MINISTRY of ENERGETICS of REPUBLIC of BELARUS

PROJECTING SCIENTIFIC AND RESEARCH REPUBLIC UNITARY ENTERPRISE
"BELNIPIENERGOPROM"

DEPARTMENT OF ENERGY OF THE REPUBLIC OF BELARUS

PROJECTING SCIENTIFIC AND RESEARCH REPUBLICAN UNITARY ENTERPRISE
"BELNIPIENERGOPROM"

JUSTIFICATION OF INVESTMENTS INTO NUCLEAR POWER STATION CONSTRUCTION IN THE REPUBLIC OF BELARUS

BOOK 11

EVALUATION OF IMPACT ON THE ENVIRONMENT

1588-ПЗ-ОИ4

PART 8

EIE REPORT

Part 8.2. Current condition of ambient environment

EXPLANATORY NOTE

(Revision 06.07.2010)

Director	A.N. Rykov
Assistant director	B.B. Bobrov
Project chief engineer	A.I. Strelkov

2010

Contents

13 CHARACTERISTIC OF AMBIENT ENVIRONMENT

13 .1 Geological medium

13.1.1 General characteristic of geomorphologic peculiarities, geological and structurally tectonic composition

Geomorphologic conditions, geological and structurally tectonic composition are characterized by certain differences within the limits of a particular part of the 30-km zone territory. Structure of the NPS site geological medium differs from that of the 30-km zone area. So, the characteristics of the 30-km zone as a whole and the NPS site are given below. Situation map–scheme for the 30-km zone and the NPS site is presented in Fig.38.

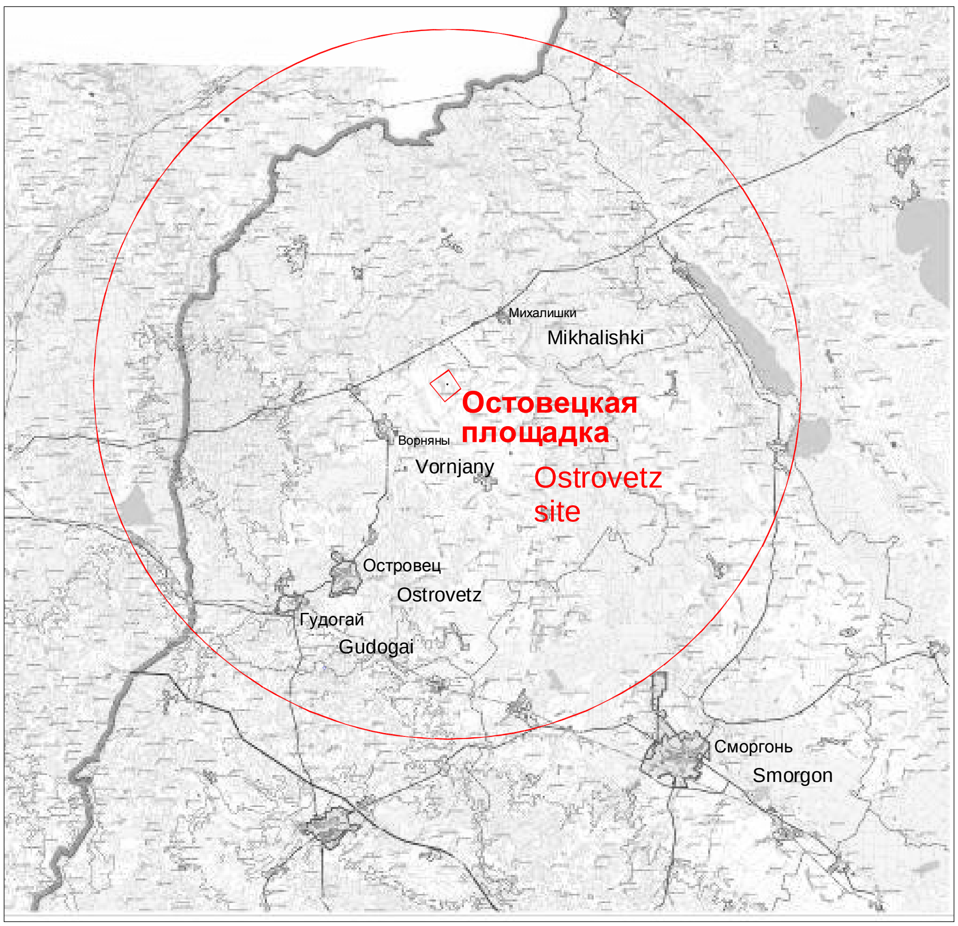


Fig. 38 – Situation map–scheme for the 30-km zone and the NPS site

13.1.1.1 NPS thirty–kilometer security zone

Thirty–kilometer security zone is characterized in accordance with the results of work performed by Republican Unitary Enterprise «Belgeologiya» [62,63,64].

The main structure elements of the surface are the Vilija river valley, the flat-wavy Vilija flat land situated at both sides of the valley and moraine elevation: Svir elevation on the North–East and Oshmjany elevation on the South–West.

Hydrographical network of the region is presented by a latitudinal area of the Vilija river crosses this region from the East to the West as well as by small rivers fell into the Vilija river, namely, the river Oshmjanka, the river Gozovka and the stream Polpe to the left, the rivers Stratcha and Sorotchanka to the right.

The river Vilija is the right feeder of the river Neman, this feeder relates to the Baltic Sea basin. The middle course of the Vilija river is situated within the expected working area. The river canal is wavy, the canal width is 65-101 m, and the depth is 1.22 м. The bottom is sandy, riffling. The bottom is encumbered by boulders at restricted river areas. The river stream middle velocity is 0.3 m/sec. Absolute marks for the low stage is changed from 120.4 m at the Oshmjanka river outlet to 116.0 m at the Gozovka river outlet. The river slope is equal to 3.6 m for distance of 16 km. Two floodplains and two above the floodplain terraces are stood out in the Vilija river valley. The river floodplain is developed at some areas, its width is no more than hundreds meters. In specific cases the floodplain width reaches 600 m (the area located above the Mikhalishki village). The floodplain height above the water edge is 0.2-3.5 m.

The first above the floodplain terrace is traced at both river banks in the form of narrow 100–200 m stripes alternating in an accord with the river bed curve (the terrace becomes apparent alternating at both banks). The width of the first above the floodplain terrace is increased repeatedly reaching 500–800 m in the vicinity of the inflow of the river Stratcha and the inflow of the river Oshmjanka. Terrace step toward the river floodplain is well-marked. The step height is 2,5 – 4 m, the step height is up to 5 m relative to the water edge.

The river Oshmjanka is the left inflow of the river Vilija of the first order. The river Oshmjanka flows as a winding tape along the western edge of the восточному краю 30-km zone. Its valley is oriented almost straight in the line of meridian direction along the moraine plane which is covered with fluvioglacial sediments in some areas. Within the area under discussion the river stream canal 15-20 m wide is everywhere followed by narrow double-sided floodplain rising above the water edge up to the height of 0.5 – 2.5 м.

The river Stratcha is the right inflow of the river Vilija. Only small part of downstream of the river Stratcha falls into the 30-km zone. The river stream canal is highly wavy, the canal width is 8-15 m. The valley is clearly defined; it is formed by double-sided floodplain 50 –150 m wide, the floodplain width reaches up to 600 m in the vicinity of the inflow of the river Stratcha to the Vilija river.

From the geology– tectonic point of view the territory under discussion is placed at the middle part of its Baltic monocline, namely, between the Vilija buried prominence of the crystal foundation and far wing of the Baltic syneclise. The depth of the foundation burial (bedrock foundation) and total value of the sedimentary cover are changed from 347 m at the Smorgon region to 536 m at the Narotsh lake region. To the east of Oshmjany this value is changed up to 438 m.

Internal structure of the foundation is nonuniform; it is defined by its position within the junction area of large-scale structure formation zones of Belarussyan– Baltic granulite belt, namely, the Ivje–Smorgon zone to the east–south–east and the Oshmjany zone to the north–west.

The boundary existing between the Oshmjany and Ivje– Smorgon zones is interzonal regional structure– formative deep break of the mantle (mantle - korov) laying of the Archean stage of the development of Baltic granulite belt. This break under the name Ostrovezki separates two structure formation zones. The rocks of different origin and different material constitution are presented in the zones.

Within the Ostrovezki edge break area in parallel to it at the distance of 2.5-5 km to the north– west the West– Ostrovezki break is located.

The sediments of four structural–material complexes have been revealed in composition of the sedimentary cover the investigated region, namely, Verhnedvinsk–lower Cambrian (late Baikal), lower Cambrian – lower Devonian (Caledonian), middle Devonian –middle Triassic (Hercynian) and middle Triassic – Quaternary (Cimmerian – Alpine) complexes.

From the point of an estimation of the influence on geological medium the upper part of the geological cross-section stacked by Quaternary sediments is of the greatest interest.

According to the geological survey data related to the territory under discussion as well as the data related to studying the cross– sections of the holes of different purposes the of the Quaternary sediments is changed from 60.6 m to 145 m. The minimal values of the thickness are observed within the Vilija valley that is within the lower marks of the day surface. The maximal values of the Quaternary sediment thickness are revealed at the finite– moraine elevations characterized by the most high relief levels, namely, the Oshmjany and Konstantinovo ridges.

In line with accepted stratigraphic scale for the Quaternary (antropogenic) sediments four sections are defined in the geological structure: lower, middle, upper and modern sections. In turn, the Brest (prior to glacial), Narevskii glacial, Beloverzski interglacial and Berezinski glacial horizons (the last three horizons are often combined by the Belarussyan superhorizon) are selected in the lower section. In the middle section the horizons Alexandrijskii interglacial and Pripjatskii glacial (with two subhorizons, namely, Dneprovskii and Sozhskii) are located. Muravinskii interglacial and Poozerskii glacial horizons are related to the upper section. The modern section is presented by the Holocene horizon.

The Brest (prior to glacial) horizon has an island structure. It is mainly formed from lacustrine sediments, least often from alluvial deposits. The thickness of these formations is no greater than 5 -10 m, the maximum thickness values are observed within the area of towns Oshmjany and Smorgon. The thickness layers are mainly presented by thin clay sand layer and (to a lesser degree) clay and sand layers. These sediments do not appear at the day surface.

The Narevskii glacial horizon is formed by the stratum consisting from coarse layers clay sand, loam and clay coloured mainly with grey and green-gray colors. This is locally spreaded; it includes the sand interlayers, segregations of chalk and Cainozoic rocks. The moraine thickness is generally equal to approximately 10-15 m; in some cases it exceeds 30 m. Fluvioglacial sand and coarse rocks, thin clay sand layers as well as horizon ribbon clay have not been remained within a whole territory. The thickness of these geological layers exceeds 10-15 m very seldom. All these rocks are presented in the glaciodislocation structure. Narevskii horizon sediments had not been revealed on the territory under discussion, but their occurrence is possible.

The Beloverzski interglacial horizon is formed by clay, thin clay sand and send layers, mainly, of lacustrine and alluvial genesis. Peat swamp and highly humic rocks are finding in isolated open-casts. These geological formations are relatively thin (generally 3-10 m), they are developed only on restricted areas; in many case they are glaciogenic allocated and play no markable role in the composition of the antropogenic sediments.

The Berezinski glacial horizon includes moraine and outwash; it is developed more widely in a comparison with the Narevskii horizon. The Berezinski glacial horizon is mainly presented in a south part of the 30–km zone. These sediments are occurred either on the more ancient (Quaternary) rocks or directly on ledge rocks. The thickness of the horizon is no more than 5-25 m; it is equal to 3-15 m in the vicinity of the site. The strata are not uniform, often it has two– or three–term composition type, it can include float stone clay sand or loam of different tints (gray or brown coloured substances with interlayers of anisomerous sand, thin clay sand and sand-gravel material). *As a rule, the Berezinski horizon outwash* in the form of anisomerous sand and lacustrine glacial clayey sediments underlays and overlappes the moraine, its thickness is changed from several meters to 20-40 m. In many cases, such strata close down with similar accumulations of the Narevskii or Dneprovskii glaciations; so, they create a nonsegmented complex characterized by the thickness of 100–120 m at glacial hollows and edge forms.

The Alexandrijskii interglacial horizon is confidently defined by paleontological attributes, it is a marking reference. The horizon is assembled by rocks of alluvial, lacustrine and paludal genesises; to a lesser degree it is presented by clay sand and loam soil, gyttja, marl, diatomite, peat. The thickness of the layers is changed from 2-5 m to 25 m. Within the 30–km zone (the borehole No 6, the village Rzodishki) the layer thickness is 12.2 m.

The Dneprovskii glacial subhorizon of the Pripjatskii glacial horizon is everywhere developed within the region under discussion. It is actually formed by glacial (moraine), outwash and periglaciological formations. The thickness of these layers is often up to 5-30 m, the maximum thickness is 43.4 m. The underlying rock rejectors are often observed in moraine. The thickness of the outwash accumulations presented together with moraine reaches several tens of meters.

The Sozhskii glacial subhorizon is spreaded widely as the Dneprovskii subhorizon. To the south from the Svir ridge the Sozhskii glacial subhorizon comes out on the day surface. In fact, the glacial drifts are particular well developed within the limits of the Oshmjany ridge. The thickness of moraine assembled by red–white coarse clay sand and loam is mainly equal to 10-25 m. It reaches 84.1 m at Oshmjany elevation (the village Rzuprany). The fluvioglacial sand and clay underlay and overlap the moraine in many places, their thickness is from several meters to 20 m, and the mean value is 7 m.

The Muravinskii horizon. The alluvial and paludal accumulations predominate within Muravinskii horizon. The Muravinskii formation thickness is upon the average equal to 2 - 6 m reaching 18-20 m for several open-casts.

The Poozerskii horizon. The boundary of the Poozerskii glacier coincides with the south boundary of the Belarussyan Poozerje. Within the area of placing the ice, the glacial and fluvioglacial sediments are accumulated; on other territory the periglaciological formations are observed. The mean horizon thickness is about 25 m; it enhances up to 60-70 m at erosion lowerings within the region of the edge formations (the village Konstantinovo). Moraine consists of reddish-brown boulder clay sand, loam and clay (mean thickness is about 20 m). Within the limits of outwash plain the fluvioglacial sand thickness is changed from 10 m to 25 m. Limnoglaciologic formations (sand, thin clay sand and clay) have the thickness values of 10 -15 m and more. Within the non- glacial zone the sediments of the first and second over– floodplain terraces (the thickness is varied from 1– 5 to several tens of meters) are attributed to the Poozerskii horizon. These sediments are mainly presented by send, lacustrine–alluvial formations created in ancient lacustrine bolsoms as well as by the locally developed lacustrine, atmogenic, outwash and other accumulations.

The Holocene horizon completes the Quaternary section. It includes the alluvial, lacustrine, boggy, outwash, atmogenic and other formations accumulated for the last 10 thousand years. The most remarkable (in respect of thickness and area of spreading) stratum of Holocene formations relate with alluvium which forms the river floodplain. Present-day alluvium is presented by channel, floodplain and former riverbed fractions. The thickness of the alluvial accumulations reaches 15-18 m at large rivers and 5-10 m at small one. Other genetic types of Holocene formations play the subordinate role within the boundaries of the rigions and they are characterized by a restricted spreading.

13.1.1.2 NPS site area

Geological structure, hydrogeological and engineering–geological conditions for the NPS site of size 2x2 km have been described in the report of the Republic Unitary Enterprise «Geoservis» [65].

The sit is situated within the limits of moraine plain with flattened relief at the river Vilija watershed, between its left inflows, namely, the river Oshmjanka and the river Gozovka.

The river Vilija (right inflow of the Neman river) go round the site to the north-east, north and north – west at the distance of 5 - 8 km. In a westward and eastward sectors the rivers Gozovka and Oshmjanka flow from the south to the north. The river Gozovka flows into Vilija at the distance of 3-4 km in a north – west direction; the river Oshmjanka flows into Vilija at the distance of 5-6 km to the east from the site.

The most elevated part of the site is the central one; it is elongated from the south to the north. Absolute marks of the surface are 176-185 m at the extreme west and east parts, 160-175 m at the parts related to the watershed slopes. The slopes are gently sloping; maximum inclination is 2-30^{o}. Outside the site contour the surface of slopes is complicated by the drain hollows of the rivers Gozovka and Vilija flowing into the valleys. Within the east part of the site region the flat depression is observed, this is the hollow riverhead going out to the hollow of the stream Polpe (left inflow of the river Vilija). The width of the hollow is 100-200 m, the hollow length (within the site limits) is 600 - 700 m.

Rivers or streams do not directly intersect the site area.

From the stratigraphic point of view the geological complex (from bottom to top) is assembled by the sediments of the water pumping upper Proterozoic, low and middle sections of the Cambrian, Ordovician, Silurian, middle section of the Devonian, low Neogene as well as by the Quaternary sediments. According to the preliminary geophysical investigation data the absolute marks for the top of crystal foundation is minus 340 – 410 m.

Typical geological geological cross-section is presented in Fig. 39.

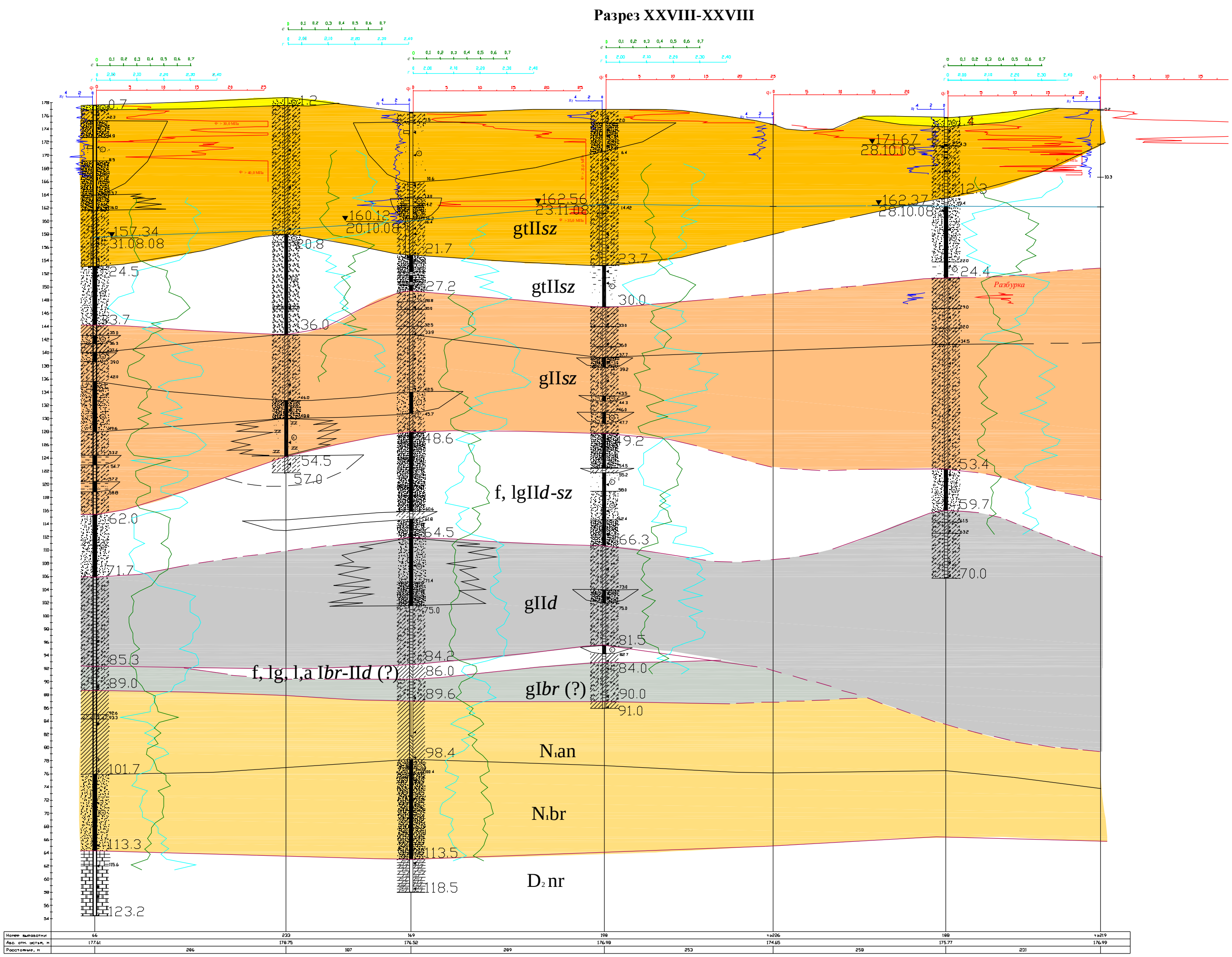
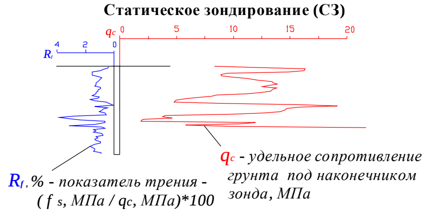


Fig. 39 – Geological cross–section along the line XXVIII- XXVIII

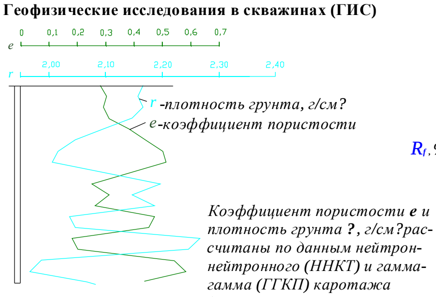
УСЛОВНЫЕ ОБОЗНАЧЕНИЯ

gtII*sz*	Конечно-моренные отложения сожского горизонта. Супеси, пески пылеватые, мелкие, средние.
gtII*sz*	Конечно-моренные отложения сожского горизонта. Пески пылеватые, мелкие, средние, гравийный грунт с линзами супеси.
gII*sz*	Моренные отложения сожского горизонта. Супеси. суглинки с линзами песков, пески пылеватые, мелкие, гравелистые.
f, lgII*d-sz*	Флювиогляциальные, водноледниковые отложения днепровского-сожского горизонта. Пески пылеватые, мелкие, средние, с линзами супеси.
gII*d*	Моренные отложения днепровского горизонта. Супеси. с линзами песков, пески пылеватые, мелкие.
f, lg, l,a I*br*-IId	Флювиогляциальные, водноледниковые. озерные, аллювиальные отложения березинского-днепровского горизонта. Пески средние, суглинки.
gI*br*	Моренные отложения березинского горизонта. Супеси.
N_1an	Отложения антопольского горизонта нижнего неогена. Суглинки.
N_1br	Отложения бриневского горизонта нижнего неогена. Пески пылеватые, мелкие, средние, гравийный грунт с линзами супесей, суглинков.
D_2 nr	Отложения наровского горизонта среднего девона. Алевролиты, мергеля с прослойками доломитов.

Статическое зондирование (СЗ)



Геофизические исследования в скважинах (ГИС)



*Коэффициент пористости **e** и плотность грунта **?**, г/см?рассчитаны по данным нейтрон-нейтронного (ННКТ) и гамма-гамма (ГГКП) каротажа (корреляционные зависимости Геофизической экспедиции РУП "Белгеология")*

The thickness of the Quaternary sediments is 71.7-102.8 m. The sediments are presented by three horizons of moraines (finite and main moraines of the Sozhskii horizon, moraine of the Dneprovskii horizon) devided by the strata of finite–moraine sand of fluvioglacial formations related to the Dneprovsii and Sozhskii horizons. The Beresinskaja moraine is separated from the Dneprovsii one by thin layers of clay sand, dusty clay sand, loam. Sometimes the layers include an addition of organic substance; they are characterized by lower values (20-40 Ohm) of the apparent resistance Кс in comparison to the sediments of the Dneprovskii moraine (80-140 Ohm).

The finite–moraine sediments (gtIIsž) in the upper part are mainly presented by clayey clay sand layer with nonuniform thickness; more seldom the loam with inclusion of gravel, pebbles up to 20-30 % as well as with inclusion of reddish-brown, brown sends with multiple layers and lenses (from dusty sand to middle-sized sand, often it is observed clay sand). The sand layer thickness is changed from 0.5 -1.5 m to 10 m. In specific cases the clay sand occurring at the depth of 20-30 m forms uniform layer without large sand lenses.

The depth of burial for the clay sand bottom including the sand lenses is varied from 1.0 – 4.0 m to 29.2 – 34.5 m. Maximum depth for the clay sand bottom (about 15-20 m) is revealed at the central part of the site. The depth is outlined by the stripe directed from the south–east to the north–west; its value is decreased in the south-west and north–east directions. In the east part the clay sand layer is completely blown out.

The clay stratum is underplayed by sand of different size; namely, from dusty to large size one. More seldom, the gravel sand with grey–yellow or dark– yellow colour is occured. The sand thickness is varied in a wide limits beginning with 1.8 - 4.3 m and and ending with 27.3 – 31.5 m. The thickness is increased in the south–west, east and north-east directions. In the east part of the site the sand is occured from the surface layer.

The Sozh moraine (gIIsž) is presented by clay sand and loam. More seldom, brown or gray clay with inclusion of gravel and pebbles is observed. Loam and clay are occurred, as a rule, at upper part of the cross–section up to the depth of 25-40 m, they are revealed by layers with the thickness up to 2-10 m. Moraine clayey soils include thin (5 - 10 mm) sand layers as well as the lenses and layers of sands of size. Often, the clay sand with the thickness from 1-2 to 6-8 m is observed.

The depth of the main Sozh moraine roof is a very changeable value, it is varied within the limits from 15.2 to 45.5 m; the absolute marks are 128.95 – 159.62 m. The thickness of the stratum is 3.1–38.3 m; the dominant thickness value is 20-30 m. General lowering the roof and decreasing the moraine thickness is observed in the south–west direction.

At the depth of 36-69 m (the absolute mark is 109 -132 m) the Sozh moraine is underplayed by fluvioglacial sediments of the Dneprovskii – Sozhskii horizons. The sediments are mainly presented by fluvioglacial yellow–gray or bright–gray sand (from dusty to gravelly sand; more seldom, the gravel and pebble soils are met). In the depth of sands the lacustrine– glacial clay sand and loam (coarse and dusty gray or blue–gray fractions) are occurred. They are mainly located in the south–east part of the site where the roof of the underlying Dneprovskaja moraine is buried; they are occurred at the depth of 51-63 m. The thickness of the clay soil layers and lenses is equal to 1- 5 m.

The general thickness of the fluvioglacial sediments is changed from 1.8 – 4.8 m in the west part of the site to 23.9-26.4 m in the central and east parts.

The Dneprovskaja moraine (gIId) is presented by clay sand and loam with inclusion of gravel and pebbles as well as by brown–gray, bright–gray sand of different size with clay sand lenses and loam layers (the thickness is up 2-8 м). The roof is more stable in comparison to the Sozh moraine; it is buried as a whole in the south–east direction. The roof is disclosed at depths of 49.5 – 78.5 m. The absolute marks are 99.7 – 118.61 m.

The thickness of the sediments in the south and central parts of the site is less than 20 m (11.3-19.6 m); in the north–west part it is mainly equal to 20-24 m. Absolute marks for the footing are 88-96 m at these areas. Moraine is buried in the north–east part filling the paleocut in the roof of the Neogene (absolute mark for the footing is 75-82 m); its thickness reaches 30.0-35.8 m.

The Sorzskaja and Dneprovskaja moraines have no breaks within the range of spreading; erosion “windows" had not been revealed.

On the whole site area except north–east part (between the Sorzskaja and Dneprovskaja moraines at the depth of 72.0 m – the borehole No 52 and 87.4 m – the borehole No 53) the dusty blue–gray or gray clay sand and loam (often with addition of organic substance), dusty middle–sized sand which is conventionally referred to a non–partitioned complex of the low mid–Quaternary Berezina–Dnepr fluvioglacial, lacustrine and alluvial sediments (f,lg,l,aIbr-IId) (Belovezhskii interglacial period) are open. Absolute marks for the roof are 89.2 – 96.9 m. The thickness is 0.6-1.1 – 5.8 m.

The Berezinskaja moraine (gIbr) is presented by gray or green–gray clay sand and with inclusion of gravel and pebbles, up to 5-10 %, having thin sand layers. They are open at the depth of 67.6 – 89.4 m under the non–partitioned Berezina–Dnepr sediments or under the Dneprovskaja moraine. In the last case the boundary between the moraines are made conventionally based on the results of geophysical investigations (based on the value of apparent resistance). The absolute marks for the roof are 89.3 м (the borehole No 174) – 96.3 м. The thickness is 2.8-6.0 m.

The Quaternary sediments are underplayed by dusty gray or green–blue–gray loam as well as by dark–brown or dark–gray clay. The sediments taking into account the results of geophysical investigations have been referred to Antopolskii (N1an) horizon of low Neogene (Miocene). Loam includes an addition of organic substance (from 1-2 % to 8 %). The layer thickness for the peated soils (the content of the organic substance is more than 10 %) is equal to 0.3-1.4 m.

The Antopolskii horizon roof is rather flat (the depth is 79.4-96.0 m, the absolute mark is 86.3-92.8 m), it is sagged only in the north–east part of the site (the depth is 82.0-102.8 m, the absolute mark is 75.7-81.6 m) forming a hollow stretched from south–east to north–west.

The thickness of the sediments is 6.7 – 16.5 m; in the north–east direction the thickness is 3.2 – 4.7 m.

Below the sediments of the Brinevskii horizon of the low Neogene (N1br) are buried, namely, fine, dusty (very seldom, middle–sized) bright–gray or whitish sands which are uniform according to granulometric composition. Large–fragmental soils were revealed in the sand roof stratum with the help single boreholes. Loam lenses are met in sands at different depth (0.7-6.4 м). Total thickness of the sediments is 9.1 – 14.5 m.

Neogene sands are underplayed by sediments of Narovskii horizon of mid– Devonian (D2nr), namely, by siltstones and marls often interleaved by dense cracked dolomites with sublayers. The layers of clay and chalk are also met in marls. There are blue–green–gray sediments and speckled gray–brown siltstones. The revealed thickness is 2.2-11.8 м.

The Devonian roof depth is 99.8 m (the borehole No 56) – 116.0 m (the borehole No 60); the absolute marks are 62.7 m (the borehole No 162) – 66.4 m (the borehole No 195).

The hydrogeological conditions are characterized by practical absence of underground water up to the depth of 10 – 24.4 m within the main site area. The Quaternary sands (finite Sozh moraine, Dneprovskii–Sozhskii intermoraine and sand lenses in the main Sozh, Dnepr and Berzina moraines) located below of this depth are fully water-saturated.

First from the surface water-bearing horizon of the Sozh finite–moraine sediments is pressured– nonpressured. Water–bearing soils, namely, sends with different size (from dusty to gravel sands). The level depth is 8.4 – 24.4 m depending on the hypsometrical relief marks; the absolute marks are 154.36 – 162.48 m. In the region where the foot of upper layer of moraine clay sand is lowered the layers are characterized by hydraulic drop from 0.9-1.0 m to 13.5-14.6 m. The horizon is drained by rivers; it feeds small streams of water related with drain hollow.

In accord with chemical content, waters are classified into fresh water and normal water; more seldom, alkaline and hydrocarbonate calcium-magnesium waters with mineralization of 224.24 – 442.46 mg/dm^3 are revealed. Total water hardness is changed within the limits of 2.2-11.0 mg-equivalent/dm^3. Enhanced nitrate content (up to 74.0 mg/dm^3) is found. The content of other makrocomponents are less than the maximum permissible concentration (MPC).

Underground waters are not aggressive relative to reinforcement of concrete constructions and to the concrete of the types W_4, W_6, W_8 (from the position of water permeability); in single cases, waters are weakly aggressive relative to the concrete of the type W_4.

Sporadically distributed waters coupled with widespread layers and sand lenses. These waters are formed due to infiltration of atmospheric precipitation and backwater from the water-bearing horizon of the Sozh finite- moraine sediments. They are found at different depths; but they are relatively seldom located at upper part of the cross–section at the depth of 3.6- 5.0 m (the absolute mark is 155.77-173.01 m). More these waters are met in the middle and lower parts (7-26 m), when theirs foot comes below the water-bearing horizon level.

Waters are not aggressive relative to the concrete of any types (from the position of water permeability) or they are weakly aggressive relative to the concrete of the type W_4.

Inter– moraine water-bearing complex of the Dneprovskii – Sozhskii horizons is of the force-feed type. Water– enclosing soils are sands of different size and gravel soil. The piezometric head level is 19.6-29.6 m; the absolute marks are 148.18 -154.72 m.

In accord with chemical content, waters are classified as fresh waters, mainly hydrocarbonate calcium-magnesium waters with mineralization of 146.7–279.16 mg/dm^3 and soft waters. Total water hardness is 1.2-2.4 mg-equivalent/dm^3. The content of the main makrocomponents are less than he maximum permissible concentration (MPC) with an exception of nitrate content (up to 58.0 mg/dm^3).

Lenses of sands (dusty fine- middle- and large-sized as well as gravel sands) are founded in moraine clay sands and loams of the main Sozh, Dnepr and Berezina moraines at different depth. The thickness of sand layers is from 1-2 m to 6-8 m. In the course of future work the special hydrogeological boreholes (with pumping) will be drilled in direction of the largest lenses with the aim of determination of the head of water, piezometric level and qualitative evaluation of a possible hydrological connection with the inter– moraine water-bearing horizons.

Water-bearing horizons are isolated one. Moraines dividing these horizons are uniform within the spreading area. No «windows» of moraine washways or clayey sediments of the Antopolskii horizon of the Neogene have been revealed.

The thickness of soils creating the geoloical cross–section of the NPS site is divided into 27 engineering–geological elements. Theirs names and physical–technical parameters are given in Tabl. 47.

Tabl. 47 - Evaluated soil parameters

IGE	Soil	Soil density, r, g/cm^3	Specific weight, g, kN/m^3	Specific adhesion C, kPa	Angle of internal friction j, degree	Deformation module E, MPa	Accepted value q_c, MPa
Finite-moraine sediments of Sozhskii horizon (gtIIsž)							
1	Weak moraine clay sand (upper zone)	2,05	20,5	23	26	5	≤ 1
2	Moraine clay sand of middle strength (upper zone)	2,10	21,0	27	27	10	2
3	Moraine clay sand, strong (upper zone)	2,20	22,0	33	27	20	4
4	Moraine clay sand, very strong	2,20	22,0	40	29	40 and more	8
2a	Moraine clay sand, middle strong	2,20	22,0	33	27	20	4
5	Dusty sand, middle strength	1,69/2,01	16,9/10,1	3	29	14/10	4
6	Dusty sand, strong	1,79/2,07	17,9/10,7	5	33	25/20	10
7	Fine sand, middle strength	1,68/2,00	16,8/10,0	2	32	15	5
8	Fine sand, strong	1,78/2,06	17,8/10,6	4	36	30 and more	25
9	Sand of middle size, middle strength	1,68/2,00	16,8/10,0	1	35	16	5
10	Sand of middle size, strong	1,78/2,06	17,8/10,6	2	38	35 and more	25
11	Sand of large size, gravel sand, strong	-/2,03	-/10,3	1	41	40 and more	25
Moraine sediments of Sozhskii horizon (gIIsž)							
12	Weak moraine clay sand (upper zone)	2,25	22,5	23	26	5	≤ 1
13	Moraine clay sand of middle strength (upper zone)	2,25	22,5	25	27	8	1,5
14	Moraine clay sand, strong (qc= 3-5 MPa)	2,27	22,7	32	27	18	3,5
15	Moraine clay sand, strong (qc= 5-7 MPa)	2,27	22,7	37	28	30	6
16	Moraine clay sand, very strong	2,30	23,0	40	29	40 and more	8
17	Loam, clay	2,10	21,0	45	27	30	5
Fluvioglacial inter–moraine sediments (f,lgIId-sž)							
18	Dusty sand	–/2,07	–/10,7	5	39	20	> 15
19	Fine send	–/2,06	–/10,6	4	36	30 and more	> 15

Continuation of Tabl. 47

IGE	Soil	Soil density, *r*, g/cm^3	Specific weight, *g*, kN/m^3	Specific adhesion *C*, kPa	Angle of internal friction *j*, degree	Deformation module *E*, MPa	Accepted value q_c, MPa
20	Sand of middle size	$\frac{-}{2{,}06}$	$\frac{-}{10{,}6}$	2	38	35 and more	> 15
21	Coarse sand, gravel	$\frac{-}{2{,}03}$	$\frac{-}{10{,}3}$	1	41	40 and more	> 15
22	Coarse clay sand	2,22	22,2	32	27	20	~ 4
23	Dusty clay sand, loam	2,15	21,5	56	13	15	~ 3
Moraine sediments of Dneprovskii horizon (gIId)							
25	Moraine clay sand (soft)	2,27	22,7	33	27	20	4
26	Moraine clay sand (hard)	2,27	22,7	38	28	30	5-6
27	Dusty clay sand	2,12	21,2	42	26	22	4

Note. For sands: the values of *r* above the line relate to the small– moist condition, and the values under the line relate to the water-filled one; the values of *g* above the line relate to the small– moist condition, and the values under the line given taken into account the uplift of water action.

Conditions for the site foundation seem to be relatively favourable. There are possibilities for building the main constructions on the soil foundation (this is the most economical version). Building conditions will be dry; several lenses of water-filled sands in the moraine (water of sporadical spreading) can be drained using the surface unwatering in foundation pits.

Rocky ground has not been found up to the depth equal to two reactor diameters (110-120 m). Therefore, the most critical constructions will be rested on compressed clay or layered base.

Along with it, there are the complicated factors:

– potentially, the site can be underflooded when technical leakage takes place;

– it is possible the change of strength and deformation properties of soils during anthropogenic watering especially by waters with enhanced temperature and «unnatural» chemical content.

13.1.2 Analysis of existing and predictable negative endogenous and exoge nous processes and phenomena

*13.1.2.1 NPS thirty–kilometer security zon*e

The territory under discussion is influenced by different natural and anthropogenic physical–geological processes. Depending on energy source all processes are divided into three classes: exogenous, endogenous and anthropogenic.

Exogenous class

Among this class the plain and line erosion of temporal water courses, erosion and accumulative activity of rivers, lacustrine accumulation and abrasion as well as gravitational, eolian and biogenic processes are prevailed.

Plain (dealluvial) washout is the most widespread present geological process which intensity is mainly varied within the interval from 0 to 5 mm/year.

Trails are formed during the plain washout at the footing of slopes. Maximum thickness of the trails is more than 165 cm.

Dealluvial processes influence on the reconstruction of earth surface; it can assist to accumulation of harmful discharges at the footing of slopes and lead to a sedimentation of water bodies and watercourses.

Erosion and accumulative activity of rivers. Activity of constant line watercourses is the most active present physical–geological process. The result of this activity is the dense net of river valleys. Information about a size of the created forms and about a volume of alluvial sediments with the site area can be obtained by analysis of parameters of the largest valley of the river Vilija. The valley banks are often bluffed along almost the whole length of the valley. The precipice height is mainly equal to 15-17 m. The valley width is up to 1-3 km; sometimes the valley is restricted by the distance of 0.4 km. It is marked out the floodplain with the height under the water surface in the river watercourse of 1-2 m and up to 4 over– floodplain terraces (4-5 m, 9-10, 12-14 and 15-20 m). The floodplain width is 200-800 m; the width of terraces is up to 0.3-0.5 м. The thickness of floodplain alluvium is up to 5-10 m. Taking into account valley parameters it is possible to evaluate that during Holocene period approximately $1.6{\cdot}10^9$ m^3 alluvium had been accumulated in the valley. The valley size for the rivers Narotsh, Oshmjanka, Stratcha and some other is rather small, but the sum effect of the geological activity of these rivers is approximately comparable with that of the river Vilija.

The coefficient of the relief horizontal partitioning can be used as an index of intensity of alluvial processes. The mean value for that index is approximately 0.4 km/km^2 (the main variation limits are from 0.3 to 0.7 km/km^2).

Analysing the geological river activity is important to track the results of a manifestation of floods and spates in theirs valleys. In other words, it is important to take into account such phases of the hydrological regimes when an abrupt rise of the water levels are take place. This leads to a flowage of floodplains, transfer and deposition of considerable volumes of alluvial sediments which can accumulate not only on low floodplain but also on higher hypsometrical levels. In the Vilija basin these elevations reach 3-5 m with the flow depth for that floodplain is equal to 0.5-1 m. When the flood is taken place, the territories laying in the vicinity of 1–3 km from the river watercourse are also underflooded, especially, within the areas of shallow watercourse entry.

Line erosion of temporal watercourses. In the region of a possible placing of the NPS the process of this type is developed very well. As a result of action of the process the net of ravines, gullies and multiple rain canals has been created. The rain canal length is about tens of meters (up to 100 m), the depth is up to 1.0 m. The ravines are normally characterized by the length of hundreds meters (up to 1500 m), theirs depth is often varied within the interval of only 5-10 m, for some places up to 17-24 m. The gullies are characterized as larger objects: the length is up to 4-5 km, the depth is 20-30 m.

The line erosion is widely manifested in the Vilija (at inflow of the river Oshmjanka, the villages Podvarishki, Voidatishki and other), Oshmjanka (at the town Oshmjany) basins and on the regions of a spreading of the edged glacial elevations between the villages Zharneli, Ignatsevo, Lipki, Kotlovka located in the south–west part of the area. The density of the forms is normally equal to 1-2.5 $unit/km^2$.

Accumulation and abrasive action of water reservoirs on the investigated territory plays remarkable role in a transformation of earth surface. The largest lake is Svir.

The lake Svir area is about 22.28 km^2, the Svir length is 14.1 km, the width is up to 2.27 km, the depth is up to 8.7 m (mean value is 4,7 m). The lake banks are mainly low, the bottom is sandy up to the depth of 3-4 m; at greater depths the siliceous sapropel layer with the thickness of up to 5.6 m (mean value is 2.6 m) is located.

The other lakes are characterized by smaller dimensions. Accumulation of the sediments in a large volume (some of these sediments, sapropel, can be used for balneology or agricultural applications) takes also place in these lakes.

Gravitational processes. The shift of the sediments under influence of the gravitational forces depends of the ambient conditions. The slow movement of materials at slopes (creep) and processes going with a relatively high rate (landslides and taluses) are distinguished on the investigated region. The necessary condition for the start of these processes is the presence of relatively steep slopes (more than 2^o for the creep and about $5\text{-}20^o$ for the landslides and taluses).

The landslides and taluses are met practically along all length of the Vilija river valley, on slopes of the river Narotsh valley as well as on slopes of the rivers Oshmjanka and Gazovka. These processes are also revealed in many open-casts and some road earth cut. Generally, the volumes of shifting rocks are less than tens of cubic meters.

The creep is met on a rather greater area of the territory. Maximum rate of slow shifting of the material along the slopes is registered within the north–west and south–west parts of the region as well as on small areas at the villages Shakishki and Golginishki. The creep rate values of about 2 – 4 mm/year are recorded for above mentioned areas and for the north–east part of the region. For the rest part of the territory the rate is less than 2 mm/year. The creep is absent at flatten swampy surfaces.

Eolian processes. Wind is additional agent of the present material movement. Eolian activity becomes apparent in some extent on a whole territory of the region. Eolian factor begins to reveal starting from the material erosion stage. The erosion is divided into the daily (or local) erosion and the erosion in the form of so called dust storm. The daily erosion (when hundreds kilograms of soil per hectare is shifted every year) is taken place on the tilled lands.

The most remarkable results of the wind geological activity are the relief forms created of it. Small ridges and hills which linear dimension (length) is commonly less than 0.4 km, the height is less than 3-5 m are the typical forms for the region territory. Such forms are met in the valleys of the rivers Vilija, Narotsh, Oshmjanka, Stratcha and some others when they are presented as winnow embankments.

The dust storm is the extreme form of the eolian processes. During period of 1966-1993 years every weather station located on the investigated region territory (in the towns Vileika, Vologin, Dokshitsy, Oshmjany) has been registered from 1 to 6 dust storms. According to the calculations under an influence of these dust storms up to 3.5 metric tons of soil were removed from every hectare (approximately 0.2 ton/hour). On the base of that data Yu.A.Chizhikov attributes the areas of the Ostrovetz point on the stage of the regionalization of the Belarussyan terrotory to the category of soils characterize by small or middle probabilities of an appearance of the extreme deflation phenomenun.

Biogenic processes play also definitive role in a modeling of the ground surface. In order to evaluate in full measure the geological effect of these processes it should be noted that besides of peat accumulation they determine the content of atmosphere and in large measure the content of hydrosphere. The content of atmosphere influences on the climate. In its turn, the climate peculiarities influences on parameters of the rock weathering process. Also, organic substance takes part in the material transportation with the transfer performed by means of mechanical action and by the processes involving dissolved and colloid forms.

On the region territory the biogenic processes led mainly to a formation of multiple peat swamps. The most large peat massives are located to the south of the lake Narotsh between the rivers Narotsh, Vilija, Oshmjanka and Losh, to the west and south–west from the town Oshmjany. The peat layer thickness is mainly less than 4 – 5 m. A commercial peat excavation is performed on many sections.

Endogenous processes

Among this class of the physico–geological processes on the region territory the leading one are seismic processes, vertical and horizontal movement of the earth crust, processes specified direction and configuration of hydronet forms as well as formation of geophysical and geochemical anomalies.

The seismic activity is generally related with the fractures being active on up-to-date stage. On the greatest part of the territory a possible magnitude of the shakability is less than 5. But, there is the zone located in the south–west part of the region (along the Oshmajany fracture) within the limit of which a possible magnitude of the shakability can reach 7. Earthquake with such magnitude value was registered for this zone in 1908 year.

Everywhere on the territory under discussion the vertical movements of the earth crust are revealed. On a general background of the mean–year movement speed values of approximately minus 1 mm/year the local value can be varied from plus 1-2 to minus 1-2 mm/year. Within the zones which are active on up-to-date stage of the fracture development the speed amplitude reaches the value of 12-20 mm/year with the direction of the earth crust movement being changeable from year to year, but the mean year values are less than several millimeters.

Considerably less data ware collected on the territory under discussion for revealing the horizontal movements. Unfortunately, the instrumental studies for that type of the movement were performed only within the boundary of the Volozin graben. For that area the measured graben movement speed along the Karelitshi fracture was as high as about 40 mm/year. But, the combined analysis of geomorphological, geological and tectonic data allow us to suggest that the horizontal shifts of the earth crust blocks go along a series of other fracture. In particular, it is likely to reveal the traces of such earth crust movement along the village lines Nestanishki – Bogdanishki, Sloboda – Tsheremshitsy near the village Markuny.

Available archive data related to modern vertical movements of the earth crust (СВДЗК) obtained for the period from 1913 till 1979 year allow us to conclude that within the Ostrovetz site area the speed of modern earth crust movements is relatively small, it is approximately equal to V = - 0,1 mm/year (there is a tendency for slow down movement).

In accordance with the requirements of the document ТКП 098-2007 [66] on the investigated territory the geodesic works directed to determination of the modern movements of the earth crust (СДЗК) are performed; these works will be finished in 2010 year before the beginning of the onset of the building of the NPP.

Anthropogenic processes

Today the anthropogenic physico–geological processes on the territory of the site are a rather visible factor of transformation of the earth surface. Man armed by modern techniques creates a principally new relief forms and sediment types. This man activity effects on the flow of natural processes. Now, the anthropogenic relief (with ploughed field) is developed on area of no less than 1/3 of whole area of the territory. Without the contribution of the ploughed field the anthropogenic forms occupy about 2-5 % of the territory.

The roadway excavations and earthfills (theirs height and depth are about 7– 10 m with the sum length of hundreds kilometers), the terraced surfaces of the centers of population, the open pits (with the depth of 10 – 15 m) as well as the soil-reclamation canals, ponds, peat extraction fields an so on are the most characteristic forms created by the human. In addition to a direct influence on the earth surface the human initializes starting the series of natural geological process (landslips, screes, rock subsidences, deflation, linear and surface erosion and so on).

As a whole, a value of the earth surface anthropogenic transformation evaluated through the utilization of mean volume of the shifted substance (material) on the investigated area is varied from 40000-60000 m^3/km^2 to 600000-1000000 m^3/km^2 at the parts with the greatest anthropogenic development. The edged glacial formations along the roadways, river valleys and peat swamps as well as the areas in the vicinity of the centers of population were changed in a maximal extent. Often, the earth surface acquires the qualitatively new outline on those areas. Stability of these formations relative to action of the anthropogenic loads is decreased up 50 % level and less. This is an indicator of starting the irreversible change of natural complexes.

Summarizing the results of the carried out investigation of the peculiarities of the modern geological process demonstration on the territory under discussion it should be noted the following. It has been revealed no serious appearances of the modern geodynamics which could be considered as the unfavorable factors inhibited the building of the related engineering constructions.

13.1.2.2 NPP site area

An appearance of the exogenous processes (landslides, karsts, erosive leakage, swamp formation and so on) does not been revealed.

However, there are the conditions for development of surface underflooding on the site when the anthropogenic leakages or violation of the surface drainage are taken place. The underflooding is caused by an occurrence at the ground surface of the relatively seasoned moraine clay sands with the widespread sand layers and sand lenses. Sands are characterized by different granulometric content and filtering behavior. Spreading and thickness of the lenses are differed widely; the regularity in theirs appearance does not been ascertained. So, the underflooding can be localized on certain areas of the constructions or on the whole site.

The underflooding due to rise of the level of first water-bearing horizon is little likelihood when the regime of the unloading bases for the rivers Vilija, Gazovka and Oshmajnka is not changed.

13.1.3 Seismic behavior analyses

Seismic behavior analyses have been carried out by the Nature Management Institute of the BNAC and the Geophysical Monitoring Center of the BNAC [67].

Seismic 24/7 tool-empowered observations in the area of Ostrovetskaya site are performed by the local network made up of 5 seismic stations (Teliaki, Litviany, Ginkishki, Selische, Porakity). Seismic activity has not been registered.

On the whole the area in question is typically low in seismic activity. However there have been rather powerful seismic events in the area. In 1908 according to the archives and literary sources a big earthquake took place in Ostrovetsky district with the epicenter being near the settlement of Gudogai. It measured 6-7 on the MSK-64 scale and the effects were substantial in magnitude. On October the 17th of 1987 a minor earthquake was registered. Its epicenter was located 10 km east of Ostrovets town (forest zone, the Losha River). The magnitude of the earthquake was insubstantial. Seismic danger for the APP site in close proximity is largely determined by the seismicity of Belarus's territory.

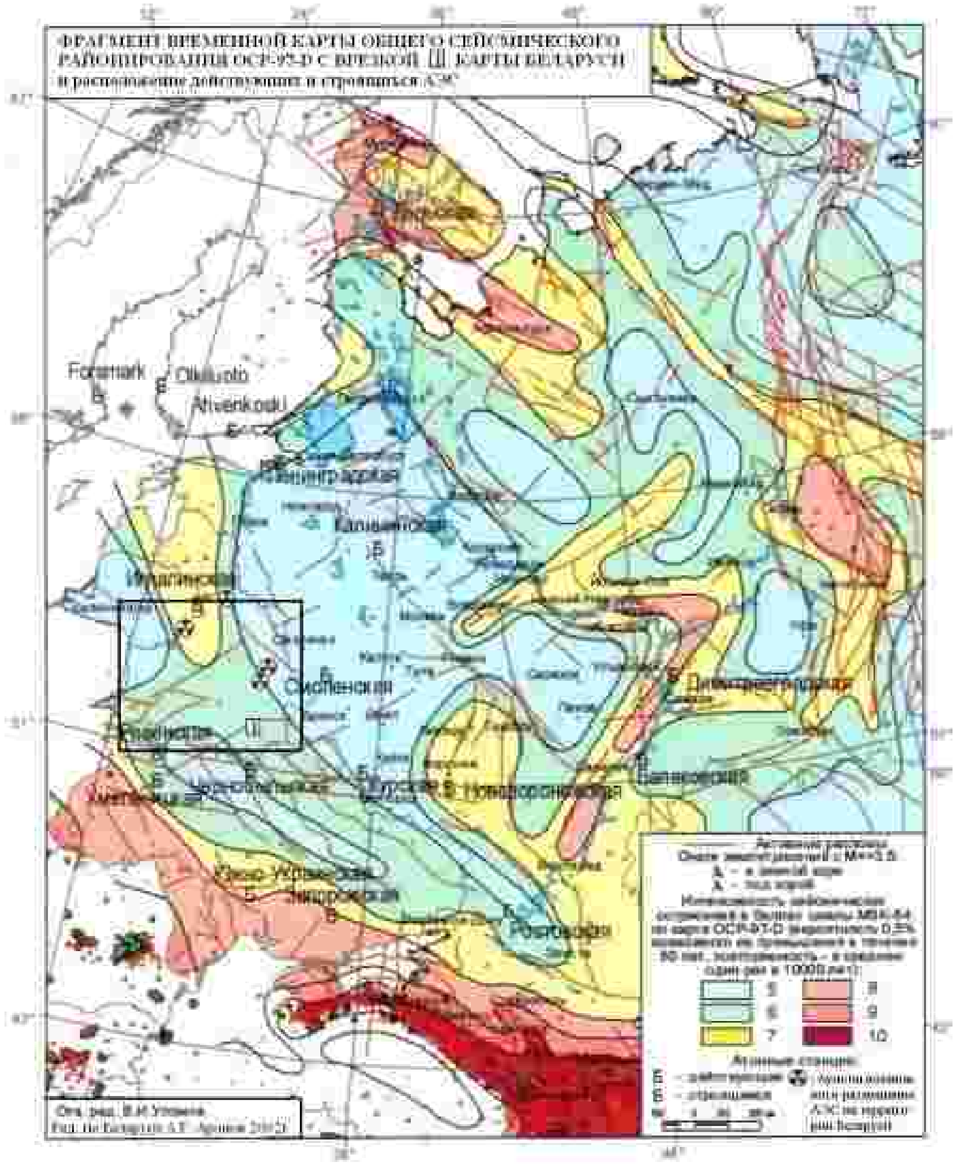
Depending on the depth and the radius of its effects the seismicity of the Vrancea zone is divided into the crust one (near the surface) when a relatively small area is affected and into that of 'undercrust' (with centers going deeper than the bottom of the earth's crust). The effects of the latter reach far away regions. The peculiar difference of the Carpathian earthquake effects on the territory of Belarus the Ostrovetskaya site including is the stretching of the isoseismal lines north-east from the epicenter of an earthquake. These isoseismal lines are well represented by ellipses. There have been made an estimate of the earthquake intensity (EI) and an outside estimate of the intensity of an earthquake (OEI). The average distance from the Vrancea zone epicenters to Ostrovetskaya site is 900 km. This value has been calculated according to the formulae of spherical geometry without taking into account the elliptical shape of the Earth which is quite acceptable for the estimates. The calculations were based on the least distance from the epicenter to the site. The Richter scale estimate of the OEI (frequency of occurrence 10 000 years) for the Ostrovetskaya site amounted to IOEI=5. The relation between the estimates of EI and OEI has been used for the Richter scale estimate of EI. Normally the average value of the difference between the two estimates is one point. Therefore we accept the EI as IEI=4 points.

As all-inclusive seismotectonic analysis was carried out potentially active structures were studied. Using such an all-inclusive approach has been helpful in identifying PES zones, determining their characteristics, and estimating the level of potential danger including for the territory of the construction site. These are the nearest PES zones to the Ostrovetskyay site: Oshmyanskaya seismogenic zone situated in 39 km south and Daugavpilsskaya seismogenic zone located 67.5 km to the north. The estimate of seismic intensity from local PES zones has been carried out. It took into account seismotectonic potential which may be regarded as the M_{max} estimate. It also took into account the hypocentral distance between PES zone and the site as well as the depth of the source typical of this PES zone. With regard to Oshmyanskaya PES zone (seismotectonic potential M_{max} = 4.5; the depth of the source 5 km) the calculated value of the seismic magnitude comes down to I = 5 points the calculation being made with the use of the equation for a drop in seismic magnitude. As regards the Daugavpilsskaya PES zone (seismotectonic potential M_{max} = 4.5; the depth of the source 8 km) the calculated value of the seismic magnitude amounts to I = 4 points the calculation being made with the use of the same equation.

Maximum earthquake magnitude which may be expected from the nearest PES zones is 5 points (Oshmyanskaya PES zone).

The level of the Carpathian earthquake magnitude also does not exceed five points for OEI. With regard to EI it does not exceed four points.

The general North Eurasia map of seismic risk zoning OCP-97-D with the scale of 1:10000000 is accepted as a legal foundation (TKP 45–3.02–108–2008) to evaluate the level of seismic danger, Belarus being represented in the map. The map is in keeping with the re-occurrence of seismic effect once in 10000 years on average (yearly average risk being 10^{-4}) as well as the probability P=0.5 % of the occurring and possibly exceeding during 50 years the seismic effect showed in the map in points of the MSK-64 scale. The map is meant for evaluating seismic danger in areas where atomic power stations, nuclear waste disposals, and other facilities of the utmost importance are situated.



Active faults
Earthquake sources M=>3.5:
A'– in the Earth crust
A – under the Earth crust
The magnitude of seismic
shakings measured by MSK-64 scale
according to OCP-97-D map (0.5% probability
of its possible exceedance during

50 years, reoccurrence – an average of once in 10000 years):

5 8
6 9
7 10

Atomic power plants:

Б'– in operaton * possible sites for the APP location in the territory of Belarus

Б – under construction

Figure 40 – A fragment of the general seismic zoning map OCP-97-D with an inset map 1 of Belarus

According to the map OCP–97–D the territory of the Ostrovetskaya site is in the seven point zone. Consequently the estimate that can be accepted based on this map must equal seven points on the MSK-64 scale. This estimate is in keeping with the OEI level. According to the established practice accepted in many regions the magnitude of EI is taken to be equal to the value of OEI minus one point.

The final estimate for the Ostrovetskaya site (subsoil of category II) is to be as follows: the estimate of earthquake intensity value EI is 6 points; the outside estimate of earthquake intensity is 7 points. There are no seismotectonic factors disallowing the setting up of the NPP on the Ostrovetskaya site.

To make an evaluation of the change in the intensity of seismic effects and to mark areas within the site that have different seismicity seismic microzoning is carried out.

13.2 Chemical and Radioactive Pollution

13.2.1 Surface Water

13.2.1.1 The Quality of Water according to Chemical Measurements

As part of the National Environment Monitoring System in the Republic of Belarus the surface water monitoring is carried out in accordance with the Regulations concerning the procedure for the conduct of surface water monitoring and the usage of its data the Regulations being approved by Ruling № 482 issued by the Cabinet of the Republic of Belarus on April the 28th 2004.

There are stationary observation sites in the territory of Ostrovetsky district. These sites which monitor the quality of surface water are situated on the Oshmyanka River (0.5 km above Velikie Yatsyny) and the Viliya River (0.3 km north east of Bystritsa). The observation site on the Oshmyanka River was set up in 1956. Monitoring investigations of the river water quality were carried out 7 times a year during basic phases of hydrological regime (the flow, the peak period, and the ebb, minimum and maximum water flow during summer steady low-water season, in the fall before freeze-up, and during winter low-water season).

According to the Secretary's Order the collecting and hydrochemical investigation of samples taken in the trans-border area of the Viliya river (0.3 km north east of Bystritsa) shall be carried out 12 times a year starting from April the 1st of 2004 (Order № 66 of March the 17th 2004 by the Secretary of the Nature Resources and Environmental Protection concerning the Organization and the Implementation of Surface Water Monitoring in the Transborder Areas of the Rivers of Belarus. This Order established the list of observation sites in the transborder areas of water bodies as well as the parameters and the periodicity of investigations.

Observation sites monitoring the water ecosystem conditions of the Viliya and the Oshmyany rivers are included in the State Observation Sites Register of the National Environment Monitoring System in the Republic of Belarus.

According to the results of hydrochemical investigations over the period of 2004-2007 the surface water of the Oshmyanka River was characterized by higher (408.7-417.6 mg/dm^3 in 2000-2001) and medium (358.1-400.0 mg/dm^3 in 2002-2007) mineralization. The mineralization during these years was largely due to Ca^{2+} ions (59.6-71.8 mg/dm^3) and hydrocarbonates (235.1-260.5 mg/dm^3), Fig. 41.

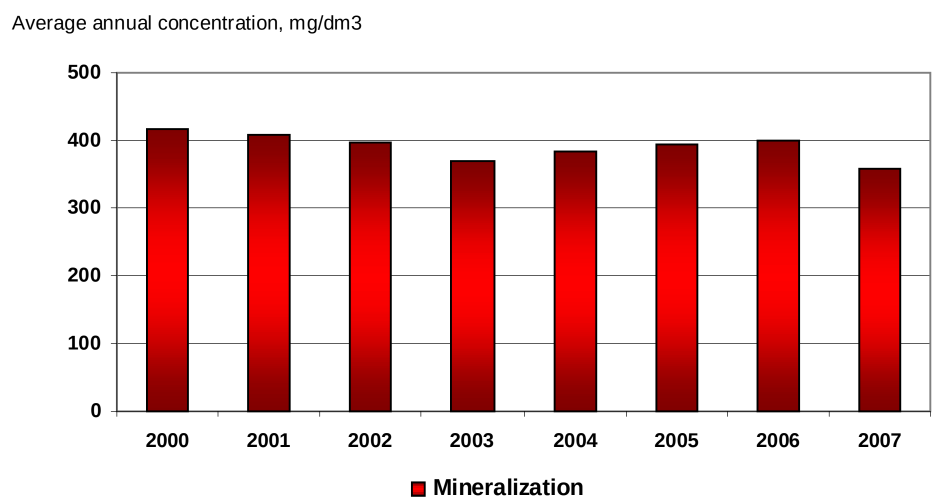


Figure 41 – The dynamics of the annual average values of the mineralization in the Oshmyanka River water above Velikie Yatsyny over 2000-2007

The dynamics of the gas and thermal behavior of the stream flow testified to the satisfactory functioning of the river water ecosystem over a long observation period. The annual average concentration of dissolved oxygen varied from 8.79 mgO_2/dm^3 to 11.61 mgO_2/dm^3.

As a rule the level of organic matter in the river water was found to be within the range of naturally occurring values. The annual average BOD_5 values have been determined to be in the range of 1.42 mgO_2/dm^3 – 2.52 mgO_2/dm^3 (figures 42, 43).

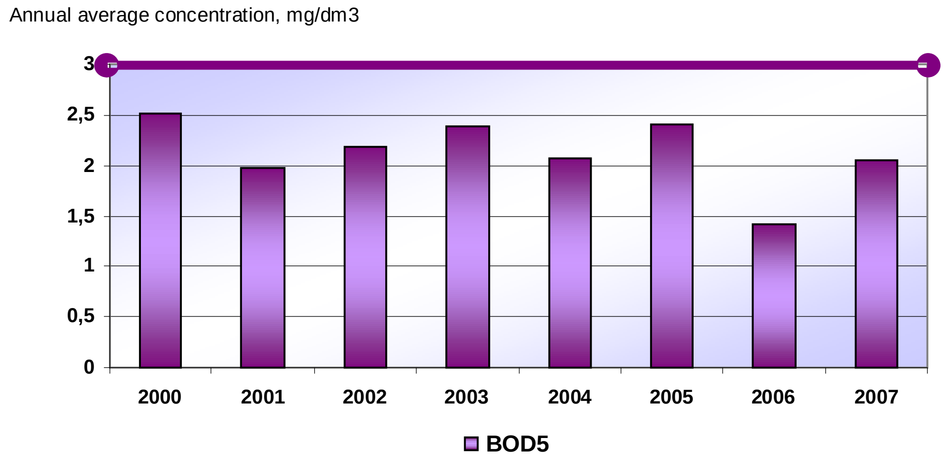


Figure 42 – The dynamics of the annual average concentrations of unstable organic compounds (according to BOD_5) in the Oshmyanka River water above Velikie Yatsyny over the period of 2000-2007

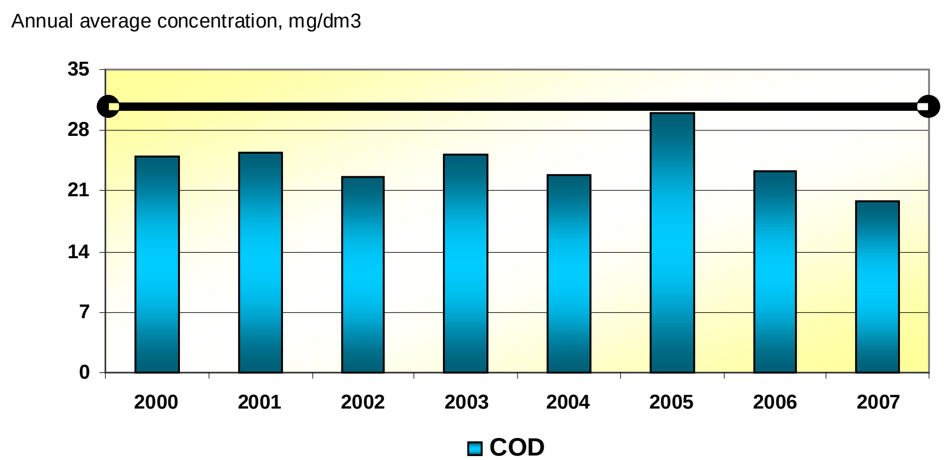


Figure 43 – The dynamics of the annual average concentrations of organic sub stances (according to COD) in the Oshmyanka River water above Velikie Yatsyny over the period of 2000-2007

As for 2006 and 2007 the variability of BOD_5 and COD values testify to a slight organic 'strain' on the river waters during all periods of observation.

Over the 2000-2004 period ammonium nitrogen was a major biogenic 'stress' on the water ecosystems of the Oshmyanka River. Its annual average concentrations were found to be 1.2-1.5 of MPC. Average concentrations of other forms of nitrogen (nitrate and nitrite) over this period were determined considerably below the MPC level. During 2006-2007 a higher concentration of ammonium nitrogen was found in certain water samples collected in a cold season (January – March). The dynamics nature of average ammonium nitrogen concentrations had also changed. Figure 44.

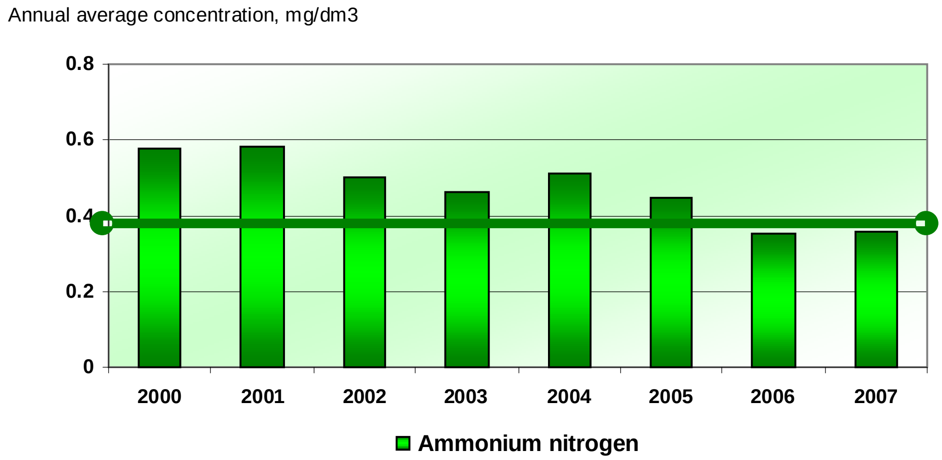


Figure 44 – The dynamics of annual average ammonium nitrogen concentrations in the water of the Oshmyanka River above Velikie Yatsyny over 2000-2007

The annual average concentrations of phosphates at the level 0.2-0.3 of MPC as well as the analysis of the inorganic phosphorus annual cycle show the satisfactory condition of the river's water ecosystem from the standpoint of the presence of one of the major eutrophication elements of environmental waters (figures 45, 46).

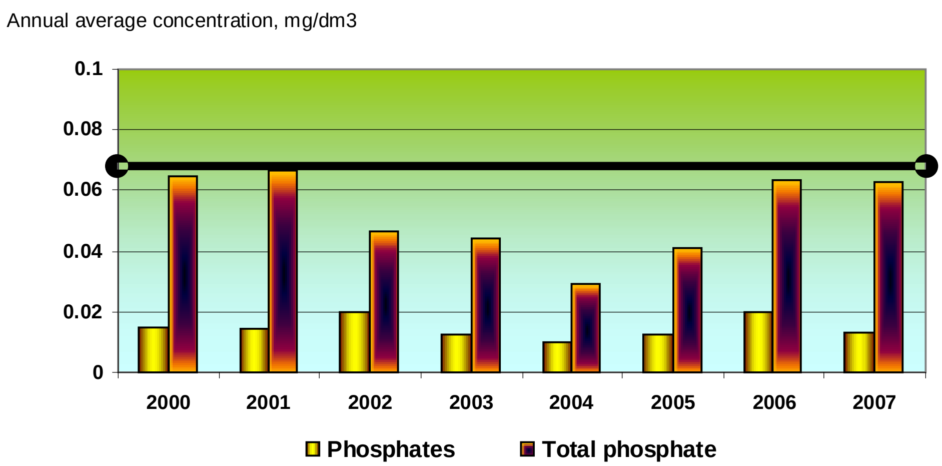


Figure 45 – The dynamics of annual average inorganic phosphorus concentrations in the water of the Oshmyany River above Velikie Yatsyny over 2000-2007

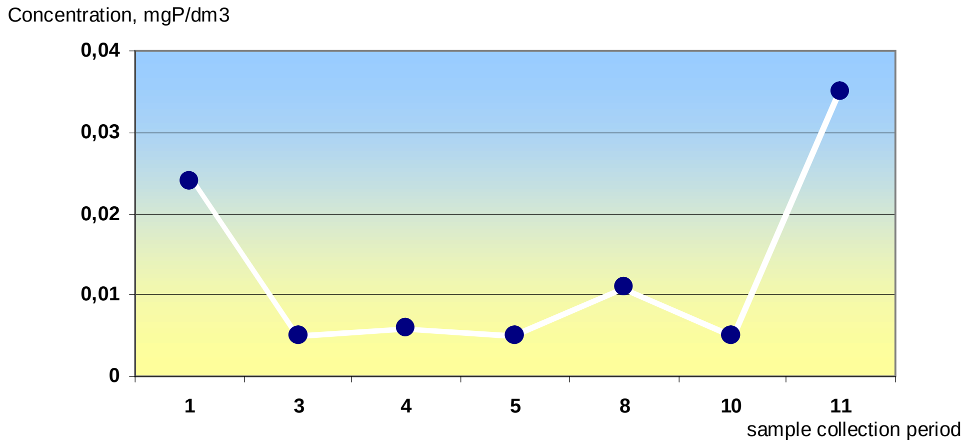


Figure 46 – Annual distribution of inorganic phosphorus concentrations in the water of the Oshmyanka River above Velikie Yatsyny in 2007

Higher annual average concentrations of Total Ferrum (0.112-0.287 mg/dm^3), copper compounds (0.003-0.010 mg/dm^3), and manganese (0.016-0.077 mg/dm^3) established for the Oshmyanka River are typical of practically all water bodies of the country. The annual average concentrations of Zink compounds exceeded MPC 1.1-3.1-fold which is connected with the peculiarities of groundwater inflow and the incoming of Zinc compounds from scattered (diffuse) sources of pollution. While on the other hand the annual average concentrations of the other metal – nickel – were found to be in the acceptable range (figure 47).

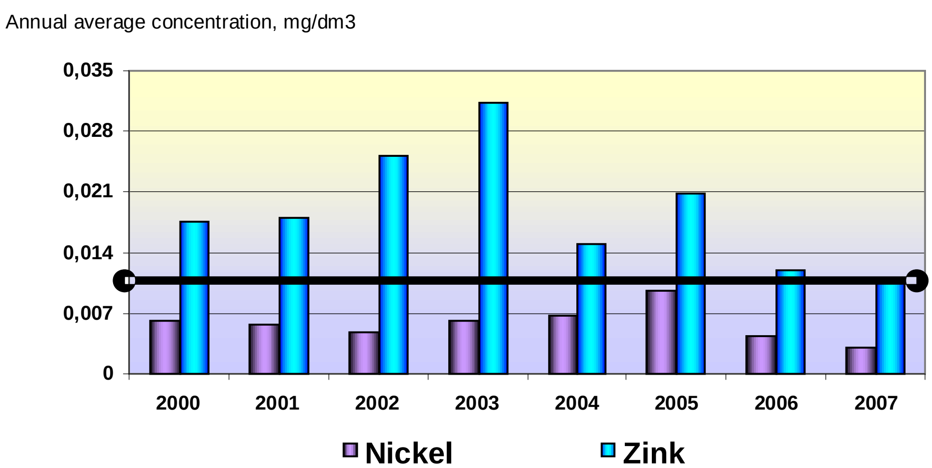


Figure 47 – The dynamics of annual average concentrations of zink and nickel compounds in the water of the Oshmyanka River above Velikie Yatsyny over the period of 2000-2007

The concentrations of lead, cadmium, and synthetic surface–active substances continued low in a stable manner throughout the yearly observation period. During the period of 2000-2007 the tendency towards the contamination of the Oshmyanka River with oil products had not been displayed in a distinct way. The annual average concentrations of oil products 1.0 of MPC and higher (2003-2006) are accounted for by the re-occurrence of samples with the concentrations exceeding the normative standard in the yearly period. The results of observations over 2007 allow one to state a drop in anthropogenic stress on the stream flow (figure 48).

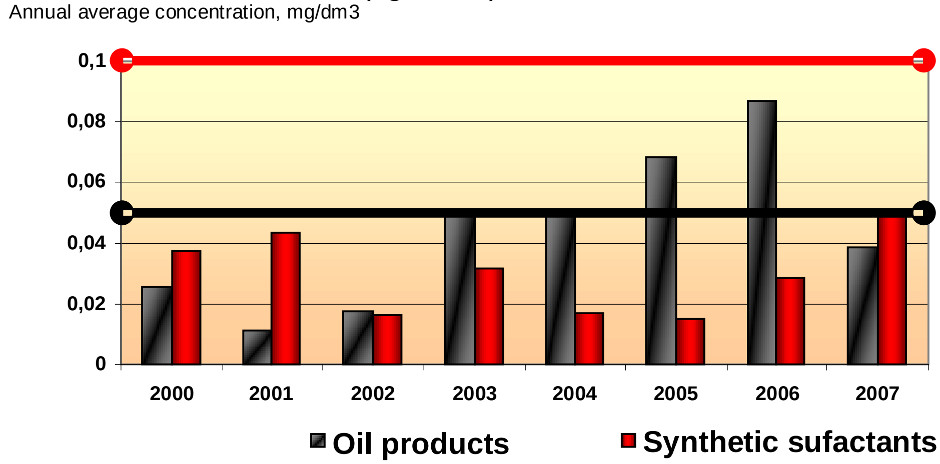


Figure 48 – The dynamics of the annual average concentrations of oil products and synthetic surfactants in the water of the Oshmyanka River above Velikie Yatsyny over the period of 2000-2007

The dynamics of the pollution index of the water in the Oshmyanka River is unstable. In 2007 according to the accepted evaluation standard the quality of the water in the river corresponded to 'relatively pure' category – II (WPI=0.6) (figure 49).

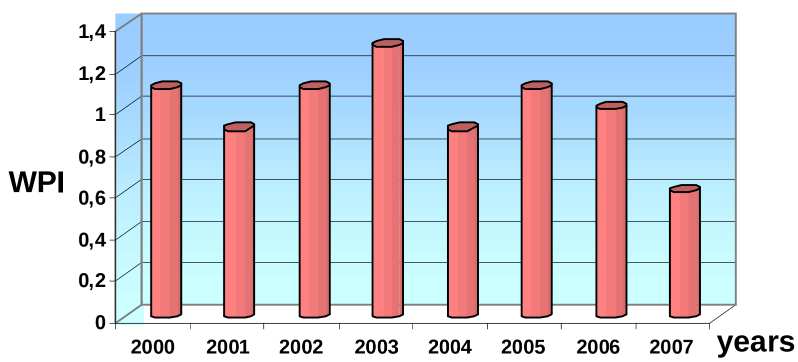


Figure 49 – The dynamics of the water pollution index (WPI) of the Oshmyanka River above Velikie Yatsyny over 2000-2007

During observation period 2004 – 2007 it was typical of the transborder waters of the Viliya River at Bystritsa to have higher concentration of Total Ferrum (0.309-0.405 mg/dm^3), copper compounds (0.001-0.004 mg/dm^3), manganese (0.002-0.007 mg/dm^3) which is characteristic of not only the majority of transborder observation sites but also of most water bodies of the Republic. The annual average concentrations of the other metals – zink and nickel – were found to be in the range that is significantly lower than MPC. Moreover, there is a strong tendency towards further decrease in the annual average concentrations of these ingredients (figure 50).

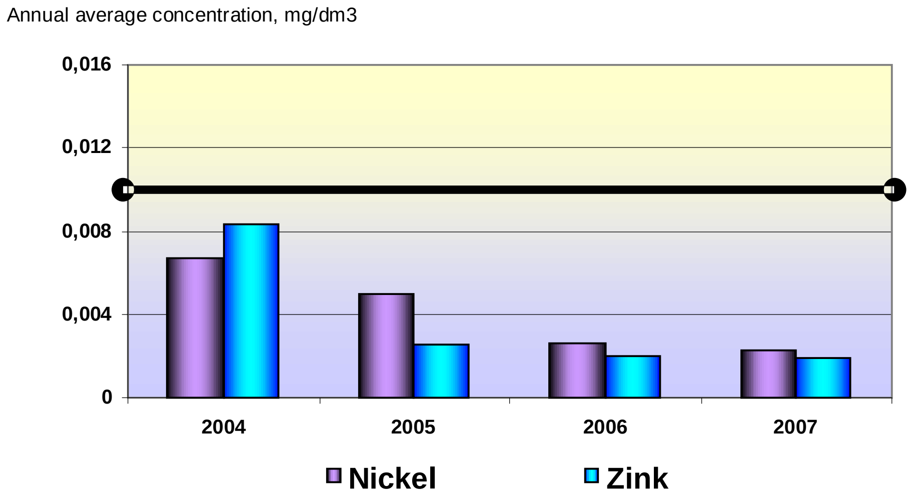


Figure 50 – The dynamics of the annual average concentrations of zink and nickel compounds in the water of the Viliya River at Bystritsa over the period of 2004-2007

The investigation of hydrochemical data concerning the concentrations of oil products and synthetic surfactants testifies to the absence of pollution across this stretch of the river by major contaminants.

Figure 51 shows the dynamics of the annual average concentrations of oil products and synthetic surfactants in the water of the Viliya River over the period of 2004-2007 rr.

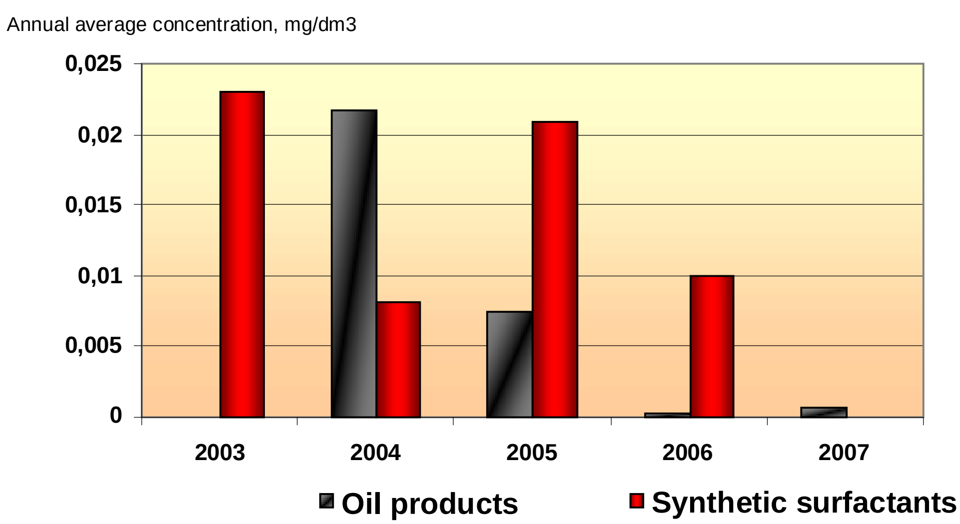


Figure 51 – The dynamics of the annual average concentrations of oil products and synthetic surfactants in the water of the Viliya River over 2004-2007

There remained components of basic salt composition against the regional background. The data of the monitoring observations characterizes the Viliya waters at Bystritsa as those of medium mineralization (234.0-287.4 mg/dm^3) with the absolute dominance of cations Ca^{2+} and hydrocarbonates in the salt composition (figure 52).

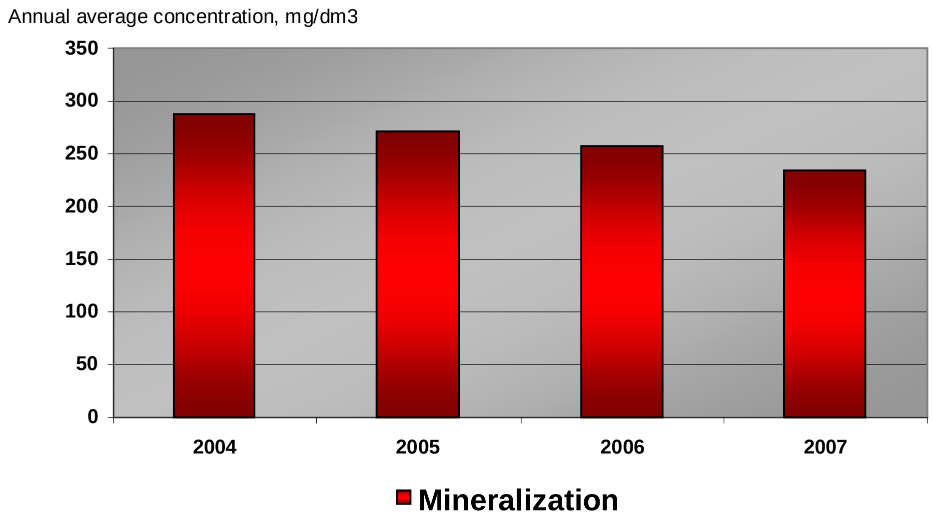


Figure 52 – The dynamics of the annual average values of mineralization in the water of the Viliya River at Bystritsa over the period of 2004-2007

Despite the fact that the annual average dichromate values (COD_{Cr}) reflecting the general level of organic stress on the stream flow remained in the range of medium values (17.7-23.6 mgO_2/dm^3), BOD_5 values testifying to a content of easily oxidizable organic matter were found to be 1.0-1.2 of MPC (figures 53, 54).

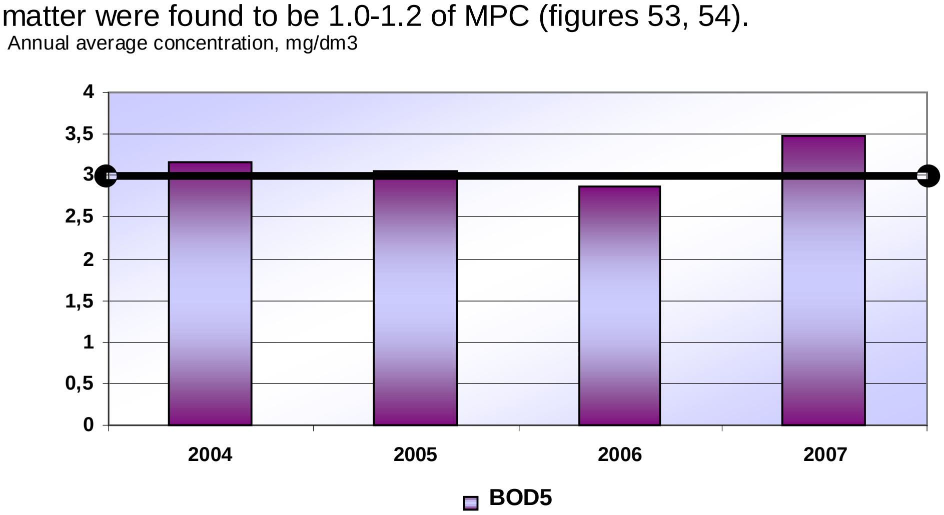


Figure 53 – The dynamics of the annual average concentrations of easily oxidizable organic compounds (according to BOD_5) in the water of the Viliya River at Bystritsa settlement over the period 2004-2007

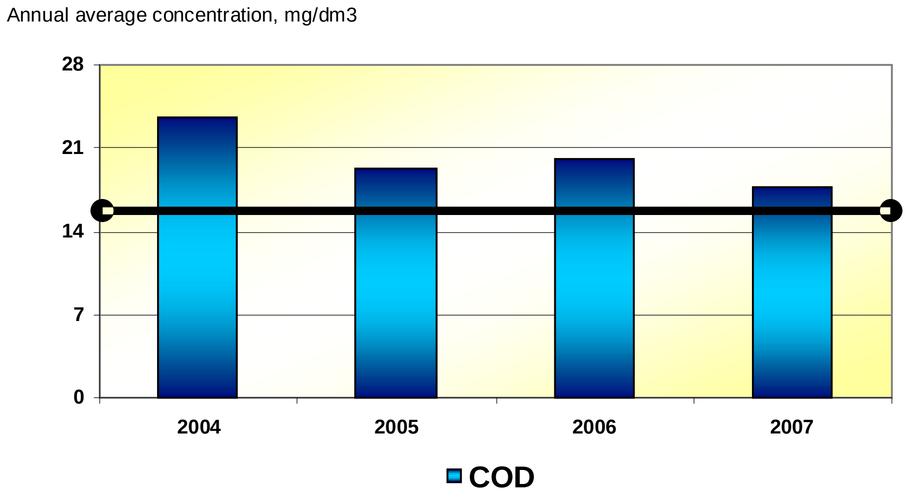


Figure 54 – The dynamics of the annual average of organic compounds (COD_{Cr}) in the water of the Viliya River over the period 2004-2007

The analysis of the hydrochemical behavior of nitrogen and phosphorus compounds testified to the satisfactory state of the water ecosystem (figures 55, 56). However, from the standpoint of protecting the rivers from eutrophication the annual average concentrations of nitrate nitrogen and inorganic phosphorus exceeded the ecologically acceptable value of 0.5 mgN/dm^3 for nitrate nitrogen and 0.030 mgP/dm^3 for inorganic phosphorus.

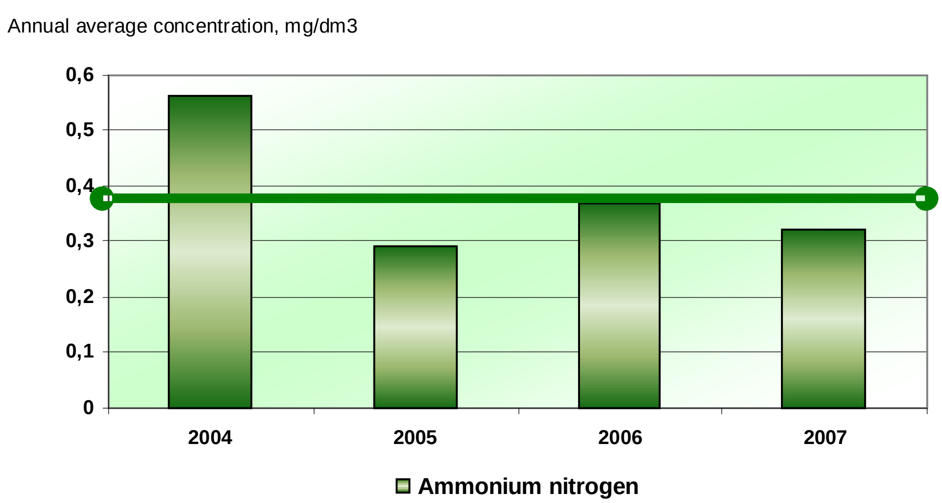


Figure 55 - The dynamics of the annual average concentrations of ammonium nitrogen in the water of the Viliya River over the period 2004-2007

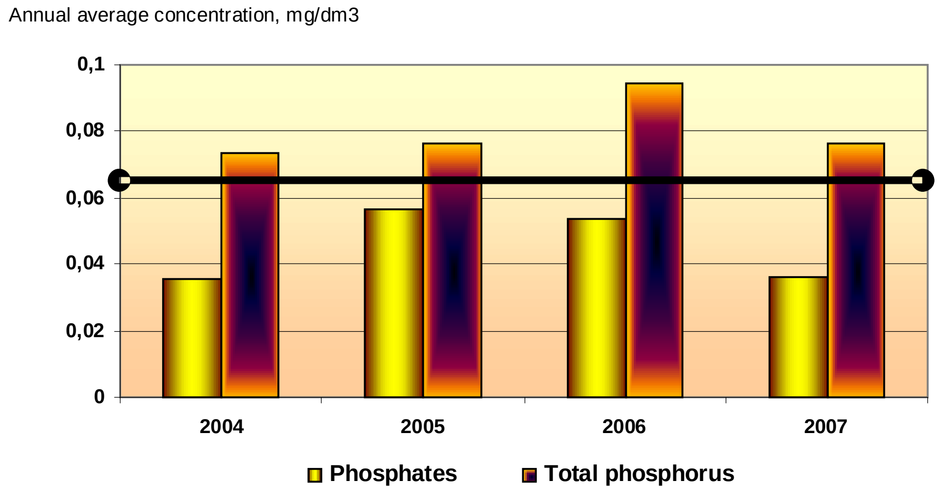


Figure 56 – The dynamics of the annual average concentrations of inorganic and total phosphorus in the water of the Viliya River at Bystritsa over 2004-2007 period

Figure 57 shows the dynamics of the water pollution index (WPI) of the Viliya River at Bystritsa over the period 2004-2007

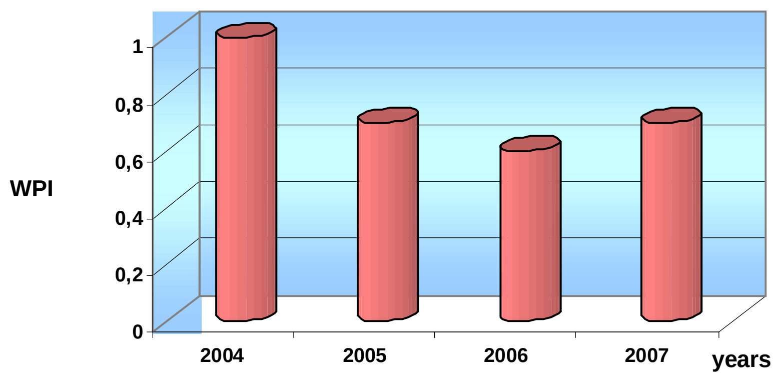


Figure 57 – The dynamics of the water pollution index (WPI) of the Viliya River at Bystritsa settlement over 2004-2007 period

According to the accepted evaluation standard the quality of the Viliya River waters was characterized by 'relatively pure' category (WPI=0.6-1.0).

13.2.1.2 The Expeditionary Investigations Data

During the expeditionary investigations carried out in 2008 – 2009 at the water bodies within the 30-km zone of the belarusian NPP water sample were collected from the following water bodies: the Viliya R. at Mikchalishki s. (within the borders of the settlement), the Gozovka R. at Goza s. (1.0 km. above the s.), the Losha R. at Gervyaty s. (2.0 km. above the s.), the Oshmyanka R. at Velikie Yatsyny s. (2.0 km above the s) (figure 58).

The Gozovka River (Goza v.) The Losha River (Gervyaty v.)

Figure 58 – Photos of the Gozovka and Losha Rivers where the samples were taken

'First day analysis' measurements were taken at all the water bodies in regard to biogenic substances and the major ions of salt composition as well as in regard to 'prioritized' organic substances, trace elements (heavy-metal ions), and major contaminants. The gauging of temperature, dissolved oxygen, pH, as well as the conserving of the samples and the measuring of BOD_5 were all carried out at the spot of sample collection. The determining of the other hydrochemical measures was performed in the GU RTSRKM laboratories of water chemistry and physico-chemical measurements which meet the criteria of the Belarus accreditation system and have been accredited in regard to independence and technical expertise in accordance with the STB ISO/MEK 17025 regulations.

The results of the hydrochemical analysis of the water samples are shown in Table 48. Careful consideration of the tabular data testifies that according to the 'first day analysis' results all rivers have slightly alkaline water (the value being pH 7.82 – 8.28). The lowest and the highest dissolved oxygen content value are these: 8.50 mgO_2/dm^3 (the Gozovka River at Gaza s.) and 10.48 mgO_2/dm^3 (the Oshmyanka River at Velikie Yatsyny s.) the oxygen saturation being 111%. According to the water pollution evaluation standard (MPC) the dissolved oxygen content during summer season in the water bodies should be no less than 6 mgO_2/dm^3. Carbon dioxide content values were found to be in the range of 7.9 – 14.1 mg/dm^3 while there was no carbon dioxide to be found at the sample collection sites of the Losha River at Gervyaty s. and the Viliya River at Mikchalishki. That is typical for the summer season end when plant life is rampant in the water bodies.

BOD (biochemical oxygen demand) measure serves as the quantification of easily oxidizable organic substances showing the oxygen quantity used up for the oxydizing of organic substances oxidize over a period of time (5 days). The highest biochemical oxygen demand (BOD_5) value was found in the Viliya River within the borders of Mikchalishki settlement – 5.93 mgO_2/dm^3 (about 2 of MPC) which testifies to the fact that there is a higher content of easily oxidizable substance in the water.

Organic carbon is indicative of the aggregate content of organic substance in the water. The simplest and the most prevalent way of identifying the content of organic substance is the method of determining the water oxidizability by the oxygen quantity used up for oxidizing (oxidizer $K_2Cr_2O_7$). As for the rivers under study the maximum dichromate value 31.6 mgO_2/dm^3 is found in the Viliya River within the borders of Mikchalishki settlement while the minimum one of 16.3 mgO_2/dm^3 in the Oshmyanka River 0.5 km above Velikie Yatsyny settlement.

Table 48 – Hydrochemical analysis results of water samples

Name of ingredient	Gozovka R Goza V.	Losh R Gervyaty Town	Viliya R Mikchalishki V	Oshmyanka R Velikie Yat-syny V	MPC
Date of sample taking	02.09	02.09	02.09	03.09	
Time	14.20	17.45	19.00	14.15	
Temperature	12,5	15,8	16,7	17,6	
pH	7,84	8,15	8,28	7,82	6,5-8,5
Oxygen, mg/dm^3	8,50	10,17	10,45	10,48	<6,0
Carbon dioxide, mg/dm^3	14,1	0	0	7,9	
BOD_5, mg/dm^3	2,79	2,67	5,93	3,14	3,0
% oxygen saturation	82	106	111	108	
Colour grade	19	13	30	20	
COD, mgO/dm^3	19,8	17,8	31,6	16,3	
Ammonium Nitrogen, mgN/dm^3	0,41	0,34	0,39	0,26	0,39
Nitrate Nitrogen, mgN/dm^3	0,48	0,24	0,007	0,10	9,03
Nitrite Nitrogen, mgN/dm^3	0,007	0,008	<0,005	0,007	0,024
Phosphates, mgP/dm^3	0,019	0,015	0,014	0,015	0,066
Total phosphorus, mgP/dm^3	0.024	0.023	0.024	0.032	0,200
Total Ferrum, mg/dm^3	0,17	0,08	0,05	0,17	0,10
Silicon, mg/dm^3	2,7	2,3	2,7	3,2	10,0
Hydro carbonate, mg/dm^3	228,8	237,3	226,9	265,4	
Total water hardness, mg-eq/dm^3	4,40	4,22	4,18	4,90	<7,0
Sulphates, mg/dm^3	15,0	16,7	18,4	27,4	100,0
Chlorides, mg/dm^3	28,7	17,0	25,8	14,1	300,0
Calcium, mg/dm^3	62,3	53,1	55,5	55,1	180,0
Magnesium, mg/dm^3	15,7	19,1	19,1	26,1	40,0
Solids content, mg/dm^3	324,8	283,2	264,8		
Oil products, mg/dm^3	0,06	0,03	0,03	0,03	0,05
Phenols, mg/dm^3	0,004	0,003	0,003	0,002	
Total Chrome, mg/dm^3	0,002	0,001	0,001	0.001	0,005
Synthetic Surfactant, mg/dm^3	0,024	0,024	0,041	0.028	

End of the table 48

Name of ingredient	Gozovka R Goza V.	Losh R Gervyaty Town	Viliya R Mikchalishki V	Oshmyanka R Velikie Yatsyny V	MPC
Suspended solids, mg/dm^3	<5,0	<5,0	8,0	5.0	Increase by 0,25
Diaphaneity cm	49	49	25	49	
Electrical conductivity cm/cm	0,000445	0,000460	0,000411	0,000489	

Nitrogen, silicon, phosphorus and ferrum compounds belong to a group of biogenic substances. Ammonium, nitrite, and nitrate ions that are interconnected and can turn into one another belong to inorganic nitrogen compounds.

The highest ammonium nitrogen content values were found in the following rivers: the Gozovka (1.0 km above Goza s.) – 0.41 mgN/dm^3 and the Viliya (within the borders of Mikchalishki s.) – 0.39 mgN/dm^3 (over 1 of MPC). Nitrate and nitrite nitrogen content in the rivers under study was not found to be above MPC.

Phosphorus in the waters of the rivers is present in the form of inorganic as well as organic compounds. Phosphorus compounds content in the river waters is usually in the tenths of a milligram/liter while higher concentrations of phosphorus are indicative of the waters' pollution since phosphorus compounds belong to the break down products of composite organic substances. The inorganic phosphorus content in the waters under study is 0.014 – 0.019 mgP/dm^3 while the total phosphorus content (both organic and inorganic) is in the range of 0.023 to 0.032 mgP/dm^3 which does not exceed the acceptable values of MPC.

Ferrum compounds get into the waters of the rivers by way of groundwater inflow, industrial as well as agricultural waste waters, and as a result of the chemical erosion of earth material. Maximum values as to the Total Ferrum content – 0.17 mg/dm^3 (over 1.0 of MPC) - were found in the following rivers: the Goza at Gozovka s. and the Oshmyanka at Velikie Yatsyny s.

Based on the results of the analysis of core-basal salt composition ions the rivers under study belong to the rivers with small and medium mineralization the highest value (according to solids content) being 324.8 mg/dm^3. The total water hardness value of the rivers is not high while the maximum value is 4.90 mg-eq/dm^3 (the Oshmyanka River at Velikie Yatsyny s.). Out of major ions (macro-components) the ones that dominate are hydrocarbonate and calcium ions.

The following trace elements were found in the rivers under study: copper, zink, nickel, lead, cadmium, and manganese.

Out of major pollutants the following were found in the rivers' waters: oil products in the Goza River 1.0 km above Gozovka s. – 0.06 mg/dm^3 (over 1 of MPC), aggregate phenols yielded values that are in the range of 0.002 – 0.004 mg/dm^3. Neither synthetic surfactants (SS) nor total chrome content in the rivers under study were found to be above MPC norms.

As for the rest measures and ingredients found in the water bodies of the Ostrovets land plot nothing was registered that would rise above MPC.

13.2.2 Radiation situation

In the republic radiation monitoring is led in accordance with following regulatory legal acts:

– Regulation on procedure of radiation monitoring and applying of its data within a framework of National system of environmental monitoring, confirmed by the Resolution of Council of Ministers of the Republic of Belarus on May 17, 2004, No 576;

– Instruction on procedure of radiation monitoring by establishments subordinate to Ministry of natural resources and environment, confirmed by the Resolution of Ministry of Natural Resources of the Republic of Belarus on November 11, 2008, No 98;

13.2.3 Surface water and bottom sediments

During the field work in 2008 – 2009 surface water and bottom sediments samples were collected on the river Viliya – settlement Mikhalishky (within the settlement), settlement Bystritsa (near the road bridge), settlement Muzhily, on the river Gozovka – settlement Goza (1,0 km above the settlement), on the river Losha – rural settlement Gerviaty (2,0 km above the settlement), on the river Oshmianka – settlement Velikie Yatsyny (0,5 km above the settlement), on the river Polpa – settlement Voleikuny, on the river Straga – settlement Olkhovka, and also on water storage basin near settlement Olkhovka.

Results of radioactive nuclides determination in surface water samples are introduced in Table 49.

Table 49 – Determination of radioactive nuclides in surface water samples collected from the examined bodies of water in Ostrovetsky district Grodno region. Date of collection is September 2, 2008

Sampling point	Volumetric activity, Bq/l	
	^{137}Cs	^{90}Sr
r. Gozovka (settl. Goza)	0,006±0,001	0,008±0,002
r. Losha (settl. Gerviaty)	0,007±0,001	0,007±0,002
r. Viliya (settl. Mikhalishky)	0,007±0,001	0,010±0,002
r. Oshmianka (settl. Velikie Yatsyny)	0,006±0,001	0,009±0,002

During the field work bottom sediments samples were collected; results of radioactive nuclides determination in bottom sediments samples are introduced in Table 50.

Table 50 – Determination of radioactive nuclides in bottom sediments samples

Place of sampling, date of sampling	Sampling point	Weight, kg	Specific activity, Bq/kg					
			^{40}K	^{238}U	^{232}Th	^{226}Ra	^{137}Cs	^{90}Sr
r. Gozovka (settl. Goza) 03.09.2008	T.1	0,600	424±17	4,4±0,4	21,0±1,9	13,1±1,2	1,5±0,2	1,9±0,8
	T.2	0,789	421±16	4,8±0,4	15,4±1,3	11,9±0,9	2,05±	1,3±0,6
	T.3	1.062	411±15	6,8±0,3	19±1,9	12,9±1,2	1,9±0,2	1,1±0,5
r. Losha (settl. Gerviaty)	T.1	1,467	375±18	7,5±0,6	9,3±0,8	6,8±0,6	0,6±0,1	0,8±0,4
	T.2	1,215	373±19	5,8±0,5	12,3±1,4	7,9±0,7	1,2±0,1	1,1±0,5

03.09.2008	T.3	0,965	393±19	8,5±0,6	10,3±0,9	7,7±0,7	0,9±0,1	0,6±0,2
r. Viliya (settl. Mikhalishky) 03.09.2008	T.1	1,376	386±16	7,6±0,6	16,5±1,8	10,6±1,1	1,7±0,2	1,3±0,6
	T.2	1,129	420±16	4,8±0,4	15,4±1,3	10,6±0,9	4,7±0,3	1,0±0,5
	T.3	0,988	394±15	7,6±0,6	12,8±1,0	10,9±0,8	2,6±0,2	1,7±0,7
r. Viliya (settl. Bystritsa) 06.05.2009	T.1	1,639	451±110		15,9±4,1	10,4±2,7	3,0±0,8	
	T.2	1,204	320±46		12,8±2,4	6,6±1,3	5,0±1,0	
	T.3	0,774	360±18		11,1±0,5	7,3±0,4	5,5±0,4	
	T.4	0,578	431±21		14,5±0,6	9,1±0,4	6,7±0,4	
r. Viliya (settl. Muzhily) 06.05.2009	T.1	0,633	355±28		15,7±1,4	9,1±0,8	5,4±0,6	
	T.2	1,425	338±82		10,5±2,5	7,6±1,8	5,5±1,3	
	T.3	1,184	328±47		9,8±1,5	6,7±1,7	7,2±1,2	
	T.4	1,120	334±84		12,8±3,4	7,9±2,1	7,9±1,9	
r. Stracha – (settl. Olkhov-ka) 06.05.2009	T.1	1,000	328±47		9,8±1,5	6,7±1,7	2,6±0,7	
	T.2	0,700	282±12		15,9±0,2	7,9±0,4	1,1±0,2	
	T.3	0,650	316±16		12,8±0,6	7,4±0,4	1,2±0,2	
	T.4	0,668	335±28		8,8±1,1	7,9±0,8	1,0±0,4	
Olkhovka water storage basin (settl. Olkhov-ka) 06.05.2009	T.1	0,774	487±24		15,4±0,7	10,0±0,5	0,7±0,1	
	T.2	1,440	414±100		13,9±3,7	9,7±2,5	1,2±0,3	
	T.3	1,458	373±82		9,8±2,4	6,69±1,5	1,2±0,3	
	T.4	1,773	394±85		9,9±2,4	7,2±1,7	0,4±0,1	

It is clearly described in Table 50 that levels of technogenic radioactive nuclides in bottom sediments of the examined rivers are close to global fallout level. Specific activity levels of natural radioactive nuclides in the collected samples of bottom sediments correspond to mean activity levels of these radioactive nuclides which are typical for soddy podzolic and podzolic soil.

13.2.4 Soil

During the field work in 2008-2009 assessment of radiological situation and technogenic pollution was made in the area of settlements Goza, Aveny, Valeikuny in Ostrovetsky district Grodno region (figure 59), and also on the territory of the planned construction site of the NPP. Figure 60 shows sketch map of reference sites (RS) where soil samples were collected.

RS No 1 settl. Goza RS No 2 settl. Aveny

Figure 59 – Photo of reference sites territory, on which the field work was made

RS

Figure 60 – Sketch map location

The selected sites were situated on the open territory, there were no dwellings and other buildings, no areas coated with asphalt. Surface of the area is 200 m x 200 m.

On the RS soil samples were collected by envelope method. On sampling points gamma-radiation intensity (INT) was measured at the height of 1 m and 2-3 cm from soil level.

Radiation dosimeters ДБГ-06Т, МКС-1117 with measurement range from 0,10 to 99,99 µSv/h, and relative measurement error of not more than 20 % was used for INT measurement. Sampling equipment of 200 mm height, 40 mm diameter was used for soil sampling.

On each RS soil profile was cut for assessment of regional redistribution of radioactive nuclides in vertical profile of soil.

13.2.4.1 Technogenic pollution

Whereas there are no big highways and industrial production within the site area of the Belarusian NPP, fixed stations for examination of chemical polluting agents and heavy metals content in soil are absent. Ecological state of soil was estimated by results of field work.

Analysis of soil samples for content of chemical polluting agents was made in laboratory of soil pollution monitoring and laboratory of chemical measurements of Republican Centre of Radiological Monitoring, SE.

The collected soil samples were dried in room temperature until they became air-dry, then they were meshed in big porcelain mortar and bolted (mesh size – 1 mm). By quartering method an average sample was collected from this bolted sample.

Chemical analysis of heavy metals content was made in accordance with Temporary guidelines for soil pollution control. Part 1.- M., 1983. Termination of analysis was made with the help of atomic absorption spectrophotometer AAS - 3.

Content of sulphate in soil was detected with the help of spectrophotometer СФ-46 according to method described in the same guidelines.

For soil characterizing pH was detected by potentiometric method using GOST 26423-85 Soils. Methods of Detection of Electric Conductivity, Ph and Dissolved Solids in Water Extract.

Petroleum product analysis was made with the help of gravimetric procedure according to method described in Guidance for hygienic rating of chemical substances in soil.

Nitrate detection in soil was made according to GOST 25951-66 Soils. Nitrate Detection by Ionometric Technique.

Detection of heavy metals in soil was made with the help of atomic absorption spectrophotometer with electrothermal atomizer NovAA-400 «Analitique Yena», German Democratic Republic, working range: (190-860), detection limit of Ni – 0,3 µg/l, Pb – 0,08 µg/l, Cu – 0,19 µg/l, Mn – 0,014 µg/l, Cd – 0,007 µg/l, Zn – 0,003 µg/l. Measurement error is 5 %.

Measurement results of chemical polluting agents and heavy metals content are shown in Tables 51 and 52.

Table 51 – Content of chemical polluting agents in RS soil samples

RS No	Sampling point No	pH	Sulphates mg/kg	Nitrates mg/kg	Petrolium products, mg/kg
RS No 1 Goza	1	6,85	11,3	3,5	<5,0
	2	7,13	20,7	2,8	10,0
	3	6,85	16,0	3,1	10,0
	4	7,15	16,0	3,0	13,3
	5	7,01	20,7	3,6	10,0

RS No 2 Aveny	1	6,81	26,9	4,9	6,7
	2	7,00	23,8	4,9	13,3
	3	7,12	26,9	5,1	10,0
	4	6,96	31,7	12,9	16,7
	5	6,52	37,9	9,6	6,7
RS No 3 Va-leikuny	1	6,92	30,1	12,9	<5,0
	2	6,88	22,2	8,1	<5,0
	3	7,10	31,7	9,1	<5,0
	4	6,51	22,2	25,1	10,0
	5	6,80	53,6	4,5	20,0
MPC*			160	130	50

** MPC – Maximum permissible concentration of chemical polluting agents*

Table 52 – Content of heavy metals in soil samples collected on reference sites (RS) within 30-km area.

RS No	Sam-pling point No	Cadmium mg/kg	Zinc, mg/kg	Lead, mg/kg	Copper, mg/kg	Nickel, mg/kg	Manga-nese, mg/kg
RS No 1 Goza	1	0,07	12,7	6,8	1,0	4,1	57,2
	2	0,13	11,7	9,1	1,1	4,1	54
	3	0,1	16,7	6,8	2,0	8,5	199
	4	0,18	14,6	8,5	1,5	5,4	64
	5	0,08	13,7	7,2	1,4	4,6	103
RS No 2 Aveny	1	0,14	21,1	7,6	1,6	5,6	358
	2	0,14	22,7	8,7	1,7	5,9	585
	3	0,14	24,4	8,0	1,6	5,0	423
	4	0,13	24,8	9,1	8,2	1,4	718
	5	0,17	21,5	8,7	1,6	5,3	629
РП RS No 3 Valeikuny	1	0,14	21,1	6,0	1,8	5,9	285
	2	0,12	19,4	5,8	1,6	5,4	305
	3	0,12	21,0	7,5	1,6	5,7	326
	4	0,19	22,4	8,0	2,0	5,9	356
	5	0,15	21,9	7,2	1,9	6,6	368
Variation range		0,07-0,19	11,7-24,8	5,8-9,1	1,0-8,2	1,4-8,5	54-718
MPC *		2,0	220	32,0	132	80	1500

** Value of maximum permissible concentration (MPC) if pH value is > 5*

It is clearly described in Tables 51, 52 that content of chemical polluting agents and heavy metals in the collected soil samples do not exceed maximum permissible values.

13.2.4.2 Radioactive contamination

Within 30 km-area from the Belarusian NPP there are no fixed stations for radioactive soil contamination surveillance because this territory hasn't almost been effected as a result of the accident at Chernobyl NPP, however in data base of the Republican Center of Radiation Control and Environment Monitoring there are results of surveys on environment contamination of all territory of the Republic of Belarus made during first years after the accident at Chernobyl NPP, including data on soil radioactive contamination in 252 settlements situated within 30-km area. In 243 settlements average contamination density with ^{137}Cs amounts to less than 0,1 Cu/ km ^{2} (3,7 kBq/m $^{2)}$, in 9 settlements average contamination density with ^{137}Cs is within 0,1 – 0,28 Cu/km^2
(3,7 – 10,4 7 kBq /m^2).

In soil samples collected in 122 settlements radioactive nuclides ^{90}Sr were identified, in 46 settlements isotopes of plutonium were identified.

Measurement of gamma-emitting radioactive nuclides content and detection of ^{90}Sr in soil samples collected during field work was made in radiation analytic department of Republican Center of Radiation Control and Environment Monitoring, SE.

Content of ^{238}U was detected according to Measurements Techniques. MH 1497–2001 This is a method of uranium detection in soil and aerosol filter which determines radiochemical and radiometric procedures used while detection of alpha-emitting radioactive nuclides of uranium by radiochemical method and is applied for soil samples, bottom samples, bottom sediments samples, vegetation samples and aerosol filters.

Minimum detected activity of uranium radioactive nuclides amounts to 0,005 Bq/sample if counting efficiency of alpha-particles is 30 %, time of measurements is less than 20 000 s and the least permissible uranium radioactive yield is 20 %. Minimum detected activity of uranium radioactive nuclides at radioactive yield of 60 % is 0,002 Bq/sample.

Method gives opportunity to analyze samples with specific activity for ^{238}U not less than 0,1 Bq/kg. During analysis of samples with specific activity of less than 0,1 Bq/kg made with the help of this method, permissible error limits in detection of ^{238}U activity are not more than 40 % and acceptable probability is 0,95.

Radiation intensity levels at the height of 1 m from soil level are within 0,10 - 0,17 µSv/h. Results of ^{137}Cs and natural radioactive nuclides detection in soil samples, collected at RS, are shown in Table 53.

Table 53 – Results of radioactive nuclides detection in soil samples collected at RS

Sampling point No	Contamination density, kBq/m^2					
	^{40}K	^{232}Th	^{226}Ra	^{238}U	^{137}Cs	^{90}Sr
RS No 1 Goza, year 2008						
1	160 ± 6	7,4 ± 0,6	5,1 ± 0,4	2,3± 0,2	1,5 ± 0,1	0,47± 0,2
2	158 ± 6	6,5 ± 0,6	4,8 ± 0,5	3,6± 0,3	1,8 ± 0,1	0,35± 0,2
3	184 ± 7	9,2 ± 0,7	6,0 ± 0,5	3,8± 0,3	1,5 ± 0,1	0,18± 0,2
4	142 ± 6	5,7 ± 0,6	4,4 ± 0,4	2,4± 0,2	1,3 ± 0,1	0,22± 0,2
5	196 ± 8	8,4 ± 0,7	6,2 ± 0,5	3,8± 0,3	1,0 ± 0,1	0,23± 0,2
average	168	7,4	5,3	3,2	1,4	0,29
RS No 2 Aveny, year 2008						

End of the table 53

Sampling point No	Contamination density, kBq/m^2					
	^{40}K	^{232}Th	^{226}Ra	^{238}U	^{137}Cs	^{90}Sr
1	192 ± 10	6,6 ± 0,7	4,9 ± 1,2	2,6± 0,2	1,4 ± 0,1	0,49±0,2
2	155 ± 8	5,4 ± 0,4	4,1 ± 0,3	3,1± 0,2	1,3 ± 0,1	0,19±0,2
3	152 ± 7	5,3 ± 0,4	3,9 ± 0,3	2,3± 0,2	1,5 ± 0,1	0,26±0,2
4	172 ± 9	6,3 ± 0,6	4,1 ± 0,4	2,5± 0,2	1,8 ± 0,1	0,20±0,2
5	181 ± 9	7,6 ± 0,6	5,4 ± 0,4	3,4± 0,3	2,1 ± 0,1	0,95±0,2
average	170	6,2	4,5	2,8	1,6	0,42
RS No 3 Valeikuny, year 2008						
1	153 ± 8	5,6 ± 0,5	3,5 ± 0,3	2,2± 0,2	0,8 ± 0,1	0,68±0,2
2	154 ± 8	5,5 ± 0,5	3,8 ± 0,3	2,3± 0,2	0,6 ± 0,1	0,54±0,2
3	160 ± 8	6,2 ± 0,5	4,1 ± 0,3	2,6± 0,2	1,5 ± 0,1	0,46±0,2
4	156 ± 8	5,6 ± 0,5	3,7 ± 0,3	3,3± 0,3	1,6 ± 0,1	0,64±0,2
5	161 ± 8	6,2 ± 0,5	4,1 ± 0,3	3,5± 0,3	1,2 ± 0,1	0,23±0,2
average	157	5,8	3,8	2,8	1,1	0,51
RS No 4 Rudnishky, year 2009						
1	176 ± 41	7,9 ± 1,9	5,8 ± 1,4	2,7± 0,2	2,0 ± 0,5	0,22±0,2
2	180 ± 25	7,0 ± 1,2	4,6 ± 0,7	2,1± 0,2	1,4 ± 0,3	0,21±0,2
3	166 ± 37	5,8 ± 1,4	4,1 ± 1,0	2,6± 0,2	1,7 ± 0,4	0,22±0,2
4	175 ± 42	6,6 ± 1,6	5,1 ± 1,2	3,2± 0,2	1,9 ± 0,4	0,53±0,2
5	132 ± 29	4,5 ± 1,1	3,1 ± 0,7	2,9± 0,3	2,6 ± 0,6	0,29±0,2
average	166	6,4	4,5	2,7	1,9	0,29
RS No 5 Shulniky, year 2009						
1	159 ± 37	6,7 ± 1,5	4,7 ± 1,1	2,8± 0,3	2,1 ± 0,5	0,55±0,2
2	162 ± 8	5,4 ± 0,5	3.8 ± 0,4	2,4± 0,2	1,5 ± 0,1	0,34±0,2
3	187 ± 47	6,8 ± 1,7	4,5 ± 1,1	2,2± 0,2	0,7 ± 0,2	0,41±0,2
4	154 ± 34	5,2 ± 1,2	3,8 ± 0,9	3,3± 0,3	3,7 ± 0,9	0,76±0,2
5	181 ± 9	6,4 ± 1,4	4,1 ± 0,3	3,1± 0,3	1,3 ± 0,1	0,43±0,2
average	169	6,1	4,2	2,8	1,9	0,50

Content of ^{238,239,240}Pu in soil samples collected at reference sites is within 0,026 – 0,074 kBq/m^2 (0,0007 – 0,002 Cu/km^2).

On the territory of the NPP planned construction site 15 soil samples were collected. Scheme of sampling points location is shown on Figure 61.

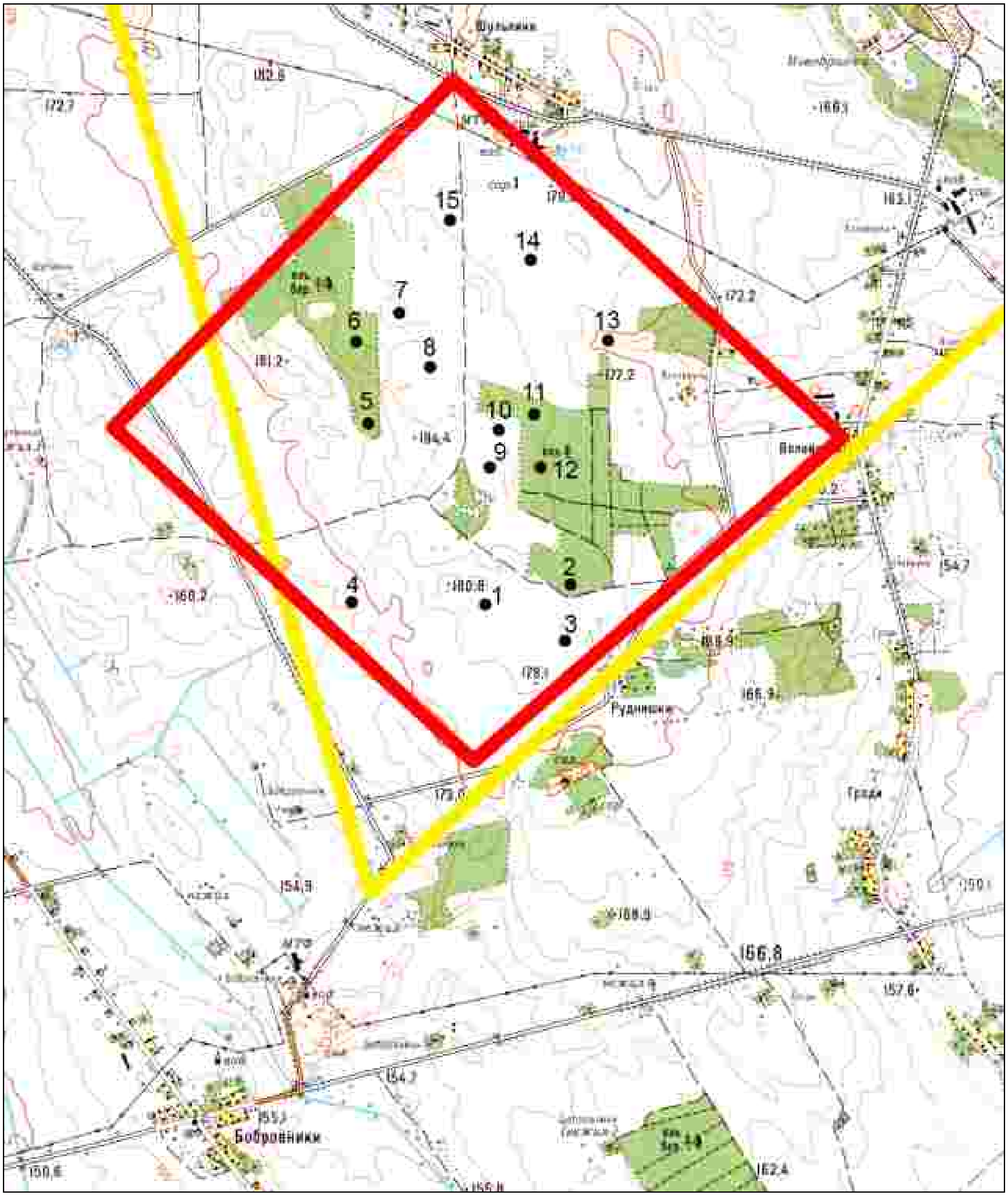


Figure 61 – Scheme of sampling points location on the planned construction site of the belarusian NPP

Results of gamma-emitting radioactive nuclides detection in collected soil samples are shown in Table 54.

Table 54 - Results of gamma-emitting radioactive nuclides detection in soil samples collected at the planned construction site of the belarusian NPP

Sampling point No	Contamination density, kBq/m^2					
	^{40}K	^{232}Th	^{226}Ra	^{238}U	^{137}Cs	^{90}Sr
1	185 ± 7	7,4 ± 0,6	5,0 ± 0,4	2,9± 0,3	1,8 ± 0,1	0,37± 0,2
2	158 ± 6	6,3 ± 1,2	3,7 ± 0,7	2,2± 0,2	2,2 ± 0,3	0,25± 0,2
3	162 ± 36	7,3 ± 1,7	5,0 ± 1,2	3,7± 0,3	1,9 ± 0,3	0,19± 0,2
4	174 ± 44	6,7 ± 1,7	4,3 ± 1,1	2,8± 0,3	1,2 ± 0,3	0,24± 0,2
5	142 ± 11	6,0 ± 0,9	3,6 ± 0,6	3,6± 0,3	1,0 ± 0,1	0,23± 0,2
6	160 ± 8	6,3 ± 0,5	4,5 ± 0,4	2,4± 0,2	1,9 ± 0,1	0,37± 0,2
7	173 ± 14	6,5 ± 0,6	4,3 ± 1,0	3,5± 0,3	1,1 ± 0,2	0,33± 0,2
8	191 ± 27	7,0 ± 1,2	5,1 ± 0,9	3,7± 0,3	2,2 ± 0,5	0,19± 0,2
9	180 ± 40	6,3 ± 1,5	4,1 ± 1,0	2,6± 0,2	1,3 ± 0,1	0,24± 0,2
10	177 ± 25	6,5 ± 1,0	4,1 ± 0,7	3,6± 0,3	1,7 ± 0,4	0,21± 0,2
11	141 ± 7	5,3 ± 0,4	3,8 ± 0,3	2,3± 0,2	2,5 ± 0,2	0,37± 0,2
12	154 ± 6	7,2 ± 0,6	3,9 ± 0,3	3,3± 0,3	1,8 ± 0,1	0,31± 0,2
13	204 ± 45	6,5 ± 1,5	4,7 ± 1,1	3,8± 0,3	1,6 ± 0,4	0,17± 0,2
14	203 ± 51	8,4 ± 2,1	5,8 ± 1,4	2,4± 0,2	1,8 ± 0,5	0,24± 0,2
15	189 ± 9	7,1 ± 0,6	4,0± 0,5	3,7± 0,3	1,5 ± 0,1	0,29± 0,2
average	173	6,7	4,4	3,1	1,7	

Levels of soil radioactive contamination at the site almost conform to global fallout observed before the ChNPP accident.

Levels of natural radioactive nuclides activity in the collected samples correspond to levels of average activity of these radioactive nuclides specific for soddy-podzolic and podzolic soil.

13.2.5 Soil generalization according to radioactive nuclides migration intensity in typical soil within 30-km area of the belarusian NPP

Capacity of radioactive nuclides to redistribute among ecological system components mostly depends on their physical-chemical condition and migration capacity in soil covering. It is the most important element of biosphere which defines radioactive nuclides inflow to natural water, vegetation, atmospheric boundary layer and, finally to human body. Condition and behavior of radioactive nuclides in soil considerably influences radioecological situation in whole area.

Geological structure of Belarus is determined by its location in the Western part of the Russian plain, where 2 structural stages are presented in geological column – crystalline basement and sedimentary cover. Wide complex of ice, lake, alluvial, wind and boggy deposits enter in anthropogenic sediments rock mass structure. In methodological composition of anthropogenic sediments the following rocks predominate:

– morainic loam soil and sand clay;

– fluvioglacial and alluvial sands;
– glaciolacustrine sands, loam soil and clay soil.

The mentioned circumstances determine complexity and variety of soil covering of the Republic of Belarus.

13.2.5.1 Soil generalization according to migration intensity of ^{137}Cs

Whereas soil solutions play determining part in chemical elements mass transfer, including radioactive nuclides, a distribution coefficient K_d in 'solid phase – vapor solution' system was used as one more parameter characterizing migration capacity of ^{137}Cs in soil medium.

Coefficient of interphase distribution $^{137}Cs^+$ is an extent of sorption capacity towards radioactive nuclide. The higher distribution coefficient K_d is, the less capacity of ^{137}Cs of turning from solid phase into soil solution becomes, and the less its mobility in the soil becomes.

Based on the results of evaluation of interphase distribution coefficient ^{137}Cs in 'solid phase – vapor solution' system, mineral and organic soil was differentiated in groups by migration capacity of radioactive cesium (Table 55).

Table 55 – Differentiation of soil by mobility of ^{137}Cs.

Group	Soil	Mobility ^{137}Cs	Кd value, l/kg
	Non-organic soil		
I	Soddy-podzolic friable sandy	Relatively high	< 1000
II	Soddy-podzolic sandy loam	Medium	1000 - 3000
III	Flood plain sod sandy loam	Low	3000 - 7000
IV	Soddy-podzolic loam clay	Very low	> 7000
	Organic soil		
I	Highly organic peat-bog (RH ≥ 95 %), acid and very acid (pH_{KCl} <5)	Relatively high	< 1000
II	Boggy and peaty (RH = 14-60 %), slightly acid and close to neutral (pH_{KCl} 6-7)	Medium	1000 - 3000
III	Peaty (RH = 30-60 %), close to neutral (pH_{KCl} 6-7)	Low	3000 - 7000
IV	Boggy and peat-bog (RH up to 80 %), slightly acid, close to neutral and mildly alkaline (pH_{KCl} 5-8)	Very low	> 7000

The defined generality of radioactive nuclides migration and also Soil map of the Belarusian SSR with a scale of 1:600 000 (year 1977) was taken as a basis while carrying on soil generalization within 30-km area from the belarusian NPP.

All soil variants seen within 30-km area of the belarusian NPP were classified by characteristic of ^{137}Cs migration intensity. Results of generalization are shown in Table 56 and on Figure 62.

Table 56 – Soil classification based on migration intensity of ^{137}Cs

Group	Soil type number	Mobility ^{137}Cs	Colour on the map
I	42; 43	low	
II	4; 6; 7; 11; 12; 13; 19; 32; 40; 47; 48	moderate	
III	27; 28; 14; 15; 16	increased	
IV	44; 46	high	

Подвижность цезия-137	^{137}Cesium mobility
низкая	Low
умеренная	Moderate
повышенная	Increased
высокая	High

Figure 62 – Generalization of soil by upright migration intensity of ^{137}Cs within 30-km area of the belarusian NPP

It is clearly described on Figure 62 that within 30-km area of the NPP planned construction, about 10 % of the territory is occupied by soil with low migration level of ^{137}Cs, more than 60 % of the territory is occupied by soil with moderate migration capacity of this radioactive nuclide, 4,4 % - is occupied by soil with increased migration capacity, and 25,2 % of the territory is occupied by soil where high migration capacity of ^{137}Cs is observed.

Therefore more than 70 % of 30-km area's territory is occupied by soil where mobility of ^{137}Cs is low and moderate. This is a positive factor in the site assessment from the point of view of NPP location. The territory of the site of the Belarusian NPP itself is mostly occupied by soil with moderate migration capacity of ^{137}Cs.

13.2.5.2 Generalization of soil by migration intensity of ^{90}Sr

On the basis of experimental findings concerning ^{90}Sr distribution over vertical soil profiles a migration parameters of ^{90}Sr in various types of soil was defined, i.e. coefficient of quasidiffusion (D_k) in accordance with Konstantinov-Kovalenko quasidiffusion model of radioactive nuclides migration and effective displacement velocity of ^{90}Sr weighted average number coordinate [68-70].

Differentiation of soil taken from control stations by migration capacity of ^{90}Sr in accordance with effective velocity of radioactive nuclide weighted average coordinate deepening (V, cm/year) is shown in Table 57.

Table 57 – Differentiation of soil by migration intensity of ^{90}Sr in accordance with effected displacement velocity of its weighted average coordinate

Group	Soil	Migration intensity of ^{90}Sr	V_D, cm/year
I	– waterlogged peat-bog; – soddy-podzolic friable sandy	high	more than 1,5
II	– soddy-podzolic gleyic and gley (overmoisturized); – soddy-gley (overmoistened)	increased	1,0–1,5
III	– automorphous soddy-podzolic of various texture (sandy, sandy loam, loamy soil, clay); – semihydromorphic (temporary overmoistened) soddy-podzolic , sod and alluvial sod	moderate	0,5–1,0
IV	– meliorated boggy and peat-like	low	less than 0,5

Differences between migration intensity of ^{90}Sr in various types of soil are determined by different physicochemical condition of radioactive nuclide in soils, which differ by texture, content and mineral and organic constituent composition, acidity, water holding, watering conditions.

Based on the results of interphase distribution coefficient of ^{90}Sr in 'solid phase – vapor solution' system evaluation, for soil samples of various types and analysis of available data, soil was differentiated by migration capacity of radioactive nuclide. The defined soil groups and corresponding value of interphase distribution coefficients of ^{90}Sr (K_d) are introduced in table 58.

It is obvious from the available data that in most of organic soil in condition of full water saturation, an amount of ^{90}Sr in interstitial water (1,0–3,2 %) exceeds the corresponding amount of radioactive nuclide in interstitial water of soddy-podzolic soil (0,6–0,9 %). This could occur because organic soil samples are more high water-holding, their water-holding capacity could achieve 500 % and more, while water-holding capacity of mineral soil samples do not exceed 85 %.

Table 58 - Differentiation of soil by migration intensity of ^{90}Sr in accordance with value of coefficient K_d

Group	Soil	Migration capacity of ^{90}Sr	K_d,
A	Soddy-podzolic friable sandy	high	≤ 50
B	Soddy-podzolic sandy loam Alluvial sod	moderate	> 60–80
C	Meliorated boggy and peat-like, slightly acid and close to neutral	low	90–200
D	Highly organic peat-bog soil	very low	≥ 500

While differentiation of soil within 30-km area of the belarusian NPP by migration intensity process of ^{90}Sr the following data were used:

– data on upright migration of radioactive nuclide in soil of various types, contaminated with products of Chernobyl blow out [68-70];

– results of ^{90}Sr distribution between vapor solution and solid phase of soil, which is in ultimate water saturation, if radioactive nuclide is in equilibrium distribution in 'solid phase – vapor soil solution' system [71-75];

– peculiarities of soil sorption complex and soil medium which influence on physicochemical condition and migration of ^{90}Sr in soil.

Taking into consideration influence of various factors, generalization of soil by migration intensity of ^{90}Sr was made, results are shown in Table 59 and Figure 63.

Table 59 – Differentiation of soil within 30-km area of the Belarusian NPP by migration intensity of ^{90}Sr

Soil type number	Mobility of ^{90}Sr	Colour on the map
No	low	
4; 6; 7; 11–15; 19	moderate	
27; 28; 32; 40; 42; 43; 47	increased	
16; 44; 46; 48	high	

It is clearly described on Figure 63, that most of the territory of 30-km area (85,4 % of the Belarusian territory area) is occupied by soil for which moderate mobility of ^{90}Sr is typical.

Surface of soil with increased mobility of ^{90}Sr is 9,4 %, and soil with high mobility of radioactive nuclide is 5,2 % of the Belarusian territory within 30-km area of the Belarusian NPP.

The soil map shows that the examined territory is almost free from soil with low mobility of ^{90}Sr.

Подвижность стронция-90	Mobility of stronium-90
умеренная	Moderate
повышенная	Increased
высокая	High

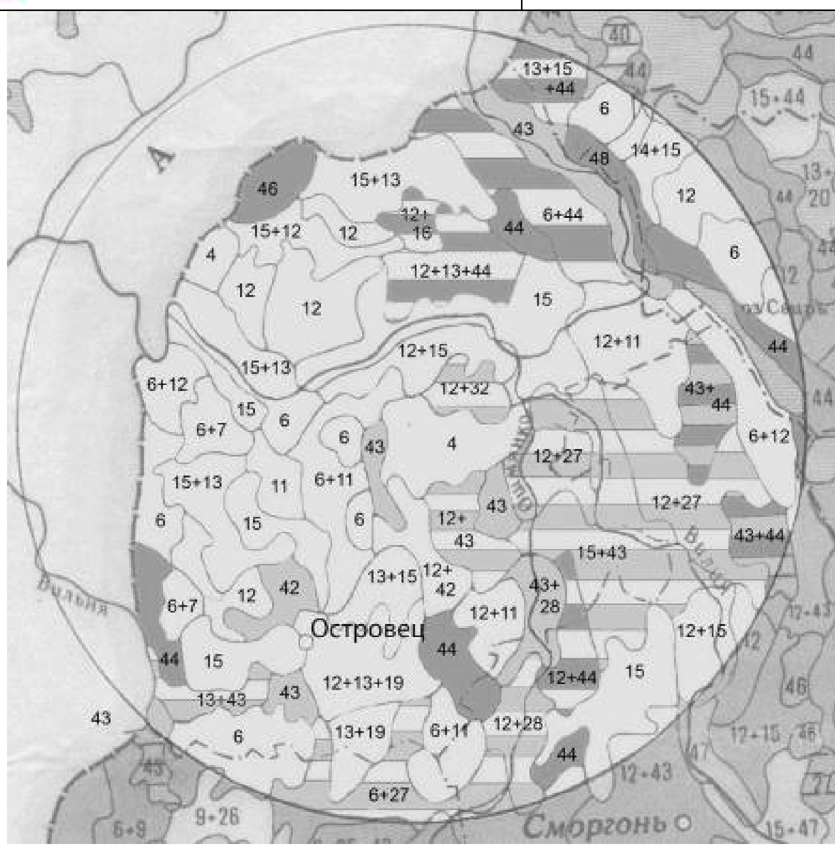


Figure 63 - Generalization of soil within 30-km area of the belarusian NPP by migration intensity of ^{90}Sr.

Thus the most territory of 30-km area around the planned construction site of the belarusian NPP is occupied by soil with moderate mobility of ^{90}Sr. This factor is of advantage while evaluation of site availability for location of radiation-dangerous object.

13.2.6 Atmosphere

13.2.6.1 Chemical contamination

In the republic atmosphere monitoring is made in accordance with following regulatory legal acts:

- Regulation on procedure of atmosphere monitoring and applying of its data within a framework of National system of environmental monitoring, confirmed by the Resolution of Council of Ministers of the Republic of Belarus on April 28, 2004, No 482;
- Instruction on procedure of atmosphere monitoring confirmed by the Resolution of Ministry of Natural Resources of the Republic of Belarus on August 7, 2004, No 70;

Whereas atmosphere air is not monitored within the land site of the Belarusian NPP, the following approximate background concentration of contaminating agents in atmosphere (maximum concentrations from single ones, values of which are exceeded in 5% of cases):

- solid particulates - 0,53 MPC;
- sulfur dioxide – 0,03 MPC;
- carbon oxide – 0,40 MPC;
- nitrogen dioxide – 0,18 MPC.

Table 60 - Values of maximum permissible concentration of contaminating agent in atmosphere.

Agent description	Formula	MPC value, μg/cubic meter		
		max single	daily average	annual average
particulates Σ		300,0	150,0	100
sulfur dioxide	SO_2	500,0	200,0	50,0
carbon oxide	CO	5000,0	3000,0	500,0
nitrogen dioxide	NO_2	250,0	100,0	40,0

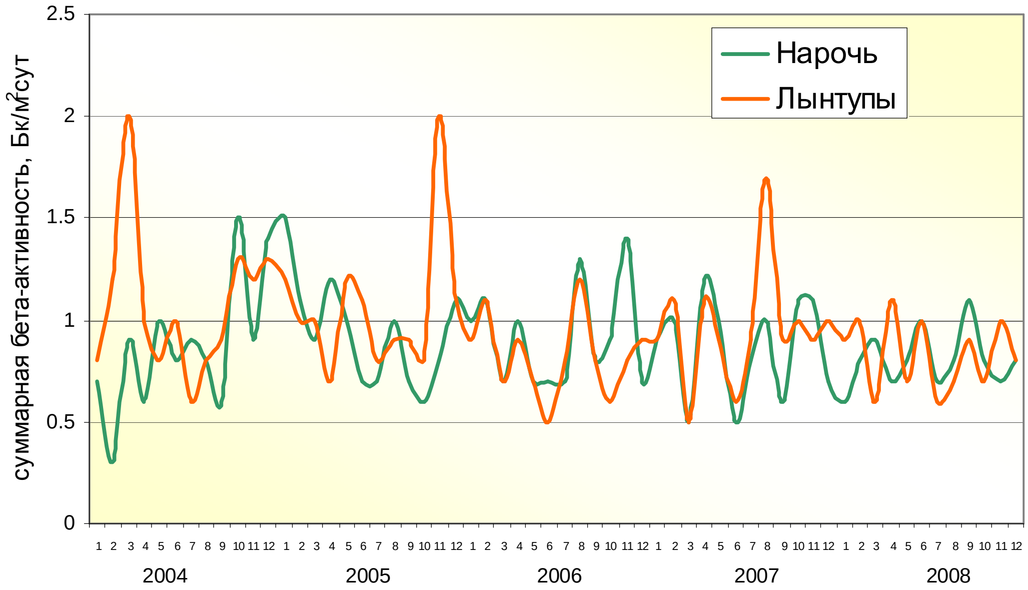
13.2.6.2 Radiation situation

In 30-km area of the belarusian NPP atmosphere radiation monitoring was made in five settlements: Oshmiany, Lyntupy, Naroch, Vileyka, Volozhin. Here are radiation monitoring stations where gamma-radiation intensity (INT)is measured every day.

Results of radiation monitoring show that during the period of years 2003 – 2008 average annual INT in survey points was within: city of Oshmiany, Grodno region 0,10 – 0,11 mcSv/h, settlement Lyntupy, Vitebsk region - 0,10 – 0,12 mcSv/h, health resort Naroch, Vitebsk region - 0,10 – 0,11 mcSv/h, city of Vileyka, Minsk region - 0,10 – 0,11 mcSv/h , city of Volozhin, Minsk region– 0,10 – 0,12 mcSv/h , and this correspond with long-term set values.

In survey points Lyntupy (~55 km from the NPP site) and Naroch (~60 km from the NPP site) sampling of natural fallout from surface level of atmosphere was made with the help of horizontal lipped boards. Sampling is made every day and total beta activity is measured in samples, and content of gamma-emitting radioactive nuclides is measured in combined monthly samples.

Time history of total beta-activity content in samples of radioactive fallout from surface level of atmosphere, collected in survey points Lyntupy and Naroch is shown on Figure 64.



total beta-activity, Bq/m^2-day

Naroch
Lyntupy

Figure 62 - Time history of the total beta-activity change in samples of radioactive fallout, collected in survey points settlement Lyntupy and health resort Naroch of Minsk region for the period of years 2004-2008

During field studies made in 2008, air samples for detection of radioactive aerosol were collected with the help of walk-up filter units.

Bleed down time is 8 hours, air volume is 1109,2 m^3. Measurement of activity concentration of ^{137}Cs in air samples was made in gamma-spectrometric laboratory of the Republican Center of Radiation Control and Environment Monitoring Composite assay made of 4 radioactive aerosol samples was analyzed. The assay was analyzed with the help of gamma spectrometer ADCAM/100, ORTEC, USA, gamma range: 50-3000 keV. Measurement error was 20-25 %. In radioactive aerosol composite assay, content of ^{137}Cs corresponded to the long-term level typical for this district and amounted to $0{,}12 \cdot 10^{-5}$ Bq/m^3 .

13.3 Meteorological and aerological conditions

According to climate classification of B.P.Alisov which is based on atmosphere circulation conditions, 30-km area of the belarusian NPP is situated in temperate climatic zone, where air mass of middle latitudes prevails.

According to climatic zonation [National Security Standard 2.04.02-2000 Construction climatology] territory under examination is situated in the second climatic region (subdistrict IIB).

Maritime and continental types of climate are defined in temperate zone depending on maritime or continental air mass origin. Nature and intensity of main climate forcing considerably differs during seasons of the year.

Winter. On the site area territory mostly mild winter is caused by influence of warm maritime air mass from the Atlantic and the Mediterranean Sea. Frequent change of these air masses by cold arctic and continental masses leads to constant change of frosty periods and period of thaw. In winter cloudy weather prevails, there are precipitations in more than half of winter days. Precipitations are mostly in the form of snow, but in thaw periods they also could be in the form of drizzle, continuous rain or snowy rain. The most cold winter month is January, its monthly mean air temperature is 6,5 below zero … 6,7°C below zero.

Spring. In spring there is a quick rise of air temperature, active melting of snow. Cloudiness and air relative humidity decreases. Nevertheless, in spring there could be periodical returns of cold weather because of Arctic air intrusion. Arctic air leads to sudden fall of temperature and air and ground frost. This could last till mid-May, and sometimes could be even in June. In spring there are about 12-15 days with precipitations in each month. Precipitations pattern changes and continuous rains change into downpour.

Summer is warm, temperate and humid. In summer circulating processes slacken, and solar radiation role in weather formation increases. This becomes a reason for settled weather in summer. In some years even in the middle of summer a fall of temperature is possible because of Arctic air mass intrusion, when maritime air from the Atlantic Ocean brings cool and rainy weather. In about 12-15 days of each month heavy but not continuous rains are possible. Often downpour is accompanied by thunderstorms and sometimes hails. The most warm month is July, its monthly mean air temperature is 16,9-17,0 °C, but in some years the most high temperatures were fixed in August or June.

Autumn. When autumn comes solar radiation inflow decreases and cloudiness increases. Cyclonic activity and western air-mass transfer increases and brings much moisture which leads to continuous cloudiness formation and continuous precipitations. In spite of general weather deterioration and temperature decrease there could be returns of warm weather in autumn. Temperature fall is accompanied by increase of relative air humidity. Quantity of overcast days increases. Often there are mists. In November the first snow cover could be formed.

Main characteristics of district climate within 30-km area of the belarusian NPP are submitted on the basis of observation data of nearby meteorological stations Oshmiany and Lyntupy. Meteorological stations are situated at a distance of 30 and 40 km from the NPP site (Lyntupy and Oshmiany correspondingly). Aerological characteristics of atmospheric boundary layer were given on the basis of aerological station Minsk and Kaunas. Sometimes aerological data submitted by aerological stations Mozyr (Gomel region) and Brest were used for assessment.

Meteorological conditions of the North part of 30-km NPP area are submitted by meteorological station Lyntupy, and of the South part - by meteorological station Oshmiany. Such conditional zoning of 30-km area territory supposed to reveal zoning (regularity) of various meteorological features change on the territory of the area. Nevertheless, the territory of the area is very small to do this and is within one physiographic region and most of the meteorological features are practically similar for the whole area (temperature and air humidity, cloudiness, exhalation, solar radiation, prevailing wind transfer, snow cover, etc). All mentioned meteorological stations have long-term periods of records (more than 40 years) by main meteorological parameters and this provides their reliability..

13.3.1 Meteorological conditions

13.3.1.1 Insolation condition

Description of solar radiation in NPP area is made on the basis of long-term data records of the nearest meteorological station which makes full actinometric observations (city of Minsk). The station is indicative for 30-km area of the belarusian NPP under consideration. Information on sunshine duration is submitted by meteorological station (MS) Oshmiany.

The following data are considered: direct, diffused and total solar radiation on horizontal surface and radiation balance under average cloud conditions, and also sunshine duration (Table 61).

The highest value of solar radiation is in June – July, the lowest – in December. Annual total amount of direct solar radiation within 30-km NPP area is 1705 mJ/sq.m, of diffused solar radiation is 1973 mJ/m^2.

Таблица 61 – Total amount of direct, diffused and total solar radiation on horizontal surface and radiation balance under average cloud conditions mJ/m^2, sunshine duration in hours

Month												Year
01	02	03	04	05	06	07	08	09	10	11	12	
Direct solar radiation												
15	39	116	179	282	309	300	241	140	61	15	8	1705
Diffused solar radiation												
49	89	160	221	284	293	292	245	166	97	45	32	1973
Total solar radiation												
64	128	276	400	566	602	592	486	306	158	60	40	3678
Radiation balance of active surface												
-18	-6	56	190	294	322	315	241	126	42	-4	-18	1540
Sunshine duration												
37	59	126	173	262	252	270	236	142	109	39	25	1730

Sunshine duration is determined by time when the sun is over the horizon and by cloudiness. It is influenced by shielding of horizon by buildings (especially in cities), forests, and hills.

Sunshine duration during year amounts to 1730 hours. The lowest value of sunshine duration is fixed in December (25 hours), the highest is fixed in July (270 hours). Almost 80 % of the annual sunshine duration falls to warm six months.

13.3.1.2 Air temperature

One of the main climatic features describing peculiarities of district thermal conditions is a mean air temperature. Its annual change depends on radioactive conditions and seasonal changes in atmospheric circulation and is characterized by small variation from month to month in winter and summer and acute variation in mid-seasons (spring and autumn).

Annual change of monthly mean air temperature on the territory of 30-km area of the Belarusian NPP is characterized by the highest values in July (16,9-17,0 °C) and the lowest values – in January (6,5 °C below zero … 6,7 °C below zero).

In some years monthly mean air temperature in July was just 13,2-13,4 °C (year 1979) or reached 21,0-21,3 °C (year 2001); in January when winters were relatively warm monthly mean air temperature had above zero values 0,5-0,6 °C (year 1989), and in severe winters monthly mean air temperature reduced to 16,2°C below zero …16,3 °C below zero (year 1987). Maximum air temperature characterizes the hottest part of a day and is observed at 14 – 15 o'clock. Annual change of maximum air temperature is similar to annual change of monthly mean air temperature. The lowest values are fixed in winter months, the highest – in summer.

Absolute maximum and absolute minimum of air temperature illustrates its highest and lowest values in particular days.

Since December to February absolute maximum of air temperature is 9-14 °C; after final loss of snow cover its values grow intensively and reach 18-19 °C in March, 26-28 °C in April, 30-31 °C in May. The highest temperature is observed in July – August (34-35 °C).

In October temperature decreases, however return of warm weather could lead to a rise in air temperature to 22-23 °C. In December absolute maximum of air temperature falls till 9-10 °C.

Absolute maximum air temperature 34,6 °C is accepted as an absolute maximum for 30-km area of the belarusian NPP. During observation periods under consideration the hottest summer was in 1999.

Considerable fall of air temperature occurs due to travel of cold arctic mass with low humidity, and also due to inflow of cold continental air from the East.

The lowest air temperature is in January-February. Extremely low air temperature (absolute minimum) is also fixed during these months. On the territory of the area under consideration absolute minimum is 37,3 °C below zero …39,8 °C below zero. The coldest winter on the territory under consideration was fixed in years 1962-1963 and 1984-1985.

On the territory of the area frost-free season lasts about 140-149 days. Its longest duration was observed in 1967 (181 days), the shortest – in 2004 (109 days).

Diurnal change of air temperature depends on weather type. In summer this dependence is more expressed than in winter. When the weather is quiet and fine diurnal temperature is almost twice higher than that when the weather is cloudy and windy. In winter the biggest diurnal range is determined by frontals passage and sudden air mass change. In spring and autumn the biggest diurnal range is observed if air is well warmed and well cooled at night because of nocturnal radiation.

Maximum diurnal ranges of air temperature on the territory under consideration are observed in summer, Minimum ranges are in November .

Analysis of temperature condition within 30-km area of the belarusian NPP shows that temperature characteristics of air are almost similar over the area.

13.3.1.3 Soil temperature

Temperature of soil depends on many factors – air temperature, physical and mechanical soil composition, moisture content of soil, plant or snow cover, height of station, etc. Temperature lapse rates have various sign in winter and summer periods. In warm seasons temperature of soil falls when passing to more deep soil layers, in cold seasons temperature rises. Diurnal oscillation of soil temperature is intense.

The highest temperature of soil is observed in July. In August temperature of soil starts to decrease. During succeeding months (September-October) temperature decrease becomes more intensive. The lowest temperature in soil surface is in January – February. In Table 62 annual change of monthly mean temperature of soil surface is shown, and also absolute maximum and minimum temperature is indicated.

Yearly average temperature of soil surface on the territory under consideration is 6 - 7 ºC, and this temperature is a little bit higher than yearly average air temperature (5,2-5,4 ºC). Absolute minimum of soil surface temperature is within 54-60 ºC, and absolute minimum reaches 36 ºC below zero.

In spite of the fact that types of soil surface are various its temperature on the territory under consideration is characterized by almost same values.

Таблица 62 – Yearly and monthly average temperature. Maximum and minimum soil surface temperature, ºC

Feature	Month												
	01	02	03	04	05	06	07	08	09	10	11	12	Год
Meteorological station Oshmiany, sandy loam													
Average	-7	-6	-2	6	15	19	20	19	12	6	1	-4	7
Absolute maximum	11	13	28	43	47	50	54	47	45	32	16	9	54
Absolute minimum	-32	-35	-28	-9	-6	1	6	4	-3	-11	-24	-36	-36
Meteorological station Lyntupy, loamy sand													
Average	-7	-7	-4	6	15	20	21	19	12	6	0	-4	6
Absolute maximum	9	12	32	49	54	58	60	54	45	31	17	9	60
Absolute minimum	-34	-36	-33	-16	-6	0	3	3	-6	-20	-26	-36	-36

Analyses of data on average monthly and yearly soil temperature at standard depth with the help of pull-out temperature gauge shows that yearly average soil temperature is almost the same at various depth.

In cold seasons of the year meanly below zero temperature is only at the depth of 0,2 m and is 0,1 ºC below zero … 0,5 ºC below zero. In deeper layers temperature remains above zero but continues to fall till March-April.

At the depth of 3,2 m the highest soil temperature is in September (10,6-11,0 ºC), while at the depth of 0,2 maximum temperature is in July (17,0 -18,2 ºC).

13.3.1.4 Atmospheric humidity

Atmospheric humidity is determined by content of water vapors in the air. Atmospheric humidity influences such nature processes as evaporating rate on water reservoir surface and soil surface, transpiration from vegetation, appearance of frosts and mists.

Atmospheric humidity is characterized by following indexes: partial pressure of water vapor, relative humidity, saturation deficit (Table 63).

Annual change of air relative humidity is characterized by the highest values during cold period of a year and the lowest – during warm period, while annual change of partial pressure and saturation deficit repeats annual change of air temperature, i.e. the highest values are observed in the hottest summer months, the lowest are observed in winter months.

Table 63 – Average monthly and annual values of atmospheric humidity

MS	Month												year
	01	02	03	04	05	06	07	08	09	10	11	12	
Oshmiany	Relative air humidity, %												
	87	85	80	74	69	72	75	76	81	85	89	90	80
	Partial pressure of water vapor												
	3,8	3,9	4,8	6,8	9,7	12,6	14,1	13,5	10,8	8,2	6,0	4,6	8,2
	Saturation deficit, hPa												
	0,4	0,5	1,2	2,9	5,3	5,9	5,7	4,8	2,8	1,5	0,6	0,4	2,7
Lyntupy	Relative air humidity, %												
	88	86	81	75	69	72	75	78	83	86	90	91	81
	Partial pressure of water vapor, hPa												
	3,9	3,8	4,5	6,7	9,4	12,4	14,1	13,7	10,9	8,1	5,9	4,6	8,2
	Saturation deficit, hPa												
	0,5	0,6	1,2	3,0	5,5	5,8	5,7	5,4	3,2	1,6	0,7	0,5	2,8

Characteristics of atmospheric humidity within the territory under consideration shown in Table 63 are almost similar:

- average yearly relative humidity is 80-81 %;
- average yearly partial pressure of water vapor is similar on both stations and is 8,2 hPa;
- saturation deficit is 2,7-2,8 hPa.

Generally during a year number of humid days, i.e. days with relative humidity of 80 % and more, is great – 145-147 days. Their maximum quantity is observed in December – 26-27 days, minimum – in May – 4 days.

In the examined district there is a small number of dry days, when in daytime relative humidity falls below 30 % – 11-12 days. They are typical for warm period of the year and their maximum quantity is fixed in May – about 5 days.

13.3.1.5 Cloudiness

Character of cloudiness is determined by interaction of main climatic forcing - atmosphere circulation, radiation factors and underlying surface. The principal one is atmosphere circulation, especially in cold part of the year.

In present chapter basic quantitative characteristics of cloudiness are discussed, such as quantity of total and lower cloud cover and number of fine and cloudy days (Table 64).

Table 64 – Average monthly and yearly total and lower cloud cover, points

Cloud cover	Month												Год
	01	02	03	04	05	06	07	08	09	10	11	12	
Oshmiany													
Total	7,9	7,7	6,7	6,5	5,8	6,0	6,0	5,5	6,3	7,0	8,3	8,5	6,9
Lower	6,9	6,5	5,2	4,6	3,8	4,0	4,1	3,6	4,8	5,8	7,5	7,8	5,4
Lyntupy													
Total	8,1	7,8	6,7	6,6	6,1	6,3	6,3	6,1	6,6	7,3	8,5	8,5	7,1
Lower	6,8	6,1	4,8	4,2	3,3	3,5	3,6	3,5	4,4	5,6	7,5	7,6	5,1

Annual cloudiness within the territory under consideration amounts to 6,9-7,1 points by total cloud cover and 5,1-5,4 points by lower cloud cover. The most part of the sky is covered with clouds within cold period (6,7-8,5 points by total cloud cover). The lower cloud cover is more expressed in November-December (7,5-7,8 points). The lowest total cloud cover is observed in August (5,5-6,1 points), the lowest lower cloud cover is observed in May (3,3-3,8 points). Diurnal course of cloudiness in cold period is weak, in warm period the highest cloudiness is observed at midday hours, when convective processes are more developed, the lowest cloudiness is observed at night.

Annual change of fine and cloudy days number by total and by lower cloud cover is well-defined (Table 65). During the year most of the fine days by total cloud cover are observed in August, by lower cloud cover are observed in May and August, the lowest number of them is in November-December. Most cloudy days are observed in cold period of the year with maximum number of them in December, the lowest number of them is in warm period of the year with minimum number in July-August.

Table 65 – Average number of fine and cloudy days by total and lower cloud cover

Cloud cover	Month												Год
	01	02	03	04	05	06	07	08	09	10	11	12	
Oshmiany													
Fine days													
Total	1,7	1,4	3,4	2,7	3,0	2,1	2,1	3,3	2,6	2,2	1,0	0,9	26
Lower	3,3	3,3	6,4	6,1	7,5	5,9	5,2	7,6	5,1	4,4	1,9	1,7	58
Cloudy days													
Total	18,2	15,3	12,6	10,5	7,6	8,1	8,2	5,7	9,3	13,4	18,4	20,0	147
Lower	14,1	11,7	7,8	4,8	2,9	2,7	2,1	2,1	5,2	9,5	15,9	17,3	96
Lyntupy													
Fine days													
Total	1,5	1,3	2,9	2,3	2,6	2,1	1,8	2,7	2,2	1,7	0,8	0,8	23
Lower	4,3	4,4	7,7	8,7	11,2	8,7	7,9	9,7	6,8	5,3	2,2	2,1	79
Cloudy days													
Total	18,4	15,2	13,0	10,9	8,9	9,3	9,9	7,3	11,0	13,5	19,1	19,6	156
Lower	13,5	10,7	7,4	4,5	2,3	2,2	1,9	1,3	4,2	7,7	14,5	15,9	86

13.3.1.6 Atmospheric precipitation

By quantity of atmospheric precipitation the district under consideration as well as whole Belarus is considered to be a sufficiently moisturized zone. All types of precipitation are fixed here: rain precipitation, solid precipitation and combined precipitation (Table 66). Within a year a way of precipitation distribution is irregular. Total precipitation within winter is just 17 % of annual precipitation, within spring is 21 %, within summer is 37 % and within autumn is 25 %.

In annual change of precipitation the lowest monthly precipitation is observed in February (31-39 mm). Quantity of precipitation gradually increases starting from March till July, when there maximum monthly precipitation (89-91 mm) is observed. Quantity of precipitation gradually decreases starting from August and reaches 35-44 mm in January. Annual precipitation of the North area is 741 mm, of the South is 645 mm.

Depending on the type of atmospheric precipitation a year is divided into two periods: cold (November-March), where solid precipitation prevails and warm, where rain precipitation prevails (April-October). On the territory of 30-km area of the Belarusian NPP in cold period there are 29-32 % of annual precipitation and in warm period – 68-71 % of annual precipitation.

Thus, within the district under consideration a continental type of precipitation annual change is observed, where total precipitation of a warm period exceeds total precipitation of a cold period.

Within 30-km area of the belarusian NPP maximum annual total precipitation is 1075 mm in the North and 828 mm in the South of the area. Minimum monthly total precipitation of 215-322 mm falls in August.

The least annual total precipitation within 30-km area of the belarusian NPP changes from 445 mm in the South part of the area to 527 mm in the North.

Table 66 – Monthly and annual quantity of rain, solid and combined precipitation, mm

Precipitation	Month												Year	
	01	02	03	04	05	06	07	08	09	10	11	12	мм	%
Oshmiany														
Solid	15	16	16	3							6	13	69	11
Rain	5	6	9	30	51	76	91	83	59	48	24	16	498	77
Combined	15	9	9	9	3					4	16	13	78	12
Lyntupy														
Solid	34	27	18	2	1					1	10	21	114	15
Rain	1	2	8	27	56	87	89	86	68	50	29	12	515	70
Combined	9	10	17	20	3				3	10	19	21	112	15

Solid and combined precipitation falls out in autumn, winter and spring months, Quantity of solid precipitation is 11-15 % of their total annual quantity, quantity of rain precipitation is 70-77 % and of combined precipitation is 12-15 %.

Daily precipitation differs from precipitation within long periods of time and has more expressed local peculiarities.

In the South part of the territory under consideration diurnal maximum of precipitation was fixed in May, in the North part – in June. Moreover diurnal maximum of precipitation in the South part of the area (101 mm) exceeded diurnal maximum of precipitation in the North part of the area (80 mm).

The lowest diurnal maximum of precipitation is observed in cold period of the year (13-17 mm).

In warm seasons of the year diurnal precipitation quantity could be close to monthly precipitation or exceed it.

Rains which bring more than 30 mm of precipitation for 24-hour period are classified as abundant and considered to be dangerous for national economy. Mostly they fall in summer period, however they are possible in May and September.

Within 30-km area of the belarusian NPP average number of days with precipitation varies from 184 to 193 days, the maximum number varies from 206 to 235 days. Maximum number of days with precipitation is in July – about 15 days.

Average and maximum monthly and annual duration of all precipitation type is shown in Table 67, values are in hours.

Table 67 – Average and maximum monthly and annual duration of all precipitation type, hours

MS	Month												Year
	01	02	03	04	05	06	07	08	09	10	11	12	
Oshmiany	Average duration of precipitation												
	156	157	110	68	54	43	42	40	51	78	115	150	1064
	Maximum duration of precipitation												
	236	221	205	117	104	87	107	138	123	201	160	205	1329
Lyntupy	Average duration of precipitation												
	191	187	138	92	69	60	47	54	68	118	151	180	1355
	Maximum duration of precipitation												
	276	246	236	182	139	126	124	176	148	234	205	243	1669

In the North part of 30-km area, duration of precipitation is longer than in the South part. The most long-lasting precipitation is in winter, when average duration of precipitation is 150-191 h/month.

Data on maximum precipitation rate within various time periods are introduced for the period of 1991-2008 and submitted by meteorological station Oshmiany, on which recording rain gauge is located (Table 68).

Table 68– Maximum precipitation rate within various time periods, mm/minute (observed)

Feature	Size	Time period				
		Minute			Hour	
		10	20	30	1	6
Rate	mm/min	1,65	1,12	1,07	0,86	0,25
Precipitation deoth		16,5	22,4	32,0	51,5	88,5
Date		15.06.1998	28.05.2002			

Analyses of data on atmospheric precipitation within 30-km area of the belarusian NPP sowed the following:

- precipitation distribution over the territory is local. In North part of the area average annual precipitation is the highest (741 mm), in South is the lowest (645 mm);
- diurnal maximum of precipitation reaches highest values in South part of the area (101 mm) and lowest values – in the North part (80 mm);
- precipitation rate within various periods of time is approximately accepted as the same for the whole area.

13.3.1.7 Snow cover

During cold period of the year part of precipitation falls in the form of snow. Position of snow cover is characterized by its depth, density and water storage in a snow.

Snow cover on the territory under consideration is formed within approximately a month starting from the date of snow cover appearance till the date of steady snow cover formation, i.e. from November 6 -7 till December 7-14.

In some years snow cover could be formed before the mentioned mean dates or after them.

First snow doesn't' lie during whole winter, it melts and goes away and then is formed again.

Fracture of stable snow cover is observed in March. Therefore, within 30-km area of the belarusian NPP number of days with snow amounts to 11-120 days (Table 69). Intensity of stable snow cover fracture and its loss depends on local conditions. In low protected places and in forests snow melting goes slower. Last dates of stable snow cover fracture – are April 14-30.

Table 69– Average number of days with snow cover, dates of formation and loss of snow cover

MS	Date of snow cover formation	Date of stable snow cover formation	Date of stable snow cover fracture	Date of snow cover loss	Number of days with snow cover
Oshmiany	6.11	14.12	9.03	14.04	111
Lyntupy	7.11	7.12	28.03	14.04	120

Since the moment of stable snow cover formation its depth during winter gradually grows and in the third ten-day period of February reaches its maximum depth. On the territory under consideration average ten-day period snow cover depth at the end of February is 19-26 cm; the deepest of the average snow cover is 25-34 cm. Maximum depth of snow cover during winter is 58-72 cm and was fixed in the first ten-day period of March.

Density of snow cover depends on weather conditions. Average values of snow cover density in December, when new snow is still friable and not compact, are 0,19-0,22 g/cm^3. In March when there is a snow melting and its compaction, snow cover density grows up to 0,26-0,32 g/cubic cm. Average density of snow cover at its highest ten-day depth is 0,24-0,25 g/cm^3.

Water equivalent of snow cover at the beginning of winter (December) is 15-23 mm; it increases to the end of February up to 49-69 mm. During winter the highest water equivalent in snow cover was 195 mm. Water equivalent of snow mostly depends on its location height, its protection and indentation of territory.

Seasonal earth freezing depends on many reasons: degree of soil moistening, depth of snow cover, type of soil and its mechanical composition, land configuration, etc.

In Oshmiany average of the highest earth freezing depth during year is 78 cm, the highest is 142 cm. Soil in this district is in the form of light silty loam, underlaid at depth of 0,5 m by moraine loam. In Lyntupy soil is a sandy loam underlaid by sand. Average of the highest earth freezing depth in winter here is 63 cm, the highest is -123 cm.

13.3.1.8 Evaporation

Evaporation is an inflow of water vapor into atmosphere from water, snow, ice, moistened soil surface, etc.

Evaporation from water surface or evaporation from overmoistened land represents a potentially possible evaporation in present district in atmospheric conditions typical for it.

Total evaporation from soil and vegetation is defined with the help of evaporation tank by changing of weight soil monolith with vegetation on it for a period between separate weighting of evaporator.

Evaporation observation starts in spring after snow cover loss, since the moment of soil passage into a well-moistened state and continuous till freezing of soil to the depth of more 5 cm in autumn or till the moment of stable snow cover formation.

Data on evaporation from soil and vegetation on the territory under consideration is shown in Table 70 (by information submitted by meteorological station Volkovysk).

Table 70– Total evaporation from soil and vegetation during warm period, mm

Month						05-10
05	06I	07	08	09	10	
82	75	83	64	39	27	370

Total land evaporation (gross evaporation) during warm period within the territory under consideration is 370 mm, the highest monthly amount is 83 mm, and falls on July.

Depending on meteorological conditions of each year evaporation values sufficiently deviate from mean values.

Таблица 71 – Evaporation from water surface within period when ice is not formed in years which differ by moistening (calculated), mm

Year characteristic, P %	Month								April-November period
	04	05	06	07	08	09	10	11	
Average, 50 %	20	66	92	112	97	61	35	25	509
Dry, 95 %	25	82	113	139	120	76	44	31	630

During a year of average moisture (50 % of exceedance probability) total evaporation from water surface within a period when ice is not formed on the territory of Ostrovetsky district Grodno region is 509 mm, during a dry year (moisture is 95 % of exceedance probability) – 630 mm (Table 71).

The highest monthly total evaporation from water surface is observed during a period from June till August and in dry year could make up 113–139 mm monthly. In a year of average moisture during the same period evaporation amounts to 92–112 mm monthly which is 19 % less.

13.3.2 General atmospheric circulation

General atmospheric circulation is one of the characteristics of the condition of the climate system and has a great impact on the formation of climate regime of individual regions. The main objects of the general atmospheric circulation are low-pressure cells (cyclones) and high-pressure cells (anticyclones).

Atmospheric processes are the main factor, defining the diffusing power of the atmosphere over any location. The circulation condition defines the aeroclimatic parameters and characteristics of the location, including: the repeatability, yield and intensity of temperature inversions (near the ground, when the temperature rise starts from the ground surface, and raised, when the temperature rise starts from a certain point above the ground surface), the direction and speed of the wind on heights, necessary to calculate the diffusing power of the atmosphere.

Based on the results of long-term observations of the pollution condition of the atmosphere, the following unfavorable synoptic situations, which define the formation of long periods pertaining to the high pollution level, have been detected:

- a non-mobile cyclone or wedge;
- a degraded gradientless baric field;
- periphery of a cyclone or wedge.

Air masses, moving from the Atlantic Ocean, prevail over the territory of the Republic of Belarus. Transfer of the air masses takes place in the course of various circulation processes as a result of activity of the cyclones, which move in series, and anticyclones or high-pressure wedges, which form in the rear of the cyclones. Cyclones, which generally move from the East to the West (due to the influence of the Corioli force), bring the sea air with great deposit of moisture. In most cases cyclones, while moving to the East, are filled or do not change their intensity, and only a few, which pass over the territory of Belarus, continue deepening. After filling, some cyclones become non-mobile, and then cloudy weather with slight frost and snowfall is observed for a few days in winter, and in summer the weather is cloudy and rainy at the beginning, and then, when the air warms up, it changes to unsteady with showery rains and thunderstorms. These conditions are unfavorable for the development of inversions and accumulation of polluting substances.

In all seasons the repetitiveness of the cyclonic circulation form in the territory of the Republic of Belarus, as well as over the territory under review, is more anticyclonic. The weather is often influenced by peripheral parts of cyclones and anticyclones. At average, cyclonic processes are observed for up to 200 days (55 %) a year, and anticyclonic – for up to 150 days a year (about 40 %).

In winter, the territory of the Republic of Belarus is usually influenced by North-Western and Western cyclones. Long-term warming takes place, when the North of Western Europe is occupied by a vast area of low pressure, and the South – by a high pressure area or a wedge of the Azores anticyclone. In that case, Western flows prevail, carrying warm moist air from the Atlantic to the territory of the Republic. The spread of warm air masses takes place in the course of other atmospheric processes as well. The most intensive warming with thaw, considerable rainfall, snowstorms and glaze are observed when South-Western (Mediterranean) and Southern (Black Sea) cyclones emerge, bringing very warm air from corresponding seas in their warm sectors. Heat efflux is observed less frequently under North-Western current, when cyclones from the North of the Atlantic "dive" into the South-Eastern part of Western Europe along the periphery of the anticyclone, which occupies Western Europe. The approach of such cyclones causes short-term warming, which alternates to a cold snap after the cyclone passes. The latter is accompanied by a significant wind power increase, snowfalls and snowstorms. Raised inversions usually form in these transitional baric fields, which are characterized by heat efflux.

The invasion of colder air masses – arctic air – takes place in the rear of cyclones and in the front area of anticyclones. With the invasion of arctic air the weather changes significantly. From the North-West, from the area of the Norwegian and Greenland seas Arctic sea air invades, which soon cools down while moving over the snow mantle of land. It comes to Belarus thoroughly cooled and is often accompanied by mainly clear weather. Continental Arctic air occurs in the area of territories under consideration much less frequently. It invades from the direction of Kara and Barents seas and brings about clear weather. Alongside with that further cooling occurs, a motionless cyclone is formed and powerful ground inversions develop.

In spring, winter processes gradually change to summer ones. The repetitiveness of South-Western and Southern cyclones increases, which is closely connected with the powerful warm air flow from the Mediterranean. These first long-term heat effluxes are unmistakable signs of spring coming. In many cases in the areas of territories under consideration returns of cold weather are observed, caused by the flow of Arctic air from North-West, North or North-East. It brings about cold snaps and ground frost.

In summer the influence of Black Sea and static cyclones, which bring about intense and long-lasting rains, increases. Intense coldbursts, which are often accompanied by storm and hail, are observed in the course of transit of slowly moving cold fronts with waves and withdrawal of Southern cyclones. Rainfall takes place in plain air masses in case of development of thermal convection in the second half of the day.

In summer the wedge of the Azores cyclone develops significantly, which brings about very warm dry weather to the Republic. The most dry and hot weather is observed in case of settlement of the anticyclone over the South-Eastern part of Eastern Europe and low-gradient areas of high pressure, formed in warm dry air. Hot weather is also caused by Southern cyclones, in the warm sectors of which tropical air efflux takes place.

In autumn summer, processes change to winter ones, therefore the repetitiveness of North-Western and Western cyclones increases. During this period the weather is cloudy and it often rains. Most rainfall is carried by cyclones, moving from the Mediterranean and Black seas, but their repetitiveness is low. Warm and sunny days also occur in autumn (also known as “Indian summer”). Such weather is preconditioned by the efflux of air masses from the South along the Western periphery of a motionless anticyclone, located over the South-Eastern part of Eastern Europe, or the influence of the Azores anticyclone wedge. The invasion of Arctic air masses and their additional cooling at night under the anticyclonic weather regime causes the formation of powerful ground inversions in Belarus.

In general, in connection with the variability of the atmospheric circulation and interchange of air masses, which vary in their characteristics, quite favorable conditions for the spread of pollutants over the territory of Belarus, especially in its North-Eastern part, are observed.

13.3.2.1 Wind regime (in accordance with the data from surface observations)

Wind is the horizontal movement of air against ground surface. Wind speed and its direction are considered to be its characteristics. Both of them are defined by the baric field, which is, in this case, characteristic of Belarus as a whole and the roughness of the geological substance of the territory under consideration.

Wind regime is the main factor, defining the spread of pollutants. Horizontal transmission of polluting substances, their evacuation from the emission point and removal beyond the boundaries of the 30-killometer zone are connected with the wind.

Unfavorable conditions for the spread of pollutants and atmosphere self-purification are formed in case of weak winds at the speed of less than 2 m/s and still air.

For the analysis of wind within the 30-killometer zone of the Belarusian nuclear power station the observation data from Oshmiany and Lyntupy weather stations were used.

In the course of the year within the 30-killometer zone of the Belarusian nuclear power station winds from the South-Western quarter of the horizon prevail, whereas in the Southern part the most clearly marked is the Western direction (11%) and in the northern part - the southern one (12 %).

In winter the repetitiveness of winds of Western and South-South-Western directions (12 % each) in the Southern part of the 30-killometer zone is the highest, in the Northern part the repetitiveness of winds of the Southern direction is the highest (13 %).

In spring winds of the Western direction prevail in the Southern part of the zone (9 %), in the Northern part – the winds of the Southern direction (10 %).

In summer in the Southern and Northern parts of the zone winds of the Western direction prevail (13 %).

In autumn the repetitiveness of winds of Sothern, South-South-Western, South-Western and Western-Southern-Western directions (11% each) in the Southern part of the 30-killometer zone is the highest, in the Northern part the repetitiveness of winds of the Southern direction is the highest (15 %).

The number of calmness periods during the year is the greatest in the Northern part of the zone (9 %), and the least in the Southern part (3 %).

Showing individual seasons the greatest number of calmness periods occurs in summer with 5 % in the Southern part of the zone and 14 % in the Northern part.

In tables 72 and 73 data on repetitiveness of wind directions in various parts of the territory of the 30-killometer zone of the Belarusian nuclear power station are given per month, per season and per year.

Characteristics of wind speeds according to directions in the territory under consideration are also given in tables 72 and 73, and without directions – in table 74.

As you can see from tables 72 and 73 winds of Southern, South-South-Western, South-Western and West-South-Western directions have the highest average speeds per direction (2.9-3.0 m/s) within of the territory of the 30-killometer zone of the Belarusian nuclear power station during the year, winds of North-North-Western, Northern and North-North-Eastern directions have the lowest (1.8-1.9 m/s) speed.

Showing individual seasons the highest average seasonal speeds in spring and autumn (3.0 m/s) belong to winds of Sothern and South-Western directions. In winter the highest average seasonal speeds (3.2 m/s) belong to winds of Southern, South-South-Western and South-Western directions. In summer the highest average seasonal speeds belong to winds of South-Western and West-South-Western directions (2.6 m/s).

Within the year in the Southern part of the 30-killometer zone of the Belarusian nuclear power station the highest yearly average wind speeds according to directions (4.1 m/s) belong to winds of Western and West-North-Western directions, the lowest speeds (2.4 m/s) belong to winds of East-North-Eastern and Eastern directions

Table 72 – Repetitiveness of wind directions and calmness periods according to directions in the southern part of the 30-kilometer zone of the Belarusian nuclear power station, Oshmiany weather station

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	C3	CC3	Calm ness
I	3	3	4	3	4	4	4	5	9	13	12	13	12	5	3	3	3
II	4	5	7	6	6	5	5	4	8	10	9	9	11	4	4	3	3
III	3	4	6	7	8	7	5	5	9	9	8	9	10	4	3	3	3
IV	6	6	7	7	8	6	5	5	6	6	6	8	9	5	5	5	4
V	7	8	8	7	8	5	4	4	6	5	5	7	9	6	6	5	4
VI	7	6	6	5	5	3	2	3	6	6	6	10	14	8	7	6	5
VII	6	6	6	5	5	3	3	3	5	7	8	10	12	8	7	6	5
VIII	5	5	6	6	5	3	3	4	7	8	8	11	13	7	5	4	7
IX	5	5	5	5	5	4	4	4	9	10	10	11	10	5	5	3	5
X	3	3	3	4	5	5	5	5	10	11	12	11	10	5	4	4	3
XI	3	3	3	4	5	3	5	8	13	12	12	11	9	3	3	3	3
XII	3	2	3	3	4	4	4	6	11	13	13	11	11	5	4	3	2
Winter	3	3	5	4	5	4	4	5	9	12	11	11	12	5	4	3	3
Spring	5	6	7	7	8	6	5	5	7	6	6	8	9	5	5	5	4
Summer	6	6	6	5	5	3	3	3	6	7	7	10	13	8	7	5	5
Autumn	4	4	4	4	5	4	5	5	11	11	11	11	10	4	4	3	3
Year	5	5	5	5	6	4	4	5	8	9	9	10	11	5	5	4	4
I	4,3	3,1	3,0	2,2	2,4	2,7	2,8	3,7	4,0	4,3	4,3	4,5	4,6	4,9	4,3	4,5	
II	3,6	3,7	3,3	2,7	2,3	3,1	3,0	4,0	3,7	4,2	3,9	4,1	4,2	4,1	4,0	4,0	
III	4,3	3,3	3,2	2,9	2,6	3,0	3,6	4,0	3,9	4,0	3,8	3,9	4,5	4,8	4,3	3,7	
IV	4,1	3,7	3,3	2,8	2,7	3,2	3,7	4,0	4,0	4,0	3,5	3,6	4,1	4,1	4,1	4,2	
V	3,8	3,6	3,2	2,7	2,5	2,3	3,3	3,5	3,8	3,3	3,1	3,2	3,8	3,8	3,8	3,9	
VI	3,7	3,3	2,9	2,4	2,3	2,8	2,8	3,2	3,2	3,1	2,9	3,2	3,6	3,7	3,7	3,6	
VII	3,2	2,9	2,6	2,2	2,1	2,4	2,7	2,7	3,0	2,9	3,1	3,0	3,4	3,3	3,4	3,5	
VIII	3,0	2,9	2,5	2,0	2,0	2,1	2,5	3,1	3,1	2,9	2,8	3,0	3,6	3,6	3,6	3,2	
IX	3,6	3,1	2,9	2,3	2,2	2,7	3,2	3,4	3,7	3,5	3,2	3,5	3,8	3,8	3,7	3,4	
X	3,8	3,1	2,5	2,2	2,1	2,9	3,5	3,9	3,9	3,9	3,9	4,0	4,3	4,1	3,5	3,8	
XI	3,9	2,9	2,4	2,3	2,6	2,8	3,6	4,0	4,2	4,1	4,2	4,2	4,7	4,0	3,8	4,2	
XII	3,8	3,5	3,3	2,4	2,6	2,8	3,4	3,7	4,1	4,4	4,3	4,6	4,7	4,6	4,5	4,2	

End of the table 72

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	ЮЮЗ	ЮЗ	ЗЮЗ	З	ЗСЗ	СЗ	ССЗ	Calm-ness
Winter	3,9	3,4	3,2	2,4	2,4	2,9	3,1	3,8	3,9	4,3	4,2	4,4	4,5	4,5	4,3	4,2	
Spring	4,1	3,5	3,2	2,8	2,6	2,8	3,5	3,8	3,9	3,8	3,5	3,6	4,1	4,2	4,1	3,9	
Summer	3,3	3,0	2,7	2,2	2,1	2,4	2,7	3,0	3,1	3,0	2,9	3,1	3,5	3,5	3,6	3,4	
Autumn	3,8	3,0	2,6	2,3	2,3	2,8	3,4	3,8	3,9	3,8	3,8	3,9	4,3	4,0	3,7	3,8	
Year	3,8	3,3	2,9	2,4	2,4	2,7	3,2	3,6	3,7	3,7	3,6	3,7	4,1	4,1	3,9	3,9	

Table 73 – Repetitiveness of wind directions and calmness periods according to directions in the southern part of the 30-killometer zone of the Belarusian nuclear power station, Lyntupy weather station

	N	NNB	NB	BNB	B	BSE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calmness
I	2	3	3	2	3	5	6	8	12	12	12	11	10	5	4	2	5
II	4	5	5	5	4	4	6	8	12	9	9	9	9	5	3	3	5
III	3	4	5	5	6	5	6	10	14	8	7	9	8	4	3	3	8
IV	4	6	6	7	6	5	5	8	9	5	7	8	10	5	4	5	10
V	6	8	8	7	5	5	4	7	8	5	6	7	9	5	4	6	12
VI	5	7	8	5	4	3	3	6	7	6	7	11	12	6	4	6	12
VII	5	7	6	4	3	3	3	5	7	6	8	12	14	7	5	5	13
VIII	4	6	6	3	3	3	3	5	10	7	9	13	14	6	3	5	16
IX	4	5	5	4	3	3	4	7	12	9	11	12	12	4	2	3	12
X	3	3	3	2	3	4	6	9	15	11	11	10	9	5	3	3	6
XI	3	3	3	3	4	3	6	8	18	12	12	9	7	4	2	3	3
XII	3	3	3	2	3	3	4	8	16	13	12	11	9	4	3	3	4
Winter	3	4	4	3	3	4	5	8	13	11	11	10	9	5	3	3	5
Spring	4	6	6	6	6	5	5	8	10	6	7	8	9	5	4	5	10
Summer	5	7	7	4	3	3	3	5	8	6	8	12	13	6	4	5	14
Autamn	3	4	4	3	3	3	5	8	15	11	11	10	9	4	2	3	7
Year	4	5	5	4	4	4	5	7	12	9	9	10	10	5	3	4	9
I	1,6	1,7	1,7	1,6	2,1	1,9	2,1	2,8	3,1	3,2	3,3	3,3	3,1	2,4	2,3	1,9	
II	1,6	2,0	2,0	1,8	2,0	2,0	2,6	2,9	3,2	3,1	3,1	3,1	2,8	2,4	1,9	1,9	
III	2,1	2,0	2,3	2,3	2,6	2,1	2,4	2,7	3,2	3,0	3,2	3,1	3,1	2,6	2,3	2,2	

End of the table 73

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calmness
IV	2,2	2,2	2,5	2,4	2,5	2,5	2,3	2,6	2,9	3,0	2,9	2,9	2,9	2,5	2,2	2,1	
V	2,1	2,2	2,5	2,6	2,4	2,3	2,3	2,5	2,8	2,7	2,8	2,6	2,5	2,2	2,2	2,1	
VI	1,9	1,8	2,1	2,2	2,2	2,1	2,0	2,3	2,4	2,5	2,6	2,7	2,6	2,1	1,9	1,9	
VII	1,7	1,8	2,1	1,8	1,9	1,9	2,1	2,2	2,4	2,5	2,7	2,6	2,4	2,1	2,0	1,6	
VIII	1,5	1,8	2,0	2,0	1,7	1,8	1,8	2,2	2,6	2,4	2,5	2,6	2,4	2,1	1,9	1,8	
IX	2,0	1,9	2,2	2,0	2,3	2,3	2,0	2,4	2,8	2,7	2,7	2,7	2,5	2,1	2,1	1,8	
X	1,7	1,9	1,9	1,8	2,0	2,2	2,7	2,7	3,0	3,0	3,1	2,9	2,7	2,2	1,7	1,9	
XI	1,8	1,7	1,9	1,7	1,9	2,1	2,4	2,8	3,2	3,1	3,2	3,0	2,8	2,4	2,1	2,0	
XII	1,8	1,9	1,6	2,0	1,8	1,9	2,7	2,8	3,4	3,2	3,3	3,0	3,0	2,6	2,2	1,8	
Winter	1,7	1,9	1,8	1,8	2,0	1,9	2,5	2,8	3,2	3,2	3,2	3,1	3,0	2,5	2,1	1,9	
Spring	2,1	2,1	2,4	2,4	2,5	2,3	2,3	2,6	3,0	2,9	3,0	2,9	2,8	2,4	2,2	2,1	
Summer	1,7	1,8	2,1	2,0	1,9	1,9	2,0	2,2	2,5	2,5	2,6	2,6	2,5	2,1	1,9	1,8	
Autamn	1,8	1,8	2,0	1,8	2,1	2,2	2,4	2,6	3,0	2,9	3,0	2,9	2,7	2,2	2,0	1,9	
Year	1,8	1,9	2,1	2,0	2,1	2,1	2,3	2,6	2,9	2,9	3,0	2,9	2,8	2,3	2,1	1,9	

Showing individual seasons the highest average seasonal speeds in winter (4.5 m/s) belong to winds of the Western and West-North-Western directions. In spring the highest speeds (4.2 m/s) belong to winds of the West-North-Western direction. In summer the highest seasonal average speeds (3.6 m/s) belong to winds of the North-Western direction. In autumn the highest speeds belong to winds of the Western direction (4.3 m/s).

Table 74 – Average monthly and yearly speeds without directions, m/s

WS	Month												Year
	01	02	03	04	05	06	07	08	09	10	11	12	
Oshmiany	4,3	4,0	3,8	3,7	3,4	3,3	3,1	2,9	3,4	3,9	4,1	4,2	3,7
Lyntupy	2,9	2,8	2,7	2,4	2,2	2,1	2,0	1,9	2,2	2,6	2,9	2,9	2,5

As you can see from table 74 the yearly average speed (without directions) in the territory of the zone under consideration increases from 2.5 m/s in the Northern part of the zone to 3.7 m/s in the Southern part. In winter monthly average speeds are between 2.8-2.9 m/s in the Northern part and 4.0-4.3 m/s in the Southern part.

The repetitiveness of various wind speeds (without directions) is given according to the data from Oshmiany weather station in table 75.

Table 75– The repetitiveness of various wind speeds (without directions) (% from the whole number of periods of wind observation)

Month	Wind Speed, m/s								
	0-1	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17
I	7,2	28,6	36,7	18,5	6,0	2,0	0,8	0,2	0,04
II	9,3	31,1	37,2	16,0	5,3	0,9	0,2	0,04	
III	10,9	36,2	32,7	14,9	4,4	0,8	0,1		
IV	15,4	38,4	29,7	12,1	3,8	0,4	0,2		
V	15,0	38,8	29,1	12,6	3,6	0,8	0,1		
VI	16,3	42,5	27,9	10,8	2,1	0,4	0,04		
VII	18,9	42,9	27,7	8,4	1,6	0,4	0,1		
VIII	20,6	43,9	26,6	6,9	1,6	0,4			
IX	18,3	41,8	27,0	10,0	2,5	0,4			
X	11,7	38,6	32,7	12,9	3,6	0,4	0,1		
XI	8,8	35,1	37,6	14,2	3,8	0,4	0,1		
XII	7,3	33,9	39,0	14,9	4,4	0,4	0,1		
Year	13,3	37,6	32,0	12,7	3,6	0,6	0,2	0,02	0,003

Within the year wind at the speed of up to 5 m/s (82.9% of cases) is observed, speeds of 6-9 m/s are observed in approximately 16.3% of cases, and speeds of 10 m/s – in less than 1% of cases.

In summer th repetitiveness of low wind speeds rises significantly. Wind speeds of 2.5 m/s are observed in all wind directions and show to be most sustained.

In summer the number of calmness periods rises significantly – from 5 at Oshmiany weather station to 14 at Lyntupy weather station.

According to observations at Oshmiany weather station wind speed of 13 m/s can be observed once in 2 years, 16 m/s – once in 5 years, 18 m/s – once in 10 years, 20 m/s – once in 20 years and 24 m/s – once in 50 years. Maximum wind speed was recorded in 1969 and constituted 30 m/s, maximum wind gast of 36 m/s was recorded in 1967.

13.3.2.2 Wind regime (according to the data from up-air observations). Wind diagrams at the height of 100, 200, 300 and 500 m

Description of the wind regime for the heights of 100, 200, 300 and 500 meters above the sea level. Average wind speeds and repetitiveness of wind directions are estimated. According to the data from observations of upper-air stations in Belarus within a year winds of Western directions prevail in the wind diagrams during the year with a slightly overwhelming repetitiveness of winds of the South-Eastern quarter marked in spring (see table 76).

Table 76 – Repetitiveness of wind directions at the height of 100, 200, 300 and 500 meters according to 16 rhumbs showing individual seasons and per year (wind diagram) according to the data from the Minsk upper-air station, %

Season	Repetitiveness, %, of wind directions (%) according to 16 rhumbs															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
at the height of 100 m																
Winter	2	2	2	2	2	5	7	5	7	9	10	12	12	12	11	4
Spring	7	4	5	5	6	7	9	9	6	7	6	5	5	6	6	6
Summer	7	5	4	3	3	4	3	3	5	6	7	9	9	11	11	9
Autumn	5	3	2	2	3	3	6	7	7	9	10	10	10	11	8	6
Year	5	4	3	3	4	5	6	6	6	8	8	9	9	10	9	6
at the height of 200 m																
Winter	3	2	2	2	2	3	7	6	8	8	10	10	13	11	8	5
Spring	6	5	4	5	4	5	8	10	6	7	7	5	7	8	7	6
Summer	7	6	5	3	3	2	4	3	5	6	7	7	11	11	10	10
Autumn	5	4	2	1	2	3	6	6	9	7	9	9	13	9	10	5
Year	5	4	4	3	3	3	6	6	7	7	8	8	11	10	9	6
at the height of 300 m																
Winter	3	3	2	2	4	6	11	10	9	9	8	6	9	7	6	5
Spring	6	2	6	5	5	5	7	8	9	8	11	7	7	6	5	3
Summer	9	8	6	4	3	3	1	5	3	6	4	6	16	13	7	6
Autumn	3	1	1	1	1	0	1	4	8	6	13	11	15	17	10	7
Year	5	4	4	3	3	3	5	7	7	7	9	8	12	11	7	5
at the height of 500 m																
Winter	5	1	3	2	4	4	9	10	7	10	10	6	7	9	7	6
Spring	7	3	4	4	2	4	8	10	9	9	10	6	8	7	5	4
Summer	8	10	5	4	4	3	4	3	4	5	4	5	12	11	11	7
Autumn	4	2	1	1		1		2	6	7	11	14	16	15	12	8
Year	6	4	3	3	3	3	5	6	6	8	9	8	11	10	9	6

According to the data from upper-air stations in general moderate winds are characteristic of the territory of Belarus up to the height of 500 meters: annual average values are changes from year to year within the boundaries of 4-6 m/s at the height of 100 meters to 10-13 m/s at the height of 500 meters. In wind speed distribution there is a consistent, almost synchronic increase connected with the increase of height. A general tendency of average wind speed increase with the increase of height is observed in the cold season of the year (Table 77).

Table 77 – Distribution of average wind speeds at the heights of 16 (at the meteorological pad), 100, 200, 300 and 500 meters per season and per year, m/s

Height, m	Winter	Spring	Summer	Autumn	Year
16	3,1	2,8	2,2	2,7	2,7
100	8,1	6,7	6,0	6,8	6,9
200	9,4	7,6	6,7	8,2	8,0
300	9,9	8,0	7,1	9,0	8,5
500	11,7	9,0	7,7	10,4	9,7

In wind speed distribution there is a consistent, almost synchronic increase connected with the increase of height. Of all seasons, winter is marked with the highest wind speeds, the lowest wind speeds are observed in summer, with spring and autumn showing intermediate values. The speed of autumn winds increases more significantly with the increase of height.

As it can be seen from table 78, the distribution of average speed in rhumbs has a seasonal pattern: the highest speeds at the heights of 100, 200, 300 and 500 meters are recorded in autumn and winter and fall at the winds of the Western, Southern and Northern quarter and range from 6-7 m/s at the height of 100 meters to 12-13 m/s at the height of 500 meters. Summer is characterized by minimum wind speed values, although in the directions, mentioned above, speeds are the highest. The lowest speeds fall at the North-Eastern and Eastern rhumbs in almost all seasons of the year.

Table 78 – Distribution at the height of 100, 200, 300 and 500 meters according to 16 rhumbs per season and per year, m/s

Season	Repetitiveness, %, of wind directions (%) according to 16 rhumbs															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
at the height of 100 m																
Winter	4,4	4,4	4,9	5,7	5,4	8,4	7,4	7,3	6,6	6,7	7,0	6,6	7,1	6,8	6,5	6,1
Spring	5,5	5,0	4,9	5,8	5,7	5,9	6,6	6,7	6,4	6,2	5,8	5,7	6,0	5,4	6,0	5,1
Summer	4,4	4,3	4,0	4,1	4,2	4,6	5,4	5,5	6,0	5,5	4,9	5,1	4,9	5,1	5,0	4,5
Autumn	5,4	4,0	3,5	4,3	5,5	7,0	6,9	7,3	5,8	5,3	6,7	6,0	6,0	6,0	5,6	4,9
Year	4,9	4,4	4,3	5,0	5,2	6,5	6,7	6,8	6,2	5,9	6,2	5,9	6,0	5,8	5,8	5,2
at the height of 200 m																
Winter	5,7	5,9	6,3	7,3	7,4	9,2	10,6	9,4	8,6	8,6	9,3	9,5	9,6	9,6	9,5	8,6
Spring	7,3	6,5	6,9	7,3	7,9	7,4	7,8	8,7	8,3	7,9	7,8	8,0	8,2	7,5	6,6	6,2
Summer	6,1	6,3	5,7	5,6	5,3	5,3	5,9	7,2	7,0	7,2	6,4	7,0	6,7	6,9	7,4	6,6
Autumn	7,4	6,7	6,1	5,0	6,0	8,1	9,2	8,8	7,7	8,8	8,5	7,6	8,5	8,9	8,0	7,6
Year	6,6	6,4	6,3	6,3	6,7	7,5	8,4	8,5	7,9	8,1	8,0	8,0	8,3	8,2	7,9	7,3

Season	Repetitiveness, %, of wind directions (%) according to 16 rhumbs															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
at the height of 300 m																
Winter	6,8	7,4	7,5	6,5	7,7	11,8	10,6	9,7	9,1	8,4	9,4	9,7	11,5	9,7	8,9	10,1
Spring	6,6	6,6	6,5	6,2	5,5	5,9	8,3	6,8	8,3	9,4	8,6	8,2	8,1	7,4	7,6	7,3
Summer	7,7	7,9	5,5	7,5	5,4	4,3	5,6	9,0	6,9	6,6	4,8	6,6	6,7	5,6	8,0	5,8
Autumn	6,3	8,5	6,3	5,3	4,0	4,0	6,7	10,0	9,6	10,7	10,8	10,0	10,9	10,2	9,3	11,4
Year	6,9	7,6	6,4	6,4	5,7	6,5	7,8	8,9	8,5	8,8	8,4	8,6	9,3	8,2	8,4	8,6
at the height of 500 m																
Winter	7,8	9,8	7,2	6,2	6,6	7,0	9,7	11,3	9,4	9,6	8,8	9,6	12,0	12,5	9,9	10,8
Spring	6,8	6,6	7,5	6,7	7,7	6,6	7,6	6,8	9,6	8,7	10,3	9,1	9,3	8,5	7,7	6,0
Summer	6,7	6,8	6,3	6,7	6,0	6,4	6,1	6,6	7,6	9,4	6,8	6,7	7,6	8,2	6,9	7,8
Autumn	9,1	6,3	6,0	5,4	5,4	6,0	6,0	8,3	12,5	11,3	9,2	11,1	12,6	10,1	10,3	12,0
Year	7,6	7,4	6,8	6,3	6,4	6,5	7,4	8,2	9,8	9,7	8,8	9,1	10,4	9,8	8,7	9,2

In the repetitiveness of wind according to the grading a consistent growth of repetitiveness of high wind speeds with the increase of height is observed (see table 79). Strong winds (16 m/s and higher) are observed in from less than 0.5% of cases at the height of 100 m and to 9% of cases at the height of 500 m. In some seasons of the year (in winter mostly) this value rises to 10-15%.

Table 79 - Repetitiveness of average wind speeds according to grading at the height of 100, 200, 300 and 500 meters per season and per year, %

Season	Repetitiveness, %, of average wind speeds according to grading							
	0-1	2-3	4-5	6-10	11-15	16-20	21-25	26-30
at the height of 100 m								
Winter	2	11	17	54	15	1		
Spring	2	19	31	43	5			
Summer	4	29	28	35	4	0		
Autumn	2	9	21	58	10			
Year	2	17	24	48	9	0		
at the height of 200 m								
Winter	1	7	11	44	32	5		
Spring	1	14	23	45	16	1		
Summer	2	17	25	42	12	2		
Autumn	0	5	12	53	28	2		
Year	1	11	18	46	22	2		
at the height of 300 m								
Winter	0	7	11	37	32	12	1	
Spring	1	12	20	45	20	2		
Summer	3	20	21	39	15	2	0	
Autumn	1	4	10	41	36	8		
Year	1	11	15	41	26	6		

End of the table 79

Season	Repetitiveness, %, of average wind speeds according to grading							
	0-1	2-3	4-5	6-10	11-15	16-20	21-25	26-30
at the height of 500 m								
Winter	1	6	12	34	28	15	4	0
Spring	2	10	18	45	19	5	1	
Summer	4	18	22	36	12	7	1	
Autumn	0	5	7	40	36	10	2	0
Year	2	10	15	38	24	9	2	0

the impact of the nuclear power station on the environment it is necessary to analyze the repetitiveness of various wind speeds, including calmness (low wind).

In accordance to the zonation carried out in the territory of the former USSR the territory of the Republic of Belarus lies in the second zone after the zone of sea and ocean coasts. In the open and elevated areas of the country calmness periods (0-1 m/s) are possible in 20-25 % of cases during the year, in some areas (topographic low; along the valleys of small rivers) in up to 30-35 %, and in some cases – up to 40 %.

The distribution of polluting substances in the atmosphere depends on the pattern of daily and yearly calmness (low wind) frequency. A smooth rise in frequency of low wind up to the height of 0.2 km form winter to summer takes place over almost the whole European territory of Russia and CIS countries (including the territory of the Republic of Belarus and neighboring Lithuania) (see table 80).

Table 80 – Repetitiveness of calmness (0-1 m/s) up to the height of 0.2 km per season and per year, %

Upper-air station	Winter	Spring	Summer	Autumn	Year
Minsk	2,3	3,8	3,0	1,6	10,7
Kaunas	2,4	4	6	3,9	16,3
Mozyr (Gomelski region)	6	11	16	9	42

The highest value of repetitiveness of calmness falls at the Southeastern, most continental areas of the republic (Mozyr upper-air station).

Apart from the yearly pattern, a daily pattern of repetitiveness of low wind up to the height of 0.2 km is observed. Its range is different and depends on the season of the year, as well as the geographical position and the altitude of the station above the Baltic sea level: an increase in frequency of calmness periods with a move towards South-East, i.e. towards the most continental part of the Republic of Belarus, is tracked (table 80).

Table 81 – Daily pattern of repetitiveness of calmness (0-1 m/s) season and per year, %

Upper-air station	Time of day	Winter	Spring	Summer	Autumn
Minsk	night	3	2,3	3,6	0,6
	morning	2	5	5	5
	day	2,3	3,6	3	1,4
	evening	2,3	4,3	2,2	2,2
Kaunas	night	1,4	2	3,3	1,3
	morning	4	4,6	10	2,9
	day	2	5	6	4
	evening	2,3	6	7	2,2
Mozyr	night	4,7	9	9	8
	morning	6,5	12	18	8
	day	10	14	15	11
	evening	2,5	8,5	16	6

The duration and vertical longitude of calmness are, first of all, connected with the synoptic processes, particularly with motionless anticyclones or non-gradient fields of the type, such as degraded anticyclone or baric saddle. The territory of the Republic of Belarus is included into the second zone (according to the zonation carried out in the territory of the former USSR), where the uninterrupted duration of low wind (0-1 m/s) is up to 1-5 days a month.

Powerful layers of long-lasting low wind form, as a rule, in the anticyclone field, less frequently – in the conditions of filling cyclones. The repetitiveness of low wind (0-1 m/s) in the ground layer up to the height of 0.2 km, according to the data from ground level and upper-air observations for various geographical points of the Republic of Belarus, all other synoptic processes being equal, is closely connected (table 82). As the repetitiveness of calmness periods at the height of 300 meters and 500 meters constitutes less than 0.5 %, they were not estimated.

Table 82 – The dependency of repetitiveness of low wind (0-1 m/s) in the layer up to 0.2 km and ground level data per seson and per year, %

Station	Minsk		Mozyr		Brest	
	0,01 km	0,2 km	0,01 km	0,2 km	0,01 km	0,2 km
Winter	3	1	7	2	4	1
Spring	5	1	10	4	6	2
Summer	8	1	14	5	8	3
Autumn	5	1	10	3	7	1
Year	5	1	10	4	6	2

13.3.3 Categories of atmospheric stability

Evaluations of repetitiveness of categories of atmospheric stability per month and per year are given in table 83, rated yearly average repetitiveness of categories of atmospheric stability is given in table 84, rated yearly average repetitiveness of categories of atmospheric stability at Oshmiany weather station for the period of 1999-2008 is given in table 85.

Table 83 - repetitiveness of categories of atmospheric stability, %, Oshmiany weather station, for the period of 1999-2008

Category of stability	Month												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
A	0,0	0,0	0,2	1,0	3,6	4,4	5,3	2,5	1,0	0,1	0,0	0,0	1,5
B	0,0	0,2	4,7	12,3	13,6	16,6	16,9	14,3	10,9	1,8	0,3	0,0	7,6
C	1,0	6,3	11,6	17,6	21,6	20,5	22,2	21,3	13,7	8,7	2,7	0,2	12,3
D	46,5	43,3	44,1	38,5	35,4	31,8	27,3	30,0	39,0	63,7	67,9	56,9	43,7
E	16,1	13,6	9,4	9,5	9,1	10,3	10,4	10,1	7,9	10,3	8,3	12,3	10,6
F	22,9	21,7	16,7	13,0	11,9	12,3	12,7	14,3	18,5	11,2	13,5	20,2	15,7
G	13,5	15,0	13,3	8,0	4,7	4,0	5,2	7,6	9,0	4,2	7,3	10,5	8,5

In this classification the stability state of the atmosphere is described in seven categories:

– A – very strong instability;
– B – moderate instability;
– C – weak instability;
– D – indifferent state;
– E – weak stability;
– F – moderate stability;
– G – very strong stability.

In general, in the course of the year indifferent state is recorded most frequently (D category). Repetitiveness of instable states (categories A-C) is low and constitutes 21.4 %. The indifferent state is marked in 43.7 % of cases, and stable states (categories E-G) are marked in 34.8 % of cases. Category A (very strong instability) has the lowest frequency of occurrence (1.5 %) and is not recorded from November to February. Category A occurs most frequently in July. All the instable states have a similar yearly pattern with a maximum in summer and minimum in winter. Category C prevails during the whole year. The highest frequency of stable states is marked in the winter months. The Indifferent state has a yearly pattern different from all the other states and has the maximum frequency of occurrence in October and November. It is due to the increase of cyclonic activity, which was suppressed by the Azores maximum in summer, the increase of cloudage and higher wind speed. A slight secondary maximum is marked in April, which is also connected with the circulation processes – the Siberian anticyclone loses its ground and the activity of cyclones increases. The minimum frequency of occurrence of D categories falls at summer months.

Depending on wind direction (see table 83) winds of rhumb E have the highest frequency of occurrence for the categories of atmospheric stability A and B, winds of rhumb

W have the highest frequency of occurrence for categories C,D, E, F, winds of rhumb WSW have the highest frequency of occurrence for category G.

Table 84 - Rated yearly average repetitiveness of atmospheric stability categories (per mile), Oshmiany weather station, for the period of 1999-2008

Rhumb	Categories of stability							Total
	A	B	C	D	E	F	G	
NNE	1	4.8	7.2	16.4	5.4	5.8	4	44.6
NE	1	5.1	7.1	15.1	5.8	6.7	4.4	45.2
ENE	1.3	5.8	7.8	15.5	4.5	11.2	8.3	54.4
E	1.4	7.7	8.4	16.5	4.3	13.6	9.7	61.6
ESE	1	4	5.9	12.1	3.5	6.3	4.4	37.2
SE	0.5	3.5	4.6	14.9	4.1	5	2.4	35
SSE	0.9	2.9	6	21.9	5.4	6.4	1.7	45.2
S	1.1	5.2	8.8	35	8.8	10.6	4.8	74.3
SSW	0.8	5.7	8.7	41.3	9.4	13.9	6.9	86.7
SW	1	4.4	8.4	39	8.4	13.2	6.2	80.6
WSW	1.1	6	10.9	49.9	9.8	17.8	10.1	105.6
W	1.3	7.4	13.7	74.3	13.3	21	9.7	140.7
WNW	0.7	3.7	8.1	26.8	6.1	6.8	3.9	56.1
NW	0.7	3.4	5.6	19.7	5.7	6.3	2.3	43.7
NNW	0.7	3.3	5.8	18.4	5.9	5.6	2.4	42.1
N	0.8	3.7	6.2	20.4	5.6	6.8	3.9	47.4
Total	15.3	76.6	123.2	437.2	106	157	85.1	1000

Table 85 - United table of stability categories, speed and direction of wind for the 16 main rhumbs (per mille per grading) at the height of 10 m, Oshmiany weather station, for the period of 1999-2008

Rhumb 1 N (Direction from the North to the South)							
U m/s	A	B	C	D	E	F	G
0-1	0.44	0.41	1.16	1.13	0	2.46	2.26
1-2	0.31	1.13	1.13	1.81	1.51	1.06	1.61
2-3	0	0.82	0.92	3.87	1.37	1.98	0
3-4	0	0.96	0.72	4.55	0.75	1.33	0
4-5	0	0.41	1.13	3.39	1.2	0	0
5-6	0	0	0.92	1.92	0.75	0	0
>6	0	0	0.24	3.7	0	0	0
Rhumb 2 NNE							
U m/s	A	B	C	D	E	F	G
0-1	0.58	0.68	1.33	1.2	0	1.92	2.5
1-2	0.44	1.61	1.57	1.16	1.4	1.06	1.51
2-3	0	1.2	0.86	2.87	1.3	1.64	0
3-4	0	0.99	0.92	3.63	0.51	1.16	0
4-5	0	0.34	1.44	2.74	1.61	0	0
5-6	0	0	0.65	1.68	0.58	0	0
>6	0	0	0.41	3.11	0	0	0
Rhumb 3 NE							
U m/s	A	B	C	D	E	F	G
0-1	0.62	0.79	1.47	0.86	0	1.95	2.22

Continuation of table 85

Rhumb 3 NE							
U m/s	A	B	C	D	E	F	G
1-2	0.38	1.33	2.12	1.71	2.02	1.2	2.19
2-3	0	1.13	0.89	3.28	1.37	2.16	0
3-4	0	1.3	0.75	4	0.58	1.44	0
4-5	0	0.51	0.92	2.26	1.23	0	0
5-6	0	0	0.75	1.09	0.58	0	0
>6	0	0	0.17	1.85	0	0	0
Rhumb 4 ENE							
U m/s	A	B	C	D	E	F	G
0-1	0.79	1.03	2.02	1.81	0	3.35	4.04
1-2	0.48	1.88	2.5	2.5	1.75	2.29	4.28
2-3	0	1.61	1.13	3.94	0.65	4.24	0
3-4	0	0.99	0.79	3.35	0.31	1.3	0
4-5	0	0.27	0.82	2.16	0.92	0	0
5-6	0	0	0.48	0.79	0.86	0	0
>6	0	0	0.03	0.92	0	0	0
Rhumb 5 E							
U m/s	A	B	C	D	E	F	G
0-1	1.03	1.33	2.26	2.16	0	5.2	5.47
1-2	0.34	3.18	2.98	2.7	2.05	3.11	4.24
2-3	0	1.51	1.13	4.48	0.82	3.32	0
3-4	0	1.44	0.65	3.9	0.55	1.98	0
4-5	0	0.21	0.89	1.71	0.62	0	0
5-6	0	0	0.44	0.65	0.24	0	0
>6	0	0	0.07	0.86	0	0	0
Rhumb 6 ESE							
U m/s	A	B	C	D	E	F	G
0-1	0.75	0.62	1.2	1.68	0	2.26	2.02
1-2	0.21	1.37	1.57	2.05	1.54	1.2	2.36
2-3	0	1.03	0.68	2.6	0.62	1.98	0
3-4	0	0.72	0.86	2.4	0.27	0.86	0
4-5	0	0.31	0.99	1.54	0.89	0	0
5-6	0	0	0.34	0.82	0.17	0	0
>6	0	0	0.27	0.99	0	0	0
Rhumb 7 SE							
U m/s	A	B	C	D	E	F	G
0-1	0.48	0.27	0.41	0.92	0	1.03	1.06
1-2	0.07	1.3	1.13	1.33	1.23	0.48	1.33
2-3	0	0.86	0.55	3.28	0.72	2.4	0
3-4	0	0.79	0.72	3.28	0.62	1.09	0
4-5	0	0.31	0.96	2.84	1.2	0	0
5-6	0	0	0.72	1.23	0.34	0	0
>6	0	0	0.14	1.95	0	0	0
Rhumb 8 SSE							
U m/s	A	B	C	D	E	F	G
0-1	0.55	0.31	0.68	1.2	0	1.44	0.65
1-2	0.34	0.82	0.86	1.47	1.09	0.68	1.03
2-3	0	0.72	0.75	3.7	1.03	2.26	0

Continuation of table 85

Rhumb 8 SSE							
U m/s	A	B	C	D	E	F	G
3-4	0	0.82	1.09	5	0.72	2.02	0
4-5	0	0.27	1.68	4.62	1.92	0	0
5-6	0	0	0.82	2.12	0.68	0	0
>6	0	0	0.14	3.8	0	0	0
Rhumb 9 S							
U m/s	A	B	C	D	E	F	G
0-1	0.96	0.82	1.54	2.6	0	3.08	2.63
1-2	0.14	1.47	1.06	3.18	1.75	1.03	2.16
2-3	0	1.16	1.13	7.19	1.71	3.8	0
3-4	0	1.13	1.54	8.21	0.99	2.67	0
4-5	0	0.58	2.09	6.09	3.18	0	0
5-6	0	0	0.96	2.81	1.16	0	0
>6	0	0	0.44	4.93	0	0	0
Rhumb 10 SSW							
U m/s	A	B	C	D	E	F	G
0-1	0.62	0.99	1.64	2.33	0	3.59	3.42
1-2	0.21	1.71	2.16	4.48	2.43	1.68	3.52
2-3	0	1.37	1.37	8.42	1.95	5.34	0
3-4	0	1.2	1.33	9.14	1.27	3.32	0
4-5	0	0.41	1.03	7.66	2.94	0	0
5-6	0	0	0.82	3.08	0.82	0	0
>6	0	0	0.31	6.19	0	0	0
Rhumb 11 ЮЗ							
U m/s	A	B	C	D	E	F	G
0-1	0.68	0.75	1.68	2.26	0	2.98	2.57
1-2	0.31	1.54	2.19	4.11	1.95	1.68	3.59
2-3	0	0.89	1.16	7.87	1.81	4.86	0
3-4	0	0.92	1.13	8.18	0.82	3.66	0
4-5	0	0.27	1.51	6.3	2.98	0	0
5-6	0	0	0.51	3.87	0.82	0	0
>6	0	0	0.21	6.43	0	0	0
Rhumb 12 WSW							
U m/s	A	B	C	D	E	F	G
0-1	0.79	1.3	2.4	2.53	0	3.05	4.28
1-2	0.31	2.12	3.46	5.71	2.02	3.25	5.82
2-3	0	1.23	1.2	9.58	2.36	7.77	0
3-4	0	1.03	0.86	9.68	1.27	3.73	0
4-5	0	0.31	1.4	8.52	3.18	0	0
5-6	0	0	1.27	4.48	0.99	0	0
>6	0	0	0.31	9.41	0	0	0
Rhumb 13 W							
U m/s	A	B	C	D	E	F	G
0-1	0.79	0.82	2.26	3.08	0	4.11	3.7
1-2	0.55	2.6	3.11	5.54	2.87	2.98	6.02
2-3	0	2.02	1.68	13.31	3.28	9.68	0
3-4	0	1.44	2.02	14.75	1.78	4.28	0
4-5	0	0.55	2.81	13.17	3.87	0	0
Rhumb 13 W							
U m/s	A	B	C	D	E	F	G
5-6	0	0	1.33	7.73	1.54	0	0
>6	0	0	0.48	16.7	0	0	0

End of table 85

Rhumb 14 WNW							
U m/s	A	B	C	D	E	F	G
0-1	0.62	0.65	1.44	1.03	0	1.95	1.68
1-2	0.1	0.75	1.47	1.71	1.33	0.89	2.22
2-3	0	1.13	1.09	4.21	1.57	2.63	0
3-4	0	0.96	1.44	5.03	0.48	1.33	0
4-5	0	0.24	1.61	4.55	1.68	0	0
5-6	0	0	0.89	2.67	1.06	0	0
>6	0	0	0.21	7.6	0	0	0
Rhumb 15 NW							
U m/s	A	B	C	D	E	F	G
0-1	0.41	0.44	0.65	1.13	0	1.51	1.03
1-2	0.27	0.72	1.03	1.09	1.71	0.68	1.23
2-3	0	0.96	0.65	3.7	1.27	2.57	0
3-4	0	0.96	1.03	4.35	0.68	1.51	0
4-5	0	0.27	1.16	3.52	1.51	0	0
5-6	0	0	0.96	1.68	0.51	0	0
>6	0	0	0.1	4.24	0	0	0
Rhumb 16 NNW							
U m/s	A	B	C	D	E	F	G
0-1	0.41	0.41	0.96	0.72	0	1.81	1.23
1-2	0.31	1.09	0.96	1.33	1.4	0.72	1.16
2-3	0	0.44	1.06	3.25	1.27	2.05	0
3-4	0	1.13	0.65	3.97	0.75	1.06	0
4-5	0	0.17	1.23	2.94	1.57	0	0
5-6	0	0	0.68	1.81	0.86	0	0
>6	0	0	0.24	4.35	0	0	0

In the course of analysis of stability categories for various wind directions depending on wind speed (table 85) it can be noted that for winds of rhumbs N, NNE, S, SSW, SW,SWS and NW the highest repetitiveness for atmospheric stability category D is observed at wind speed of 3-4 m/s. For winds of rhumbs NE and SE the highest repetitiveness for atmospheric stability category D is observed at wind speed of 2-3 m/s. For winds of rhumbs ENE and ESE the highest repetitiveness for atmospheric stability category G is observed at wind speed of 0-1 m/s. For winds of rhumb SSE the highest repetitiveness for atmospheric stability category D is observed at wind speed of 4-5 m/s. For winds of rhumbs W, WNW and NNW the highest repetitiveness for atmospheric stability category D is observed at wind speed of ≥6 m/s.

13.3.4 Strong wind, squalls, whirlwinds

Dangerous meteorological phenomena, including strong wind, squalls, whirlwinds, are characterized by high variability in time and space and vary greatly in complexity and other characteristics. Very limited information is available due to the fact that a part of the occurrences doesn’t fall into the scope of research because of discreteness and short duration. Therefore generalization of data is carried out not for separate points but for certain areas. In connection with that dangerous weather phenomena, including strong wind, squalls, whirlwinds, characteristic of the 30-killometer zone of the Belarusian nuclear power station can be found in an area, larger than the 30-killometer zone of the Belarusian nuclear power station. In this case the territory of the following administrative regions: Grodno, Vitebsk and Minsk region.

Strong wind (instantaneous speed ≥25 m/s). In general for the period under consideration strong wind (instantaneous speed ≥25 m/s) in the territory of Vitebsk and Grodno regions was marked in 25 years out of 33-35 in at least one point of the region. The repetitiveness of years with strong wind in at least one of the points of the region constituted correspondingly 69 % and 71%. In the territory of the Minsk region such wind was marked in 20 years 35 in at least one point of the region, The repetitiveness of years with strong wind in at least one of the points of the region constituted 63 % (see table 86).

Squalls (a short-time increase of wind speed up to 21-35 m/s). Squalls are sharp, short-time wind speed increases, occurring usually prior to storms. A squall is a whirlwind with a horizontal axis , emerging in a powerful cumulonimbus cloud or under it and reaching ground. It is characterized not only by high speed, but also by swift changes of wind direction. Squalls form, mainly, when a cold front passes and can emerge almost simultaneously in different places along the front line, air-mass squalls are recorded less frequently. At average squalls are recorded once in 5 years in one point, generally during the warm half of the summer. At that time the speed exceeds 10 m/s, but usually constitutes 16-20 m/s. Squalls with the wind speed exceeding 25 m/s are most dangerous, bringing damage to buildings, communication and power lines. As the area of spread of squalls is not large, the data available is incomplete. Destructive squalls are rare in one point.

Whirlwind is a strong small-scale tornado, which forms under well-developed cumulonimbus clouds and spreading in the form of a gigantic cloud belch, which goes down to the ground or sea surface in the form of a funnel. The wind speeds that develop in these vertical whirlwinds , going down from the clouds in the form of a cloud funnel, can reach 50 m/s and more. As a result of spinning an exhaustion occurs within the whirlwind and strong, up to 70-90 m/s ascending air motions. This leads to heavy objects in the way of the whirlwind being sucked into the whirlwind area, lifted by it and carried away for long distances. Whirlwind is a short-term occurrence. It usually lasts for only a few minutes in one point, and its zone of destruction is relatively small – several tens or hundreds of meters wide and a few kilometers or tens of kilometers long.

According to the contour map of zonation of the territory of the former USSR according to whirlwind danger and the catalogue of whirlwinds in the territory of the former USSR (РБ-022-01) and the Republic of Belarus, the territory of the 30-killometer zone of the Belarusian nuclear power station refers to the areas with high whirlwind danger. In general, during the period under consideration in the territory of Grodno region, where the platform of the Belarusian nuclear power station is situated, Vitebsk and Minsk regions, located in immediate neighborhood of the Belarusian nuclear power station, 3,8 and 9 cases of whirlwind were recorded correspondingly (see table 87). The possibility of occurrence of a whirlwind in the territory of Grodno region (in one of the points) is 5 % (once in 20 years), in the territory of Vitebsk region (in one of the points) – 14 % (once in 7 years), in the territory of Minsk region (in one of the points) – 16 % (once in 6 years). Most of them refer to 1-2 intensity class on the Fujitah scale (table 88).

On the 6th of September 1997 a whirlwind occurred in the territories of Oshmiansky and Smorgonsky districts, neighboring to Ostrovetsky district. It rooted out and broke trees, tore away roofs of houses, destroyed household outbuildings and damaged power lines in its way. As explained by the eye-witnesses, the storm lasted about 20 minutes. According to the damage it can be referred to the 2nd class on Fujitah scale. Although no whirlwinds have been registered in the territory of the platform under consideration during the observation period, the possibility of their occurrence cannot be ruled out. The territory may incur whirlwinds, strong enough to be referred to class 3 of intensity. In accordance with РБ-022-01the calculated characteristics of the whirlwind are given for the class 3 whirlwind (table 89).

Table 86 – Repetitiveness (number and %) with strong wind (instantaneous speed ≥25 m/s) in at least one point of the region

Number of years with the occurance	%	Number of years generalized
Vitebsk region		
25	69	33
Minsk region		
20	63	32
Grodno region		
25	71	35

Table 87– Repetitiveness (number and %) with destructive squalls and whirlwinds in general per region (in at least one district of the region)

Regions	Destructive squall			Destructive whirlwind		
	Number of years with the occurance	%	Number of years generalized	Number of years with the occurance	%	Number of years generalized
Vitebsk	17	49	35	8	14	56
Minsk	13	37	35	9	16	56
Grodno	14	40	35	3	5	56

Table 88– Whirlwinds with the intensity of 1-2 balls, recorded in Grodno, Vitebsk and Minsk regions

Place of record	Date	Intensity class
Chashnitski district, Vitebsk region	06.07.1947	1
Molodechno, Minsk Region	09.06.1950	1
Ushachski district, Vitebsk region	17.06.1951	1
Chervenski district, Minsk region	18.08.1956	2
Mozolevshchina village, Minsk region	28.05.1966	1
Krupsky district, Minsk region	23.05.1967	2
Malyi Zboisk Croft, Grodno region	21.09.1967	1
Zamoshye district, Minsk region	13.05.1969	2
Ananitsy township, Minsk region	15.05.1969	1
Uzdzenski district, Minsk region	31.05.1969	2
Novogrudsky district, Grodno region	14.08.1982	1
Miorsky district, Vitebsk region	11.08.1990	2
Oshmiansky and Smorgonsky districts, Grodno region	06.09.1992	2
Volozhinsky district, Minsk region	06.09.1992	2
Sharkovshynsky district, Vitebsk region	17.08.1993	2

Table 89- Rated characteristics of whirlwinds with specified reliability

Rated characteristics of whirlwinds	Value for a whirlwind with reliability $1{\cdot}10^{-5}$	Value for a whirlwind with reliability $1{\cdot}10^{-6}$
Rated class of the expected whirlwind, k_p	1,5	3,0
Possibility of exceeding (occurance/year)	$1{\cdot}10^{-5}$	$1{\cdot}10^{-6}$
Maximum funnel spin rate, V_p (м/с)	50	81
Speed of the forward motion of the whirlwind, U_p (m/s)	12,6	20,3
Pressure differential between the center and the periphery funnel of the whirlwind ΔPp (hPa)	31,0	81
Length of the whirlwind pathway, L_p (km)	5,0	28,6
Width of the whirlwind pathway, W_p (km)	0,05	0,29

13.4 Surface waters. Quantity and qualitative adjectives

13.4.1 Exemplary scheme of water intake, water supply and water discharge of belarussian nuclear power plant. Alternatives

The river Vilia is considered as the main source of technical water supply of belarussian nuclear power plant. Area “settlement Malie Svirianki - settlement Muzhili” (picture 65) was chosen for industrial water supply of belarussian nuclear power plant for the placement of surface water abstraction. It is planned to place a surface water abstraction at the river Vilia for two power units lower than human settlement Malie Svirianki. Water from the river Vilia is taken in and is pumped over to the area of nuclear power plant through pressure conduits of first and second stages. Taking into consideration information of industrial republican unitary enterprise “Belkommunmash” the length of supposed drainage system lines from water abstraction location range at given area to the area of nuclear power plant is 9,9 km. Water abstraction constructions at the river Vilia are located at the left bank.

Picture 65 – the river Vilia at the zone of location of surface water abstraction at 500 m lower than settlement Malie Svirianki

Productivity of the pump station is 220 000 m^3/day, first reliability category. Pumps are placed under the bay from minimal expected water level in the river.

Reliability category of pump station power supply – I.

Water delivery from water abstraction at the river Vilia to the area of nuclear power plant is provided by two strings of steel water conduits with diameter of 1000 mm. Each string of water conduits is meant for passing of 70 % from consumption for industrial water supply of two power units of nuclear power plant.

Reserve water supply sources could be used for providing of guaranteed regular water supply mode of nuclear power plant.

- Vileiski reservoir with a distance from water abstraction of belarussian nuclear power plant to weir of reservoir up to 140 km, water volumes in the reservoir could vary from 260 million m^3 to 25,1 million m^3 (project drawdown of the reservoir is 6,0 m);

- Olchovski reservoir of bed-type at the river Stracha (reservoir of Olchovski hydro power) with a distance through watercourses to the area of water abstraction location up to 19,2 km (payload volume is 1,4 million m^3, maximum level difference is 3,0 m, water-surface area 0,7 km^2, average depth 3 m);

- Snigyanski reservoir of bed-type at the river Oshmianka (reservoir of Oshmianka hydro power) with a distance through watercourses to the area of water abstraction location up to 55 km (payload volume is 1,21 million m^3, maximum level difference is 5,0 m, water-surface area 1,5 km^2, average depth 1,42 m).

Drinking and technical (during building) water supply of nuclear power plant in volumes up to 1 850 m^3/day will be provided from underground water abstraction which will be placed at the distance of 3,0-4,5 km to the north from the centre of area.

Technical waste waters in a volume of 0,48-0,69 m^3 (41,47-59,62 thousand m^3/day – 1EB), 0,96-1,38 m^3/day (82,94-119,24 thousand m^3/day – 2 EB) will be drained into the river Vilia through separate water conduit and will be thrown into the river at the approximate distance 2,7 km lower than water abstraction near human settlement Malie Svirianki (directly lower human settlement Muzhili).

Service-utility waste waters from the territory of nuclear power plant through system of manifolds go to the sewage pump station and with the help of pumps is pumped over to the station of sewage treatment plant. Sewage treatment plant is planned in the sanitary-hygienic zone of nuclear power plant. Sewage treatment is full biological with full removal of nitrogen and phosphorus and with post-treatment. Volume of sewage discharge is supposed to be 910,9 m^3/day, it will be discharged into one of the nearest watercourse which is the river Polpe (right tributary of the river Vilia). The placement of housing settlement is supposed to be at the base of town Ostrovets so discharge of sewage at the settlement area is supposed to be made at existing treatment facilities with their reconstruction and expansion.

Rain waters from the territory of nuclear power plant's area are collected into existing pump station of rain waste waters transfer with the help of free-flow nets which efficiency is 100 m^3/hour with balance tank which capacity is 60 m^3 and it is pumped into free-flow nets of the district rain sewage of joint auxiliary unit. Annual volume of rainfalls which are directed into water body is 66 thousand m^3/year.

Exemplary scheme of water intake, water supply and water discharge of belarussian nuclear power plant in the picture 66.

Principal technological scheme of water treatment for circulating water system feed with splash pools includes:

–treatment from particulate pollutants at a screen filters of coarse purification;

– direct-flow coagulation;

– removal of suspended matters and organic impurities at the ultrafiltration plant;

– acidation with sulfuric acid for bicarbonate destruction;

– disperse particles removal at cartridge filters;

– demineralization of water at the reverse osmosis plant.

Post-treatment of demineralized water in order to replace losses in nuclear power plant contours after reverse osmosis plant is made by the scheme:

– hydrogen cycle in counterflow filters;

– removal of carbonic acid in precalciners;

– anation in double-chamber counterflow filters;

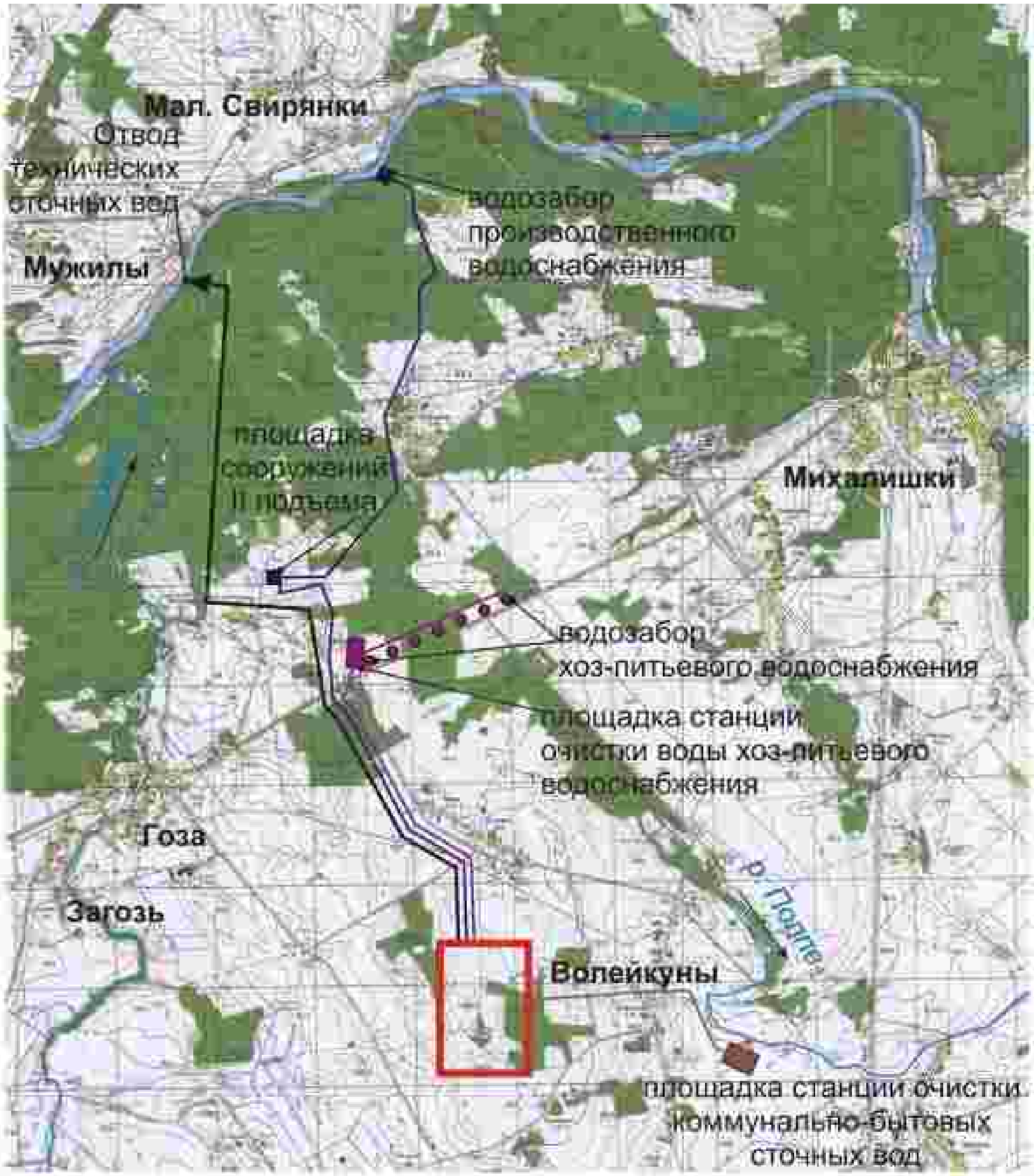
– deep desalination and desiliconization of water in mixed beds.

Efficiency of water treatment plant on demineralized water for feed of splash pools of two power units of nuclear power plant – 174 m^3/hour.

Efficiency of water treatment plant on demineralized water for feed of splash pools of two power units of nuclear power plant – 174 m^3/hour.

Diversion of technical wastewaters
Malie Sviryanki
Muzhili
the river Vilia
water intake of industrial water supply
area of building of the II rise
Mikhalishiki
water intake of utility drinkable water supply
area of the station of cleaning of water of utility drinkable water supply
Goza
the river Polpe
Voliekuni
area of clearance station of public utility wastewater
Zagoz

Reference designations:
Ostrovets area of placement of belarussian nuclear power plant
Route of water conduits of industrial water supply of belarussian nuclear power plant
Route of water conduits of utility drinkable water supply of belarussian nuclear power plant
Route of pipelines for outlet of public utility wastewater of belarussian nuclear power plant
Outlet of technical wastewaters of belarussian nuclear power plant



Условные обозначения:

- Островецкая площадка размещения белорусской АЭС;
- Трасса водоводов производственного водоснабжения белорусской АЭС;
- Трасса водоводов хоз-питьевого водоснабжения белорусской АЭС;
- Трасса трубопроводов для отвода коммунально-бытовых сточных вод белорусской АЭС;
- Отвод технических сточных вод белорусской АЭС.

Picture 66 – Exemplary scheme of water intake, water supply and water discharge of belarussian nuclear power plant. (two power units

13.4.2 Modern state of surface water

13.4.2.1 Hydrographic characteristics in 30 kilometers zone of nuclear power plant's area

Area's territory is situated in north-west part of Belarus in bounds of west part of Naroch-Vilia plain and it is a flat and wavy plain which consists of clod massifs, of high and wavy thin plains and not very high and sloping wavy fluavisive plains and low places of lake age. Water-bearing horizonts and complex are represented by accumulation of ground water mainly in sand-clayey- detritus rocks.

Agricultural development of lands is 50-60 %. Land resourses are represented by mainly forest and open lands and by land under constant crops. Intensity of usage of agricultural lands is 35-45 %. Amount of forests on the territory is 40-50 %. Territory with favourable conditions for rest

.**Hydrographic network** in bounds of 30 kilometers zone of belassian nuclear power plant includes 70 water objects, 5 of them are transboundary, 52 of them are situated at the territory of Belarus, 13 are situated at the territory of Lithuania. The list of water objects, their hydrographic and main morphometric characteristics are in the table 90 [76, 77].

Such rivers as the Vilia, the Polpe, the Gozovka, the Stracha, the Oshmianka, the Losha, Snigiani reservoir (reservoirs of hydro power Rachuni), reservoir of Olkhovski hydro plant are the main water objects of placement of belarussian nuclear power plant. The scheme of hydrographic network in 15-kilometer zone of belarussian nuclear power plantin is shown in the picture 67.

Table 90 – List of water objects in 30 kilometers zone of nuclear power plant's area their hydrographic and main morphometric and hydraulic characteristics

Channel order	Name of water-course	Length, km	Catchment basin, km^2	Forest coverage, %	Bogginess, %	Lakeness, %	Tilled condition, %	River network density, km/km^2	Water surface slope, ‰	Average annual waterflow, m^3/day
Transboundary watercourses										
-	the Vilia	498	25100	30	5	2	45	0,45	0,3	186
1	the Baloshinka	14	64,5	40	21	1	35	0,74	2,9	0,44*
2	the Struna	31	194	35	25	1	25	0,63	0,8	1,5
1	the Vilna	80	624	60	5	2	25	0,46	1	4,28*
2	the Kaponishku	6,1	16,1	80	3	1	10	0,41	5,1	0,11*
Territory of the Repuclic of Belarus										
1	the Polovoika	14	48	17	27	0	55	0,46	3,4	0,33*
1	the Ustizerki	11	47	65	8	1	10	0,23	2	0,32*
1	the Oshmianka	105	1490	20	12	1	50	0,41	0,8	13,4
1	the Polpe	9,2	30,8	10	1	1	80	0,43	3,2	0,0016*
1	the Stracha	59	1140	40	5	10	35	0,39	1	9,1

Channel order	Name of water-course	Length, km	Catchment basin, km^2	Forest coverage, %	Bogginess, %	Lakeness, %	Tilled condition, %	River network density, km/km^2	Water surface slope, ‰	Average annual waterflow, m^3/day
1	the Sorochanka	29	201	40	10	1	10	0,32	1,4	1,75
1	the Dudka	8,5	34,6	22	11	0	50	0,69	6,37	0,24*
1	the Gozovka	17	88	15	17	1	65	0,44	2,5	0,41*
1	the Ritenka	9,3	38,2	15	2	2	60	0,64	4,9	0,26*
1	the Senkanka	13,2	45	26	3	1	60	0,37	4,35	0,31*
1	the Tartak	5	28	18	1	1	40	0,32	7,4	0,05*
1	the Bistritsa	3,8	4,7	40	1	3	40	0,71	7,2	0,031*
1	the Michailovo	6,4	15,2	50	2	3	30	0,52	7,1	0,1*
2	the Gaigolka	4,7	16,4	5	1	1	85	0,44	4,1	0,11*
2	the Losha	55	455	40	2	2	40	0,46	1,34	3,9
	the Ratagol	12	29	40	7	0	40	0,35	1,5	0,2*
2	the Kernova	19	103	16	11	0	60	0,42	2	0,71*
2	the Sikunia	12	75	15	7	0	70	0,63	4,9	0,52*
3	the Komar	5	17,4	10	5	1	75	0,58	2,9	0,12*
3	the Kamenka	7,4	18,2	30	4	1	55	0,57	3,9	0,13*
4	the Malka	10	25,2	50	8	1	30	0,53	2,1	0,17*
4	the Paroka	14	102	24	13	1	50	0,39	3,2	0,12*
2	the Tushanka	11	86	12	25	2	30	0,81	1,2	0,59*
2	the Sikunka	11	89	40	10	3	20	0,29	0,9	0,61*
2	the Yazvinka	5	18,6	90	5	1	2	0,45	7,9	0,13*
3	the Pelenka	21,1	80,9	50	15	0	10	0,68	2,8	0,56*
Territory of the Republic of Lithuania										
2	theSkiardiksna	13,12	46,96	45	25	5	20	0,41	2,67	0,32*
2	the Miara	48,9	186,4	60	15	10	10	0,38	1,84	1,28*

Basin name	Water-surface area, km^2	Length, km	Admit of width, km	Coastline length, km
Hydrographic basin characteristics of 30-kilometer area basins of belarussian nuclear power plant				
Territory of the Repuclic of Belarus				
the lake Gomel	0,07	0,38	0,23	1,01
the lake Slobodskoye	0,075	0,44	0,26	1,16
the lake Bik	0,14	0,49	0,36	1,36
the lake Rizheye	0,59	1,16	0,72	1,88
the lake Mertvoye	0,27	0,84	0,38	2,26

* water discharge are estimated with the help of calculating technique with the usage of П1-98 СНиП 2.01.14-83 «Identification of calculating hydrologic characteristics» (2000)

Table continuation 90

Basin name	Water-surface area, km^2	Length, km	Admit of width, km	Coastline length, km
Hydrographic basin characteristics of 30-kilometer area basins of belarussian nuclear power plant				
ponds of fishery "Soli"	1,63	2,01	1,17	6,01
lake Tusha	0,34	0,85	0,66	2,83
lake Bildzhio	0,096	0,5	0,31	1,42
Sorochanskaya lake group				
lake Vorobii	0,46	1,12	0,57	2,9
lake Gulbeza (Gubeza)	0,23	0,94	0,39	1,94
lake Edi(Edovo,Edovskoe)	0,61	1,6	0,52	3,74
lake Golodianka (Podkostelok)	0,33	0,9	0,49	2,59
lake Golodno (Golubina)	0,14	0,78	0,25	1,81
lake Tumskoye	0,86	3,22	0,45	7,6
lake Kaiminskoye (Kaimin)	0,43	1,55	0,38	4,3
lake Zolovskoye	0,24	0,87	0,37	2,56
lake Turoveiskoye (Turovie)	0,38	1,57	0,39	3,87
lake Beloye	0,34	1,05	0,39	2,8
lake Klevel (Klevie)	0,12	0,85	0,23	2,26
lake Baranskoye	0,17	1,08	0,3	2
The lake of Narochanski national park				
lake Vishnevskoye	9,97	4,38	3,52	13,6
lake Svir	22,28	14,12	2,27	31,15
lake Glukhoe	0,15	0,55	0,38	1,35
Svirnishe	0,38	0,87	0,57	2,39
Reservoirs				
Olkhovskoye	0,7	3,7	0,3	11,5
Yanovskoe	1,1	7,7	0,4	10,8
Snigianskoye (reservoir of Ra-chunski hydro power)	1,5	5,5	0,8	12,7
Territory of the Republic of Lithuania				
ponds of fishery "Margeiski'	7,42	4,01	3,61	14,32
lake Karotski	0,16	0,66	0,36	1,69
lake Vakstel	0,065	0,52	0,19	1,22
lake Rakovina	0,16	0,92	0,27	2,28
lake Dyatlovina	0,078	0,31	0,29	1,01
lake Ungurinis	0,35	1,72	0,4	5,14
lake Sheima	0,085	0,43	0,39	1,4
lake Pyarunas	0,29	0,71	0,55	2,03
lake Atimets	0,31	0,87	0,41	2,36
lake Glyadne	0,12	0,42	0,29	1,21

Reference designations:
Ostrovets area of placement of belarussian nuclear power plant
Water objects
Channels and land reclamation networks
Forest massif
Overwetting territories
Settlements
Highways

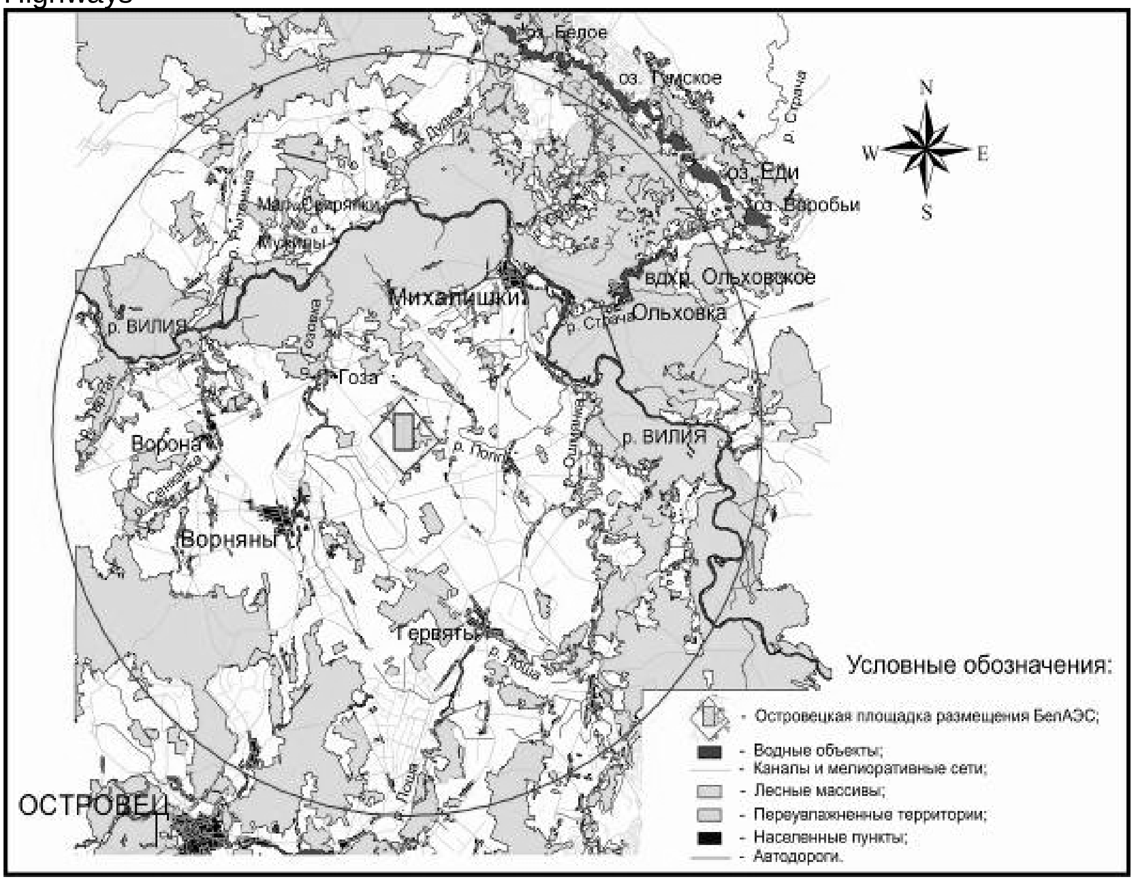


Figure 67 – Scheme of the hydrographic network in range of 15 km from belarusian nuclear power plant

The Vilia is the main source for the water supply for the productive purposes of the belarusian nuclear power plant. The Vilia is the biggest tributary of the Neman. It flows from a small swamp, located in 1 km South-West to Velikoe Pole (settlement), Doshitski district. It flows into the Neman near Kaunas. The river length is 498 km. The length on the territory of Belarus is 264 km. The total area of the river basin is 25 100 km^2, in Belarus – 11 050 km^2. The total inflow within the territory of Belarus is 90,6 m, the water surface slope is 0,3 %, the rate of sinuosity is 1,98.

The main tributary are the Servech, the Naroch, left – the Dvinosa, the Ilia, the Usha, the Oshmianka. The network of the river is well developed and comprises 1570 rivers those length is more than 1km. The Vileyski reservoir is built on the river, part of water of which is directed to the Svisloch through Vilia-Minsk hydrologic system.

The drainage is symmetrical (α=0,05), with insignificant prevalence of the left-bank, has the shape of the improper square (IV type). It si situated in Narochanski-Vilia depression. It is limited by the southern slopes of Svencenski range from the North, by

Minsk upland in the South, By Oshmiany upland in the South-West. It is related to the Vilia hydrologic district. The watershed is quite accurate and has complex contour. The relief is represented by terminal moraines formation, abounding with hilly ranges and groups of hills with swampy lowlands between them. The highest point with average heghts up to 100 m (some hills of the Minsk upland) goes to the Naroch-Vilia lowland.

The average height of water drainage is 190 m, the average slope is 9, 24 %. The soils are mainly sandy-loam and loamy including detritus and pebbles, peaty in lowland. The total percentage of forest land is about 30 %, including 5 % of swampy forests.

The lakes occupy 2 % of the catchment area, they are mostly located on the right bank. The biggest of them are the Naroch, Miastro, Svir, Vishnevskoye, Bolshie Shkvashty. Weighted average of the lakes is 0,03 %. Swamp massive and marshy lands are situated mainly in the upper part of the catchment area and make 10 % of its area.

The valley of the river sinuous. It narrows from 1-3 km in the upper flow to 0,2-0,4 km to the mouth along the whole length of the terrace. Flood plain in the upper flow is mainly swampy. Its width is 200-400 m, the lower part is interrupted. It's width is 50-70 m, in some places is 600 m. In the distance between the settlements Stakhi and Bolshiye Razdory there are many former river beds. The riverbed in the riverhead is highly sinuous. The width is from 1 to 2 m. At the mouth of the Usha – 40-60 m (100 m in some places) up to influx of the Baloshinka is 60-70 m. There are many islands, sand bars, sometimes there are places full of rapids. The banks in the riverheads are peaky.

The flood begins in the end of March and lasts about 50 days. The river regime is significant with intensive spring flood (about 45 % of flow) and low water standing in summer normal water level. After the Vilia reservoir was put into service, level and drain regimes lower from the dam on the territory of Belarus are controlled. The river freezes in the upper flow in the beginning of December, in the central and lower parts – in the beginning of January. Drifting of ice starts in the second half of March from the mouth to the riverhead.

Spring flood starts at the end of March and it continues for about 50 days. River mode has a peculiarity of intensive spring flood (about 45 % flow) with low water standing in summer water standing. After putting into operation of the Vilia reservoir level mode and flow mode which are situated lower than weir in Belarus are regulated. The river freezes in upcoarse at the beginning of December, in middle course and lower courses it freezes at the begginig of January. Ice drift starts at the second half of March from the mouth to riverhead.

In the riverhead there is a hydrologic wildlife preserve Verkhnevileiski, in the mouth there is a nature's monument Bereza's giant oak. Recreation zones Vileika, Plesi, sanatoriums "Zalesie", "Lesnaya polyana" are situated at the banks. [78].

According to the construction peculiarities of the valley and of the riverbed two areas could be selected: the first (upper) is "riverbed – mouth of the river Usha" (the length is 151 km), the second (lower) is "mouth of the river Usha – mouth of the river Baloshinka" (length is 125 km).

Area of nuclear power plant is situated in the district 2 of (lower) area. Ar this area the valley trough-shaped, very twisting, its width is 300-400 km maximal is 1 km. The slopes are steep sometimes abrupt with height of 10-20 m, in some places up to 30 m, they are crossed by deep ravines, consist of sandy and argillo-arenaceous deposits. Almost all the time the terraces cold be seen. Flood plain is discrete it alternates on the banks it is narrow, it width is 50-70 m, only at area from settlement Rudnya to settlement Danushevo, from settlement Markuni to settlement Mikhalishiki it is increased to 0,6 km. Flood plain's surface is wavy, more often it is sandy. Predominant widths of the mouth are 60-70 m, separate broadenings (mouth of the river Stracha) reach 200 m. Along the whole length there are small sandy islands, sand bars and braid bars. At the area between settlement Garavishki and settlement Dubok the riverbed is notable by considerable rapids. The bottom is sandy and stony, lower settlement Garavishki it is rich with separate boulders of different size. Banks are mainly steep, quite often are abrupt with height of 2-10 m, sandy-loam and are cut with ravines everywhere. There are outlets of groundwater in some areas.

The river Vilia and its tributaries are of great importance for providing favorable conditions for migratory, fluvial anadromous and other types of fish and also for preserving biological and landscape diversity of hinterlands. Lithuanian part of the river Vilia (the Neris) is a zone “Natura-2000”, which was created for protection of salmon, otter, lampern, bitterling and other types of fish.

The river Oshmyanka is left tributary of river Vilia. The river is situated in Grodno district. The length is 105 km, catchment basin is 1490 km^2, average water surface slope is 0,8 %, average annual consumption in the mouth is 13,4 m^3/s. The river takes its begging near the settlement Murovannaya Oshmyanka, in the riverhead it flows through central part of Oshmyani elevation, in middle and lower regions it flows through Naroch-Vilia low place. The main tributaries: right tributaries are the rivers Panarka, Goruzhanka, Sikunka; left tributaries are the rivers Losha, Kernova. Valley is expressive, its width is 200-300 m, there are few lakes there, the biggest one is the lake Rizhee. The riverbed in low water up to the mouth of the river Goruzhanka has a width of 3-5 m, lower it is 15-20 m, for a distance of 6,3 km it is canalized from settlement Murovannaya Oshmyanka to the mouth of the river Zabolot. The banks are abrupt. It freezes at the middle of December, the floating of ice is at the end of March. The Snigyanski reservoir (the reservoir of Rachunski hydro power). At the banks of the river there are recreation zone Osmyanka and medical rehabilitation center “Oshmyani” [76].

The river Stracha is the right tributary of the Vilia. It flows through the territories of Postavi district, Ostrovets district and Myadel district. The length is 59 km, catchment basin is 1140 km^2, average water surface slope is 1 %, average annual consumption in the mouth is 9,1 m^3/s. The river takes its begging from the lake Malie Shvakshti, it flows through south-western slopes of Sventsyanski ridges, flows into the Vilia in 2 km from south-east from settlement Mikhalishiki. The riverhead is situated at the territory of hydrologic wildlife preserve Shvakshti. The main tributaries: right tributaries are the rivers Lintulka, Struna; left tributaries are the rivers Sviritsa, Tushanka. In the basin there are a lot of lakes with which it is connected by rivers, brooks, channels (Svir, Vishnevskoye, Bolshie I Malie Shvakshti, Balduk, Glublya, Glubelka, Vorobii, Gubeza, Edi and others). The valley at the upstream it is indistinct, along the rest of the length of the river it is trapeziform. The flood plain is double-sided, swampy its lengh is 50-150 m. The riverbed is twisting in the upper flow it is full of rapids, its width in low waters in upper and middle is 8-12 m, in lower it is 15-20 m. The river is canalized at the length of 6,1 km from settlement Olshavi to settlement Selevichi. The river takes the flow of land reclamation channels. The river is a popular place for water tourism [76].

The river Gozovka – the left tributary is the river Vilia. The river flows through the territory of Ostrovets district. The length is 17 km, catchment basin is 88 km^2, average water surface slope is 2,5 %. The river takes its begging from the settlement Chizhovshina, it flows into the river Vilia to the south-east from the settlement Potoki, in the lower reach it flows through the forest massif. At the length of 9,6 km the riverbed is canalized [76].

The river Polpe - the left tributary is the river Vilia. The river source is situated at the west of the settlement Poboli of Ostrovets district in Grodno region. The river Polpe flows into the river Vilia at the east of the settlement Markuni of Ostrovets district in Grodno region. The length of the river is 9,2 km. Catchment basin is 30,8 km^2.

Olkhovski reservoir is the reservoir of Olkhovski hydro power it is situated in Ostrovets district at the river Stracha. It was built in 1951 at the river Stracha in 26 km to the north-east from the settlement Ostrovets for water supply of the cardboard factory “Olkhovka”. Maximal water level difference between upper and lower reaches is 3,0 m, water volume is 2,1 million m^3, catchment basin is 1140 km^2, conservation zone is 1,4 million m^3, water-surface area is 0,7 km^2, average depth is 3 m, full depth is 5,2 m, length is 3,7 km, full width is 0,3 km. The banks are abrupt, in some places the height is up to 7 m, become overgrown with forest. Bottom is slimy. There are three islands with gross area of 0,1 hectare [76]. The distance from the area of placement of surface water abstraction of nuclear power plant at the river Vilia is not less than 5 km. This reservoir could be used as one of reserve sources of industrial water supply of nuclear power plant.

Snigyanski reservoir (reservoir of Rachunski hydro power) is situated in Smorgon district at the river Oshmyanka. It was built in 1958-1959 in 13 km to the north-west from Smorgon for the needs of energy sector (Rachunski hydro power). Maximal level difference between upper and lower reaches is 5,0 m, water volume 1,21 million m^3, water-surface area is 1,5 km^2, average depth is 1,42 m, full depth is 4,7 m, length is 5,5 km, full width is 0,8 km, water volume is 2,29 million m^3, catchment basin 840 km^2. It is used for fish breeding. The kettle consists of two bays, the banks are mainly high, near the sothern part of the reservoir there is an island of area 0,1 km^2. It is overgrown. At the banks there are the house of the fisher and boating station. The distance to the area of placement of surface water abstraction at the river Vilia is not more than 41,5 km. It could be used as a reserve sources of industrial water supply of nuclear power plant.

The river Losha – left tributary is the river Ohmianka. It flows through the territories of Ostrovets and Oshmiani districts. The length is 55 kilometers, the area of catchment area 455 km^2, middle water surface slope 1,34 %, average annual spending in the mouth is 3,9 m^3/second. It takes the beginning in 1,5 km from south-east of settlement Volkovshina, in the river head it flows through south slopes of Oshmiani upper land, than through small woodland. It flows into the river Oshmiani at south-north from the river Zarechie. Main tributary is the river Kovalevka. River valley up to Losha settlement is inexpressive, lower is trapeziform with width 200-300 m, between settlements Polushi and Ostrovets up to 1 km. The flood plain is double-sided, mainly its width is 100-150 m. For a distance of 12 km from the river head the riverbed is canalized and at reminded area it is twisting. The banks at the riverhead are abrupt. Yanovski reservoir is built at that river. [76].

13.4.2.2 Directional property and change intensity of condition of the structure of the drainage-area

The bulk of the reservoirs in catchment area of the Vilia river refers to category of small reservoirs (which is the bulk volume is less then 30 mln. of cubic metres), which is perform the daily or shallow season regulation of the drainage. Their impact to the stream flow is insignificant and die out very fast to the downstream. Many of reservoirs were created on the base of lakes with the small domatic crystals drawdown and those reservoirs are dedicated to maintain a fixed level of the lake reservoir and has no impact to the water resources of those reservoirs. A modification of annual distribution of stream flow for those two types of reservoirs, which differ from one to another by small shares of the active storage capacity as regards to the stream flow of the regulated river, happens within the natural variability.

The largest reservoir is the Vilia reservoir. This reservoir allows essentially change the annual distribution of the Vilia river.

An agricultural reclamation takes an extra place and represent by itself the largest pattern impact to the environnement. In the river basin of the river Vilia 60 channels were regulated all along (1.22 % from total number) of 518 km, 94 channels were regulated partially (5.9% from total number) of 565.3 km. Primary the rivers of the mileage to 25 km were totally regulated (94.5 %). Overwhelmingly under the particulate channel regulation the cutoff must be made.

13.4.3 Drain characteristic of water objects

The drain characteristics of water objects in 30-km area of belorussian APS are defined essentially by the distribution according to their bailing territory of the flow rates l/(s*km2), wherefore the schematic maps are working up.

The schematic maps of the flow rates are used essentially to define the norm of the annual flow. The hydrological map of Belarus, maked in 2000 (П1-98 к СНиП 2.01.14-83) is the fullest. An average error of the standart-settings of annual stream flow by map, using the interpolation method, is about 10-15% and depends on the observational series duration, on the drainage density in a giving region, on the relief flowing in a giving region and some other values. Rate flow values for catchment areas of main channels of belarussian APS region are representing in table № 91.

Table № 91 - Rate flow values for catchment areas of main channels belarussian APS region

River	Cathcment areas, km^2	Medium-longstanding spending, m^3/s	Annual flow module, l/s km^2		
			medium-longstanding	maximal	minimal
Vilia	11050	79,6	7,2	9,67	4,86
Oshmyanka	1490	13,4	9,0	9,7	6,84
Losha	455	4,10	9,0	9,9	6,5
Stracha	1140	8,55	7,5	8,50	4,80

The hydrological regime of the Vilia has been metamorphosed in the giving area in the context of creation of hydrologic system Vilia-Minsk (BMBC), including the Vilia reservoir. The Vilia reservoir was dedicated to provide a diversion of runoff flow to the Svisloch river and ensure some sanitary expenditures. Main characteristics of the Vilia reservoir are given in the table № 92.

Table № 92 - Main characteristics of the Vilia reservoir

Parametres	Characteristics	Computed values
Water levels, m BS	highest water level	159,80
	normal water level	159,00
	lower water level	153,00
Water level, million m^3	highest water level	330
	normal water level	260
	lower water level	25,1
Mirror area, hectare	highest water level	9000
	normal water level	7700
	lower water level	1500

According to the water balance of the reservoir out of the project specification of water system Vilia-Minsk for one year of 95 % of prosperities [79] the water transfer is planned to 13.2 m^3/s.

Water levels in this reservoir are changing from 260 mln m^3 to 25.1 mln m3 (the reservoir drawdown is planning 6.0 m).

An observation data for the level-sensitive mode of the Vilia reservoir shows that the stream flow control of the Vilia river is realized not by the full capacities provided by the project specifications. So, for example in 2005 the water levels were changing in low ranges - from 159.31 to 157.78 m (on 1,73 m). For the last years the transfer of the flow through the Vilia-Minsk water system decreased, especially for irrigation of the river Svisloch. According to the data of Administration of usage of the Vilia-Minsk water system from 1993 and till now the transfer of the flow from the river Vilia decreased from 7,06 million m^3 to 5,04 million m^3 (almost to 30 %). At the constant volume of the transfer of the flow into the reserve reservoir of the Vilia-Minsk water system, the transfer of the flow into the river Svisloch decreased from 3,80 million m^3 to 1,70 million m^3 (almost to 55 %). Total change of flow of the Vilia (to which extent has water consumption in comparison to natural mode decreased) in the range of the Vilia reservoir (lower reach) at the project usage of the reservoir was 11,0-15,0 m^3/s (accounting losses for evaporation and ice formation). For the last years because of the decrease of water diversion into the Vilia-Minsk water system the decrease of consumption is approximately two times less it is for 6 m^3/s.

Maximal water consumption in the river Vilia of provision are not less than 1 % lower than settlement Mikhlishiki for natural conditions can be more than 1600 m^3/s. According to the project of the Vilia reservoir the maximal regulated outlet water consumption of the spring flood is 0,01 % of provision is considered equal to 1560 m^3/s, and in the year 1 % of provision – 993 m^3/s. Changing of hydrologic mode which is connected with the creation of the Vilia-Minsk water system at the period of of the spring flood plays a positive role, decreasing negative consequences.

For the reason that at the distance from the Vilia reservoir to the border with Lithuania the flow which catchment area is more than 6000 km^2 is formed, the regulating influence of reservoir is not considerable (except big flows when the volume of flow can be decreased by keeping of its part(which falls to the catchment area higher than the weir is) in the Vilia reservoir.

Flowing characteristics (estimated volume flow of given probability of excess) are estimated with the usage of П1-98 to СНиП 2.01.14-83 according to observation data for water mode of the Vilia in the river range near the settlement Mikhlishiki with recount to the range of the placement of surface water abstraction and to the transboundary range (tables 93 – 95).

The full complex of hydrologic investigations and calculations is made at the stage of choice explanation for the area of nuclear power plant for ranges of the Vilia near the settlement Muzhili and for the transboundary range. Water intake flow near the settlement Malie Sviryanki is situated 2,4 km higher than the flow near the settlement Muzhili. At this given area there are no concentrated tributaries, water intakes and discharge water. So taking into consideration the change of the area of water abstraction water consumption in the river in the flow of the settlement Malie Sviryanki differ from water consumption in the settlement Muzhili not more than to 0,5 %, which is in the limits of error of hydrologic sizes measure. So for the flow of water intake at the area “settlement Muzhili - settlement Malie Sviryanki” estimated flow for the flow near the settlement Muzhili are taken.

Table 93 – Counted annual average water consumptions in the river Vilia (variation coefficient C_v =0,244, coefficient of skewness C_s=5,5 C_v)

Possibility of excess	Water consumptions, m³/sec "Mikhalishiki settlement – confluence into the river Stracha")	Water consumptions, m³/sec (water intake location "Muzhili settlement – Malie Sviryanki settlement"	Water consumption, m³/sec (transboundary transit)
average annual flow	63,50	64,90	68,12
50 %	62,70	64,08	67,26
75 %	55,00	56,21	59,00
80 %	53,20	54,37	57,07
90 %	48,90	49,98	52,46
95 %	45,70	46,71	49,03
97 %	43,80	44,76	46,99

Table 94 – Counted maximum water consumptions in the river Vilia (C_v =0,491, C_s=4,5 C_v)

Exceedance probability	Water consumption, m³/sec (Mikhalishiki settlement)	Water consumption, m³/sec (water intake location "Muzhili settlement – Malie Sviryanki settlement"	Water consumption, m³/sec (transboundary transit)
0,01 %	4248	4341	4557
0,1 %	2857	2920	3065
0,5 %	1903	1945	2042
1,0 %	1567	1601	1681
5,0 %	918	938	985
Maximum unfixed water consumption (1958)	1570	1605	1684

Table 95 – Minimal calculated water consumption in the river Vilia

Hydrological conditions	Possible excess	Water expenditure, m^3/s (settlement. Mihalishki)	Water expenditure, m^3/s (water abstraction in «settlement Muzhili - settlement Malie Svirianki» region)	Water expenditure, m^3/s (transfrontier section line)
The minimal daily water consumption in low-water winter period	95 %	18,20	18,60	19,52
	97 %	17,50	17,89	18,77
The minimal monthly water consumption in low-water winter period	95 %	30,85	31,53	33,10
	97 %	29,90	30,56	32,08
The minimal daily water consumption in low-water summer-autumn period	95 %	23,60	24,12	25,32
	97 %	22,40	22,89	24,03
The minimal monthly water consumption in low-water summer-autumn period	95 %	30,30	30,97	32,51
	97 %	29,20	29,84	31,33
The minimal ever registered water consumption (august 1992 г.)		23,9	24,43	25,64

In table 96 you can see an annual flow distribution for different hydrological conditions. It was calculated with help of period-composition method.

Table 96 – An annual flow distribution in the river Vilia for transfrontier section

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
An average water content year												
Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
% from yearly flow	6,49	5,63	13,44	18,23	9,71	7,65	6,19	5,00	5,14	6,19	7,93	8,40
Water consumption	52,35	45,38	108,4	147,0	78,31	61,69	49,89	40,34	41,41	49,89	63,94	67,69
Shallow year 95 % possibility of excess												
Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
% from yearly flow	5,65	5,14	16,10	21,15	11,51	6,80	5,63	4,94	4,91	5,38	5,93	6,86
Water consumption	33,26	30,25	94,73	124,4	67,69	40,02	33,15	29,07	28,86	31,65	34,87	40,34
Very shallow year 97 % possibility of excess												
Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
% from yearly flow	8,05	8,89	14,57	17,95	10,48	6,76	5,49	4,84	4,88	5,36	5,94	6,78
Water consumption	45,49	50,21	82,28	101,4	59,22	38,19	31,00	27,36	27,57	30,25	33,58	38,30

13.4.4 Level and speed mode characteristics

Water level characteristics of the river Vilia for water consumtion of intended supply can be clearly traced in tables 97-99. The graph of interdependance between water consumption and water level in Muzhili settlement and water abstraction in «settlement Muzhili - settlement Malie Svirianki» region can be traced in table 97.

Table 97 – Calculated water levels in the river Vilia, which correspond to annual water consumption.

Possibility of excess	Water level, m base station (Mihalishki settlement)	Water level, m base station (water abstraction in «settlement Muzhili - settlement Malie Svirianki» region)	Water level, m base station (transfrontier flow)
Average annual flow	120,00	117,10	112,30
50 %	119,98	117,08	112,29
75 %	119,84	116,87	112,14
80 %	119,80	116,89	112,10
90 %	119,70	116,81	112,02
95 %	119,63	116,75	111,96
97 %	119,58	116,71	111,92

Table 98 – Calculated water levels in river Vilia, which correspond to maximal water consumption.

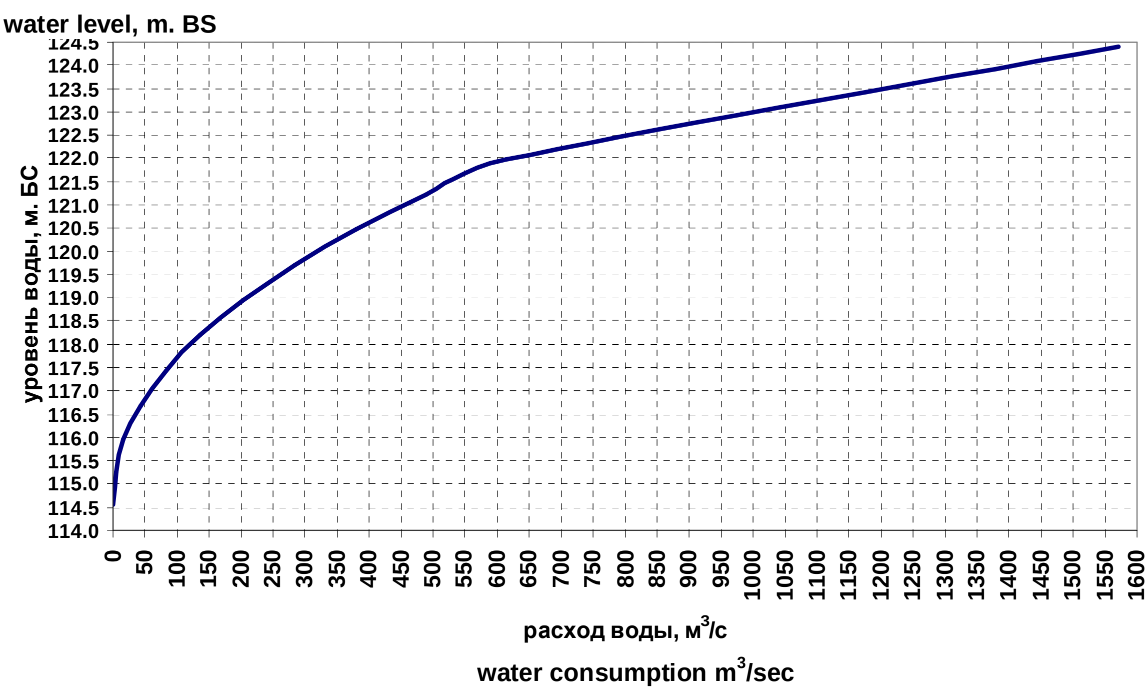
Possibility of excess	Water level, m base station (Mihalishki settlement)	Water level, m base station (water abstraction in «settlement Muzhili - settlement Malie Svirianki» region)	Water level, m base station (transfrontier flow)
0,01 %	131,00	128,58	122,22
0,1 %	128,14	125,63	121,34
0,5 %	126,18	123,61	120,39
1,0 %	125,49	122,89	119,81
5,0 %	123,87	122,47	117,84
Within the maximal registered water consumption (1958)	125,32	122,90	119,82

Nuclear power plant ground won't be flooded even in case of maximal water level, because ground surface marks on it's territory is 175-176 m BS. This is 4 m higher, than maximal water levels registered in river Vilia region.

Table 99 – Calculated water levels in river Vilia, which correspond to minimal water consumption.

Hydrological conditions	Possibility of excess	Water level, m base station (Mihal-ishki set-tlement)	Water level, m base station (Muzhili settle-ment)	Water level, m base sta-tion (trans-frontier flow)
The minimal daily water consump-tion in low-water winter period	95 %	118,64	116,03	111,33
	97 %	118,62	116,01	111,29
The minimal monthly water con-sumption in low-water winter period	95 %	119,12	116,37	111,68
	97 %	119,08	116,35	111,66
The minimal daily water consump-tion in low-water summer-autumn period	95 %	118,84	116,17	111,54
	97 %	118,80	116,14	111,51
The minimal monthly water con-sumption in low-water summer-autumn period	95 %	119,10	116,36	111,66
	97 %	119,06	116,33	111,64
The minimal ever registered water consumption (august 1992)		118,86	116,18	111,54

Dependence of consumption from water level Q(Y) for river's water system the Vilia (settlement Muzhili)



Picture 68 - Dependence of consumption from water level Q(Y) for river Vilia's water system the (water intake location is Muzhili)

The Vilia at area from Mikhalishiki to belarussian-lithuanian border is characterized by rather high speeds of water course. Average speeds at this area vary depending on hydrologic mode from 0,35 (minimal water consumption) to 0,8 m/second.

13.4.5 General characteristics of a winter regime

The first ice formations on the river Vilija in an alignment of a post of Mihalishki occur mainly in late November, the earliest was thus marked 30.10.1979, and the latest – 29.12.1949. The autumn ice drift begins also in the third decade of November in a few days after first ice formations, only in 1988 it has come on January, 4th, and in 1990 – on December, 18th. The maximum duration of an autumn ice drift – 96 days was observed during the autumn-winter period 1954-1955

The earliest ice formation was observed on 20.11 in 1965 and 1994, and later – on 11.03.2005. The maximum duration of ice – 117 days, was observed during the autumn-winter period 1963-1964, and last years – 111 days during the winter period of 1993-1994 the Thickness of ice reaches according to long-term supervision up to 54 sm, and recent years – up to 46 sm.

As positive air temperatures set in at spring time thawing and destruction of an ice cover begins. Destruction of an ice cover on the river Vilija occurs almost simultaneously on all its extent.

The spring ice drift on the river Vilija in an alignment of a post of Mihalishki begins mainly in the end of March, thus the earliest approach of a spring ice drift was observed on January, 30th, 2002, and later – on April, 12th, 1963. Duration of a spring ice drift fluctuates from 2 to 17 days according to long-term supervision, and recent years – from 1 to 14 days.

Clarification of the river Vilija in an alignment of a post of Mihalishki from ice occurs mainly in the end of March, thus the earliest was observed on January, 10th, 1990, and on April, 18th, 1956 the latest.

The maximum duration of the ice period is 131 day (2005), and 39 days (2007) as minimum.

Ice dams on Vilija (during ice thawing in autumn-spring period) are formed almost annually, are powerful and enduring (reached 117 days in 1996). The maximum ice dam height reaches 139 sm (1988) against post "zero" as to a water level before ice dams formation was 117 cm. Settlement value of the maximum rising level during ice dam period at probability of excess P=1 of % makes $\Delta h_{jam,P=1\%} = 125$ sm.

In an alignment of a post of Mihalishki on the river Vilija ice jams are not annual. Sometimes duration reached 17 days (1995), and the max height of water rising as to «post zero» reached 2 m (1994) which in relation to a water level before jam formation was 109 sm. Settlement value of the maximum rising of water level during the mash period at probability of excess P=1 of % makes $\Delta h_{dam,P=1\%} = 118$ sm.

Evidence of a dangerous ice phenomenon, including ice dams and jams, causes requirements for its control. For that reason supervision over an ice regime on the relevant parts of water withdrawal on the river Vilija is essential, as well as taking measures for prevention and decrease in adverse effect of the ice phenomena**.**

13.4.6 Sediments and characteristics of river bed evolution

The analysis of sediments in the river Vilija on industrial water withdrawal of Belarusian nuclear plant "np Malye Sviryanki - np Muzhily " showed that coarse, medium and fine sand mainly dominate here, and coarse sand with pebbles prevail by the right bank. The average diameter of soil particles of sediments d 50 % equals:

-by the left bank - 0,84 mm;

- in the middle of the river - 0,87 mm;

- By the right bank - 2,81 mm.

Sediments width (thickness) is not significant and varies in the nuclear plant placement up to 8 sm. Dynamics of sediment movement, and areas of its highest accumulation are mostly applicable to the concave parts of the coast. At a distance of 2 m, regardless of the characteristics of the coast (straight, convex and concave), the thickness of sediments can reach 15-20 sm in some places, due to the process of reshaping of the coast during the river meandering.

Characteristics of bottom deposits pollution of the river Vilija are based on analysis of sediments samples in the alignment of water withdrawal placement "np Muzhily - np Malye Svirianky” and are presented in Table 100.

Table 100 –Characteristics of bottom deposits pollution on the river Vilija in water withdrawal placement

Pollution index		Unit	300 m below the np Muzhily, The water depth is 1.3 m, thickness of the sediment - 6 sm	300 m below the np Malye Svirianki . The water depth is 1.3 m, thickness of the sediment – 8 sm
1	pH of the aqueous extract	-	7,62	7,46
2	Chlorides	mg / kg	32	36
		%	0,0032	0,0036
3	Sulfates	mg / kg	24	43
		%	0,0024	0,0043
4	Petroleum	mg / kg	3,48	5,85
5	Copper	mg / kg	0,95	0,90
6	Lead	mg / kg	1,05	1,05
7	Zinc	mg / kg	7,25	7,30
8	Nickel	mg / kg	5,35	5,05
9	Cadmium	mg / kg	0,03	0,03
10	Chromium general	mg / kg	4,10	4,30

Currently, Belarus has no standards for maximum chemicals concentration in sediments allowed, and therefore it is impossible to determine the environmental status of the sediment.

River bed evolution of meandering type dominates in the part of the river Vilija in the nuclear plant site in the Belarusian-Lithuanian border, which characterizes the winding sections of rivers, regulated by natural ways where meandering river channel types are natural. According to estimation no substantial change in river bed is expected.

Despite of the small thickness of sediment layer, the river Vilija is characterized by intensive river bed evolution due to erosion and sedimentation at high midstream speed, which leads to horizontal (plan) and vertical (depth) deformation.

Horizontal (plan) river bed deformation of Vilija during 31-year period, equals to average of 11-12 m (up to 40 sm per year), maximum - up to 28 m in the area between firth of the river Dudka and firth of the river Gozovka. Information is based on mapping information and aerospace photos.

Vertical (depth) river bed deformation of Vilija caused by erosion and sediment transfer are up to 0,45 m, which is based on calculations and field studies 2008-2009 in the section "np Muzhily - NP Small Sviryanki ". The presence and extent of river bed deformations necessitates fixing the bank at the place of withdrawals location. In the past 25 years the river Vilija is characterized by low turbidity. Thus, during the observation period from 1993 to 2006. maximum turbidity was observed during the spring flood in April 1999, which was near the town Vilejka - 37 mg / dm ^{3}, near the town Steshitsy - 25 mg / dm ^{3}. The pilot studies 2008-2009 showed an average turbidity of the river Vilija neaar np Mikhalishki 4.9 mg / dm ^{3}, and 5,3 mg / dm ^{3} near np Muzhily.

Estimated speed of particles intension in suspended sediments depending on hydrological conditions range from 0,001 to 0,012 m / s (increase with the reduction of axial velocities) at the site location withdrawals "np Small Sviryanki - np Muzhily ".

13.4.7 Water quality according to hydrochemical values and its integrated assessment

13.4.7.1 Water quality assessment of the river Vilija and its tributaries by hydrochemical parameters (as a fishery water body)

Quality assessment of the river Vilija in the area from Smorgon to np Bystrica by the main hydrochemical parameters was carried out according to observations of the National Environment Monitoring System (NEMS) of the Republic of Belarus for the period 2003-2008. Concentrations were compared with standards for fishery water bodies (PDKr/h), as well as with the values of baseline indicators for the River Vilija, based on [80], with the values obtained from observations of water quality in the alignment of the river Ilija np Ilya, which is the background for the basin of the river Vilija [81].

The averaged and maximum concentrations of total iron in the investigated cross-sections of observations of the river Vilija exceed the values PDKr /h, because of its natural regional origin, since the average concentration does not exceed the background values in the river Ilija np Ilya.

The values of salinity, chlorides, sulfates, nitrogen, nitrate, cadmium, phosphorus total during the observations in the river Vilija do not exceed PDKr/h.

Averaged values of suspended solids exceed the background values for the basin of Vilija which is 7 mg / dm ^{3}.

Averaged and minimum bichromate oxidizability values are within the background values in the alignment of the river Ilija np Ilya (48.6 mg / dm ^{3}), and increased values of maximum concentrations are due to the influence of sewage in the low-flow period.

Averaged and minimum values of BOD_5 meet the standards for fishery water bodies, increased values of maximum concentrations due to sewage enterprises of housing and communal services in low-flow period.

Averaged and minimum concentration of ammonia nitrogen, nitrite nitrogen, phosphorus, phosphate does not exceed PDKr /h, and some high maximum values are due to flushing in the spring and summer from the territories occupied by animal husbandry, poultry farms, fertilized fields and pastures.

Averaged and minimum concentration of copper did not exceed its background value (0,005 mg / dm ^{3}). Averaged and minimum nickel concentration does not exceed the value PDKr /h, and the maximum does not exceed the background values for nickel basin of the river Vilija (0,02 mg / dm ^{3}).

Averaged and minimum values of manganese, surfactants are in the range of background values in the alignment of the river Ilija np Ilya (0.086 mg / dm ^{3} and 0.029, respectively).

Thus, the averaged annual concentrations of pollutants comply with good water quality in the river Vilija, and the maximum values are once recorded and have either regional background nature (heavy metals), or the surface destruction of catchment area in the low-flow period.

Integral assessment of water quality in river Vilija was conducted on water pollution index (WPI) during the period 2003-2008, the calculations were performed using the following formula [82] $WPI = \frac{1}{6}\sum_{i=1}^{6}\frac{C_i}{PDK_i}$ for the annual average concentrations of dissolved oxygen, BOD_5, ammonia nitrogen, nitrite nitrogen, phosphorus, phosphate and petroleum products and their standards for water fishery. The calculation results are given in Table 101.

Table 101 - WPI Values in the river Vilija for the period 2003-2008

Observation alignments	2003 .	2004	2005.	2006 .	2007	2008
river Vilija - 4 km NE np Smorgon	0,95	0,97	0,88	0,82	0,81	0,59
river Vilija - 6 km NE np Smorgon	1,00	0,99	0,95	1,05	0,61	0,58
river Vilija - 0,3 NE np Bystritsa.	0,68	0,89	0,68	1,89	0,63	0,58

As seen from the table, an integral index WPI for the river Vilija during the period 2003-2008, 4 km NE of np Smorgon varies from 0,59 to 0,95 (which corresponds to the classification of [82] II class quality - relatively clean water) in the alignment of 6 km NE np of Smorgon, which is located downstream of the previous alignment, it varies from 0.58 (which corresponds to the classification of [82] II class quality, relatively pure water) to 1.05 (which corresponds to the classification of [82] III class quality, moderately polluted water) in the alignment of 0,3 NE np Bystrica, which is a transboundary district, WPI changed from 0.58 (which corresponds to the classification of [82] II class quality, relatively pure water) to 1.89 (which corresponds to the classification of [82] III class quality, moderately polluted). So, the water in the river Vilija is characterized by II-III class quality in its entirety on the territory of Belarus. It should be noted that there is a tendency to water quality improvement over the past 2 years.

According to the field hydrologic study water quality of major feeders of the river Vilija in the nuclear power plant districts (rivers Gozovka and Polpe) complies with MAC of fishery, except for total iron and manganese concentrations, which are higher (up to 10 MACs) due to their natural content (the mentioned feeders do not have waste water outlets, human pressure in the area is low).

13.4.7.2 Assessment of water quality in the river Vilija and reservoirs by hydrochemical parameters (as the main source industrial water supply)

Comparative analysis of concentrations of pollutants in the region. Vilija as the main source of production water from the cultural norms of domestic and drinking-water showed that the water in the river Vilija is not satisfied (for maximum value) specified norms for such ingredients as iron total, ammonia nitrogen and BOD $_5$. As mentioned above, this is due to regional natural origin of iron, as well as discharges of sewage and surface destruction with a catchment area of low-flow period. I.e. using water from the river Vilija for drinking purposes requires iron removal plants.

The results of field expedition studies undertaken during the development of hydrological characteristics of NPP in all phases of the hydrological regime during 2008-2009 showed good water quality for the hydrochemical parameters of rivers and reservoirs (the source of water supply of Belarusian nuclear plant): in the river Vilija and its major reservoirs in the area : Olhovskoe and Snigyanskoe (Table 102, 103).

Table 102 - Characteristics of water quality in the river Vilija for hydrochemical values based on research expeditions

Pollution index		river Vilija (np Muzhily)			river Vilija (np Mihalishki)			Mac cultural and general/ EMP requirements
		Average	MAX	MIN	Average	MAX	MIN	
1	Temperature, C	12.9	23.8	5.6	11.66	23.8	5.7	
2	Odor at 20 и 60 (point)	0	0	0	0	0	0	
3	Dry residue (mg/dm^3)	262.3	279	244	249.2	267	240	
4	Chroma (degree)	18.6	26	13	18.9	26	12	
5	Muddiness (mg/dm^3)	4.94	10.2	3.2	4.65	9.8	2.2	
6	pH Value	8.09	8.29	7.96	8.044	8.25	7.9	6.5-8.5
7	Suspending solids (mg/dm^3)	3.96	7.4	0.8	6.32	17.6	1.2	
8	Calcium, Ca^{2+} (mg/dm^3)	61.23	64.91	58.46	59.15	63.71	53	
9	Magnesium, Mg^{2+} (mg/dm^3)	15.75	17.19	13.37	14.53	17.13	12	
10	Sodium, Na^{2+} (mg/dm^3)	6.65	8.12	5.6	5.96	7.75	5	200

The end table 102

11	Potassium, K^+ (mg/dm^3)	2.65	2.96	2.25	2.27	2.5	1.9	
12	Iron total (mg/dm3)	5	***0.312***	0.03	0.190	0.242	<0.03	/0.3
13	Manganese, Mn^{2+} (mg/dm^3)	0.049	***0.138***	0.01	0.052	0.098	0	0.1
14	Aluminium, Al^{3+} (mg/dm^3)	0.028	0.049	0.007	0.025	0.043	0	0.5
15	Cuprum, Cu^{2+} (mg/dm^3)	0.015	0.02	<0.001	0.002	0.002	<0.001	1
16	Lead,Pb^{2+} (mg/dm^3)	0.001	0.001	<0.001	0.005	0.005	<0.001	0.03
17	Zinc, Zn^{2+} (mg/dm^3)	0.011	0.011	<0.005	0.0083	0.013	<0.005	1
18	Phosphate, PO_4^{3-} (mg/dm^3)	0.097	0.171	0.015	0.078	0.13	0	-
19	Chloride, Cl^- (mg/dm^3)	13.78	16.55	11.75	12.05	13.63	11	350
20	Sulfate, SO_4^{2-} (mg/dm^3)	25.88	30	18.9	25.73	28.75	19	500
21	Hydrocarbonate (мг-экв/$дм^3$)	224.74	236.09	207.2	214.45	235.77	183	
23	Hydrogen sulfide, H_2S (mg/dm^3)	не обн.	не обн.	не обн.	не обн.	не обн.	не обн.	
24	Silicon, SiO_3^{2-} (mg/dm^3)	6.44	***10.04***	2.4	5.35	9.21	2.2	10
25	Hardness total (мг-экв/$дм^3$)	***4.37***	***4.61***	***4.02***	***4.15***	***4.59***	3.6	/4.0
26	Carbonate (мг-экв/$дм^3$)	3.68	3.87	3.4	3.51	3.86	3	
27	Constant (мг-экв/$дм^3$)	0.67	0.74	0.62	0.64	0.75	0.5	
28	Ammonium, NH_4^- (mg/dm^3)	0.153	0.3	0.04	0.23	0.6	0	1
29	Nitrate, NO_3^- (mg/dm^3)	4.29	8.4	0.8	2.67	7.8	0	45
30	Nitrites, NO_2^- (mg/dm^3)	0.041	0.074	0.006	0.038	0.074	0	3.3
31	Petroleum (mg/dm^3)	0.0094	0.015	0.006	0.0084	0.013	0	0.3
32	SPAW (mg/dm3)	0.025	0.065	0.005	0.01525	0.05	0	0.5
33	Phenol (mg/dm^3)	0.003	0.003	не обн.	<0.0005	0.00157	не обн.	0.001
34	BOD_5 (мг·O_2/ dm^3)	3.24	3.95	2.17	3.168	4.2	2.4	4
35	COD (мгO_2/ dm^3)	22.99	28.1	17.4	24.83	***31.1***	20	30

Table 103 - Water quality characteristics of the river Stracha Oshmyanka (reservoir Snigyanskoe) for hydrochemical values as a result of research expeditions

Pollution index		river Stracha (350 м down the stanch of the Olhovsky reservoir)			river Oshmyanka (Snigводохраниуан-skoe reservoir)			Mac cultural and gen-eral/ EMP re-quirements
		Aver-age	MAX	MIN	Aver-age	MAX	MIN	
1	Temperature, C	10.6	24	5.6	12.88	23.5	5.7	
2	Odor at 20 и 60 (point)	0	0	0	0	0	0	
3	Dry residue (mg/dm^3)	245	263	224	293.8	327	276	
4	Chroma (degree)	13.75	21	4	15.6	20	7	
5	Muddiness (mg/dm^3)	2.44	4	1.7	2.85	4.7	0.8	
6	pH Value	6.21	8.14	0.8	8.08	8.2	7.89	6.5-8.5
7	Suspending solids (mg/dm^3)	1.55	3.6	0.6	3	5.6	1.2	
8	Calcium, Ca^{2+} (mg/dm^3)	59.01	63.71	50.45	69.95	76.76	66.03	
9	Magnesium, Mg^{2+} (mg/dm^3)	14.64	18.58	11.66	17.13	18.47	15.8	
10	Sodium, Na^{2+} (mg/dm^3)	5.19	5.8	3.82	8.17	9.41	6.93	200
11	Potassium, K^+ (mg/dm^3)	2.18	2.42	1.58	3.84	4.53	3.33	
12	Iron total/ (mg/dm^3)	0.212	***0.309***	0.13	0.23	***0.401***	<0.03	0.3
13	Manganese, Mn^{2+} (mg/dm^3)	0.074	0.088	0.052	***0.103***	***0.219***	0.042	0.1
14	Aluminium, Al^{3+} (mg/dm^3)	0.026	0.041	0.014	0.026	0.038	0.017	0.5
15	Cuprum, Cu^{2+} (mg/dm^3)	0.0016	0.002	<.0.001	0.0011	0.0012	0.001	1
16	Lead,Pb^{2+} (mg/dm^3)	0.001	0.001	<.0.001	<0.001	<0.001	<0.001	0.03
17	Zinc, Zn^{2+} (mg/dm3)	0.0055	0.006	<0.005	0.011	0.011	<0.001	1
18	Phosphate, PO_4^{3-} (mg/dm^3)	0.238	0.82	0.008	0.181	0.253	0.034	-
19	Chloride, Cl^- (mg/dm3)	10.4	11.69	8.8	16.05	18.6	12.66	350
20	Sulfate, SO_4^{2-} (mg/dm^3)	24.94	27.25	23.5	27.50	35.27	18.9	500
21	Hydrocarbonate (мг-экв/ dm^3)	212.32	234.49	171.5	258.11	282.68	234.49	

The end table 103

23	Hydrogen sulfide, H_2S (mg/dm^3)	не обн.	<0.02	не обн.	не обн.	не обн.	не обн.	
24	Silicon, SiO_3^{2-} (mg/dm^3)	5.33	8.94	2.1	8.44	***12.33***	3.5	10
25	Hardness total (мг-экв/дм^3)	***4.15***	***4.71***	3.48	***4.90***	***5.31***	***4.6***	/4.0
26	Carbonate (мг-экв/dm^3)	3.48	3.84	2.81	4.23	4.63	3.84	
27	Constant (мг-экв/ dm^3)	0.68	0.87	0.52	0.67	0.77	0.62	
28	Ammonium, NH_4^- (mg/dm^3)	0.19	0.28	<0.01	0.15	0.34	0.03	1
29	Nitrate, NO_3^- (mg/dm^3)	3.18	7.1	0.6	5.48	9.8	1.3	45
30	Nitrites, NO_2^- (mg/dm^3)	0.042	0.07	<0.01	0.08	0.14	0.039	3.3
31	Petroleum (mg/dm^3)	0.007	0.009	<0.005	0.0064	0.008	0.005	0.3
32	SPAW (mg/dm^3)	0.031	0.07	0.004	0.035	0.065	не обн.	0.5
33	Phenol (mg/dm^3)	не обн.	<0.0005	не обн.	0.0014	0.0014	не обн.	0.001
34	BOD $_5$ (mg·O_2/dm^3)	2.58	3.46	1.96	2.98	3.77	2.16	4
35	COD (mgO_2/dm^3)	24.77	30	17.89	21.56	28	15.46	30

13.4.8 Environmental health of the main watercourses and water reservoirs

The sanitary-hygienic state of the major watercourses (rivers Vilija, Polpe, Gozovka) and water basins (Snigyanski and Olkhovsky reservoirs) in the area of the nuclear plant, which is determined by the sanitary and microbiological values for the different phases of the hydrological regime, and results of research expeditions showed that the values of the indicators meet the requirements of SanPiN 2.1.2.12-33-2005. No pronounced tendency of water quality deterioration is observed. The following indicators were examined: total coliform bacteria (EDB), thermotolerant coliform bacteria, kolifagi, causative agents of intestinal infections (dysentery, salmonellosis).

13.4.9 Thermal regime of water bodies

To assess the characteristics of the temperature regime of river water raw data are summarized and generated in tables in alignment of the river Vilija - np Mikhalishki for which a representative observation period of water temperature, taken into account, was 32 years (1976-2007 years). This range is quite sufficient for reliable conclusions on possible natural oscillations of the adverse temperature conditions, as this value doesn't vary muh in long-term perspectives (C_V = 0.16). Fluctuations in water temperature during the year are also quite smooth seasonal, flat changing year in year out.

Basic analysis and calculations were made based on the average water temperature, as due to the low volatility of this index, it is possible to get more detailed specifications, including fixed-term values, using some of the coefficients. For example, special studies on diurnal fluctuations in water temperature showed that the maximum emergency water temperature can exceed the average daily (monthly average) value (on bi-terminable or four-terminable observations) at an average of 1.5 ^{0}C. Further we proceed with this data.

Analysis of the initial ranges showed that the estimated range of the period when they can mark the maximum water temperature is - from May to August. The probability of occurrence of the maximum temperature in the year in a given month is significantly different: May 3 % in June -26 %, -20 % in July, August – 5 %, that is the most likely period is at the beginning and middle of summer - in June, July – 83 %.

During June - August intervals fluctuations in water temperature and its availability are following:

- 15 ^{0}C - 17 ^{0}C - 5,1 %;
- 17 ^{0}C - 19 ^{0}C - 46,9 %;
- 19 ^{0}C - 21 ^{0}C - 38,8 %;
- 21 ^{0}C - 23 ^{0}C - 7,2 %;

-> 23 ^{0} C – 2 %.

Curve of the average water temperature and supply curves of the maximum monthly average (for the whole summer) and the maximum term water temperatures were (mutually) constructed for the June-July period. The coefficient of variation C_V = 0,05, skewness C_s = 0,1 for the constructed curves security. Estimated values of water temperatures in the river Vilija in np Mikhalishki with 0,01 % occurrence were received using the probability curves. (Table 104).

Table 104 - Characteristics of the observed and estimated maximum water temperatures of the river Vilija in np Mikhalishki

Air temperatures observed °C			Specified temperature °C, ensured P=0,01 %	
Monthly average high	Max decade (june-july)	Max terminable (daily)	Monthly average high	Max terminable (daily)
23,7	23,7	27,5	26,5	28,0

13.4.10 Water users and consumers

Since in the basin of Vilija Vileyka reservoir was built, Vileika-Minsk water system began to operate since 1976, and drainage of the river Vilija undergone significant changes. After creating the reservoir, average annual runoff of the river Vilija in np Mikhalishki decreased by 12%, maximum - 16%, minimum - 11%. according to the observation period from 1976 to 2007

As studies have shown, the value of recent impact of economic activities in the water-shed area on water regime is within the accuracy of calculations.

Regulated runoff from the land is low. There are 100 ponds in the basin of the river Vilija, with total area of 950 ha and a volume of 14,437.3 m^3.

The value of water withdrawals in the basin of the river Vilija are 104.5 million m^3 and 96.59 million m^3 from surface of natural water sources, 32.76 million m^3 and 30.46 million m^3 from groundwater sources according to data for 2007 and 2008 respectively. Removal of runoff from the river at present does not exceed 124 million m^3 per year, which is less than 10 of the annual flow of 97 above security np Mikhalishki, therefore, there is no significant effect on changes in the drainage regime of the river. Planned growth of non-refundable exemptions for the needs of water in the river basin will not exceed 10 of the runoff 95 occurrence, which is within the inaccuracy of the hydrological variables and will not have significant effects on the hydrological regime of river Vilija.

13.4.11 Protected areas of water bodies

Water protection zones and coastal strips are protected areas of water bodies.

According to the designed project of water protection zones and coastal strips of the river Vilija within the Grodno region [83], which was approved by the Decision of the Grodno regional executive committee dd 30.12.2004 № 709, the minimum protection zone on the left bank of river Villija shoul be 700 m in the np Mikhalishki and 350 m in the np Zabelishki, and the minimum width of the coastal strip along the left bank of the river should be 50 m.

According to Art. 77 of Water Code placing sewage ponds, fields, irrigation, sewage, and other objects capable of causing chemical or biological contamination of surface and groundwater, posing a threat to life and health of people who violate other requirements of ecological safety device objects disposal and storage of waste, except for authorized places of temporary storage of waste shall be prohibited within the boundaries of protection zones.

in addition to the above deployment of facilities for sewage treatment (except for facilities for treatment of storm water) and processing of sewage sludge within the coastal strips should be prohibited.

Within the coastal strips the following construction and reconstruction are allowed:
– waterworks, including water wells and water regulating facilities, as well as hydropower plants, pipelines, engineering infrastructure;

– meteorological survey stations;

– other objects defined by the Council of Ministers upon consultation with the President of the Republic of Belarus.

The following can be held within the coastal strips:

– works related to strengthening the banks of water bodies;

– repair and maintenance of waterworks, including water wells and water regulating facilities, as well as hydroelectric plants, bridges and inland waterways;

– other types of work determined by the Council of Ministers upon consultation with the President of the Republic of Belarus.

Analysis of the size of the water protection zones and locations of sites of the Belarusian nuclear power plant showed that the site is not located in the water protection zone of the river Vilija.

13.5 Assessment of aquatic ecosystems in the 30-km nuclear plant zone

13.5.1 Aquatic ecosystems condition in the 30-km nuclear plant zone

On the territory of 30-km zone around the nuclear plant there is a number of rivers and reservoirs of significant ecological value located. Ecosystem of the river Vilija and its tributaries is unique from an ecological point of view, where rare for Belarus species of salmon live and spawn, which are listed in the Red Data Book. Part of aquatic ecosystems within 30-km zone is a part of the protected areas. There are very beautiful Sorochanskie lakes, possessing a high recreational potential, which are the core of the reserve "Sorochanskie Lakes", as well as large bodies of water lakes Svir and Vishnevskaya (National Park Narochansky) which are very important in the fisheries and recreation. Particular attention should be paid to the fact that the 50-km zone around the power plant captures a significant area of National park "Narochansky". It gets a unique lake ecosystem, a national Belarusian treasure – lake Naroch where the largest recreation and wellness center is located.

The special significance of assessing the impact of nuclear power plants on aquatic ecosystems and, above all, their biological components, is due to the fact that a large part of any chemical and radionuclide contaminants coming both into the air and the soil, later on by the gradient of surface runoff and then as a result of lateral migration enters the water. These pollutants can have serious impacts on biodiversity and gene pool of water bodies and watercourses, as well as on the formation of water quality, which is carried out mainly by biotic cycling of substances and energy flows as a result of life activity of aquatic organisms.

Biotic community (plankton, periphyton, benthos, macrophytes) in the process of life influence the quality of water, determine the intensity of biological purification and the level of productivity of water bodies. Biological processes considerably determine the behavior in water such specific pollutants of nuclear power plants, as radionuclides. Among the basic biological processes that determine the transfer of radionuclides into water and regularity of their distribution in the components of aquatic ecosystems are the processes of biosynthesis of organic substances and their further biogenous transformation. Biological structures constantly formed in the process of photosynthesis, such as phytoplankton, periphyton, macrophytes, as well as products of their transformation - the detritus and heterotrophic organisms, immobilize radionuclides and include biomasses in the composition. Thus, with the new formation of organic substance (primary product) is related to the functioning of the biological pump, continuously pumping radionuclides from the dissolved form into balanced. The subsequent fate of radionuclides and other contaminants associated with biological structures, is determined by biotic cycles, where trophic relationships of aquatic organisms are considered to be an essential element. Radionuclides transferred into a balanced form migrate through the food chain, partly accumulate in the biomasses and partly returne to the aquatic environment with the products of metabolism of aquatic organisms.

Microfine biological structures (planktonic algae and bacteria, detritus particles, weighted products of plankton metabolism) and allochthonous particulate transfer radionuclides from water into bottom sediments during sedimentation process. Sedimentation to some extent is controlled by the biological processes which modify the dimensional range of the suspension. These processes are microbial aggregation of fine particles and fecal excretion of zooplankton. With an average sedimentation rate of seston less than one meter, or about one meter per day sedimentation rate of fecal pellets and fragments of dozens and hundreds of meters per day.

A critical role in radionuclide migration in aquatic ecosystems plays environment-modifying activity of aquatic organisms. For example, the processes of microbial degradation leads to a change in redox potential of medium, formation of anaerobic zones, production of ammonia, etc., which in turn has a direct influence on the sorption-desorption of radionuclides and, consequently, leads to secondary contamination of the water mass.

The project made two rounds expeditionary surveys of aquatic ecosystems, located in the 30-km zone of the Belarusian nuclear power station. Studies conducted in the spring (in May) and in the middle of summer (early August), 2009, periods which reflect the characteristics of the functioning of aquatic ecosystems in a better way.

The aim was to assess the level and intensity of biological processes that determine the formation of water quality, as well as analysis of the structural organization of communities of aquatic organisms, reflecting the ecological status of the investigated reservoirs and streams. Objects of the station and the sites for monitoring are chosen in such a way that the results of their study were given an integral assessment of the ecological situation in water reservoirs and streams, and eventually could be used in a system of environmental monitoring of surface waters.

Samples were taken in May at two cross-sections: the river Vilija: above NPP station - allignment "Mikhalishki" and downstream – alignment "Tartak". Samples taken n the main tributaries of Vilija: river Stracha - in the reservoir Olhovo, river Oshmyanka - at np Yatsyne, river Losha - at np Gervyaty, river Gozovka - at np Gozovka. In all cases, samples were taken in the rivers from bridges in three replicates: the right bank, left bank of the river and the center.

In August 5 more samples were taken in overlying segment of the river from the village Cameno (above Vilejka reservoir) to np Zhodishki, in order to trace the formation of the ecological state of the river Vilija on its way to 30-km plant zone.

In both periods of observation Sorochansk group lakes were investigated: Beloe, Turoveyskoe, Zolovskoe, Kayminskoe, Tumskoe, Golubino, Yedi, Gubeza, Vorobji, as well as lakes Svir and Vishnevskoe. In May samples were taken at each lake at three stations in shallow lakes - at depth of 1 meter and in deep lakes - at several horizons. In August, samples were taken at one station in the pelagic zone of each reservoir in several layers.

The following parameters were specified: transparency, the vertical profile of temperature and dissolved oxygen concentration of suspended solids, chlorophyll content, electrical conductivity (E), pH, organic carbon, total phosphorus, gross and net primary production, destruction, biochemical oxygen demand BOD_5, species composition, abundance and biomass of phytoplankton, zooplankton and benthos, periphyton structure, abundance, biomass and morphometric parameters of bacterioplankton composition of macrophytes. Together, they reflect the structural organization and intensity of life processes of biological unit in the investigated aquatic ecosystems.

Basic morphometric parameters of studied lakes are presented in Table 105.

Table 105 - General information about the surveyed lakes, located in the 30-km nuclear plant zone

Lake name, river basin	Surface area, km^2	Drainage area , km^2	Max depth., m	Average depth, m	Lake volume, mln m^3
Beloe	0,34	н	4,0	2,0	0,69
Turoveyskoe	0,38	131,0	4,7	2,7	1,04
Zolovskoe	0,24	140,0	12,6	4,9	1,17
Kayminskoe	0,43	159,0	19,5	7,6	3,26
Tumskoe	0,86	172,0	9,2	4,8	4,16
Golubino	0,14	4,3	21,0	8,1	1,13
Yedi	0,61	4,3	19,7	7,9	4,84
Gubeza	0,23	6,0	12,9	6,6	1,32
Vorobji	0,46	8,2	3,1	2,0	0,94
Vishnevskoe	9,97	56,2	6,3	2,1	19,79
Svir	22,28	364,3	8,7	4,7	104,30

To assess the ecological status of aquatic ecosystems located in the 30-km zone of the Belarusian nuclear power station, published materials, as well as stock and archival were taken in consideration [84-89].

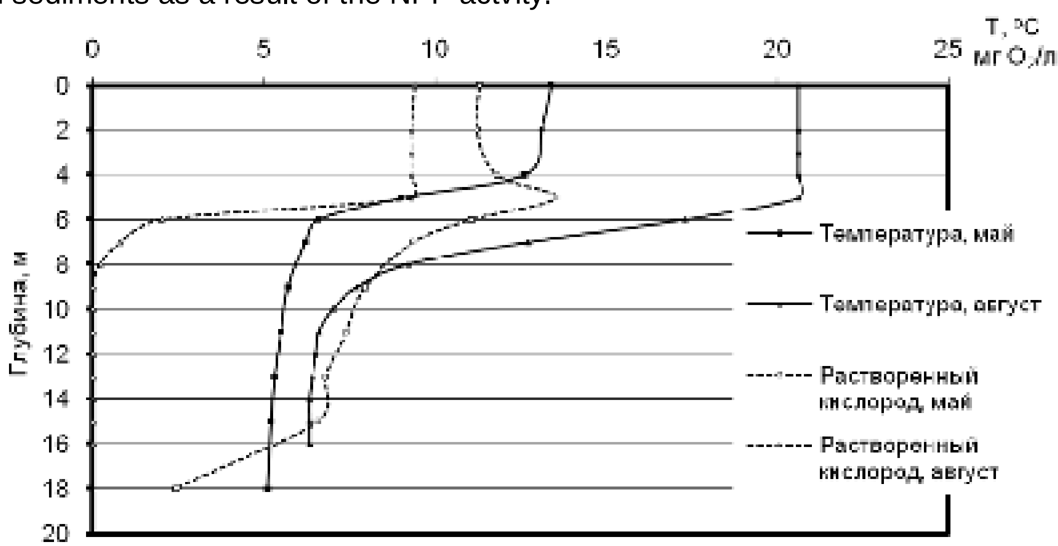
An earlier-than-normal spring warm-water mass in 2009 leded to intensive development of phytoplankton and its high photosynthetic activity. In early May, almost all of the studied streams supersaturation of surface layers of water with oxygen was observed. In the district of river Vilija in np Tartak and river Losha oxygen content was at the highest rate - above 130 %, on the other rivers, it ranged within 105-115 %. In August, the oxygen content in the river Villija and its tributaries also exceeded 100 % saturation.

Supersaturated river waters indicate a high level of photosynthetic aeration, which plays an important role in the processes of biological self-purification and the formation of water quality. Rapid warming of the surface layers of water in the absence of wind mixing in the period preceding May studies, had caused the temperature stratification of water masses, even in shallow Sorochansk lakes, which was accompanied by a natural decline in dissolved oxygen with depth. Attenson should be paid to the fact that of early formation of a sharp shortage of oxygen in the bottom layer in a number of lakes (Lake Beloe, Turoveyskoe, Vishnevskoe).

In May in deep lakes of Sorochansk Group (Gubeza, Yedy, Golubino, Kayminskoe) specific for dimiktic lakes temperature and oxygen vertical profile features were formed with division of water mass in the epi-, meta-and hypolimnion, as illustrated by Figure 69. Oxygen content decreased sharply with depth in the hypolimnion.

In August, the oxygen content in the surface horizons exceeded 100 % saturation in a group of shallow lakes, except Lake. Podkostelok. A lack of it, mostly close to zero values in the bottom layer, was observed only in the lakes Beloe and Zolovskoe. In the deep and medium deep Sorochanskie lakes (Gubeza, Yedy, Golubino, Kayminskoe, Tumskoe) the nature of the temperature and oxygen vertical profiles were similar. In each of these lakes in the entire layer below the upper metalimnion oxygen is absent completely in the bottom layers marked by the smell of hydrogen sulfide.

As a matter of record it can be suggested that by the middle of the growing season in lakes with anaerobic hypolimnion secondary contamination of the water column by some nutrients and heavy metals and radionuclides becomes possible, if they accumulate in sediments as a result of the NPP actvity.



Vertical: Depth, m
Temperature, May
Temperature, August
Dissolved Oxygen, May
Dissolved Oxygen, August

Horizontal: T ºC, mg O2/l

Figure 69 - Temperature and oxygen content in water of the lake Yedy

A characteristic feature of aquatic ecosystems is the presence of special structural and functional component - seston (a combination of suspended particles in the water column). Seston is extremely heterogeneous and includes microscopic forms of living organisms, their remains, as well as lifetime isolations and rejections of bacterio-, phyto- and zooplankton. The structure of seston consists of organic and mineral particles, formed from physical and chemical processes in the water column, re-suspended from sediments and entering water from watershed. Also a large part of the substances formed during decomposition of macrophytes and other large benthic and nekton organisms are transformed from the finely divided suspension.

The role of seston in the functioning of aquatic ecosystems is large and diverse. As seston consists of living organisms, all aspects of the metabolism of plankton are closely connected with mentioned structural unit of ecosystem, firstly, main elements of the biotic cycle - production, transformation and mineralization of organic matter. However, not only planktonic organisms, but also the whole complex of seston as a combiation of fine particles has a significant influence on the circulation of substance and energy flows in the ecosystem. For example, suspended solids actively influence the processes of degradation and livelihoods of microbial community. The suspension fully determines the possibility of existence of essential and specific component of aquatic ecosystems - communities of organisms with filtration feeding type. By means of sedimentation seston is aliened to life activity of benthic communities and is an important functional element in the system "water - bottom sediment.

A major component of seston is phytoplankton, where chlorophyll a is widely used as a marker of abundance in the practice of Hydrobiological studies - the main photosynthetic pigment involved in the processes of autotrophic biosynthesis of organic substance. Taken together, suspended matter (seston) and chlorophyll "a" are informative indicators of the level of lake trophy. Data of seston and chlorophyll concentration in the rivers are presented in a Table 106.

Seston concentration in the studied plots of the river Vilija is high - 13,7-15,5 mg / l with a significant relative share of chlorophyll-a (0,58-0,60%). The absolute values of chlorophyll-are very large - 81.4 and 90.2 mg / l in alignments of np Mikhalishki and np Tartak respectively. This high level of chlorophyll content shows a high proportion of phytoplankton in the total mass of seston and typical for highly eutrophic aquatic ecosystems.

Trophy level of tributaries of the river Vilija is much lower; however, all of them belong to the class of eutrophic waters. The concentration of particulate matter in the tributaries in May quite similar (5,0-6,4 mg / l), except for a small river Gozovka (3,4 mg / l). The concentration of chlorophyll-a is also close in tributaries (16-20 mg / l), except river Oshmyanka where its content exceeded 40 micrograms per liter. The high degree of correlation (r = 0,96) of particulate matter concentration containing chlorophyll-a indicates the important role of plankton in the formation of suspended solids in the studied rivers.

In August,in the river Vilija in alignment Mikhalishki and Tartak concentration of suspended solids (10.7 and 14.9 mg / l, respectively) differed only slightly from the values observed in May, despite the fact that the absolute content of chlorophyll-a decreased by almost half, accounting for 42.9 and 49 , 5 mg / l, respectively. As a result, their relative share in the dry mass of particulate matter decreased up to 0,40 and 0,34%, reflecting the diminishing role of autotrophic component of plankton in the formation of a common pool of particulate matter.

Table 106 - The concentration of seston and chlorophyll-a in the river Vilija and its tributaries

River, alignment	Seston, mg/l	Chlorophyll-*a,* mkg/l	Chlorophyll share in seston, %
Vilija, Mihalishki	13,7±1,6	81,4± 6,0	0,60±0,04
Vilija, Tartak	15,5±1,8	90,2±1,8	0,58±0,02
Stracha	5,0±0,23	15,8±0,8	0,31±0,01
Losha	6,4±2,6	16,3±1,8	0,26±0,09
Oshmyanka	6,2±0,6	40,9±2,1	0,62±0,03
Gozovka	3,4	20,0	0,59

As follows from the data presented in Table 107, in May in shallow lakes of Sorochanskaya group, as well as in lakes Svir and Vishnevskoye concentration of suspended solids was close to that observed in the tributaries of the river Vilija being in range of 4,6-8,2 mg / l. A notable uneven distribution of indicators in lakes, with rare exceptions, were not observed. Chlorophyll-a in shallow lakes Sorochanski practically identical - 24,2-28,7 mg / l. In larger open lakes Svir and Vishnevskoe, both absolute and relative content of chlorophyll-a was significantly lower - 15.5 mg / l and 0.34 % in the lake Svir and 5.3 mg / l and 0.10 % in the lake Vishnevskoe. The low proportion of chlorophyll-a in sestone of the lake Vishnevskoye - 0,10 % versus 0,31-0,61 % in the other lakes, is due to apparently hit in the suspension of silt particles in the resuspension of bottom sediments.

In deep lakes Yedy, Gubiza and Golubino concentration of seston and chlorophyll-a in both the periods of observation were lower than in shallow waters with a pronounced unevenness in depth. In the bottom layer of lakes Gubeza, Kayminskoe, Tumskoe with depths observation stations of 10,7 and 8.5 m a sharp increase in the amount of suspended solids at the bottom with a decrease in the relative proportion of chlorophyll-a in their composition had been noted. In all of these lakes under anaerobic conditions of hypolimnion a significant part of chlorophyll is for bacteriochlorophyll.

Table 107 - The concentration of seston and chlorophyll-a in the lakes

Lakes	Seston, mg/l	Chlorophyll-*a,* mkg/l	Chlorophyll share in seston, %	Transparence, m
Beloe	5,5±0,6	24,2±2,1	0,45±0,02	1,5±0,1
Vorobji	8,2±0,4	25,4±3,0	0,31±0,03	1,3±0,1
Turivejskoe	4,6±0,9	28,7±10,5	0,61±0,10	1,7±0,4
Zolovskoe	5,4±0,3	29,9±3,8	0,56±0,08	1,6±0,2
Tumskoe	3,8±0,7	18,5±1,3	0,50±0,08	1,9±0,2

Gubeza	1,7±0,3	1,9±2,0	0,13±0,03	4,6±0,1
Kajminskoe	3,4±0,9	28,0±8,5	0,81±0,12	1,6±0,2
Golubino	2,1±0,3	5,4±0,2	0,26±0,03	2,3±0,2
Yedi	2,0±0,6	3,4±0,1	0,17±0,03	4,7±0,0
Svir	4,6±0,2	–	–	2,3±0,1
Vishnebskoe	5,3±0,3	–	–	1,8±0,1

Water quality, biological productivity and overall ecological status of aquatic ecosystem is formed during the complex processes of biotic cycle, which serves as a trigger for the operation of autotrophic communities. As a result of their livelihoods in the process of photosynthesis organic matter is growing (primary production), which is then transformed and mineralized by heterotrophic communities. In the studied reservoirs and streams in 30-km zone of the Belarusian nuclear power plant in conjunction with measurements of gross primary production of plankton degradation (rate of consumption of oxygen in the water column)was determined, which characterizes the activity of heterotrophic plankton community. A value of biochemical oxygen demand - BOD_5 was also measured. The latest value, often used in the practice of health research, describes an important parameter of water quality - the number of labile fraction of organic matter. The values of gross (WFP), net (NPP) primary production, decomposition (D) and BOD_5 in the river Vilija and its tributaries are listed in Table 108.

Table 108 - Primary production, destruction and BOD_5 in the river Vilija and its tributaries

River	WFP	D	NPP	BOD_5, mg O_2/l
	mg O_2/l per day			
river Vilija, Mihalishki	7,89±0,65	0,88±0,05	7,01±0,60	4,01±0,17
river Vilija, Tartak	7,73±1,37	0,96±0,02	6,77±0,02	4,66±0,43
river Stracha	1,73±0,08	0,49±0,03	1,24±0,05	2,09±0,24
river Losha	1,94±0,47	0,37±0,09	1,57±0,46	1,70±0,18
river Oshmianka	5,82±0,08	0,64±0,12	5,18±0,12	2,85±0,13
river Gozovka	1,85	0,27	1,58	1,52

Extremely high gross of primary production of plankton was observed in the river Vilija in both alignments (7,9 and 7,7 mg O_2 / l • day). At relatively low organic matter destruction plankton net production was significant (7.01 and 6.76 mg O_2 / l • day). The values of BOD5 - 4,01 and 4,66 mg O_2 / l higher than fisheries regulations MCL (3.0 mg O_2 / l). High values of gross and net primary production were recorded in the river Oshmyanka (5,8 and 5,2 mg O_2 / l • day) at a relatively low value of BOD_5 (2.85 mg O_2 / l• day). In other rivers the values of all examined parameters were significantly low and corresponded to the level typical for reasonably eutrophic waters.

In August river Vilija and its tributaries, the level of all, without exception, quantities of production-destructive performance was reduced. Especially large changes (more than two orders of ranges) reached the level of primary production in the river Oshmyanka. Thus, WFP in August amounted to 0.38 mg O_2 / l day. versus 5.82 mg O_2 / l day., NWP - 0,10 mg O_2 / l day. verus 5.18 mg O_2 / l day.

During the both terms of lakes observation, level of primary production was significantly lower than in the river Vilija. In May, the gross primary production in the surface layer of all the surveyed lakes was 0,51-2,47 mg O_2 / l • day., Destruction - 0,25-0,92 mg O_2 / l • day. BOD_5 varied in the range from 1,2 mg O_2 / l (Lake Yedigei) to 4.26 mg O_2 / l

(Lake Sparrows). In August, in lakes, in contrast to streams, the levels of production indicators increased.

In shallow lakes Beloe, Turoveyskoe, Svir, Vishnevskoye WFP was in the range 2,5-3,4 mg O_2 / l • day., Destruction 0,6-1,0 mg O_2 / l • day., BOD_5 - 2,0 -3.7 mg O_2 / l. Similar values of the indicators observed in lakes Zolovskoe, Tumskoe and Kayminskoe. The lowest values of indicators in this group of lakes were observed in the lake. Podkostelok - WFP - 1,0 mg O_2 / l day., D - 0,5 mg O_2 / l day. BOD_5 and - 1,5 mg O_2 / l, the highest - in the lake Sparrows, respectively - 5,9 mg O_2 / l day., 1,6 mg O_2 / l day and 6.4 mg O_2 / l.

Based on materials of observations made in spring, correlation between the studied hydro-indicators of water quality in river and lake ecosystems was estimated. The results are listed in the Table 109.

In the absence of serious violations of the typically -functioning aquatic ecosystems there should be a close relationship between the various parameters characterizing the intensity of production processes and quality of water. Data on the correlations in the studied ecosystems in the table 109 indicate their functioning in a normal regime, which is characteristic for each of the studied reservoirs and streams

Table 109 - Correlation coefficients (Pearson) between the individual hydro rates in the studied lakes and rivers

Lakes							
Datas	$C_{sest.}$	C_{chl}	C_{org}	P_{total}	WFP	D	BOD5
$C_{sest.}$, mg/l	1,00	–	–	–	–	–	–
C_{chl}, mkg/l	**0,75**	1,00	–	–	–	–	–
C_{org}, mg C/l	-0,03	0,00	1,00	–	–	–	–
P_{total}., mg R/l	**0,97**	**0,84**	0,05	1,00	–	–	–
WFP, mg O_2/l*day	**-0,60**	-0,54	-0,15	**-0,77**	1,00	–	–
D, mg O_2/l*day	-0,11	-0,28	**-0,63**	-0,21	**0,67**	1,00	–
BOD_5, mg O_2/l	-0,58	-0,55	-0,10	-0,62	**0,98**	0,64	1,00
pH	-0,24	-0,55	0,08	-0,34	0,36	0,07	0,32
Transparency , m	-0,46	-0,19	**0,67**	-0,37	0,28	-0,16	0,25
Rivers							
$C_{sest.}$, mg/l	1,00	–	–	–	–	–	–
C_{chl}, mkg/l	**0,94**	1,00	–	–	–	–	–
C_{org}, mg C/l	**0,65**	**0,62**	1,00	–	–	–	–
P_{total}., mg R/l	**0,79**	**0,89**	0,50	1,00	–	–	–
WFP, mg O_2/l*day	**0,82**	**0,94**	0,46	**0,83**	1,00	–	–
D, mg O_2/l*day	**0,87**	**0,94**	**0,68**	**0,75**	**0,91**	1,00	–
BOD_5, mg O_2/l	**0,90**	**0,97**	**0,66**	**0,79**	**0,94**	**0,95**	1,00
Note - statistically significant coefficients are bold faced ($p < 0,05$)							

The set of given materials allows us to conclude that among the ponds and streams 30-km zone around the nuclear plant stands out the river Vilija with high trophy level and high-speed neoplasm of fine biological structures (phytoplanktonic organisms and products of their transformation). This, undoubtedly, will determine the nature of the processes of biological purification, distribution of individual biological components of river ecosystems and the migration of radionuclides and other pollutants entering the river in during nuclear power plant activity.

13.5.2 Structural organization of biotic communities

13.5.2.1 Phytoplankton

Species rwealth of phytoplankton in rivers and reservoirs in 30-km zone around the nuclear plant is high (Table 110). During the study 209 species were identified.

Comparison of species composition and quantitative development of phytoplankton in the studied rivers and lakes showed that in May, the highest species richness and the highest rates of quantitative development of phytoplankton, as well as the level of its products, shows the river Vilija. In other rivers, as compared with the river Vilija, biomass of phytoplankton, for example, was nearly 5-fold below.

Table 110 – Species of algae saturation of phytoplankton in May in the studied streams

Section, klass	river Vilija	river Stracha	river Losha	river Oshmyanka	river Gozovka
Diatomaceous	26	13	15	20	17
Green:	21	5	9	19	7
– chlorokok	17	5	9	17	6
– volvate	3	0	0	2	1
– desmids	1	0	0	0	0
Golden	7	10	7	9	5
Blue-green	8	2	1	2	1
Cryptophytic	6	4	4	4	3
Dinophisis	2	0	1	2	0
Vglenovye	3	2	0	3	2
Total	73	36	37	59	35

The greatest number of species was found in the river Vilija (73), the lowest - in the river Gozovke (35). The second-highest number of species - river Oshmyanka (59). Diatoms are of greatest species wealth in all streams. The second highest number of species in all rivers, except for the river Stracha (right tributary of the river. Vilija, all the others are left tributaries) are green and gold in the river Stracha, where the number of species two times higher the number of species of green algae. The number of species of blue-green algae and cryptophytae in the river Vilija appeared more than in other streams, as well as three representatives of euglenophytes and volvoks. The golden ones held the third place in all streams, except river Vilija.

The studied streams have different divisions of algae species wealth, indicating that the originality of their species composition. In all studied streams diatoms dominated. The peculiarity of the studied streams during the study period was excessive development of golden algae. In the river Vilija they constituted 9.6% of the total number of species, in the tributaries - 27,8 (river Stracha), 18,0 (river Losha), 15,3 (river Oshmyanka) and 14,3% (rver Gozovka). In the most amount of small rivers golden ones belonged to the dominant complex, or were in the rank of the dominant (more than 10 % of the total number of phytoplankton) or subdominants (5,1-10,0%), yielding the main dominants - representatives of diatoms and algae cryptophytae.

Summer phytoplankton of the studied streams differed significantly from the spring ones, which is evident from species wealth, composition of the dominant species complexes, the quantitative indicators of the overall phytoplankton and its constituent divisions of algae. The number of species found in the processing of quantitative sediment samples of phytoplankton in the tributaries of river Vilija in August was considerably lower than in May and only the river itself Vilija showed greater species diversity - 117 species in August against 73 in May. Among the species found in the river, 41% belonged to the green algae, 81,2 of which were chlorokokk, 23,9 - diatoms – and 17,9 % - blue-green, golden ones amounted to 6,8, other ranks had only 2,6-3 , 4.

As well as in the rivers, in all lakes, except the shallow lake Vorobji there were diatoms which showed the most diversity. Their number was averagefor all lakes - 33,5 % of the total number of identified species. The most dominant sets along with diatoms in lakes (Cyclotella meneghiniana, Aulacoseira ambigua, Aulacoseira granulata, Cyclotella sp., Synedra acus, Fragillaria crotonensis, Tabellaria fenestrata, Melosira varians), was golden one, also widespread (Dinobryon sociale, Dinobryon divergens, etc .), and rare not only for Belarus but also for other countries (Uroglenopsis apiculata, Uroglena gracilis, Kephyrion sphaericum, Pseudokephyrion entzii). For example, Uroglenopsis apiculata was a member of the dominant complex of biomass in all types of lakes:

- In shallow lakes Beloe and Turoveyskoe its biomass was at some stations up to 42.5 and 56, 3 %, respectively;
- In average deep lake Zolovskoe - up to 64,5 %, while in a deep lake Kayminskoe - up to 71,9 %.

Indicators of species diversity (Shannon index) and the equalization of community index (Piel) for the lakes, as well as for the rivers were high, close to the upper level of their values. High index values indicate the great diversity of phytoplankton communities and polydominant, and this, in turn, implies a fairly high degree of resistance to environmental factors. The dominance of representatives of golden algae, along with diatoms characterizes the studied lakes as clean.

13.5.2.2 Zooplankton

In the plankton of the rivers in 30-km zone of the belarusian nuclear power plant during the study 21 species were revealed, and in the plankton of lakes - 32 species of invertebrates, indicating a considerable species wealth of zooplankton in the studied region. Among the rivers the greatest number of species was identified in the river Vilija (21), the lawest - in the river Gozovka (9). The values of abundance and biomass of zooplankton were also maximal in the river Vilija (219,3 ± 108,2 thousand copies. / M 3 and 0,415 ± 0,169 g/m3) and exceeded the related values in other rivers 3-13 and 3-20 times

This is compliance with the RTSRKM data obtained at the fixed network of NEMS during the period 2004-2007. Among the studied lakes the largest number of species was identified in average deep laskoeke Tum (22) and deep lake Kayminskoe (21). In other lakes, the number of zooplankton species was close to 11-14 species. The highest total abundance and biomasses of zooplankton were observed in a shallow lake Vorobji - 3446.4 ind/m3 with biomass of to 6.72 g/m3, which is 1,5 to 30 times more than the value set for the other surveyed lakes. In rivers and shallow lakes, the bulk of the total number and biomass of zooplankton made rotifers, which are typical for the spring period. In average deep and deep lakes rotifers also dominated, and in biomass - Copepods.

A high indicator value among organisms, zooplankton have rotifers genus Brachionus. Almost all the rivers studied, except for the river Gozovka, the species of this genus were marked - Brachionus angularis, B. calyciflorus and B. urceus urceus. Moreover, in the river Oshmyanka B. angularis was a member of the dominant species with a share of the total number of zooplankton, equal to 15,4%. The three rivers - Vilija, Stracha and Losha rotifer Brachionus urceus urceus was awarded with a relatively small number - 9,7, 1,1 and 0,9 thousand specimens/m^3, respectively. It is important to note that this species is an indicator of polluted water and live in the watersof increased saprobity. In four of the investigated lakes -Beloe, Zolovskoe, Tumskoe and Kayminskoe rotifer genus Brachionus were also specified. In the lake Kayminskoe Brachionus diversicornis homoceros was found, with the number of 1,2 thousand specimens/m^3. This species are found in waters of high trophy. It should be noted that the number of species of the genus Brachionus in zooplankton of studied rivers and lakes, except for the river Oshmyanka is low. However, the presence of rotifer genus Brachionus indicates the high content of organic matter.

The index of Shannon, which characterizes the overall diversity of the community, and the index Piel, which characterizes the uniformity, as for the rivers and the lakes are high. Thus, the values of Shannon index lie within 1,54-3,07 bits / instance (0,94-2,34 bit / g); index Piel - 0,49-0,96 bits / instance (0,29-0 75 bit / g).

Thus, according to aggregate indicators of the structural organization of zooplankton communities, we can conclude that the ecosystems of investigated reservoirs and streams in 30-km zone around the nuclear plant operating in steady regime.

13.5.2.3 Periphyton

A characteristic feature of any freshwater ecosystem is the presence of large or smaller scale of the boundary surface separating the liquid (water) and solid (the substrate of different nature and origin) phase. At the interface of a range specific physical-chemical and hydrodynamic conditions work, which determine the separation of independent biotope - perifitali. Perifitalyu is related to the existence of periphyton. According to the existing views, under the periphyton we understand the complex which is formed on the surface of a solid substrate, regardless of the origin of the latter (natural, artificial), in a more mobile conditions than in the bottom of the reservoir, and include autotrophic (algae, cyanobacteria) and heterotrophic (bacteria, fungi, invertebrates) organisms and organic matter from different backgrounds and varying degrees of processing (detritus). Periphyton can be seen as bright example of "edge effect", ie "Thickening of life" at the interface of the liquid (water) and solid (the substrate of different nature and origin) of the phases, which substantially increase species diversity, biomass and metabolic activity of organisms. In small lakes and rivers through periphytons unit a significant flow of matter energy can go. The importance of periphyton in the formation of water quality is greate. Periphyton, along with other intertidal communities, accumules nutrients and pollutants coming from the catchment acts as a buffer, and provide the stability of ecosystems to human impacts. Periphyton plays an important role in the processes of self-purification of aquatic ecosystems from contamination, as characterized by extremely high rates of accumulation of radionuclides (up to 104). Periphyton is widely used as a monitor of all types of pollution, including radioactive. The above features of periphyton necessitate a comprehensive study of this block of aquatic ecosystems in 30-km zone of the Belarusian nuclear power station.

Studies of periphyton in rivers and lakes in 30-km zone around the nuclear plant were made in two directions:

- Assessment of the abundance of periphyton as a single complex, combining the biota and detritus, and identification the key indicators of its structural organization;
- Study of the species composition and structure of algal communities, which have the highest proportion among the biotic components of the periphyton.

It was specified that the abundance of periphyton in streams varies widely. Maximum number of periphyton observed in the river Vilija (84,9 ± 75,1) mg/10 cm^2, which corresponds to the general high level of trophy river, the minimum values found in the river Stracha (1,0 ± 0,3) mg/10 cm^2.

Abundance of periphyton on macrophytes in lakes of the 30-km nuclear plant zone is much lower than in rivers. Mean values for the lakes ranged from 3.9 to 25.8 mg/10 cm^2. The maximum value of the total mass of periphyton observed in the lake Yedy, minimum - in the lake Zolovskoe.

In periphyton of all surveyed rivers mineral fraction predominates over organic. The minimum value of ash content was 57.3% (river Stracha), maximum - 78.6% (river Vilija). Ash content of periphyton in lakes is much lower compared to periphyton in rivers: in most lakes values fall within the limits (49-61) %. An exception is the Lake. Golubino, where periphyton organic fraction is much higher than the mineral one (ash 29.5 %).

An important indicator of the structural organization of the contents of the periphyton is its content in the mass of chlorophyll. It is possible to determine the biomass of algae with a help of chlorophyll, as well as the approximatly estimate the ratio between autotrophic and heterotrophic components of periphyton. The content of chlorophyll in periphyton in the studied rivers varied within a narrow range - from 1,9 to 2,5 mg / mg dry weight of periphyton. The limits of the values in the lakes significantly wider - from 1.0 ug / mg (Lake Gubeza) to 3.9 ug / mg (Lake Beloe).

Periphyton in surveyed rivers and reservoirs is characterized by high species wealth of algae. During the study 168 species were identified, including 116 in the rivers and 123 in lakes. The maximum number of species found in the river Vilija (77), minimum - in the river Gozovke (39).The number of species In lakes ranged from 46 (Lake Golubino) to 59 species (Lake Tumskoe).

Diatoms are characterized by the highest species diversity and abundance in rivers and the lakes. They form the basis of the dominant set of all surveyed ecosystems.

Indicators species diversity of communities of periphyton (Shannon index) and the equalization index (Piel) in the rivers are very high. In all the surveyed rivers Shannon index was about 4.5, while the index Piel approximately 0.8 bits / instance. Indicators of diversity of periphyton in lakes are generally lower than in rivers. Index values for different lakes vary considerably. The minimum values of the indices of Shannon and Piel are typical for periphyton in lake Golubino (1,9 and 0,38 bits / instance), the maximum for the lake Vorobji (4.35 and 0.8 bits / instance).

In general, indicators of the structure of periphyton in surveyed reservoirs and streams meet the prevailing notions about the structural organization of periphyton in aquatic ecosystems of the biochemical type and characterize the regme of their functioning as normal.

13.5.3 Water quality and ecosystem state assessment by hydrobiological indicators

Features of the structure and functioning of aquatic communities are largely related to the quality of the aquatic environment. Many studies have shown that any stressful event leads to significant shifts in the structure and functioning of communities. Therefore, we can solve the inverse problem using the communities state - to evaluate the quality of the environment. That community's parameters are key to assessing the state of ecosystems and further the calculation of environmental risks. Stress effects lead to significant shifts in the structure and functioning of communities. Therefore, community's parameters are key indicators to assess ecosystem conditions and further calculate an environmental risk.

Water quality in the studied rivers and lakes was evaluated on the basis of structural and functional indicators of biological communities and biotic indices. Key indicators are presented in Tables 111-113

Table 111 – Range of changes of the total number of species in different communities of studied rivers and lakes

Type of water bodies	Community	Number of Species
Rivers	Phytoplankton	33-65
	Periphyton	34-54
	Zooplankton	9-21
Lakes	Phytoplankton	33-48
	Periphyton	30-54
	Zooplankton	9-23

Table 112 - Average values of water quality in the rivers studied (numerator) and the ranking of the rivers descending water quality (denominator)

River	Indicators of structural diversity*		Indicators of Eutrophication		Indicators of organic pollution*	The average value in series (descending quality)
	Shanon index, bits /individual	Piel Index	The presence of rotifers in zooplankton p. Brachionus	WFP /D	Pantle Bucca Index of saprobity	
Vilija	3,33 4	0,68 4	2 % 3	8 4	1,77 4	3,8
Stracha	2,48 5	0,62 5	1 % 2	3 1	1,65 2	3,0
Losha	3,68 2	0,84 2	2 % 4	5 2	1,71 3	2,6
Oshmianka	3,47	0,77	17 %	9	1,86	4,2

	3	3	5	5	5	
Gozovka	3,82 1	0,87 1	– 1	7 3	1,56 1	1,4

* Mean values for the phytoplankton, periphyton and zooplankton

Table 113 - Average values of water quality in the studied lakes (numerator) and ranking lakes descending water quality (denominator)

Lake	Indicators of structural diversity*		Indicators of Eutrophication		Indicators of organic pollution*	The average value in series (descending quality)
	Shanon index, bits /individual	Piel Index	Pantle Bucca Index of saprobity	WFP /D	Индекс сапробности по Пантле-Букк	
Beloe	2,78 5	0,65 5	<<1%	2 4	1,66 8	5,5
Vorobji	3,14 5	0,67 3	–	3 9	1,52 1-2	3,9
Turavejskoe	3,17 1	0,73 1	–	3 7	1,65 7	4,0
Zolovskoe	2,74 7	0,61 7-8	<<1%	2 5	1,67 9	7,1
Tumskoe	2,61 8	0,61 7-8	–	2 2	1,62 5-6	5,8
Gubiza	2,96 3	0,70 2	–	3 8	1,52 1-2	3,6
Kajminskoe	2,79 4	0,62 6	<<1%	2 6	1,62 5-6	5,4
Golubino	2,37 9	0,56 9	–	1 1	1,61 4	5,8
Yedi	2,75 6	0,66 4	–	2 3	1,58 3	4,0

* Mean values for the phytoplankton, periphyton and zooplankton

Data analysis of the structural diversity was performed on the basis of calculation of Shannon and Piel indexes for phytoplankton, zooplankton and periphyton. It is need to specify that, in the rivers and the lakes, species wealh of phytoplankton and periphyton community is about the same (30-50 species in the sample), and several times greater than zooplankton (10-20). Considering the difference of species wealth of communities, the Shannon index values for the zooplankton community were obtained lower than for the phytoplankton and periphyton on the same stations observing at the same time.

The Shannon and Piel indexes in the community of phytoplankton in different rivers, compared with other communities, changed in a very narrow range - respectively 3,2-4,0 and 0,7-0,8 bits / individual. Compared to phytoplankton, the indexes calculated from periphyton samples showed a clear difference between the studied watercourses, as the level of species diversity of communities, and on equalization.

In lake ecosystems, periphyton community was characterized by the maximum difference of indexes, which indicates a higher potential for fouling the indicator.

The level of biodiversity in the lakes were not significantly different, the values of the Shannon and Piel indexes were slightly lower in the lake Golubino, the maximum - in lakes Turaveyskoe and Gubiza.

In general, in lakes, in comparison to river ecosystems, biodiversity indicators were slightly lower.

Indicators of primary production and destruction have a quick response to changing environmental conditions, which allows the use the ratio of production-destructive characteristics for rapid assessment of the aquatic environment. Thus, in zones of polluted waste water ratio of production and destruction falls below 1, with high nutrient load – is much higher.

In rivers, the ratio of gross primary production of plankton in the destruction (WFP / D) ranged from 3 to 9, the maximum values recorded for the rivers Vilija and Oshmyanka, minimum - for the river Stracha.

Unlike rivers, the ratio of the WFP / D in the lakes was lower, varying from 1 in Lake. Golubino to 3 in the lake Vorobji, which indicates a more balanced production-degradation processes in lakes.

The calculation of the saprobity index in rivers and lakes was carried out for the phytoplankton, periphyton and zooplankton, and the calculated parameters were close enough to the different communities, varying within 1,5-2,0.

In general, the studied rivers and lakes can be attributed to β-mezosaprobic zone, while river Gozovka and lakes are at its border with oligosaprobic zone, which allows to characterize the quality of water in them as fairly good.

The analysis of the rivers showed that they are all characterized by similar values of structural and functional indicators of biological communities and good quality water. The highest water quality characteristic were for the river Gozovka, then for the river Losha, Stracha and Vilija, the lowest - in river Oshmyanka.

The studied lakes are also a fairly homogeneous mass. When analyzing the data no significant differences between them was revealed. Values of structural and functional indicators and saprobity indexes in different reservoirs are very close, while the average for the lakes was slightly lower than for rivers. The lakes Gubiza, Vorobji, Turaveyskoe and Yedy are characterized by a little higher rates. Zolovskoe lake takes the last place is among the studied lakes.

Thus, we can conclude that all the studied rivers and lakes are characterized by fairly good indicators of water quality.

The use of periphyton communities as an indicator of the state of the aquatic communities structure is the most promising.

13.5.4 Springs

In the 30-km nuclear power plants zone and adjacent territories there is a special type of aquatic ecosystems - the springs, which play an important role in shaping the overall biological diversity of water bodies of Belarus. A number of cold-loving species of freshwater invertebrates, those from rivers and lakes in northern Europe and mountain reservoirs in Central Europe, in the territory of Belarus can only exist in a pure and cold-water springs.The springs in 30-km zone are inhabited by at least 25 rare, first detected in Belarus, aquatic invertebrates, not recorded previously in any type of water [90.91].

A very rare type of beetles that inhabit springs in Belarus is the Agabus guttatus. It can be assumed that this species is representative of aqueous glacial relict fauna. Among the crustaceans raznonogogo crustacean sinurellu Synurella ambulans Müller should be allocated, 1846 (cem. Gammaridae). Sinurella is unique for the fauna of Belarus ancient fresh water kind of North American origin. As a relic of pre-glacial epoch in the fauna of Belarus S. ambulams has great scientific value. The springs are a refugia for a number of relics of previous geological epochs, as well as a connecting link between the fauna of rivers and lakes of northern Europe and fauna, cool mountain waters of central Europe. At the same time springs ecosystems, as compared with lakes and rivers, were the least resistant to human impacts. Thus, the ecological value of spring ecosystems on the one hand, and their vulnerability on the other hand, determine the need to provide special measures to preserve the springs. Among these measures may be adding springs to nature monuments or sanctuaries with the appropriate regime s for their protection.

In the northwest Ostrovetsky district, Grodno region within Oshmiany hill near the village Varona, Kemeleshki, Bistritsa there is a number of spring-strand complexes, which are characterized not only by the peculiarities of the morphological characteristics, but also their inherent uniqueness of the fauna. In these water bodies there are rare species of benthic invertebrates and fish exist. It is the only region of Belarus for anadromous fish spawning - trout and salmon. This area is located in the basin of the river Vilija. Near the point states geodetic network, combined with the center points of the Dugi Struve "Conrads". Altitude is 300 m.

Nine springs were examined - springs complexes presented in figure 70:

1) № 1 - Spring-strand complex. Boloshina,
2) № 2 - Spring-strand complex. Poruba,
3) № 3 - Spring-strand complex. Klevatishki,
4) № 4 - Unnamed spring. The right bank of river. Vilija. District Bystrica
5) № 5 - Separate spring-water solution. Stream untitled,
6) № 6 - Separate spring-water solution. Stream untitled,
7) № 7 - Spring-strand complex Tartak. Before flowing into the river Vilija,
8) № 8 - Spring field. Upper Tartak,
9) № 9 - Spring-strand complex Senkanka. Varona.

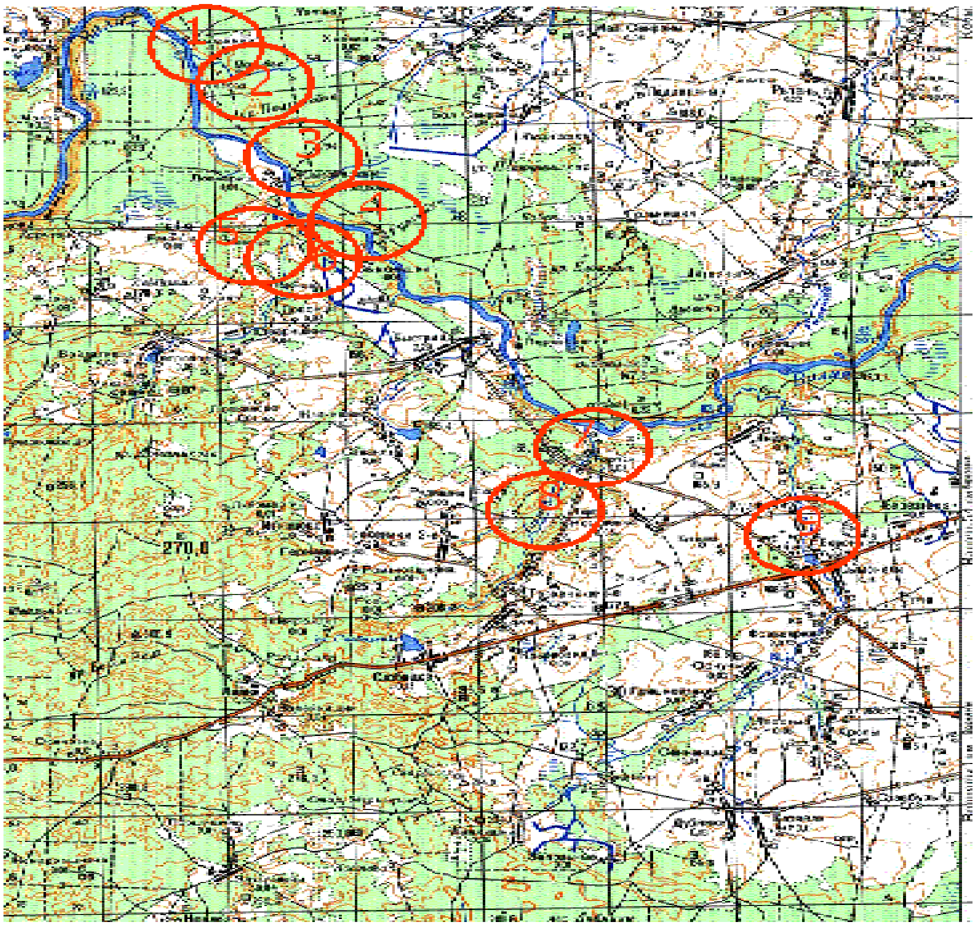


Figure 70 - Schematic map of the localization of surveyed spring-strand complexes in the villages Varona, Kemeleshki, Bistritsa

Accept spring-streams complexes of Oshmiany hills there is an information about the whereabouts in 30-km zone of the spring "Krynichka To bagini" on the right bank of Vilja around the village Dubok (Smorgon rn). Spring is encapsulated. Not protected. In its original form, probably is a limnokren. Main forest-ing species are birch, alder with noe assential admixture of spruce and pine. Spring with an artificial grotto, and is located approximately 500 meters away Catholic chapel used for religious ceremonies. The anthropogenic pollution of adjacent territory is virtually absent.

Location of the springs in National Park "Narochansky" on the border with 30-km zone is shown in Figure 71. This group of springs is located on the territory Svirskaya boundary glacial ridges and refers to a system of river Stracha, right tributary of the River Vilija (basin Neman) [92.93].

Figure 71 - Schematic map of the localization of springs in national park "Narochansky". Yellow ellipse comprises a group of springs № 1-6, located on the border of the 30-km zone (marked orange)

13.6 Groundwater. Assessment of current state

13.6.1 Hydrogeochemical map

As the main object for the construction of hydro-geochemical maps of the 30-km zone of the Belarusian nuclear power station Dnieper-Sozh aquifer was selected, which had, unlike all the other horizons ubiquitous in research and which are essential operational horizon, which equipped with the vast majority of water wells.

The basis for hydrogeochemical maps made the materials of hydrogeological and engineering geological survey, scale 1:200 000 and 1:50 000, made in different years in the sheet N-1935-VIII, N-1935-IX, N-1935-XIV, and N -35-XV [89-93], as well as materials of Cadastre of underground water of Belarus [94-96], the results of hydrogeological studies undertaken in the exploration of underground water intakes in the GP Ostrowiec, Oshmiany and Smorgon, observations of the quality of groundwater for household and drinking purposes, which was carried by the Centers for Hygiene and Epidemiology (TsGiE) of Ostrovetsky, Smorgon, Ashmyany and Postavsky areas, as well as information on the geochemistry of groundwater obtained in the course of the UE "Geoservis" integrated engineering-geological and hydrogeological survey with a scale of 1:50 000 Ostrovetsky item (area 25 km^2) [94]

The chemical composition of groundwater in representative areas (60 points) is characterized by a pie chart, in which the size of the color sector reflects the ratio of the concentrations of major anions (HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-) and cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+), expressed in%-eq. The numbers on the water area sign indicate its catalog number, the total mineralization of water (g/dm^3) and the depth of sampling (m), and alphabetic indexes - on the geological age of the water-bearing sediments. When building a hydro-geochemical maps of the aquifer Dnieper-Sozh deposits in the strata Sozh and the Dnieper moraines overlying and underlying the aquifer were classified as closely related bearing.

Areas with agricultural and municipal and domestic groundwater pollution of Dnieper-Sozh aquifer were allocated according to the contents in the waters of the most characteristic components of this pollution (NO_3^-, Cl^-, SO_4^{2-}, Na^+ and K^+). As the contaminated water were considered, in which the concentrations of these components was more than 5 times higher than in their natural geochemical background of Cl^- - 4,0 mg / dm ^{3}; SO_4^{2-}- 6,2 mg / dm ^{3}; NO_3^- - 0,5 mg / dm^3; Na $^+$ - 4,6 mg / dm ^{3} and K $^+$ - 1,1 mg / dm ^{3} [98] in the pressure of underground waters of Quaternary deposits of Belarus.

On most territories of the studies Quaternary deposits underlain the Devonian (D_2nr). Devonian horizon contains mostly freshwater, but in some places it hydrogeochemical anomalies were observed, where the salinity increase to 1,2-3,16 g/dm^3 and acquire water get sulfate and calcium chloride-sulfate sodium-calcium composition. At the hydrogeochemical map these plots are shown as plots of hydrogeochemical anomalies, formed deep inflow of saline waters and dissolution of gypsum-bearing deposits, confined to thicker Narovski horizon of the Middle Devonian (D_2nr).

Aquifer of Dnieper-Sozh deposits in the research is pervasive and is in most parts of it is first from the surface of confined aquifers. The depth of the roof horizon varies from 2,0 up to 100,0 m, averaging about 25-40 m. The thickness of the horizon changes from 1,0 to 33,0 m, but averages 8-15 m of water-bearing deposits are primarily fluvioglacial sands (from gravel to silt). There are often thicker layers of lake-glacial sandy loam and loam up to 5.2 m.

The horizon crossed with moraine Sozh (gIIsz) is presented by dense sandy loam and loam with inclusions of gravel and pebbles. Capacity thickness varies within1 to 50 m, the highest in – 20-30 m. Mostly Sozh morena lies on surface.

Dnieper-Sozh aquifer underlain Dnieper moraine (gIId). It is represented by dense sandy loam and loam with inclusions of gravel and pebbles. Its thickness varies from 10 to 50 m, averaging about 20-30 m.

In the depth of Sozh and Dnieper moraines lenses of sand can often be met (from silty to coarse), the capacity of which reaches 5-10 m.

Geochemical appearance of water in Dnieper-Sozh aquifer and closely related sporadic distribution of water in the moraine deposits of the Dnieper and Sozh age are predominantly bicarbonate magnesium-calcium. Their salinity varies from 0,15 to 0,73 g/dm^3, averaging 0,30-0,40 g/dm^3. The pH varies in the range from 6.6 to 9.46, averaging about 7,4-7,7. In the waters of the horizon often observed higher contents of Fe - to 1,4-5,6 mg / dm ^{3}, which exceeds the level of MPC - 0,3 mg / dm ^{3}, set for drinking water [95]. In some instances it exceeds the acceptable level of total water hardness (MCL - 7,0 mg / dm ^{3}). In general, it varies in the range from 0,8 to 16,3 mg-ekv/dm3.

The distribution in the study of groundwater with different levels of mineralization is typical. For example, areas where groundwater salinity is minimal (0,15 - 0,3 g/dm^3), they are usually related to watersheds and uplands. As an example, should be mentioned the watershed area of the rivers Gozovka, Viliya, Oshmyanka and Losha, where the place of potential nuclear plant construction is situated. Moreover, similar sites are located on watersheds the rivers Gozovka and Senkanka, Oshmyanka and Ustizerki, Vilija and Klevel, as well as in the south and south-west area within Oshmiany ridge. This location is a consequence of nutrition of elevating areas of the Dnieper Sozh aquifer. Here the levels of groundwater are at levels considerably above the piezometric levels of groundwater Dnieper-Sozh horizon, that provides its own power due to overflowing of the water table. Low salinity of groundwater at such sites is formed due to a high washing of surficial sediments, and relatively small residence time of water in a horizon. It should be noted that the relation of sites with minimal salanity of groundwater in areas of nutrition on watersheds ins also observed in other areas of Belarus, in Polesie particularly [96].

13.6.2 Existing anthropogenic pollution

Dnieper-Sozh aquifer in the most of the researched territory is the first from the surface of confined aquifers. Because of its relatively shallow occurrence (25 - 40 m) in the waters of the horizon are often observed traces of anthropogenic pollution, mainly agricultural and household. This appear in the growth of ions in groundwater content NO^{3-}, Cl^{-}, SO_4^{2-}, Na^{+} and K^{+} to the levels many times higher than their natural geochemical background of fresh groundwater in Belarus [97]. At high levels of pollution geochemical type of water may vary. For example, the most intensive contamination of groundwater in Dnieper-Sozh horizon was found in hydrogeological wells № 72 near the village of Old Rudnia of Smorgon district. Here, at a depth of 36,2-42,0 m were found water with NO_3^{-} equal to 98.0 mg / dm ^{3} (levels of MCL for nitrate in drinking water is 45 mg / dm ^{3} [101]). Water also has higher concentrations of Cl^{-} - 37,0 mg / dm ^{3}, SO_4^{2-}- 33,3 mg / dm ^{3,} Na^{+} - 22,0 mg / dm ^{3} and K^{+} - 12.7 mg / dm $^{3.}$ These contents are below acceptable levels in drinking water, but many times higher than levels of natural geochemical background. In general, the water had dramatically abnormal chloride-nitrate sodium-calcium composition.

This cartographic generalization of hydrogeochemical materials on the Dnieper-Sozh aquifer revealed restriction sites with traces of contamination of underground water to the fields of nutrition to this horizon. It is clear, that the overwhelming downward movement of groundwater in these areas, including in the groundwater, promotes the transfer of pollution from the surface zone in the deeper layers of groundwater. Territorial coincidence is typical of the majority of sites where contamination detected in places with groundwater with minimal mineralization (0,15 - 0,3 g/dm^3) which as mentioned before also comply to the areas of nutrition of Dnieper Sozh aquifer.

As an important additional information on the hydrogeochemical map the position of hydrogeochemical anomalies that are confined to the first surface of the aquifer pre-Quaternary sediments - Devonian (D_2nr) is shown. This horizon has spread throughout the most territory of the studies, contains mostly fresh water and is among the most important operational aquifers. However, in the northern area of research in a broad band, which lays from village Mostyany to village Losey of Ostravets district, in the Devonian aquifer mineralized water is spread (from 1,2 to 3,16 g/dm^3). They were opened here at depths from 61 to 102 m, which characterize them as hydrogeochemical anomalies. In the interval of mineralization from 1,2 to 2,7 g/dm^3 these waters are bicarbonate-sulphate and sodium-calcium and with the mineralization of 3.16 g/dm^3 acquire chloride-sulfate magnesium-sodium-calcium composition. The formation of these hydrogeochemical anomalies apparently associated with the processes of underground dissolution of gypsum-bearing deposits, confined to the depth of narovski horizon of the Middle Devonian (D_2nr). Limit distribution of gypsum-bearing packets narovskogo horizon in this area can be traced on the right bank of river Vilija [98]. Its presence is probably the main reason underlying the sharp decline of capacity of fresh water in the zone - from 300-350 m and 100-150 m. The existence of hydrogeochemical anomalies sulfate-calcium type indicates, on the one hand, the processes taking place in underground dissolution gypsum-bearing deposits, and on the other hand - on the related dissolution of karst processes. The reality of such processes is indicated, in particular, by collapse breccias encountered in the Devonian context.

Formation of hydrogeochemical anomalies could be influenced by Berezovsky fault which is allocated to this area from geophysical data. The band with hydrogeochemical anomalies [99] (from village Mostyany to village Losey) is paralleled to the line of the fault. Anomalously high content of Cl^- and Na^+ in the waters of the Devonian horizon in the borehole at the village Zhukoyni Zhelyadskie may be due to inflow along the fault deep mineralized water

13.6.3 Usage

As a result of performed hydrogeological studies it was revealed that the Ostravets district is adequately resourced fresh groundwater. As of 01.01.2008 on the territory of the test site for industrial development are explored 5 fields of fresh water located at a distance of 20 to 40 km from the site and are confined to the Quaternary, Proterozoic and Cambrian sediments, Ordovician carbonate complex, Silurian carbonate complex. Currently the following water withdrawals are active in Ostrowiec - Ostrowiec, Oshmiany - "Vaygeta", Smorgon - "Koreni", resort area Naroch "Malinovka-1, Lake Naroch -" Baloshi "(figure 72). For drinking water in rural areas single departmental wells are used. Wells exploited aquifers of the Quaternary, Devonian, Silurian and Ordovician sediments.

In rural areas, along with centralized water supply local people for household needs traditionally use wells.

Analysis of previously performed studies on this area shows that the use of groundwater can be increased substantially.

Natural resources represent the total flow rate of underground water, drained by the river network and secured by infiltration of precipitation. The total value of the natural resources of the Grodno region is 7158 thousand.m^3/day. Within the territory of Ostravets area based unit of administrative division of natural resources varies from 0,6 (Myadel district) to 4,45 l / s * km^2 (Ostrovets district).

The uneven distribution of natural resources is related primarily to the nature of the relief, lithology and covering the water-bearing rocks. Total natural resources in the area are 662.2 thousand m^3/day. Their distribution within individual administrative districts is given in Table 114.

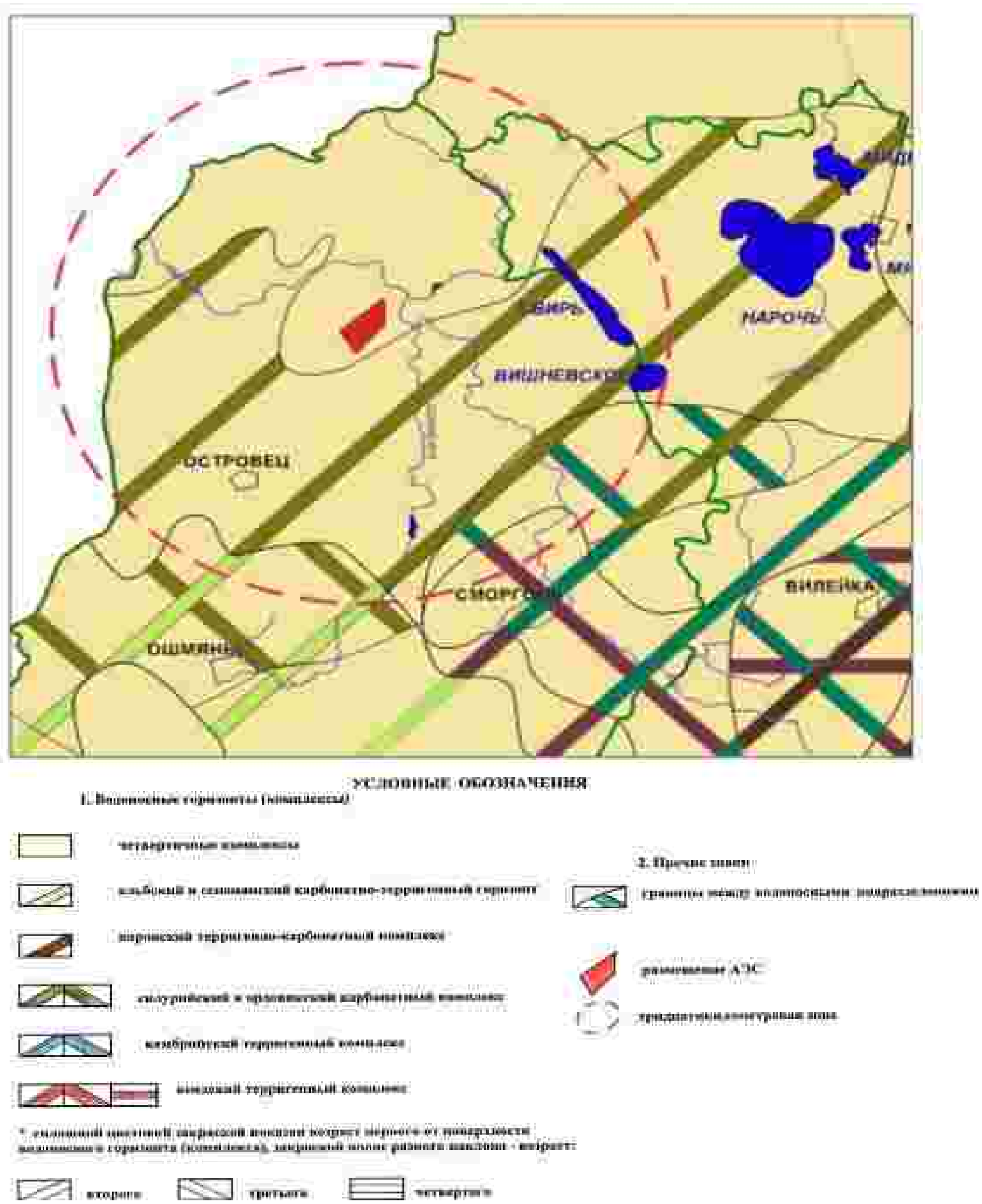


Figure 72 - Map of major aquifers (complexes), promising for use in household and drinking water supply. Scale 1:500 000

Table 114 - Distribution of natural resources in Administrative Areas

Administrative region	Total squire, km²	Squire within the site, km²	Natural resources module, L/s km²	Natural resources, thousand m³/day
1 Ostravetski	1560	1549,34	4,45	595,7
2 Postavski	2079	49,97	2,5	10,8
3 Myadelski	1956	215,44	0,6	11,2
4 Smorgonski	1490	272,27	1,17	27,5
5 Oshmyanski	1207	45,7	4,32	17,0
Total		2132,7		662,2

Groundwater recharge is better insured within Ostrovetsky district. The maximum value of natural resources is fixed - 595.5 thousand m^3/day. The value of the module is 4.45 l/s.km^2. Territory of Postavsky and Miadzel areas are characterized by slow water exchange: a generalized power module is 0,6 and 1,17 l/s.km^2, values of natural resources are about 11 l/s.km^2.

Projected operating resources characterize the use of groundwater. They estimated the amount of groundwater quality and specific purpose, which can be obtained within the hydro area, river basin or a territorial unit of the Republic of Belarus and show the potential use of groundwater.

Modules of operational resources and total estimated resources across administrative area, within investigated area are presented in Table 115.

Table 115 - Distribution of expected resources within administrative districts

Администра-тивный район	Total squire, km²	Squire within the site, km²	Operation life module, l/s km²	Estimated operational life, thousand m³/day
1 Ostravetski	1560	1549,34	5,19	694,7
2 Postavski	2079	49,97	3,90	16,8
3 Myadelski	1956	215,44	2,96	55,07
4 Smorgonski	1490	272,27	5,4	127,97
5 Oshmyanski	1207	45,7	4,79	18,9
Total		2132,72		913,5

Proven Operating reserves are determined by the amount of groundwater, which can be obtained by rational, technical and economical intake facilities for a given operating mode, as well as water, sanitary requirements during the current period of water consumption.

Data on the total resources and reserves of underground water on the site are presented in the table 116 and 117.

From the ratio of the values of the performance of resources to the natural area of Ostrovetsky district is extremely heterogeneous. The areas with equal or operating and natural resources quantities close to each other characterized by favorable supply (Ostrovets and Oshmiany areas). The least favorable conditions for ground water recharge in Miadel and Smorgon district, where the projected Operating resources exceed the natural almost 5 times, and recharge of aquifers in ensured due the lately mentioned areas varies from 20 to 45 %.

The degree of knowledge of estimated resources (the ratio of the performance of reserves to forecast resources) in the study area is very low and is about 4%. Thus, there is a reserve to meet the demand for drinking water, and there are opportunities for exploration for the needs of farmlands and villages.

To select a specific site for placing the water withdrawal it is necessary to make research to explore a place that can satisfy the stated need (550 - 650 m^3 / h) of water of drinking quality.

Table 116 - Information Concerning the explored deposits of underground waters

Administrative region	town	Water with-drawal	Ex-ploited aquifer index	Stocks of under-ground waters, A+B, thou-sandsm^3/day	Deposit state	% of proved reserve usage
Ostrovetski	Os-trovets	Ostrov-ets	S	5,3	on stream	25
Smorgonski	Smor-gon	Koreni	V+Є	28,3	on stream	40
Total				33,6		

Table 117 - Resources and reserves of groundwater

Administrative region		Ground water resources thousand m^3/day		The ratio of the performance of natural resources, %	Proved reserves for Operating Category m A+B, thou-sandsm^3/day	The ratio of the performance of reserves to the commercial resources, %
		Natural	Projected operational			
1	Ostrovetski	695,2	694,7	100	5,3	0,8
2	Postavski	10,8	16,8	155		
3	Myadelski	11,2	55,07	492		
4	Smorgonski	27,4	127,97	467	28,3	22
5	Oshmyanski	17,0	18,9	111		
	Total	761,6	913,5	120	33,6	3,8

13.6.4 Ground water protection

13.6.4.1 Protection assessment criteria

The natural protection of ground waters is determined by a set of parameters the main ones being:

- depth of occurrence, ion-salt and gas composition of ground waters;
- aerated zone capacity, capacity of grounds and soils composing the zone;
- soil pattern (soil type, soil texture, mineralogical composition of soil, its hydrophysical condition) and sorption characteristics;
- capacity, behavior and composition of hydrometeors (rain, snow);
- filtration parameters of grounds and soils;
- pollutant types and physicochemical properties.

In the stage of the first EIA examinations it is justified to operate some of the following types of information listed below: Data, concerning depth of occurrence of the most vulnerable ground waters and its quality; characteristics of soil mantle as a medium of radionuclide migration; migration process characteristics and distribution of ^{90}Sr and ^{137}Cs in the soil mantle of Chernobyl fallout area as sample ones. Despite the information we have at our disposal seems to be limited, however it is enough for making up a general model of ground water protection in the range of 30 km area of Ostrovets site for probable NPP construction.

13.6.4.2 ^{137} Cs and ^{90}Sr migration parameters

The analysis of ^{137} Cs and ^{90}Sr redistribution through the depth of soil profile showed [100,101] that:

- even after 15-20 years passed since the Chernobyl NPP accident, 95-98% of ^{137} Cs storage is concentrated in the upper 0-5 sm layer, in some cases in 0-20 sm layer in the majority of soil types, regardless the density of ^{137} Cs fallouts. The main storage of ^{90}Sr (same 95-98%) is concentrated in the 0-15 sm layer, in some cases in 0-25 sm layer (Krasnoselje, sand dune, 21 km from Chernobyl NPP);
- linear migration speed of ^{137}Cs (V) and quasidiffusion coefficient (D) are varied in wide range: V – 0,11-2,66 sm/year, D – 0,01-1,40 sm^2/year. For ^{90}Sr the same parameters of vertical migration through the soil profiles are given 0,14-7,14 sm/year and 0,01-19,00 sm^2/year

A statistically valid (R^2=0,58-0,77) tendency of decreasing of ^{137} Cs migration parameter values (V, D) in time was determined for mineral automorphic soddy-podzolic soils (Podzoluvisol) of second bottoms and terraces above the flood-plain being accounted for the irreversible ^{137} Cs sorption by soil solid substratum as a result of diffusion and isotope demobilization in an interlayer space of clay minerals [106,107]. The tendency is valid for the rest soil types - hydromorphic, peat-bog and semihydromorphic fluvial soddy soils (Histosol and Fluvisol). Semihydromorphic waterlogged soddy-podzolic soils of lake catchment basins are the only exceptions, on the contrary being characterized by increasing of the parameters in time due to the high percolation mode and convective mass transfer overlapping on the diffuse flow as a result.

^{90}Sr migrates in automorphic mineral soddy-podzolic sandy soils (Podzoluvisol) actively. A growth of migration parameters in time was detected for the type of soil (R^2=0,7-0,9). A tendency of migration parameter growth in time was also determined for semihydromorphic soddy-fluvial sandy loam soils (Fluvisol) of bottoms and second bottoms.

The decrease or constancy of migration parameters in time was determined for hydromorphic highly organic peat-bog soils (Histosol).

Thus, *localization of main storage* of Chernobyl radionuclides ^{137}Cs и ^{90}Sr at the depths below 5-25 sm of soil profiles indicates a rather effective, in general, shielding role of Belarusian grounds and soils in the processes of vertical redistribution of *main storage* of radionuclides to the level of ground waters even after 15-20 years passed since the accidental fallout.

13.6.4.3 Radioactive pollution protection

The radiation condition analysis of ground waters occurring at the depths down to 2 m in the areas of Chernobyl fallouts [104,105] actually showed relatively low levels of its current (as of 2002-2007) ^{137}Cs and ^{90}Sr pollution (0,02-0,58 and 0,012-2,206 Bq/dm^3, respectively). However if one compares the activities listed with the preaccident radiation pollution levels of r. Prypiat (0,006-0,066 Bq/dm^3 of ^{137}Cs and 0,003-0,018 Bq/dm^3 of ^{90}Sr), that were (mainly) connected with global fallouts as a result of nuclear tests in atmosphere, they (activities) appear to be rather high in the context of nonthreshold impact on human body. With that one should take into account that in the regions of agricultural industry and application of ions NH^+_4 and K^+ competitive with radiocesium during fertilization of soil mantle the threat of additional ^{137}Cs-pollution of ground waters is increased. In the same regions the intensity of ^{90}Sr migration processes to the ground water level increases due to the mineralization of soils' organic matter.

Summing up it should be noted that in the regions with the depth of ground water occurrence down to 2 m the soil mantle isn't capable of forming an effective pollution protection from surface pollution sources, including “plane” surface source of radionuclides (^{137}Cs, ^{90}Sr and etc.). Areas with thick (more than 2 m) aeration zone should be considered as regions with rather effective soil shielding of ground waters.

This statement is depicted by a radiation protection sketch map (figure 72) of Ostrovets site 30 km area showing the areas with low depth of ground water occurrence, within a broad background of relatively fine ^{137}Cs and ^{90}Sr protection of ground waters, as the most sensitive to pollution by such radioisotopes.

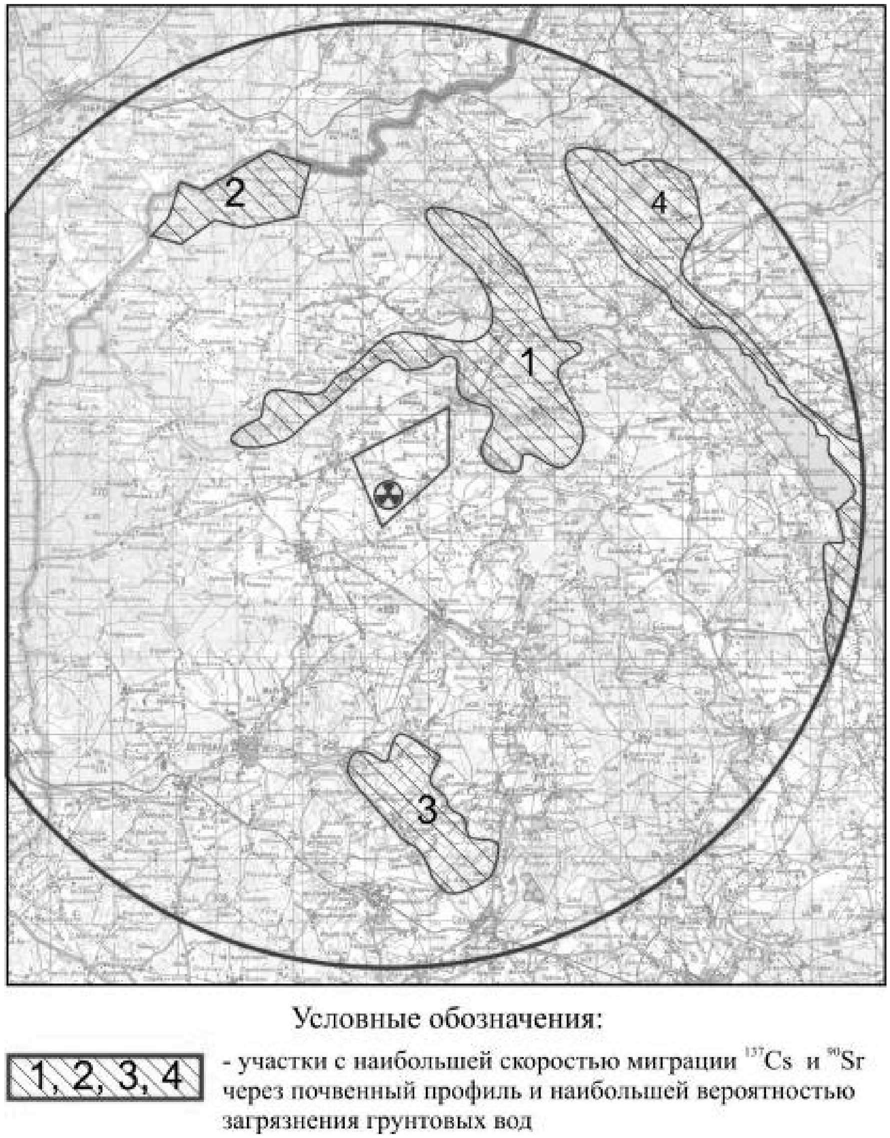


Figure 73 – Location on the sketch map of chosen characteristic areas being the most sensitive to the set of natural factors

13.7 Soils. Agriculture. Agro-ecosystem radiation risk assessment

13.7.1 Agro-ecosystem radiation risk assessment. Purposes and objectives

Ensuring the radiation safety of population and environmental protection from radioactive pollution is one of the most important objectives of nuclear energy program implementation. Despite almost half-century experience in using NPP indicates small levels of radioactive pollution in the range of its 30 km areas of observation [108], this issue remains to be actual as the way from entering radioactive materials into the atmosphere to dose-formation in biota and human body is very complicated. There is an extremely broad range of natural conditions, physicochemical properties of radionuclides, agro-ecosystem features defining significant uncertainty of NPP radiation impact assessments and necessity of complex problem resolution in every particular case.

Therefore assessment of radioactive pollution levels of environment and products used by human, firstly, agricultural products is extremely important. Finally, within a very small probability of NPP accidents one can't help considering the peculiarities of radioactive pollution and biota radiation dose formation within such an adverse development of events, that will be basic for making up a set of protective measures.

Thus a complex assessment of radiation impact on agro-ecosystems was the purpose of research scientific work implementation.

To reach the objectives the following examination tasks are set:

- characteristic analysis of entering the radionuclides into agro-ecosystem within conventional and emergency fallouts;
- verification of radionuclide distribution models in agro-ecosystems and prediction of radionuclide content in agricultural products based on the models;
- separation of agro-ecosystem components being critical to ionizing irradiation impact, predictive assessment of external radiation dose for biota and possible radiation-induced effects;
- development of suggestions concerning agro-ecosystem local radio ecological monitoring system;
- formulation of proposals on the system of protective measures in agricultural industry within NPP emergency fallouts.

13.7.2 General mechanisms of radionuclide ingress

Radioactive pollution of plant complex components and values of radiation dose for biota and human body connected with it are determined as follows [109-112]:

- activity of radionuclides emitted into environment;
- peculiarities of propagation and deposition of radioactive emissions;
- physicochemical properties of radionuclides;
- properties of vegetative ground cover.

In the most common case the value of radionuclide concentration in main ecosystem components and the corresponding irradiation doses are directly relative to emission activity of radioactive source (emergency or normally operated NPP reactor).

Propagation of radioactive materials and intensity of deposition are determined by the features of emission [109,110]:

- within normal exploitation there is a constant emission of a certain amount of radioactive materials into the environment along with the build up of long-life radionuclides in various agro-ecosystem components;
- within radiation accident there is possible a short-term high activity emission of radioactive materials with a broad range of physicochemical properties from completely or partly depressurized active zone. The spatial distribution and intensity of deposition are determined by meteorological conditions at the moment of the greatest radionuclide concentrations in atmosphere [113].

As a rule, a smaller extent of distribution and a greater value of deposition on adjacent area is noted within prevalence of unstable categories of atmosphere condition and influence of hydrometeors [114,115]. The underlying terrain undulation determined by terrain relief, activity features, presence of certain natural complexes plays an important part in deposition. Propagation of radioactive emissions is directly relative to the height of its rise established by the difference of temperatures in source and environment.

Throughout the reactor operation a build up of a broad range of radionuclides (fission, activation products and transuranium elements) with various physicochemical properties occurs in the reactor fuel. Inert radioactive gases make the main contribution to the activity of both conventional and emergency emissions [116]. However owing to its chemical properties they are slightly stopped by filtration protective systems, don't participate in migration across the components of agro-ecosystem and in formation of internal radiation dose due to its alimentary entrance [117]. With that they are capable of defining the additional external biota radiation.

Radioactive isotopes of iodine make a significantly greater contribution to internal radiation dose, dose formation and endanger the thyroid body of animals and humans at the initial moment of emergency fallouts (first of all ^{131}I and ^{132}I with parent ^{132}Te) [117].

When considering the radionuclide migration in the components of agro-ecosystems and food chains a special attention should be paid to long-life radioactive isotopes of biogenic chemical elements or to those which possess similar biogenic elements [109,110,117]. First of all ^{137}Cs (chemical analogue of potassium) and ^{90}Sr (analogue of calcium) should be concerned as such elements. A long half-life period determines a gradual build up in environment due to conventional emissions or a long-lasting migration between ecosystem components along with incorporation in food chains as a result of emergency pollution. At the same time various chemical properties of such radionuclides determine significantly different redistribution mechanisms in ecosystems [118]. So, a relatively high fugacity in radioactive emissions, a significant foliar build up in plants, a non-exchangeable sorption type in fine soil fraction, a prevailing build up in plant root systems and a relatively uniform distribution inside the body of animals and humans is typical for ^{137}Cs being an alkaline metal. A smaller foliar entrance in plants, an exchangeable sorption type by soil mineral matter and a non-exchangeable type by organic matter is established for ^{90}Sr being an alkaline-earth metal. A prevailing build up in aboveground biomass of plants and an osteotropic type of distribution in body of animals and humans is typical for the radionuclide.

Properties of vegetative ground cover determine the deposition value of radioactive emissions on the ground since one of the most important ground characteristics for propagation of impurities in atmosphere, its undulation, is connected with the properties [119]. Forest range plays a special part here. Depending on the wind speed the deposition of radionuclides in forest can be 6-12 times higher than in meadow vegetation within equal meteorological conditions and the depletion rate of radioactive cloud is 3,7-5 times higher when it moves above the forest-covered terrain rather than open grass vegetation covered spaces.

It important to note that a pattern of radionuclide distribution across the components of agro-ecosystems accompanied by corresponding biota radiation doses and radionuclide build up in agricultural products are determined by intensity and duration of radioactive emission so radionuclide redistribution in the biogeocenoses under consideration should be considered separately for both conventional radioactive emissions within normal reactor operation mode and pollution as a result of maximum projected accident.

13.7.3 General agricultural plant characteristics of Belarusian NPP location area, made up using materials of surveying work s at the stage of site selection

All the territory of Ostrovetski region as well as part of Smorgonski and Oshmianski regions is included in the range of Belarusian NPP site. The amount of soil resources of the mentioned area in Grodnenski region is 215,37 ths. ha., including:

- lands for agricultural organizations - 86,31 ths. Ha (40,1 %);
- Individual lands -10,42 ths. ha (4,8 %);

- lands for state forestry organizations -109,37 ths. ha (50,8 %);
- lands for industries, transport, communication, power engineering, military defense and other purposes - 5,15 ths. ha (2,4 %);
- lands in general use in settlements - 3,19 ths. ha (1,5 %);
- reserve lands - 0,66 ths. ha (0,3 %);
- lands for environmental, sanitary, recreation and historical-cultural purposes - 0,27 ths. ha (0,1 %).

So as it appears from the mentioned data, the main part of the territory under consideration is occupied by forest ranges and agricultural lands (nearly 90%) where the intensive activity is carried out at the present time.

Agricultural industry. Agricultural organizations situated on the territory given are specialized in cereal, flax, sugar beet, rape, potato, feed crop farming, milk and meat production.

In 2008 agricultural enterprises on the territory under consideration produced plant and livestock production in comparable prices to the amount of 66,3 bln. roubles. Livestock production produces 52,7 % of the whole output, with plant taking up 47,3 %. Households produce 3,4 % of region's agricultural production.

Plant production. Plough lands take up 62,5 % of the whole agricultural land area, meadows taking up 37,4 % (2/3 part is improved). Nearly 3,5 % of plough lands are subjected to wind erosion, 11 % - to water erosion, 6,4 % - stone polluted lands. Ploughed up lands occupy 63 %.

Quality score attributed to agricultural lands is 28,8 and to plough lands – 30.

Productivity of cereal and pulse crops in processing weight has increased from 30,8 to 39,6 dt/ha, flax-fiber – from 6,2 to 6,8, rape oilseeds – from 12,8 to 27,3 dt/ha. The cut yield of sugar beet is 342 dt/ha.

In 2008 the gross yield of cereals and pulse crops in processing weight was 70718 t., flax-fiber – 336 t., sugar beet – 21191 t., rape oilseeds – 3799 t., potatoes – 4648 t., vegetables – 61 t.

In 2006 the amount of manufactured products in terms of feed units (f.u.) was 133,3 ths. t., in 2007 - 181,2 ths. t., in 2008 - 200,9 ths. t., including plough lands – 112,3, 155,4 and 175,3 ths. t. respectively.

Averagely in 2006 24,1 dt. of f.u. were harvested from every 1 ha of agricultural lands, in 2007 - 32,7 and in 2008 - 37,3 dt. of f.u. The productivity of plough lands reached 33,3, 46,1 and 52,0 dt. of f.u. respectively. From ballohectare of plough lands the output increased from 1,11 dt. of f.u. to 1,73 dt. of f.u. in 2008.

Averagely in 2008 37,3 dt. of f.u. were harvested from every 1 ha of agricultural lands. The productivity of plough lands reached 52,0 dt. of f.u. respectively. From ballohectare of plough lands the output increased from 1,11 dt. of f.u. to 1,73 dt. of f.u. in 2008.

In 2009 cereal and pulse crops are planned to be farmed on the area of 17,9 ths. ha (53,2 % of plough land structure) including 9,3 ths. ha of winter crops sown in autumn 2008.

Feed crops are planned to be located on the area of 13,1 ths. ha (38,7%).

Livestock production. In 2008 the produced amount of milk reached 34011 t., raised livestock and birds – 7105 t. Average milk yield from a cow for 2008 reached 4677 kg, 477 kg more than in 2007. The average daily weight gain of cattle stock on raising and fattening increased from 626 gr. In 2007 to 653 gr. In 2008 (values for region from 522 to 549 gr.), swine – from 573 to 595 gr. (values for region from 522 to 549 gr.) respectively. On January, 1 2009 the livestock population in households reached 27621 heads, including cows – 7341, swine – 14526 heads. All types of fodder were procured in the amount of 86356 t. of feeding units for collective livestock population, including bundle feed – 40564 t. of feeding units per one animal unit – 20,2 dt. of feeding units.

In livestock industry it is planned to produce 35110 t. of milk, raise 7580 t. of livestock and birds for meat.

13.7.4 Radioecological assessment of current condition of agro-ecosystems and agricultural production

Pollution density of soil by ^{137}Cs is less than 2 kBq·m^{-2}, ^{90}Sr – less than 2 kBq·m^{-2}. According to the values region is comparable with the rest republic territory polluted only by global emissions from nuclear tests (pollution density for ^{137}Cs is less than kBq·m^{-2} and for ^{90}Sr is less than 1,8 kBq·m^{-2} [113]). The exposure dose in the air is less than 0,15 mcZb·h^{-1} and determined by natural radiation environment.

On the territory of Ostrovetski region monitoring of ^{137}Cs content in agricultural production is implemented at the expense of Ostrovetskaya laboratory of veterinary-sanitary examination. In 2008 determination of the radionuclide content was implemented in a broad range of plant and livestock production manufactured on the territory of the region.

There were examined 2474 t. of rye seeds from 9111 t. stored, 10113 t. of wheat from 21156, 7793 t. of triticale from 16402, 8844 t. of barley from 19273, 3827 t. of oat from 8882, 215 t. of pulse crops from 3225, 25 t. of rape from 3798 and 670 t. of fodder grain from 41438. All the examined production possesses specific activity of ^{137}Cs less than Bq·kg^{-1}. Approximately the same specific activity of the radionuclide was noted in the examined lots of corn, millet, flax seeds. Specific activity less than 50 Bq·kg^{-1} was established for haylage and herbage (additional feeding). The amount of the types examined was 19740 and 740 t. from 70257 and 91058 t. respectively.

In 2009 members of Radiology Institute accomplished an additional sample selection of agricultural production manufactured in public and private households. There were selected 31 samples of milk, 33 samples of cereals, 18 samples of root and tuber crops and 53 samples of fodder production. Specific activity of ^{137}Cs in the samples examined was determined with γ-spectrometric complex Canberra. Radiochemical extraction of ^{90}Sr was performed according to standard methodology CINAO with radiometric completion on α-β counting-tube Canberra-2400. Measurement instrumental error was below 20 %.

As was stated by examinations performed the specific activity of ^{137}Cs in milk and market products is at the level of global emissions and in a number of cases lower than MDA (minimum detected activity is equal for γ-spectrometric complex Canberra 2,6 Bq·kg^{-1}). Specific activity of ^{137}Cs in hay is below 10 Bq·kg^{-1}.

^{90}Sr pollution levels of milk were below 0,6 Bq·kg^{-1} that is at least 5-6 times lower than standard values (3,7 Bq·kg^{-1}). Specific activity of ^{90}Sr in hay is below 18,7 Bq·kg^{-1}. In general, average values for all the settlements of ^{90}Sr content in samples examined may be placed in the following row of radionuclide concentration decreasing:

- hay - 5,54±3,78 Bq·kg^{-1};
- grain (rye, oat, wheat, barley) – 1,81±0,85 Bq·kg^{-1};
- grain (corn) - 0,95±0,38 Bq·kg^{-1};
- beet - 0,76±0,23 Bq·kg^{-1};
- potato - 0,70±0,32 Bq·kg^{-1};
- carrot - 0,59±0,3 Bq·kg^{-1};
- milk - 0,45±0,11 Bq·l^{-1}.

Consequently, the values of specific activities received are tens of times lower comparing with actual standard values. Particularly, according to actual republic accepted level of ^{137}Cs and ^{90}Sr content in agricultural raw materials and fodder specific activity of ^{137}Cs in grain for food needs shouldn't exceed 90 Bq·kg^{-1}, and for ^{90}Sr – 11 Bq·kg^{-1}, in milk for processing to whole milk products, cheese and cottage cheese - 100 and 3,7 Bq·kg^{-1}, respectively [120,121].

Generally, the values of ^{137}Cs and ^{90}Sr content in agro-ecosystem components on the territory examined are similar to the values on adjacent regions polluted only by global emissions as a result of nuclear tests.

13.8 Landscapes, flora, fauna

13.8.1 Landscapes

The region of NPP construction is entirely located in the range of one landscape province – Poozerskaja province of glaciolacustrine, moraine- and hilly-moraine-lacustrine landscapes. For their altitudinal location the region's landscapes are referred to all the three groups of landscapes present on the territory of Belarus – elevated, medium-altitude and low. Elevated landscapes occupy its marginal parts - north-eastern and south-western. When moving to center the landscape changes to medium-altitude and low [122,123].

13.8.1.1 Landscape potential

Natural soil fertility for the majority of landscapes is relatively low. Quality score attributed to the lands is lower than the region average value. A high relief roughness determines small outlines of the lands. For the reason the development level of 30 km area is not much of intensity. Natural complexes remain here to a wide extent with the forests prevailing. Agricultural lands occupy approximately half of its area.

Comparatively low economical development of 30 km area in combination with its natural properties – great amount of lakes and favorable environmental condition – provides bright background for recreation usage of the given territory. According to regionalization scheme of Belarusian territory for sanatorium-resort and recreation development there are three landscape-climatic regions in the 30 km area under consideration: Narochansko-Glubokski (north-eastern part), Molodechensko-Vilejski (central part) and Oshmianski (south-western part). Its adequacy for resorting purposes was assessed according to three private criteria: landscape esthetic quality, its ecological condition, bioclimatic conditions as well as integral criterion of opportuneness based on the synthesis of these conditions

Among the three regions assessed one of them – Narochansko-Glubokski – has the most favorable resorting conditions, with the rest two also possessing favorable conditions. So generally, the region possesses a high recreation-sanatory natural resources potential. A part of the largest Belarusian recreation area of republic assignment created on the base of "Narochanski" national park is located in the range of this region. In addition recreation areas and objects of local assignment are also located here. All of them are situated 20 km from the site. Sanatorium-preventoriumes and children's holiday camps located here are designed for cotemporary rest of 600 persons.

Specially protected territories located in the region such as sanctuaries of republic and local assignment can also be considered as potential recreation objects. They are prosperous for ecological tourism development.

Mineral resource potential of the territory under consideration is formed by deposits of building raw materials, peat and sapropel. 7 deposits of building raw materials are located in its range [124]. These are deposits of building sands, sandy gravel and clays. Only two of them are being developed: one – building sands and the other – clays.

There are 11 deposits of peat [125]. Its area is small in the majority of cases and equals from 100 to 700 ha. And only two largest of them occupy more than 1 ths. ha. The average occurrence depth of peat varies from 1,1 to 2,7 m, and its geological reserves - from 60 to 2500 ths. t. Total reserves of peat are relatively small. All the large peat beds are dried and used generally as agricultural lands.

The region possesses significant sapropel resources. There are 46 lakes with putrid mud in total. 88,5 mln. $м^3$ of raw sapropel are located here. Siliceous and calcareous types prevail. At the present time there is no sapropel production.

13.8.1.2 Landscape pollution resistance

Migration of chemical materials on the territory is determined by its landscape geochemical conditions. In eluvial landscape type its carry-over prevails, in eluvial accumulative one carry-over is combined with build up and in superaqual (swamped) landscape they build up [126, 127].

In the range of 30 km area approximately 50% of the total area is occupied by eluvial landscapes along with eluvial accumulative landscapes occupying nearly 90%. Superaqual landscapes account for 7 % of the total. Natural ecosystems have a similar landscape structure.

In grain-size texture sandy loam soils on loose powdery psammitic and psammitic sand loams occupying nearly 52 % of the total on 30 km area. In natural ecosystems sandy soils prevail occupying 58 % of its total area.

Soil-forming materials are of non-uniform structure and often there are bi- or trinomial structures of soil profile. Specific weight of sandy loam soils possessing binomial structure (sandy loam-sandy clay) is rather high and reaches 35 %. Uniform soil profile structure is typical to a greater extent for sandy types occupying 34 % of 30 km area;

Typomorphic elements of landscapes are hydrogen ion (H^+) and ferric ions (Fe^{2+}) and to a smaller extent calcium ions (Ca^{2+}) forming the following landscape classes depending on oxidation-reduction conditions: sour – 38 %, sour-fen clayed – 18 %, fen clayed – 1%, sour calcareous – 23 % and sour calcareous fen clayed – 20 %;

Sour eluvial landscapes with forests (mostly coniferous) on sandy deposits are the most common in the range of 30 km area. They are widespread along the valley of r. Vilija, in western part of 30 km area, in interfluve area of r. Oshmianka and r. Vilija and also in northern and north-western parts.

In the range of 5 km area sour landscapes occupy 18 %, sour fen clayed – 7%, fen clayed – 8 %, sour calcareous – 40 % and sour calcareous fen clayed – 26 %. Sour calcareous eluvial and transeluvial landscapes on sandy loam deposits underlain by moraine sandy clay are the most common. Practically everywhere the given landscapes are developed for agricultural needs. Forest sour eluvial landscapes on sands are present as small lots mostly in northern part.

Generally, natural ecosystem conditions of 30 km NPP location area are conductive to formation of acid soil reaction that leads to high mobility of chemical elements in landscapes and encourages its carry-over from soils with infiltration waters and its transfer into plants;

Practically everywhere in the range of 30 km and 5 km area radial geochemical barriers are indicated. Biogeochemical forest, internal soil sorption and temporary fen clayed barriers are the most common for 30 km area the most typical ones being biogeochemical forest – temporary fen clayed, internal soil sorption – temporary fen clayed, biogeochemical forest – internal soil sorption. For natural ecosystems biogeochemical in combination with temporary fen clayed barrier is the most typical. In the range of 5 km area sorption internal soil and temporary fen clayed barriers as well as their combinations are the most common. In the context of chemical element (sorption) accumulation (including atmospheric fallouts) biogeochemical barrier plays the most important part.

Generally on an aggregate basis of natural factors landscapes resistant to chemical pollution prevail in the region. They occupy 57 % of the total area; in natural ecosystems – 64 %. It means that the processes of chemical element carry-over with water flows (due to land runoff and internal soil infiltration) are typical for the leading automorphic eluvial landscapes developed on light deposits according to grain-size texture.

The assessment of present heavy metal content (Pb, Zn, Cu, Ni, Cr) in mineral and peat soils adjacent to the territory of NPP site showed that its concentrations are of significant variability (Table 118). A higher average content of zinc, copper and nickel and a lower data scattering for all the examined elements are typical for peat soils comparing with mineral soils.

Table 118 – Heavy metal content in soils of 30 km area, mg/kg

Factor	Pb	Zn	Cu	Ni	Cr
Minimum content, mg/kg	6,9	5,2	0,9	1,4	6,7
Maximum content, mg/kg	42,0	65,5	10,3	10,9	91,4
Average for selection, mg/kg	14,7	20,9	3,8	4,9	41,3
Occurrence of values above MAC/APC, %	ind. sample	ind. sample	–	–	–
Maximum ratio of exceeding MAC/APC	1,3	1,1	–	–	–
Background content	6,0	28,0	11,0	15,0	30,0

Content of lead is varied from 6,9 to 42,0 mg/kg. Its average value equals 15,2 mg/kg that is 2,5 times higher than background level. Exceeding of allowed concentration occurs in one case. It equals 1,3 times and is observed in the sample taken in forested area on the bank of r. Oshmianka (figure 74).

Zinc concentration values in the majority of soils examined are close to background values and vary from 5,2 to 65,5 mg/kg within average content 22,9 mg/kg. Content of the element being higher than APC is observed in two areas both of them being situated in the bottomland of r. Gozovka.

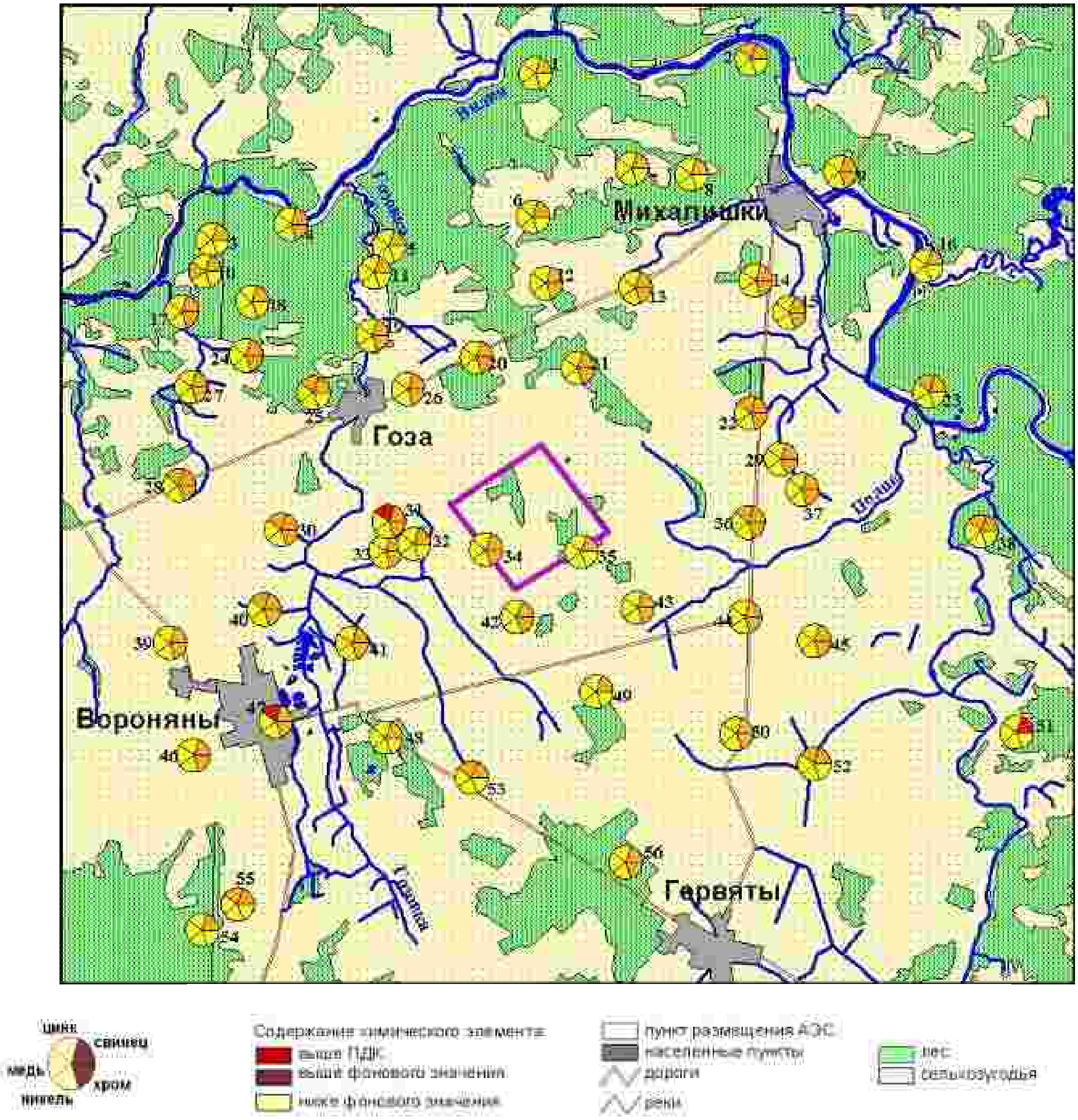


Figure 74 – Heavy metal pollution of soils on the territory adjacent to NPP location site

Copper concentration in the soils of natural ecosystems is averagely 3,8 mg/kg of soil and varies from 0,9 to 25,3 mg/kg. In comparison with background for soils of Belarus the examined soils are depleted concerning the element. A similar situation is for nickel with its average content being 2,8 times lower than background values and equal to 5,3 mg/kg, varying from 1,4 to 14,0 mg/kg.

Chrome content in examined soils lies between 5,0 mg/kg and 91,4 mg/kg with average value 40,3 mg/kg of soil. The excess of background being equal 1,5-3,0 times is observed in 41 % of selected samples. No APC excesses were indicated.

The given heavy metal concentrations in soils of the region prove its ecological purity. The excess of allowed levels was determined only in individual cases being of a small value (1,3 times for lead and 1,1 times for zinc).

To predict the soil pollution in future there was performed a modeling [128] of lead and cadmium content in the soil for a 40-year prediction period according to two scenarios: within present level of emissions and with its 2 times increasing. The data obtained states that concentration of the elements will either remain on the present level or be slightly increased (up to 1,2 times) but in every case they will not exceed MAC/APC and also will not be higher than critical loads on natural ecosystems they are causing.

13.8.2 Natural greenery structure

Natural greenery in the range of the territory under consideration occupies nearly a half of the area (figure 75). Forests appear to be its dominant type occupying 37,7%. Swamps, natural meadows and water ecosystems taken together occupy 10,6%.

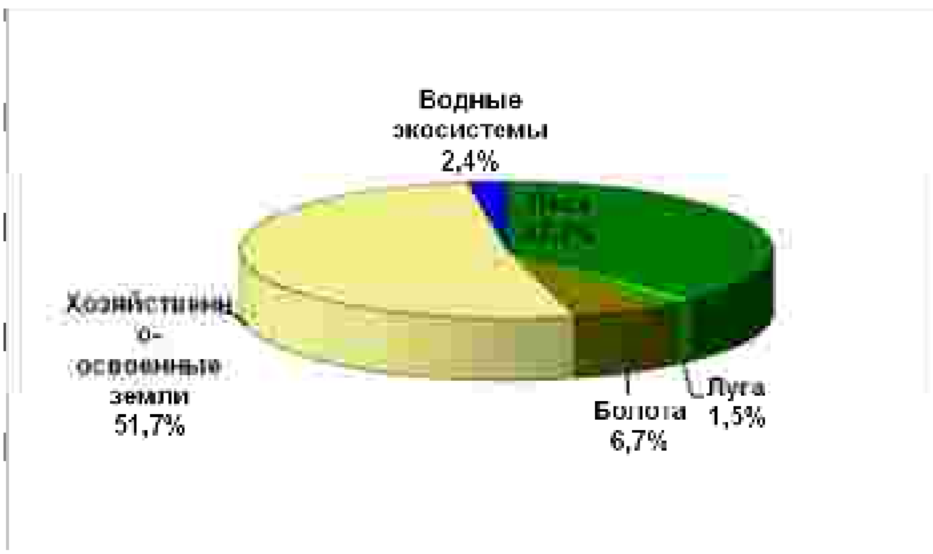


Figure 75 – Land structure of NPP location 30 km area

Formational-typological structure of forests is determined by a complex of natural and anthropogenic factors. As a result of poor sandy soil prevalence pine forests dominate among other forest types (68,1% of forested area). Spruce forests (12,1 %) and nodding birch forests (13,4 %) occupy relatively large area. Sticky alder forests, gray alder forests, pubescent birch forests and broad-leaved (oak, lime, ash) forests occupying 6,4 % of forested area are present fragmentarily. Plantations of mossy (35,2%), adder-spitted (15,9 %), wood-sorrel (9,8 %) ericetal (7,4 %) series of forest types prevail in the spectrum of typological variety.

Anthropogenic impact on forest greenery of 30 km area is insignificant and consists, generally, in performing of final felling and improvement felling, artificial forest creation involving, generally, pine monocultures on the place of natural sometimes complicated spruce-pine plantations. Such plantations occupy 20,3% of state forest reserves on the area. The greater part of artificial plantations was created from wood species not corresponding to the habitat conditions (mainly spruce cultures). This leads to simplifying of the forest composition and structure, degradation of forest regeneration, floristic composition depletion and elimination of economically valuable as well as rare and relic species from it, formation of unstable plantations. Thinning of moss cover, forming gramineous green mossy and gramineous digressive groupings is observed in pine forests.

Swamps are introduced mostly by bottom type (78 %). Upper swamps occupy 20 % of the total area with transitional swamps occupying 2 %. As a result of drainage amelioration performed in 1960-1970 the most part of large swamp areas was dried. Its remaining parts are small outlined.

Eutotrophic grassy swamps are associated with negative relief factors in river valleys and on watersheds. Presence of grass cover consisting of hydromesophilic and mesohydrophilic species with prevailing sedges, horsetails, cereals and species of swamp herbs is typical for them. Mesotrophic swamps are formed in the kettle of interfluve area on the territories with depleted mineral feeding and well-developed peat deposit. Upper oligotrophic swamps are typical for domination of *Sphagnum magellanicum* in the moss cover. The tree layer is absent or is introduced by thinned or strongly oppressed *Pinus sylvestris* f. Litwinowii.

Meadow lands are most widely introduced in the bottom of r. Vilija and its feeders Oshmianka, Stracha, Losha and also in valleys of a number of lakes. Productivity (yield capacity) of communities' plant formations correlates with the soil richness. Communities of swampy, fallow and moist meadows possess its highest value.

There are 44 species of higher (vascular) plants (183 of them are on the territory of Belarus) including 24 species of true aquatic, 20 of aero-aquatic and semi-aquatic plants in water bodies and constant stream flows on the territory under consideration. The number includes 1 rare relic species entered the Red Book of Republic of Belarus (saw grass - Cladium mariscus (L. Pohl), Lake Glubelka) and 18 species of economically valuable resource-forming plants, 2 species (sweet flag, Canadian pondweed) being stranger and denizen species. Lakes Svirj, Vishnevskoje and lakes from Sorochanskaja group are notable for its flora richness with less various flora being in rivers Vilija and Stracha. There is a poor flora of water plants in shallow rivers of the second order.

Grade of water overgrowing in lakes and rivers of the territory and quantitative development of higher aquatic plants there correspond to the mode of overgrowing in general for Belarus. The main quantity of lakes and rivers of the territory are typical for low and moderate grade of overgrowing from 10 to 40% of aquatic area (the number includes nearly 70% of water bodies for Belarus). Only lake Vishnevskoje and separate parts of rivers Stracha, Oshmianka with streaming flow are referred to strongly or fully (40-80 % of aquatic area) overgrown water bodies (progression of such lakes is 30% for Belarus). The great majority of water bodies (55 % of the total examined) possess a low biomass of higher aquatic plants (less than 0,2 kg/m^2) with only 5 % of water bodies possessing high biomass (more than 0,4 kg/m^2).

In the structure of land reserves of near 5 km area as well as the site itself agricultural lands take up a dominating position – more than 80%. Forests occupy 10% and 20 % respectively. Spruce forests prevail in the forested area of the site (86 %).

The average age of the region's forest plantations is 49 years. Young forests (I-II age classes) occupy 22,6 % of forested area, middle-aged forests (III class) – 36,4%, ripening (IV class) – 27,1 %, mature (V-VI class) – 13,4 %, overmature forest stands (VII class and higher) – 0,4 %.

The average forest stand normality is 0,70. Forests of medium normality (0,6-0,8) prevail occupying 88,9 % of forested lands. Forest stands of low (0,3-0,5) and high normality occupy 5,3 % and 5,8 % of forest area respectively.

The average quality class of plantations is 1,6. Highly productive (1,6-1 quality class) forests occupy 49,6 % of forested area and are located on the region's periphery, especially in western and north-eastern parts and also along the whole length of river Vilija. Middle-aged and ripening plantations of the forests possess 210-230 m^3/ha of forest yield. Middle (II-III quality classes) and low-productive (IV-V) plantations occupy 47,4 % and 3,0 % respectively. The forest yield of middle-aged and ripening plantations is 160-190 (for middle-aged) and 60-100 m^3/ha (for ripening).

Total forest yield in forests of the region as of 01.01.2006 is worth 17677 ths. m^3. The basic tree species here is coniferous forming more than ⅔ part of the total reserve with hardwood accounting for the remainder. Forests are exploited intensively enough though violated age structure doesn't allow to use the forest resources to the full.

According to natural fire protection forests are divided into 5 classes. In the 30 km area 22,8 % of forests are referred to I class, 0,4 – to II class, 41,9 – III, 30,7 – IV and 4,2 % to V class. Generally, forest fire danger is moderate its average class being equal to 3,0.

Forests of very high natural fire danger (I class) are spread relatively uniformly across the 30 km area and are combined with the forests of medium and low natural fire danger. The greatest aggregation of forests of high natural fire danger is noted to be located to the east and south-east of NPP location point. Some forest areas of high natural fire danger are located in the vicinity of the site (1,5 km from the site).

Chemical and radioactive greenery pollution. To assess the present radioactive and chemical pollution of greenery in the range of 30 km area samples of various plant components were selected and analyzed for the content of cesium-137 and heavy metals. Selection of the latter was performed taking into account the emission amounts of these matters into environment, its toxicity and ability to build up in life forms and included 9 elements: cadmium, lead, zinc, chrome, cobalt, nickel, copper, vanadium, manganese. Forest and meadow ecosystems were the objects of examination.

Radioecological situation in the forest ecosystems was assessed according to accumulation of cesium 137 in tree layer, undergrowth shrub layer, shrub layer, live ground layer, mushrooms, soil, underlayer. Within common low content of the given element in all the forest greenery components its highest levels of content were indicated in conventional radionuclide accumulators: forest underlayer and plants of grass-shrub-moss layer. The largest build up among them was indicated in green mosses and epiphytic lichens.

In the structure of tree and grass-shrub layers the highest levels of radiocesium content were obtained for red bilberry and blackberry, the lowest – for wood.

In various production types of secondary forest exploitation the content of cesium-137 is many times lower than value established in sanitary regulations. Thus in mushrooms (the main accumulator of the given element) it turned out to be 6,9 times less than stated standards, in berries of blackberry and red bilberry – 22 times, in drug raw material (springs of blackberry and red bilberry) – 5-8 times.

In swamp and meadow plant formations the dominants of plant cover and grass sod were analyzed. The results obtained showed that its radiocesium content is 16-55 times lower than allowable level.

The obtained data on the present cesium-137 content in greenery components show its correspondence with the background values. The data can be used as input parameters when organization and performing of long-term radioecological monitoring of plants in the region of NPP construction.

The content of heavy metals in plants of forest biogeocenoses is within the background level in the great majority of cases. Lead is the main element with stable excess of background concentrations being observed. Apparently such situation is the result of a higher lead content in soils comparing with the background (2,4 times higher).

The excess content of lead is indicated practically in all the components of greenery. In pine needles it is equal to 1,7 times, in the pine bark – 1,8 times, in epiphytic lichen – 2,1 times, in ground biomass of blackberry – 2,2 times. More higher concentrations in comparison with background values were obtained for other elements – chrome, vanadium, copper, nickel – in various plant components.

In all the cases a low level was detected for values of integral plant pollution index. Such assessment depicts a favorable ecological situation established in the region concerning chemical pollution index.

13.8.3 Protected plant species

Directly on the site of NPP construction there are no species entered the Red of Republic of Belarus (2005) or species from the "List of plants and mushrooms requiring preventive protection". This is associated with the fact that agricultural lands are widely introduced here when forest areas are mostly small outlined and young in its age.

In 5 km-radius area around the site one species of protected plants Trollius europaeus L. – European globe flower – was noted. The plant grows 2,2 to south-west from v. Goza. The planned construction works may exert negative influence on it. In order to save the species in the present ecotope it's necessary to support the existing ecological regime. It's important to replant the species to adjacent suitable ecotope within necessity of building or laying communication paths. It transplants well.

In the near area 4 species from the "List of plants and mushrooms requiring preventive protection" were also found. Though it will not be seriously affected by the planned works. It's popularity and variety in the region under consideration and on the adjacent areas are rather high. It is typical for a rather high reproductive capacity.

30 km area examinations revealed the presence of 11 protected plant species in its range besides those that grow in sanctuaries and in "Narochanski" national park and are protected. Majority of them (7 species) is referred to IV protection category, 1 – to III, 2 – to II and 1 – to I category. The most representative ecotopes for growing of the discovered rare plant species turned out to be valleys of rivers and streams, lake kettles and large forest areas.

Practically all the discovered populations of protected plant species are distant enough from the site of NPP construction and the planned works will not be able to affect its existence directly. though a possible indiret influence is associated with water depression or on the contrary with water raising, high anthropogenic pressing and etc.

13.8.4 Specially protected natural areas (SPNA), protected forests, valuable plant communities

There are situated "Sorochanskie ozera" landscape sanctuary of republic assignment, a part of forests of "Narochanski" NP and 3 landscape sanctuaries of local assignment ("Golubyje ozera", "Serzhanty", "Ozero Byk") as well as 3 natural monuments of local assignment ("Lipovaja alleja s tremia dubami" and "Starazhytny dub") in the range of 30 km NPP location area.

Large SPNA are located mostly in north-eastern parts of the area. There is located "Sorochanskie ozera" republic sanctuary with a total area of 13 ths. ha containing a separately allocated "Starazhytny dub" natural monument of local assignment as well as a part of "Narochanski" National park territory (7748,8 ha of forested area).

"Ozero Byk" and "Serzhanty" landscape sanctuary of local assignment and "Lipovaja alleja s tremia dubami" natural monument of local assignment are situated in south-western part of 30 km area. In south-eastern part of the territory “Golubyje ozera” landscape sanctuary of local assignment is situated.

Summarily the specially protected natural areas occupy nearly 15 % of 30 km NPP location area that stands for the high index of region's protected natural object saturation and requires special attention to supporting of their functioning stability in conditions of anthropogenic press increasing as a result of NPP construction and operation.

Forests of I group in 30 km area occupy 62,5 % of forested area and include forbidden (water protection) belts, protective belts along the roads, protective belts along the railways, national park forests, forests of sanctuaries of republic assignment, forest-park parts of green belts, forestry parts of green belts. According to average taxational indices and formation structure they aren't different from all the forests of the territory under consideration.

The special distribution of I group forests is determined by location features of developed and urbanized territories, specially protected natural territories and water ecosystems. Particularly water protection forests are concentrated generally along the r. Vilija. Protective forests along auto-roads and railroads occupy relatively large areas in south-western, southern and northern parts of 30 km area. Forests of “Narochanskij” national park and “Sorochanskije ozera” landscape sanctuary are located in north-eastern part of the territory under consideration. Forests of green belts are mostly located around town Ostrovets and town Oshmiany.

The central part of 30 km NPP location area is sparsely forested and includes small areas of water protection and merchantable forests.

In the range of 30 km area a set of categories of valuable plant communities was selected. The set includes areas of the following forest communities: less damaged by economic activity; old-growth; complicated in its composition and structure of plantations or forest stands with single trees of previous generations; rare and endangered forest types; with populations of rare or endangered species of flora and fauna; with presence of rare broad-leaved species in the tree layer (maple, lime, wych elm, elm); in natural river bottoms, around the river sources and springs; With limited accessibility (islands on the lakes, mineral islands on the open swamps). They occupy 7,1% of region’s forested area. There also were selected 17 categories of rare and unique meadow ecosystems requiring protection.

Generally natural greenery of the region is of high nature-oriented value. To minimize the influence on it the following measures are necessary when NPP construction and exploitation:

- data recording on location of outstanding greenery communities and rare protected species and also resource-important areas when developing of station construction project and accompanying infrastructure.
- discovery and organization of protection of rare plants and outstanding greenery communities, performing the monitoring of its condition;
- system creation and performing monitoring of natural greenery general condition (forest, meadow, swamp, littoral water greenery) in the NPP impact area.
- strict adherence of fire-fighting measure performance, including organization of fire-fighting forest management, arrangement of fireproof breaks and mineral belts, creation of operating supervision system for forest fire beds (observation towers, remote monitoring), secondary flooding of abandoned dried peats;
- plan development and plan implementation for special forest management of recreation forests to be exposed to high loads from the side of the resting.

13.8.5 Fauna

According to zoogeographical regionalization in Belarus the region of NPP is situated in the western zoogeographical region. Geobotanically the territory is located in the area of taiga forests being typical for its faunal complexes.

13.8.5.1 Ground invertebrata

Ground invertebrata fauna of coniferous (pine and spruce) forests prevailing in the composition of region's natural greenery is generally typical for its poor species composition and small population. Most of the insects in forest ecosystems are bounded with soil and underlayer as well as with wood plants.

Insects-xylobinotes inhabiting under the bark and in the wood of coniferous and broad-leaved trees comprise a special large grup in forest ecosystems. It, generally, includes beetles, hymenopteran and dipteran butterflies. The discovered coleopterous represent a complex consisting of the main trophic groups: xylophages actually feeding with wood and not associated with certain types of mushrooms, saproxylophages eating wood injured by mushroom mycelium, mycetophages using mycelium or mushroom fruit bodies as a feeding substrate.

Coleopterans also dominate in shrub and undergrowth shrub layers of coniferous forests. Families of weevils, leaf beetles and elaters are the largest of them.

13.8.5.2 Ichthyofauna

Ichthyofauna of water bodies and water runoffs of 30 km area is very rich in relation to species. It is represented by 42 species of fish being referred to 13 families [129,130]. It also includes 8 from 11 present on the territory of Belarus species of fish-like vertebrates and fish entered the Red Book of Republic of Belarus [131]. Besides 3 of them are salmon, salmon trout and river lamprey occurring in the country range only in those parts of r. Vilija and its feeders being located in the range of 30 km area.

Along with r. Vilija its feeders of the first order are also referred to the main fishery water bodies of the territory - rr. Oshmianka and Stracha. They are typical for its various species composition and relatively large fish reserves.

Ichthyofauna of river Vilija includes 42 species of fish within rheophilic species dominating. Both conventional species represented in many water bodies of Belarus – bream, orfe, chub, asp, pike-perch, burbot, pike, tench, carp, crucian carp, Prussian carp, with less valuable – roach, dace, perch, ruff, lookup, silver bream, redeye, gudgeon and some others and "specific" ones – anadromous salmons (salmon and salmon trout), sabrefish – inhabit here. Rare fish species entered the Red Book of Republic of Belarus (2004) – brown trout, grayling, vimba, barb and sneep inhabiting in channel, flinty-pebble, semigravel areas are met in the area of given river in the range of Ostrovetski region. In r. Vilijaa fish-like vertebrate rare for Belarus – river lamprey - can possibly be met too.

There are commercial species of fish such as bream, silver bream, roach, perch, pike, asp, pike-perch and orfe within catfish and eel sometimes being met there. Carp, prussian carp, crucian carp, tench and loach inhabit back waters and adjacent water bodies. The total fish stock of the river Vilija is 138 kg/ha. In the present time there's no fish cropping on channel areas of the river Vilija as it is fished by sport fishermen.

The river Vilija is the only water flow on the territory of Belarus with its channel having no regulating stanch and providing a natural way to the Baltic sea that is extremely important for migrating fish species. Valuable migratory salmon fish species such as Atlantic salmon and salmon trout appear in the given river and its feeders for a spawning season there also remaining a possibility of entrance the spawning areas for other migrating species of fish-like vertebrates and fish:

- river lamprey;
- sea whitefish.

There also a possibility of occupying the nursery grounds for valuable migrting species – freshwater eel.

Ichthyofauna of the rivers Stracha and Oshmianka compared with the similar in dimensions rivers of other river basins is typical for its variety of fish species composition (from 13 to 26 species on different areas) owing to the species entering them for spawning from the r. Vilija (sneep, vimba, grayling, brown trout). In the ichthyofauna composition of the given rivers as well as of the river Vilija rheophilic fish species prevail:

- dace;
- chub;
- lookup;
- gudgeon;
- verkhovka;
- char;
- minnow;
- riffle minnow;
- burbot;
- bullhead.

There also are met conventional freshwater species – pike, eel, roach, redeye, silver bream, tench, crucian and prussian carp, loach, spined loach, perch, ruff, three-spine stickleback and some others.

The total fish stock of the rivers Stracha and Oshmianka is 71 kg/ha. In the present time there is no fish cropping in the rivers being fished only by sport fishermen.

Due to the NPP construction the maximum priority should be given to the r. Gozovka. It is referred to small rivers. The ichthyofauna of the river is not typical for a great variety of species (5-8 fish species) and a fish stock amount (50 kg/ha). With that it includes the rarest and the most protected species. There are habitats and spawning areas of brown trout its population condition being assessed as good and spawning areas of two migrating from the Baltic Sea salmon fish species – salmon trout and salmon. In the r. Gozovka from 2002 to 2006 there was noted a passage for spawning of 7-13 spawners of salmon trout and establishment of 4-8 spawning redds (“nests”) of the species.

13.8.5.3 Toadfish- and herpetofauna

Toadfish- and herpetofauna of the region is typical for its relatively characteristic for Belarusian Poozerje species composition (12 species of amphibian – 92% of Belarusian fauna and 5 species of reptiles 71% of Belarusian fauna) [132,133].

The most dominating in frequency of occurrence are brown frog and common toad as well as edible frog subdominant being common newt and common and sand lizards. The rest species are relatively rare – green toad, crested newt, running toad, deaf adder, fire-bellied toad which localities occurring individually.

Central part of the territory under consideration in 5 km-radius from the site is inhabited by only 4 species typical for open developed in agricultural relation territories with spiked forest cover. The area of forests and density of hydrographic network is increased moving to its periphery. These factors provide increasing of reptiles and amphibian variety from 4 to 17 species. There are also 2 species entered the Red Book of Republic of Belarus (*Triturus cristatus, B. calamita*) and 2 species entered the Red Book of IUCN (*T. cristatus, Bombina bombina*).

13.8.5.4 Bird fauna

Region's bird fauna is represented by 151 species of nesting and migrating birds taking up 48,1% of country's bird fauna. Owing to presence of various biotopes on the examined territory members of practically all the orders registered in Belarus were detected in its range. Majority of bird species are referred to perching birds (48,3%) [134].

As soon as the territory is typical for its dense forest cover more than half of bird fauna here is represented by species referred to *forest* and *tree-shrub* ecological complexes. They take up 45% and 12% of all the noted species respectively (figure 76).

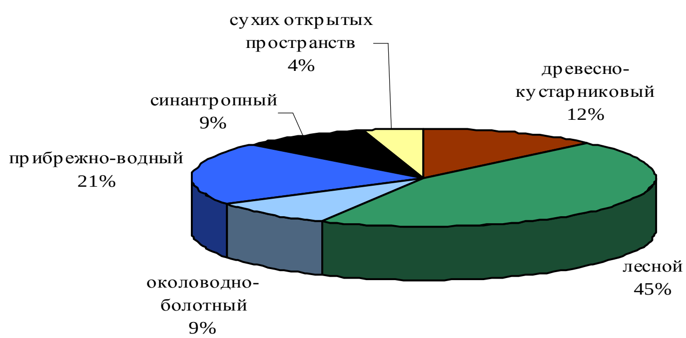


Figure 76 – clockwise – Forest – 45 %
Coastal aquatic – 21 %
Tree-shrub – 12 %
Semi-aquatic-swamp – 9 %
Synanthropic – 9 %
Dry open spaces – 4 %

Figure 76 – Relation between bird species of different ecological complexes

Owing to presence of such large lakes like Svirj and Vishnevskoe as well as the group of lakes Sarochanskie and a set of other smaller water bodies, river bottoms, channels, ponds, swamp areas species referred to coastal aquatic and semi-aquatic swamp ecological complexes are widely represented in the region. They take up 30% of the examined bird fauna.

In total there were determined 41 species of aquatic and semi-aquatic birds from 9 orders. The greatest variety of representation is typical for anseriformes – 18 species. Main places of the largest geese concentration in the period of spring migration (end of March – first half of April) are located on lakes Svirj and Vishnevskoe and also on agricultural lands in 3-8 km from the NPP site. For the latter its construction can be a factor of disturbance.

There were registered habitats of 23 bird species entered the Red Book of Republic of Belarus in 30 km area of NPP location.

- black-throated loon (*Gavia arctica);*
- bittern (Botaurus stellaris);
- white egret (Egretta alba);
- black stork (Ciconia nigra);
- smew (Mergellus albellus);
- buff-breasted merganser (Mergus serrator);
- merganser (Mergus merganser);
- white-tailed eagle (Haliaeetus albicilla);
- marsh harrier (Circus cyaneus);
- lesser spotted eagle (Aquila pomarina);
- osprey (Pandion haliaetus);
- merlin (Falco columbarius);
- little crake (Porzana parva);
- corncrake (Crex crex);
- gray crane (Grus grus);
- curlew (Numenius arquata);
- mew gull (Larus canus);
- gnome owl (Glaucidium passerinum);
- great gray owl (Strix nebulosa);
- kingfisher (Alcedo atthis);
- green woodpecker (Picus viridis);
- white-backed woodpecker (Dendrocopos leucotos);
- three-toed woodpecker (Picoides tridactylus).

The main habitats of protected bird species are concentrated at least 10 km away from the site and are associated mostly with large lakes and forest areas with water bodies. So the construction itself will not exert any influence on them. An increasing intensity of recreating territory usage due to population development associated with NPP construction will be a disturbance factor.

13.8.5.5 Hunting species

Hunting animal species in the region are notable for being rather various. Elk, roe, wild boar are typical and royal stag and fallow deer are imported in the places. Brown hare inhabits the farm lands. Typical forest species are blue hare, squirrel, common marten. Water bodies are inhabited by otter, mink, beaver having rather large population.

There are bird species on farm lands such as partridges, quails. In forests, mostly in coniferous, there are wood grouses, hazel grouses; in mixed forests – black grouses, wood pigeons, woodcocks. Gray geese, dabbling and diving ducks, bald coots are nesting at water bodies.

7 hunting entities are fully or partly located on the territory under consideration. The population of hunting species inhabiting there is mostly medium. In the group of the most valuable species – hoofed – roe has the largest population followed by boar, elk and deer. The hunting capacity is varied in the following sequence: boar – 49 % of the total population, roe – 11 %, elk – 4 %, deer - is not hunted.

A complicated mosaic structure of various lands - forests, open spaces, water bodies, swamps - typical for the 30 km area creates favorable conditions for nesting of birds of prey. There were noted 13 such species. Common species for diurnal birds of prey are common buzzard, marsh and Montagu's harriers. In the vicinity of large lakes there inhabit two species of fish-eating birds of prey - osprey and white-tailed eagle being rather rare on the territory of Belarus but in the region under consideration they are *nesting rather often.*

Among vespertinal birds of prey there were found 4 of 10 owl species nesting in the country. The most typical of them are boreal owl and tawny owl.

A group of woodpeckers is represented fully enough in the region. There were found 8 species of 10 inhabiting in Belarus. Greater spotted woodpecker is the most common representative of woodpeckers having the larges population. The given species besides all the rest provides favorable conditions for habitats of small species of nesting cavity birds - tomtits, flycatchers, some of owls and etc.

Wildlife of agro-ecosystems. Species composition of insects in agro-ecosystems is significantly depleted in comparison with natural biocenoses and is typical for domination of some species. Ground beetles are dominating in the ground layer. Representatives of snout-beetles, lady-bugs, cicadas and some other dipterous insects are typical for field layer. Population of ground insects on developed fields is not large as its associations are exposed to influence as a result of chemical processing.

The same poorness of species composition is typical for the variety of amphibian and reptiles. Edible frog, brown frog, common toad are dominating in agro-ecosystems. With that two of the latter being typical for forests are found only on the borders of deforested areas of agricultural lands.

Bird fauna of agro-ecosystems is not typical for a large amount of species and a comparatively large bird population either. Skylark is dominating on the fields developed for cereals. Winchat can also be referred to dominating species on the areas of lands with perennial artificial herbs. The number of habiting bird species is increased from 12 to 32 on perennial hayfields with small swamps, shrub curtains and low forests.

Hunting species of animals in the region are typical for its significantly large variety. Elk, roe, wild goat are typical and royal stag and fallow deer are imported in the places. Brown hare inhabits the farm lands. Typical forest species are blue hare, squirrel, common marten. Water bodies are inhabited by otter, mink, beaver having rather large population.

There are bird species on farm lands such as partridges, quails. In forests, mostly in coniferous, there are wood grouses, hazel grouses; in mixed forests – black grouses, wood pigeons, woodcocks. Gray geese, dabbling and diving ducks, bald coots are nesting at water bodies.

Relative populations for majority of hunting species of mammals in the region is medium, for birds it is low (Table 119). Among mammals deer, stone-marten, common squirrel, musk beaver, blue hare are referred to species with relatively small population. Among birds – gray goose, mallard, gadwall, shoveler, widgeon, garganey teal, green teal, snipe, black grouse, gray partridge, quail, moorhen, rail

The usage of separate hunting species including all the hoofed is standardized. Some beasts of prey such as wolf, red fox and raccoon dog in their present population are classified as nuisance.

7 hunting entities are fully or partly located on the territory under consideration. In the structure of hunting lands forest lands play the main part. They occupy 48 % of these lands' area. Meadow lands occupy 46 % of area and wetlands – 6 %.

In the group of the most valuable hunting species – hoofed – roe has the largest population followed by boar, elk and deer. The hunting capacity is varied in the following sequence: boar – 49 % of the total population, roe – 11 %, elk – 4 %, deer - is not hunted.

Table 119 – Relative population and habitat features of hunting species in 30 km NPP area

Species	Relative population	Habitat features	Species status
MAMMALS (animals)			
Cloven-hoofed mammals			
Elk	Meduim	Permanently	Standartized
Deer	Low	Permanently	Standartized
Roe	Meduim	Permanently	Standartized
Boar	Meduim	Permanently	Standartized
Beasts of prey			
Wolf	Low	Permanently	Nuisance
Red fox	Meduim	Permanently	Nuisance
Raccoon dog	Meduim	Permanently	Acclimatized, nuisance
Common marten	Meduim	Permanently	Hunting
Stone marten	Low	Permanently	Hunting
Ermine	Meduim	Permanently	Hunting
American mink	Meduim	Permanently	Acclimatized
Polecat	Meduim	Permanently	
True otter	Meduim	Permanently	Standartized
Rodents			
Squirrel	Low	Permanently	Hunting
European beaver	Meduim	Permanently	Standartized
Musk beaver	Low	Permanently	Acclimatized
Double-toothed rodents			
Brown hare	Meduim	Permanently	Hunting
Blue hare	Low	Permanently	Hunting
BIRDS			
Anseriformes			
Gray goose	Low	Passing	Hunting
White-fronted goose	Meduim	Passing	Hunting
Bean goose	Meduim	Passing	Hunting
Mallard	Low	Nesting	Hunting
Gray duck	Very low	Nesting	Hunting
Shoveler	Very low	Nesting	Hunting
Widgeon	Low	Passing	Hunting
Garganey teal	Low	Nesting	Hunting
Green teal	Low	Nesting	Hunting
Charadriiformes			
Snipe	Low	Nesting	Hunting
Woodcock	Meduim	Nesting	Hunting
Galliformes			
Black grouse	Low	Permanently	Standartized
Hazel grouse	Meduim	Permanently	Hunting species
Common partridge	Low	Permanently	Hunting
Quail	Low	Nesting	Hunting
Gruiformes			
Moorhen	Low	Nesting	Hunting species
Bald coot	Meduim	Nesting	Hunting
Rail	Low	Nesting	Hunting

Main concentration areas of hoofed animals are associated with large forest areas. They are located far from the NPP construction site (figure 77).

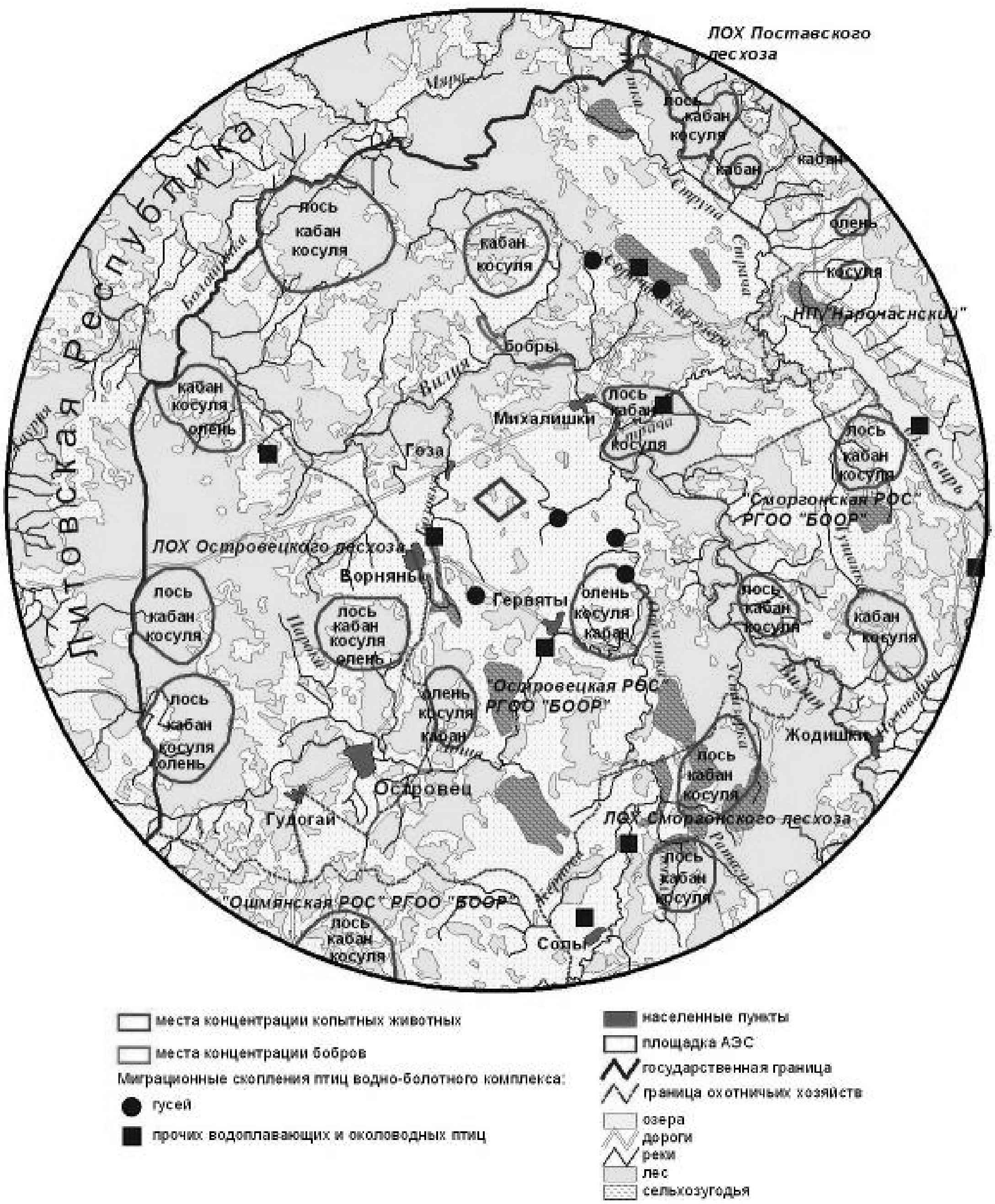


Figure 77 – Hunting entities and the most valuable hunting species of animals in the 30 km NPP location area

Wildlife of adjacent 5 km area is not rich in species relation and comparatively low in population considering majority of animal classes. Hunting value of the given territory is not high either. No ecosystems – places of habit for protected animal species –

were detected in its range. The r. Gozovka make the only exclusion where valuable and rare fish species inhabit.

13.8.5.6 Chemical and radioactive animal pollution

To determine chemical and radioactive pollution of animals in 30 km area there were selected samples of muscular tissue of mammals, birds and fish. There was performed an analysis of radioactive element content for: strontium-90 and cesium-137 as well as for heavy metals: copper, zinc, ferrum, cobalt, manganese, lead, cadmium, tin, aluminum, antimony, nickel.

The objects of examinatin were mammals (murine rodents, common shrew, and also hoofed: roe, elk, boar), birds (mallard, woodcock, wood pigeon, crow), amphibian (brown frog), fish (northern pike, river perch, bream, chub, prussian carp, silver bream).

Based on the analysis performed the content of radioactive elements in all the examined animals was determined to be low. So for cesium-137 it is less than 6 and 2% of the permitted level for fish and hunting animals respectively.

There were detected excesses of sanitary standards concerning heavy metal content for two elements – lead and cadmium in tissues of commercial mammals and birds. The maximum lead concentration excess was equal to 16,8 times for mallard and cadmium excess – 7,6 times for roe. Presence of the indicated chemical pollution proves that even in the 30 km area under consideration being an ecologically clean region there is a possible danger of a high heavy metal build-ups in muscular tissues of animals.

13.9 Population and demography

13.9.1 Demographic situation in 30 km Belarusian NPP area

When disposing Belarusian NPP on Ostrovets site in the range of 30 km area there will be located settlements of the Republic of Belarus and Lithuania. The demographic situation analysis was performed for the population living in 30 km area of the site on the territory of the Republic of Belarus.

In 30 km area there area situated settlements of Ostrovetski, Oshmianski, Smorgonski districts of Grodno region; Miadelski district of Minsk region; Postavski district of Vitebsk region.

Totally in 30 km area of Ostrovets settlement there are 35682 persons living as of 01.01.2007, 6191 of them (17,3%) being younger than working age, 19571 persons (54,9%) being at working age, 9920 persons (27,8%) being older than working age. Population density in the region under consideration is 15 pers./km^2 (without considering Lithuania). In the settlement structure small settlements prevail in amount (less than 100 persons), the specific weight of it being equal to 85,6% [137].

There are no settlements in 1,5 km-radius area away from the Ostrovetskaja site, 765 persons live in the 5 km-radius area, 122 of them (15,9 %) being younger than working age, 361 of them (47,2 %) - at working age, besides 195 persons of them live in 3 km away from the site, with 29 persons (14,9 %) being younger than working age, 88 persons (45,1 %) being referred to labor force (figures 78, 79) [138].

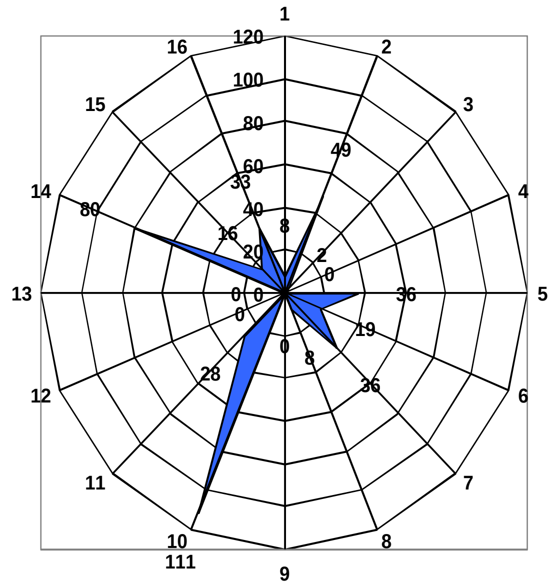


Figure 78 – Bearing distribution of popularity living in 5 km from the Ostrovetskaja site

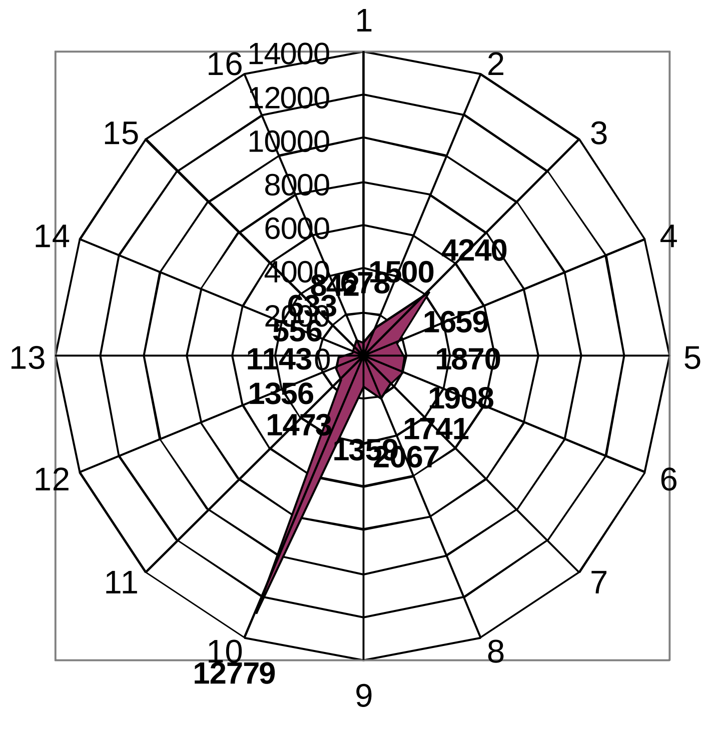


Figure 79 – Bearing distribution of popularity living in 30 km from the Ostrovet-skaja site

13.9.2 Comparative primary disease incidence analysis of adult population in Grodno, Vitebsk and Minsk regions in 2004-2008.

A comparative disease incidence analysis of population for five-year period was performed based on data of annual statistical reports made by medical and preventive treatment institutions of republic. The data were obtained from Ministry of Health of the Republic of Belarus.

The primary disease incidence analysis of population of the Republic of Belarus was performed in terms of 13 main disease classes in accordance with ICD-10. There was determined a structure of disease incidence in 2004 and in 2008. A comparative structure analysis of primary disease incidence of adult population in cases of diseases diagnosed for the first time showed no significant changes in 2008 compared to 2004 concerning the analyzed disease classes (figures 80,81) [139,140].

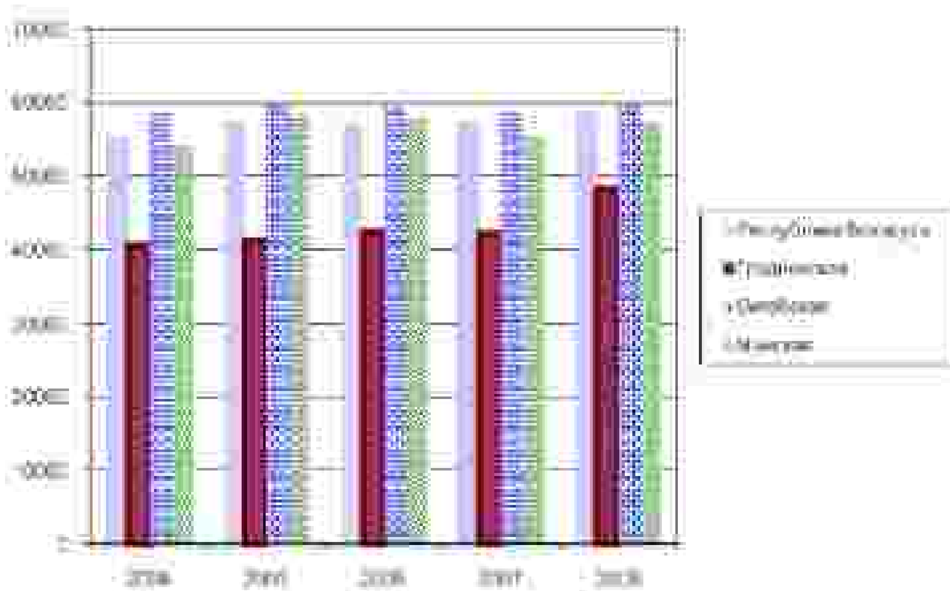
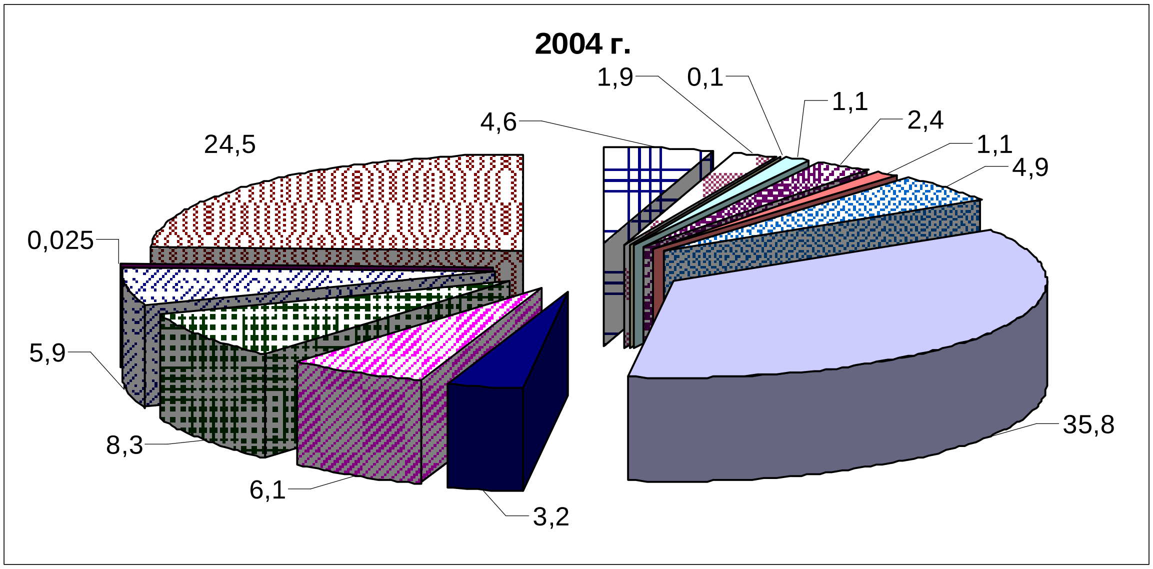


Figure 80 – Dynamics of primary disease incidence on all the disease classes of adult population in the regions of the Republic of Belarus in 2004-2008 (per 100 ths. of population)



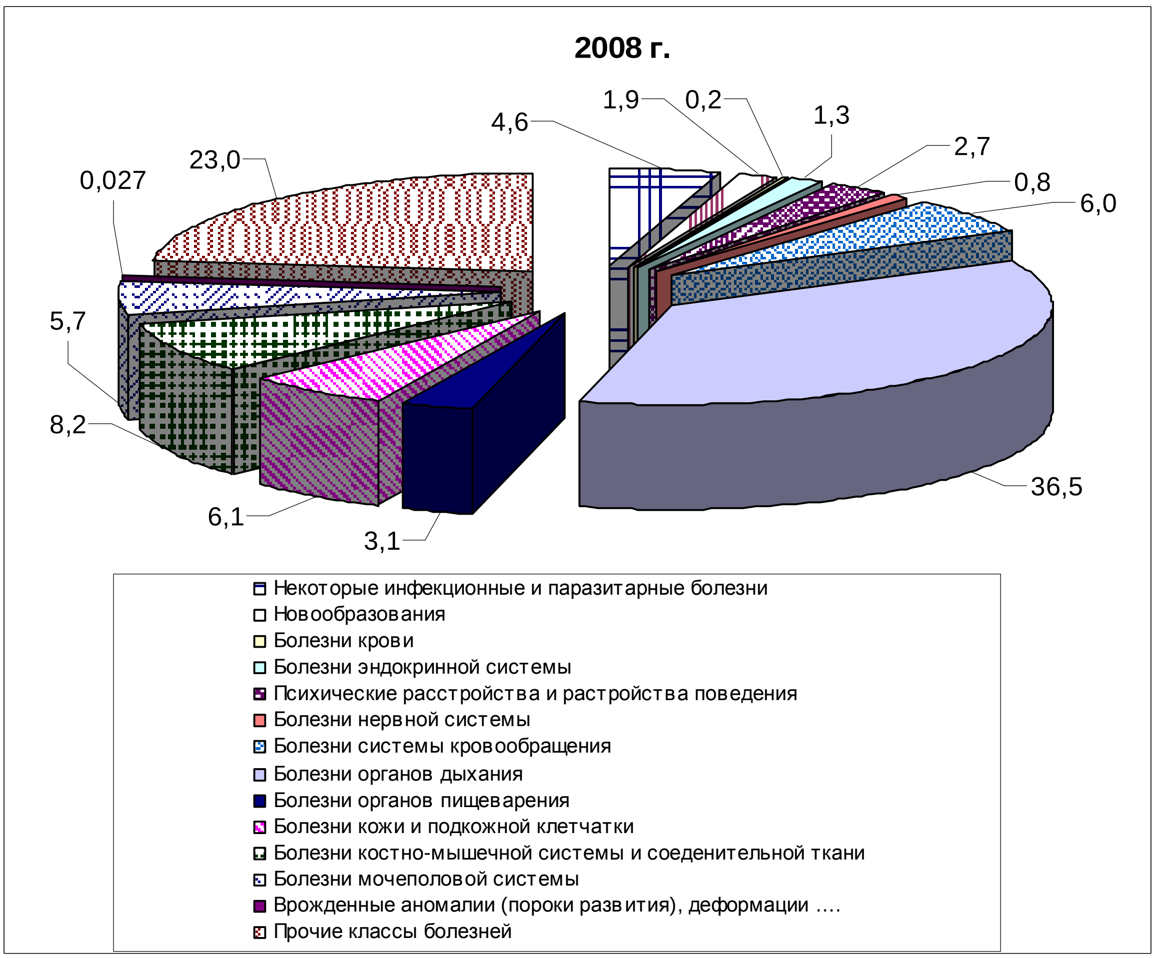


Figure 81 – Structure of primary disease incidence of adults in the Republic of Belarus in 2004 and 2008, %

The first rank place both countrywide and regionwide was taken by respiratory diseases – from 33,9 % in Grodno region to 40,5 % in Vitebsk region in 2004, from 32,9 %

in Grodno region to 41,8 % in Vitebsk region in 2008. This disease class took up from 35,8 % to 36,5 % countrywide respectively.

The second rank place was taken by diseases of musculoskeletal system and conjunctive tissue – from 6,6 % in Grodno region to 10,6 % in Minsk region in 2004 and from 6,7 % in Vitebsk region to 9,1 % in Minsk region in 2008. The given disease class took up from 8,3 % to 8,2 % countrywide respectively.

The third rank place was taken by skin and hypoderm diseases – from 6,4 % in Minskaja and Grodnenskaja regions to 7,7 % in Vitebsk region in 2004 and from 5,3 % in Grodnoregion to 8,1% in Vitebsk region in 2008. The disease class took up from 6,1 % countrywide both in 2004 and in 2008.

The fourth rank place was taken by circulatory diseases - from 5,0 % in Vitebsk region to 6,1% in Grodno region in 2004, and from 5,0 % in Vitebsk region to 9,2 % in Grodno region in 2008. There should be noted an increasing of specific interest of the disease class in Grodno region – from 6,4 % to 9,2 % and in Minsk region – from 5,8 % to 7,8 % over a period of 2004-2008. The interest of given class diseases has been increased from 4,9 % in 2004 to 6,0 % in 2008 countrywide.

The fifth rank place in the structure of primary disease incidence of adult population was taken by urogenital system diseases its interest varying from 4,2 % in Grodno region to 5,6% in Minsk region in 2004 and from 4,2 % in Grodno and Minsk regions in 2008. This disease class took up from 5,9 % to 5,7 % countrywide respectively.

The sixth rank place was taken by class of infectious and parasitic diseases its interest varying from 4,0 % in Minsk region to 6,0 % in Vitebsk region in 2004 and from 3,5 % in Minsk region to 5,3 % in Vitebsk region in 2008. The interest of infectious and parasitic diseases hasn't changed through the mentioned period being equal to 4,6 % countrywide [141-144].

Interest of the mentioned six disease classes in the primary disease incidence structure equaled 65,6 % in 2004 and 67,1 % in 2008 [140].

For a five-year period the is observed an increasing of primary disease incidence in all the disease classes both among adult population of republic in general (6,4 % higher) and among population of the region analyzed: from 2,5 % in Vitebsk region to 18,4 % in Grodno region.

The following disease classes are notable for the greatest increasing of the disease incidence level [141-144]:

- blood diseases,
- endocrine system diseases,
- circulatory system diseases,
- congenital anomalies (birth defects), malformations and chromosomal violations,
- mental behaviorial disorders.

In the rest disease classes there were noted both increasing and decreasing of primary disease incidence levels for adult population region wide and countrywide. It should be noted that disease incidence concerns revealed, registered cases of disease, i.e. a complex of diseases being the reason for population to seek medical treatment for the first time in the given year. This limited understanding should always be kept in mind as the level of registered disease incidence is determined by such objective factors as accessibility of medical institution, amount and specialization of treatment, security of health care workforce in general and functional specialists in particular, availability of the necessary medical equipment [141-144].

13.9.3 Comparative primary disease incidence analysis of children and adolescents (0-17 years inclusively) in Grodno, Vitebsk and Minsk regions in 2004-2008.

Comparative primary disease incidence analysis of children and adolescents showed insignificant specific weight variations of main disease classes for a five-year period.

The first rank place in overall disease structure was taken by respiratory diseases – from 69,0 % in Grodno region to 71,2 % in Vitebsk region and 68,0 % countrywide in 2004 and from 73,5 % in Minsk region to 77,2 % in Vitebsk region in 2008 within the interest of respiratory diseases being equal to 72,4 % countrywide in 2008. The interest of the rest 5 classes is much smaller.

The second rank place was taken by infectious and parasitic diseases – from 4,0 % in Minsk region to 6,4 % in Vitebsk region and 4,7 % countrywide in 2004 and from 3,5% in Minsk region to 3,9 % in Grodno region and 3,7 % countrywide in 2008.

The third rank place was taken by skin and hypoderm diseases – from 3,8 % in Vitebsk region to 4,7 % in Minsk region and 4,3 % countrywide in 2004 and from 2,6 % in Vitebsk region to 4,5 % in Minsk region and 3,9 % countrywide in 2008.

The fourth rank place was taken by digestive tract diseases – from 2,5 % in Vitebsk region to 3,4 % in Minsk region and countrywide in 2004 and from 2,5 % in Grodno region to 2,8 % in Vitebsk region and countrywide as well.

The fifth rank place was taken by diseases of musculoskeletal system and conjunction tissue – from 1,0 % in Vitebsk region to 1,4 % in Minsk region. Generally countrywide the specific weight of this disease class was equal to 1,3 % in 2004. There is noted a decreasing of the specific weight in 2008 - from 0,7 % in Grodno region to 1,0 % both in Minsk region and countrywide.

Having low specific weight urogenital system diseases were on the sixth rank place – from 1,1 % in Grodno and Vitebsk regions to 1,4 % in Minsk region and 1,2 % countrywide. in 2008 specific weight of the disease class was equal to 0,9 % in all the three regions and 1,1 % countrywide [141-144].

The interest of diseases taking first six rank places in the disease structure was 82,9 % in 2004 and 84,9 % in 2008.

The lowest temper of disease incidence level increasing in all the disease classes among all the regions was detected in Minsk region - 7,9 %, the highest being in Grodno region - 15,6 %, in Vitebsk it was equal to 12,8 %.

The highest temper of disease incidence level increasing was detected in:

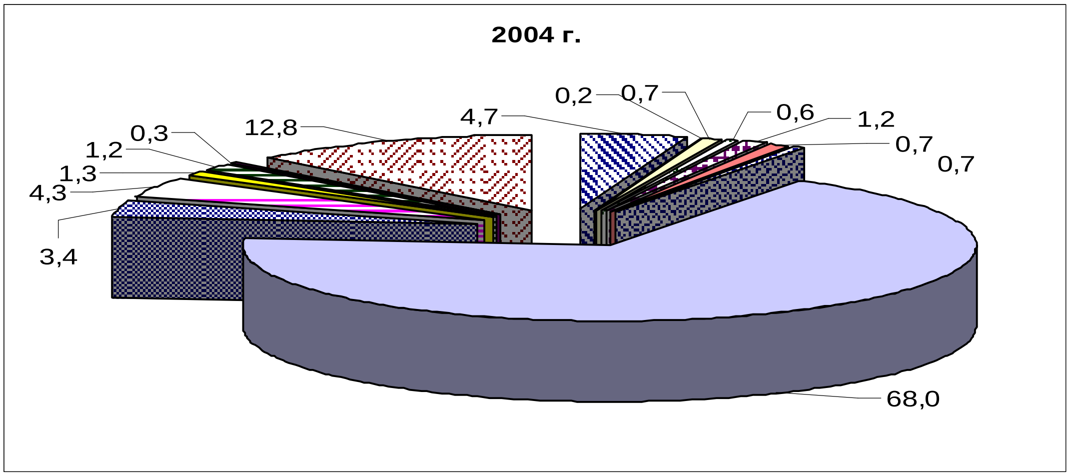
– class of respiratory diseases,
– class of congenital anomalies (birth defects), malformations and chromosomal violations,
– class of neoplasms.

The most significant disease incidence level decreasing in 2008 in comparison with 2004 was detected in:

- class of circulatory system diseases,
- class of endocrine system diseases,
- class of mental disturbances and behaviorial disorders,
- class of diseases of musculoskeletal system and conjunction tissue,
- class of digestive tract diseases.

The disease incidence level decreasing was 8,5 % countrywide [141-144].

Structure of primary disease incidence of children and adolescents is represented in diagram (figure 82).



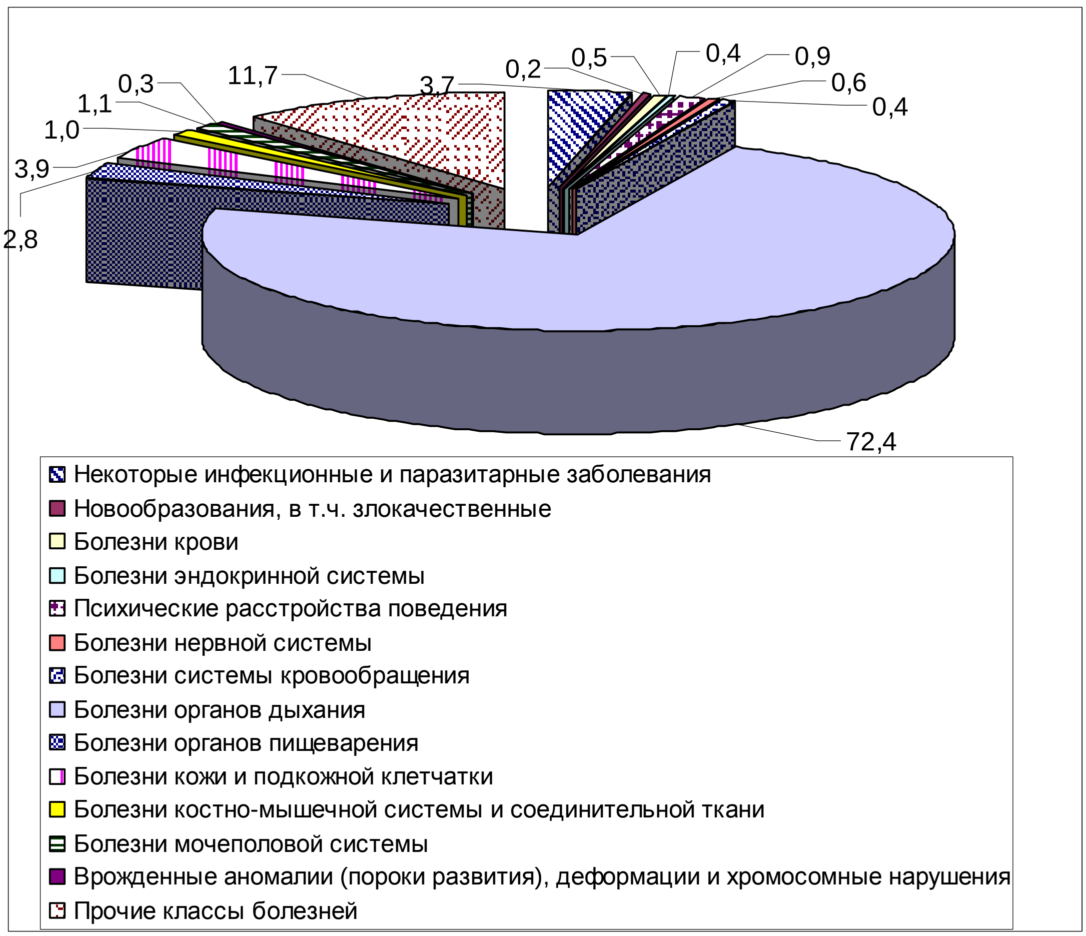


Figure 80, 82 – some infectious and parasitic diseases
Neoplasmas, including malignant
Blood diseases
Endocrine system diseases
Mental behaviorial disorders
Nervous system diseases

Circulatory system diseases
Respiratory diseases
Digestive tract diseases
Skin and hypoderm diseases
Diseases of musculoskeletal system and conjunction tissue
Urogenital system diseases
Congenital anomalies (birth defects), malformations and chromosomal violations
Other disease classes

Figure 82 - Structure of primary disease incidence of children and adolescents (0-17 years inclusively) in the Republic of Belarus in 2004 and 2008, %

13.9.4 Analysis of primary disease incidence associated with malignant neoplasms of population in Grodno, Vitebsk, Minsk regions and separate districts of the regions in 2004-2008.

Neoplastic processes are typical for extraordinary variety of its clinical and morphological evidences. The malignant neoplasms attack rack of different organs and systems is not similar not only for different countries but for separate areas of one country (regions and districts). The tendencies of disease incidence dynamics are varied in time as well as its structure is varied depending on etiological factors inducing cancerogenese in separate organs.

Assessing the dynamics of primary oncological disease incidence of republic's population for the period of 2004-2008 an increasing of disease incidence should be noted countrywide by 6,9 % and in Grodno, Minsk and Vitebsk regions the increasing was varied from 2,8 % to 8,8 %. Concerning separate districts of the regions there was a decreasing in Oshmianski district by 13,8 %, in Smorgonski district - by 13,5 %, in Postavski district – by 5,3% In Oshmianski district there was an increasing by 10,6 % and being the most worrying there was detected a significant increasing of disease incidence in Miadelski district by 55,8 % [141-145]. Dynamics of primary disease incidence associated with neoplasms of adult population as well as of children and adolescents in regions of the Republic of Belarus for a period of 2004-2008.

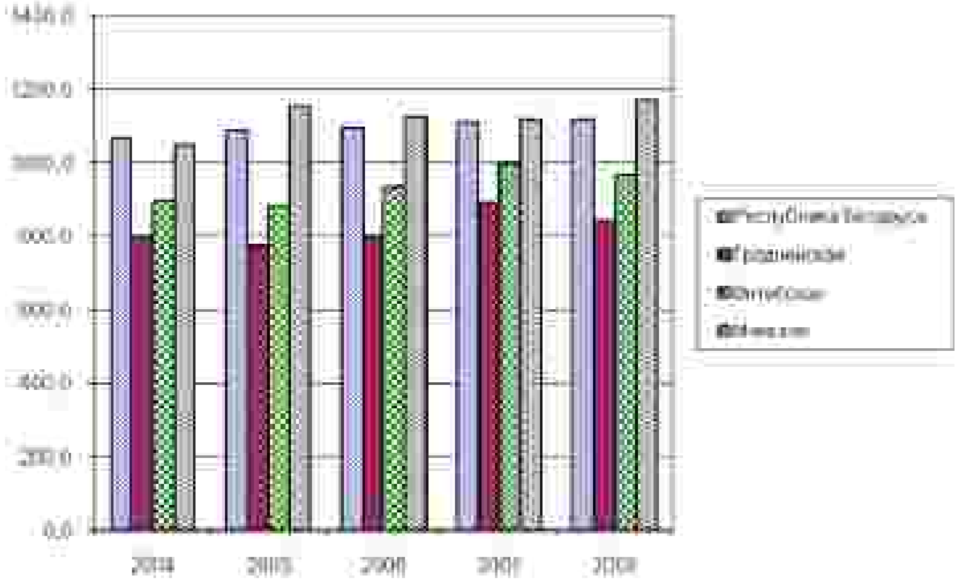


Figure 83 – Dynamics of primary neoplasm disease incidence of adult population in the regions of the Republic of Belarus in 2004-2008 (per 100 ths. of population)

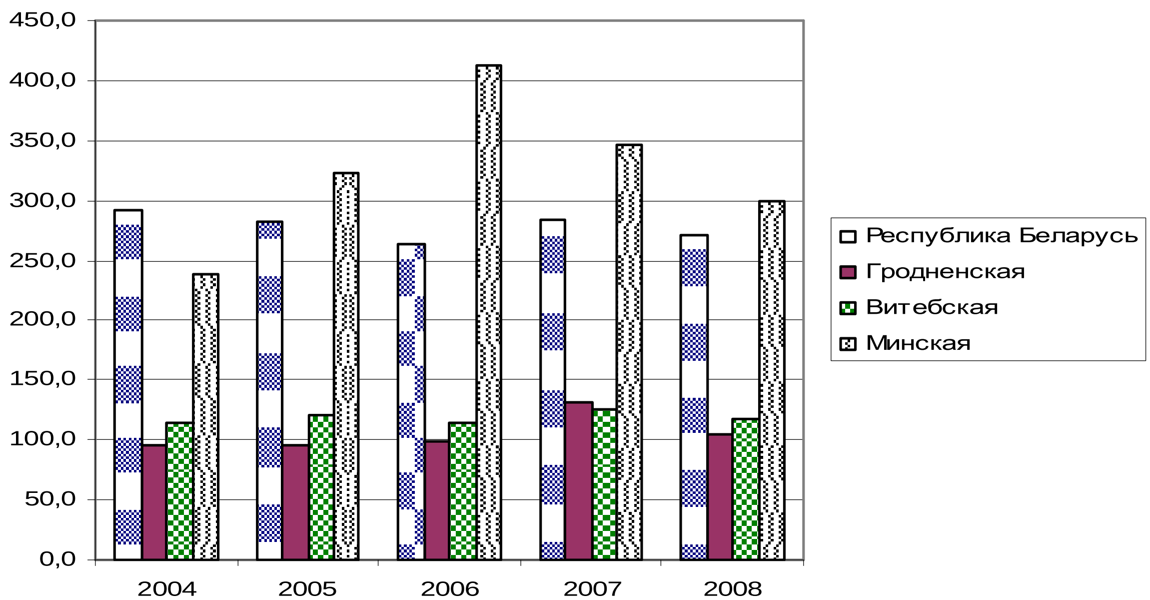


Figure 84 – Dynamics of primary neoplasm disease incidence, including malignant, of children and adolescences (0-17 years inclusively) in the regions of the Republic of Belarus in 2004-2008 (per 100 ths. of population of the given age)

Average indices of disease incidence for a five-year period in the regions and districts were varied from 320,3 cases to 392,8 cases per 100,0 ths. of population and only in Miadelski district the index was equal to 469,1 per 100,0 ths. of population significantly exceeding the republic and regional levels.

In 2004 the indices of disease incidence were higher than average republic level in Vitebsk region, Postavski district and Minsk region the indices being lower than republic level in all the districts of Grodno, Vitebsk regions in 2008. The index of disease incidence in Minsk region exceeded the republic level by 2,9% in Miadelsk district being higher than republic level by 33,1% (figure 85) [141-145].

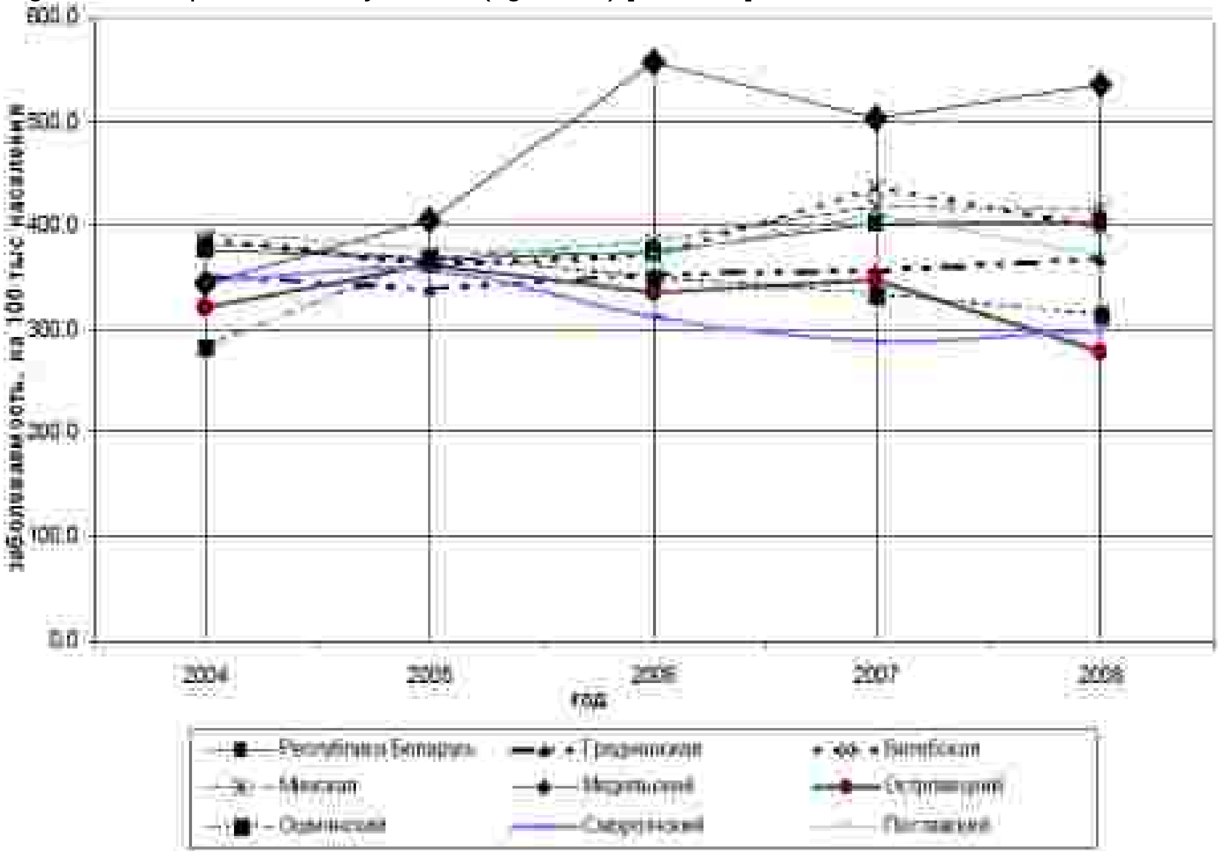


Figure 85 – Dynamics of primary oncological disease incidence in the regions of the Republic of Belarus in 2004-2008 (per 100 ths. of population)

The average republic thyroid carcinoma incidence hasn't changed significantly for the period analyzed (2004-2008). The average indices of thyroid carcinoma incidence of analyzed regions' population were lower than republic level for a period of 2004-2008 and only in Smorgonski district the disease incidence was equal to 13,6 cases per 100,0 ths. of population being insignificantly higher than average republic value - 11,2 per 100,0 ths. of population. The increasing of disease incidence in Ostrovetski and Smorgonski districts can be considered statistically uncertain and the growth temper calculated for these districts should be assessed with a certain extent of care due to a small number of cases of registered thyroid carcinoma in the examined districts for a period of last five years.

13.10 Historical and Cultural Heritage of the Ostrovetskil region

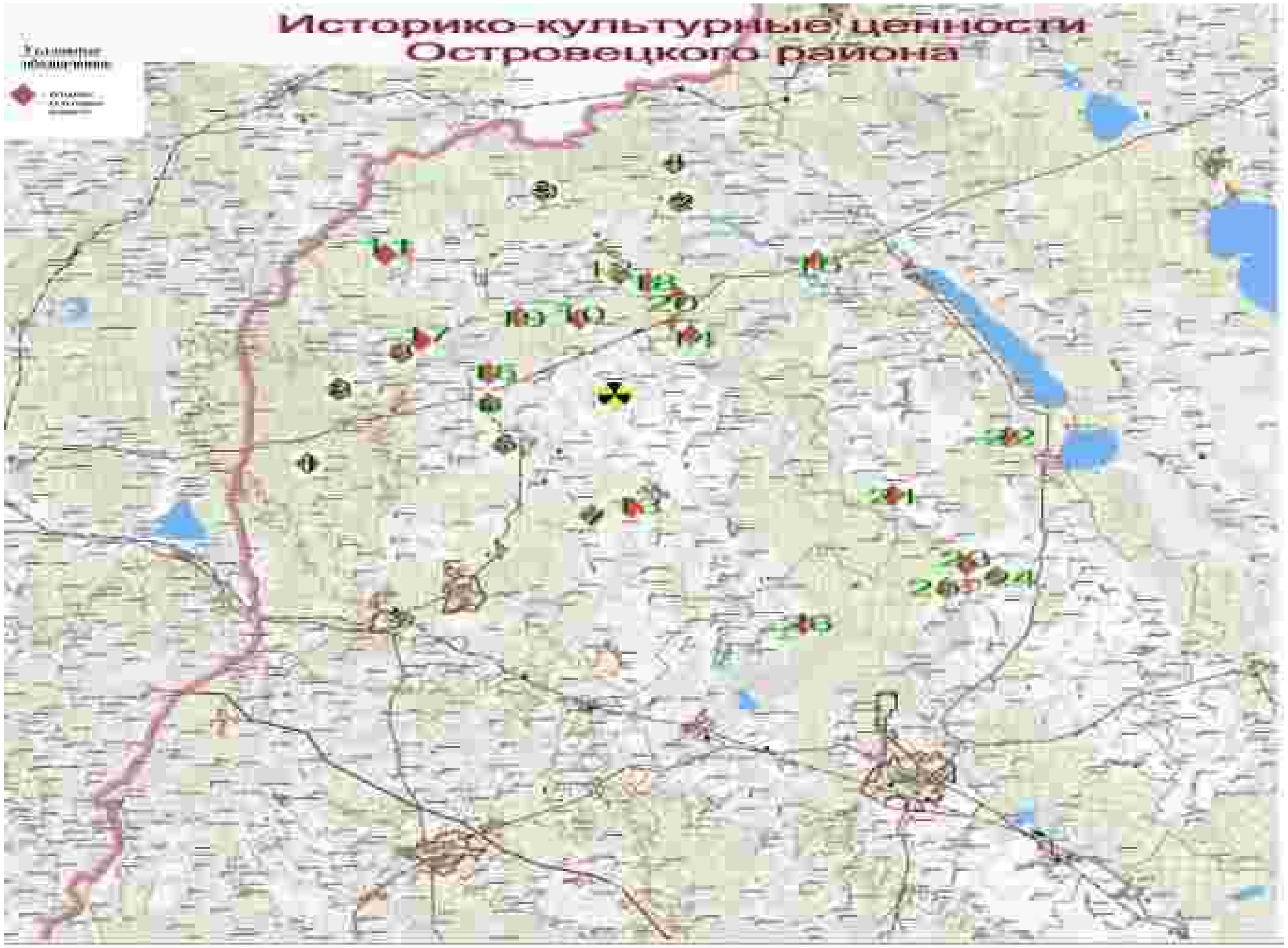
The list of the historical and cultural heritage of the Ostrovetskij region in Grodnenskaya oblast is given in the table 120 [146].

Table 120 – Historical and Cultural Heritage of the Ostrovetskil region.

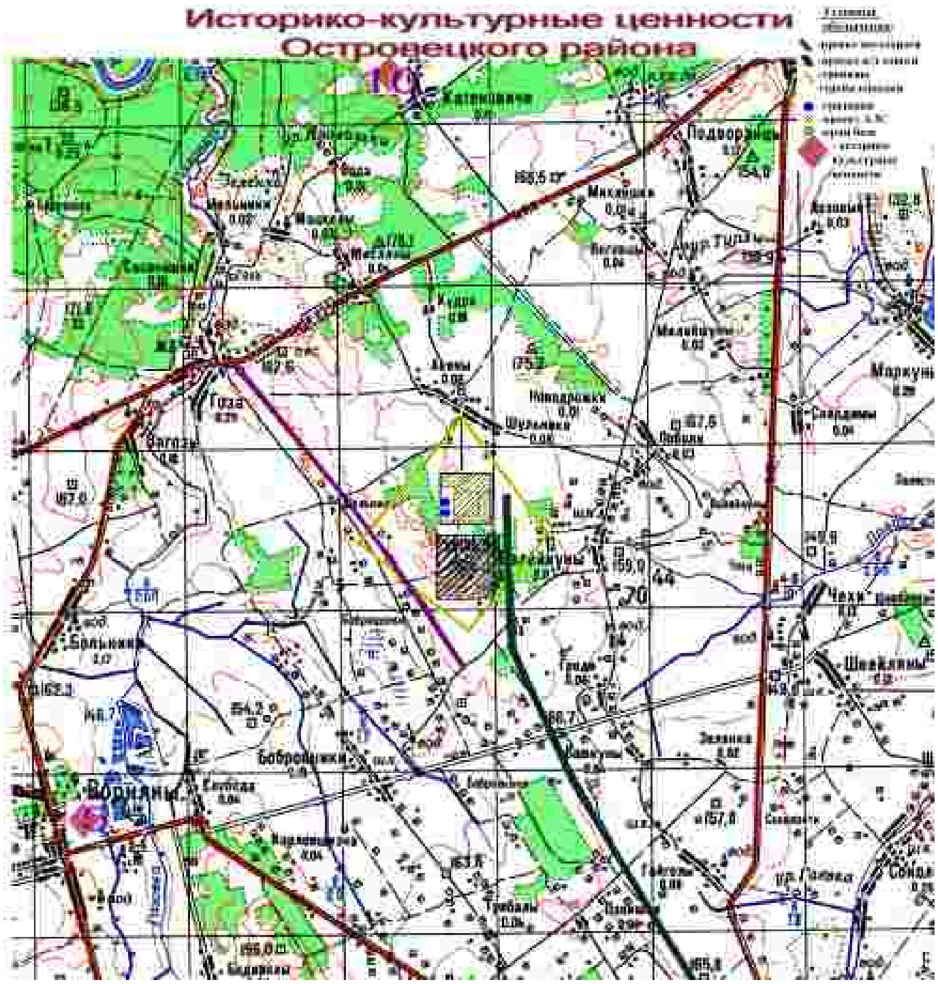
Name of the Heritage	Time of Origin	The Location of the Heritage	The Numeral Sign
The Geodesic Arch in Struve: area "Konrady"	XIX century	Ostrovetskij region; 2,8 km to the north-west from the Kandraty village	1
The Site of the Mesolithic Period	7-6 thousand years of BC	Akarteli village; 0,5 km to the south-east from the village	2
The Castle of the Ascent of Holy Cross	Year 1760	Village Bystritsa	3
The Burial Mound of the Earlier Medieval Period	The end of the 1st thousand years of BC	Budrany village; 0,7 km to the south-west from the village	4
The Architect Ensemble of the village Vornjany	Year 1770; XVII – XIX century	Vornjany village	5
St. George Castle	The middle of the XVIII century	Vorona village	6
Site of Ancient Settlement	XI – XIII century	Gury village; 2 km to the north-east from the village	7
Site of Ancient Settlement	XI – XIII century	Ignatovo (Ignatsovo) village; 1,5 km to the west from the village	8
Site of Ancient Settlement	XI – XIII century	Koronjaty (Korenjaty) village; 1,8 km to the north-west from the village	9
The Burial Mound Ground	1-2 thousand years of AD	Katsenovichi village; 1,5 km to the north-west from the village	10
The Castle	Year 1900	Kemelishki village	11
The Burial Mound Ground	The end of the 1st thousand years of AD	Malye Svirjanki village; 1,1 km to the north-east from the village	12
The Burial Mound Ground	The end of the 1st thousand years of AD	Motski (Matski) village; 1,5 km to the north from the village	13
St. Mikhail Castle	XVII century	Mikhalishki village	14
Site of Ancient Settlement	XI – XIII century	Nidzjany village; 1 km to the south-west from the village	15
The Burial Mound Ground	The end of the 1st thousand years of AD	Podkolotjok village; 0,5 km to the east from the village	16
The Troitskaja Church of Old Believer	XVIII – XIX century	Podolskij village soviet; the isolated terrain feature Strypishki	
The Burial Mound Ground	The 2nd half of the 1st thousand years of AD	Polushki village; 0,6 km to the south-east from the village	
The Burial Mound	The 1st thousand years of AD	Perevozniki village; 1 km to the west from the village	17

The Burial Mound Ground	The 2nd half of the 1st thousand years of AD	Pilviny village; 1,3 km to the south from the village	18
The Burial Mound Ground	the 1st thousand years of AD	Savishki village; 1,2 km to the south from the village	19
Site of Ancient Settlement	XI-XIII century	Sorochie village; 0,5 km to the west from the village	20
The Burial Mound of the Iron Age	V-VI century	Andreevtsy village; on the right shore of Vilija river	21
The Burial Mound	IV-VII century	Vygolenenty village; 1,5 km to the east from the village	22
Site of Ancient Settlement of the Iron Age	The 1st thousand tears of BC – V century of AC	Garony village; 1,5 km to the north-west from the village	
The Presaint Trinity Castle	Year 1612	Zhodishki village	23
The Former Country Estate	XVII century	Zhodishki village	24
The Water Mill	Year 1871	Zhodishki village	25
The Settlement of the Mesolith Period	7-6 thousand years of BC	Zaozertsy village; between the center of the village and the north-east shore of Ryzhee river	26

There is a plan, on the picture 86, with all cultural and historical places of heritage which are shown on it.



Picture 86 – The plan of Ostrovetskij region



Picture 87 – The plan of 5 kilometers area around the Atomic Power Station's (APS) ground

On the picture 84 there is the plan of 5 kilometers area around the APS. As we see, the road that is planned, is going to be near 3 km from "The Architect Ensemble of the Center of the Village Vornjany" and "The Burial Mound Ground" in the Katsenovichi village. At the same distance from these cultural monuments will also be a railway.

13.11 Summary

In this part there is a short characteristic of the main elements of the environment, which will be influenced by the NPPin the process of all vital cycle. To sum up all the results we can say the following.

13.11.1. The Geological Environment

The geological environment of 30 kilometers zone is described with the certain differences within the bound of this or that part of the territory. In particular, the geological structure of the NPP's ground differs from the 30 kilometers zone.

13.11.1.1. The 30 kilometers zone of the NPP

The main elements of the structure of the surface are: the valley of Vilija river, flat-undulating Vileiskaja plain on the both sides of the valley and moraine elevation, such as Svirskaja at the north-east and Oshmjanskaya at the south-west. In geology-tectonic attitude this territory is located on the Pribaltic trap, in its middle part that is located between the Vilejskij crest ledge of the crystallize base and distant wing of Baltic sineclise. In the structure of sedimentory cover of examined region were found deposits of four structural-substantial complexes: uppervendskij-downcambrian (latebaikal), downrcambrian-downdevone (caledone), middledevone-middletrissic (gertsin), middletrissic-quaterial (cimmerian-alpian). In geological structure of quaternary deposits dominate moraine formations of sozh's frozen, in the west and south-west combine northern and nothern-eastern hiils Oshmjan elevation. In the north-east with high details were examined 2 final-moraine ridge – Svirskaja and Konstantsinovskaja, streched from the north-west to the south-easr inappearance of 2 strips of moraine formations with width of 4-6 km.

13.11.1.2. The NPP's Ground

In geomorphologic attitude the ground is situated in the bound of moraine plain with its compressed relief, on the watershed of Vilija river, between its left tributaries – Oshmjanka and Gozovka. The absolute points of surface are 176-185 m., at the extreme western and eastern parts, that are timed to the slopes – 160-175m. The location of the ground on the watershed provides the superficial flows, there are no signs of turning it into swamp. The surface of the watershed is enough plain, that is why there is no need in large volume of planned work. In stratigraphic attitude the geological complex (from the bottom to the top) is represented by the deposits of the top proterozoiceon, bottom and middle parts of the cambrian, ordovic, scilur, middle part of the devon, the bottom of the neogene and quaternary's deposits. The ground located on the virgin block of the crystallize base. By the preliminary results of the geophysical exploration the absolute marks of crystallize base's roof is minus 340-410 m. The power of the quaternary's deposits – 71,7-102,8 m. They are represented by 3 horizons of moraines (final and main moraines of the sozh's horizon, moraine of the dneprov's horizons), by the divided thickness of the final-moraine's sands, water-ice formations of dneprov's and sozh's horizons.

There are the possibilities to build the main structure on the foundation (the most economical option). The conditions of the building will be dry, the separate rich-watered lenses of sands in moraine (sporadic spreading waters) may be drained by the superficial pumping in foundation pits.

The exogenous geological processes, outside of the ground can not influence on the stability of the NPP because of theirs distance. On the ground itself there was not established any displays of dangerous geological processes, such as landslides, karsts, turns into swamp, etc. The seismic of the NPP's ground:

- the planning earthquake (the probability is 1 time in 100 years) PZ – 6 points;
- maximum calculation of earthquake (the probability is 1 time in 1000 years) MRZ – 7 points.

The degree of the influence of the outer geological natural factors on the steadiness of the building and the NPP's structure depends on characteristics and steadiness of the geological environment. The belarusian NPP ground's geological environment, characterize of sufficient steadiness, does not show any negative influence on the NPP structure's work.

13.11.2. Chemical and Radioactive Pollution

The analysis of the structure of the superficial waters of Gozovka river (Goza village), Losha river (Gervjaty village), Vilija river (Mihalishki village), Oshmjanka river (Big Jatsyny village) shows, that the explored rivers belong to the rivers with little and average mineralization, the maximum value (according to the dry rest) – 324 mg/dc^3. The general rigidity in the rivers has not very high value, but the maximum value – 4,90 mg-eqv/dc^3 (Oshmjanka river – locality Big Jatsyny). Among the amount of the main ions (macrocomponents) the main are gidrocarbonate's ions and ions of calcium.

Among the main polluted components in the rivers were found mineral oils in Goza river – 1,0 km higher Gozovka location – 0,06 mg/dc^3 (more than 1 PDK), according phenols the total values are from 0,002-0,004 mg/dc^3. The maximum value of BCO's (Biological Consumption of Oxygen) index was received in Vilija river in the boundary of Mikhalishki location – 5,93 mgO_2/dc^3 (near 2 PDK) which shows that there is heightened content of easy-oxidized organic components in the water. According the content of nitrogen ammonium, the maximum values were received in rivers: Gozovka (1,0 km higher Goza location) – 0,41 mgN/dc^3 and Vilija (in the bound of Mikhalishki location) – 0,39 mgN/dc^3 (more than 1,0 PDK). Maximum values according the content of general iron – 0,17 mg/dc^3 (more than 1 PDK) were detected in rivers: Goza – Gozovka location and Oshmjanka – Big Jatsyny location. That is why, in the NPP's project it is necessary to provide for measures for removing iron from the natural waters, that will be used in technological NPP's cycle.

In the rest of indexes and substances, that are determined in water objects, that are located in the immediate vicinity of proposed place of building the Belarusian NPP, an exceeding PDK were not fixed.

The content of chemical polluted substances and heavy metals in the ground assays, that were selected in the bound of Ostrovets plot, do not exceed limit-permissible values.

According the information of the dispatch investigation and the information about middle levels of radioactive pollution of the locations in the Republic, that are in the database of the Department of Hydrometeorology of Nature in Minsk, among 251 locations, situated in 30 kilometers zone around the proposed place of the NPP, 17 locations have the average density of pollution, about ^{137}Cs, that negligible exceed the level of global fallings. The maximum value of content in ^{137}Cs were found in Sailjuki location, Murovano-Oshmjanskij rural council, Oshmjanskij region – 0,26 Ki/km^2 (9,6 kBk/m^2). The average density of pollution in ^{90}Sr in 30 kilometers zone's locations are in the bound 0,01-0,02 Ki/km^2 (0,37-0,72 kBk/m^2), that correspond to the level of global fallings of this radionuclide.

The level of activity of natural radionuclide in selected ground assays and bed densities correspond to the levels of middle activity these radionuclide, that is typical of turf-podzoly and podzoly grounds.

The results of carried out ground generalization on the sign of intensive processes of migration show, that near 10 % of Belarusian territory in 30 kilometers zone of APS are grounds with low intensive of migration of ^{137}Cs, a little bit more than 60 % are the grounds with temperate migration ability of this radionuclide; 4,4% are the grounds with increased migration ability and 25,2 % are the grounds in which can be seen relatively higher mobility ^{137}Cs.

The temperate mobility of ^{90}Sr is typical for the most territories of the belarusian NPP 30 kilometers zone (85,4 % from all Belarusian territory). The area of plots with high mobility of ^{90}Sr are 9,4 % and the plots with high mobility of radionuclide – 5,2 %. According to the Ground map, it can be said, that on the examined territory there are almost no ground with low mobility of ^{90}Sr.

What is more, more than 70 % of the territory of the 30 kilometers zone around the belarusian NPPare the grounds in which the mobility of ^{137}Cs and ^{90}Sr are low and temperate, that is the positive fact during the valuation the alternative ground according to the point of view of its suitability for allocation the NPP. Almost all the territory of the ground of belarusian NPP is under the grounds with temperate migration of radionuclide.

The analysis of actual distribution of radionuclide on vertical ground's type show, that even in grounds with almost high migration ability of radionuclide have the main reserve of ^{137}Cs in the upper 15 cm of the ground.

13.11.3. Meteorological and Aerological Conditions

The territory of 30 kilometers zone of belarusian NPP is located on the north-west of Belarus in Grodno region on the territory of Narochano-Vilejskoi area. The territory of the ground located in temperate climatic zone, where predominate the air masses of temperate latitude.

The average annual air temperature of the Belarusian NPP's 30 kilometers zone is in the bound 5,2-5,4 ºC, absolute maximum – in the bound of 34,0 – 34,6ºC, absolute minimum – in the bound of minus 31,8 – 39,8ºC. For the NPP ground the rated average annual air temperature is 5,4ºC. The air temperature in July vary from 16,9 to 17,0 ºC, and in January – from minus 6,5 to minus 6,7ºC. As a rule, the period when there is no frosts lasts for 140-149 days. Maximum twenty-four hours amplitudes on this territory can be seen in summer and vary from 10.6 to 11,1ºC.

The average annual relative humidity is 80-81 %, average annual pressure of water steam is 8,2 gPa, the shortage of saturation is 2,7-2,8 gPa.

The annual amount of cloudiness in the bound of the examined territory is 6,7-7.1 points, according to the general cloudiness and 5,1-5,4 points according to the lower.

According to the felt precipitation the examined region, as the whole Belarus, belongs to the zone with sufficient humidifier. There are all types of precipitations here: watery, solid and combined. The precipitations fall irregular during the year. The total amount of precipitations during the winter are just 17 % at annual amount, during the spring – 21 %, during the summer – 37 % and during the autumn – 25 %. The annual amount of precipitations in the northern zone are 741mm; in the southern – 645mm. During the frizzing period at the 30 kilometers zone of the belarusian NPP only 29-32% from the annual amount of precipitations can fall and in warm period the number is 68-71 %. The maximum total annual amount of precipitations at the Belarusian NPP's zone is 1075 mm. in the north and 828 mm. in the south. The maximum monthly amount of precipitations - 215-322 mm. – fall to August. The smallest annual amount of precipitations on the territory changes from 445 mm. in the southern part of the zone to 527 mm. in the northern. The biggest twenty-four hours maximum of precipitations in the southern part of the examined territory was in May, in the northern part in June. What is more, the twenty-four hours maximum of the southern part (101 mm.) exceeded the twenty-four hours maximum of the northern zone (80 mm.). The average number of days with precipitations during the year in the bound of the zone fluctuate from 184 to 193 days, the greatest – from 206 to 235 days. The greatest amount of days with precipitations are in June – near 15 days.

The amount of days with blanket of snow at the 30 kilometers zone of the belarusian NPP are 111-120 days. The average ten-days period's high blanket of snow at the end of February at the examined territory is 19-26 cm; the biggest among the average – 25-34 cm. The maximum high blanket of snow during the winter was 58-72 cm. and was noted at the first decade of March. The annual density of blanket of snow by the biggest decade's high is 0,24-0,25 g/cm^3. The largest reserve of water in blanket of snow during the winter was 195 mm.

The annual amount of fumes from the surface of the land (the total fumes) during the warm period in the bound of the examined territory is 370 mm., the biggest monthly amount – 83 mm – in July.

During the year at the 30 kilometers zone of the belarusian NPP there are winds from the south-western quarter of horizon. What is more, for the southern part of the zone more frequent is eastern direction (11 %0, in northern – southern (12 %).

The biggest amount of calms during the year are in the northern part of the zone (9 %), the smallest – in the southern (3 %). Among the separate seasons the main amount of calms are in summer. There are 5 % of calms in the southern part and 14 % in the northern.

The average annual velocity of wind (disregarding directions), on the territory of the examine zone, increasing from 2,5 m/s in the northern part of the zone to 3,7 m/s in the southern. During the winter period the average monthly velocity of wind are in the bound 2,8-2,9 m/s in the northern part and 4,0-4,3 in the southern.

The calm's and slight winds' frequency are in the bound of permissible conditions for locating the NPP. As a whole, it can be nearly 30% during the year and nearly 24% during the frizzing period (from October to March).

In average at the territory of the 30 kilometers zone of the belarusian NPP there are 67 foggy days in the northern zone and 70 days in the south. During the warm period there are 20 foggy days in the northern zone and 22 days in the south. During the frizzing period the number of foggy days changes from 47 days in the north to 48 days in the south.

During the year the average number of stormy days, at the examined territory, is 21-23, the biggest – 37-38 days. The biggest thunder activity is during the summer period (May-August), sometimes there can be and winter storms.

The dangerous weather phenomenon, which are significant for 30 kilometers zone of the Belarusian NPP, can be displayed at the main part of the territory of Belarus. In that case examine the territory of the administrative regions: Grodnenskaja, Vitebskaja and Minskaja. From the dangerous meteorological phenomena at the examined territory took place heavy rains (the amount of precipitations ≥ 50 mm during the 12 hours and less); big hail (diameter ≥ 20 mm.); the wind with the velocity ≥ 25 m/s, hurricanes, squalls and tornados; heavy snowstorms (with the wind velocity ≥ 15 m/s); snowfalls (the amount of precipitations ≥ 20 mm for 12 hours and less); heavy fogs (visibility less than

100 m.); heavy black ice (diameter of deposits ≥ 20 mm.). In the individual cases these phenomena inflicted damage to the agriculture located on the examined territory.

Distribution of the average wind velocity has a seasonal character: high speed at the attitudes of 100, 200, 300 and 500 meters were pointed in autumn and winter and come to winds of western, southern and northern quarter – vary from 6-7 m/s on the attitude of 100 meters to 12-13 m/s on the attitude of 500 meters. The increase of amounts of calms and slight winds during the frizzing seasons in the zone of the Belarusian NPP can assist the development, in the individual years of the winter maximum, air pollution.

The ground's inversions of temperature even distribute by the seasons. Slightly raised temperature inversions in winter happens in 2 times often, than in spring, and almost in 3 times often than in summer. In autumn their parts are also considerable. The maximum of repeat the ground's inversions are during the warm period of the year, slightly raised – during the frizzing period.

13.11.4. The Evaluation of the Conditions of Water Ecosystems at the 30 kilometers Zone of the belarusian NPP

The evaluation of the conditions of water streams in basin of Vilija river at the 30 kilometers zone of the belarusian NPP shows, that there is a normal work of theirs ecosystems. Community of fito-plankton, fito-perfitone, zoo-plankton and macro-zoo-benthos are characterized by high species resources. The quantity of biothetic index were in the bound of 7 to 10 (I-II types of cleanliness), the values of the EPT index also reached points 6-15. The quantity of saprobe index, that were calculated by fito-plankton, modified from 1,33 to 2,08; by zoo-plankton – from 1,34 to 2,31; by fito-perifiton – from 1,60 to 2,07, that corresponds to II-III classes of cleanliness and let refer this water streams to the β-methosaprobe zone.

There were no essential changes of trochaic status of shallow lakes of Sarochanskaja group during 11-years period, passed between the complex explorations of lakes in the years 1980 and 1991. The beginning of harsh shortage of oxygen in by-beds layers in summer in 1991 in the lakes Beloe, Podkostjolok, Turovejskoe, show the considerable roles of beds deposits in forming oxygen conditions in lakes, that can attest to the real beginning of unusual phenomena in winter period.

The track down tendency of worsening ecological condition of Tumskoe lake from the group of Sorochankie lakes with the middle depth. In this way, the transparency in the lake in 1957 was 2,7 m., in 1980 – 1,9 m and in 1991 was only 1,3 m. In 1991 was noted a considerable oxygen supersaturated of the upper water layers (177 %) and its harsh decreasing with increasing of depth. This fact has not noted earlier. The common biomass of fito-plankton increased from 2,5 in 1980 to 7,0 g/m^3 in 1991. The observed changes attest to the increasing of the trophs level of the lake and worsening water quality. There are no essential changes in the conditions of Gubeza lake, in comparation with 1957.

There track down the increasing of the trophs level in Edi and Golubino lakes of the group of deep Sarochanskie lakes.

Svir and Vishnevskoe lakes are characterized as evtrophic reservoirs. The water quality in these lakes, according to the saprob index, evaluate to III class (moderate-polluted waters).

Thus, generalization and analysis of the results of the research, carried out within the limits of this project, and also available materials of last years let conclude, that water steams ads reservoirs of the 30 kilometers zone of the Belarusian APS are situated on the different levels of the evtrophian process, however, work in normal regime, are characterized by high species variety, considerable biological self-purification potential and meet requirement to the basic conditions of the ecosystems of the appropriate bio-limnitial type.

13.11.5 The Subterranean Waters

According to hydrogeologic process of distraction the territory of 30 kilometers zone of the belarusian NPP is timed for the western slope of the Belarusian hydro-geologic mountain mass. Its hydrogeologic conditions are determined by the geological structure and climatic peculiarities of the temperate continental zone with abundant moistening.

Considerable power of the precipitations deposits, the absence of secure staunched waterproofs and also predominance of the amount of precipitations above the total fumes create favorable prerequisites for accumulation of fresh subterranean waters and of theirs active circulation in wide bounds from 70,0 m in the north of the territory to 300,0 m. and more in the south. The fresh subterranean waters contain in the deposits of the quateral, cretatius, devonian, silurian, ordovic and cambrian systems.

In the bound of the Belarusian NPP, the hydrogeologic conditions of the quateral deposits are characterize by almost full absence of subterranean waters up to the depth of 10-24,4 m. at the main part of the ground. Beneath these depths the quateral sands (the final sozh's moraines, middle-moraines dnepro-sozh's, and also sand's lens in the main sozh's, dneprov's and berezina's moraines) are fully water-saturated.

In general, for the subterranean waters of the 30 kilometers zone of the belarusian NPP s typical the straight vertical hydrogeochemic zonal: fresh hydrocarbonate calcic waters; mineralized sulfate-calcic; chlorinate sodium waters. The power of fresh waters zone - 100-300 m. The intensive hydrogeochemic anomaly can be found on the plot more north-westen to the planned ground of the APS. At the region of Losi village, Zhukoini village, Zheljadskie village and Mostjany village in the thickness of devone's deposits, the roof of which lies here on the depth 61-103 m., reveal chloride-sulphate and hydrocarbonate-sulphate, sodium-calcic and sodium-magnesium-calcic waters with the mineralization 1,2-3,16 g/dc^3. Evidently, the forming of this hydrogeochemic anomaly connect with processes of dissolving gypsum deposits of narov's horizon of the middle devone (D_2nr), and also with the flows of depths mineralized waters of chloride sodium composition by the zone of Berezovsk break. On the modern period this indicate the opportunity of appearing the cave's processes in the gypsum deposits of devone and on the presence, at this region, tectonic weakening zones, through which the depth mineralized waters' flows can appear.

As a rule, the fresh subterranean waters, in the bound of the 30 kilometers zone of the Belarusian APS, are hydrocarbonate sodium-calcic; theirs mineralization changes in the range from 0,15 to 0,76 g/dc^3. The plots of spreading subterranean waters with minimal mineralization (0,15-0,30 g/dc^3)are attracted towards high water shared plots, that became for this horizon the regions of supply. Ostrovets point (between Gozovka, Vilija, Oshmjanka and Losha rivers) is situated in the bound of one of that water shared plots.

The subterranean waters of not deep lie water carried horizons are exposed to anthropology pollution (agricultural and public-domestic).

Now there are no any tracks of the anthropology pollution in the fresh subterranean waters of the by-quateral deposits (cretatious, devone, silurian, ordovic and cambrian water carried horizons).

The mineral waters, that are spread on the examined territory, do not extract, however, there are good perspectives for using them in the capacity of medical and medical-table waters.

Nowadays, the subterranean waters are used for drinking water supplying through the use of water taking in country Ostrovets – “Ostrovets”, country Oshmjamy – “Vaitega”, country Smorgon – “Koreni”, holiday resort Naroch “Malinovka-1”, Naroch lake – “Baloshi”, in rural locations the single departmental boreholes are used. The exploited water carried horizons are water carried horizons and complexes of quateral, devone, silurian and ordovic deposits.

The discover degree of the prognosis recourses (attitude of the exploitation supplies to the prognosis recourses) on the explored territory is very low and is only 4%. Thus, there is an essential reserve for the satisfaction of needs in drinking water.

13.11.6 The Grounds. The agriculture

The main part of the examined territory of the 30 kilometers zone around the belarusian NPP is occupied by forests and agricultural plantations (near 90%), on which, an intensive economical work is taking place now. The agricultural works specialize in cultivation cereals, flax, sugar beet, rapes, potatoes, fodder crops, production of meat and milk.

The density of ground pollution ^{137}Cs on this territory is from 0,7 $kBk \cdot m^{-2}$ to 2 $kBk \cdot m^{-2}$, the power of the equivalent doze in the air – 0,10-0,15 $mkZv \cdot h^{-2}$ and according to these indexes it is comparable to the rest of the territory of the Republic, that is polluted only by the global fallings from the test of the nuclear weapon.

The content of ^{137}Cs in the agricultural products does not exceed the value of minimum detected activity (<2,7 $Bk \cdot kg^{-1}$), ^{90}Sr amounts to the tenth part of $Bk \cdot kg^{-1}$ and by these indexes does not single out of the rest of the territory.

13.11.7 The landscapes, flora and fauna

The ground of the NPP in the 30 kilometers zone of the belarusian NPP locates in the bound of Poozerskaja province of lake-glacier, moraine and hilly-moraine-lakes landscapes, that, according to theirs aesthetic, bioclimatic and ecologic characteristics, have a high recreation-health potential. The landscape-geochemical conditions of the natural ecosystems of the region characterize, on the one hand, by high migration activity of chemical elements, that are made conditional upon the predominance of acid environment’s reaction, and, on the other hand, by practically universal spreading of geochemical barriers, on which their elements can accumulate.

The degree of economic assimilation of the territory is temperate. Its woodiness is 37,7 %, that is on the middle level for the country and is enough for maintenance in the region the ecological balance. Amounting forests, predominate pine forests, the part of which is 70 % from the forests area and the same situation is with timber reserves. The forests productivity is high, the half of them has the first class of bonitate. The anthropology influence on the forests is relatively slight, theirs ecological conditions are satisfactory. The deforestation of small areas of forests massive on the NPP building ground does not tell on the conditions of the ecological balance in the region.

The ichtyfauna of water leaks and reservoirs of the region distinguish by high species variety and number the 42 fish types. Vilija river with its tributaries is the only in

Belarus river basin, in which there are 8 protected fish and fish-looked types, including 2 salmon types.

The ornithofauna of the territory represents 162 birds types, that is the half of the species content of the ornithofauna of Belarus. The density of valuable types of hunting mammal (hoofed) in the hunter keeping region is mainly middle.

The chemical pollution of the territory of natural ecosystems is negligible. The concentration of heavy metals in the grounds and natural production are practically on the level of backgrounds values. The PDK exceed is marked in isolated cases and on the small quantity. The pollution of trade animals is a little bit higher.

The 30 kilometers zone of the belarusian NPP has an essential value for saving the biological and landscape varieties on the national and international level. The particularly saved natural territories occupy here near 15 % of the area, that excel in 2 times the analogous index for the whole country. They all are situated on the distance more than 7 km from the ground and the building itself does not influence on them.

The index of the first group forests' part in the 30 kilometers zone is 63 %, that is almost in 1,3 times higher of the middle level for Belarus and is the evidence of increased nature-protecting significance of that territory. The most large massive of the protected forests lay along Vilija river and make a complete ecological passage, that combines OOPT of Belarus and protected nature objects of Lithuanian Republic.

In the region were found the places of growth of 17 rare types of plants – the tenth part from theirs total amount in Belarus. There were also found 45 types of protected animals. The areal of concentration of rare types of plants and animals are enough far from the ground, except Gozovka river, where salmons live.

13.11.8 The Population and Demography

13.11.8.1. The Initial Sickness Rate of the Grown-up People.

As the result of analysis of the initial sickness of the grown-up people in Grodno, Vitebsk and Minsk region of Republic of Belarus in years 2004-2008, the main classes of sicknesses (there are 13 main classes of sicknesses according to the MKB-10) were established the followings:

- on the first rank place, as in the whole Republic and regions, were the sicknesses of breathing organs, that were from 33,9 % in Grodno region to 40,5 % in Vitebsk region in 2004.; and from 32,9 % in Grodno region to 41,8 % in Vitebsk region in 2008. In general, in the Republic this class of sicknesses was from 35,8 % to 36,5 % accordingly;
- on the second rank place were sicknesses of bone-muscle system and connective tissue – from 6,6 % in Grodno region to 10,6 % in Minsk region in 2004 and from 6,7% in Vitebsk region to 9,1% in Minsk region in 2008. In general, in the Republic this class of sicknesses was from 8,3 % to 8,2 % accordingly;
- on the third rank place were sicknesses of skin and hypodermical cellular tissue – from 6,4% in Minsk and Grodno regions to 7,7% in Vitebsk region in 2004 and from 5,3% in Grodno region to 8,1% in Vitebsk region in 2008. In general, in the Republic this class of sicknesses was 6,1% in 2004 and in 2008;
- there was also an increase of sickness of the grown-ups for the 5-year period according to the all types of sicknesses in the examined regions: from 2,5 % in Vitebsk region to 18,4 % in Grodno region. In general in the Republic the increase of level of sickness was 6,4 %;
- the most essential increase of level of the initial sickness among the grown-ups was pointed in such types of illnesses as: sickness of blood, sickness of endocrine sys-

tem, sickness of system of blood circulation, innate anomaly (mature disorders), deformation and chromosome disorders, mental behavior disorders.

13.11.8.2. The Initial Sickness Rate of Children

As the result of analysis of the initial sickness of the grown-up people in Grodno, Vitebsk and Minsk region of Republic of Belarus in years 2004-2008, the main classes of sicknesses (there are 13 main classes of sicknesses according to the MKB-10) were established the followings:

- the comparative analysis of structure of the initial sickness of children and teenagers showed the negligible fluctuations of the proportional weight of the main classes of sicknesses during the 5-years period;
- on the first rank place in general structure of sicknesses were the sicknesses of breathing organs – from 69,0% in Grodno region to 71,2 % in Vitebsk region and 68,0 % in the whole Republic in 2004., and from 73,5 % in Minsk region to 77,2 % in Vitebsk region in 2008. In the Republic the part of breathing organs sicknesses in 2008 was 72,4 %;
- on the second rank place were infectious and parasitical sicknesses – from 4,0 % in Minsk region to 6,4 % in Vitebsk region and 4,7 % in the Republic in 2004., and from 3,5 % in Minsk region to 3,9 % in Grodno region and 3,7 % in the Republic;
- on the third rank place were sicknesses of skin and hypodermical cellular tissue – from 3,8 % in Vitebsk region to 4,7 % in Minsk region and 4,3 % in the Republic in 2004., and from 2,6 % in Vitebsk region to 4,5 % in Minsk region and 3,9 % in the Republic in 2008.;
- the most high increase rate of sickness level was pointed in such sicknesses as: sickness of breathing organs, innate anomalies (mental disorders), deformation and chromosome disorders.

13.11.8.3. The Oncologyl Sicknesses.

The analysis of oncology sickness of population in Grodno, Vitebsk and Minsk regions of the Republic of Belarus shows the followings:

- during the 5-years period there was an increase of oncology sicknesses in the Republic in 6,9 % and in regions this increase was in the bound from 2,8 % to 8,8 %, as to the separate regions, it is necessary to pay attention to an essential increase of sickness in Mjadel region in 55,8 %;
- the average indexes of oncology sicknesses during the 5-years period according to the examined oblasts and regions were in the bound from 320,3 cases to 392,8 cases for 100 000 of population, and only in Mjadel region this index was 469,1 on the 100 000 of population and was extremely higher than was the republican and regional levels;
- under the consideration of the initial sickness of lunge cancer of population, it can be mentioned, that during the 5-years period there were no any special changes in the structure of this sickness among the population of the examined regions. As a positive moment it is necessary to mention the reduction of rates of increase in the whole Republic on 1.1 %, in Grodno region on 9,0 %, in Vitebsk region on 10,3 % and only in Minsk region there was an increase on 10,1 %. The average, during the 5-years period, level of lunge cancer sickness in the Republic was 44,5 cases on 100 000 population, in all examined regions the level of sickness was higher than the republican and only in Grodno region it was lower than the republican (44,0 cases on 100 000 population);

- the average level of stomach cancer during 5 years was 53,5 cases on 100 000 population, in Vitebsk region was 38,8 cases, in Minsk region – 39,4 cases on 100 000 population. As to the other regions, in Postav and Mjadel regions this index was a little bit higher than the republican one. The stomach cancer sickness, in the general structure of oncology sicknesses in 2008 in the Republic was 8,6 %, in Grodno region – 8,6 %, in Vitebsk region – 9,1%, in Minsk region – 9,8 %. During the regions this index changes from 7,9 % in Mjadel region to 13,0 % in Smorgon region. From 2004 to 2008 there was a reduction of the rates of increase in the Republic in general on 3,6 %, in Grodno region – on 4,6 %, in Vitebsk region in 12,5 % and almost without any changed in Minsk region.

- there is also an increase of the initial sickness of skin cancer among the population in mentioned above regions during 2004-2008 from 14,6 % to 16,4 %. The rates of increase of skin cancer sickness in the Republic and regions varied during the examined period from 11,3 % in Vitebsk region to 40,9 % in Minsk oblast, there was also an increase of this sickness in Smorgon and Mjadel regions. In all oblasts and 5th regions the average indexes of skin cancer sickness were lower, than in the Republic in general.

- in all examined regions the indexes of lastic gland sickness were lower than middle-republican level. the ranges of lastic gland sickness a little bit increasein general in Republic and in oblasts, especially in Minskaja oblast and in Postav region. The amount of women with this sickness in the structure of all sicknesses during 2004-2008 is stable and is 9,4 %, according to the examined oblasts this indexes have a little bit changed in 2008 in comparison with 2004. According to the examined regions these indexes have not changed essentialy, except Mjadel region, where the part of sick people has come down from 10,3 % to 5,5 % in 2008 in general structure of sickness;

- there were no essentil changes in thyroid gland sickness among the population in examined regions during last 5 years. The average index of the thyroid gland sickness among the population in Grodnenskaja, Vitebskaja, Minskaja oblast and Mjadelskij, Ostrovetskij, Oshmjanskij, Postavskij region during the periog from 2004 to 2008 was lower than the republican index, and only Smorgon region the average index of this sickness was a little bit higher than in the Republic;

- the average sickness of leukaemia during 2004-2008 years in the Republic was 11,4 cases on the 100 000 population, in all examined oblasts the average sickness of leukaemia has not exceed the republican level, and only in Grodnenskaja oblast this index has been higher than the republican and has been 13,2 cases on 100 000 population;

- by 2008 there was an increase of this sickness in the regions in general structure of sicknesses in Ostrovetskij region in 5,9 %, in Smorgon region in 0,6%, in Postav region in 0,2 %, in Mjadel region in 1,3 %. The average sickness of leukaemia during mentioned above 5-years period was higher than the republican (11,4 cases on 100 000 population), only in Grodno oblast – 13,3 cases on 100 000 population, including the following regions of this oblast:

- in Ostrovets region – 12,8 cases on 100 000 population;
- Oshmajnskij region – 17,0 cases on 100 000 population.