequency not more than 10^{-4} 1/ year	5		5	5
Effective dose for the population at design accident, mSv / year	-	5 [34]	-	-
Probability of serous damage in the active area, 1/ year per reactor.	1E-5	1E-5 [56]	1E-6	1E-6
Probability of serious emissions, for which there are necessary quick countermeasures outside the area, 1/ year per reactor	1E-6	1E-7 [56]	1E-7	1E-7

Tightening of requirements for safety of the new energy units (USA- APWR, EPR, NPP-2006 and others) has required development of such additional technical decisions, which have safely limited the sphere for undertaking actions of emergency nature with the most nearest from the NPP vicinity. So in the project NPP-2006 for the further softening of the consequences from heavy emergences there are incorporated two new passive systems of safety: the system of passive tapping for heat of the steam generator, safely providing preservation for functioning of the protective shell under heavy emergencies, and the system of passive tapping for heat of the protective shells, providing cooling in the active area of the reactor under full switching off of the energy unit.

In composition of the project for the NPP-2006 the maximum emergency emission is determined coming from the reached level of safety for the class of heavy emergences at the energy unit [174]:

- for early phase of emergency, connected with drains through non-dense of the double 3O and bypass for the containment, in the absence of energy supply on the energy unit: xenon -133 – 10^4 TBq; iodine -131 - 50 TBq; cesium -137 - 5 TBq.

- for intermediate phase of emergency after reconstruction of energy supply on the energy unit, connected with the emission through the ventilation pipe: xenon -133 - 10^5 TBq; iodine -131 -50 TBq; cesium -137 - 5 TBq.

For development of maximum emergency emission there was executed analysis of the radiation consequences according to the reference scenario for heavy emergences, connected with slow growing of the pressure in the containment, (total probability at the order 10^{-7} 1/year for each reactor) according to the recommendation IAEA for NPP with PWR [175]. In composition EIA of the Baltic NPP maximum emergency emission is used for preliminary estimating the volume of protection actions for the population under heavy emergency on the energy unit.

In Table 137 there are brought for comparison the calculated maximum emergency emission values and the requirements for them, installed in various countries and projects. Implementation in the projects of the marked strategy has reduced the calculated levels for maximum emergency emission, motivated according to the above indicated requirements.

Table 137 – Maximum permissible emergency emissions and the requirements to them, TBq

Dose forming nuclide	Requirements for disposition of nuclear plants, USSR 1987[1)]	Requirements and decisions of the State council of Finland 395/91	Tyanvan NPP [176]	Project NPP-2006 [174]	USA-APWR [172]
xenon -133	Not limited	Not limited	10^6	10^5	3×10^5
iodine -131	Not over 1000	Not limited	600	100	349
cesium -137	Not over 100	Not over 100	50	10	5.6
Strontium -90	Not limited	Not limited	1	0.12	0.15

1) The requirements are excluded at repeated issue of the document. With the document PNA EG-03-33-93, NP -032-01 there are harmonized requirements of the russian НД with recommendations of the IAEA (INSAG-3): measures on management and weakening of consequences after heavy emergences must reduce probability of greater emissions over the limits of the area, for which there are necessary quick counter measures outside the area, the level being 10^{-7} 1/ the year.reactor.

14.5.3.1 Calculations of contamination density in case of the beyond design basis accident. Reference data

In EIA for the new NPP, available for free access in Internet, there are used and other methodological approaches for estimations of the impact after heavy emergences on the environment within greater distances. Usually during the process of development of the EIA the detailed design of the NPP is not yet designed so for the EIA there is put the task to make a model, being general for various projects of the NPP a potentially significant situation, which renders limited impact on the environment, and the value of the risk for the supposed economic activity, herewith not being founded on the actual design decisions. The scenario for the development of reference heavy accident beyond the design basis is provided in Table 43.

As the example may serve the EIA for new NPP, designed by Finnish specialist s[177 - 179]. In the indicated document there is considered the impact of the accident beyond the design basis outside the limits of the national borders for heavy hypothetical emergency belonging to the Categories 6 ("heavy emergency") under maximum emergency emission being on the level of 100 TBq ^{137}Cs in accordance with the maximum value, installed by the Decision of the Government of Finland (395/1991). For assessment of the value for the impact, caused by the damage, there were made models of emissions and other nuclides, which form more than 90 % of the forecasted dose of irradiation, on correlation of their contents in active area of the reactor (for instance, emission ^{131}I constituted 1500 TBq.

For calculation of the radiation of the pollution under various meteo conditions in the EIA of the Belarusian NPP there are considered 2 scenarios for heavy beyond design basis accident (Table 138).

Table 138 – Scenarios for modeling of consequences after heavy beyond design basis accident

Name	Scenario 1	Scenario 2
Period for modeling	24 hours	24 hours
Duration of the emission	1 hour	1 hour
Dynamics of upper and lower border of the emission	21 – 25 m	21 – 25 m
Effective diameter of the source	3 m	3 m
Emission rate	1.8 m/sec	1.8 m /sec
Overheating	30 ^{0} C	30 ^{0} C
Iodine – 131 activity	1×10^{14}	3.1×10^{15}
Cesium – 137 activity	1×10^{13}	3.5×10^{14}

For modeling the spreading radiation pollution in the atmosphere under the beyond design basis accident in dependence from meteorological conditions there was used automated system for analysis and forecast of the radiation situations RECASS NT ("Taifun" Enterprise, Russian Hydrometeorology Service (Rosgidromet)). The RECASS NT automated system was developed within the scope of implementation of the Program of the Union State "Improvement and development of the united technology for reception, collection, analysis and forecast, keeping and spreading of hydro meteorological information and data about pollution of natural environment (the second stage) in 2003-2006 years.". The RECASS NT was introduced and within many years was successfully used in the Rosgidromet, at the Russian NPPs - Leningrad, Volgodonsk, Novovoronezh, Kolskaya, Beloyarskaya, Bilibino, Smolensk, Balakovo, Kalinin, Kursk NPPs, as well as in the Department on Hydrometeorology in the Ministry of Nature Protection of the Republic of Belarus.

The calculations for spreading the radiation pollution under the beyond design basis accident were executed with use of the models with various spatial solution. This is model:

- meso - scale – up to 100 km (was used for the maximum design accident);
- transborder - ~ 10^3 km (was used for beyond design basis accident).

The model calculated field density for pollution of the laying undersurface as a result of dry/humid sedimentation, integrated within time of the near ground concentration and the field of near ground with concentration of the radionuclides in concrete moments of the time. The calculations are completed, when the cloud deletes from the source of the emission at maximum for model distance or when the stock quantity of the radiation materials diminished up to 1 E-14 from the reference stock quantity.

For operation of the models for carrying polluting materials in the atmosphere there were used the data of objective analysis and the quantity forecast for meteorological parameters on standard geopotential surfaces from the prognosis centers of the International meteorological organization. This is the calculated fields with meteorological parameters being at the level of land (10 meters on the level of land for wind component and 2 meters on the level of land for temperature) and on standard geopotential surface - 1000 gPa; 925 gPa; 850 gPa; 700 gPa; 500 gPa. The results of modeling for carrying radiation materials in the atmosphere - the data for integral fallouts of radiation materials on the laying undersurface in 24 hours from the beginning of emergency in the manner of spatial fields with values in elements of the net with regular step having indicated accuracy and discreetness. The received data were integrated into the environment GIS Mapinfo in the manner of thematic layer on the digital map of the territory of the Republic of Belarus scale 1:100000. For modeling of carrying the radionuclides in the atmosphere there were used the prognosis data of fields with meteorological parameters in different periods of the year. In Figure 95 there is shown a scheme with indication of the wind directions in compass points and degrees.

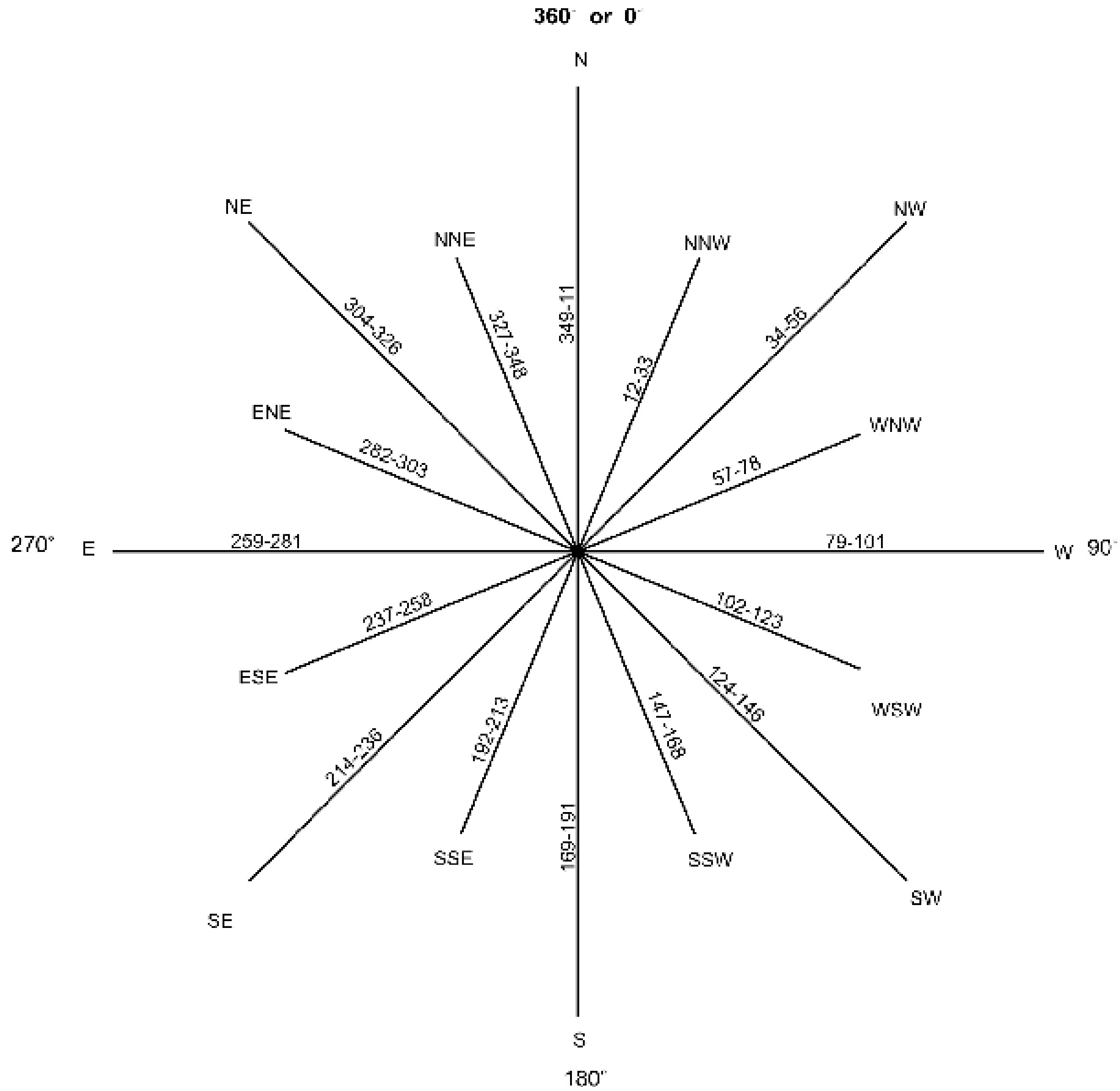


Figure 95 – Layout with designation of wind directions in compass points and degrees

Spreading radiation materials in the atmosphere occurs as a result of turbulent diffusion and wind carrying. Under mathematical modeling carrying of the radiation materials form of the trace, previously total, depends on interaction of various factors of the atmospheric diffusion and wind carrying. At long-lasting emission the radioactive cloud has a form of a stream. In as a result interaction with small scaled atmospheric curls, transverse sizes of the radiation cloud may increase by miscellaneous degree. Interaction with large-scale atmospheric curls leads to twisting of the path. The size of the atmospheric curls is determined, previously total, by vertical profile of the temperature in the atmosphere and the velocity of the wind

The calculations of radiation pollution over the territory was executed with use of the transborder model. In the event of the transborder pollution there was executed calculation of the area for the areas of pollution (for various levels), delivered on the territory of the adjacent states.

There was arranged modeling for carrying radiation materials in the atmosphere and there was evaluated density over the territory of pollution with radionuclides in dependence of meteorological conditions.

Analysis of the prepared results after modeling enabled to select 2 most conservative scenarios.

14.5.3.2 Scenario for contamination of small area

The given scenario is characterized with comparatively low velocity of the wind and sparingly firm condition of the atmosphere which defines sedimentation of big quantities of radiation materials on a comparatively small area of space - the area of maximum pollution will have the extent up to 15 km from the NPP and the width being up to 1 km. Within the limits of the area with maximum sedimentation area ~ 2000 hectares the density of the soil pollution ^{137}Cs and ^{131}I the forecast is executed within the scale from 2500 to 20000 kBq m^{-2}, and ^{90}Sr - more than 37 kBq·$м^{-2}$. The density of the soil pollution with ^{137}Cs and ^{131}I above 37 kBq·$м^{-2}$ will exist on territory of the area ~ 17500 and 22000 hectares,correpondingly.

The meteorological situation: in summer there was defined passing of atmospheric front with little activity. All around there was preserved a warm, mainly dry, only in the night at the western part of Brest area there were noted small rains. By the meteorological station of the lake Naroch on the beginning of the emergency there was registered:

- temperature of the air 14.4 °C;
- direction of the wind - 250 °C;
- western, 2 m/sec;
- pressure 1013.0 gPa;
- dew point 2.7 °C ;
- general cloudiness 90 %;
- cloud lower level - 40 %;
- category of stability – D.

At the meteorological station of Vileika there was registered:

- temperature of the air 15.9 °C ;
- direction of the wind - 350 ;
- northern, 3 m/sec, pressure 993.3 gPa;
- dew point 1.7 °C ;
- general cloudiness 90 %;
- cloud lower level - 20 %;
- category of stability -D

The modeling was executed with use of the data prognosis for fields with meteorological parameters from the Moscow prognosis centre under the following conditions:

- the wind at the height 10 meters, western, 25 km/hour;
- temperature at the height of two meters over the land - 11 °C.

Precipitations were absent. The height of the layer for mixing reached 0.11 km. The parameter of stability according to Smith -5.6.

The density of pollution with radionuclides over the territory on the axis of the trace and fields of density over the pollution territory with ^{131}I are provided in Table 139 and in Figure 96.

Table 139 - Density of radionuclides pollution over the territory on the axis of the trace B, Bq/m^2

P/н Bq/м^2	Distance, km									
050512	0.5	1	2	3	5	10	15	20	25	30
Scenario 1										
I-131	5.3E+05	7.1E+05	1.0E+06	1.1E+06	4.6E+05	1.4E+05	1.4E+05	8.7E+04	7.5E+04	5.0E+04
Cs-137	5.6E+04	8.1E+04	1.2E+05	1.2E+05	6.8E+04	1.5E+04	1.5E+04	1.1E+04	7.2E+03	5.4E+03
Scenario 2										
I-131	1.6E+07	2.2E+07	3.5E+07	3.7E+07	1.9E+07	3.9E+09	3.9E+06	3.1E+06	2.1E+06	1.6E+06
Cs-137	2.1E+06	2.8E+06	4.1E+06	4.4E+06	2.2E+06	5.4E+05	5.6E+05	3.5E+05	2.5E+05	2.1E+05

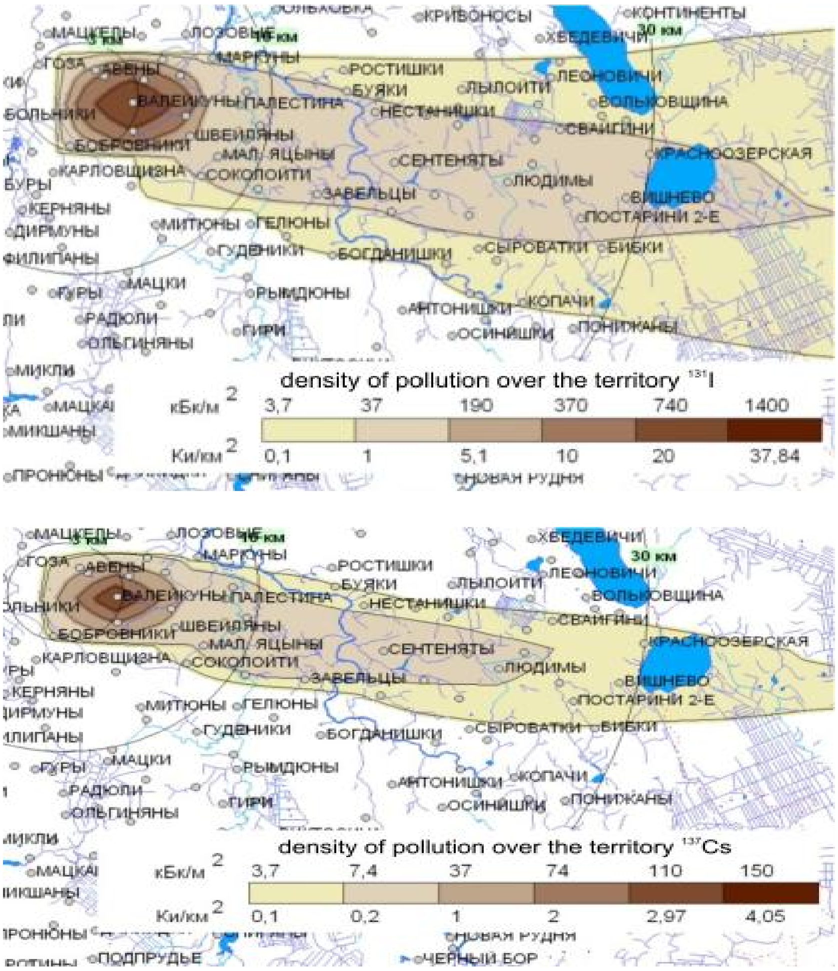


Figure 96 - Fields having density of pollution over the territory with ^{131}I and^{137}C per track B

Model making was executed with use of the prognosis data for the fields of meteorological parameters from the Moscow prognosis center under the following conditions: wind at the of height 10 meters western, 25 km/hour, temperature at the height of 2 meters on the ground - 11 °C. Precipitations were absent. The height of the layer for mixing reached 0.11 km. The parameter of stability according to Smith - 5.6.

14.5.3.3 Scenario for contamination of large area

The given scenario is characterized with high velocity of the air mass motion under moderate fluctuation which defines creation of long stretching – up to 70 km from the NPP and comparatively broad - up to 15 km of the fields with radiation pollution having comparatively low density of pollution: for ^{137}Cs range of values from 100 to 900 kBq·м$^{-2}$ is expected within the limits of the trace over the area 45000 hectares, and ^{131}I in the same diapason of pollution - about 100000 hectares. The value of density for pollution of soil 37 kBq ·m^{-2} will exceed for ^{137}Cs over the area for about 100000 hectares, and for ^{131}I - over 130000 hectares.

Meteorological situation: in summer there was defined western periphery of extensive little movable anticyclone with the centre above the Voronezh Region. Mainly without precipitations, only on the western part of Brest Region under the impact of little movable atmospheric front there passed short rains. The wind is south-eastern and moderate. At the meteorological station of Lintupy at the beginning of the emergency there was registered:

- air temperature: 4.2 °C;
- direction of the wind - 120 °;
- south-east, 1m/ sec;
- pressure 995.7 gPa;
- dew point 1.7 °C;
- general cloudicity 0 %;
- category of stability – F.

At the meteorological station of Vilnius there was registered:

- t air temperature: 5.5 °C;
- direction of the wind - 130 °;
- south-eastern, 1 m/sec;
- pressure 1001.1gPa;
- dew point 4.3 °C;
- general cloudicity 0 %;
- category of stability – F.

Precipitations were not observed.

Model making was executed with use the data of prognosis for the fields having meteorological parameters from the Moscow prognosis center under the following conditions:

- wind at the height of 10 meters, south - 20-28 km/hour;
- temperature at the height of two meters above the ground - 6.0 - 7.2 °C.

The height of the layer for mixing reached 0.4 km. Parameter of stability according to Smith - 4.

Density of pollution over the territory ^{131}I and ^{137}Cs on the axis of the trace is shown in Table 140 and Figure 97.

Table 140 - Density of radionuclides pollution over the territory on the axis of the trace Cs, Bq/m^2 (11.04.2009)

Р/н Bq/м^2	Distance, km									
110400	0.5	1	2	3	5	10	15	20	25	30
Scenario 1										
I-131	4.0E+04	5.3E+04	8.0E+04	1.2E+05	8.9E+04	1.7E+05	1.0E+05	6.9E+04	6.0E+04	5.4E+04
Cs-137	4.3E+03	5.7E+03	8.6E+03	1.3E+04	9.7E+03	1.8E+04	1.1E+04	7.5E+03	6.5E+03	5.8E+03
Scenario 2										
I-131	9.7E+05	1.3E+06	2.1E+06	2.7E+06	2.3E+06	5.0E+06	2.9E+06	2.1E+06	1.7E+06	1.7E+06
Cs-137	1.2E+05	1.6E+05	2.6E+05	3.5E+05	2.9E+05	6.0E+05	3.7E+05	2.6E+05	2.2E+05	1.9E+05

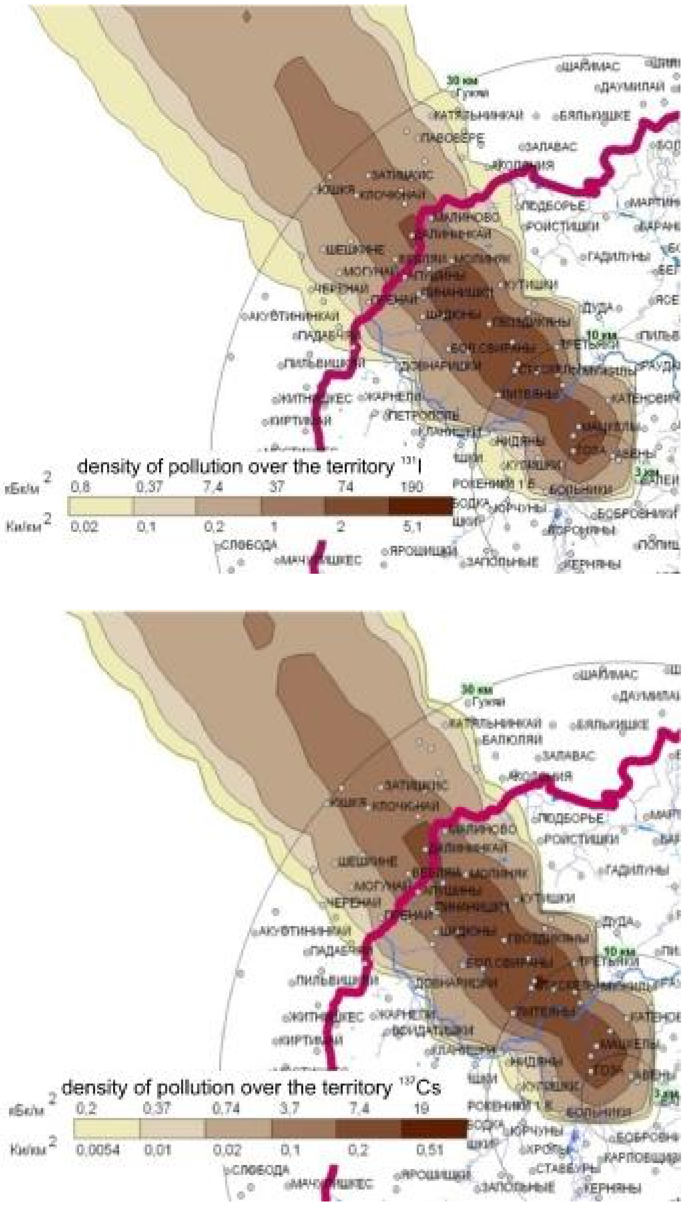


Figure 97 – Scenario 1.
Fields having density of pollution with ^{131}I and^{137}Cs over the territory (track Cs)

14.5.3.4 Assessment of possible radionuclide contamination of water streams

Changing the condition of surface waters at creation of the NPP and appearing of the emergency situation may be connected with radionuclide pollution as a result of dropping the radionuclides into the inflow of the river Viliya in composition of the sewage waters or as a result of the radionuclides emission into the atmosphere and further sedimentation on the water surface of the river Viliya and its inflows as well as on water collection area with the following washing down a part of the radionuclides fallen down by the surface sewage in to the river.

Volumes of fluid sewages tapping into the environment and delivery of radionuclides to the surface water in 2005 year related to the permissible discharges for the NPP, located in the Russian Federation, with liquid sewage tapping from the NPP of Russia were less than permitted (not exceeding the permissible discharges).

Emergence pollution with radionuclides of surface waters in the region of location for the Belarusian NPP is possible in the event of dropping radionuclides into the sewage water and further into the composition of sewage waters for the river of Polpa. For location of the given variant for development of emergency situation it is sufficiently to plan construction of rectification elements as the simplest partitioning building in the place lower the tapping down of sewage waters for interception of possible emergency pollution.

The mathematic modeling for assessment of possible radionuclide pollution of water streams and transborder transfer of the radiation pollution executed for most unfavorable situation - maximum density of precipitation for radionuclides on the water surface with taking into account maximum rain sewage from the water collecting territory, polluted with radionuclides as a result of emergency.

In generalized form the results of assessment possible radionuclide pollution in the river of Viliya and transborder transfer of radiation pollution for most unfavorable meteorological conditions under maximum precipitation of radionuclides on the water surface shown in Figures 98 - 100 and in Table 141.

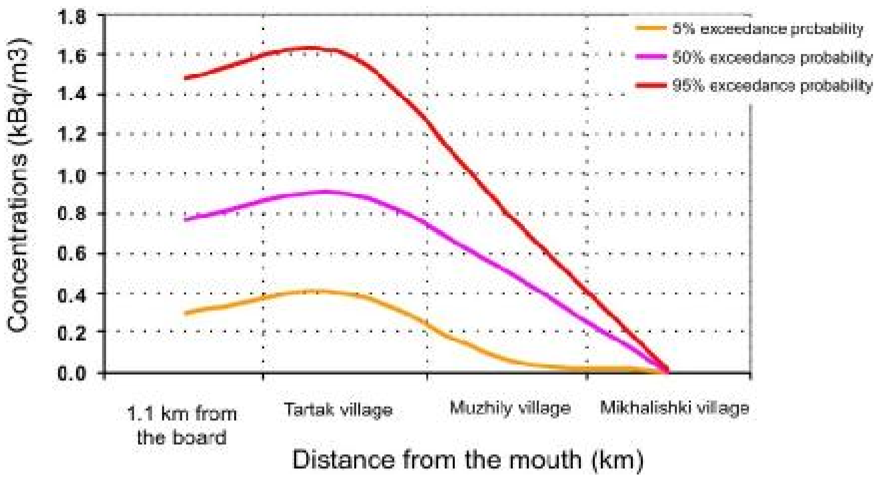


Figure 98 – ^{90}Sr concentration change along the bed of the river Viliya for various levels of water content in the river

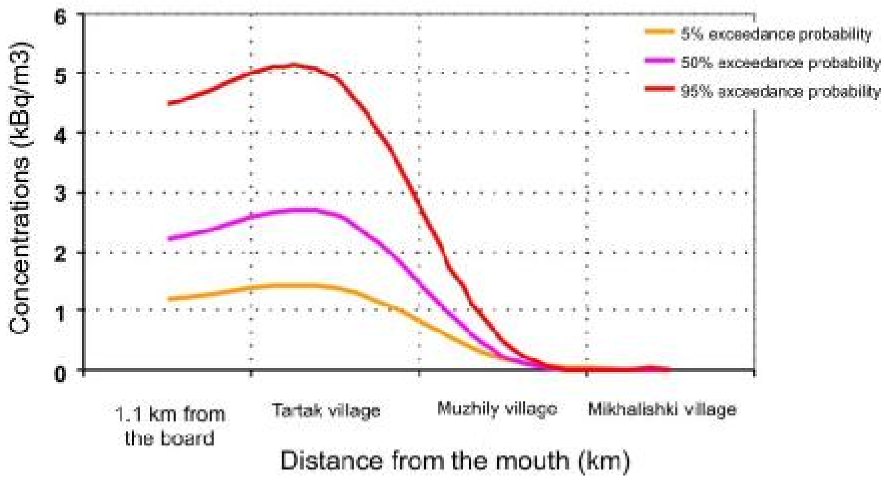


Figure 99 - ^{137}Cs concentration change along the bed of the river Viliya for various levels of water content in the river

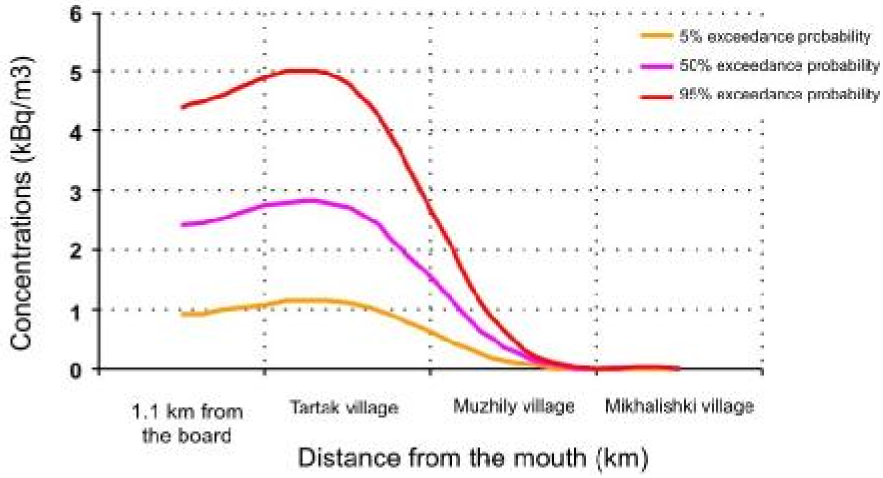


Figure 100 - ^{131}I concentration change along the bed of the river Viliya for various levels of water content in the river

Table 141 – Result of calculations for time of reaching и maximum concentration of radionuclides

Variants of water supply	Time of reaching for the front of radionuclides to the range at 1.1 km from the border, hour	Maximum concentration in transborder range at 1.1 km from the border, kBq/m^3		
		^{90}Sr	^{137}Cs	^{131}I
5 % provision	4.56	0.3	1.2	0.9
50 % provision	10.2	0.76	2.2	2.4
95 % provision	13.2	1.48	4.5	4.4

From Figures 98 - 100 it is seen that the maximum specific activity of reference radionuclides in water of the river Viliya is observed within the area 1.1 from the border up to the settlement Tartak. Lowering of specific activities in water of the river Viliya occurs at the expense of blurring convection spots in the flow and diffusion in transport of water media. In the calculations there was taken that reference radionuclides are found in waters in the diluted or adsorbed forms. During motion of the spot of the radiation pollution, its near-bed blurring takes place because of radionuclide interaction in the system "waters - suspension - bottom sediment". Full passing of the main mass of radioactive materials in the diluted form along the calculated area occurs within 100-120 hours from the beginning of the fallouts. Maximum forecasted concentrations of radionuclides (^{131}I, ^{137}Cs, ^{90}Sr) in the transborder range in case of the beyond design basis accident do not exceed the level of intervention, provided by the Standards for radiation safety (NRB-2000), according to which the level of intervention for ^{90}Sr constitutes 5 kBq/m^3, ^{137}Cs – 10 кBq/m^{3,} ^{131}I – 6.3 кBq/m^3.

14.5.3.5 Assessment of possible radionuclide contamination of water reservoirs

Under radionuclides sedimentation on water surface of the water reservoirs significantly and gradually join to the weighted particles having different diameters and within time move over to the bottom sediment. Accordingly, maximum concentration of radionuclides in water reservoirs will exist at the moment of radionuclides sedimentation, and further concentrations will fall down at the expense of radionuclides transition into the bottom sediment. For calculations of temporal sedimentation of the main radionuclides mass and accordingly lowering the concentration of radionuclides is used in the following approach:

- the calculated velocities of sedimentation particles getting on a free surface of the water reservoir and the particles residing in it in weighted condition are defined by the Shamov formula [180] with taking into account maximum velocities, under which sedimentation of the alluvium particles stops. Hydraulic size is taken in accordance with the recommendations [180].

The calculated velocities for sedimentation of the particles are as follows:

- for large particles having the diameter 0.1- 0.05 mm – 0.0067 m/sec;
- for average particles having the diameter 0.05 – 0.01 mm – 0.0007 m/sec;
- for small particles having the diameter 0.01- 0.005 mm – 0.000066 m/sec;

The calculated time for sedimentation of particles is provided in Table 142.

Table 142 - Maximum time for sedimentation of particles in water reservoirs

Name of water reservoir	Time for sedimentation, hour		
	large particles (diameter 0.1- 0.05 mm)	average particles (diameter 0.05 – 0.01mm)	small particles (diameter 0.01- 0.005mm)
15 km radius			
Olihovskoe water storage basin	0.22	2.06	21.89
Lake Slobodskoe	*0.21*	*1.98*	*21.04*
20 km radius			
Lake Gomeli	*0.21*	*1.98*	*21.04*
Lake Beloye	0.17	1.59	16.84
Lake Klevie	0.09	0.83	8.84
Lake Baranskoe	0.34	3.25	34.51
Lake Turoveyskoe	0.19	1.87	19.78
Lake Zolovskoe	0.52	5.00	53.03

Table 142 (continued)

Name of water reservoir	Time for sedimentation, hour		
	large particles (diameter 0.1- 0.05 mm)	average particles (diameter 0.05 – 0.01mm)	small particles (diameter 0.01-0.005mm)
Lake Kayminskoe	0.81	7.74	82.07
Lake Golubina	0.87	8.33	88.38
Lake Tumskoe	0.38	3.65	38.72
Lake Podkostelok	0.25	2.42	25.67
Lake Yedi	0.82	7.82	82.91
Lake Gubeza	0.53	5.12	54.29
Lake Vorobyi	0.13	1.23	13.05
Yanovskoe water storage basin	0.31	2.98	31.57
the radius 25 km			
Rachunskoe water storage basin	0.19	1.87	19.78
Lake Ryzheye	0.11	1.03	10.94
Lake mertvoye	0.07	0.63	6.73
Lake Tuscha	0.08	0.79	8.42
Lake Sviri	0.36	3.45	36.62
Lake Gluhoye	*0.21*	*1.98*	*21.04*
Lake Svirinische	0.11	1.07	11.36
Lake Byk	*0.21*	*1.98*	*21.04*
Lake Bilidzhyu	*0.21*	*1.98*	*21.04*
Lake Karotski	*0.21*	*1.98*	*21.04*
Lake Shkeyma	*0.21*	*1.98*	*21.04*
Lake Dyatlovina	*0.21*	*1.98*	*21.04*
the radius 30 km			
the ponds of fish growing enterprise "Soly"	*0.21*	*1.98*	*21.04*
Lake Vishnevskoe	0.26	2.50	26.52
the ponds of fish growing enterprise "Margeyskiy"	*0.21*	*1.98*	*21.04*
Lake Ungurinis	*0.21*	*1.98*	*21.04*
Lake Rakovina	*0.21*	*1.98*	*21.04*
Lake Vakshteli	*0.21*	*1.98*	*21.04*
Lake Pyarunas	*0.21*	*1.98*	*21.04*
Atimets	*0.21*	*1.98*	*21.04*
Gladne	*0.21*	*1.98*	*21.04*
Note: in italics there are sedimentation times for lakes, for which there are no reference data about their depth and, therefore, the calculations were carried out as for the mid-depth water reservoirs, that is for 5 m depth.			

Analysis of Table 142 shows that in the event of beyond design basis accident the majority of water basins within 30-km area around location of the Belarusian NPP may have significant concentration of radionuclides in the first day. Only lakes Baranskoe, Zolovskoe, Kayminskoe, Golubina, Tumskoe, Podkostelok, Yedi, Gubeza, Sviri, Vishnevskoye may have considerable concentration of radionuclides within first three days. In this period it will be necessary in the event of appearing the UE to provide refusal from operation of the indicated water basins, particularly for water drinking of live-stock and bathing the population. Besides, it will be necessary to conduct selection and analysis of water samples in water basins, indicated in Table 142 for acknowledgement of lowering the level for radionuclide pollution in water basins up to the safe one.

14.5.3.6 Forecast for contents of radionuclides in species of agricultural products under maximum design-basis accident and beyond design basis accident

Under all emergency situations there is created a trace of radiation pollution, configuration of which is determined by duration of the emission and meteorological factors at the time of maximum concentration for radionuclides in the atmosphere.

Under maximum design-basis accident the area of the most pollution with radionuclides will have the extension of 0.75-10 km from the NPP and the width less than 0.8 km. On this territory the area of 450 hectares with density of pollution for the soil ^{137}Cs is forecasted being within the range of 0.57-1.5 kBq· m^{-2}. For ^{131}I the territory with density of pollution above 37 kBq m^{-2} will have the area of 700 hectares. The level of pollution for the soil ^{137}Cs >0.03 kBq· m^{-2}. is expected within the area of 7000 hectares, and ^{131}I > 0.86 kBq·m^{-2}. - within 16000 hectares.

Under beyond design basis accident there will exist the most emission of radionuclides outside the limits of the active area reactor. There are considered different for the yearly conditions at the time of maximum radionuclides concentration in the atmosphere, which will bring about to quite different sedimentation on the terrestrial surface:

- scenario for pollution over a small area is characterized by relatively low velocity of the wind and moderately firm condition of atmosphere, which is determined with sedimentation of big quantities of radiation materials on relatively small area of the space - the area of maximum pollution will have extension up to 15 km from the NPP and the width up to 1 km. Within the limits of the area with maximum sedimentation over the area of 2000 hectares the density of the soil pollution with ^{137}Cs and ^{131}I is forecasted to be within the range from 2500 up to 20000 kBq· m^{-2}, and but ^{90}Sr - more than 37 kBq· m^{-2}. Density of the soil pollution with ^{137}Cs and ^{131}I above 37 kBq· m^{-2} will be observed on the territory of the area~ 17500 and 22000 hectares, respectively;

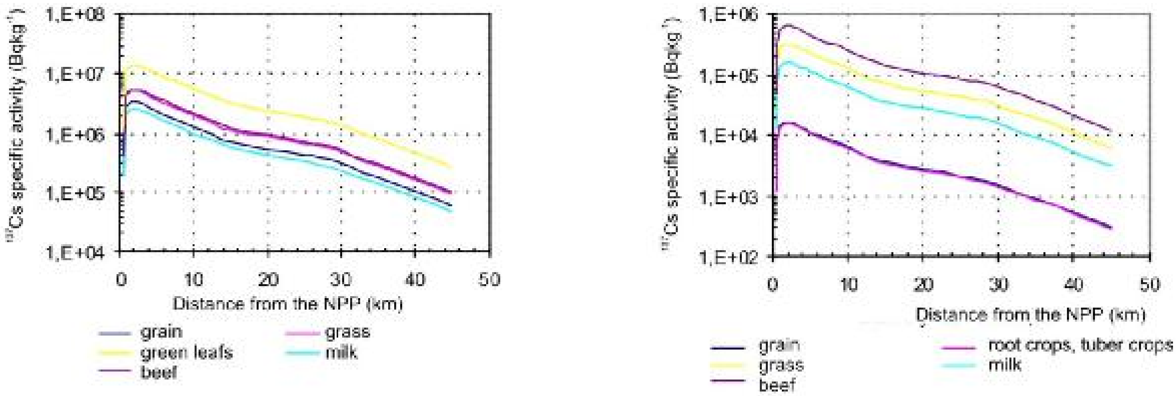
- scenario for pollution of large areas characterized by high velocity of air mass transfer with moderate fluctuation, which defines creation of extended - up to 70 km from the NPP and relatively broad - up to 15 km - fields with radiation pollution having relatively low density of pollution: for ^{137}Cs the range of values from 100 up to 900 kBq· m^{-2} is expected to be within the limits of the trace on the area of 45000 hectares, and for ^{131}I within the same range of pollution - about 100000 hectares. The value for density of the soil pollution 37 kBq· m^{-2} will be exceeded for ^{137}Cs within the area about 100000 hectares, and for ^{131}I - within 130000 hectares.

The highest level of radiation pollution is forecasted to be on the axis of the trace for radiation fallouts, respectively, these values are adopted as greatly permissible under forecasted assessment for pollution of products at agricultural facilities.

The calculations with using standard conditions testify, that in the first day after emergency fallouts (disregarding the scenario for development of the emergency situation) at the level A according to contents of ^{137}Cs and ^{131}I in leaf verdure, the surface of which in the most degree is contaminated with aerial of precipitations, may be exceeded under 1.5 kBq· m^{-2}, and ^{90}Sr - under 0.15 kBq· m^{-2}, level B - under15 and 1.5 kBq· m^{-2}, respectively. Through 20 days exceeding of the level A according to contents of ^{137}Cs in this type of products is possible under density of pollution 29 kBq· m^{-2}, and the level B - under 2.9 kBq· m^{-2}, ^{131}I - on the territory, where the density of pollution at the time of fallouts constituted 14.5 and 145 kBq· m^{-2}, respectively

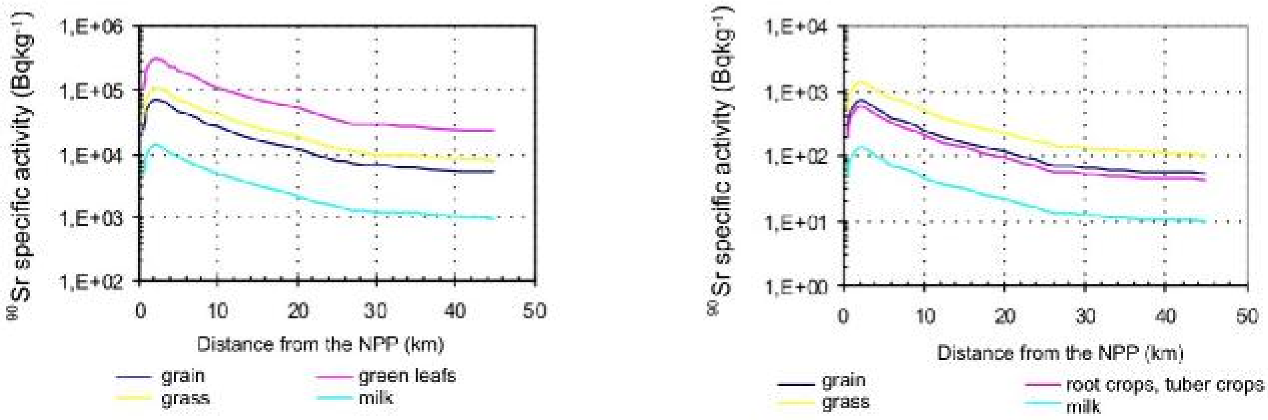
In the following years after emergency, at root delivery of radionuclides into agricultural plants, there is also probable exceeding of the permitted levels for contents of radionuclides in agricultural raw material and provender. In the first 1-2 years after emergency there is possible exceeding of the permitted level for contents of ^{137}Cs in milk under its production with use of provender, produced on soddy-podzol sandy soils with density of pollution more than 74 kBq· m^{-2} and on peat soils - above 20 kBq· m^{-2}, and for ^{90}Sr under contamination of provender fields with this radionuclide above 15 kBq· m^{-2}. In grains, the root- and tuber crops there possible exceeding of permitted standard for on ^{137}Cs under density of pollution in the soil >150 kBq· m^{-2}, and ^{90}Sr - >37 kBq· m^{-2} for grain and >6 kBq· m^{-2} for root- and tuber crops. On termination of 10 years since the moment of emergency in grains, the root- and tuber crops there is found exceeding of permitted level for contents of ^{137}Cs probably under density of pollution in the soil > 400 kBq· m^{-2}, and in milk when using provender, grown on peat soils - above 45 kBq· m^{-2}. For ^{90}Sr the critical species on contents of the radionuclides are milk and potatoes, and exceeding of permitted standard (3.7 Bq· kg^{-1}) is probably found under density for pollution of the soil >10 kBq· m^{-2}.

The scenario for pollution of small area under beyond design basis accident. The forecast for contents ^{137}Cs in species of agricultural products is shown in Figure 101, ^{90}Sr - in Figure 102, ^{131}I - in Figure 103.



a) b)

Figure 101 – ^{137}Cs specific activity in agricultural products during (a) the first and (b) subsequent vegetation seasons after emergency fallouts



a) **b)**

Figure 102 – ^{90}Sr specific activity in agricultural products during (a) the first and (b) subsequent vegetation seasons after emergency fallouts

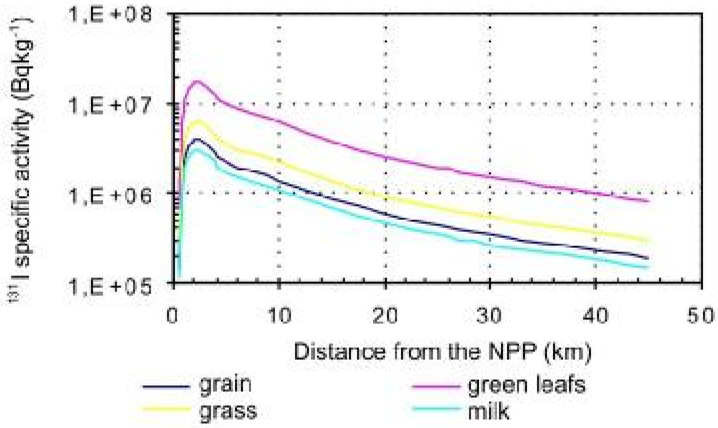


Figure 103 – ^{131}I specific activity in agricultural products during the first vegetation season after emergency fallouts

What follows from the forecasted calculations, is the most greater specific activities of the radionuclides will be observed in the first day after fallouts about leaf verdure, closely exposed to aerial precipitations and particles of fallouts which contaminated the surface.

Under the given scenario for development of the radiation situation exceeding the level A in leaf verdure will be observed on the territory of the area over 25000 hectares, and the level B – 15000 hectares.

The highest specific activities forecasted in the leaf verdure and grasses of provender taken near the axis of the trace ~10^7 Bq·kg^{-1} according to ^{137}Cs and ^{131}I, up to ~10^5 Bq·kg^{-1} according to ^{90}Sr. To a lesser extent there will be polluted grains ~10^6 Bq·kg^{-1} according to ^{137}Cs и ^{131}I, up to <10^5 Bq·kg^{-1} <10^5 Bq·kg^{-1} ^{90}Sr. During removal from the axis of the trace the specific activity will fall and at distances over 500 m will not exceed the background values.

The minimal level of pollution in the first vegetation season will be featured in root- and tuber crops closely protected from aerial fallouts (<10^3 Bq·kg^{-1}), as well as products of animals breeding (<10^6 Bq·l^{-1}).

Contents of radionuclides in the studied species of agricultural products at a distance over 20 km from the NPP is forecasted about by 10 times lower in comparison with maximum supposed values because of the smaller value for sedimentation of radionuclides on this at a distance (not more than 230 kBq·m^{-2} on^{137}Cs, 370 kBq·m^{-2} on ^{131}I, 18 kBq·m^{-2} on ^{90}Sr). Correspondingly there will be lower and the level contents of these radionuclides in all species of agricultural products.

In the following, in the first vegetation period after fallouts, the forecast for lowering specific activities of radionuclides in the studied species by 2 times each 15 days according to ^{137}Cs and ^{90}Sr and 5-7 days according to ^{131}I under "dry" at a distance. Correspondingly, through 20 days after the emergency exceeding the level B on contents ^{137}Cs being the most critical to aerial surface pollution the leaf verdure will be registered within the area not more than 17000 hectares, through 40 days - 13000 hectares, at the level A- within the area 20000 and 15000 hectares respectively. Under the atmospheric precipitations the velocity of rectification for the surface plants there is expected in proportion to the intension of precipitations and their quantity, respectively and the territory with the exceeding levels A and B will be the more less, when more precipitations will fall down on the territory of the trace.

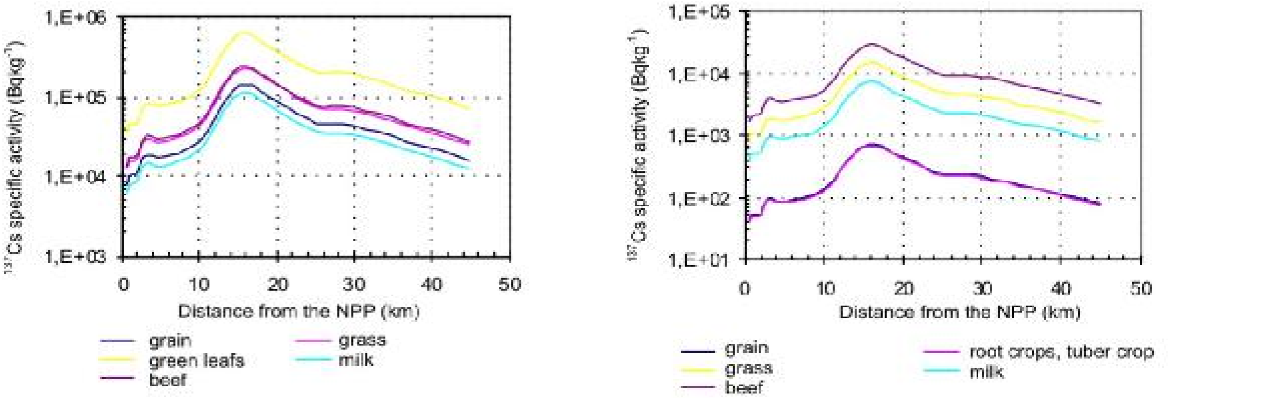
In the following vegetation season the contents of the radionuclides in agricultural products will be determined by the root delivery. Herewith the highest specific activities of ^{137}Cs and ^{90}Sr forecasted in the first year after fallouts in grasses for provender taken from the peat soil, in which specific activity of ^{137}Cs may reach tens of thousands Bq·kg^{-1} under maximum densities of pollution being on axis of the trace. The specific activity ^{137}Cs in grains and potatoes is expected to be considerably low and only under maximum density pollution may reach ~10^{4} Bq·kg $^{-1}$ on ^{137}Cs and several hundreds Bq·kg^{-1} according to ^{90}Sr.

On the axis of the trace, the national standard permissible concentrations of radionuclides (RDU) can be exceeded at a distance up to 60 km from the NPP. With removal from the axis of the trace in transverse direction there is forecasted lowering of specific activities for ^{137}Cs and ^{90}Sr, and at distances over 500 m they not will not exceed the background values.

At a distance above 20 km from the NPP on the axis of the trace which corresponds to the distance to the border of the adjacent state, the specific activities are forecasted by 10 times less in comparison with the maximum values.

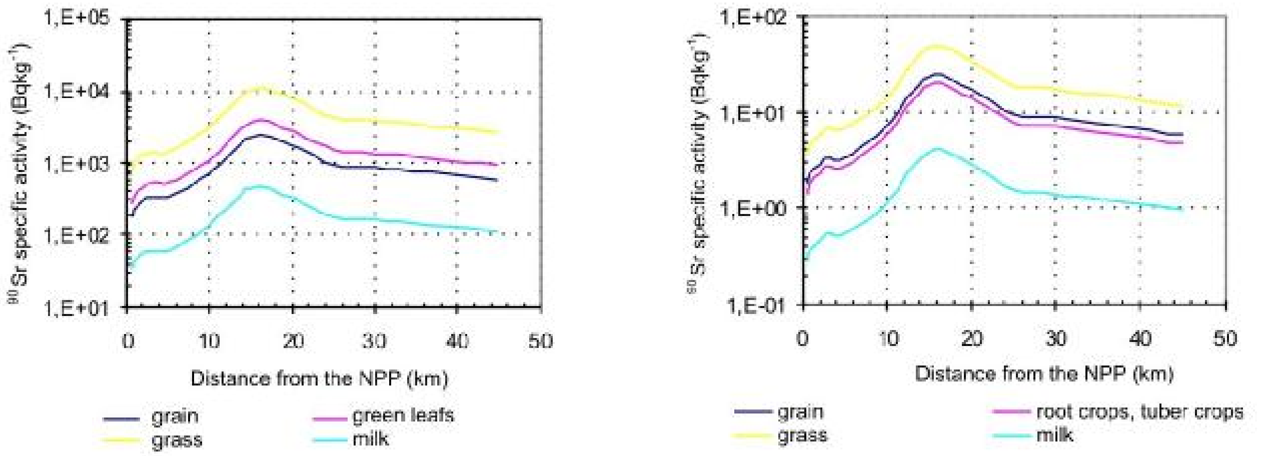
In the following years there is forecasted lowering of specific activities for radionuclides in the studied species of agricultural products, moreover the most intensive it is forecasted for ^{137}Cs: within the first 10 years after emergency lowering constitute by 4-5times, and within 20 years – by 10 times. For ^{90}Sr diminishing not so intensive - by 2 times each 20-25 years. Together with that, there are necessary restrictions for consumption of agricultural product species and at the remote stage after the emergency. On termination of 10 years from the moment of emergency in grains, root- and tuber crops exceeding the permitted level for contents of ^{137}Cs is probable under density of pollution in the soil > 400 кBq·м$^{-2}$ on the territory of the area of 10000hectares. Pollution with ^{137}Cs in milk over 100 Bq ·l^{-1} under using for its production of provender, grown on peat soils, it is possible under density of pollution in the soil 45 кBq·м$^{-2}$ on the area about 16000 hectares. For ^{90}Sr critical to receipt of milk and potatoes are the territories with density of pollution in the soil >10 кBq·м$^{-2}$ within the area of 10000 hectares.

The scenario for pollution of large areas under beyond design basis accident. The highest specific activities ^{137}Cs (See Figure 104), ^{90}Sr (See Figure 105), ^{131}I (See Figure 106) in the first day after fallouts are forecasted for leaf verdure and grasses used for provender, are found to be - 2-5·10^5 Bq·kg $^{-1}$ for ^{137}Cs and ^{131}I, up to 10^4 Bq·kg^{-1} for ^{90}Sr.



a) b)

Figure 104 – ^{137}Cs specific activity in agricultural products during (a) the first and (b) subsequent vegetation seasons after emergency fallouts



a) b)

Figure 105 – ^{90}Sr specific activity in agricultural products during (a) the first and (b) subsequent vegetation seasons after emergency fallouts

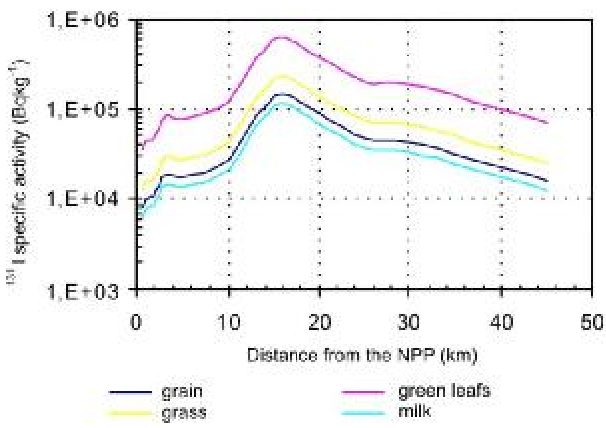


Figure 106 – ^{131}I specific activity in agricultural products during the first vegetation season after emergency fallouts

To a smaller degree probable pollution of the grain - not over 10^5 Bq·kg^{-1} for ^{137}Cs и ^{131}I. Minimum levels of pollution within the first vegetation season shall be expected for root- and tuber crops (<10^2 Bq·kg^{-1}), toughly closed from aerial fallouts, as well as products of animals breeding (<10^5 Bq·litre^{-1}). Such levels of pollution may be registered at a distance of 12-25 km from the NPP and up to 5-6 km in transverse direction from the axis of the trace under density of pollution in the soil for ^{137}Cs и ^{131}I being above 200 кBq·м$^{-2}$.

Under given scenario the beyond design basis accident exceeding the level A in the species of agricultural products may be observed on the territory of the area up to 750000 hectares, and the level B - up to 150000 hectares.

Contents of the radionuclides in the studied species of agricultural products on the territory of Lithuania at a distance over 20 km from the NPP is forecasted not more than by 5 times lower in comparison with maximum supposed values because of the smaller value of sedimentation for radionuclides on this at a distance (not more than 54 kBq·м$^{-2}$ ^{137}Cs and ^{131}I, <10 kBq·м$^{-2}$ for ^{90}Sr).

In the following, within the first vegetation period after fallouts the forecasted lowering of specific activities for radionuclides at a distance by 2 times each 15 days for ^{137}Cs and ^{90}Sr, 5-7 days for ^{131}I, under "dry" radiation materials. Thereby, exclusively at a distance under "dry" radionuclides with the surface plants through 20 days after the emergency exceeding the level B for contents ^{137}Cs in the highest critical to aerial surface the pollution in leaf verdure will be registered on the area not more than 102000 hectares, and through 40 days - < 65000 hectares, the level A - on the area of 600000 and 450000 hectares, respectively. Herewith the velocity for rectification of the surface plants will be in direct dependence from intensity and amount of the fallen precipitations

In the following years, the contents of radionuclides in agricultural products will be determined by the root delivery, and the highest specific activities for ^{137}Cs and ^{90}Sr are expected in the first years after the radiation fallouts. Amongst the investigated species of agricultural products the maximum specific activity for radionuclides is forecasted in grasses of provender in the course of the years. In grasses on peat-boggy soils the contents of both radionuclides may reach 2-4·10^3 Bq·kg^{-1} under maximum densities of pollution on axis of the trace. On soddy-podzol sandy soils contents of ^{137}Cs in grasses do not exceed 10^3 Bq·kg^{-1}, and for ^{90}Sr – ~50 Bq·kg^{-1}. The specific activity of ^{137}Cs in grains and potatoes under maximum density of pollution may reach ~ n ·10^2 Bq·kg $^{-1}$ for ^{137}Cs and up to n ·10^1 Bq·kg $^{-1}$ for ^{90}Sr.

Contents of ^{137}Cs in milk in the following vegetation season not exceed 100 Bq·l^{-1}, and ^{90}Sr constitute units Bq·l^{-1}. At a distance above 20 km from the NPP which corresponds to the distance to the border of the adjacent state, the specific activities are forecasted to be by 5 times less in comparison with the maximum values.

In the following years there will take place lowering of specific activities for radionuclides in the studied species of agricultural products, moreover the most intensive it is forecasted for ^{137}Cs: within the first 10 years after the emergency lowering constitute by 4-5 times, and within 20 years - by 10times. For ^{90}Sr it is getting not more intensive - by 2 times per each 20-25 years. Together with that, there will be necessary restrictions for consumption of the species of agricultural products on the restricted area and at remote stage after emergency. On termination of 10 years from the moment of emergency in grains, the root- and tuber crops exceeding of the permitted level for contents of ^{137}Cs is probable under density of pollution in the soil > 400 kBq·m^{-2} on the territory of the area 5000 equal to hectares. The volume activity for ^{137}Cs in milk is over 100 $Bq \cdot l^{-1}$ is possible under using for production of this product the provender, grown on peat soils, under density of pollution in the soil equal to 45 $kBq \cdot m^{-2}$ on the territory of the area about 100000 hectares. For ^{90}Sr critical to receipt of milk and potatoes there are densities of pollution in the soil >10 $kBq \cdot m^{-2}$ within the area of several hundreds hectares.

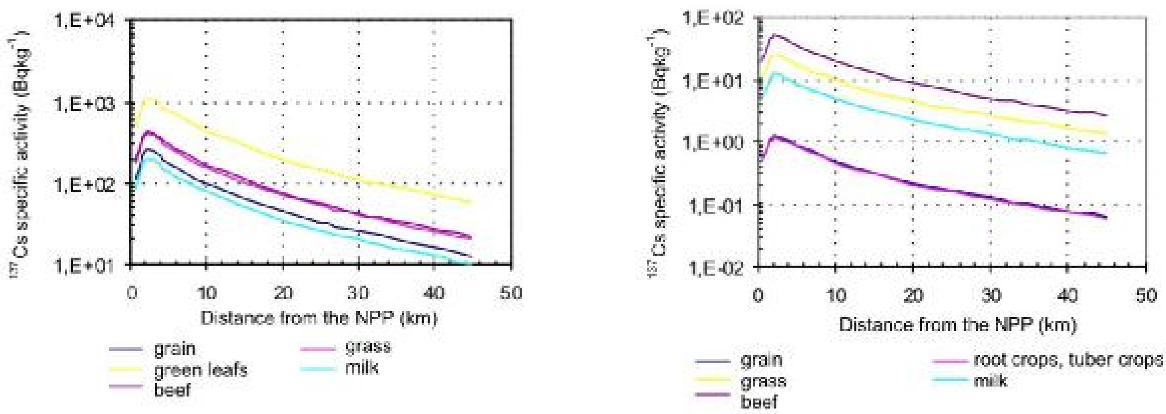
Maximum design-basis accident is the most probable variant for creation of radiation situation, connected with breach of operation at the NPP and the following emissions. However the levels of pollution in the environment will herewith be small. Exceeding density of pollution in the soil ^{137}Cs over 0.37 $kBq \cdot m^{-2}$ is forecasted on the area of 1000 hectares. For ^{131}I the area with density of pollution being above 37 $kBq \cdot m^{-2}$ constitute about 700 hectares, and from 3.7 to 37 $kBq \cdot m^{-2}$ – 12000 hectares.

The highest specific activities are forecasted in leaf verdure and grasses provender within the years on axis of the trace being up to до $7 \cdot 10^4$ $Bq \cdot kg^{-1}$ for ^{131}I, to 10^3 $Bq \cdot kg^{-1}$ for ^{137}Cs and to $\sim 10^2$ $Bq \cdot kg^{-1}$ for ^{90}Sr. Thereby, in leaf verdure there will be exceeded only contents of for at the level B within the area about 2000 hectares and at the level A- within 10000 hectares (See Figures 107 – 109)

To a smaller degree there will be polluted grains - not more than 10^2 $Bq \cdot kg^{-1}$ for ^{137}Cs, <10^4 $Bq \cdot kg^{-1}$ for ^{131}I and up to <20 $Bq \cdot kg^{-1}$ for ^{90}Sr. Alongside with removing from the axis of the trace the specific activity will fall and at distances over 800 m will not exceed the background values/

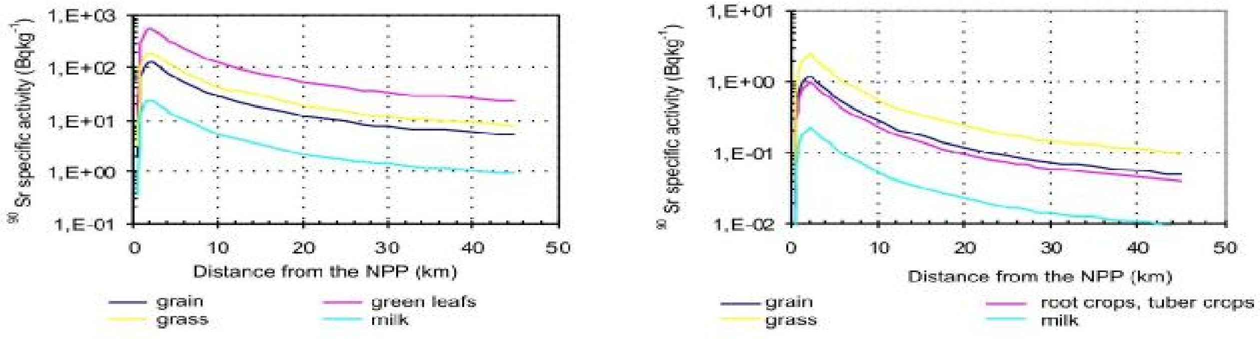
Contents of the radionuclides in the studied species of agricultural products at a distance over 20 km from the NPP is forecasted to be about by10 times lower in comparison with the maximum supposed values due to smaller value for sedimentation of radionuclides at a distance (not more than 0.28 $kBq \cdot m^{-2}$ for ^{137}Cs, 2.3 $kBq \cdot m^{-2}$ for ^{131}I, 0.075 $kBq \cdot m^{-2}$ for ^{90}Sr). Correspondingly there will lower and levels of contents for these radionuclides in all investigated species of agricultural products

Hereinafter, in the first vegetation period after the fallouts, there is forecasted lowering of specific activities at a distance for radionuclides in the studied species by 2 times each 15 days for ^{137}Cs and ^{90}Sr, 5-7 days for ^{131}I under " dry" radiation materials. However because of relatively low level of radiation pollution under a maximum design-basis accident through 20 days after the emergency the level B for contents of ^{131}I in leaf verdure will be registered on the area not more than 2000 hectares, and the level A - on the area of 6000 hectares.



a) b)

Figure 107 – ^{137}Cs specific activity in agricultural products during (a) the first and (b) subsequent vegetation seasons after emergency fallouts



a) b)

Figure 108 – ^{90}Sr specific activity in agricultural products during (a) the first and (b) subsequent vegetation seasons after emergency fallouts

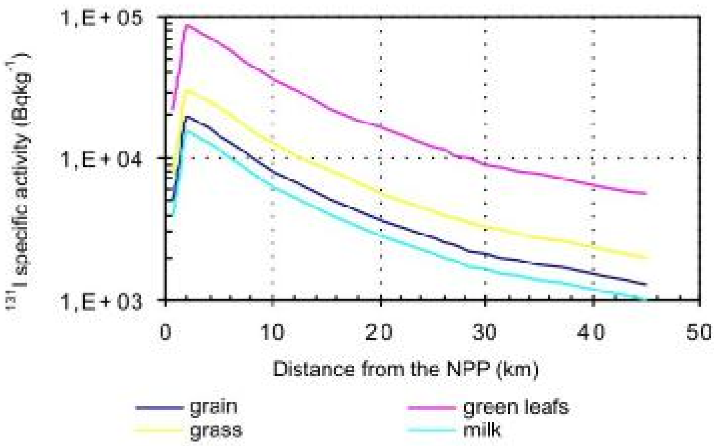


Figure 109 – ^{131}I specific activity in agricultural products during the first vegetation season after emergency fallouts

In the following vegetation season, contents of the radionuclides in agricultural products will be determined by the root delivery, however the specific activities for ^{137}Cs and ^{90}Sr will be extremely low and will not exceed the permitted standards about contents of radionuclides in agricultural raw material and provender even on the axis of the trace. In particular, the specific activity for ^{137}Cs in grasses, grown on peat soils, does not exceed 60 Bq·kg^{-1}, in milk - 20 Bq·l^{-1}, but in grains, root- and tuber crops - 1 Bq·l^{-1}. The specific activity for ^{90}Sr will be comparable with such for global fallouts: not more than 2 Bq·kg^{-1} in grasses and tenth shares of Bq·kg^{-1} in the rest species of agricultural products

14.5.3.7 Impact of ionizing irradiation on agricultural plants and animals under emergency situations

The irradiation under radiation of the emission delivered by *maximum design-basis accident* also will not render the radiation-induced impact due to small doses of ionizing irradiation. Dose -γ-irradiation from the stream of radiation gases and aerosols, expiring from the damaged containment, not exceed 4 mSv on the soil surface at distances up to 500 m from the NPP (at greater distance it scatters and there is created a cloud), the total dose from - β- and γ- -irradiation in the radioactive cloud fallouts does not exceed 0.4 mSv. Dose from γ-irradiation of radionuclides, fallen down on the ground, does not exceed 0.28 mSv·h^{-1} or 0.03 mSv within 1-st vegetation season. The indicated of dose specifications for the order of the values comparable with natural radioactive background and on this reason also will not cause radiation-induced impact on the biota.

Beyond design basis accident is accompanied with delivery into the environment of broad spectrum of radionuclides with large activity that will bring about creation of significant doses for the ionizing irradiation.

Maximum doses will be formed from the stream of gas and aerosols radiation at distances up to 500 m from the NPP. Closely to the level of the surface soil the accumulated equivalent dose from the external -irradiation may reach 3.6 Sv within the time of the emission.

Within the area of maximum sedimentation for radiation materials at a distance of 500-7500 m from the NPP the total dose for γ- и β-irradiation in the cloud radiation fallouts does not exceed 1 Sv. The dose for external -irradiation from the radionuclides, fallen down on the ground, does not exceed 200 μSv·h^{-1} in the first hours after fallouts, as a whole, within the first vegetation season the dose for external –irradiation does not exceed 130 mSv (See Figure110).

Alongside with removal from the NPP the doses will fall and at a distance of 20 km from the axis of the trace they will be by 10 times less in comparison with those shown above, through 70 km - by 10 times more.

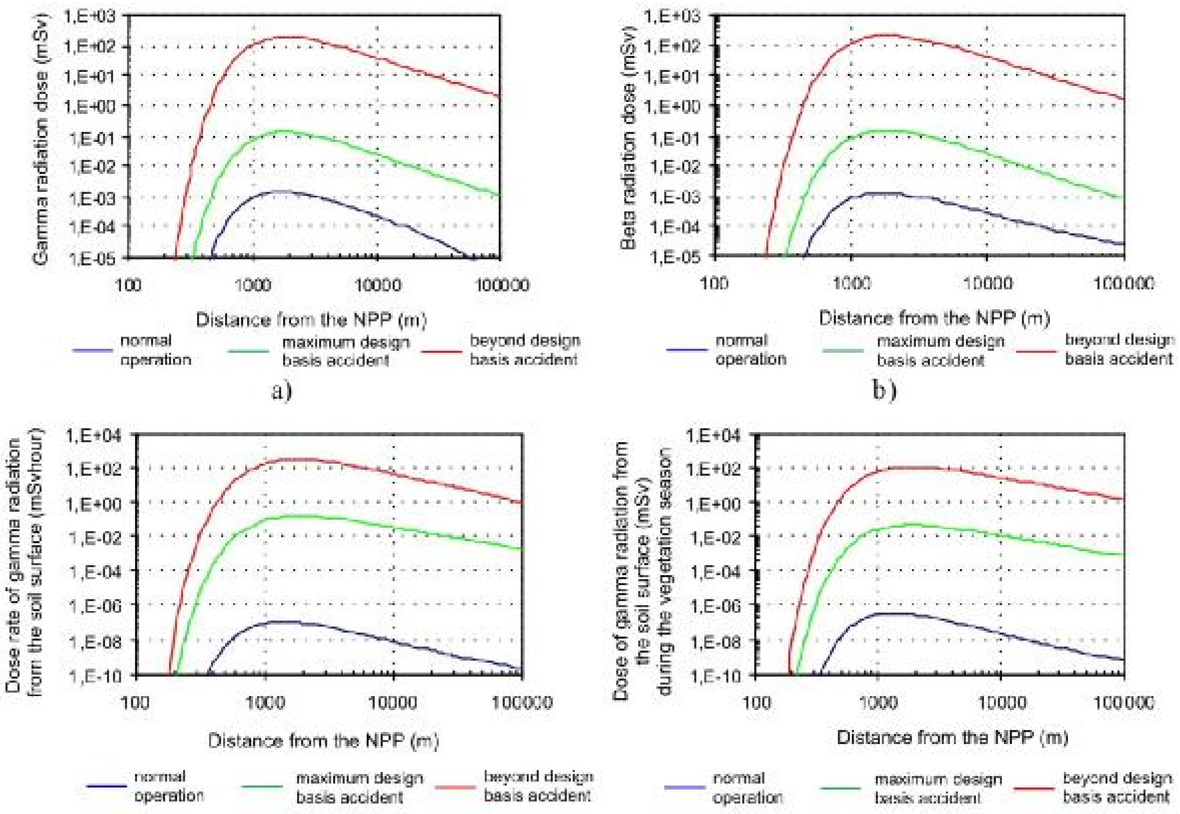


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Figure 110 – Forecasted doses from external gamma radiation in gases and aerosols (a), from external beta radiation in the cloud (b), dose rates of external gamma radiation from the soil surface (c), doses of external gamma radiation from the soil surface during the vegetation period (d)

The doses of internal irradiation for animals (up to 200 mSv on the body and up to 50 Sv on a thyroid gland) executed for maximum unfavorable variants of 20 daily pasture for animals on the axis of the trace within the area of maximum sedimentation for radionuclides (density of the soil pollution for ^{137}Cs and ^{131}I up to 20000 $kBq \cdot m^{-2}$). Considerable uncertainty of the given assessment connected with lowering of contents for radionuclides in herbs of natural pastures in the first vegetation period under emergency precipitations, in that time, as in organism of the animals contents of radionuclides, opposite, increases in the course of time. Besides, it is obvious, that within the area having maximum sedimentation of radionuclides, animals will not be pastured during 20 days, therefore, the indicated values are very approximate and reflect maximum permissible of doses for loads.

The indicated doses are considerably lower in comparison with the range of the doses values, under which there are fixed losses of the crop of agricultural plants and animals [181 - 183]. It is well known, that from the agricultural plants cereals and some species of bob are featured with the most sensitivity for radiation, for which there is observed 50 % lowering of crop within the range of doses for sharp -γ-irradiation 5-10 Gy. For agricultural animals the range of doses from sharp external γ-irradiation constitutes 3-4 Gy. Indicated within the range of considerably lower forecasted doses under sharp irradiation in the event of beyond design basis accident

For animals the doses from external β- и γ-irradiation will be considerably lower, which is connected with a number of reasons. The plants are constantly found in the area of irradiation, the animals may come out of its limits, and the pasture even in summer time occurs only during the determined time. Besides, the skin and woolly cover of the animals to a considerable degree is capable to shield β-particles, kept by this surface. Correspondingly, even under the most conservative estimations, it is obvious that the dose from β-irradiation must be as minimum by 2 times lower. Together with that, the doses on the thyroid gland of animals under the above shown conditions for pasture, could cause breaches for this organ functioning. For the animals using pasture within the area with maximum sedimentation of radiation materials there are possible some deviations in work of the organs in the system of blood creation and breaches of immune status, fixed by means of special biochemical methods.

14.5.3.8 Levels of pollution with radionuclide Cs-137 of various components in the lake of ecosystems under maximum design-basis accident and beyond design basis accident

In accordance with the model calculations, in the event of maximum design-basis accident the density for radiation pollution with ***^{137}Cs*** may vary within the limits 0.5 - 5 kBq/m^2. In water basins at the expense of the radionuclides delivery from the water collecting territory the contents of radionuclides may reach high values. On the process of migration for radionuclides into the system "water collection-lake" affect many factors. Amongst them is the specific area for water collection, nature of the ground, composition of vegetation, moisture and many others. About 80 % of the territory within 30-km area around the area occupies the soil, in which mobility of ^{137}Cs was low and very low, and considerable part of water collection territories is covered with timber and marsh vegetation, effectively keeping radionuclides, that is why it is possible to expect that the velocity for delivery of radionuclides and their quantity will not be so great. Considerable part (up to 90 %) of the radionuclides received by the water basin will be absorbed by the bottom sedimentation and extracted from the biotic rotation. The remained part will not render observed impact upon the structure and operation of the lake ecosystems.

Under the undesigned emergencies under the level of pollution for water collecting territory with radio cesium up to 5000 kBq/m^2 there is possible to have danger accumulation of radionuclides in final sections of the food chains (predatory fish) up to the level, presenting danger for human health.

For assessment of behavior of radionuclides in the lake ecosystems under the beyond design basis accident there was used software of the type MOIRA-PLUS DSS (A model based computerized system for management support to identify optimal remedial strategies for restoring radionuclide contaminated aquatic ecosystems. Decision Support System). As the object for modeling there was chosen the lake of Sviri, located on the border within 30 km area of the NPP impact. For assessment of the level for pollution at the water collecting territory there was used the data from РЦРКМ, received on the grounds of modeling for atmospheric transfer of radionuclides.

In Figure 111 there is shown the result of modeling for the level of pollution with radionuclide ^{137}Cs for various components in the lake ecosystems and their change in the course of time. According to the model calculation, a large part of pollution within a short interval of time (2-3 months) will be connected in the bottom sediments. Fine disperse biological structures (phytoplankton and bacteria, particles of detritus, suspended products from metabolism of plankton) and allochthonic suspension, possessing considerable absorption surface, actively accumulate radionuclides and in the process of sedimentation carry them from the water thick masses into the bottom sediments. The process of sedimentation in the determined amount is controlled by the biological processes, modifying the amount spectrum of the sediments. Such processes are the microbe aggregation of fine disperse sediments and fecal separations from the zooplankton. Under average velocities for sedimentation is less one meter or about one meter in the daily velocity of sedimentation for fecal fallouts and fragments constitute tens and hundreds of meters per one day. Thereby, the radionuclides delivered into the water basin, are pumped sufficiently quickly from water thick masses into the bottom sediments.

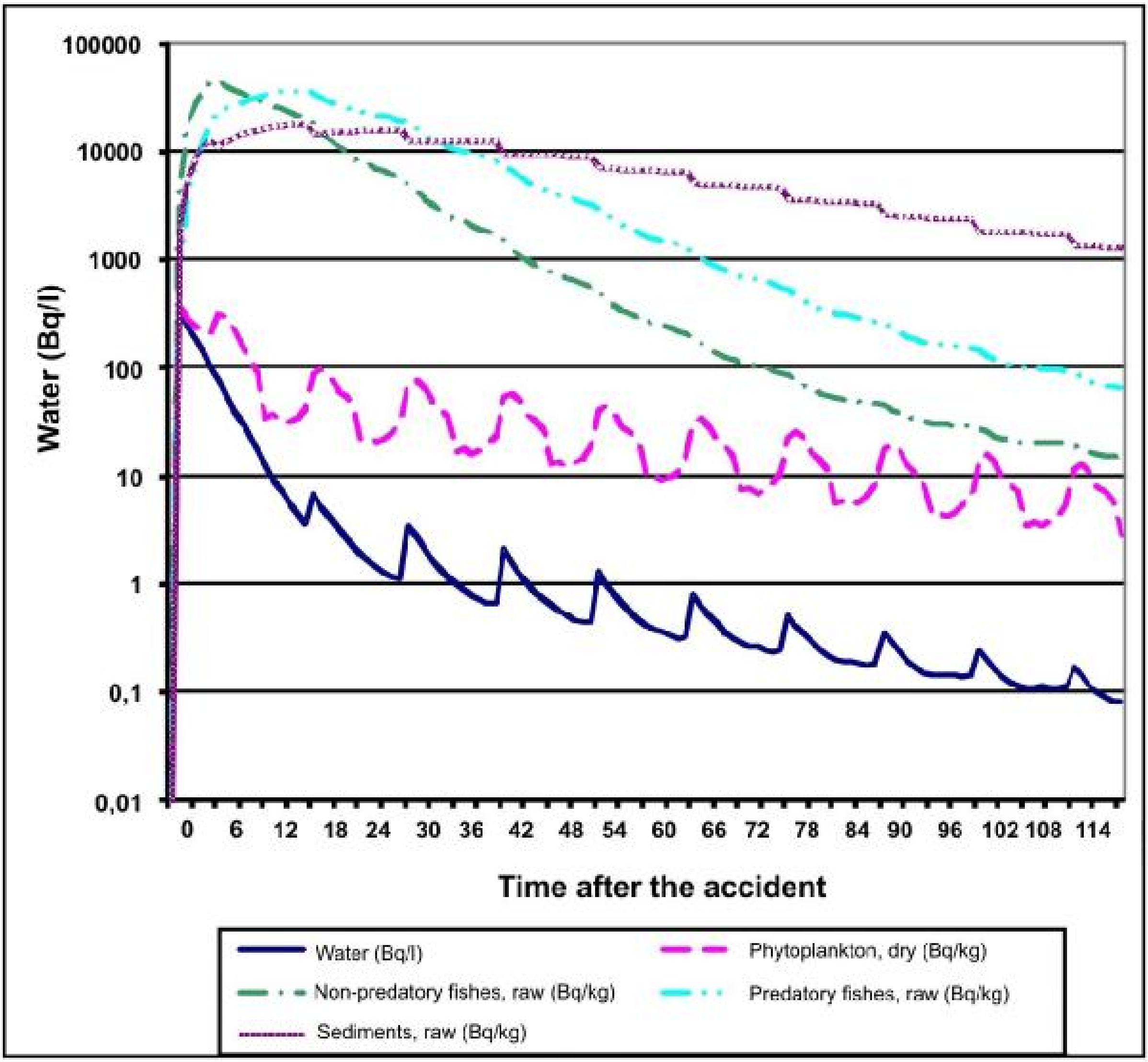

Figure 111 – ^{137}Cs content in water, bottom sediments, phytoplankton and bodies of non-predatory and predatory fishes in case of an accident beyond the design basis

The biological structures constantly creating in the process of photosynthesis, there are shown for phytoplankton, periphyton, macrophytes, as well as the products of their transformation – detritus and heterotrophic organisms, immobilize radionuclides, including them into the biomass composition. The radionuclides transformed into the sedimentation form migrate along the food chain, accumulating in the biomass. The levels of pollution for initial (the phytoplankton) and final (peace and predator species of fish) sections in the food chains noticeably differ. The peaceful species if fish reach maximum pollution through 6 months after the emergency, but the predator species through 15. Hereinafter in the lake there is tracked proper lowering of the pollution level for all components of ecosystems, conditioned by natural emission of polluting materials and low migration of radionuclides with water collection. On this background there are well tracked periodical summer oscillations of contents for radio cesium in the waters and other components of lake ecosystems, conditioned by so named secondary pollution of water masses at the expense of throwing out the radionuclides from the bottom sediments.

From the model calculations it follows that under beyond design basis accident the levels of pollution with radio cesium for peaceful e and predator fish reach the values dangerous for human being, however on functioning of the lake ecosystems this not will not make any impact.

14.5.4 Expected doses of irradiation for the population under maximum design-basis accident at the energy unit

14.5.4.1 General provisions

All modes of design emergences may be divided into three groups:
1) emergency with emission of the fissions products into containment;
2) emergency with drainage from the first contour into the second;
3) emergency with bypass of containment.

The most dangerous emergencies from the first group from the standpoint of the degree for active area damage are the modes "Instant jamming of the main circulation pumping unit" and " The mode of large flow: breakup of water piping lines in the first contour with the diameter over 100 mm, including Du 850", in which there is taking place loss of sealing 100 % for the fuel element in the active area. During the rest of emergencies from the first group for the fuel element additional loss of sealing does not take place. So the rest of the modes from the first group must have smaller radiation consequences. The exception may be only the emergency with small drain of heat carrier and fail of the sprinkler system operation.

As maximum design-basis accident there is considered the mode large flow: breakup of piping lines in the first contour with the diameter over 100 mm. As conservative one there is taken admission about 100 % of losing sealing. In the result of breakup in the first contour piping lines there is taking place drain from the first contour heat carrier and, as the effect, the pressure increasing in the containment [184].

The calculation of activities for radionuclides during emergency emission and doses for irradiation of the population was executed with use of the package InterRAS (The International Radiological Assessment System), which is intended for use of specialists, executing assessment of radiological emergences [185].

The package is designed on the base of the program U.S. NRC's RASCAL (Radiological Assessment Consequences Analyses) and is based on the document "International main standards for protection from ionizing irradiation and safety radiation sources" [186].

There was used the model “source of the emission – dose”, which estimates integrated doses, forming in the result of emergency emission with radionuclides into the atmosphere. The model allows to evaluate the consequences of the potential or occurring at the this moment emission under using the row of admissions and introductions of the data, concerning conditions of the station, meteoconditions, state of the environment [187].

In the calculations there were used determined admissions, which enabled to get scientifically motivated upper levels of doses for irradiation of the population as a result of possible emergency on the Belarusian NPP.

The emission of radionuclides into the environment at the expense of leakage through loss of density in the containment was calculated for 1 day (24 hours).

The emission is chosen as being near the ground since in the event of the near ground emission there will be formed super high levels of doses for irradiation at considerable distance from the source of the emission.

The parameters of the model, used in the calculation, are shown in Table 143.

Table 143 Parameters of the model, used in calculation

Parameter	Value
Operation power of WWER-1200 at the moment of emergency	3200 MW (heat)
Condition of the active area	100 % emission of flying fission products
Power of the emission with radionuclides from the active area	0.004 %/hour (project)
Mechanisms for diminishing of the emission	Sprinkler switched on, filters inoperable
Height of the emission	0 м (near the ground)
Free volume of containment	71040 m^3
Area of surfaces in containment	53250 m^2

For modeling of radionuclides transfer into the atmosphere there were considered 13 scenarios of possible meteoconditions and are chosen the worst i.e. such scenarios, under which the doses of the population irradiation will be maximum (the prognosis data of the fields having meteorological parameters for March 17, 2009, corresponding to the winter period, and for May 9, 2009, corresponding to the summer period) (Table 144, 145).

Table - 144 Meteorological conditions according to the state of 17.03.2009

Parameter	Value
Direction of wind	Western with transition to south-west
Velocity of wind	5.5 -11 m/sec
Pressure	1008.0 gPa
Temperature of the air	-2.5 – -1.5 within night and morning hours 3.7-1.8 – in the day and evening
Cloudicity	0 %
Height of the layer for mixing	1.2 - 1.5 km at night 0.5 - 0.3 km in the daytime and evening
Category of the atmosphere stability	F
Intensity of precipitations	From 1 to 4 mm/hour
Snow cover	Snow cover with height from 1 to 15 cm

Table - 145 - Meteorological conditions according to the state of 9.05.2009 г.

Parameter	Value
Direction of wind	south-west
Velocity of wind	6.4 – 6.7 m/sec
Pressure	993.7 gPa
Temperature of the air	20 °C
Cloudicity	100%
Height of the layer for mixing	0.6 km
Category of the atmosphere stability	D
Intensity of precipitations	absent

As for maximum design accident, and so for the beyond design basis accident there was calculated the radionuclides emission into the environment as a result of an accident:

$$Выброс = FPI_i \cdot CRF_i \cdot \prod_{j=1}^{N} RDF_{(i.j)} \cdot EF_i \qquad (8)$$

where FPI_i is the total quantity of radionuclides *i* in active area;

CRF_i is the ratio of radionuclides quantities thrown away from the active area *i* to the general quantity of radionuclides *i* in the active area;

RDF_i is the share of radionuclides *i* activities, available in the emission after action of the diminishing mechanism *j*;

EF is the share of activities, available in the emission, which was thrown out.

For the maximum design-basis accident there are calculated the following doses for irradiation, formed during early stage of emergency:

1) total effective dose (Et), which forms from the following constituent elements: effective half-century doses from inhalation, doses in consequence of irradiation from the cloud and the doses, formed during seven days from the fallouts;

2) the dose of irradiation over the thyroid gland ($D_{щж}$) from inhalation delivery of radionuclides, which presents by itself the dose for irradiation over thyroid gland of the adult person under execution by him of light activity;

3) the dose of irradiation from the cloud (D_{CS}), formed in consequence of external irradiation from passing cloud;

4) dose from fallouts (D_{GS}), formed in consequence of external irradiation from fallouts during seven days;

5) effective dose delivered from inhalation delivery of radionuclides (D_{inhal}), presenting by itself half-century effective dose for irradiation of the adult person in consequence of inhalation radionuclides [185, 188].

By means of the model (program suite) InterRAS there was executed assessment of the values for the above indicated doses of irradiation for the population, living at a distance up to 50 km from the source of the emission

There are calculated doses for irradiation: initial period of emergency (within a day, 1 month, 2 months), forming at the expense of external irradiation from fallouts and of internal irradiation in consequence of inhalation delivery radionuclides under secondary dust creation, and permanent doses (within a period of 50 years).

At calculation of doses for irradiation there were not taken into account the factors, influencing upon their diminishing (location inside the premises) i.e. there was arranged conservative assessment. Actual doses for irradiation of the population will be considerably less those calculated.

14.5.4.2 The calculation results for doses of irradiation over the population under maximum design-basis accident

The total emission of radionuclides into the environment under the maximum design-basis accidents for all scenarios constitute 1.1×10^{14} Bq (Table 146).

Table 146 - Surge of radionuclides into the environment as a result of maximum design-basis accidents, Bq

Radionuclide	Activity, Bq	Radionuclide	Activity, Bq
Kr-85	1.10E+11	Kr-85m	4.40E+12
Kr-88	1.30E+13	I-131	4.70E+11
I-132	6.70E+11	I-133	9.50E+11
I-135	8.30E+11	Xe-131m	1.80E+11
Xe-133m	1.10E+12	Xe-135	6.10E+12
Cs-134	4.20E+10	Cs-136	1.70E+10
Rb-88	1.30E+13	Ba-137m	2.70E+10
Kr-87	8.90E+12	Xe-133	3.20E+13
Xe-135m	1.30E+11	Xe-138	3.20E+13
I-134	1.00E+12	Cs-137	2.70E+10

The calculation results for the doses of irradiation over population, executed with the help of program pack InterRAS, shown in Table 147 and in Figures 112 - 115.

Table 147 - **The forecast results for doses of irradiation over the population under «summer » scenario of maximum design-basis ac cidents, mSv (mGy)**

Distance, km	Dose from the clowd, mSv	Dose from fallouts, mSv	Effective inhalation dose, mSv	Total effective dose, mSv	Dose for irradiation over thyroid gland *, mGy
1	0.021	0.019	0.068	0.110	1.700
2	0.015	0.011	0.040	0.066	1.000
5	–**	–	0.019	0.030	0.480
25	–	–	–	–	0.029
50	–	–	–	–	0.022

* Dose for irradiation over thyroid gland comprises only the doses from the iodin radiation.
** All values lower 10 µSv were considered as zero.

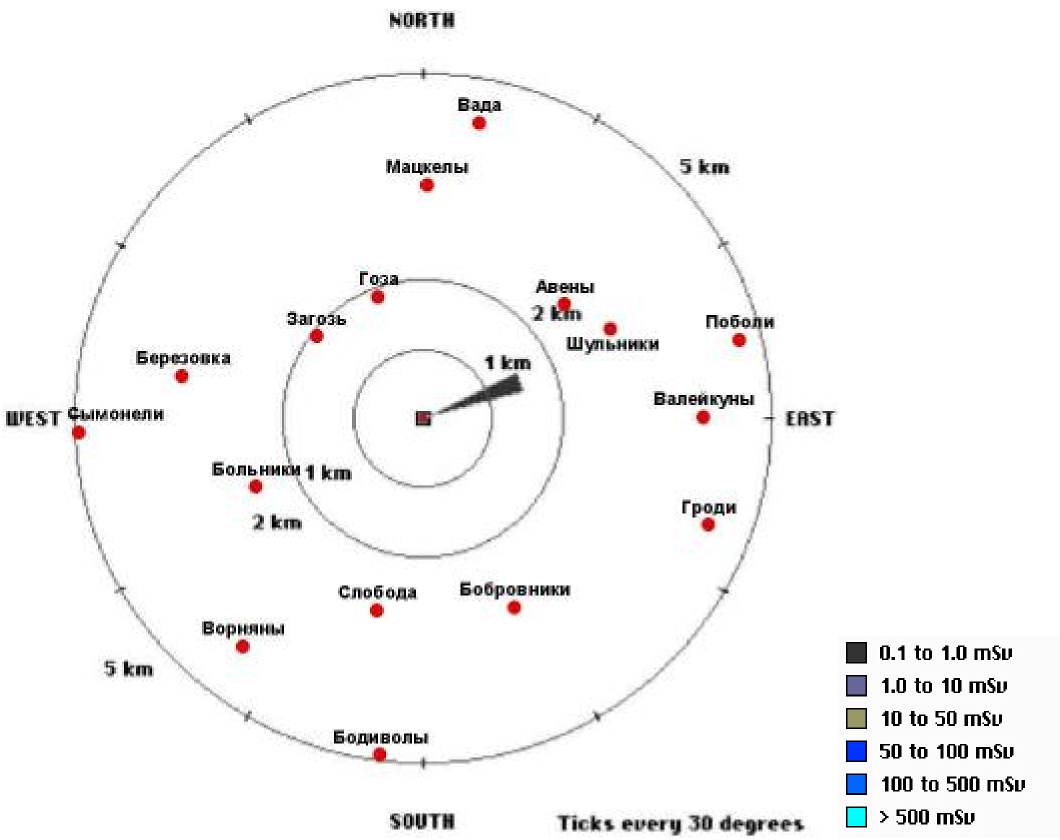

Figure 112 – Total effective dose within the near area around NPP under "winter" scenario of maximum design-basis accidents, mSv

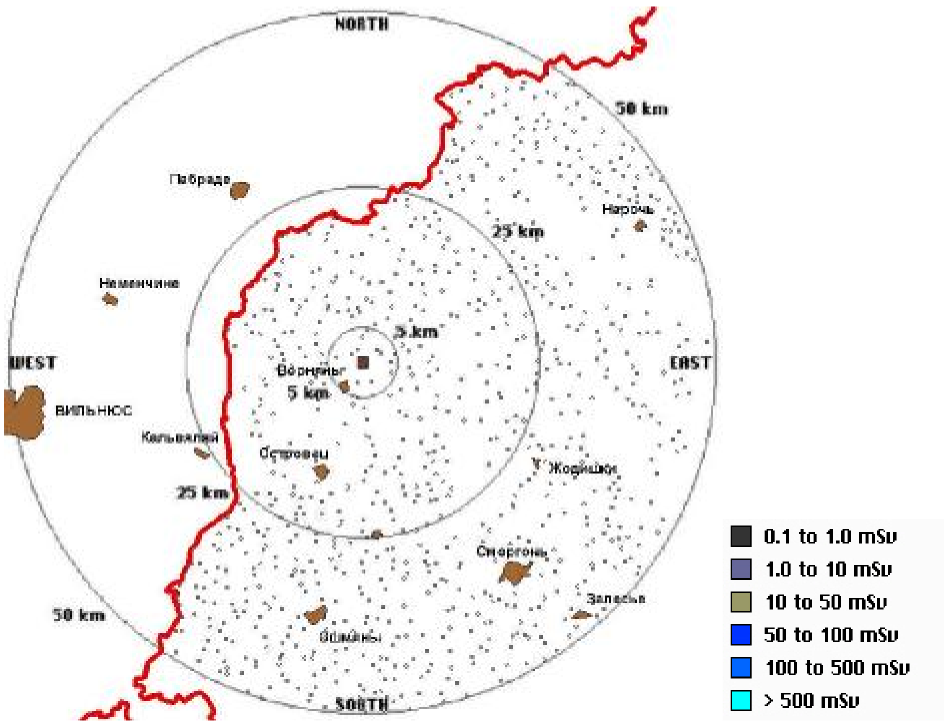

Figure 113 – Total effective dose within the remote area around NPP under «winter» scenario of maximum design-basis accidents, mSv

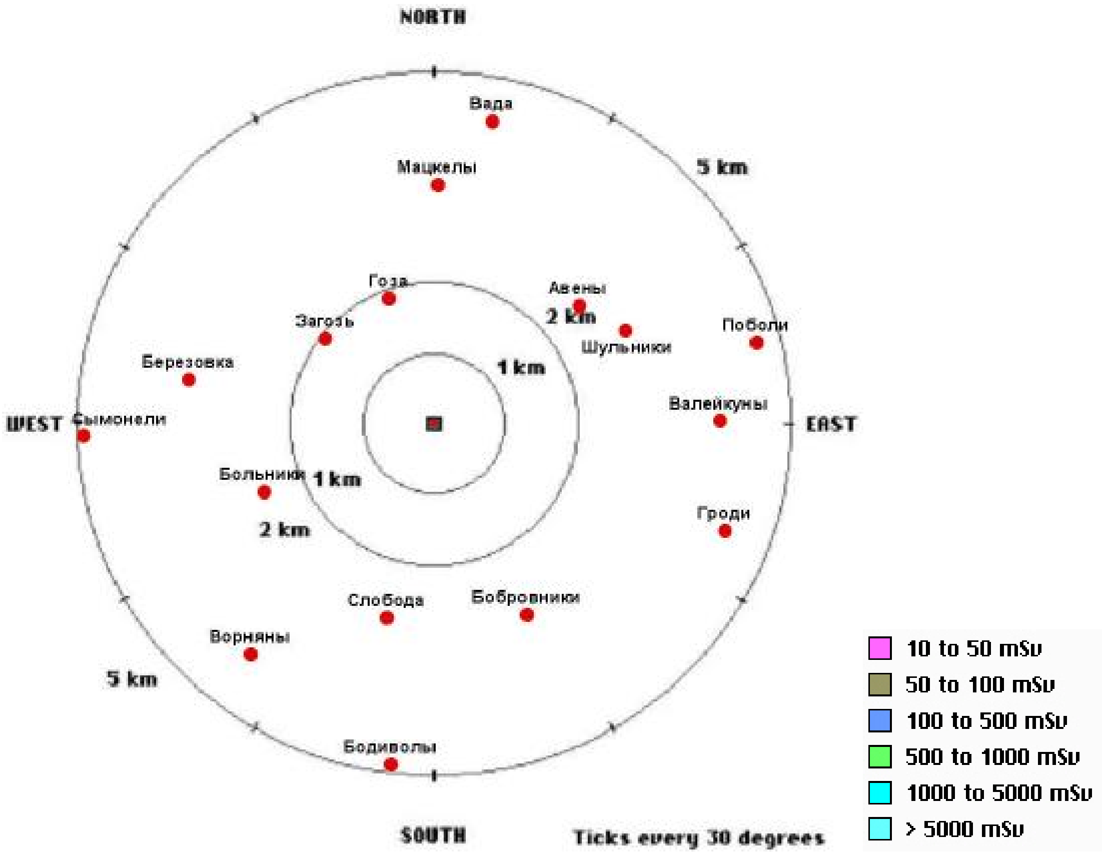

Figure 114 – Doses of irradiation over the thyroid gland within the near area around NPP under «winter» scenario of maximum design-basis accidents, mSv (mGy)

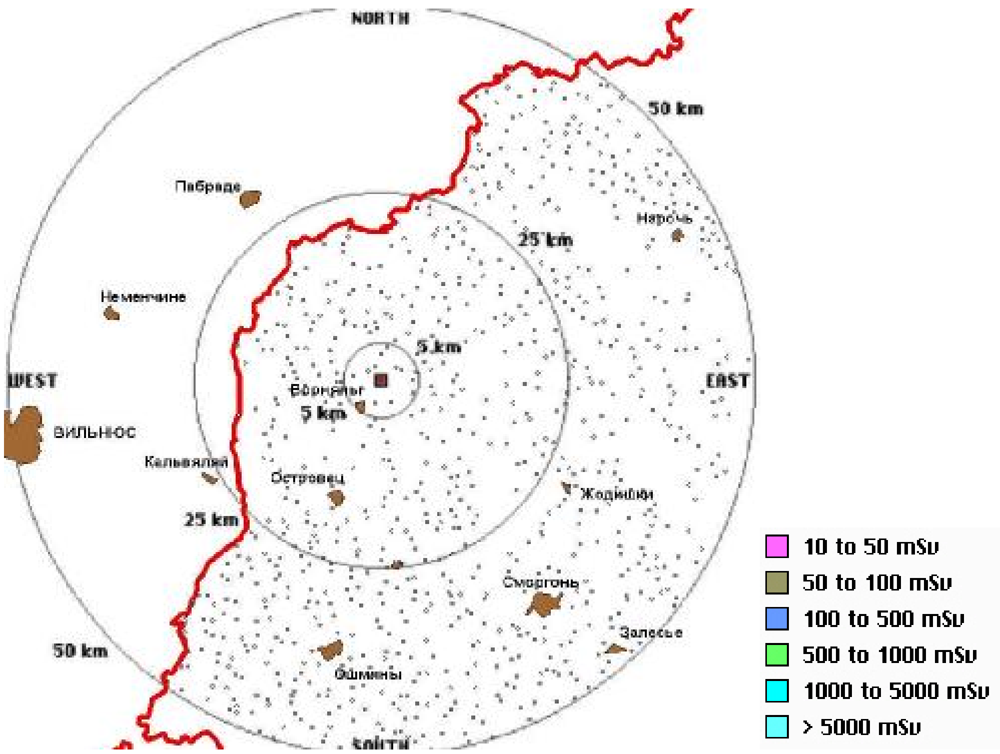

Figure 115 – Doses of irradiation over the thyroid gland within the remote area around NPP under «winter» scenario of maximum design-basis accidents, mSv (mGy)

The results of forecast doses for irradiation under «summer» scenario and emergency are shown in Table 148.

Table 148 - The results of forecast for doses of irradiation over population under the «summer scenario» of maximum design-basis accidents, mSv (mGy)

Distance, km	Dose from the clowd, mSv	Dose from fallouts, mSv	Effective inhalation dose, mSv	Total effective dose, mSv	Dose for irradiation over thyroid gland *, mGy
1	0.01	–**	0.03	0.06	0.88
2	–	–	0.01	0.02	0.37
5	–	–	–	–	0.11
25	–	–	–	–	–
50	–	–	–	–	–

* The dose of irradiation over the thyroid gland was calculated only from iodin.
** All the values lower 10 μSv were considered as zero.

14.5.4.3 Dose of internal irradiation over the population at peroral delivery of radionuclides under maximum design-basis accident

The dose from delivery of radionuclides with food-stuffs is calculated on the formula:

$$\sum_{i}^{n}(C_{f,i} \times U_{fi} \times DI_{i} \times CF_{5.i}) \times \prod RF_{f} = E_{ing} \qquad (9)$$

where $C_{f,i}$ - activity radionuclide *i* in the product *f*, kBq/kg;

$U_{f,i}$ – quantity of product *f*, consumed by the considered population per one day, kg/day or l/day (Tables 149, 150);

DI_i - the period for consumption of the product in days. In the event when $T_{1/2}$ exceeds 21 day, there are used 30 days. If the $T_{1/2}$ is not more than 21 day, is used for assessment of the average period of the isotope life:

$$T_m = T_{1/2} \times 1.44 \qquad (10)$$

where $T_{1/2}$ - the period of half-life for radionuclide;

$CF_{5,i}$ – the factor of transition to doses, mSv/kBq. The coefficients of transition to the doses of irradiation from delivery of radionuclides with food staff are shown in Table 151;

RF – the factor of diminishing (the factor for processing), equal to the share of radionuclide, remained after its natural disintegration or processing the products before consumption. In the given event the factor of milk processing is accepted to be equal to 1 i.e. processing is absent (conservative assessment) [184.185.189].

E_{ing} - effective dose from delivery with meals

Table 149 - Consumption of milk, l/day

Age, years	Rural	Urban
0-1	0.24	0.30
1-2	0.30	0.22
2-7	0.30	0.20
7-12	0.50	0.25
12-17	0.51	0.25
over 17	0.50	0.20

Table 150 - Consumption of leaf vegetables, g/day

Age, years	Rural	Urban
0-1	0	0
1-2	3	3
2-7	6	7
7-12	20	18
12-17	28	25
over 17	30	25

Table 151 - Factor of transition of doses from radionuclides delivery with food stuff, mSv /kBq

Radionuclide	children under 1 year	children of 1-2 years	children of 2-7 years	children of 7-12 years	children of 12-17 years	adults over 17 years
Cs-137	2.1E-02	1.2E-02	9.6E-03	1.0E-02	1.3E-02	1.3E-02
I-131	1.8E-01	1.8E-01	1.0E-01	5.2E-02	3.4E-02	2.2E-02

Below there are shown the results of modeling for doses, formed with biologically significant radionuclides: Cs-137 and I-131.

For the worst summer scenario of the maximum design-basis accident (doses of irradiation are maximum) there is executed assessment of doses for the internal irradiation over the population at the expense of peroral delivery for radionuclides Cs-137 and I-131 at consumption of milk and leaf vegetables (Tables 152 – 155).

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Table 152 - Doses of internal irradiation over the population at the expense of peroral delivery of milk, polluted with Cs-137 within 30 days after the emergency, mSv

Category of population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density of the soil pollution with Cs-137, kBq/m^2									
	170	210	360	530	910	230	150	100	130	78
children 0-1 years	1.956	2.416	4.141	6.097	10.468	2.646	1.725	1.150	1.495	0.897
children 1-2 years	1.397	1.725	2.958	4.355	7.477	1.890	1.232	0.822	1.068	0.641
children 2-7 years	1.117	1.380	2.366	3.484	5.982	1.512	0.986	0.657	0.855	0.513
children 7-12 years	1.940	2.397	4.108	6.048	10.385	2.625	1.712	1.141	1.484	0.890
children 12-17 years	2.572	3.178	5.448	8.020	13.770	3.480	2.270	1.513	1.967	1.180
adults (over 17 years)	2.522	3.115	5.341	7.863	13.500	3.412	2.225	1.484	1.929	1.157

Table 153 - Doses of internal irradiation over the population at the expense of peroral delivery of milk, polluted with I-131 within 30 days after the emergency, mSv

Category of population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density of the soil pollution with Cs-137, kBq/m^2									
	1200	2100	2900	3800	6400	2400	1200	870	970	630
children 0-1 years	56.01	98.01	135.35	177.35	298.70	112.01	56.01	40.60	45.27	29.40
children 1-2 years	70.01	122.51	169.19	221.69	373.38	140.02	70.01	50.76	56.59	36.75
children 2-7 years	38.89	68.06	93.99	123.16	207.43	77.79	38.89	28.20	31.44	20.42
children 7-12 years	33.71	58.99	81.46	106.74	179.77	67.42	33.71	24.44	27.25	17.70
children 12-17 years	22.48	39.34	54.33	71.19	119.90	44.96	22.48	16.30	18.17	11.80
adults (over 17 years)	14.26	24.96	34.46	45.16	76.06	28.52	14.26	10.34	11.53	7.49

Table 154 - Doses of internal irradiation over the population at the expense of peroral delivery of leaf vegetables, polluted with Cs-137 within 30 days after the emergency, mSv

Category population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density of the soil pollution with Cs-137, kBq/m^2									
	170	210	360	530	910	230	150	100	130	78
children 1-2 years	0.080	0.099	0.169	0.249	0.427	0.108	0.070	0.047	0.061	0.037
children 2-7 years	0.128	0.158	0.270	0.398	0.684	0.173	0.113	0.075	0.098	0.059
children 7-12 years	0.443	0.548	0.939	1.382	2.373	0.600	0.391	0.261	0.339	0.203
children 12-17 years	0.807	0.997	1.709	2.516	4.320	1.092	0.712	0.475	0.617	0.370
adults (over 17 years)	0.865	1.068	1.831	2.696	4.628	1.170	0.763	0.509	0.661	0.397

Table 155 - Doses of internal irradiation over the population at the expense of peroral delivery of leaf vegetables, polluted with I-131 within 30 days after the emergency, mSv

Category population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density pollution soil I-131, кBq/м^2									
	1200	2100	2900	3800	6400	2400	1200	870	970	630
children 1-2 years	4.00	7.00	9.66	12.66	21.32	8.00	4.00	2.90	3.23	2.10
children 2-7 years	4.44	7.77	10.74	14.07	23.69	8.88	4.44	3.22	3.59	2.33
children 7-12 years	7.70	13.48	18.61	24.38	41.07	15.40	7.70	5.58	6.22	4.04
children 12-17 years	7.05	12.33	17.03	22.32	37.59	14.10	7.05	5.11	5.70	3.70
adults (over 17 years)	4.89	8.55	11.81	15.47	26.06	9.77	4.89	3.54	3.95	2.57

As may be seen from Tables 161 - 164, the highest doses for irradiation from consumption of feeding products polluted with cesium-137 are observed for adults senior 17 years, the highest doses of irradiation from consumption of feeding products polluted with iodine-131 – for children under two years. In accordance with NRB-2000 the forecasted levels of doses at beyond design basis accident indicate the necessity for execution of protective actions [19].

14.5.5 Expected doses for irradiation over the population under the beyond design basis accident at the energy unit

14.5.5.1 General provisions

Analysis of the undesigned emergences is executed with the aim for determination of the borders for the area of planning urgent protective measures and the area of preventive protective measures [185.188].

Radiation safety under radiation emergency is provided by observance of normative values founded, mainly, on dose specifications. For this reason assessment of doses for irradiation under the beyond design basis accident is a key task to execute analysis over the emergence situation [19.190].

The results of given section are the reference data for the paragraph EIA, in which the obtained here of doses specifications are compared with the criterion for safety in the international normative documents.

In given section there are estimated maximum doses for sharp and long lasting irradiation, the estimated contribution from all ways of irradiation, as well as estimated the doses as functions of the distance from the NPP.

The doses specifications were estimated from two positions:

- doses for the initial period of emergency (per one hour, day, 1 month, 2 months);
- long lasting doses (per period of 50 years).

As beyond design basis accident there was taken emergency, under which occurs drain from protective shells in dry state. This scenario expects emission from the active area of reactor, which is typical under melting of the active area. Is it also expected that the emission into the protective shell of the reactor passes in dry state through the system of the first contour, not passing through other systems, which could hold down iodine or other flying products of fission. Concentration of iodine and/or other flying products of fission into the protective shell of the reactor may be diminished before being thrown into the atmosphere thanks to several factors: operation of the sprinklers system, filtering of the emission and/or natural process of disintegration. This diminishing is a function of time for holding down. In the given event the time for holding down is zero i.e. drain from the reactor began immediately. The systems of sprinkling and ventilation are unplugged. The emission is taken as a near ground process, there was taken into account the effect of the wake from the buildings and constructions, leading to greater diffusing for radionuclides around the station. The given conditions are chosen with the aim for consideration of the worst beyond design basis accident scenario.

Parameters of the model are shown in Table 156.

Table 156 - Parameters of the model, used in the calculation

Parameter	Value
Operation power of the WWER-1200 at the moment of emergency	3200 MW (heat)
Condition of the active area	10-50 % melting of the active area (quick emission of flying products of fission)
Power of the emission with radionuclides from the active area	0.02 %/hour
Mechanisms for diminishing of the emission	Sprinkling is switched off, filters inoperable
Height of the emission	0 м (near ground)
Free volume containment	71040 m^3
Area of surfaces in containment	53250 m^2

For beyond design basis accident and for maximum design-basis accident, there were calculated the following doses for irradiation, formed during the early stage of emergency:

1) total effective dose (E_t);
2) dose for irradiation over thyroid gland ($D_{щж}$);
3) dose for irradiation from radiation after passing of the cloud (D_{CS});
4) dose, obtained from fallouts (D_{GS});
5) effective dose obtained from inhalation delivery of radionuclides (D_{inhal}).

By means of the model IntrerRAS there was executed evaluation of the values for the above mentioned doses for irradiation over the population, living at a distance up to 50 km from the source of the emission.

There were calculated the doses for irradiation: initial period of emergency (per one day, the first month, the second month), forming at the expense of external irradiation from fallouts and internal irradiation in the consequence of inhalation delivery of radionuclides under secondary dust creation, and long lasting doses (within the period of 50 years).

During calculation of doses for irradiation there were not taken into account the factors, influencing upon their diminishing (location inside the premises) i.e. there was organized conservative assessment. Actual doses for irradiation over the population will considerably be less the calculated ones [185].

Meteorological conditions, under which the doses for irradiation over the population will be maximum, similar to meteorological conditions for maximum design-basis accident, shown above in Tables 144, 145 [191].

Assessment of doses for irradiation over the population were executed with supposition that the population constantly stay at the open terrain (conservative assessment).

14.5.5.2 Results of calculations for doses of irradiation over the population under beyond design basis accident

For the calculations there was used the following emission of radionuclides into the environment under the beyond design basis accident, Bq (Table 157).

Table 157– Surge of radionuclides into the environment at beyond design basis accident, Bq

Radionuclide	Activity, Bq	Radionuclide	Activity, Bq	Radionuclide	Activity, Bq
Kr-85	1.00E+13	Kr-85m	4.2E+14	Kr-87	8.4E+14
Kr-88	1.2E+15	Sr-89	3.9E+13	Sr-90	1.5E+12
Sr-91	4.60E+13	Y-91	3.30E+12	Mo-99	1.80E+13
Tc-99m	1.80E+13	Ru-103	1.20E+13	Ru-106	2.70E+12
Sb-127	1.2E+13	Sb-129	6.9E+13	Te-129m	1.1E+13
Te-131m	2.5E+13	Te-132	2.5E+14	I-131	4.1E+14
I-132	5.8E+14	I-133	8.3E+14	I-134	9.2E+14
I-135	7.3E+14	Xe-131m	1.7E+13	Xe-133	3.0E+15
Xe-133m	1.1E+14	Xe-135	5.8E+14	Xe-138	3.0E+15
Cs-134	2.6E+13	Cs-136	1.0E+13	Cs-137	1.70E+13
Ba-140	8.8E+13	La-140	4.40E+12	Ce-144	1.2E+13
Np-239	2.3E+14	Rb-88	1.2E+15	Rh-106	2.7E+12
Te-129	1.10E+13	Xe-135m	1.2E+14	Ba-137m	1.70E+13
Pr-144	1.2E+13				

Total activity of the emission constituted 1.50×10^{16} Bq for all scenarios of beyond design basis accident.

The forecasted doses for irradiation over the population at undesigned emergenc (eastern-south - eastern direction of wind according to meteoconditions of 24.03.2009) are shown in Table 158 (Figures 116 - 119).

Table 158 - Doses of irradiation at initial stage of emergency under beyond design basis accident (according to meteoconditions of 24.03.2009) at various distances from the NPP

Distance, km	Dose from cloud, mSv	Dose from fallouts, mSv	Effective inhalation dose, mSv	Total effective dose, mSv	Dose of irradiation over thyroid gland*, mGy
1	2.3	19.0	37.0	58.3	710
2	1.3	11.0	20.0	32.3	380
5	0.7	5.2	6.9	12.8	130
25	0.13	0.54	0.44	1.11	8.5
50	0.03	0.11	0.09	0.23	1.7

*Dose for irradiation over the thyroid gland comprises only the doses of radiation from iodine.

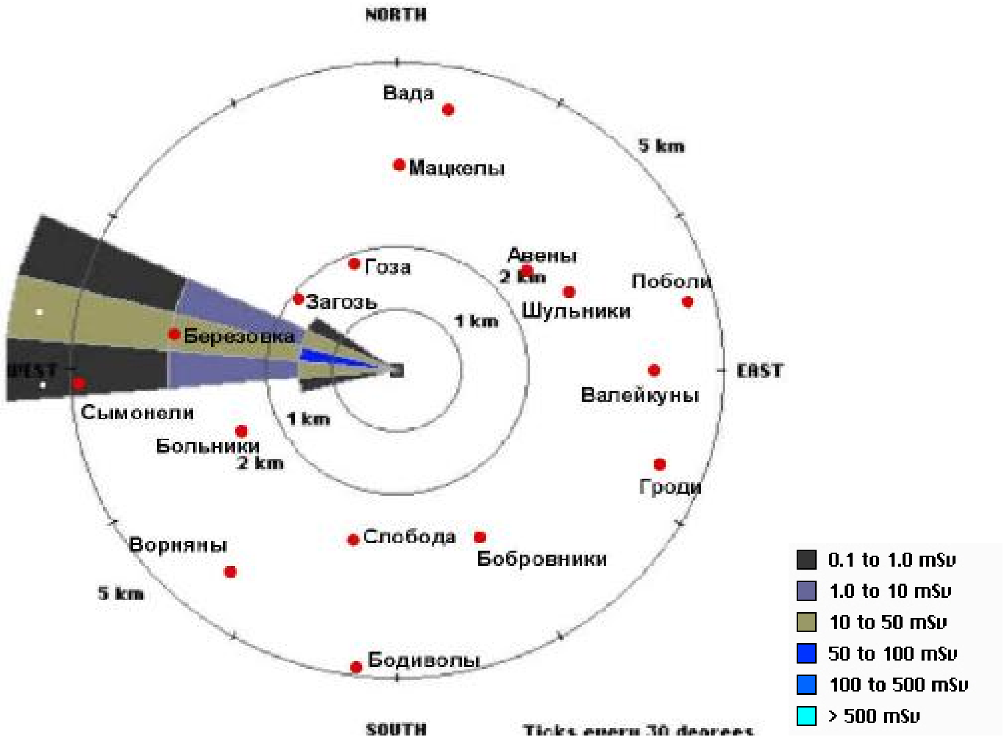


Figure 116 – Total effective dose in the area near the NPP at beyond design basis accident, mSv

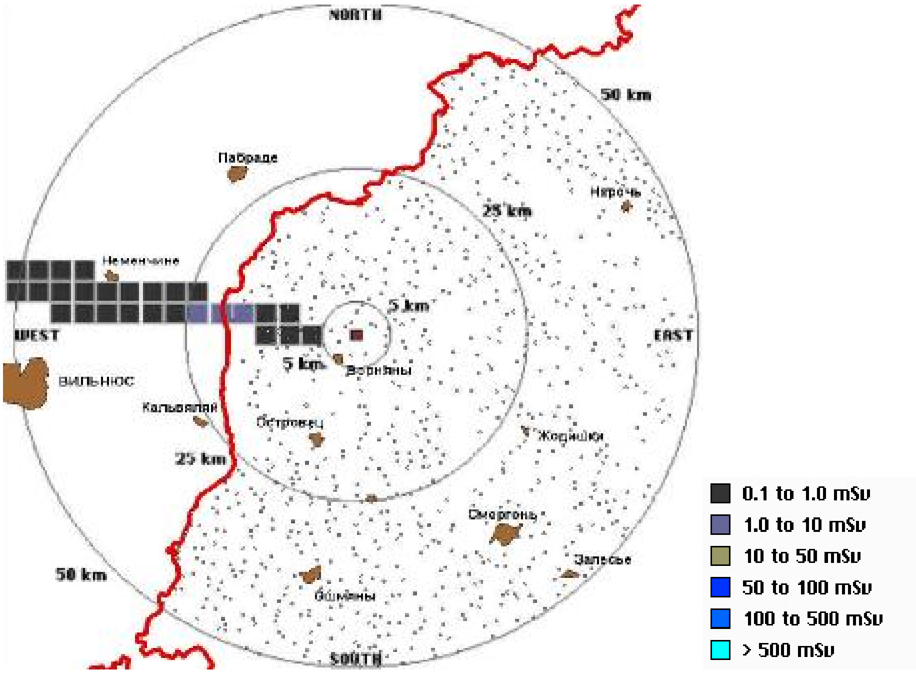


Figure 117 – Total effective dose in the area remoted from the NPP at beyond design basis accident, mSv

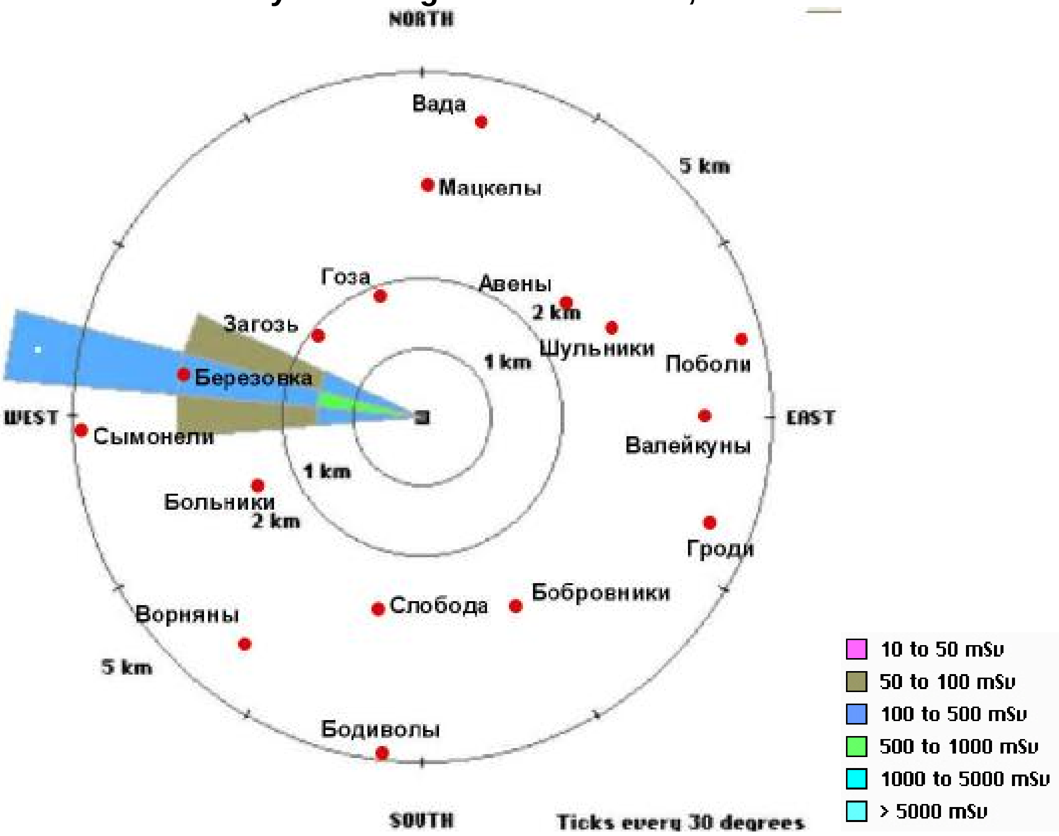


Figure 118 – Dose of irradiation over the thyroid gland within the area near the NPP at beyond design basis accident, mSv (mGy)

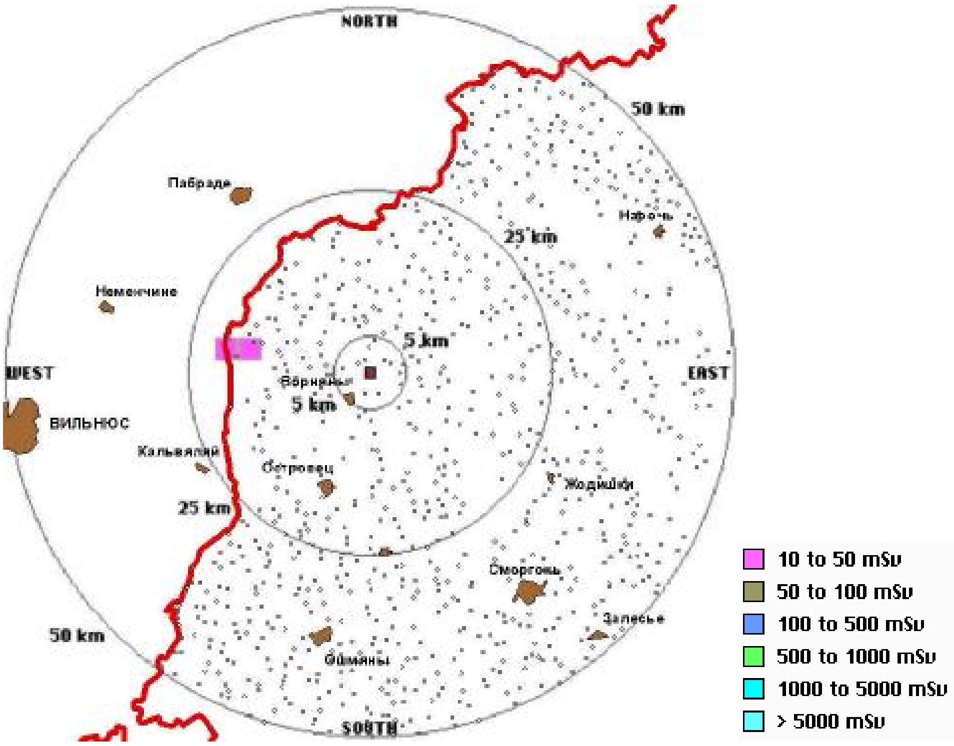


Figure 119 – Dose of irradiation over the thyroid gland within the area near the NPP at beyond design basis accident, mSv (mGy)

Forecasted doses for irradiation over the population at the most heavy scenario of beyond design basis accident (meteoconditions of 17.03.2009 г), that is under which the doses of irradiation over the population will be maximum within various distances from the NPP, are shown in Table 159 (Figures 120 – 123).

Table 159 - **Doses of irradiation at the initial stage of emergency under scenario of beyond design basis accident (according to meteoconditions of 17.03.2009) at various distances from the NPP**

Distance, km	Dose from cloud, mSv	Dose from fallouts, mSv	Effective inhalation dose, mSv	Total effective dose, mSv	Dose of irradiation over thyroid gland*, mGy
1	3.5	11.0	79.0	94.5	1500
2	2.4	6.3	47.0	55.7	910
5	1.1	2.9	22.0	26.0	420
25	0.14	0.18	1.3	1.62	25
50	0.11	0.13	1.00	1.24	19

*Dose of irradiation over the thyroid gland comprises only dosesy of radiationfrom iodine.

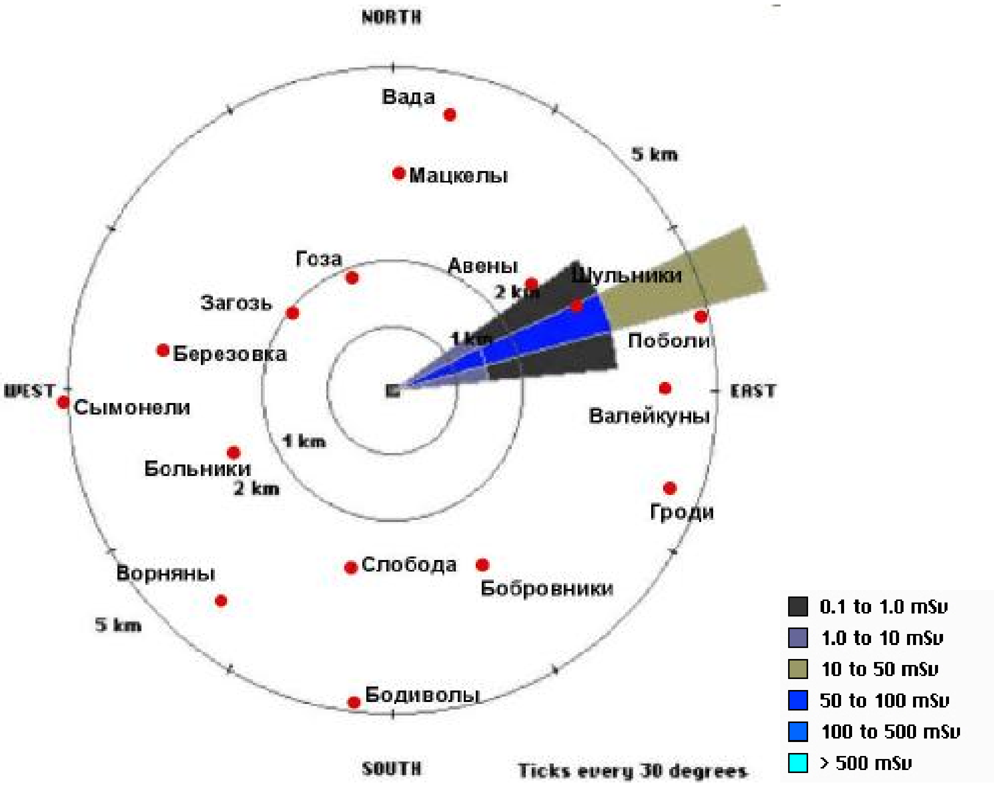


Figure 120 – Total effective dose within the area near the NPP at beyond design basis accident, mSv

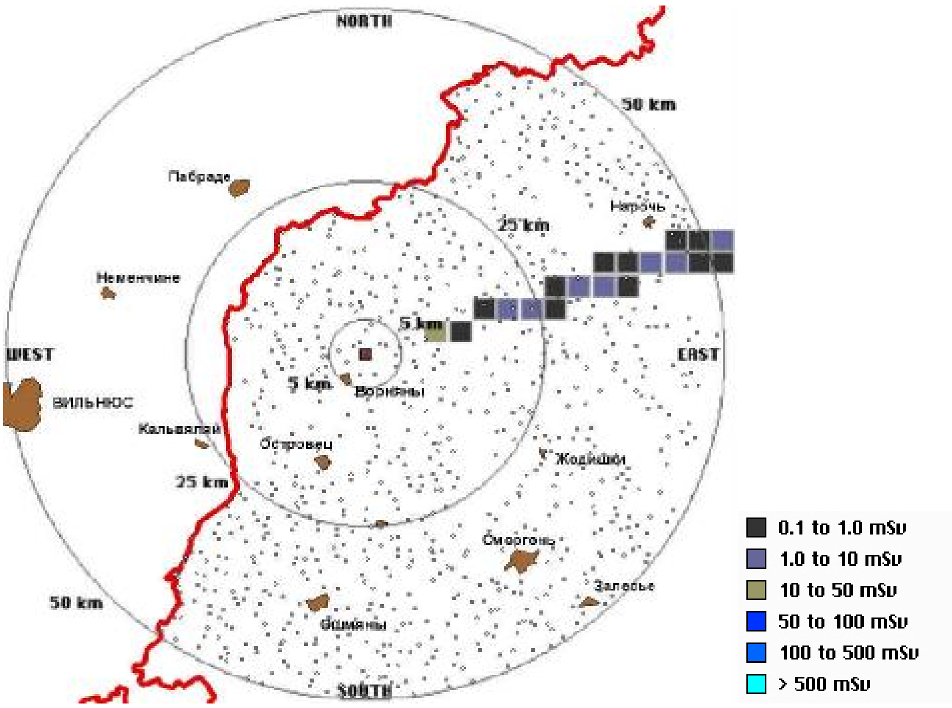


Figure 121 – Total effective dose within the area remote from the NPP at beyond design basis accident, mSv

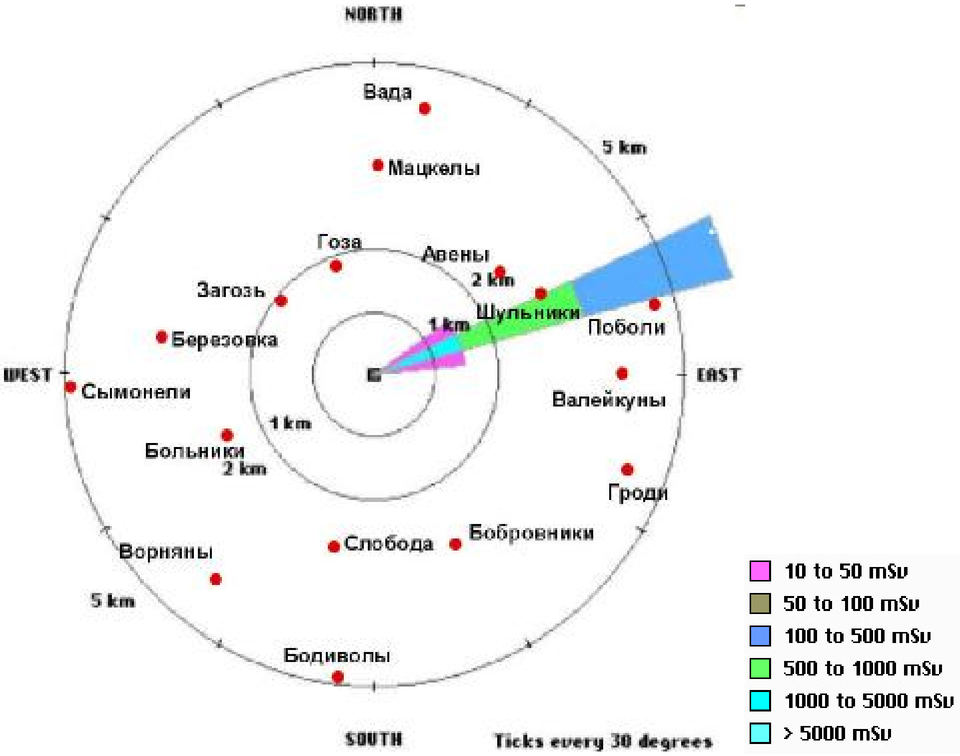


Figure 122 – Dose of irradiation over the thyroid gland within the area near the NPP at beyond design basis accident, mSv (mGy)

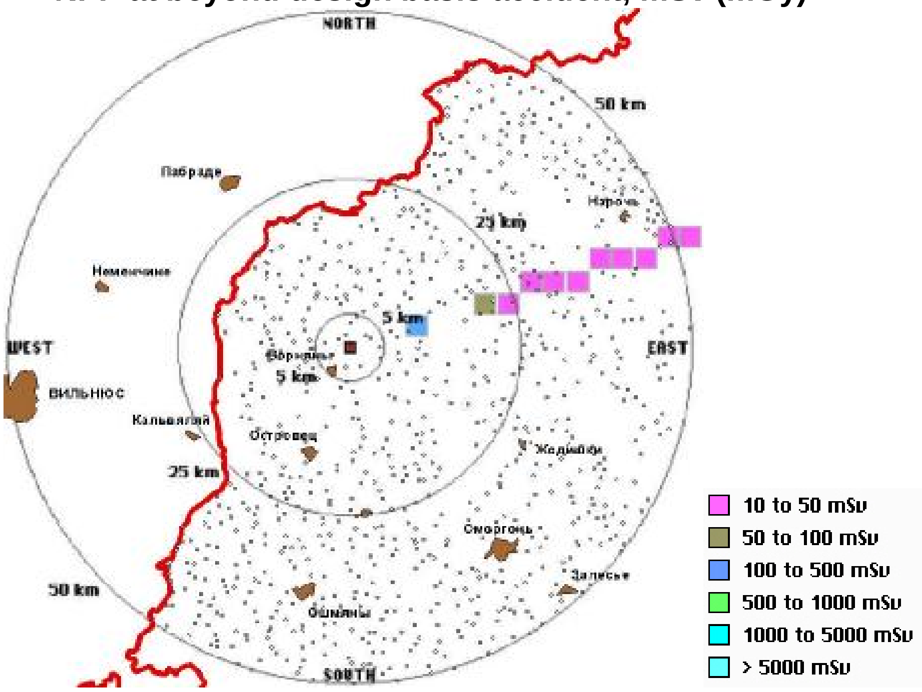


Figure 123 – Dose of irradiation over the thyroid gland within the area remote from the NPP at beyond design basis accident, mSv (mGy)

The highest doses for irradiation over the population at early stage of emergency under the "winter" scenarios of the beyond design basis accident will be observed under 6-th scenario of emergency. Maximum value of total effective dose under the given scenario constitute 94 mSv at a distance of 1 km from the NPP, the dose of irradiation over the thyroid gland - 1500 mGy on at a distance of 1 km from the NPP (Table 159, Figures 122.123).

If the wind direction will vary to east-north-easterly (direction on Vilnius) under condition of preservation for all the rest parameter for beyond design basis accident, then the doses for irradiation over the population will remain the former. In Table 160 there is shown repeatability of the wind direction in the Ostrovetskiy region.

Table 160 - Repeatability for the wind direction (%)

Month	N	NE	E	SE	S	SW	W	NW
I	5	10	8	10	18	25	16	8
II	7	13	10	12	14	20	16	8
III	6	12	13	12	16	19	15	7
IV	10	15	13	11	13	14	14	10
V	13	18	13	9	11	12	13	11
VI	13	14	8	6	11	15	18	15
VII	11	12	7	5	9	19	22	15
VIII	9	12	7	7	12	20	21	12
IX	7	9	9	8	15	24	19	9
X	6	6	8	11	17	27	17	8
XI	5	7	9	13	22	25	14	5
XII	5	8	7	10	19	27	16	8
Winter	6	9	8	10	18	24	17	7
Spring	10	15	14	11	13	14	14	9
Summer	11	13	7	6	11	18	21	13
Autumn	6	7	8	11	19	25	17	7
Perennial	8	11	9	9	15	21	17	10

14.5.5.3 Doses of internal irradiation over the population at peroral delivery of radionuclides under beyond design basis accident

There was executed assessment of doses for internal irradiation over the population at the expense of peroral delivery for radionuclides with the main of dose creating components in the feeding ration. There are given the doses for irradiation from consumption of milk and leaf vegetables, polluted with biologically significant radionuclides Cs-137 and I-131 (Table 161 – 164).

Below there are shown the results of modeling for doses at early stage of emergency (beyond design basis accident within the first 30 days).

Table 161 - Doses of internal irradiation over the population at the expense of peroral delivery of milk, polluted with Cs-137 within 30 days after the emergency, mSv

Category of population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density of the soil pollution with Cs-137, kBq/m^2									
	170	210	360	530	910	230	150	100	130	78
children 0-1 years	1.956	2.416	4.141	6.097	10.468	2.646	1.725	1.150	1.495	0.897
children 1-2 years	1.397	1.725	2.958	4.355	7.477	1.890	1.232	0.822	1.068	0.641
children 2-7 years	1.117	1.380	2.366	3.484	5.982	1.512	0.986	0.657	0.855	0.513
children 7-12 years	1.940	2.397	4.108	6.048	10.385	2.625	1.712	1.141	1.484	0.890
children 12-17 years	2.572	3.178	5.448	8.020	13.770	3.480	2.270	1.513	1.967	1.180
adults (over 17 years)	2.522	3.115	5.341	7.863	13.500	3.412	2.225	1.484	1.929	1.157

Table 162 - Doses of internal irradiation over the population at the expense of peroral delivery of milk, polluted with I-131 within 30 days after the emergency, mSv

Category of population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density of the soil pollution with Cs-137, kBq/m^2									
	1200	2100	2900	3800	6400	2400	1200	870	970	630
children 0-1 years	56.01	98.01	135.35	177.35	298.70	112.01	56.01	40.60	45.27	29.40
children 1-2 years	70.01	122.51	169.19	221.69	373.38	140.02	70.01	50.76	56.59	36.75
children 2-7 years	38.89	68.06	93.99	123.16	207.43	77.79	38.89	28.20	31.44	20.42
children 7-12 years	33.71	58.99	81.46	106.74	179.77	67.42	33.71	24.44	27.25	17.70
children 12-17 years	22.48	39.34	54.33	71.19	119.90	44.96	22.48	16.30	18.17	11.80
adults (over 17 years)	14.26	24.96	34.46	45.16	76.06	28.52	14.26	10.34	11.53	7.49

Table 163 - Doses of internal irradiation over the population at the expense of peroral delivery of leaf vegetables, polluted with Cs-137 within 30 days after the emergency, mSv

Category population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density of the soil pollution with Cs-137, kBq/m^2									
	170	210	360	530	910	230	150	100	130	78
children 1-2 years	0.080	0.099	0.169	0.249	0.427	0.108	0.070	0.047	0.061	0.037
children 2-7 years	0.128	0.158	0.270	0.398	0.684	0.173	0.113	0.075	0.098	0.059
children 7-12 years	0.443	0.548	0.939	1.382	2.373	0.600	0.391	0.261	0.339	0.203
children 12-17 years	0.807	0.997	1.709	2.516	4.320	1.092	0.712	0.475	0.617	0.370
adults (over 17 years)	0.865	1.068	1.831	2.696	4.628	1.170	0.763	0.509	0.661	0.397

Table 164 - Doses of internal irradiation over the population at the expense of peroral delivery of leaf vegetables, polluted with I-131 within 30 days after the emergency, mSv

Category population	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
	Density pollution soil I-131, кBq/м^2									
	1200	2100	2900	3800	6400	2400	1200	870	970	630
children 1-2 years	4.00	7.00	9.66	12.66	21.32	8.00	4.00	2.90	3.23	2.10
children 2-7 years	4.44	7.77	10.74	14.07	23.69	8.88	4.44	3.22	3.59	2.33
children 7-12 years	7.70	13.48	18.61	24.38	41.07	15.40	7.70	5.58	6.22	4.04
children 12-17 years	7.05	12.33	17.03	22.32	37.59	14.10	7.05	5.11	5.70	3.70
adults (over 17 years)	4.89	8.55	11.81	15.47	26.06	9.77	4.89	3.54	3.95	2.57

14.5.5.4 Contribution from various constituents into the total effective dose of irradiation over the population

Analysis of doses for irradiation showed that on the background of lowering for the general effective dose at a distance (See Figure 124) contribution from inhalation of constituent doses falls with removing from the source of the emission, while contribution of dose from clouds and fallouts grow (See Figure 125).

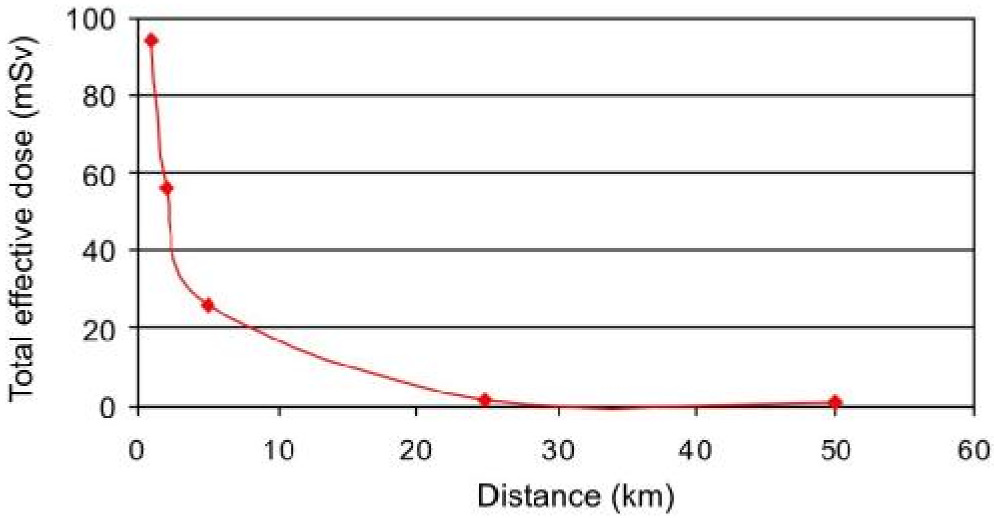


Figure 124 – Total effective irradiation dose versus distance from the source of emission

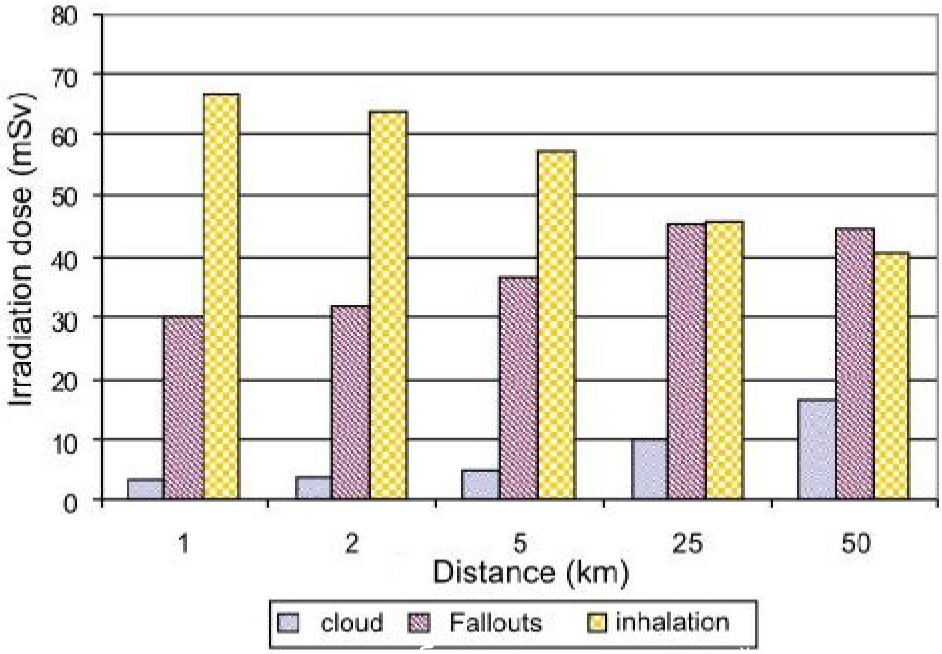


Figure 125 – Contribution of various components of irradiation doses in the total dose versus distance from the source of emission

Contribution from various ways of creation into the total dose at a distance up to five kilometers is the following:

- inhalation - about 50 %;
- from the ground - about 40 %;
- from the cloud – up to 10 %.

With twenty five kilometers contribution into the total dose through inhalation way the impact decreases up to 40 %, and the contribution from irradiation rendered by the cloud and by the fallouts increases up to 17 and 44 % respectively.

The executed above analysis for contribution of various ways for irradiation into the expected effective dose is executed for the situation under various meteoconditions, and in each concrete event the contribution of various constituent elements will be various.

14.6 Summary

14.6.1 Geological external natural factors

The degree of the impact from geological external natural factors on the stability of buildings and constructions of the NPP depends on the properties and stability of the geological environment. The geological environment of the area around the Belarusian NPP is characterized by sufficient stability, and in this connection dots not render negative influences upon the operation buildings of the NPP.

Influence of the NPP on the geological environment within the limits of the area may be connected with the fact, that on the site there exist conditions for development of surface impoundment under antropogenic drains or breach of the surface sewage. Impoundment is conditioned by laying near the surface of the ground with relatively self-possessed moraine loams with frequent layers and lenses of sand. Sands have different granulometric composition and filtration properties. Spreading and power of lenses are more different, the regularities are not installed. In this connection impoundment may be local, within the areas of separate buildings or on the whole site

Impoundment at the expense of raising the level of the first aquifer little probable during preservation of unchangeable mode for basis unloading - from the rivers Viliya, Gozovka, Oshmyanka.

Within 30-km area around the NPP, the impact from the NPP on the geological environment, may act only in the event of emergency, - herewith there is hypothetically possible pollutions of the aquifers. The executed prospecting enable to give the feature for the environment and to evaluate impact on it from construction and operation of the Belarusian NPP, however there must be executed seismic investigations of the area, special operations for study of dynamic properties (resistance to vibration) of the soil, to accomplish the geodetic observations over the modern motions in the earth crust. After tying of the NPP general plan, the engineering-geological prospecting will be executed for each concrete building and construction.

Thereby, there are permitted the forecast for the impact rendered from the NPP to the geological environment and from the geological environment to the NPP, with taking into account of the provided engineering - technical and organizing measures, reducing interconnection up to the safe level.

14.6.2 Influence on the surface waters

The main type of impact from the NPP on the surface waters after commissioning are changes of hydrological mode for water objects - the sources of production water supply for the NPP and receivers for sewage waters.

Drinking (up to 1050 m^3/day) and technical (within the period of construction) water supply for the NPP in volumes up to 800 m^3/day will be provided from the underground water extraction, which will be located on at a distance of 3.0-4.5 km to southern-east from the center of the area.

For production of water supply for the Belarusian NPP in two energy units the is planned accommodation of the surface water extraction on the left coast of Viliya within the area of " the settlement Muzhily - the settlement Small Sviryanki" being 500 m lower the settlement Small Sviryanki.

After tapping the waters from of the river Viliya along the pressure piping line are delivered to the station water preparing, and then through the pressure piping line to the corresponding constructions of the NPP. Delivery of water from water extraction on the river of Viliya to the area of the NPP is provided along two threads of steel piping lines having the diameter of 1600 mm. Each thread of the piping line is calculated for passing through 70 % from the expenditure of production water supply for two energy units of the NPP.

For provision of the guaranteed steady mode for production of water supply for the NPP in waterless periods the main source for exceeding the water supply from the river Viliya may be Vileika water stock reservoir at the expense of arrangement of tapping. The dam for water stock reservoir is located at a distance up to 139 km from for the area of location for the NPP water extraction. Volumes of water in the water stock reservoir may change from 260 million m^3 up to 25.1 million m^3 (project working out of water stock reservoir constitutes up to 6.0 m).

Also there may be used other reserve sources for water supply:

- Olihovskiy water stock reservoir of the bed type on the river Stracha (water stock reservoir for Olihovskiy hydropower plant) with distances to the water streams to the area of location for water extraction up to 19.2 km (useful volume of water stock reservoir is 1.4 million m^3, maximum swing of the level being 3.0 m, the area of the mirror 0.7 km^2, the average depth is 3 m);
- Snigyanskiy water stock reservoir of the bed type on the river Oshmyanka (water stock reservoir for Rachunsky hydropower plant) with the distances along the water streams to the area of location for water extraction up to 55 km (useful volume being 1.21 million m^3, maximum swing of the level being 5.0 m, the mirror area is 1.5 km^2, the average depth is 1.42 m).

After commissioning of the NPP for production of the water supply in the NPP for two energy units there will be realized tapping of water from the river of Viliya with expenditure being from 1.8 m^3/sec in winter time and up to 2.78 m^3/sec in summer time. Herewith the volumes of water sewage for worked out technical sewage waters constitute from 0.96 m^3/sec in winter time and up to 1.38 m^3/sec in summer time. Tapping of worked out technical sewage waters will be realized through the river Viliya 500-1000 m lower location of the water extraction near the settlement Muzhily. Irretrievable water consumption by the Belarusian NPP constitutes from 0.86 m^3/sec in winter time and up to 1.40 m^3/sec in summer time. Under accommodation of two energy units under expenditure of water in the river, close to the average perennial (63.5 m^3/sec), tapping of water from the river Viliya will constitute not over than 2.2 % from expenditure of water in the river. During waterless and very waterless conditions under expenditure of water being from 30.85 m^3/sec up to 22.4 m^3/sec - not over than 4-6 %.

Maximum lowering of the level within the area of the river Viliya takes place lower location of the water extraction and tapping technical sewage waters with taking into account irretrievable water consumption may constitute: under average perennial expenditure of water up to 3 cm to (up to 1 cm in the transborder range -TR), under minimum expenditure - up to 7 cm (up to 5 cm in the transborder range -TR). Maximum lowering of the level within the area between water extraction and discharge waters (2.7 km) and average perennial expenditure of water constitute up to 4 cm to, under minimum expenditure - up to 9 cm. The specified lowering the level of water within the area between water extraction and discharge waters will not render considerable negative impact under conditions for passing species of fish, since there is no inflows in it. Lowering the level of water in the river of Viliya at the expense of location in the Belarusian NPP within the period of spawning by 3-6 cm is not essential and decisive negative factor, considerably worsening conditions for spawning passing species of fish, since the range of lowering the level from the recommended one and the most favorable for spawning (1.5 m relatively to the "zero" post according to hydrological post of the settlement Mikhalishki) under natural conditions being up to location of the NPP within the whole period of spawning constitutes: April - up to 0.43 m, May - up to 0.66 m.

Forecast for speed mode of the river Viliya under accommodation of the Belarusian NPP showed non-considerable diminishing of average velocities of the flow (maximum – by 0.04 m/sec) within the area of the river Viliya the lower location of water extraction and non-considerable change in transborder range

In relationship with tapping of technical sewage waters from the Belarusian NPP into the river of Viliya in the volume up to 1.38 m^3/sec under the temperature 37 °C on the territory of Belarus (without transborder impact) the forecast heat pollution in the river Viliya:

- under expenditure of water in the river, close to average perennial – within the area up to 0.6 km in the period of spring-autumn and up to 1.1 km in the winter period;
- under minimum expenditure of water under conditions of strong lack of water – within the area up to 7 km within the period of spring-autumn and up to 13 km in winter period.

When cooling technical sewage waters up to 25 ^oC in spring -summer period and up to 10 ^oC in winter period there is forecasted the area of heat pollution will not be over 500 m (in average 100-150 m) which corresponds to the requirements of the quality for water of fish growing water objects located lower tapping down of sewage waters. In majority of values concentration of polluting materials in composition of technical sewage waters does not exceed the maximum permitted concentration MPC for fish growing purpose (with the exclusion of suspended materials, zinc and phosphate). Forecast for the quality of water in the river of Viliya after delivery of technical sewage waters showed that at a distance up to 29.6 km from the place of tapping occurs practically full mixing with river waters having coefficients of the quality, not exceeding the MPC within the transborder range, with the exclusion of suspended materials and phosphate (up to 2 MPC). In the event of executing recommendations for additional rectification of technical sewage waters from the Belarusian NPP there will not occur chemical pollution of the river Viliya and will not render negative (inclusive, transborder) impact.

The domestic sewage waters from the territory of the NPP along the system of collectors are delivered into the canalization pumping station and by pumps are forced into the station for rectification of sewage waters. The station for rectification of sewage waters is designed within the sanitary-protective area of the NPP. There is provided complete bio-rectification of sewage waters with deep removal of nitrogen and phosphorus and additional rectification. Tapping of cleaned public-domestic sewage waters from the area of the NPP is foreseen in the volume 910.9 m^3/day for the river Polpa. The forecast for the quality of water in the river of Viliya after delivery of cleaned public-domestic sewage waters from the Belarusian NPP during its construction and after its commissioning showed that the most considerable impact is from the sewage waters spreads within the distance up to 1 km from the place of tapping. Herewith the values for the quality will be within the limits or non-considerably exceed normative maximum permitted concentration (MPC) for fish growing water objects. Practically complete mixing with the river waters of the river Viliya occurs at a distance up to 10.4 km from the place of tapping (on the Belarusian territory and over than 20 km from the Belarusian - Lithuanian border) with small (within the limits of MPC) changes in the water quality for the river in relation to the existing and unessential transborder impact upon the quality of waters in the river of Viliya and other water objects.

The Belarusian NPP will not be located on the territory of water protection area of the river Viliya.

Since accommodation of the NPP dwelling settlement is provided on the base of Ostrovets, rectification of sewage waters from the territory of the settlement is provided at the existing rectification constructions with their reconstruction and expansion.

The quality of the rain sewage from the territory of the Belarusian NPP area, being tapped into the water object with volumes up to 66 thousand m^3/ year, will not be worse, than from natural surface of the land and will not render negative impact to the water object, because on the territory of the area there is excluded possible pollution of the indicated rain sewages.

Forecast for changing hydro geological conditions, due to concentrated compilation of underground waters and antropogenic impoundment of the territory. Assessment of the impact from operation of water extraction "Ostrovetskiy" on the level mode of the adjoining territory, including the area of location for the Belarusian NPP showed, that its operation will not considerably impact upon the general regional hydrodynamic scheme of the streams. The impact from the water extraction will be minute even through 10 000 days. The average radius of the impact rendered to the water extraction "Ostrovetskiy" will be registered at a distance of 3 km in the first aquifer and at a distance of 4 km in the exploited aquifer. The impact of this water extraction not will reach the area of the Belarusian NPP and more over it not will reach the transborder territories

As the result of decisions related to the forecast problems of antropogenic impoundment of the area i.e. determination of the size for of the dome of spreading, created at the expense of drain from the water carrying communications and water containing structures, showed that maximum rise of antropogenic aquifer within the evaluated period for operation of one Belarusian NPP reactor (50 years) constitutes from 6.9 up to 20.8 m. Radius of the dome for spreading the antropogenic aquifer may constitute from 1.44 up to 2.3 km. The results of forecasted analytical calculations are preliminary.

14.6.3 Forecast for possible radiation pollution of underground waters

Natural protection of underground waters is determined with complex of parameters, the main from which are:

- the depth of lying, ion-salt and gaseous composition of underground waters;
- power of aeration area, power of composing its ground and ground-soils;
- the nature of the soil cover (types of the ground, granulometric and mineral composition of the ground, their water-physical condition) and absorption specifications;
- volume, mode and composition hydro precipitations (rain, snow);
- filtration parameters of the ground and ground-soils;
- the types and physical-chemical properties of polluting materials.

At the first stage of the studies according to EIA it appears justified to handle with numerous from the enumerated types of information, as follows: the data about the depth of lying for the most vulnerable ground waters and their quality; the feature of the soil cover as the media for migration of radionuclides; specific migration processes and distribution of ^{90}Sr and ^{137}Cs over the topsoil in the region of Chernobyl fallouts as standard species of processes. The given information completely sufficient for creation of the general indications about protection of the ground waters within the limits of 30-km area around the Belarusian NPP.

Analysis for redistribution of ^{90}Sr and ^{137}Cs over the depth of the soil profile showed that:

- even through 15-20 years after the emergency at Chernobyl NPP in the majority varieties of the ground 95-98 % of spare stock ^{137} Cs is concentrated in the upper 0-5-cm layer, less in the layer 0-20 cm, disregarding from the density of ^{137} Cs fallouts. The main spare stock of ^{90}Sr (the same 95-98 %) is concentrated in the layer 0-15 cm, less - in the layer 0-25 cm (Krasnoselie, sandy dune, 21 km from the Chernobyl NPP);
- linear velocity of migration for ^{137}Cs (V) and the factor of quasi-diffusion (D) vary within broad limits: V - 0.11-2.66 cm/year, D – 0.01-1.40 cm^2/year. For ^{90}Sr these parameters of vertical migration along the soil profiles composition 0.14-7.14 cm/ year and 0.01-19.00 cm^2/ year.

For mineral automorphic soddy-podzol grounds (Podzoluvisol) of the high flood plains and over high flood plains terrazzos there is installed statistical reliable (R^2=0.58-0.77) trend for lowering the value of parameters for migration ^{137} Cs (V, D) in the course of time which is explained by inconvertible sorption of ^{137} Cs with hard substratum of the ground as in the result of diffusion and fastening of the isotope in the interlayer space of clay minerals. This trend exists and for the rest types of the ground - hydromorphic peat-boggy and half-hydromorphic alluvial soddy (Histosol and Fluvisol). The exception constitute only half-hydromorphic powerfully moistened soddy-podzol soils around water collection pools of lakes, which, on the contrary, considerably increase these parameters in the course time in connection with the modes with intensive washing out and, as the consequence, imposition of convective mass transfer on the diffusion stream.

^{90}Sr actively migrates in automorphic mineral soddy-podzol (Podzoluvisol) sandy soils. For this type of the soil there is registered growing of parameters for migration in the course of time (R^2=0.7-0.9). For half-hydromorphic soddy-alluvium sandy ground (Fluvisol) at low and high flood plains there is also installed a trend of growing parameters for migration in the course of time. Diminishing or constancy of parameters for migration in the course of time there is installed for hydromorphic high-organic peat-boggy (Histosol) soils.

Thereby, location of the main spare stock for Chernobyl radionuclides ^{137}Cs and ^{90}Sr at the depth up to 5-25 cm of soil profiles even on termination of 15-20 years after the emergency fallouts is indicative of sufficiently effective, as a whole, shielding mission of the Belarusian ground and ground-soils in the process of vertical redistribution of the main spare stock of radionuclides to the level of the ground waters.

Analysis of the radiation state for ground waters lying at the depth of 2 m in the region of Chernobyl fallouts really showed relatively low levels of their modern (according to the state in 2002-2007 years) pollution for ^{137}Cs and ^{90}Sr (respectively, 0.02-0.58 and 0.012-2.206 Bq/dm^3). We shall note that in the region with the depth of ground waters lying up to 2 m the soil cover is not sufficiently effective for protection them from pollution of the surface sources, including from "flat" surface of the source with radionuclides (^{137}Cs, ^{90}Sr and others.). The territory with powerful (above 2 m) area for aeration shall be considered as the region with sufficiently effective soil-ground protection of underground waters.

This is reflected by the map-scheme (See Figure 126) of the radiation protection over the territory of 30-km area around the Belarusian NPP, on which within broad background with relatively good protection of underground waters from pollution with ^{137}Cs and ^{90}Sr there is shown the territory with small depth of lying the ground waters, as being the most sensitive to pollution with these radio isotopes.

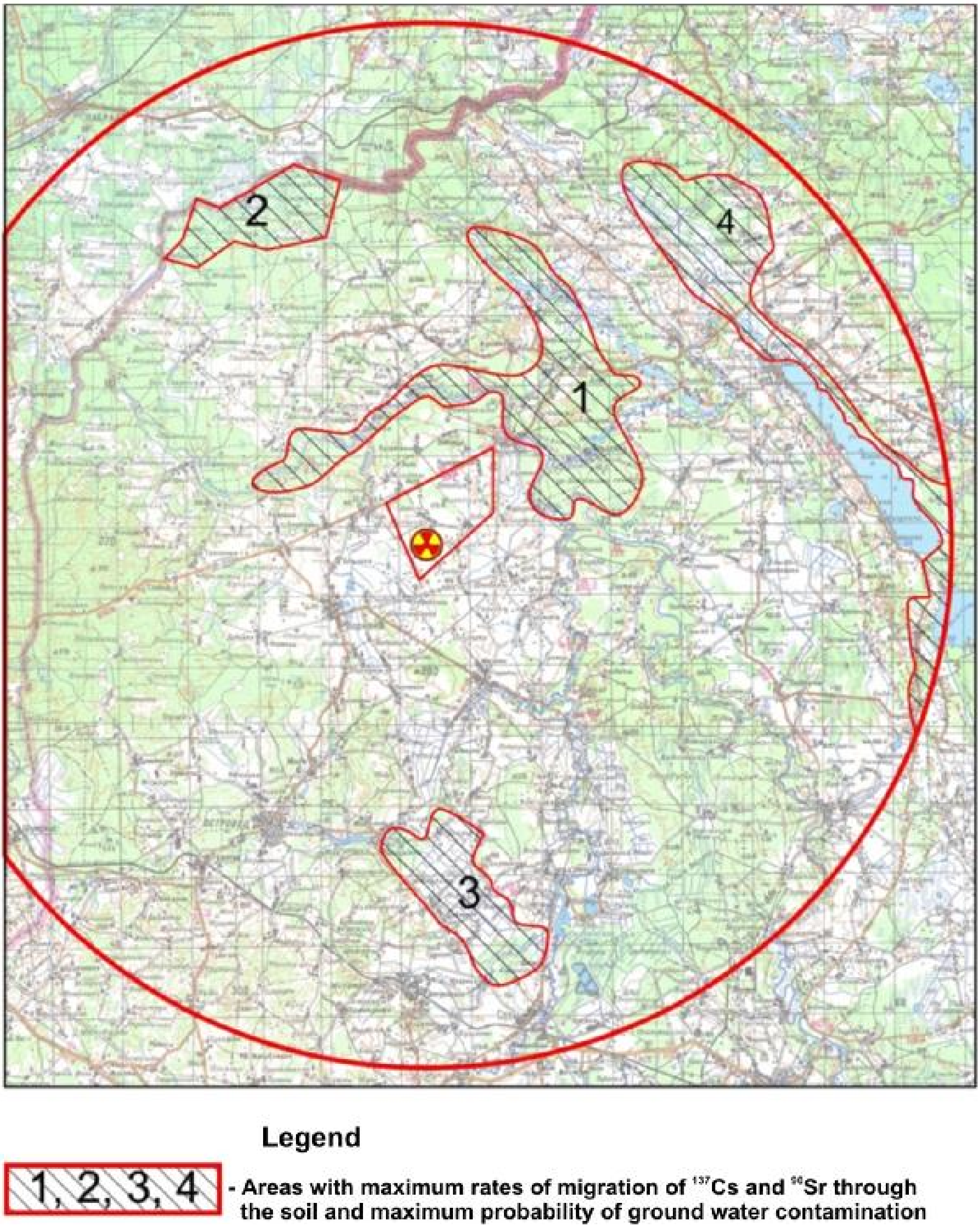


Figure 126 – The sketch map with the selected representative areas most sensitive in terms of the combination of natural factors

The results of forecasted assessment for ^{137}Cs and ^{90}Sr showed that:

- the ground waters are weakly protected from pollution with ^{90}Sr for areas with peat-boggy soils;
- disadvantageous unregistered factors, which may bring about speedup of migration processes and increase concentration of radionuclides ^{90}Sr in ground waters,

are seasonal fluctuations for the level of ground waters and condition of ploughed soils;

- under beyond design basis accident INES 5 the ground waters are practically insensitive to the considered type of pollution at the chosen weakly protected areas;

- under operation emissions and emergencies lower INES 5 at the designed NPP the probability of in the pollution ground waters, and, consequently, and in over deep horizons will neglected small.

The studies over possible radiation pollution in the underground waters from the local source in the area of impact from the designed NPP were executed on the base of hypothetical scenario for the emergency situation, connected with leakage of fluid radioactive waste. According to this scenario 15 m^3 of fluid radioactive waste the activity 600 Ci, shown by radio isotopes, were thrown out on the site, due to which the territory of the area 37.5 m^2 within the depth of 1 m was subjected to pollution.

By the forecasted assessment there was installed that even under the most conservative approach the pollution of the second and the third aquifers may to be small and neglected. These horizons are sufficiently well protected with natural barriers.

Forecast for possible chemical pollution in the underground waters. The forecasted calculations for creation of the centre for chemical pollution under operation of the Belarusian NPP showed that to the most degree there are subjected to pollution the underground waters from the first from surface of the aquifer – the ground waters. The value of concentration for polluting materials (neutral contaminant), filtering into the ground water, constitute about 1/2 from their initial contents in the sewage or production waters. The halo of pollution within the area may spread with the ground waters at a distance about 2.5 km from the area around the station. The concentration value for polluting materials, filtering into the pumped water, constitute about 10^{-4} from their initial contents in sewage or production waters. Coming from the above mentioned, chemical pollution of the first surface aquifer (pumped within water badsin Dnepr – Sozh), being created at the expense of draining sewage waters, is not forecasted.

14.6.4 NPP impact on structure and functions of water ecosystems

The main impact rendered by the NPP within the process of operation will be rendered to the river Viliya, which will be the source of cooling water and accumulate all fluid tapping waters from the nuclear plant. In accordance with preliminary water balance calculations, under the temperature of tapping sewage waters 37 °C during operation of 2 energy units. At the NPP there may be considerable heat pollution, under which the existence and normal reproduction of many rare and disappearing species of fish, registered in the Red book of the Republic of Belarus, becomes impossible. However, the danger for ecosystems over the river Viliya is presented not only by this fact.

In the present time the river Viliya presents by itself highly eutrophic water stream. Delivery with drainage waters of considerable quantity of main eutrophic elements (compounds of phosphorus and nitrogen) on the background thermal pollution, certainly, will bring about further rising of the trophic level. Under delivery into the river of technical sewage waters within volumes and levels of the pollution considered by the EIA it is possible to forecast sharp increase of the phytoplankton biomass. Basically this will occur at the expense of mass reproduction for bluish-green water plants, which worsens the quality of water and the living conditions for hydrobiotic species. There will be violated the existing trophic relationship. There will be diminished the biologic variety and ability of ecosystems to homeostasis and biological self-rectification.

It is necessary to provide in the system of water sewage additional engineering constructions, providing lowering the temperature and additional rectification of sewage waters. The level of cooling and additional rectification must provide in the river Viliya within the area for discharge waters delivery of eutrophic and polluting materials on the level of maximum permitted concentrations for water objects pertaining to the first category of the fish growing values.

Water ecosystems within 30-km area around the Belarusian NPP, with the exclusion of the river Viliya, will not be a subject to direct impact from the station since they are located within a sufficient distance from the area. The real threat for the river and lake ecosystems, possessing high recreation potential, will present increased antropogenic (recreation) load. In connection with commissioning of the NPP the amount of the population in Ostrovets will increase by about 30000 persons, which will inevitably bring about growth of antropogenic press. However this impact may to compensateв with nature protection measures.

Under maximum design-basis accident the radionuclide pollution over the water collecting territory will not result in any observable impact upon the structure of the biological community and functioning of the lake ecosystems. Under the considered in EIA scenario for the beyond design basis accident there is possible dangerous accumulation of radionuclides in final sections of the food chains (predator fish).

Some hydrobiotic species, dwelling in water basins and water streams within the 30-km area, may present by itself serious threat to the NPP operation, causing biological hindrances and damages. The highest hindrances cause overgrowing with sponges, moss-growing species and two-folded shellfish, amongst which special problems may be created by the shellfish Dreissena. The potential danger may be presented by metaphyton. Under mass creation and drift the metaphyton may create biological hindrances under water consumption at the NPP, as well as to define the spacious redistribution of pollution.

14.6.5 NPP impact on agricultural ecosystems

Under the scenario for pollution of small areas as a result of beyond design basis accident:

- in the first vegetation season there is possible exceeding of the level B (10000 $Bq \cdot kg^{-1}$) on contents of ^{137}Cs and ^{131}I in agricultural products at a distance up to 60 km from the NPP on axis of the trace within the territory with total area being up to 15000 hectares. According to ^{90}Sr level B (1000 $Bq \cdot kg^{-1}$) in agricultural products also may be exceeded at a distance up to 60 km from the NPP on axis of the trace. The level A (1000 $Bq \cdot kg^{-1}$ for ^{137}Cs and ^{131}I, 100 $Bq \cdot kg^{-1}$ for ^{90}Sr) may be exceeded at a distance up to 80 km on axis of the trace;
- in the following vegetation season exceeding of the permitted level for contents of radionuclides in products of agriculture facilities is possible at a distance up to 60 km on axis of the trace. Together with removing from the axis of the trace in transverse direction there is forecasted lowering of specific activities for ^{137}Cs and ^{90}Sr, and at distances over 500 m they not will not exceed the background values.

Under the scenario for pollution of large areas in the result of beyond design basis accident:

- in the first vegetation season after emergency there is possible exceeding the level B (10000 Bq·kg^{-1} as per contents of ^{137}Cs и ^{131}I, 1000 Bq·kg^{-1} as per ^{90}Sr) in agricultural products within up to 50 km from the NPP on axis of the trace fallouts;

- in the following vegetation season there is probable exceeding of the permitted contents for ^{137}Cs in grains (standard contents for 90 Bq·kg^{-1}) and root- tuber crops (80 Bq·kg^{-1}) at a distance 8-40 km, in milk (100 Bq·kg^{-1}), grasses (170 Bq·kg^{-1}) and beef (500 Bq·kg^{-1}) - up to 50 km from the NPP on axis of the trace. For ^{90}Sr exceeding of contents in grains (11 Bq·kg^{-1}), in milk (3.7 Bq·kg^{-1}), grasses (37 Bq·kg^{-1}) is possible at a distance of 10-25 km, for root- tuber crops (3.7 Bq·kg^{-1}) at a distance of 8-40 km from the NPP on axis of the trace.

Under maximum design-basis accident:

- in the first vegetation period after fallouts exceeding the level A (1000 Bq·kg^{-1}) as per contents of ^{137}Cs in the species of agricultural products will not be observed. Exceeding the level A (100 Bq·kg^{-1}) as per contents of ^{90}Sr is forecasted only for leaf verdure at a distance up to 10 km from the NPP on axis of the trace. The level B (10000 Bq·kg^{-1}) as per contents ^{131}I will be exceeded in the leaf verdure at a distance up to 30 km, and in grains and milk - up to 15 km on axis of the trace;

- in the following vegetation season exceeding of the permitted standard contents of ^{137}Cs and ^{90}Sr in species of agricultural products is not forecasted.

One must have in view, that the calculations shown for axis of the trace fallouts, in the course of removal from the axis of the trace in the transverse direction the contents of radionuclides will fall and at a distance up to 500 m under the scenario of pollution over a small area at undesigned and maximum design-basis accident and up to 5000 m under the scenario for pollution of large area will fall down to the background values.

In the course of time after the fallouts there will occur lowering of contents for radionuclides:

- during the first vegetation period after the fallouts there is forecasted lowering of the radionuclides activities at the expense of their radiation disintegration and removing the particles of fallouts with the surface plants. The period of "dry" half-rectification for ^{137}Cs and ^{90}Sr constitutes 15 days and 6 days - for ^{131}I, under the atmospheric precipitations it grows shorter in proportion to their quantity and intension;

- within the following the years it is forecasted lowering of specific activities for radionuclides in species of agricultural products, conditioned by diminishing their quantities in the root-dwelling layer in consequence of radiation disintegration, migration outside its limits, lowering of biologic accessibility under increase of the energy, relationship with soil absorbing complex (ageing). At the expense of the indicated processes the most intensive (nearly by10 times) lowering of specific activities for ^{137}Cs there will occur in the first 15 years after the emergency fallouts.

14.6.6 NPP impact on the population

14.6.6.1 Necessity of protective measures under the maximum design-basis accident

The results of modeling by means of the InterRAS model showed that:

- the total effective dose does not exceed the criterion interference in none of the considered scenario for the maximum design accident (100 mSv over the whole body);

- execution of countermeasures in the manner of covertures and/or evacuation of the population will not be needed;

- maximum expense dose for irradiation over the thyroid gland in case of the maximum design accident does not exceed the criterion interference (50 mSv for the first 7 days after the emergency), consequently, execution of blocking the thyroid gland is not obligatory;

- the doses at the expense of consumption polluted milk constitute units or tenth shares of millisievert.

4.6.6.2 Necessity of protective measures under the beyond design basis accident

At present day the international normative documents determine the following area for emergency planning the measures on protection of population and their volume (for reactors having the power over 1000 MW):

- the area for preventive protective measures *(3 - 5 km)* – is the area around the NPP, in respect of which there are executed actions for realization urgent protective measures in the event nuclear emergency situation with the aim of lowering the risk of appearing heavy deterministic effects outside the borders of the area. Protective measures within the limits of this area must be taken before or soon after the emission of the radiation material or irradiation on the base of situation, created at the NPP;

- the area of urgent protective measures *(25 km)* - is the area around the NPP, in respect of which there are executed actions, directed at realization of urgent protective measures in the event nuclear emergency situation with the aim of prevention stochastic effects in such degree, in which this is practically realizable, by prevention of doses in accordance with international documents. Protective measures within the limits of this area must be executed on the base of the monitoring the environment or in the proper events with taking into account the situation, created at the NPP;

- the area of restrictions for consumption of feeding products (300 km) - the area around the NPP, in respect of which there are executed actions, directed at realization of countermeasures (for instance, agricultural), preventing the radionuclides peroral arrival with water and food-stuffs of local production, and long-term protective measures with the aim to prevent great collective doses of irradiation in such degree, in which this is practically realizable, by prevention of doses in accordance with the international documents. Protective measures within the limits of this area must be executed on the base of monitoring over the environment and the products of feeding.

Analysis of irradiation doses showed that the total effective dose of irradiation over the population does not exceed the criteria for interference in no one of the given scenarios for the beyond design basis accident (100 mSv on the whole body). Execution of countermeasures in the manner of covertures, deactivation and/or evacuation for the population will not be needed.

Maximum evaluated dose for irradiation over the thyroid gland under the given scenarios of beyond design basis accident will exceed the criterion interference of 50 mSv for the first seven days after the emergency at a distance up to 25 km from the station, consequently, within the radius of 25 km from the station as the necessary countermeasure will be execution of blocking the thyroid gland at early stage of emergency.

The results of modeling by means of international models persuasively show that:

- execution of covertures and/or evacuation for the population will not be needed;
- it will be necessary to provide the possibility of efficient execution for blocking the thyroid gland on the territory up to 25 km from the station;
- there must be foreseen the possibility to introduce restrictions for consumption of potentially polluted radionuclides with milk and other products of feeding;
- there must be provided possible urgent execution of monitoring over the environment, the products of feeding and provender for animals at a distance not more than 30 km from the station;
- in future to provide execution of monitoring over the products of feeding on the whole territory of the Republic of Belarus.

15 FORECAST FOR TRANSBORDER INFLUENCE FROM THE BYELORUSSIAN NPP

15.1 General provisions

The target probable factors, determined for the energy units of the NPP-2006:

- lowering of probable emergences at the energy units with serious damage of the reactor active area up to the level of 10^{-6} 1/ year per one reactor and greater emissions outside the limits of the area, for which there are necessary quick countermeasures outside the area, at the level 10^{-7} 1/ year per reactor;
- restriction of maximum emergency with the emission of the main dose of creating nuclides into the environment under heavy beyond design basis accident with probability 10^{-7} 1/ year per reactor with the level 100 TBq of cesium-137;
- lowering maximum emergency emission of the main dose creating nuclides into the environment under heavy beyond design basis accident with probability 10^{-7} 1/ year per reactor, up to the level, under which:
- the excluded necessity to introduce immediate measures, including both obligatory evacuation, and long lasting settle out of the population outside the borders of the area; the estimated radius for the area for planning obligatory evacuation of the population does not exceed 800 m from the reactor department;
- an obligatory introduction of protective actions for the population (the coverture, iodine preventive maintenance) is limited by the area having the radius not over 3 km from the energy unit.
- the given target probable factors cover all operation states of the station, as well as all initiating factors. The indicated factors in the technical requirements to the project of the Belarusian NPP are determined as obligatory specifications.

The doses, determined for the energy unit of the NPP-2006 outside the limits and the target probable factors completely correspond to the requirements of acting Russian standard documents НД, recommendations and standards for safety from the IAEA, International consulting group on nuclear safety (INSAG1 - INSAG12) and requirements of the European operation organizations laid to the project of nuclear plant pertaining to the new generation having reactors of the PWR type. In Table 165 there is shown for comparison the target factors of radiation and nuclear safety of the energy units having increased safety for various projects of the NPP and requirements to them.

Table 165 - Factors of radiation and nuclear safety at the NPP

Criterion	EUR INSAG-3	Russian Federation norms	Project NPP-2006	Project USA-APWR
Quotas for irradiation over the population from emissions (tapping sewages) under standard operation of the NPP, μSv/ year	no restriction.	50(50)	10(10)	-
Quotas for irradiation over the population from emissions (tapping sewages) under standard operation with taking into account violations of the NPP standard operation, μSv/ year	100	no restriction	100	100
Effective dose over the population at project emergencies, μSv / event - with frequency over 10^{-4} 1/ year - with frequency not more than 10^{-4} 1/ year	 1 5	no restriction	 1 5	 1 5
Effective dose over the population under project emergency, mSv/ year	-	5	5	-
Probability of considerable damage within the active area, 1/ year per reactor	1E-5	1E-5	1E-6	1E-6
Probability of large emissions, for which there are necessary rapid counter measures outside the area, 1/ year per reactor	1E-6	1E-7	1E-7	1E-7

The suggested EUR verification procedure for power units (WWER) with increased safety enables to tie the forecasted emergency of near ground and height emissions from definite list of radiation significant nuclides with the necessity of introduction for protective measures outside the borders of industrial area disregarding conditions of the area location. The results of verification procedure for beyond design basis accident with maximum emergency emission at the Baltic NPP (project of the NPP-2006, is the analogous object) is shown in Table 166. Consideration executed for the expected emergency emissions, into the calculations there are included radionuclides, which create over 90 % of forecasted dos for irradiation.

Table 166 – The results of verification procedure, recommended by EUR, for the NPP-2006

Name of criterion	Maximum value [EUR]	the expected value for NPP-2006
Beyond design basis accident (frequency not more than 10^{-6} 1/year per reactor)		
Criterion B1 – restriction for introduction of emergency protective measures at distances from the reactor over 800 m	$< 5\cdot10^{-2}$	$1.2\cdot10^{-2}$
Criterion B2 –restriction for introduction of postponed protective measures at distances from the reactor over 3 km	$< 3\cdot10^{-2}$	$1\cdot10^{-3}$
Criterion B3 – restriction for introduction of long lasting protective measures at distances from the reactor over 800 m	$< 1\cdot10^{-1}$	$1\cdot10^{-2}$

From the data of Table 166 it follows that maximum emergency emission from the NPP-2006, adopted for the most radiation-significant nuclides, safely satisfies the acceptation criterion of verification procedure which additionally confirms execution for the Baltic NPP (is an analogues object) for the following aim:

- exclude the necessity of introduction for emergency evacuation and long settle out of the population outside the borders of the NPP area;
- restrict with a radius not over 3 km the area for planning the obligatory protective measures (coverture for the population, iodine preventive maintenance) for the population.

Assessment of the restricted impact on the economy was executed by means of comparison of the total emission on level of the ground and high-altitude emissions during emergency with criterions according to EUR. The initial data for such comparison is shown in Table 167.

Table 167 - Execution of criteria restricted for the impact rendered to economic facilities from the Baltic NPP

Radionuclide	Criterion according to EUR, TBq	Values of maximum emergency emission from the Baltic NPP, TBq
Beyond design basis accident (frequency not more than 10^{-6} 1/ year per reactor)		
^{131}I	4000	100
^{137}Cs	30	10
^{90}Sr	400	0.12

From consideration of the data, shown above, it follows that additional verification that the criteria of environmental safety EUR for the Baltic NPP (is the analogous object) are executed. Herewith it is possible to make a conclusion about the fact that the sum of the applicable in the project of the Baltic NPP active and passive safety systems completely provides execution of requirements for environmental safety EUR.

Since verification procedure EUR comprises comparison of criteria, obtained as a result of multiplying the values of maximum emergency emission from nine reference isotope groups by the normalized factors, with adopted EUR criterions, that the shown conclusions are completely applicable for the Belarusian NPP.

For the present day the international standard documents determine the following area for emergence planning measures on protection of the population and their volumes (for reactors having the power over 1000 MW):

- the area for preventive protective measures (3 - 5 km) - is the area around the NPP, in respect of which there are executed measures for realization of urgent protective measures in the event of nuclear emergency situation with the aim of lowering the risk from appearance of heavy deterministic effects outside the borders of the area. The protective measures within the limits of this area must be undertaken before or soon after the emission of radiation materials or irradiation on the base of the situation, created at the NPP;

- the area for urgent protective measures (25 km) – is the area around the NPP, in respect of which there are executed measures, directed at realization of urgent protective measures in the event of nuclear emergency situation with the aim of prevention stochastic effects in such degree, in which it is practically realizable, by prevention of doses in accordance with the international document. Protective measures within the limits of this area must be executed on the base of monitoring over the environment or under the proper events with taking into account the situation, created at the NPP;

- the area for restriction of the feeding products consumption (300 km) - the area around the NPP, in respect of which there are executed measures, directed at realization of the countermeasures (for instance, agricultural), preventing peroraly arrival of radionuclides with water and food-stuffs of local production, and long lasting protective measures undertaken with the aim of prevention for greater collective doses of irradiation in such degree, in which this is practically realizable, by prevention of doses in accordance with the international document. The protective measures within the limits of this area must be executed on the base of monitoring over the environment and the products of feeding.

15.2 Specification of the region in transborder context

The NPP site is located at the north-west of the republic in the centre of Ostrovetskiy region in Grodno area and is limited with north automobile road having the republican value R45 Polotsk-Glubokoye-border of the Republic of Lithuania (Kotlovka), with the local automobile road H-6210 Mikhalishki-Gervyaty-Izobelino, from the south and west – by the settlements respectively Voleykuny and Goza.

The distance to the borders of the adjacent states from the site of the Belarusian NPP constitutes: Republic Lithuania - 22 km, Latvian Republic - 110 km, Polish Republic - 180 km, Ukraine - 318 km, Russian Federation - 200 km.

The main transborder water stream is the river of Viliya (Nyaris), which is used for technical water supply and tapping of blowing through and technical waters of the Belarusian NPP.

The river of Viliya is considered as the main source of technical water supply for the Belarusian NPP. For production of water supply for the Belarusian NPP to accommodate the surface waters extraction there is chosen the area of "settlement of Malye Sviryanki – settlement Muzhily" (See Figure 127). For two energy units there is planned accommodation of the surface waters extraction on the river of Viliya within 500 m lower the settlement Malye Sviryanki. The water from the river Viliya is extracted and pumped to the NPP site through the pressure water pipes of the first and second rises. The length of the supposed routes for water streams leading from the range of location for water extraction within the given area to the area of the NPP constitutes 9.9 km. The water extraction constructions at the river of Viliya are situated on the lest riverside.

-

Figure 127 - The river Viliya within the area of location the surface water extraction 500 m lower the settlement Malye Sviryanki

The wind-rose, built on base perennial data of repeatability for wind direction in the region of the Belarusian NPP area is shown in Figure 128.

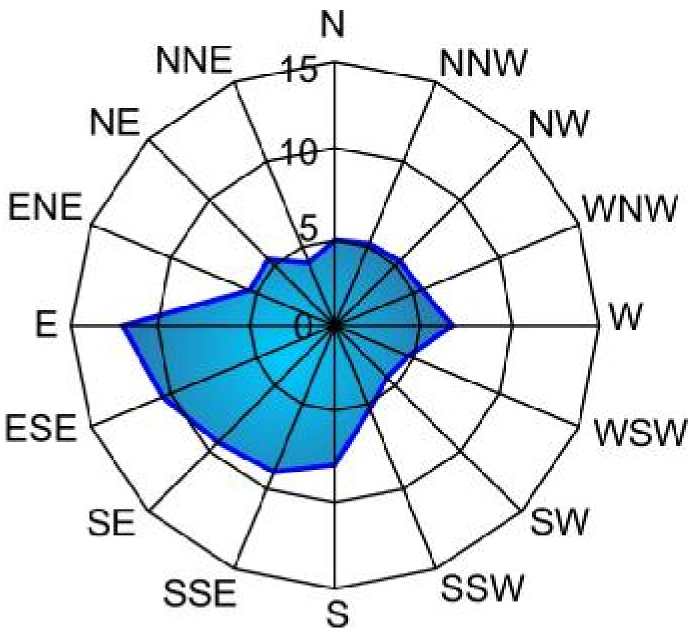


Figure 128 – The wind-rose

From Figure 128 there is seen that within the considered territory dominate winds of west - south directions.

In Table 168 in the generalized form there is shown specification of possible impact from the Belarusian NPP on the adjacent states.

Table 168 – Possible impact from the Belarusian NPP

State	Distance, km	Way impact		
		Surface water	Underground water	Atmospheric transfer
Lithuania	22	yes	no	yes
Poland	180	no	no	yes
Latvia	110	no	no	yes
Russia	200	no	no	yes
Ukraine	318	no	no	yes

With taking into account the wind-roses (See Figure 128) the most probable is the impact to the territory of Latvia and Russia by means of atmospheric transfer of the radionuclides, delivered into the atmosphere under the beyond design basis accident and the following their precipitation on the territory of the given states.

15.3 Model for calculation, the initial data and the results of assessment

To calculate the possible impact from the Belarusian NPP over the environment there were used the corresponding prognosis models, the list of which is shown in Table 169.

Table 169 - Used mathematical model

Object	Used model
Atmospheric air	Automated system for analysis and forecast for the radiation situation RECASS NT (Rosgidromet, "Taifun" Enterprise).
Surface water Heat Pollution Chemical Pollution	The method of Frolov - Rodziller and recommendations from Roshydromet. The formula of Frolov-Rodziller, the factor of turbulent diffusion D calculated with the method A.V. Karaushev
Underground water	Unified generalized multi-camera model of mixed cell (MULTIBOX).
Agricultural product	Compartment mathematical model, founded on the method of systemized analysis
Population	The package INTERRAS (The International Radiological Assessment System). The Model SOURCE OF THE SURGE - DOSE (ST-DOSE - Source Term for Dose)

The forecasted estimations are necessary for quantitative determination of possible impact and development of measures for minimization of consequences for the NPP impact on the environment in the event of beyond design basis accident.

For conservative assessment of consequences after beyond design basis accident there was taken the following reference value of emission with isotope iodine - 131 = 3100 TBq and cesium -137 = 350 TBq within the environment [12]. Besides, under the beyond design basis accident the integrity of protective shells is preserved, as minimum, within 24 hours, the leakages through containment - 0.2 % per a day and the emission stops through one day. Thereby, as a result of the beyond design basis accident in the containment there will is thrown out:

- iodine - 131: 3.1 E+15 : 0.002 = 1.55 E+18 Bq;
- cesium - 137: 3.5E+14 : 0.002 = 1.75 E+17 Bq

The given values for activities of the reference isotopes are well agreed with the emergency emission above the Chernobyl NPP (iodine 131 = 2.7 E+17 Bq, cesium 137 = 3.7E+16 Bq). The values of the emission used for assessment of consequences for reference isotope correspond to the 6 level according to the scale INES, Decision of the Government of Finland 395/1991. For introduction of assessment for the radiation emergency as heavy, over the level 6 according to the scale INES, in EIA of the Belarusian NPP there is no basis since for reception of license for construction and usage of the nuclear plant in Belarus arising of such emergency must be practically impossible.

For calculation of doses for irradiation under the beyond design basis accident there was used the following emission of radionuclides into the environment under the beyond design basis accident, Bq (Table 170).

Table 170– Surge of radionuclides into the environment under the beyond design basis accident, Bq

Radionuclide	Activity, Bq	Radionuclide	Activity, Bq	Radionuclide	Activity, Bq
Kr-85	1.00E+13	Kr-85m	4.2E+14	Kr-87	8.4E+14
Kr-88	1.2E+15	Sr-89	3.9E+13	Sr-90	1.5E+12
Sr-91	4.60E+13	Y-91	3.30E+12	Mo-99	1.80E+13
Tc-99m	1.80E+13	Ru-103	1.20E+13	Ru-106	2.70E+12
Sb-127	1.2E+13	Sb-129	6.9E+13	Te-129m	1.1E+13
Te-131m	2.5E+13	Te-132	2.5E+14	I-131	4.1E+14
I-132	5.8E+14	I-133	8.3E+14	I-134	9.2E+14
I-135	7.3E+14	Xe-131m	1.7E+13	Xe-133	3.0E+15
Xe-133m	1.1E+14	Xe-135	5.8E+14	Xe-138	3.0E+15
Cs-134	2.6E+13	Cs-136	1.0E+13	Cs-137	1.70E+13
Ba-140	8.8E+13	La-140	4.40E+12	Ce-144	1.2E+13
Np-239	2.3E+14	Rb-88	1.2E+15	Rh-106	2.7E+12
Te-129	1.10E+13	Xe-135m	1.2E+14	Ba-137m	1.70E+13
Pr-144	1.2E+13				

Total activity of the emission constituted 15000 TBq for all scenarios of the beyond design basis accident which corresponds to the requirements, laid in the Convention for nuclear safety and standard, determining the rules of technology for safety No GS-R-2, the event at the level 6 according to the scale INES (during the time of emergency over the environment there is thrown out 10000 - 100000 TBq equivalent to iodine-131).

The list of necessary protective measures under the beyond design basis accident is shown in Table 171.

Table 171 - Protective measures in the event of beyond design basis accident

Criterion of interference	Necessary protective measures
total effective dose lower 100 mSv over the whole body	Counter measures in the form of shelter, deactivation and/or evacuation for the population will not required
dose of radiation over the thyroid gland exceeding 50 mSv	Iodine prophylactics at early stage of emergency within the radius 25 km from the station

15.4 Lithuanian Republic

15.4.1 Surface water

Potential transborder impact of the Belarusian NPP on the surface water is expressed in possible change water mode for transborder and other water objects.

In the period of the NPP construction

Since under construction of the NPP for the purposes of the works execution and economic-drinking water supply will not be produced extraction of water from the surface water objects (water supply will be provided from underground water sources) in the given period there will not occur considerably changing of quantitative values in the water mode of the river Viliya and other water objects. Within the indicated period there will be executed tapping of rectified sewage waters into the river Viliya in the volume, not exceeding 1050 m^3/day.

In the period after commissioning the NPP

After commissioning the NPP in usage for production of water supply of the NPP for two energy units there will be executed tapping of water from the river Viliya with expediture up to 2.54 m^3/sec. During accommodation of two energy units under expediture of water in the river, close to the average perennial, tapping of water from the river Viliya will constitute not over 4 % from expediture of water in the river. Under conditions of waterless years and expediture of water in the river, close to minimal with average monthly the summer-autumn and winter lowest water level (95 % exceedance probability) at two energy units - not over, 8.4 %. Under conditions of very waterless year and expediture of water in the river, close to minimal average monthly the summer-autumn and winter lowest water level (97 % exceedance probability) at two energy units - not over 8.7 %.

Maximum lowering the level of water in transborder range of the river Viliya may constitute at two energy units and average perennial expediture of water up to 5 cm, under minimum expediture - up to 6 cm;

Forecast for speed mode of the river Viliya at accommodation of the Belarusian NPP showed non-considerable diminishing of average velocities of the flow (maximum - by 0.04 m/sec) within the area of the river Viliya being lower location of the water extraction and negligible change at the transborder range.

In the period for the NPP operation there will be executed tapping of rectified domestic sewage waters into the river Viliya in the volume 910.9 m^3/day with their possible maximum increase up to 3600 m^3/day.

Forecast for the quality of water in the river Viliya after delivery of rectified sewage waters from the Belarusian NPP during its construction and after commissioning showed that at a distance up to 10.4 km from the place of tapping there is taking place practically full mixing with the river waters (within the Belarusian territory and at over 20 km from the belorussian-lithuanian border) with negligible transborder impact on the quality of waters in the river Viliya and other water objects at the expense of unconsiderable (within the limits of MPC) changing the water quality in the river in relation to the existing one.

15.4.2 Underground water

Forecast for possible transborder pollution. Carrying of polluting materials in transborder aspect is preconditioned by the hydrodynamic situation. For assessment of possible transborder impact there is designed mathematical model, reflecting regional hydrodynamic scheme of the streams with underground waters within the transborder territories. Under analysis of hydro geological conditions there are chosen three most water rich horizons, located in the area of active water exchange: Dnepr-Sozh, Berezina-Dnepr and generalised before quarterly water carrying complexes, which create hydrodynamic situation within the limits of transborder territories and are used for the purposes of domestic-drinking water supply on the territory of Belarus and Lithuania (See Figure 129).

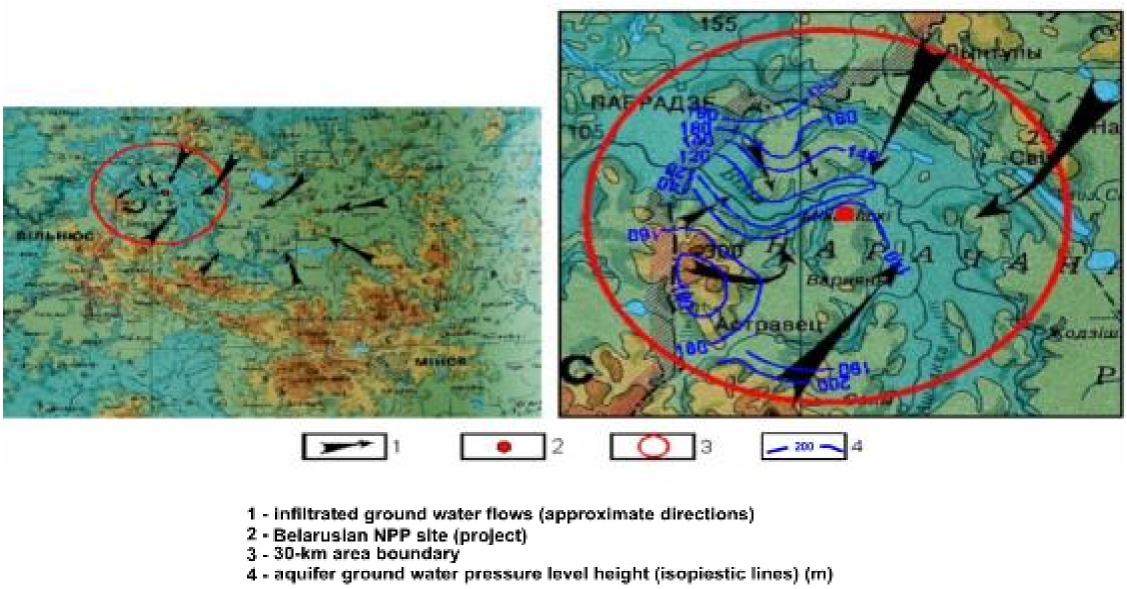


Figure 129 – Hydrodynamic situation development diagram

Coming from the result of studies over the conditions for creation and transit of underground waters of Dnepr-Sozh, Berezina-Dnepr and the united pre-quarterly water carrying complexes within the limits of greater part over the territory of 30-km area from Belarus to Lithuania is not tracked, and due to it the transborder transfer of polluting materials with underground waters may not be not forecasted.

The main antropogenic factor, rendering impact to the change of the underground waters level, is operation of group water extractions for drinking water supply. In this connection, forecast for changing hydrodynamic conditions, produced according to the mathematical model, showed that under existing and perspective water extraction at water extraction station "Ostrovets" lowering of the level (depression crater) on the territory, adjacent to the water extraction, in the exploited aquifer does not exceed the radius of 4 km. Thereby, it will not bring to the regional changing, those, within the territory, close to the border extraction of underground waters by group water extraction stations. Water extraction, realized by single bore holes in rural settlements has periodical character (functioning of the bore holes - 2-3 hours in a day) and has non-significant volume, in connection with which, on the adjacent territory there are not created depression craters, namely of the regional type.

Chemical pollution of underground waters in the region of the Belarusian NPP site there may be created at the expense of drains from the sewage water tapping systems (domestic-home, production type and others.). Distribution of pollution is preconditioned by hydrodynamic conditions of the territory, because the polluting materials move together with the stream of underground waters. Whereas, the distance from the place of supposed location of the Belarusian NPP at about 23 km to the adjacent territory of the Lithuanian Republic and the river Viliya is the main drain for underground waters from the territory of 30-km area, conditioning the direction for motion of the stream into the direction of its valley, advancement of polluting materials with the stream underground waters (as ground, so and from pressure quarterly and pre-quarterly) into the direction of the Lithuanian Republic are not forecasted.

Additional investigations on migration of polluting materials showed that accommodation and operation of the NPP within the calculated period for operation may lead to creation in the first from the surface aquifer of the halo with chemical pollution, herewith distribution of pollution (neutral component) up to the level of MPC does not move further 2.5 km from the contour of the Belarusian NPP area. Thereby, transborder chemical pollution over the underground waters within the territory of Lithuanian Republic under operation of the Belarusian NPP is not forecasted.

The executed investigations of the radiation materials migration from the site and local source showed that delivery of the radiation pollution in the river network within 30-km area is practically excluded. The area of underground waters being under the impact of local source pollution in the event of its presence on the territory of the NPP area restricted the area of penetration for the ground waters on the day surface. In this connection transborder transfer of radionuclides with underground waters is not forecasted.

15.4.3 Radioactive pollution of the territory at beyond design basis accident

For calculation of radiation pollution under various meteorological conditions there were considered 2 scenarios for undesigned emergences (heavy) (Table 172).

Table 172 – Parameters of scenarios for heavy undesigned emergences

Parameter	Scenario 1	Scenario 2
Period of modeling	24 hours	24 hours
Duration of the emission	1 hour	1 hour
Composition of the emission (reference of radionuclides)	iodine-131, cesium - 137	iodine -131, cesium - 137
Dynamics upper and lower limits of the emission	21 – 25 m	21 – 25 m
Effective diameter from the source	3 m	3 m
Velocity of the emission	1.8 m /sec	1.8 m /sec
Overheating	30 ^{0}C	30 ^{0}C
Activity of the emission: iodine -131; cesium - 137	$1.0 \times 10^{+14}$ $1.0 \times 10^{+13}$	$3.1 \times 10^{+15}$ $3.5 \times 10^{+14}$
Parameters of the emission: emission of iodine isotopes in the volume containment - emission cesium isotopes - 137	90 % in the form of aerosoles 100 % in the form of aerosoles	

Meteorological situation (See Table 173): per years was determined by western periphery of vast little movable anticyclone having the center above the Voronezh area. Chiefly with no precipitations, only over the western part of Brest region under the impact of little active atmospheric front there took place short-period rains. The wind is south-eastern moderate. At meteorological station of Lyntupy at the beginning of emergency there were registered:

Table 173 – Meteorological situation

Parameter	Lyntupy	Vilnius
Temperature of the air, ^{0}C	4.2	5.5
Direction of the wind, ^{0}	120	130
South-eastern, m/sec	1.0	1.0
Pressure, GPa	995.7	1001
Point of dew, ^{0}C	1.7	4.3
Total cloudicity, %	0	0
Category of stability	F	F

Precipitations were not observed.

Model making was executed with use of the prognosis data in the fields of meteorological parameters from Moscow prognosis center under the following conditions:

- wind at the height of 10 meters is southern - 20-28 km/hour;

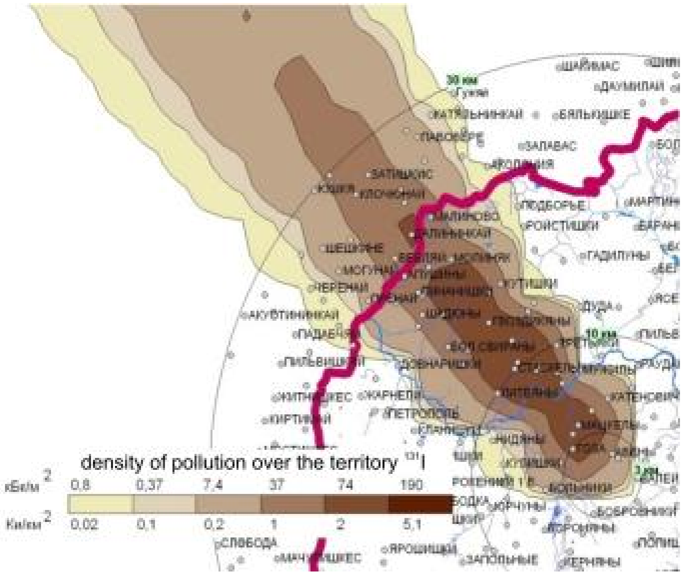
- temperature at the height of two meters above the ground - 6.0 - 7.2 °C.

The height of the mixing layer reached 0.4 km. The parameter of stability according to Smith - 4.

Density of pollution over the territory ^{131}I and ^{137}Cs on the axis of the trace shown in Table 174 and in Figure 130.

Table 174 - Density of pollution of the territory with radionuclides on axis of the trace C3, Bq/m²

Р/н Bq/m² 110400	Distance, km									
	0.5	1	2	3	5	10	15	20	25	30
Scenario 1										
I-131	4.0E+04	5.3E+04	8.0E+04	1.2E+05	8.9E+04	1.7E+05	1.0E+05	6.9E+04	6.0E+04	5.4E+04
Cs-137	4.3E+03	5.7E+03	8.6E+03	1.3E+04	9.7E+03	1.8E+04	1.1E+04	7.5E+03	6.5E+03	5.8E+03
Scenario 2										
I-131	9.7E+05	1.3E+06	2.1E+06	2.7E+06	2.3E+06	5.0E+06	2.9E+06	2.1E+06	1.7E+06	1.7E+06
Cs-137	1.2E+05	1.6E+05	2.6E+05	3.5E+05	2.9E+05	6.0E+05	3.7E+05	2.6E+05	2.2E+05	1.9E+05



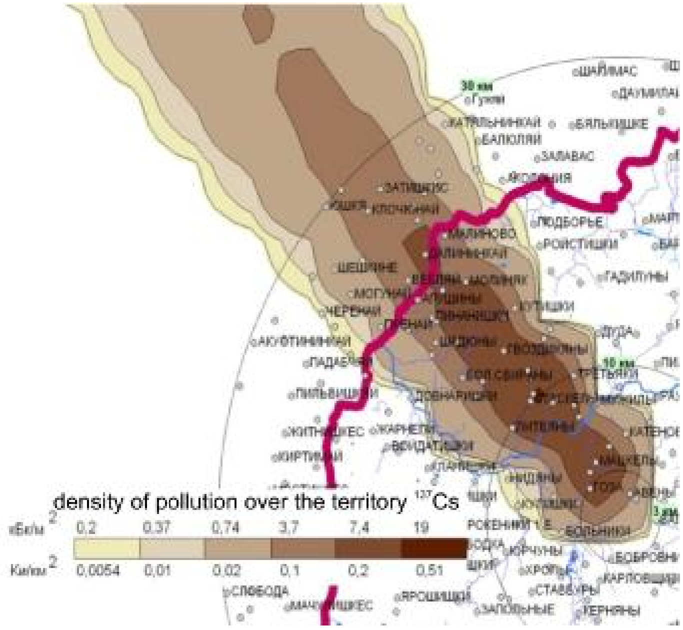


Figure 130 – Scenario 1. Fields having density pollution over the territory with ^{131}I и Cs-137 (track C3)

In Tables 175 and 176 there are shown the areas of pollution with radionuclides over the territory of adjacent states.

Table 175 - Area of pollution over the territory ^{131}I for various levels according to the results of modeling under beyond design basis accident with north-west track

Scenario 1					
Levels of pollution with ^{131}I (kBq)	**0.8-3.7**	**3.7-7.4**	**7.4-37**	**37-74**	**74-190**
Area of pollution within the level (km^2)	4400	1700	1500	150	63
Area of pollution over the territory of adjacent states within the level (km^2)	4366	1678	1371	77.3	2.4
Scenario 2					
Levels of pollution with ^{131}I (kBq)	**37-110**	**110-370**	**370-740**	**740-1900**	**1900-5700**
Area of pollution within the level (km^2)	210	300	240	310	99
Area of pollution over the territory of adjacent states within the level (km^2)	181.3	231.1	209.2	232.5	7.2

Table 176 - Area of pollution over the territory with 137Cs for various levels according to the results of modeling under beyond design basis accident with a northern-west track

Scenario 1					
Levels of pollution with ^{137}Cs (kBq)	**0.2-0.37**	**0.37-0.74**	**0.74-3.7**	**3.7-7.4**	**7.4-19**
Area of pollution within the level (km^2)	2400	1800	1600	160	79
Area of pollution over the territory of adjacent states within the level (km^2)	2320	1736	1436	89	4.1
Scenario 2					
Levels of pollution with ^{137}Cs (kBq)	**3.7-19**	**19-37**	**37-74**	**74-260**	**260-700**
Area of pollution within the level (km^2)	320	150	210	470	52
Area of pollution over the territory of adjacent states within the level (km^2)	256.9	110.3	155.9	304.9	3.8

Pollution of the territory within the adjacent state (Lithuanian Republic) if possible under N-W and S-W directions of the radiation trace of the emission under the beyond design basis accident. The results of the calculations are show in Table 177.

Table 177 – Area of radiation pollution

scenario	The area for radiation pollution, km ^{2}			
	The area for immediate settle out, Cs^{137}>1480 kBq/m^2	The area for the following settle out, Cs^{137} 555-1480 kBq/m^2	The area having the right for settle out, Cs^{137} 185-555 kBq/m^2	The area of dwelling with periodic radiation control, Cs^{137} 37 – 185 kBq/m^2
NW track				
No. 1	–	–	–	–
No. 2	–	–	3.8	459
SW track				
No. 1	–	–	–	–
No. 2	–	–	–	86.9
NW track 10.05.2009				
No. 1	–	–	–	–
No. 2	–	–	77.3	1836.6

From Table it is obvious, that pollution of the territory of Lithuanian Republic with Cs ^{137} above 37 kBq/m^2 (1 Ci/km^2) is observed for scenario No 2. In this scenario the isotopes emission was considered as being equal to: ^{131}I – 3100 TBq and ^{137}Cs – 350 TBq.

15.4.4 Assessment of radiation impact rendered by the Belarusian NPP to the population

The yearly dose of irradiation over the population within the Lithuanian border under standard operation of the Belarusian NPP is shown in Figure 131.

In Figure 132 there is shown contribution into the dose made by various ways of irradiation.

The yearly dose of irradiation over the population within Vilnius under standard operation of the Belarusian NPP is shown in Figure 133.

In Figure 134 there is shown contribution into the dose made by various ways of irradiation over the population of the town Vilnius.

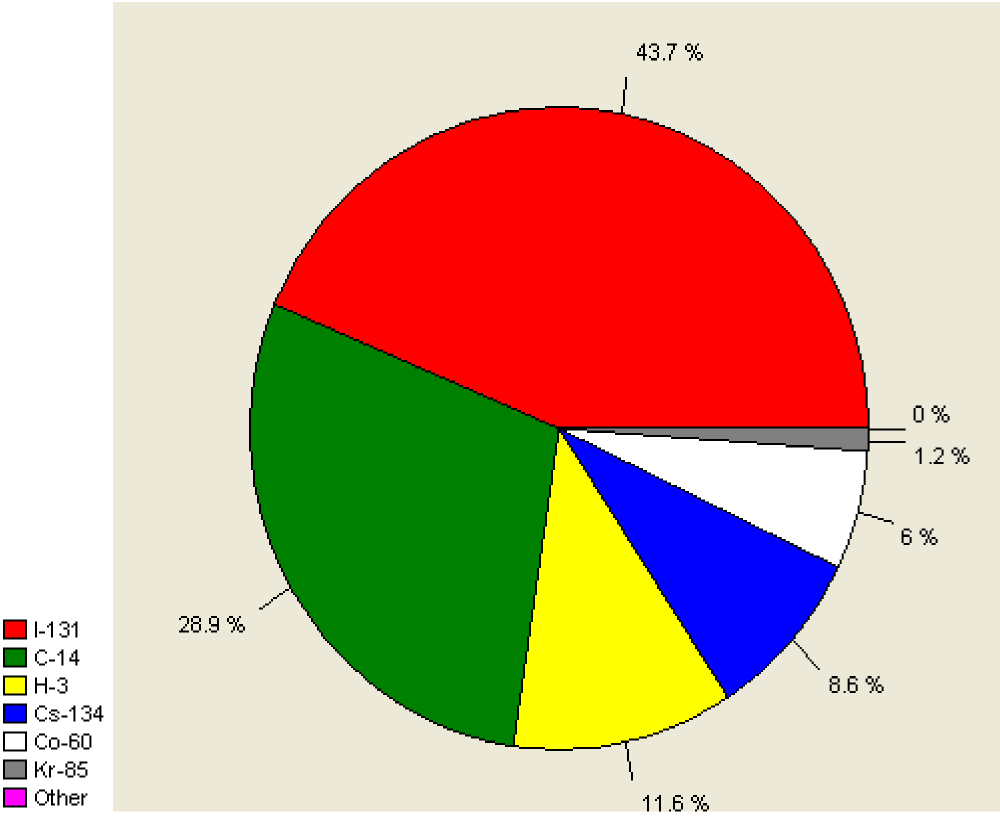


Figure 131 – Contribution of various radionuclides into the total dose

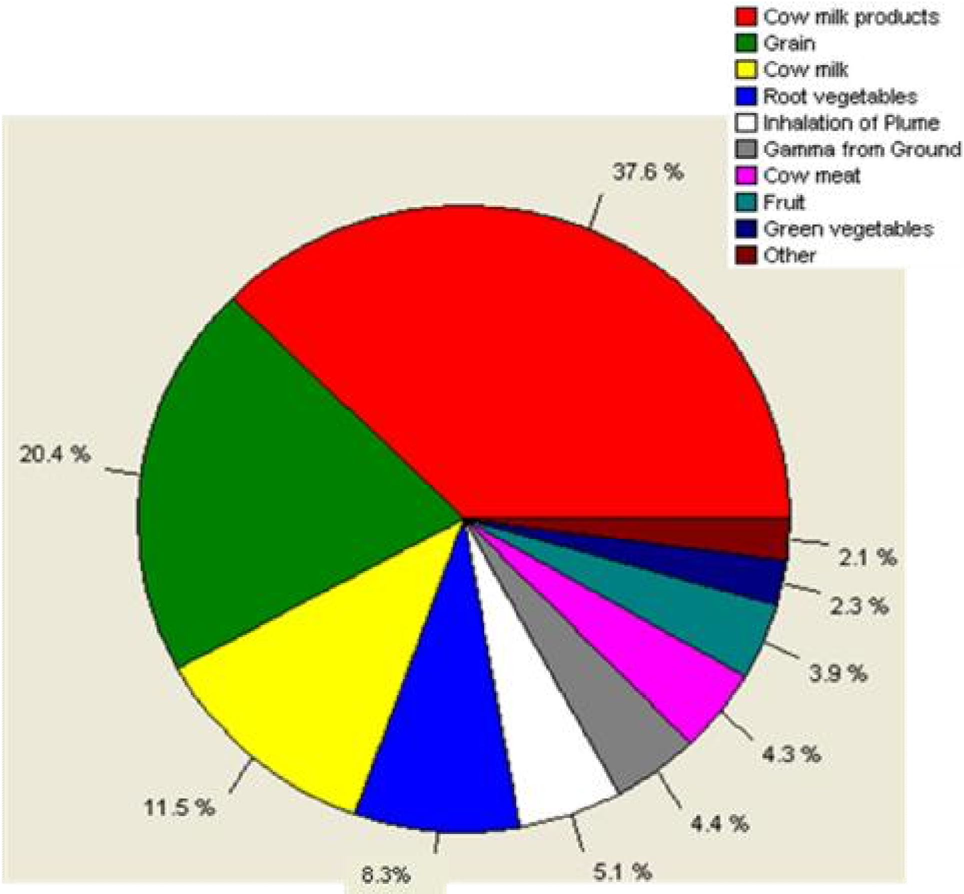


Figure 132 – Contribution of various ways of irradiation into the total dose

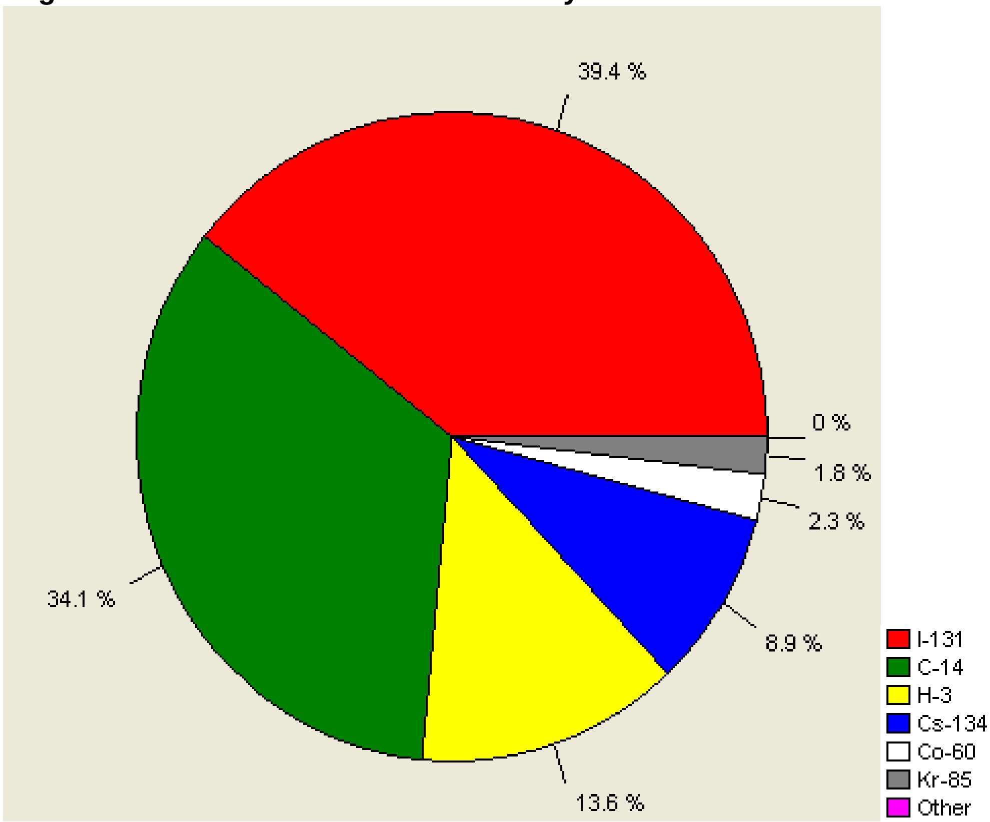


Figure 133 – Contribution of various radionuclides into the total dose (Vilnius)

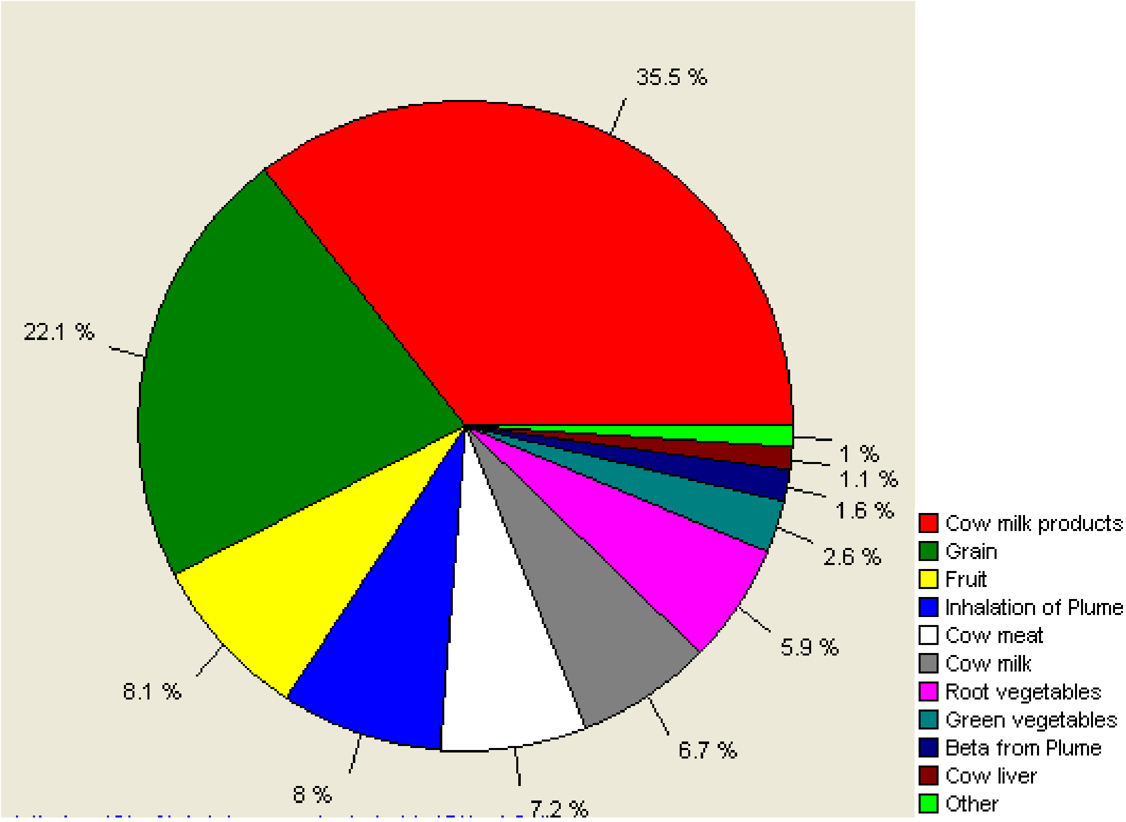


Figure 134 – Contribution of various ways of irradiation into the total dose (Vinius)

The yearly doses of irradiation over the population, dwelling within the territory near the border, constitute ***E*** $_{\textit{the year}}$ ***= 0.017 µSv.***

The yearly doses of irradiation over the population, dwelling in Vilnius, constitute ***E*** $_{\textit{the year}}$ ***= 0.004 µSv.***

The data values are equal 0.17 % and 0.04 %, respectively, from the quotas of irradiation over the population from emissions (discharges) under standard for operation of the NPP, 10 *µSv* /year.

Forecasted doses of irradiation over the population at the most heavy scenario of the endesigned emergency (meteoconditions of 17.03.2009 r), that is at which the doses of irradiation over the population will be maximum at various distances from the NPP, shown in Table 178.

Table 178 - Doses of irradiation at early stage of emergency under sce nario for undersigned emergency (meteoconditions of 17.03.2009 r.) at various distances from the NPP

Distance, km	Dose from the cloud, *µSv*	Dose from fallouts, *µSv*	Effective inhalation dose, *µSv*	Total effective dose, *µSv*	Dose of irradiation over the thyroid gland*, mGy
1	3.5	11.0	79.0	94.5	1500
2	2.4	6.3	47.0	55.7	910
5	1.1	2.9	22.0	26.0	420
25	0.14	0.18	1.3	1.62	25
50	0.11	0.13	1.00	1.24	19

*Dose for irradiation over the thyroid gland comprises only the doses from radiation rendered by iodine.

As may be seen from Table, iodine preventive maintenance under emission of 15000 TBq at early stage of beyond design basis accident should be obligatory executed within the radius of 25 km from the station.

15.5 Poland

The yearly dose for irradiation of the population over the region of Poland near the border under standard operation of the Belarusian NPP is shown in Figure 135.

In Figure 136 there is shown contribution of doses from various ways of irradiation.

The yearly dose for irradiation over the population in Warsaw under standard operation of the Belarusian NPP is shown in Figure 137.

In Figure 138 there is shown contribution into the dose from various ways of irradiation for the population of Warsaw.

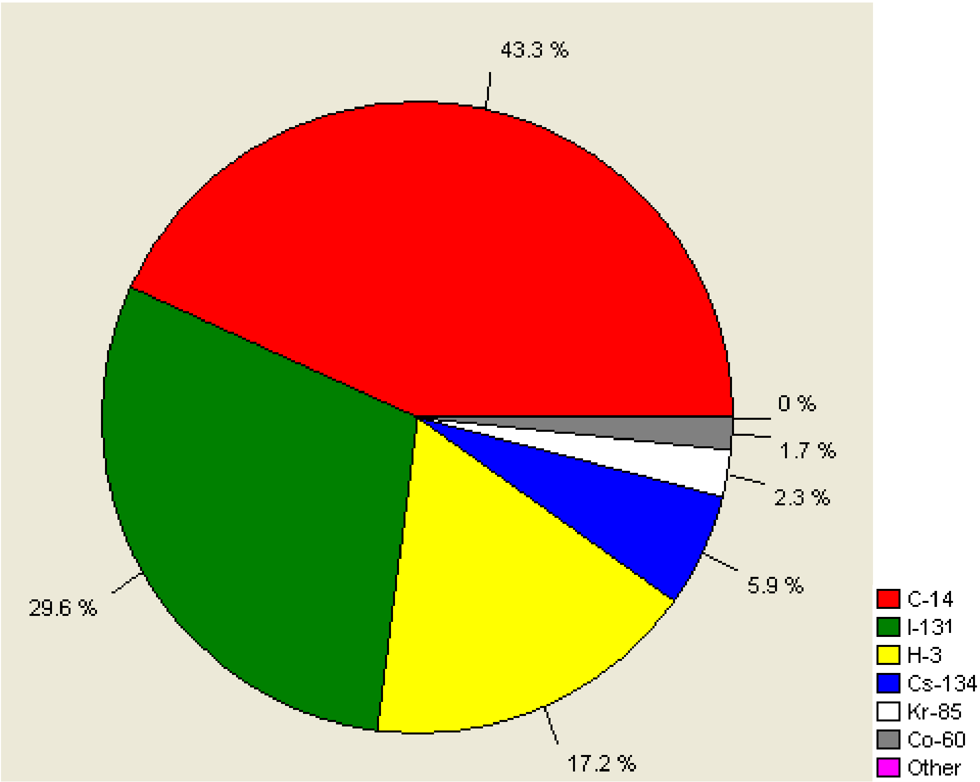


Figure 135 – Contribution of various radionuclides into the total dose

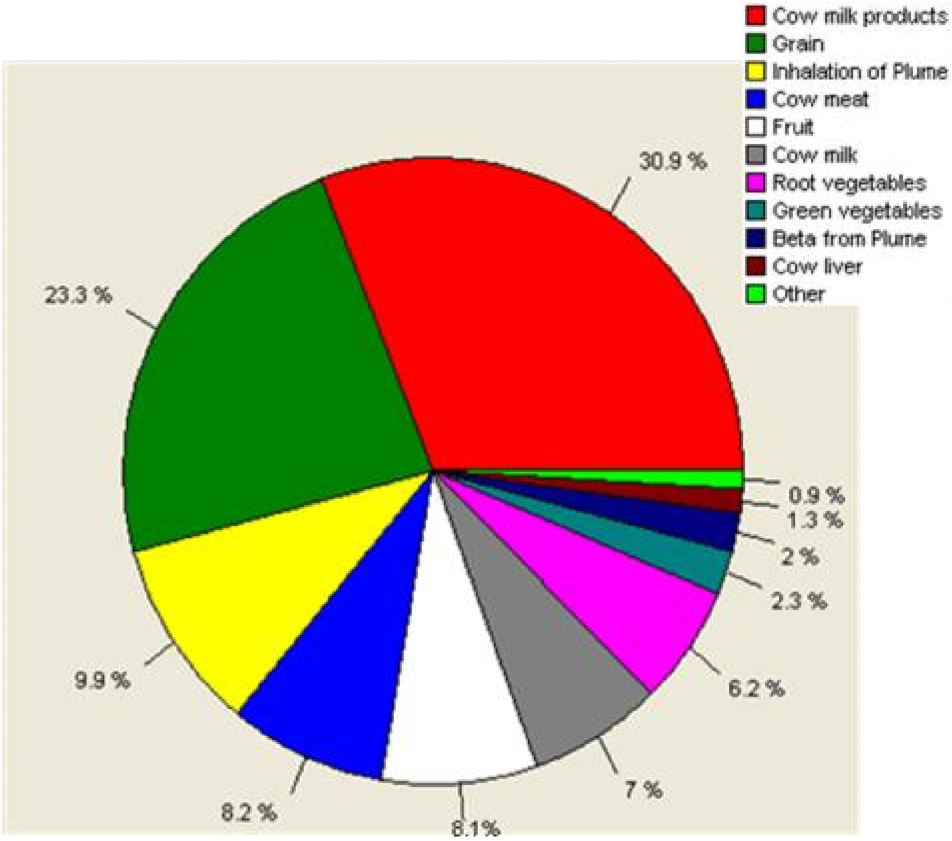


Figure 136 – Contribution of various ways of irradiation into the total dose

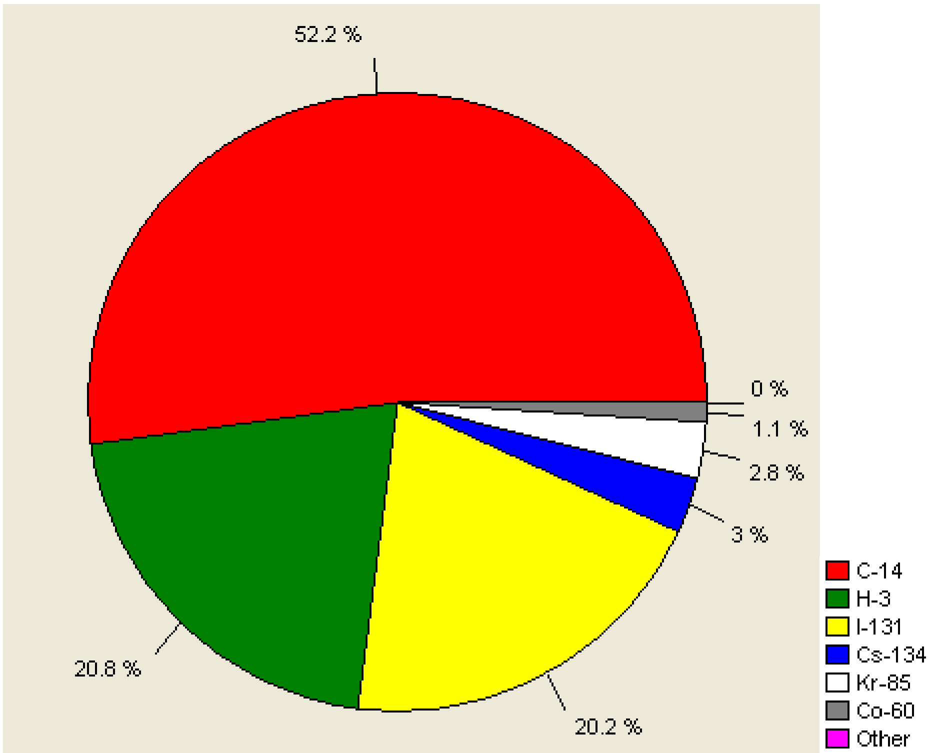


Figure 137 - Contribution of various radionuclides into the total dose (Warsaw)

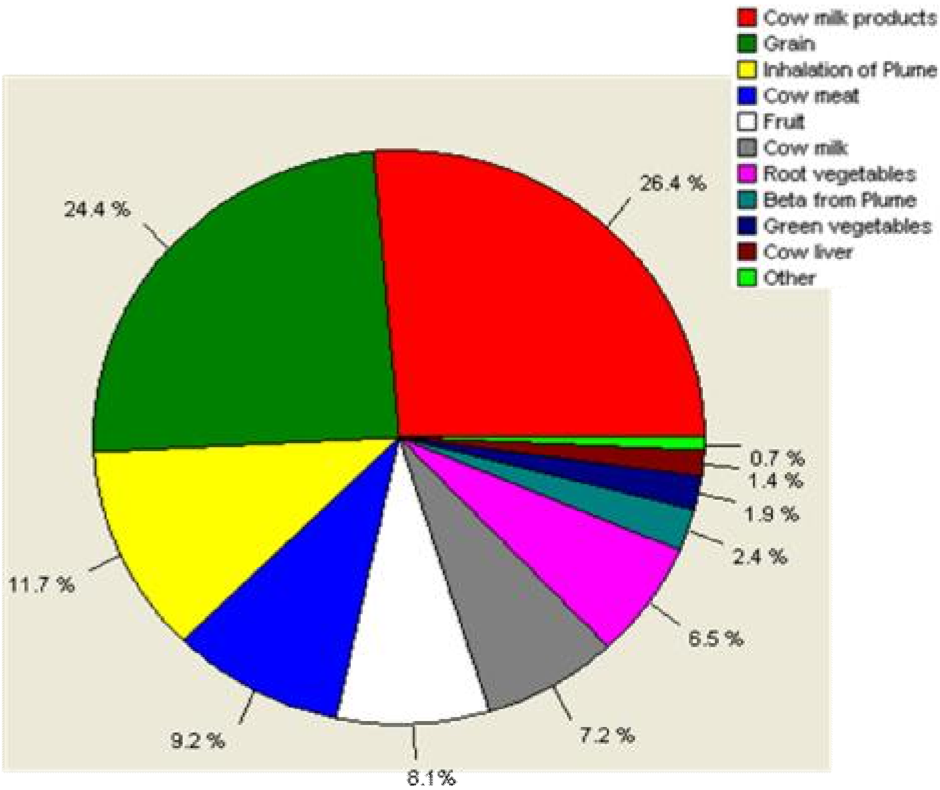


Figure 138 – Contribution of various ways of irradiation into the total dose (Warsaw)

***E* *the year* = 0.001 µSv *E* *the year* = 0.0003 µSv**

The yearly doses of irradiation over the population, dwelling within the territory near the border, constitute ***E* *the year* = 0.001 µSv.**

The yearly doses of irradiation over the population, dwelling in Warsaw, constitute

***E* *the year* = 0.0003 µSv.**

The given values are equal to 0.01 % and 0.003 %, respectively, from the quotas for irradiation over the population from emissions (tapping sewages) under standard operation of the NPP, 10 *µSv* / year.

Doses of irradiation over the population as a result of beyond design basis accident are shown in Table 179.

Table 179 – Doses of irradiation over the population

Distance, km	Effective dose, *µSv*	Dose of irradiation over the thyroid gland*, *µSv*
100	0.438	6.718
200	0.155	2.375
300	0.084	1.293
400	0.055	0.840
500	0.039	0.601

Influence, rendered to the territory of Poland from the Belarusian NPP through other ways is excluded, because we do not have general water streams, and the underground waters are not communicated.

15.6 Austria

The yearly doses of irradiation over the population, in Vienna at standard operation of the Belarusian NPP shown in Figure 139.

In Figure 140 there is shown contribution of doses rendered by various ways of irradiation over the population in Vienna.

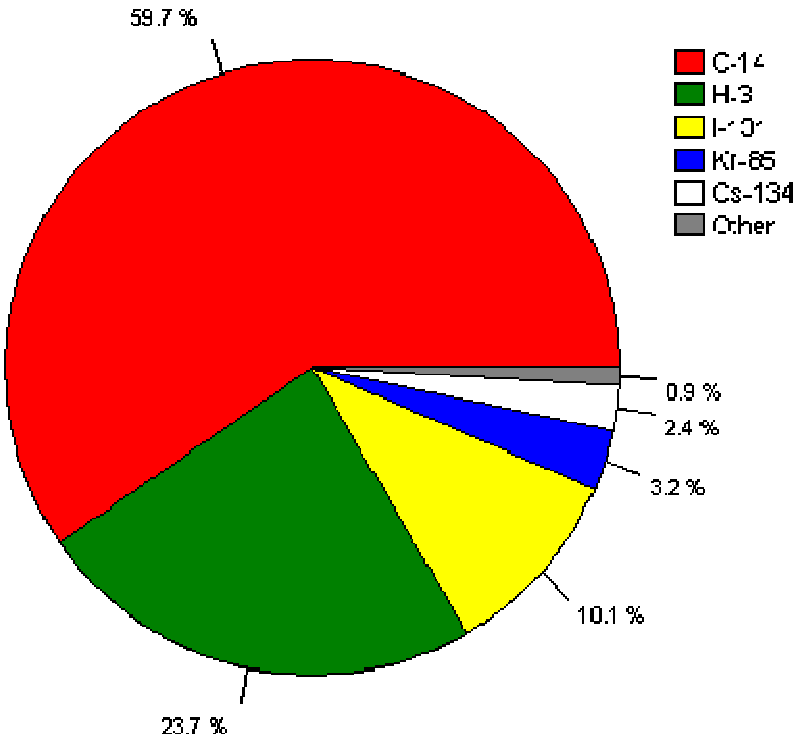


Figure 139 – Contribution of various radionuclides into the total dose

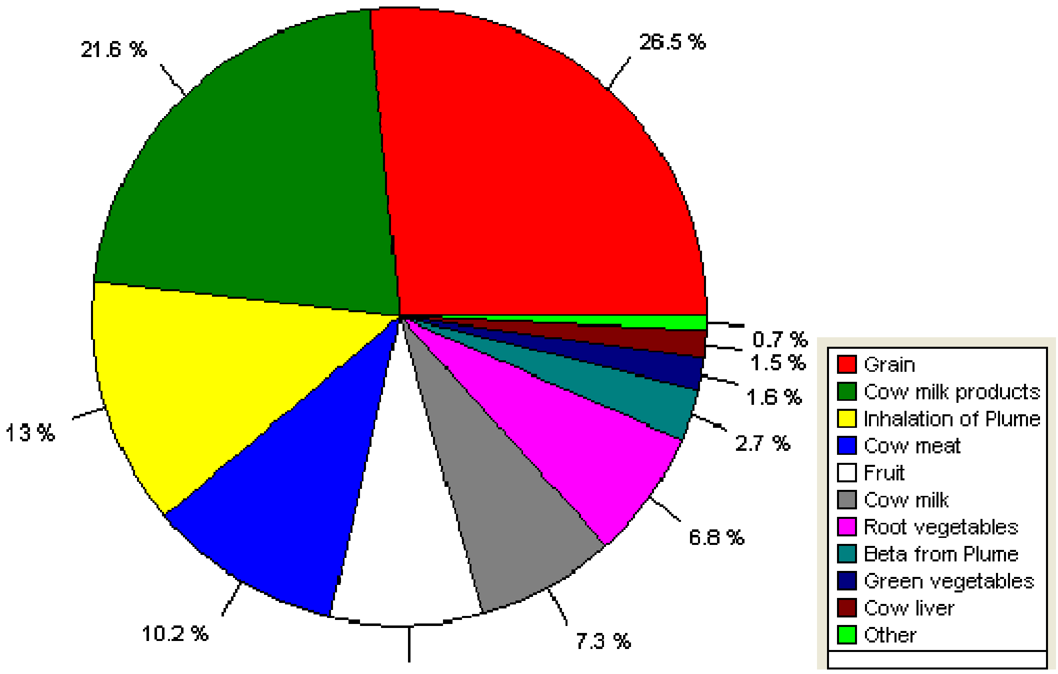


Figure 140 – Contribution of various ways of irradiation into the total dose

The yearly doses of irradiation over the population, dwelling in the city of Vienna, constitute:

E** **the year** **= 0.0001 μSv, which corresponds to 0.001 % of the quota for irradiation over the population from emissions (discharges) under standard operation of the NPP, 10 μSv/year.

The yearly doses of irradiation over the population, as a result of beyond design basis accident are shown in Table 180.

Table 180 – Doses for irradiation over the population

Distance, km	Effective dose, mSv	Dose for irradiation over the thyroid gland*, mSv
800	0.019	0.297
900	0.016	0.249
1000	0.016	0.212
1200	0.014	0.162

The impact, rendered to the territory of Austria from the Belarusian NPP through other ways is excluded.

15.7 Republic of Latvia

The yearly doses of irradiation over the population, dwelling in Riga under standard operation of the Belarusian NPP is shown in Figure 141.

In Figure 142 there is shown contribution of doses for various ways of irradiation over the population, dwelling in Riga.

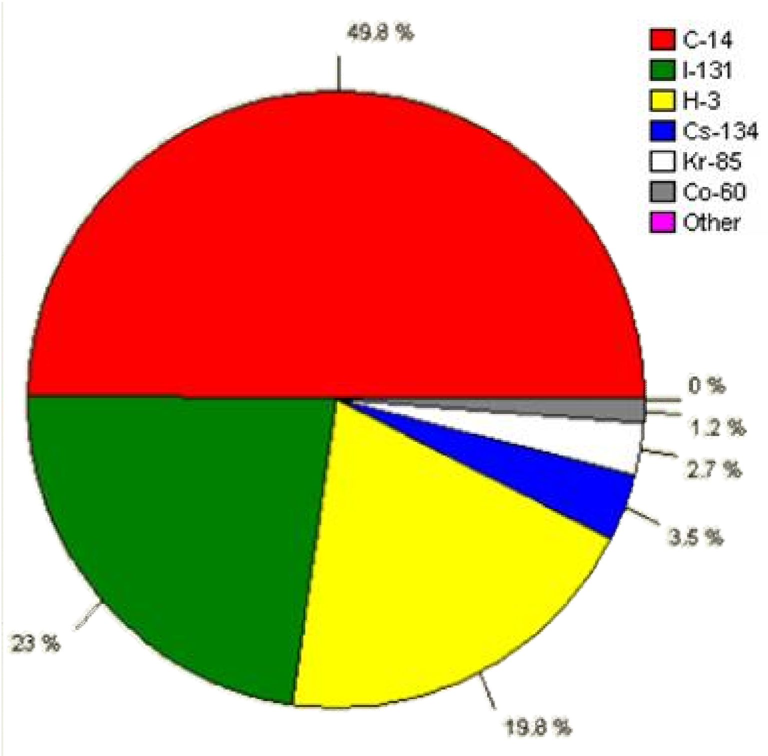


Figure 141 – Contribution of various radionuclides into the total dose

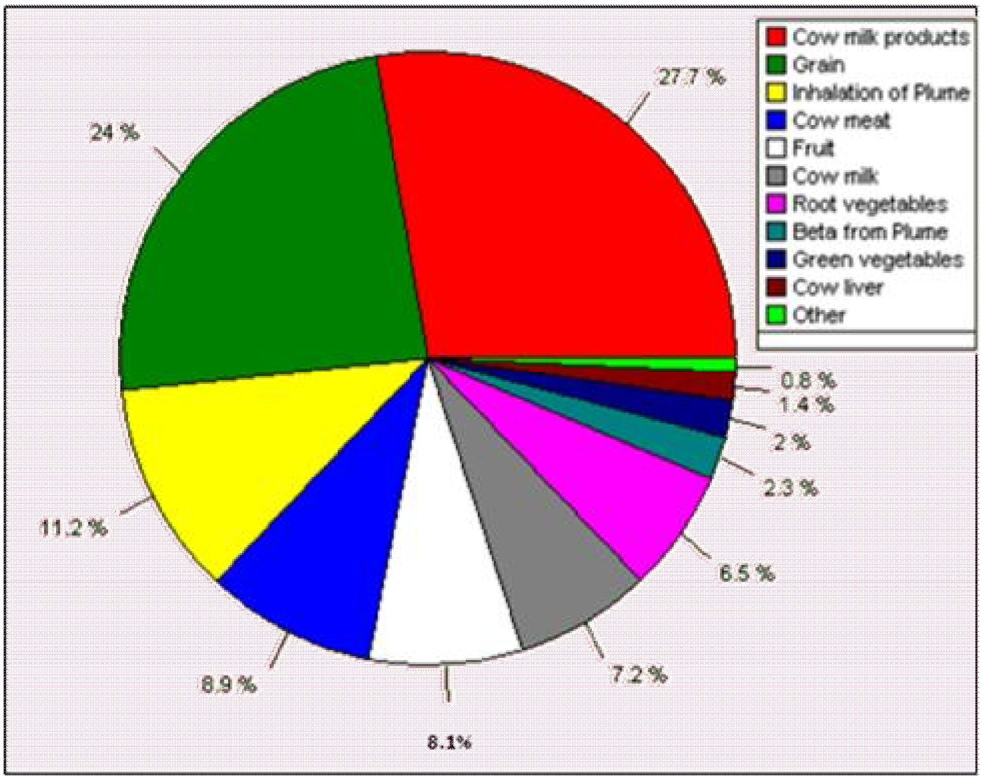


Figure 142 – Contribution of various ways of irradiation into the total dose

The yearly doses of irradiation over the population, dwelling in Riga, constitute:

E** **the year** **= 0.0004 μSv, which corresponds to 0.004 % of the quotas for irradiation over the population from emissions (discharges) under standard operation of the NPP, 10 μSv /year.

The doses of irradiation over the population as a result of beyond design basis accident are shown in Table 179.

15.8 Ukraine

The yearly doses of irradiation over the population, dwelling in Kiev under standard operation of the Belarusian NPP are shown in Figure 143.

In Figure 144 there is shown contribution into the doses rendered through various ways of irradiation over the population, dwelling in Kiev.

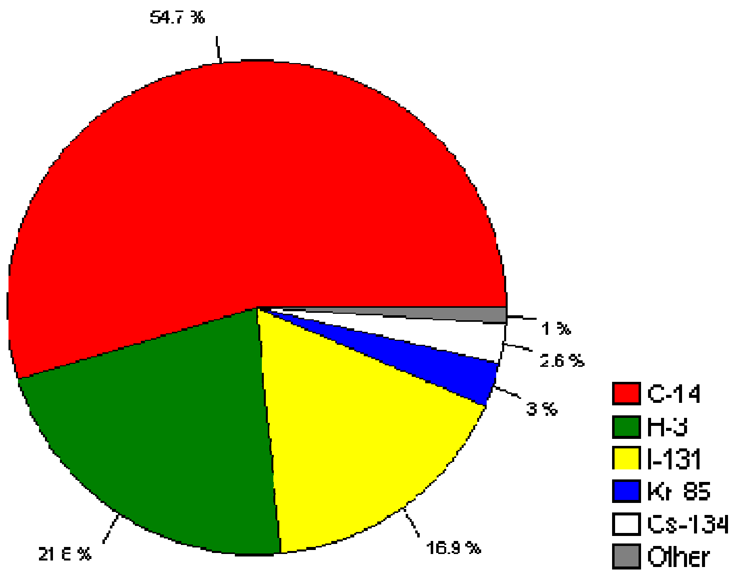


Figure 143 - Contribution of various radionuclides into the total dose

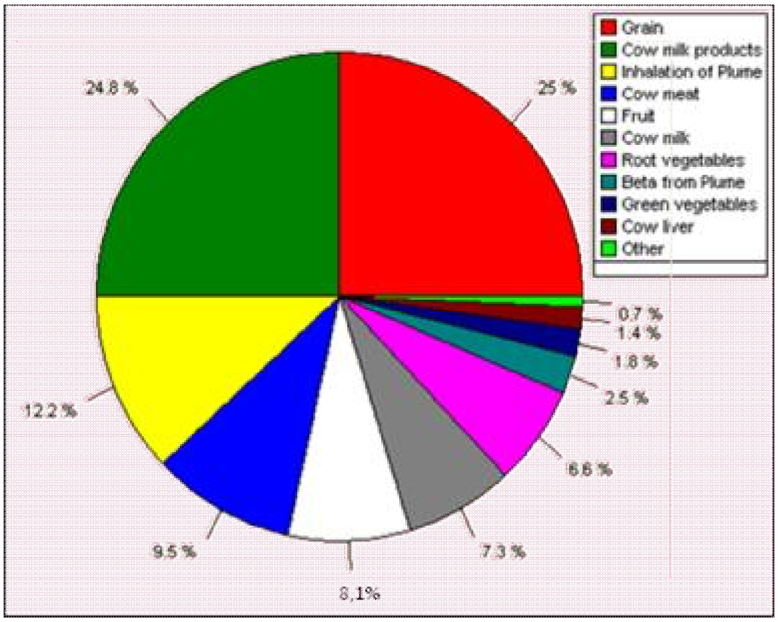


Figure 144 – Contribution of various ways of irradiation into total dose

The yearly doses of irradiation over the population, dwelling in Riga:

E $_{the\ year}$ ***= 0.0004 μSv,*** which corresponds to 0.002 % of the quotas for irradiation over the population from emissions (discharges) under standard operation of the NPP, 10 μSv /year.

The doses of irradiation over the population as a result of beyond design basis accident are shown in Table 179.

15.9 Russian Federation

Correct character of the approach and the obtained results after the modeling are approved with positive Conclusion of Federal service for environmental, technological and nuclear supervision of the Russian Federation of 12.11.2009 No VB-46/578.

The forecasted assessment of the impact from the beyond design basis accident at the Belarusian NPP over the territory of adjacent states shown in Table 181.

Table 181 – Possiblee impact, rendered to the territory of adjacent states

Parameter	Lithuanian Republic	Republic of Latvia	Republic of Poland	Ukraine	Russian Federation
Health of the population	Influence minimal	Influence absent	Influence absent	Influence absent	Influence absent
Water streams	Influence minimal	Influence absent	Influence absent	Influence absent	Influence absent
Agricultural products	Influence minimal	Influence absent	Influence absent	Influence absent	Influence absent
Underground waters	Influence absent	Influence absent	Influence absent	Influence absent	Influence absent
Biota	Influence absent	Influence absent	Influence absent	Influence absent	Influence absent
Soil	Influence minimal	Influence absent	Influence absent	Influence absent	Influence absent

16 ECOLOGICAL RESULTS OF THE EIA

In the result of the works, executed at the stages for selection of the area aimed at construction, and development of the EIA materials, was shown and scientifically grounded the following:

- the selected site has no restrictions on the basis of natural and antropogenic factors;
- there was arranged complex examination of objects within the environment in the result of which there was determined the background condition for the objects in the environment, there is given comprehensive assessment for the initial environment of the state:
- radioactive pollution of its components is found at the level of global radiation fallouts;
- chemical pollution, as a rule, does not exceed according to the restriction values;
- there are chosen the main critical elements in various components of the environment (ground, surface and ground waters, landscapes, animal and vegetable world, hydro ecosystems, agriculture).
- there is described the supposed system of control and complex radiation-ecological monitoring of the state environment within the area of observation around the NPP.
- there is shown that in the supposed to projecting NPP-2006 is used collection of passive and active systems for safety, providing the following criteria for safety and the projected limits.

The criteria for safety and the projected limits

The criteria for safety and the projected limits are taken in accordance with the acting normative documentation, and recommendations from the МКРЗ (the International commission on radiological protection) and the IAEA.

For the population there are fixed the following projected limits for the doses :

1) As quotas for standard operation in the requirements for the project of the NPP-2006 with reactors of the type WWER 1200 for54 each influencing factor (emissions/tapping sewages) there is installed the target limit - dose of 10 μSv/year; for standard of operation (the works with nominal power and at the ППР stops) and under breaches of standards for operation, as the upper border at optimization of the radiation protection, there is fixed the limit for the individual effective dose of irradiation over the population (the critical group) 100 μSv in the year which constitutes 1 % and 10 % from the main dose limit, according to the restrictions from NRB-99, NRB-200 for the population in average undesigned emergences within the following 5 years

The data outside the limits must not exceed the restrictions of sanitary-protective area (around the area) and outside its borders;

2) under design accidents at the NPP there are expected the doses of irradiation over the restricted part of the population (the critical group) within the borders of sanitary-protective area and outside its borders must not exceed 5 mSv on the whole body and 50 mSv on separate organs within the first year after the emergency;

3) under beyond design basis accident at the NPP the doses of irradiation for the restricted part of population (the critical group) within the restricted area for plan-

ning protective measures and outside its borders must not exceed 5 mSv within the whole body and 50 mSv on individual organs for the first year after the emergency.

For the working personnel of the group A under standard operation and removal of the NPP from operation there are fixed the following doses criteria:

- the average value of individual doses for irradiation over the personnel must not exceed 5 mSv/ year;

- the planned value for collective dose of irradiation over the personnel must be 0.5 persons Sv/ per a year.

The target limits of effective doses for irradiation over the personnel at the checkpoint under the considered in the projects heavy emergencies - 25 mSv/event.

In the project there is motivated, that with the corresponding mode there is provided radiation safety by means not exceeding the projected limits, which in their turn limits:

- the level of activities in the water of the first contour for the products of fission;

- the level of activities in the water (or the steam) in the second contour, in the supply system waters (during the work in a nuclear heat power plant cycle mode);

- the level of activities in the water, cooling the equipment of the first contour;

- the level activities in the water of the pool for keeping the worked out fuel;

- the emission of radiation materials in the atmosphere and in the waters must not exceed the requirements of the SP AS-03 standard;

- the levels of irradiation in the premises of the NPP.

In the project there are determined the projected limits, determined by standards for the degree of hermetic sealing of the protective barrier: the shells of ТВЭлов, the first contour, areas of localizing the contours, being adjacent with the first contour, of localizing armature, pool for keeping, protective shells.

By the project there must be installed the sizes of sanitary-protective area (restrictions of the area), the area for observations and area for planning protective measures.

From analysis of literary data there is installed that the most impact on the environment will be rendered at the stage of the NPP construction and the most critical to the given impact will be vegetation.

17 MEASURES FOR PROTECTION OF THE ENVIRONMENT

In the process of the NPP construction, when planning the territory, displacement of the ground, at storehouses of inert materials the dust pollution of the atmosphere occurs.

However this pollution is local and short-time, and with taking into account the applicable measures for dust suppression, as a matter of fact do not make changes into conditions of the environment. Dust suppression is planned to be realized at the expense of installation cyclone dust separators, filter in the systems of pneumatic transport and aspiration, installations of aspirated local covertures in places for overloading filling materials, moistening opened storehouses for filling materials in summer time.

The enterprises for fabrication of metallic constructions, pipe units with execution of painting, counter corrosion, chemical protective works are the sources for emissions of welding aerosols, manganese oxides, vapours of diluting liquids, acids and alkali. For diminishing concentration of bad materials at worker places and emissions into the atmosphere there will be foreseen local ventilation and on necessity rectification of emissions up to maximum permitted concentrations.

Concrete works is the source of the emission for burnt out oil products and dust. Diminishing of emissions with these materials is planned to reach by installation of cyclone dust separators, high temperature fireboxes for complete incineration of technological fuel and smokestack, providing necessary height and diluting of the emission

The enterprises of the automobile transport, construction machines and mechanisms throw out, basically, oxide of carbon, oxides of nitrogen and sulphur, aerosols of lead, hydrocarbons and others.

It is planned to reach reduction of emissions at the expense of optimum scheme for motion of transport and machines, regulation of the engines to achieve standard values for the emission.

All above enumerated objects, polluting the atmosphere, are found within the limits of construction base and outside the area and their impact, including noise, do not throw out outside the limits of the NPP territory and do not exceed the permitted values.

During production of works for building of the temporary buildings and construction elements of the construction base and priority works performed on the industrial NPP site there will be foreseen overtaking construction of the networks and rectification buildings for domestic-fecal and industrial-showerly kanalysation.

The quarry of loam and sandy-gravel mixture and mouldboards of soils are situated on the territory, removed from the water reservoirs over 1 kilometer, and do not impact upon conditions of water protection areas.

Tapping surface waters from interplatform automobile and railway roads will be realized by the complex of measures:

- with transverse tapping of surface waters along the planned surface of the earth plane and ballast layer into the direction of longitudal water tapping;
- with arrangement of tranches, ditches, longitudal and transverse pallets;
- by construction in proper places of small artificial erected elements.

Rectified sewage and unpolluted waters will be directed into the adjoining water reservoirs.

Thereby, it is possible to establish that significant changes in the mode of natural sewages within the limits of the NPP area will not take place.

The objects for recultivation are the territories of construction bases, mouldboards and quarries. After completion of the period for operation temporary buildings they are unmounted, there is executed planning, providing the surrface sewage. On the whole recultivated territory after its planning there is executed stowage of the soil grounds, possible fertilizing and sowing of herbs.

After working out of the quarries and mouldboards of soil there is foreseen recultivation of their territory with execution of works for its improvement. With this aim there is produced planning of the area with laying of slopes, fixing the soil layer from opening, sowing of herbs.

The soil taken in the process of construction in the places of erecting builings, is stored in temporary mouldboard, located not far from the production area, and is used in the following for recultivation and improvement.

Arrangement of the works on linear communications (automobile and railways, piping lines for technical water supply) provides maximum use for passing of automobile transport over the places of laying linear communications.

The violated adjoining bands are planned, covered with building soil, in advance taken out from the places of construction and are seed with herbs. The building waste and rubbish are transferred to the range for industrial waste remains.

With taking into account of the existing trends for growing industry of the rest in this region, manifestation of negative factors of intensive recreation impact on the vegetation already today there will appear before the society and the nature protection departments the problem about all-round assessment of its recreation potential, as well as assessment of the recreation impact on their condition and stability of vegetation.

In connection with high agricultural maintenance over the grounds within 5 km area, chosen for location of the area for construction of the NPP, the main changes in natural vegetation cover will occur in adjacent with the site territories with large unique forest massives, located from construction of the area within the radius of about 10 km and concentrated mainly along the river Viliya. So the main tasks at enterprises of timber facilities and nature protection services for protection and rational use of vegetation within the area of the NPP construction will comprise the following:

- encrease of sanitary-health function, landscape-aesthetic value, stability and improvement of the woods with the aim of creation favourable conditions for mass rest of the population;

- reinforcement of the measures on protection of the most valuable in natural attitude forest landscapes, relict structures, monuments of the nature andregions, having great protection and cultural-historical value;

- presevation of biological variety in forest ecosystems;

- execution of measures on prevention of forest planting degradation in the result of the recreation impact;

- reinforcement and further improvement of measures on protection of woods from fire.

The most expedient form of arrangement and conduct of facilities in recreation woods is development of landscape-planning, organizing, forest growing and nature protection measures on the base of special forest arrangement. Executed of functional dividing into areas, enables to define the main direction for differentiated conduct of forest growing.

In the area of active rest the main ways, recommended for prevention of recreation impact on the woods and restriction for the antropogenic impact, are:

1 Distribution of resting people by means of laying roads, pathes and with improvement of the territory. The most important element in this system of measures is laying of roads and pathes with hard covering which will enable to stabilize the routes of motion for the people and transfer significant part of loads to such roads and pathes. With the aim of distributionfor resting people and diminishing the loads rendered to the main recreation territory it is necessary to involve into the recreation use additional regions in woods and planting areas, not used for rest in view of their insufficient recreation value. Execution of corresponding forest growing measures (chopping, care, removal of waste, drainage of overmoistened areas, care for the surface cover etc.) such plantings are prepared for acceptance of resting people.

2 Creation of attractive and firm biocomplexes on the base economic and organizing measures. The main means for creation of forest landscapes and terrains are the landscape chopping (creation, reconstruction, planning, for creation edges of the forest, as well as chopping in subgrowth and undergrowth) and landscape felling (reconstruction, protective, decorative). For creation of optimum landscape-planning and volumeно-spaceous system for plantings there is necessary to develop special projects. Herewith special attention is attracted by high prime cost of the indicated measures. This forces to consider attentively determination of practicability for their execution and to the choice of the priority objects. In the first place with these meas-

ures must be covered the territory, adjoining to the institutions of rest and medical treatment, to access roads, promenade and tourist routes, coast areas, and edges of the forest.

Within the forest area it is possible to undertake special measures, directed at raising stability and reconstruction ability of degraded recreation woods. As the most economically efficient forest growing action is application of the mineral fertilizers. Maximum ecological efficiency is obtained with fencing the degraded recreation plantings with simultaneous application of the mineral fertilizers. However cost-performance under the impact of these measures is considerably less, than under the influenceм of the fertilizers. The reason is big expences of fence-making. The cost-performance of fence-making without fertilizers is provided only in greatly degraded areax, usually at IV stage of degression. The more positive economic effect is obtained with mulching of the degraded recreation woods.

Under conditions of moderate recreation usage (the area of mastering), the main measures are directed as at raising stability and recreation value of the plantings, so at prevention of their possible overloading. Any special forms for arrangement of forest facilities with the aim of transformation for the landscape is not provided. It is necessary only to pay attention to improvement of the territory, also there is possible laying of separate promenade routes in the direction of motion for the main mass of resting people.

In the reserve area there are executed usual forest growing measures, directed at growing of sound, firm and long lasting plantings with high aesthetic and sanitary-hygienic properties.

After termination of construction it is necessary to conduct recultivation of territories with mouldboards and quarries, located within them. After removal from operation of temporary buildings, the objects of construction industry, they are unmounted, there is executed planning, providing surrface sewage. On the whole recultivated territory after its planning there is produced laying of the ground soil, possible fertilizers and sowing of herbs or growing of forest cultures.

Operation of the NPP. At the stage for operation of the NPP the impact on the environment will be connected with extraction of water for technological necessities from the river of Viliya, as well as with the emission and tapping of polluting materials. Extraction of water from the river Viliya may cause lowering the level as its most, so of falling into it inflows. Taking into consideration the role of the river Viliya as place for dwelling big quantities of rare and valuable species of fish, for which such lowering may have negative consequences, there must be provided possibility of regulation for its level mode.

The indicated adjustment must provide maintenance in the river Viliya of the water level close to their average perennial values according to the season of the year. Herewith critical (least) level of water in it within the spring period must be not more than 150 cm over the mark "0" of hydrometeorological post Mikhalishki. During the year the given river must have the following dynamics of the filling - 55 % sewage in spring period, 37 % in summer-autumn and 18 % in winter period

The shown dynamics will create favourable conditions for spawning of fish and growing of their fry. For prevention of their loss in the most place for water extraction it follows to provide special fish protective constructions

Tapping of technical sewage waters from the nuclear plant in the river Viliya create danger for its chemical and heat pollution. For prevention of chemical pollution there are needed measures on rectification of the indicated sewage waters up to their correspondence for the MPC of fish growing purpose.

The most sensitive to heat pollution are salmon fish. Spawning of such type fish as salmon occurs from the end of November to January under the water temperature 1-6 ^{0}C and kumzha – from the end of October to December under the temperature of water 3-5 ^{0}C. The maggots salmon fish go out in spring time (March-April). Temperature of water in the process gowing out must not be above 12 ^{0}C. However after gowing out the maggots within more than a month lie still between pebble in spawning hill, the temperature of water herewith must not exceed 14 ^{0}C.

For prevention of heat pollution of the river Viliya and for preservation of favourable conditions for dwelling in it of salmon fish there must be taken measures for cooling of thrown from the station warmed technical sewage waters. During determination of the parameters for the temperature mode in these waters under their delivery in the river of Viliya, it is necessary to take into consideration The resolution of the Ministry for natural resources and protection of the environment in the Republic of Belarus and Ministry of Public Health of the Republic of Belarus from 8 May, 2007 No 43/42 "About some problems for standardization over the quality of water for fish growing water objects".

According to the indicated documents, the temperature of water in fish growing water object must not increase over 5^{0}C in comparison with its natural temperature. Except this for water objects, in which there dwelling the salmon types of fish and to which pertains the river of Viliya, total rise of the water temperature r must not exceed 20 ^{0}C in summer time and 5 ^{0}C in winter time.

During assessment of polluting impact from the NPP on the natural ecosystems it follows to take into consideration the radiation impact. The considered 3 forecast scenarios for such impact, respectively under standard operation of the nuclear plant, under maximum design-basis accident and beyond design basis accident.

Standard operation of the NPP is accompanied with delivery into the environment of more small quantities of radionuclides. Their accumulation in ecosystems and contribution in the doses of external and internal irradiation foe living creatures are negligible.

The executed calculations of dose loads on the vegetable world within 30-km area under standard operation of the NPP showed that their value will be suffisiently small and will not cause any need for introduction of restrictions on usage of the biological resources. As preventive measures it is recommended to execute radiometric and biochemical control ober individual species of products from additional operation of forest: mushrooms – accumulators of toxic materials, moss, branch provender and some other.

In the event of maximum design-basis accident it is necessaty to pay special attention for radioactive pollution of high mushrooms and wild growing berry cultures as the main products of additional forest operation. According to the obtained calculated data, the level accumulation of the main indicator for radiation pollution with ^{137}Cs both in mushrooms, and in berries will be considerably lower the standards existing now for its contents (the national standard permissible concentrations of radionuclides, RDU).

In the near area (within the radius of 2 km) in the year emergency the factor of concentration for ^{137}Cs will be within the limits of 0.1- 0.45 from the national standard permissible concentrations of radionuclides (for edible mushrooms) and 0.1- 0.12 (wild growing berries). In the course of removing from the NPP multiplication of ^{137}Cs deposition in them decreases. So, at a distance of 10 km from it the multiplication falls by 2 times. On termination of the forecasted time (60 years) in the near area the

^{137}Cs concentration in mushrooms and berries will decrease up to 1.5 – 0.3 % of the national standard permissible concentrations of radionuclides.

Under the beyond design basis accident radioactive materials in the forest ecosystems will be in the forest bedding; later, they will gradually migrate into the soil. The calculations related to accumulation of ^{137}Cs in timber testify about the dependence of its levels from the types of soils. The minimum levels are forecasted in the woods on rich soils having normal moistening, the maximum - on peat soils rich with minerals.

On the trace formed in the result of beyond design basis accident with the top density for radiation pollution having concentration of ^{137}Cs by many times exceed the national standard permissible concentrations of radionuclides (RDU) for all species of forest products: timber, mushrooms, and berries. The evaluation was organized for the following activities of reference radionuclides in the emission:

- cesium - 137=3.5 $\times 10^{14}$ Bq;
- iodine - 131=3.1 $\times 10^{15}$ Bq;

Growing the number of population in the region. Increase in the region of the population number by 30 thousand people in relationship with the NPP construction will cause the total growth of the loads on its natural environment. These loads will are be connected mainly with exceeding creation of sewage waters in the place of residence for the arriving population, reinforcement of intensity for recreation nature operation and, respectively, trampling down, damage and use of forest vegetation, increasing dangers of forest fires, reason for which nearly always are people, possible growing of poaching.

Since the arriving population will be accommodated in the settlement of Ostrovets, the volume of sewage waters will increase namely here. Their receiver is the river of Losha, which, like many other inflows of the river Viliya, serves the place of dwelling for specifically sensitive to the water quality for rare and valuable species of fish. For prevention of its pollution there will be erected constructions of the new powerful rectification elements.

Increase of tapping sewage waters from the part of the settlement Ostrovets in combination with their creation at the same NPP is capable to intensify total polluting impact on the river of Viliya. In this connection there arises necessity for realization water protection measures on the territory of the total water collection pool presented by the river Viliya. These measures may touch creation of water protection areas, rectification of sewages from the animals growing farms, diminishing the process of washing down polluting materials from the agricultural fields etc.

The main load rendered by the resting peopele will feel vegetation, located closely near the coast band along rivers and lakes, previously total in the places for active rest. With increase of trampling down decreases the total spare stock of the forest bedding and the ground is packed down. These changes at the beginning will impact on growth and development of the lower levels of vegetation, and then of wood valance, which in total leads to considerable loss in spare stock of raw timber, mushrooms and wild growing berries, lowering of oxygen productivity in forest phytoscenosis.

In present time the most strong recreation impact is rendered upon the woods, located near great populated points: the settlements of Ostrovets, villages of Mikhalishki, Voronyany, Zhodishki, settlement of Sviri, as well as near the rivers Viliya, Oshmyanka, lake of Sviri, Sorochansky and other water reservoirs. For significant recreation loads there are subjected, pine woods, located along the river Viliya. Reinforcement of the impact rendered to them from the resting people may cause deterioration of their ecological state

Not to allow degradation of forest vegetable community, in connection with growing recreation loads it is necessary to introduce special modes of forest operation in the most visited woods, as well as project making for the created rest areas. The most important value herewith has determination of their maximum possible recreation capacitiy, providing determination of such maximum quantities of resting people which will not bring about violation of stability for the vegetation complexes and their capabilities for self restoration.

Since many attractive in recreation attitude woods are featured with high firing danger, and increasing the quantities of the resting people will raise the threat of the fire aising, then it will be necessary to intensify measures for firing safety.

Taking into consideration presense in region of big quantities of protected species of plants and animals, special value here has planning of tourist routes, ecological paths, parking platforms for automobile transport, other objects, intended for rest. They must not violate conditions for existence of these species.

To eliminate the threat rendered to resourse animals and particularly to protected types of fish in connection with possible growing for poaching there are needed measures for reinforcement of control over their state and use. For improvement of natural conditions for reproduction the most valuable species of fish – salmon, there will promote liquidation on the spawning rivers of beaver settlings and dams, which prevent the producers from coming into them. Besides it is reasonable to creaty a fish nursery aimed at artificial reproduction of salmon and other valuable in commercial attitude species of fish. Such measure will enable not only to compensate the damage from unfavourable impact on these species and save their resourse potential, but also will give the right on reception of the quotas for catching out the salmon (kumzha) in the Baltic sea.

18 PROPOSALS ON ORGANIZING THE PROGRAM FOR ENVIRONMENT MONITORING

18.1 General provisions

The base for environmental safety of the Belarusian NPP is monitoring over over the environment on the site and in the area of observation. It must be executed within the framework of the National environment monitoring system in the Republic of Belarus in accordance with the acting legislation:

- the Law of the Republic of Belarus "About protection of the environment" of 17.07.2002 No 126-3;
- the Regulations about national system for monitoring over of the environment in the Republic of Belarus, approved by the Resolution of the council of ministers of the Republic of Belarus of 14.07.2003 No 949.

In accordance with Item 2 of the Regulations about national system for monitoring over of the environment in the Republic of Belarus, National environment monitoring system includes organizing-independent and executed on the general principles the following types of monitoring over over the environment:

- monitoring over lands;
- monitoring over surface waters;
- monitoring over underground waters;

- monitoring over atmospheric air;
- radiation monitoring;
- geophisical monitoring and others.

Realization of general principles for execution of monitoring over the environment is realized by means of development and execution of programs for observation of conditions in the environment and impact on it rendered from natural and antropogenic factors, for restriction of collection and treatment of the data, analysis and keeping in storage of the information, ensuring the information exchange within the framework of National environment monitoring system, development of forecasted state for the environment and impact on it from natural and antropogenic factors, preparation and submission of the information into the state organs, juridical persons, citizens.

Ecological monitoring, being the "complex system for observation, assessment and forecast of the changes in the state environment under the impact of natural and antropogenic factors", in the regions of nuclear plant location must consist of subsystems for monitoring over the main impact factors (radioactive, chemical materials, heat) and response from ecosystems (biological monitoring) on changing the parameter of the environment.

Radiation monitoring over the construction site of the Belarusian NPP, in its SPA and ЗН will be executed by the laboratory of radiation safety and external of dose measuring (ЛВД) and Republican centre for radiationro control and monitoring.

During developmant of the Program for ecological monitoring in region of the projected Belarusian NPP site must be taken into account the information, concerning characterиcs of agricultural lands, critical ecosystems and vegetation community which monitoring is necessary first of all, the given material is comprised into the corresponding sections of the Belarusian NPP EIA.

The main purpose of the Program is determination of general requirements to arrangement of the structure and emission data from the ecological monitoring (the structure, objects of natural environment, nomenclature and inaccuracy of the controlled parameters measurement).

The main requirements to arranhement structure of ecological monitoring in the region of the Belarusian NPP site is provision of the information reception, necessary for validation of correspondence of the forecasted impact from emissions/tapping of radiation and chemical materials from the projected NPP, the level of acceptable risk, comparison with the risk from the natural and antropogenic radiation background, from the background of pollution with natural environment chemical materials, from emissions/tapping of other enterprises.

The main reference data for assessment of the radiation risk are the values for effective doses over the population and corresponding risk factors. Methdological approaches to assessment of chemical risk are founded on the principles, adopted by the Ministry of health, Ministry of nature of the Republic of Belarus, IAEA. The main reference data for assessment of risk for the population from pollution with natural environment chemical materials are their concentration in water, air, food, and the corresponding risk factors.

Considering that the hydrosphere is final "reservoir" and the natural way for migration of atmospheric fallouts of radionuclides and chemical materials on the ground surface, observations over the dynamics of chemical materials concentration in hydrographic networks are necessary within the area, being close to the area of the radiation monitoring (in SPA and ЗН stations).

The area of ecological monitoring around the Belarusian NPP will be determined at the stage of architectural projects. The network of stations for observation must be chosen with taking into account direction of the flow of the controlled tapping waters, existing wind rose and existing specially protected natural territories.

18.2 Specifically protected natural territory

Within the limits of 30-km area around location of the NPP there are located 5 specifically protected natural territories (See Figure 145). Into their composition enter: a part of the territory from the National park "Narochanskiy", completely national landscape reserve "Sorochanskiye lakes", as well as 3 local landscape reserves ("Golubye lakes", "Serganty", "Lake Byk") and 2 local natural sites ("Lipovaya Alleya s tremya Dubami " and "Starazhytny Dub").

The largest specially protected natural territory concentrated in the north-easterly part of the region. Here is situated the republican reserve "Sorochanskiye lakes" having the total area about 13 thousand hecters, within which limits is individually treated the local monument of the nature "Starazhytny oak", and also the part of the National park "Narochanskiy" territory (7.7 thousand hectares of the area covered with woods). In the south-western part of the 30-km area there are located local landscape reserves "Lake "Byk" and "Serganty", and also the local monument of the nature "Lipovaya Alleya s tremya Dubami ". In the south-east part of territory there is located the local landscape reserve "Golubye Ozera".

In total the specifically protected natural territories occupy about 15 % of lands within 30-km area for location of the NPP which is by 2 times greater the average for Belarus factor and is the a certificate for high value of the region for preservation of biological and landscape variety within the national level. All of them are found at sufficiently large distance from the area of construction, and execution of construction works itself will not render impact to them.

Protected woods. Available in the region protected woods (the woods pertaining to the I group) include water protection bands, protective belts along the automobile roads and railways, woods in the national parks, reserves, green areas around cities. The highest area occupy water protection woods concentrated on the coast of rivers and lakes - about 30 % of the area covered with woods (See Table 182). The one sixth of forest areas are the especially protected natural territories, and the one tenth are the protective belts along roads.

Table 182 – Distribution of lands in the forest fund within 30-km area around the NPP according to the categories of economic operation

Category	Area	
	Thousand hectares	%
Woods of the I group,	**57.8**	**62.5**
including the category of protection: - restricted (water protection) bands	27.7	29.9
- protective belts along the automobile roads	1.2	1.3
- protective belts along railways	9.4	10.1
- wooden national park	7.3	7.8
- wooden reserves, having republican value	7.8	8.5
- green belts with forests and parks	0.2	0.3

Table 182 (continued)

Category	Area	
	Thousand hectares	%
- green belts with forests having operation value	4.2	4.6
Woods of the II group (the exploited woods)	34.8	37.5
Total	**92.6**	**100.0**

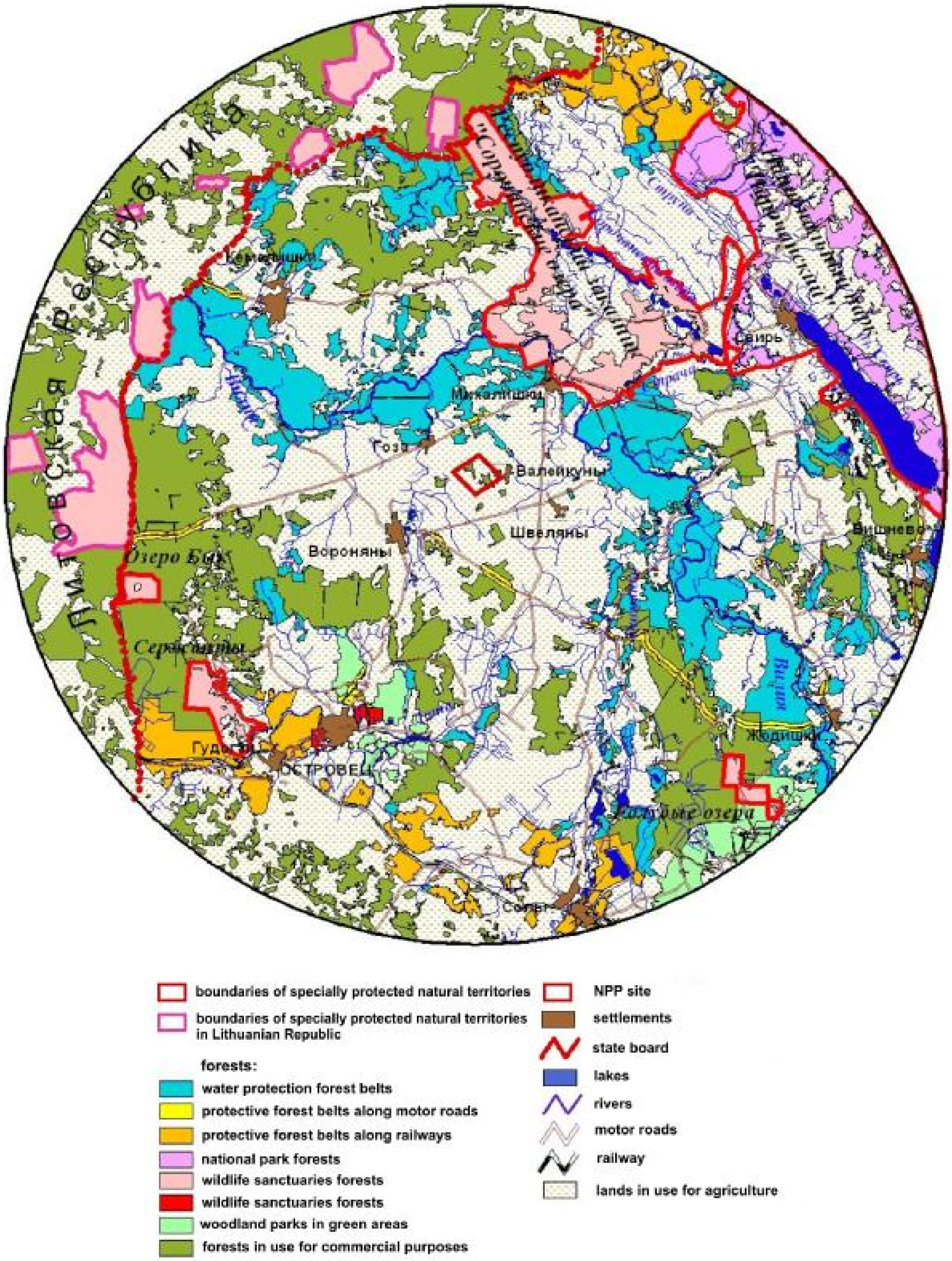


Figure 145 – Specially protected natural territories within 30-km area around the NPP site

The spaceous distribution for woods of the I group is determined by location particuliarities of economically exploited and urbanized, the especially protected natural territories and water ecosystems. In particuliar, the water protection woods are mainly concentrated along the river of Viliya. They act as the environmental corridor having the international value, connecting specifically protected natural territories of Belarus and Lithuania.

The woods of the I group in total occupy 62.5 % of the covered with woods area within 30-km area, which by 12 % is higher than the average for Belarus factor and also is indicative of high nature protection value for the region.

Valuable forest ecosystems. Within the borders of 30-km area there is marked out a category row for valuable forest communities, not all from which have a status of being protected, but all of them need for protection in the power of their high ecological and resouse value. They comprise the following communities:

- little violated forest areas (protected areas of reserves and difficult for reaching massives at flood plains and amongst the marhy regions);
- areas with old woods;
- areas of complex composition and structure of forest plantings or tree standing with single trees remaining after the previous generations;
- areas of woods with rare and residing under threat of disappearance types of wood;
- areas with populations of rare or threatened species of flora and fauna;
- areas with the presense in the wood level of rare wide-leaf species (the maple, lime, elm-tree);
- areas with woods in natural flood plains of the rivers, around the sources of rivers and springs;
- areas with woods with restricted accessibility (the islands on the lakes, mineral island amongst open marshes.

The indicated valuable vegetation communities have in the region rather broad distribution. They occupy 7.1 % of its covered with woods area. These communities are met in the form of small areas practically within the whole 30-km area. Mainly they are tied to its south-eastern sector. In the center part of the territory, closely to the site of construction and within the radius of 5 km around it, such communities are not revealed.

Protected types of plants. Totally in the region there are discovered 17 protected species of plants (See Figure 146) the most representation ecotopes for growing these plants are valleys of the rivers, hollows of lakes and large areas of forest arrays. Their list comprise the following species.

1 Huperzia selago (L.) Bernh. – Плаун-баранец. IV category of protection (NT). It is revealed in sourly fir-grove with birch, pine forest with spruce and alder near the streams.

2 Berula erecta (Huds.) Cov. – Берула прямая. III category of protection (VU). It is revealed within coasts of small streams, within the river low forest.

3 Carex rhizina Blytt ex Lindbl. – Осока корневищная. IV category of protection (NT). It is revealed on the grown slope of ravines.

4 Pulsatilla pratensis – Прострел луговой. IV category of protection (NT). Is revealed in mossy pine forest.

5 Ajuga pyramidalis L. – Живучка пирамидальная. IV category of protection (NT). It is revealed among mossy vegetation.

6 Lilium martagon L. – Лилия кудреватая. IV category of protection (NT). It is revealed in the wood on ravines declivity.

7 Listera ovata (L.) R. Br. – Тайник овальный. IV category of protection (NT). It is revealed in pine forest with spruce and alder near streams.

8 Malaxis monophyllos (L.) Sw. – Мякотница однолистная. II category of protection (EN). It is revealed birch forest with alder.

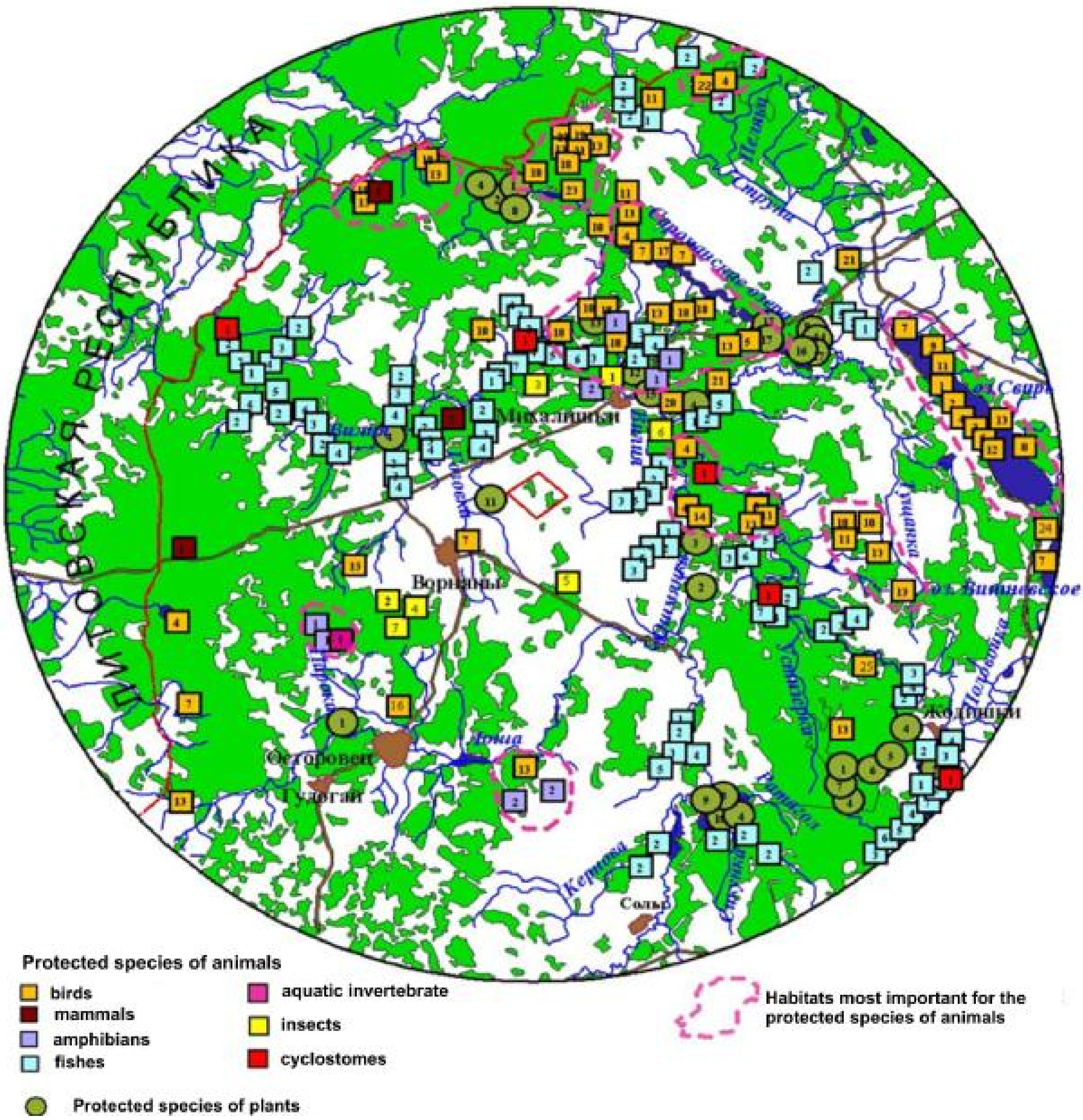


Figure 146 – Protected species of plants and animals within the 30-km area around the NPP site

9 Liparis loeselii (L.) Rich. –II category of protection (EN). It is revealed in birch-alder and birch-sedge forests.

10 Saxifraga hirculus L. –I category of protection (CR).

It is revealed in birch-sedge forests.

11 Trollius europaeus L. –IV category of protection (NT). It is revealed in birch nemoral-grass forest.

12 Ветреница лесная – Anemone sylvestris. L. IV category of protection (NT). It is revealed in pine mossy forest.

13 Gymnadenia conopsea (L.) R.Br. –III category of protection (VU). It is revealed on mezophylic cereal-grassy meadow.

14 Coeloglossum viride (L.) C.Hartm. –. III category of protection (VU). It is revealed on moistened cereal-grassy meadow.

15 Orchis morio L. –. II category of protection (EN). It is revealed on mezophylic cereal-grassy meadow.

16 Baeothryon alpinum (L.) Egor. –III category of protection (VU). It is revealed in birch-pine sedge forest.

17 Eriophorum gracile Koch –III category of protection (VU). It is revealed in in birch-pine sedge forest.

Practically all discovered populations of protected species of plants are found at considerable distance from of the area of the NPP construction and the planned operation may not render to them any direct impact. The exception constitutes one type - *Trollius europaeus L.*, growing in 2 km from the area.

Protected species of animals

Within 30-km area of the NPP site there is registered dwelling of 25 protected species of birds, 2 mammals, 2 amphibious, 7 insects, 1 water invertebrates and 8 species of fish (See Figure 146).

Protected types of invertebrates. There are discovered 7 species. 4 of them are revealed in woods, mainly, in pine boggy fore. This is violet ground beetle, (Carabus violaceus L.), sgagreen ground beetle (Carabus coriaceus L.), springdung-beetle, (Geotrupes vernalis (L.)), lattice ground beetle (Carabus cancellatus Ill.). Per one type there are found respectively in moistured mixed wood - (Pericallia matronula (L.)), on pasture - (Emus hirtus L.), on boggy territory - (Colias palaeno (L.)).

Protected types of fish. All 7 protected species of fish, and also 1 type of fish similar species - a river lamprey dwelling in the river of Viliya and its inflows. The spawning places of atlantic salmon are discovered in the rivers of Viliya, Senkanka, Dudka, probable their presense is also in the rivers of Oshmyanka, Gozovka, Stracha. The spawning places of kumzha are noted in the riverss Senkanka, Gozovka, Dudka, their greatest number is registered in the river of Tartak.

The total quantity of producers for communicating salmon fish, entering for spawning into the indicated water streams of the Viliya pool is small. It constitutes about 250-300 exemplares. Besides this in small amount these fish enter into 12 small streams more.

Dwelling of stream trout is noted in 18 rivers – inflows of the river Viliya. The given type is the most multiple amongst the protected species of fish. Distribution of trouts within separate areas of the rivers changes from 20-30 (the rivers of Tartak, Sorochanka, Ratagol and others) up to 100-150 per km (the rivers of Pelyaka, Senkanka). As a whole the condition for its population in the pool of the river Viliya may be characterized as favourable.

The common barbell is met in the rivers of Viliya, Stracha, Oshmyanka. Its amount is small and in average within the area of water in the river of Viliya, constitutes 5-10 per hectare.

European umber dwells in the rivers of Viliya, Stracha, Oshmyanka and Losha. The given type is small, but in the main places of dwelling its density approaches to 70 per hectare

Rybec common (syrty) is discovered in the rivers of Viliya, Stracha and Oshmyanka. The number of rybec common is small and in average along the riverbed of the river Viliya constitutes 10-15 per hectare.

Podust common dwells in the river of Viliya. Is the type having the most small population. Its number along the riverbed of the river Viliya does not exceed 5 per hectare.

Protected types of amphibious. There are discovered 3 local local representatives of rushy toad (Bufo calamita) and 8 local representatives of triton pectinate (Triturus cristatus). All of them are dwelling at a distance over 5 km from of the area for the NPP construction.

Protected types of birds. There were revealed 25 species of birds, registered in the Red book of the Republic of Belarus (2004.). Nearly half of them (10 of species) dwell on water basins or near such reservoirs, 9 species of them inhabit woods, 3 types - dwell in marshes, 3 types – within the open space.

Protected types of mammals. There is discovered dwelling two of species of mammals - badger and lynx. In the northern part of the region there is noted also the brown bear.

The main area for dwelling of protected species of invertebrate, amphibious, birds and mammals concentrates at a distance not more than 10 km from of the area and is tied mainly to large lakes and forest massives filled with water reservoirs. So the construction itself will not result in any impact to them.

At sufficiently large distance from the area there is found the majority of the rivers – inflow of the river Viliyai, into which enter for spawning the protected species of fish. The exception constitutes the river of Gozovka, which right inflow is located at a distance not more than 1 km from the area.

18.3 Organizing structure of ecological monitoring

Within the framework of the united system for ecological monitoring it is necessary to distinguish monitoring over the polluting materials, the main task of which is observation, assessment and forecast for the levels of pollution (radiation and chemical monitoring), and monitoring of the biota response (biological monitoring), into which task enters clarification of response reactions from the components of overland and water ecosystems to the external impact.

In sanitary-protective area and the area for observation over the projected Belarusian NPP there must be organized points of constant observation over the contents of radionuclides and chemical materials in the natural environment (the air, waters, ground), component being overland (including agrarian and forest) and water ecosystems, and also there must be measured the power of exposed doses and the absorbed dose in the air.

Observations over contents of radionuclides and chemical materials must executed at specially equipped posts for observation. The simultaneous measurement of meteorological parameters (direction and velocity of the wind, temperature of the air, moisture, atmospheric pressure) is executed at the post ofcontrol, located in SPA of the station. At selection of the places for location of observation posts there must be taken into account the necessity to receive the representation information about the levels of pollution in the atmospheric air within the area of greatly possible impact on the population and the environment: on the site, in the settlements and places for production of agricultural products, especially protected natural territories etc. The obtained results of measurements must be sent into the centre for collection and analysis of information. It is reasonable to execute observations over pollution of the overland ecosystems in the points of constant observation over condition in the atmospheric air.

It is reasonable to execute biological monitoring over the overland ecosystems, the aim of which will be assessment of the impact rendered by emissions within the

Belarusian NPP on critical components, within the radius of 3 km and at control point, located outside the impact of emissions from the Belarusian NPP.

The volume of monitoring over water ecosystems may be motivated after 3 years of observations over the chemical composition, temperature and volume of fluid sewages from the Belarusian NPP with the aim of final development according to restrictictes observations and the list of the values being under definitions.

It is necessary to organize reception of the representative meteorological information for identification from the source of probable pollution for near ground atmosphere with radionuclides and assessment of dissipation from gas-aerosole emissions rendered by the Belarusian NPP, located near radiation objects, and the influences from the cooling towers.

18.3.1 Requirements to the emission data from ecological monitoring

The types of objects in the environment, volume, place, periodicity for selection of the test samples, nomenclature of controlled parameters are defined with the aim:

- to minimize the probability not to find changing in natural environment and components of ecosystems, at the moment of their appearance;
- arrangement, technical and methodical facilities will be sufficient for identification in natural objects of low (background) concentration for radionuclides and chemical materials;
- to execute quantitative assessment of contribution from emissions/tapping of the Belarusian NPP into changing parameters of the ecological situation within the region of its location.

18.3.2 Radiation monitoring

Radiation monitoring must provide reception of information, being necessary for:

- identification and ranking the sources of techniogenic radionuclides in the natural environment (waters, air, ground) and components of ecosystems (overland, water, agrarian);
- assessment of contribution, rendered by gas-aerolosole emissions from the Belarusian NPP to the dose loads on the population;
- identification of the most impact areas from the emissions and tapping sewages of the Belarusian NPP on the environment and radionuclides, contributing the main contribution into the doses of irradiation over the population;
- revealing the reguliarities in long-term dynamics of pollution for natural environment and ecosystems under operation of the Belarusian NPP;
- assessment of doses for external and internal irradiation over the population, uncertainties of assessment for dose loads and radiation risk.

Collection of information about contamination of natural environment with radionuclides must be executed within the process of current monitoring of the atmosphere, hydrosphere, overland components, including the agrarian, forest and water ecosystems.

The data about the emission/tapping of radionuclides and chemical materials are given by the enterprises on application.

In accordance with the Program in the obligatory order there must be executed analysis of pollution over the natural environment (air, water, soil) and biotas of gamma-irradiating radionuclides (antropogenic and natural). The gamma spectre measuring analysis is the most informative method and enables to define concentration of suppressing majority of radionuclides as of natural, so of antropogenic origin within broad energy range (50-2000 keV) with inaccuracy not over 15-20 %.

For lowering uncertainties under assessment of the dose loads within the program for monitoring there is provided regular (once per 4-5 years) reception of information about specific/volume activity of tritum, strontium-90. plutonium isotope, as well as natural radionuclides from uranium-torium row in components of natural environment.

It is necessary that the results of monitoring will be complemented by the value of diffusing the emissions of carbon-14 and tritium and of dose loads according to the models, verified by the regional data. Keeping, analysis, showing of the information must executed by means of the bank data and the package of applied programs.

The organizing, technical and methodical facilities must be sufficient for identification in natural objects of low (background) concentration of radionuclidesat the level of global fallouts.

The objects of radiation monitoring are:

- natural environment (the air - aerosole and gas components, atmospheric precipitations, surface and undergraund water, drinking waters, ground);
- components of overland ecosystems, including agrarian and forest ecosystems (long-living herbs, pine-needles, moss, mushrooms, berrys, timber bedding, milk, grains and other agricultural products of the local production);
- components of water ecosystems within rivers and lakes 3H (the plankton, wate plants, bottom sediments, fish, suspension);
- absorbed dose, power of esposed doses.

The list of controlled in natural environment radionuclides is determined by nomenclature of radionuclides, thrown out by the local radiation objects under their standard r operation (carbon-14, tritium, inert radioactive gases, cesium-134.137, cobalt-60. manganese -54, iodine-131, strontium-89.90. torium-232, uranium -238, radium-226, polonium -210), list of radionuclides, forming the antropogenic (the tritium, cesium-134.137, strontium-90. plutonium-239.240. torium-232, uranium -238, radium -226) and natural (torium-232, uranium -238, radium -226, potassium-40. radon-226) radiation background, and probable of dose loads on the population under hypothetical emergencies (iodine-131, gamma-spectrum).

18.3.3 Chemical monitoring

The aims for chemical monitoring in region of the Belarusian NPP site are:

- determination of levels and dynamics of pollution with chemical materials of the air, water, overland components and water ecosystems;
- determination of contribution from emissions/tapping of the Belarusian NPP into pollution over the natural environment with chemical materials.

The sources of pollution over the environment in the region of the Belarusian NPP site with chemical materials may to be store houses of radiation waste, boilers, and other industrial enterprises, the place for storage domestic waste, automobile transport, surface washing down of fertilizers fron the agricultural filelds, located near water collection pools or water objects.

The objects of chemical monitoring are: over ground air, surface and undergraund water, vegetation and animal world, and also the products of feeding from the local production.

Into list of chemical materials, subjected tocontrol, there are included:

- oil products and heavy metals (Fe, Al, Su, Mn, Zn, Pb, Co, Mo, Cd, Ni, Cr, Sr, V, Hg);
- polycyclic aromatic hydrocarbons and heterocyclic compounds;
- polychlorated dioxins and biphenyls;
- inorganic polluting materials (sulphur, nitrogen oxides);
- surfactants;
- nitrogen and phosphorus;
- chlorides, sulphates, contents of salts in the ground.

As a whole, the list of controlled chemical materials is determined on the grounds of the data from enterprises about discharge / emissions into the environment.

Chemical monitoring over the surface waters provides the reception of the information about the hydrochemical mode and the quality of natural waters: pH, chlorides, sulphates, contents of salts, susperded materials, the forms of nitrogen and phosphorus, oxygen, carbon, biological and chemical consumption of oxygen. Taking out of the test samples for contents of the specified polluting materials in the objects of water environment is executed in the tapping channels of the enterprise, rivers of the water collection pool. The points of taking out the test samples from the air and overland environment are determined in the points of constant observation in accordance with the character of the wind rose and the landscape.

For observation over the background condition in the water basin there is chosen the station, where there are excluded evident influences upon the quality of water from such tapping of enterprisees or agricultural complexes, inflow of sources, operation on deepening of the riverbed, etc. The points of taking out the test samples and periodicity of taking out the samples from the atmospheric component and overland environment are the same, as in the system of the radiation monitoring, in particular, for analysis of heavy metals contents is distinguished out the quantity of general sample.

Analysis of the test samples from the objects of natural environment is executed in stationary analytical laboratory by commonly adopted methods.

Analytical equipment must provide the required sensitivity for determination of chemical materials concentrationat at the level of natural contents in the natural objects.

It is reasonable to check delivery of chemical materials with drainage waters from the enterpriser by means of posts for observation, equipped with automatic systems for checking the sewage waters.

Besides the stationary base analytical laboratory and the observation posts, to provide operative control it is necessary to have portable, and also mobile laboratories for chemical control over the quality of water and pollution of the atmosphere.

18.3.4 Biological monitoring

Biological monitoring must be oriented to obserbation over conditions in biological systems being organized at different levels: populations of separate species-indicators, bioscenoses (according to dynamics of structural and functional values).

The purpose of the biological monitoring - assessment and forecast for changing the state of overland and water ecosystems. Basing on the data about radiation and chemical monitoring, biological monitoring enables to evaluate reaction of the biota on the antropogenic loads.

The base for monitoring over overland ecosystems are complex field investigations of their state, including determination of the current and being in dynamics levels of agroscenosis state, topsoil, vegetation (the phytoscenosis), of the animal world, determination and analysis of contents for radionuclides, heavy metals and other possible polluting materials in components of overland ecosystems.

At the chosen constant test areas and control areax within three years there are executed investigations with the aim of final development according to the observation restrictions and the list of definied values.

Within the first 3 years in the settlements monitoring over hydrochenical parameters must be organized and executed in the form of observations over hydrobiological factors of the state in water objects. Besides, observations must be organized over the parameters of the state in the bottom sediments. Location of the points for observations must be chosen with taking into account morphological particularities, impact of sewage waters fron the Belarusian NPP, as well as the data about the system of water usage, and other accompanying volumes of economic activity.

Into composition of hydrobiological studies enters: the study of quantitative characteristics for hydrobioscenoses (the phyto-, zoo- and bacillary plankton, bentos, peritophon, macrophytes, ichthiofauna); the study migration characteristics of hydrobionts; determination of sanitary-hygienic state in the water object.

For assessment of the current chemical composition in the bottom sediments and its change there are taken out test samples in layers from the bottom sediments. In the selected test samples there are defined antropogenic and natural radionuclides, heavy metals. Selection of the tested suspensions and bottom sediments is executed once in 4 - 5 years.

For specifications of mechanical composition in the surrface layer and according to the profile of bottom sediments there are defined hranulometric specifications, volume mass, natural moisture, density and power of individula layers of the bottom sediments. For assessment of velocities for the processes of sedimentation and accumulation of sediments in water there is defined concentration of suspensions under various hydrometeorological conditions, their distribution according to water profile and within the area of water, internal perennial and internal seasonal changeability.

Final development of restrictions over observations and the list of definied values for the state of natural environment, components of overland and water ecosystems is executed on the results of observations in the first three yeas after the station commissioning.

Except the aboveenumerated works for undertaking ecological monitoring in overland and water ecosystems in the region of the Belarusian NPP site there are executed observations over the level and dynamics of radionuclides and chemical materials in the underground waters.

19 SUMMARIES OF NON-TECHNICAL CHARACTER

With the aim of the state energy policy there is greatly efficient to use natural fuel-energy resources (ТЭР) for providing the economic growth and raising the life quality for the population of the country. Optimizing the consumption part of the fuel-energy balance provides overcoming the trends of natural gas dominating at the internal energy market with diminishing its share from 79.7 % in 2008 up to the level about 50-60 % by 2020 year. This will considerably raise the level of energy safety for the country, particularly under conditions growing the prices for organic fuel. By 2020 yeary in the republic there will appear the first generating powers based on alternative source forms, including NPP (2.240 MW), on carbon (about 1000 MW), GES (290 MW), TES on local species of fuel (up to 265 MW).

The main direction for development of the thermal energy complex (ТЭК) branches in the country are determined by the Concept for energy safety of the Republic of Belarus, confirmed by Edict of the President of the Republic of Belarus dated September 17, 2007 No 433, Directive of the President of the Republic of Belarus No 3 "Economy and thrift – the main factors for economic safety of the state".

Within the framework for realization of these strategic documents in the country there is accepted and realized a package of the state programs. The main of them "State complex program for modernization of the main production funds for the Belarusian energy system, energy economy and increasing the share of using in the republic of the own fuel-energy resources within the period by 2011". (The similar program for the period 2011-2015 years is under development).

Realization of the programme documents will enable in the nearest time to put into commission 1146.6 MW of highly effective generating powers (within the period of 2006 – first half of 2009 there were put in to commission 420 MW), to spare by 2011 in total within the country over 7.55 million thermal units including on the system of "Belenergo" 1.15 million thermal units (for the period of 2006 and 1st half of 2009 there was spared about 5.5 million. thermal units within the country, and on the system of "Belenergo" -1.05 million thermal units).

The volume consumption of local and renewed species of fuel by 2011 yeary will be brought to the level of 6.48 million thermal units.

By 2011 year energy consumption of the ВВП is planned to reduce by 31% related to relastion level of 2005, in 2015 year - by 50 %, and in 2020 year by 60 %.

Belarus does not possess perspective hydro resources for creation large hydroelectric stations. Other real alternative sources of energy having the necessary power, except the TES (basing on gas) for the given region does not exist. Coming from economic and ecological considerations the NPP in the given event is more preferable.

The site for construction of the Belarusian NPP is located in the agricultural area in north-west of the Republic of Belarus.

The hunting fields of the territories with valuable and rare types of vegetation and animal world after impoundment of the territory will not suffer.

Influence upon the hydrological mode of the terrain is restricted by local redistribution of the streams with near ground waters, which mode is determined basically by the atmospheric precipitations. The hydrological mode of the located in region rivers and lakes will not suffer any changes. Using circulating system for technical water supply with evaporation cooling towers minimizes extraction of water from the river Viliya (feeding) and practically excludes chemical and heat impact on the region. Influence of the moisture emission from the cooling towers is minimum and does not present dangers for the population and ecosystems of the region for the NPP site.

The NPP is designed in such manner that the radiation impact on the population and the environment in standard long lasting operation, supposed explotation breaches and the design accidents does not lead to exceeding of the installed doses for irradiation over the population and is limited under the undesigned emergencies. Radiatione impact on the population and the environment is supported by considerably lower than the installed normative limits and at sensibly attainable low level.

Under standard operationof the energy units the main source of radionuclides delivery into the environment is gaseous–aerosol emission through high-altitude vent pipe. Besides the gases and aerosols, in the process of the energy units operation fluid and hard radioactive wastes are created and accumulated. The liquid wastes are processed and converted into solid waste. All radioactive wastes are kept within the NPP territory.

Throwing out harmful non-radiactive materials into the environment is excluded technical means. The treated sewage waters are used in the operation cycle of the plant. Non-radiactive wastes are subject to transportation on the range for industrial remainders.

Electromagnetic irradiation, noise and harmful emissions from the NPP buildings are found as being within the permitted limits and do not impact upon the surrounding natural environment and the population dwelling outside the borders of the object area.

The impact on the soil, air and water environment, vegetation, animal world of the region in the period of the NPP construction is unconsiderable.

For execution of control over condition of the surrounding natural environment, including the radiation situation, there is provided creation of local monitoring networks fully matching with the national system of monitoring over the environment in the Republic of Belarus.

In accordance with the law "On nuclear power use" and the normative requirements to accommodation of nuclear plants in the region of location for the Belarusian NPP will be installed the protective area and the area of observation.

In the area of observation there is provided constant monitoring over the parameters for radiation situation and the population health.

For non-stop control and forecast of the radiation situation on the territory of the Belarusian NPP and in the area of observation there is provided:

- creation of automated system for radiation monitoring and putting into commission the automatic system for checking radiation situation;
- control of all radiation parameters for the environment, including the radiation background, near ground layer of the air, of atmospheric precipitations, water environment, soil, vegetation;
- execution of monitoring over the population health;
- control over agricultural products produced and comsumed by the population

The provided project decisions in the field of execution nuclear and radiation safety provide the level of safety, corresponding to the existing requirements of the law and standards.

With technical decisions there is reached minimal consumption of water for the necessities of the NPP. The quantity of waste is minimimal.

The quality specifications and some available quantity specifications forecast for the condition in the surrounding natural environment and conditions for dwelling of the population enable to value the Belarusian NPP, as ecologicalle safe.

In the process of development and validation for investments into the NPP construction, assessment of its impact on the environment will be shown to the public and subjected to the state ecological expertize in accordance with normative requirements and the acting legislation.

It is necessary to note also big social-economic value of the Belarusian NPP construction for the north-west region of Belarus and, certainly, for Grodno Region and Ostrovets District, and also positive attitude of population to the NPP location in this district.

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21 ABBREVIATIONS

АСРТК - automatic radiation process control system
АСУ ТП - automatic process control system
АЭС – nuclear power plant
АЯЭ – nuclear energy agency
$БОП_5$ - biochemical oxygen consumption
БПУ - checkpoint
БРУ-А - high-speed reduction device for tapping into the atmosphere
БЭР - electric distribution unit
БТЕ - British thermal unit
ВВП - gross domestic product
ВАО - highly active waste
ВКУ – iternal corps device
ВВК - conclusion of internal reactor device
ВАБ - probability analysis for safety
ВХВ - harmful chemical materials
ВКР - upper end breaker
ВХР - water chemical mode
ВПП - gross primary product
ВПФ - external natural factors
ВХБ - water operation balance
ВМВС - Viliya-Minsk water system
ГЦНА - main circulating pumping unit
ГЦН - main circulating pump
ДР – distance lattice
Д - destruction
ЖУ - hard rest base
ЖРО - liquid radioactive waste
ЖРС - liquid radioactive medium
ЖРС - beyond design basis accident
ЗО - protection shell
ЗКД - area for controlled access
ЗРУ - protection distributing device
ЗН – observation area
ИС – initial event
ИЗВ – index of pollution for water
КИУМ - ratio for utilization of installed power
КИП - measuring instruments
КГС - factor of hydraulic resistance
КТП - factor of heat mixing
МЭА - International Energy Agency
МДР - minimum possible expenditure
МД - power doses
НК - guiding channel
НЗХК - Novosbirsk Chemical Concentrates Works
НКВ - lower end breaker
НИОКР - research and development works
НТД - normative technical documentation
НЭ - normal operation
ННЭ - breaches of normal operation
НЗК - an irretrievable protection container
ОЭСР – Organization for economic cooperation and development
ОЯТ – spent nuclear fuel
ОАО - open join-stock company

ОКБ ПГ - experiment design bureau "Hydropress"
ОКБ - general kolimorphic bacillas
ООПТ - specially protected natural territory
ОВК – integrated auxiliary facility
ПС СУЗ - consuming peg
ПЭЛ - consuming element
ПООБ - preliminary report on safety validation
ПГ – steam generator
MPC - maximum permissible concentration
ПАВ - maximum emergency emission
РАО - radioactive waste
РУ - reactor installation
РНУ КИ - Russian Scientific Centre "Kurchatov Institute"
РВ - radioactive materials
РСА - diffusing ability of atmosphere
РП – NPP site
СУЗ - system for control of protection
СРК - system of radiation control
СПП - separator-industrial overheater
СПОТ ПГ - system of passive tapping for heat of the steam generator
СПОТ ЗО - system of passive tapping for heat of the protective shells
СПОТ - system for passive tapping of heat
СЗЗ - sanitary-protection area
СПАВ - syntetic surfactants
СКУ АЭС – NPP monitoring and control system
ТЭЦ – thermal electric center
ТЭР - fuel energy resources
ТЭС - heat electric station
ТЭК - fuel energy complex
ТВС – heat producing assembly
ТЗ - technical requirements
ТТО - transport-technological operations
ТРО - hard radioactive waste
УТВС - advanced heat producing assembly
УЛР - device for localizing melted materials
УУФ - installation of UV filtration
УОО - installation of the inverse osmosis
УВ - level of intervention
ХТРО – storehouse for solid radiation waste
ХПК - chemical consumption of oxygen
ЦМС - center material storehouse
ЦВД - high pressure cylinder
ЦНД - low pressure cylinder
ЦДР – zirconium distance lattice
ЭБ - energy unit
OOOKS - building for treatment of low-active waste
UKS - auxiliary reactor buildings
UIS - premises of reactor buildings