Elaboration of Priority Components of the Transboundary Neman/Nemunas River Basin Management Plan (Key Findings)

June 2018

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EXECUTIVE SUMMARY

The programme of pilot projects on adaptation to climate change in transboundary basins under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (hereinafter referred to as the Convention), adopted by the United Nations Economic Commission for Europe (UNECE), aims to support countries in their efforts to implement the Convention and develop adaptation strategies and measures in transboundary basins. The pilot project "River Basin Management and climate change adaptation in the Neman River basin" was implemented in 2012-2015 in the framework of this programme. This project laid the foundation for the improvement of comprehensive transboundary cooperation in the context of climate change in the Neman River basin and building the capacity for the adaptation to climate change of the countries sharing the Neman River by maintaining their dialogue and cooperation and defining the strategic areas of adaptation of the Neman River basin to climate change.

To enable implementation of the results of the pilot project and the strategic areas of adaptation of the Neman River basin to climate change, a meeting involving representatives of UNECE, the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus, the Ministry of Environmental Protection of the Republic of Lithuania, as well as experts from Belarus and Lithuania, was held in Minsk on 16-17 December 2015. At that meeting, Belarus and Lithuania expressed their readiness to strengthen cooperation in the Neman River transboundary basin. The cooperation could aim at developing and implementing the joint Neman River Basin Management Plan. In particular, this can be achieved by reviewing and agreeing on the Neman/ Nemunas River Basin Management Plans prepared by both parties in the areas, where there are some common interests (e.g. improving the water quality) and readiness for gradual progress towards coordinated and, ultimately, joint river basin management. In continuation of the transboundary cooperation on the Neman River basin, a similar meeting was held in Minsk on 14 November 2016 as the first expert group meeting on enhancing technical cooperation in the Neman river basin. That meeting resulted in proposing specific activities to elaborate the priority components of the Transboundary Neman/Nemunas River Basin Management Plan to be supported by UNECE.

Since 2017, these activities have been financed under the work programme of the Convention (with financial support from the Netherlands) and the EU-financed regional programme "European Union Water Initiative Plus for the Eastern Partnership countries (EUWI+)", launched in 2016 as a follow up to a previous phase of the European Union Water Initiative. The EUWI+ helps Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova, and Ukraine to bring their legislation closer to EU policy in the field of water management, with a focus on the management of transboundary river basins. Taking into account the priorities expressed by the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus, support to transboundary cooperation with Lithuania on the Neman basin and with Latvia on the Western Dvina/Daugava basin has been included in the national workplan of Belarus under the EUWI+.

The first stage, which covered the first half of 2017, involved a detailed analysis of one part of the Neman River basin – the Shchara River basin, one of the largest left-bank tributaries of the Neman River on the territory of Belarus. The findings on the Shchara River basin were discussed during the second expert group meeting held in Vilnius on 12-13 July 2017.

Building on the results of the second expert group meeting, the following activities were proposed and implemented in late 2017 – early 2018 to further develop the priority components of the Transboundary Neman / Nemunas River Basin Management Plan:

1. An overview of the Neman River basin on the territory of Belarus was prepared in line with the recommendations of the Water Framework Directive.

2. Bodies of surface water and their homogeneous parts ("water bodies") were identified taking into account the key point pollution sources within the Belarusian part of the Neman River basin based on the case of the Shchara River and for the Neman River basin in general.
3. The systems of monitoring and assessment of the ecological status of water bodies of Belarus and Lithuania were compared in terms of physicochemical, hazardous pollutant, and biological (hydrobiological) parameters.
4. The status of bodies of surface water and their homogeneous parts ("water bodies") within the Belarusian part of the Neman River basin was assessed—in line with the assessment systems of Belarus and Lithuania—in terms of physicochemical, hazardous pollutant, and biological (hydrobiological) parameters. The overall ecological status of surface water bodies and their homogeneous parts ("water bodies") was identified, with a comparative analysis of the assessments prepared and their results mapped.
5. The factors and sources of heavy impact on the surface water within the Neman River basin were identified, including point and non-point (diffuse) pollution sources, taking into account the characteristics of water and land use based on the data of the State Water Cadastre (SWC), local monitoring (LM), statistical data of the National Statistical Committee of the Republic of Belarus, international projects, the degree of change in the hydromorphological indicators, as well as climate change.
6. The groundwater bodies subject to heavy anthropogenic impacts were identified within the Belarusian part of the Neman River basin, based on the case of the Shchara River and for the Neman River basin in general. In total, 13 groundwater bodies were identified within the Neman River basin, 6 of which are also located within the Shchara River basin.
7. The factors and sources of heavy anthropogenic impacts on groundwater bodies (their status in terms of quantitative and chemical indicators) were identified within the Neman River basin on the territory of Belarus.

The key findings presented in this report were discussed and approved in the frames of the third expert group meeting, held in Minsk on 15 May 2018 with participation of the representatives of UNECE, the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus, the Ministry of Environmental Protection of the Republic of Lithuania, as well as experts from Belarus and Lithuania.

The following experts contributed to the report preparation:

– from the Republic of Belarus: Vladimir Korneev, Kanstantsin Tsitou, Artsiom Aukhimovich, Liudmila Nuprienok, and Katsiaryna Vasilionak; and
– from the Republic of Lithuania: Tomas Virbickas, and Jurgita Vaitiekūnienė.

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– Alisher Mamadzhanov and Sonja Koeppel (Secretariat of the UNECE Water Convention);
– Nickolai Denisov (UNECE consultant);
– Sergei Zavyalov, Tatsiana Slizh (Ministry of Natural Resources and Environmental Protection of the Republic of Belarus);
– Audronė Pumputytė, and Gintarė Bevainienė (Ministry of Environmental Protection of the Republic of Lithuania), Jurga Arustienė (Geological Service of the Republic of Lithuania); and
– Olga Vasniova (Institute of Geology, a branch of the Republican Unitary Enterprise "Research and Production Centre for Geology", Republic of Belarus).

The photo on the cover page of the report, showing a transboundary segment of the Neman River (Belarus-Lithuania), was provided by Kanstantsin Tsitou.

1 OVERVIEW OF THE NEMAN RIVER BASIN ON THE TERRITORY OF BELARUS

1.1 General description of the Neman River basin on the territory of Belarus

The Neman River basin lies at $56^{0}15'$-$52^{0}45'$ N and $22^{0}40'$-$28^{0}10'$ E. The total length of the river is 937 km, and the basin area constitutes 98,200 km^2. The basin is located on the territory of Belarus, Lithuania, and Russia (Kaliningrad region).

The water resources of the Neman River basin are mainly formed on the territory of three countries: Belarus, Lithuania and Russia. The tributaries, the headwaters of which are located in Poland and Latvia, contribute an insignificant quantity of runoff (about 0.3 %). In the average water year, Belarus accounts for 43.5 % of the total Neman River runoff, Lithuania – for 50.0 %, and Russia – for 6.2 %. The river is fed mainly by snow melt (33-40 %), rain (25-23 %), and ground water (10-40 %). Most of the river flow is formed as a result of land runoff, with the snow melt on average contributing 40 % of this runoff.

In terms of territorial and administrative division, the Neman River basin partly or fully covers 37 rayons [districts] of Grodno, Minsk, Brest, and Vitebsk oblasts [regions] of the Republic of Belarus, including one oblast centre (the city of Grodno) and 27 towns and urban settlements of rayon subordination (Figure 1.1)

The catchment area of the Neman River has a characteristic pear-like shape, which is typical for large river basins. The Neman River basin stretches from the northeast to the southwest. Within the territory of Belarus, up to the mouth of the Chernaya Gancha River, the basin area is 35,000 km^2. The average height of the catchment area is 75 m above sea level, the average gradient is 11.8 %. The average width of the catchment area is 180 km.

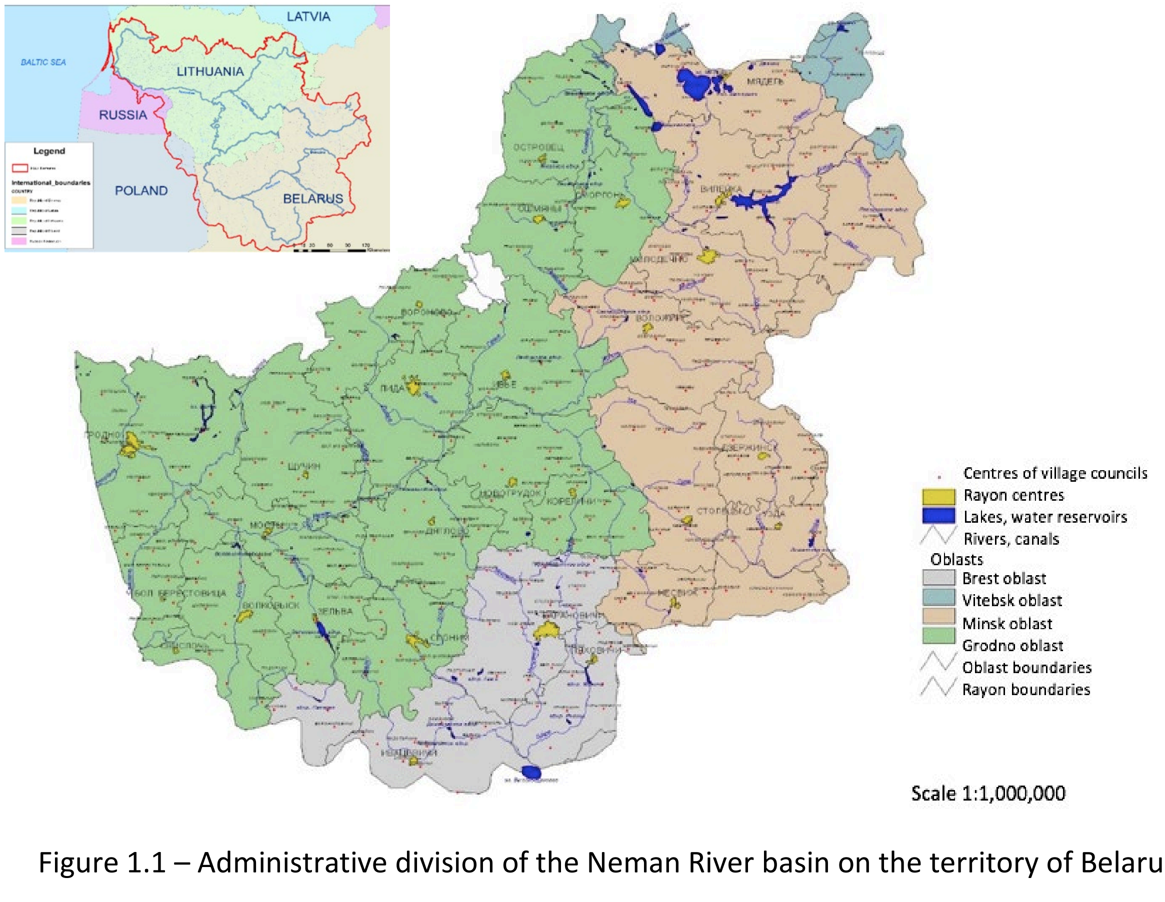

Figure 1.1 – Administrative division of the Neman River basin on the territory of Belarus

In terms of the territorial and administrative division, the Neman River basin partly or fully covers 37 rayons of Grodno, Minsk, Brest, and Vitebsk oblasts of the Republic of Belarus. Grodno oblast is almost completely located within the basin: 16 out of its 17 administrative rayons are entirety within the river basin; and in the case of Svisloch rayon, 48 % of its area forms part of the basin. As to Minsk oblast, 13 of its administrative rayons are within the basin, with only 3 of them—Volozhin, Molodechno, and Slolbtsy rayons—being entirely located within the basin and the remaining ones being only partially covered by it (the area within the basin ranges from 1 % to 99 %). Brest oblast is represented within the territory of the basin by 4 rayons, and only one of them—Baranovichi rayon—is entirely located within the basin. Vitebsk oblast accounts for an insignificant part of the Neman River basin, with three of its administrative rayons partially covered by the basin.

The basin relief is a hilly plain with moraine formations in the form of ridges or groups of hills. The landscape is fairly level, the basin belongs to the type of lowland river basins characterised by a small surface slope and, thus, is not highly prone to erosion. The average height of the catchment area is 175 m, the average gradient is 11.8 %.

The morphometric parameters (depth, width, profile, flow velocity, etc.) of the Neman River vary a lot, depending on the number of tributaries and the intensity of their network within the basin. The depth ranges from 1 m in the upstream section to 3 m in the lower reaches.

The average riverbed slope changes in the following way: it is 0.00016 m/m in the upstream section, 0.00023 m/m in the middle reaches (between the points of confluence of its two tributaries – the Kotra River and the Vilia / Neris River), and 0.00010 m/m in the lower reaches (below the point of confluence of the Neris River).

The Neman River is a highly meandering river with large and wide curves and turns. The mean meander ratio is 1.76, ranging from 1.86 in the upstream section, to 2.26 in the middle reaches, and 1.21 in the lower reaches. The intensity of the river network within the Neman River basin typically ranges from 0.40 to 0.50 km/km^2.

The riverbed is clean, the aquatic vegetation is found only along the banks in irregular stripes up to 8-10 m wide. The river bottom is sandy and stony sandy between the villages of Slavichi and Kukali. Long stretches of the sandy, sandy clay banks merge with the slopes of the valley.

The climate in the Neman River basin is moderately continental. The thermal regime is characterised by a gradual increase in temperature from the northeast to the southwest (to the southeast in summer). On average, the temperature increases by 0.5 °C per each 200 km southward. The average air temperature in July ranges from 17.5 °C in the north to 18.5 °C in the south of the basin, and in January – from -6.5 °C in the northeast to -5 °C in the southwest. On average, the temperature drops by 0.5 °C per each 100 km eastward.

The Neman River basin is situated in the area of sufficient humidity. The mean annual precipitation is 560-620 mm, turning higher (700 mm and more) in the area of the Novogrudskaya and Slonimskaya Uplands. The precipitation is unevenly distributed within the year. The warm period accounts for about 70 % of the annual amount, with more than a third registered in July and August, the lowest precipitation is observed in February and March, when the cyclonic activity is weakening. The overwhelming majority of precipitation is liquid, with snow accounting for 10-15 % of the annual amount. The thickness of the snow cover is low, ranging from 15 to 30 cm from the southwest to the northeast and sometimes reaching 35 cm. The number of snow cover days ranges from 80 to 115. The average water content in the snow goes down from 80 mm in the north to 45 mm in the south, exceeding the 80 mm level within Novogrudskaya Upland. Every year, there are thaws almost in every winter month. The number of thaw days ranges from 35 in the northeast to 45 in the southwest.

The soil surface vaporisation ranges from 450 mm in the northwest to 600 mm in the southwest. The water surface vaporisation is 600-630 mm.

The relative humidity is high at 84-90 % in the spring and 66-78 % in the summer.

The climate change affects the hydrological regime (runoff, groundwater level, soil moisture) and the hydrochemical regime (oxygen and carbon dioxide solubility, changes of the content of biogenous elements in the aquatic environment).

Atlantic air masses of temperate latitudes prevail in the river basin for most of the year. Tropical and Arctic air masses penetrate the territory much less often. As a result of such air mass circulation, south-westerly, westerly, and north-westerly winds prevail.

The Neman River basin is located in the subzones of the oak-dark coniferous and hornbeam-oak-dark coniferous forest. The average forest cover of the region is 33 %. Forests are predominantly coniferous, while birch, black alder, oak, hornbeam, and ash forests are found less frequently. Some large forest tracts – *puschas* – have been preserved: Nalibokskaya Puscha, Lipichanskaya Puscha, and Grafskaya Puscha. The woody vegetation is typically represented by spruce, pine, oak, hornbeam, maple, ash, linden, birch, aspen, willow, and alder.

The region is rich in diverse fauna. There are 74 species of mammals found in the forests of the Neman River basin. Among them, the most common are elk, wild boar, roe deer, wolf, fox, brown hare, red squirrel, polecat, and pine marten. Less common are red deer, lynx, and badger. The rare and protected species include brown bear (in the northern part of the region), common raccoon, and some species of bats.

There is a wide diversity of bird species: tit, bullfinch, crane, white stork, hazel grouse, black grouse, blackbird, black woodpecker, cuckoo, hawk, kite, icterine warbler, jay, leaf warbler, flycatcher, shorebird, etc. Rare and protected species include black stork, eagle-owl, booted eagle, roller, great-crested grebe, bald coot, pochard, tufted duck, red-breasted flycatcher, greenish warbler, boreal owl, etc.

The river floodplains are the habitat of beavers, otters, American minks, waterfowl, grass snakes, and fresh-water turtles. Floodplains are the main centres for the reproduction of game birds and rare species of birds and the major ways of migration and concentration of migratory birds.

The rivers and water bodies of the Neman River basin are rich mostly in representatives of the carp family – bream and roach, as well as pike, salmon trout, catfish, perch, burbot, stickleback, eel, ide, chub, and asp. The valuable protected species in the Neman River basin include grayling, barbel, brook trout, and salmon. The amphibians are commonly represented by frogs, toads, and newts.

The special protection areas (SPAs) in the Neman River basin are represented by the following categories: "Narochansky" National Park, national and local nature reserves – *zakazniks*, national and local natural monuments.

The fuel and energy complex of the Neman River basin consists of three oblast power systems: Grodnoenergo RUE [republican unitary enterprise], Brestenergo RUE, and Minskenergo RUE, which are subordinated to the State Production Association (SPA) 'Belenergo'. The total rated output power of the region's thermal power stations is 257.9 MW or slightly less than 3.5 % of the country's total. The region is characterised by a well-developed hydropower sector, represented by small hydropower stations. There are 13 small hydropower stations in the Neman River basin with the rated capacity totalling 4,110 kW (Figure 1.2). Grodno Hydropower Station of a rated capacity of 17.8 MW is up the Neman River from the city of Grodno. The design of Nemnovskaya Hydropower Station of a rated capacity of 18.2 MW, which is to be built on the Neman River downstream from the city of Grodno, is underway.

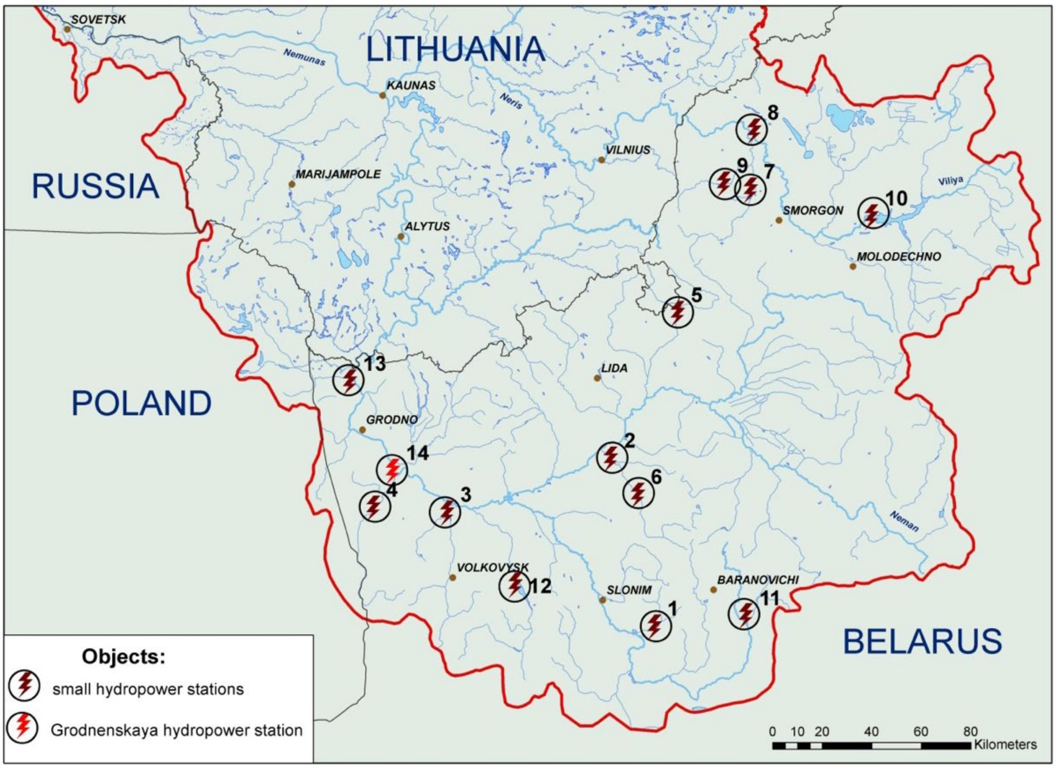

Figure 1.2 – Map of hydropower stations located in the Neman River basin

The development of non-conventional energy sources in the region is a promising area. There are two wind power plants (250 and 600 kW) located near the village of Zanaroch, Myadel rayon, Minsk region.

A nuclear power plant of a planned capacity of 2,400 MW is under construction in Ostrovets rayon, Grodno oblast.

The Neman River is used for local navigation. Other rivers of the Neman River basin are not on the list of inland waterways of the Republic of Belarus and not used for navigation.

The key manufacturing sectors in the Neman River basin include the light, food, chemical and petrochemical, timber, woodworking, pulp and paper, machine building and metalworking, and construction materials industries.

The industry is concentrated mainly in large and medium-sized cities of Grodno, Minsk, and Brest oblasts: Grodno, Lida, Slonim, Volkovysk, Baranovichi, and others.

Farmlands accounts for about 53 % of the Neman River basin, of which ploughlands are 39 %, hayfields and pastures are 14 %.

The key areas of crop farming include growing grain and grain legume crops, forage crops, sugar beets, potatoes, rapeseed, and vegetables. The share of these products in the total agricultural output is about 40 %.

1.2 Description of the hydrographic network

The hydrographic network of the Neman River basin was formed in the late quaternary period. The upstream section of the basin is the oldest, formed before the last glacial period, while the midstream and downstream segments were formed during the last glacial period.

The Neman River basin is characterised by a dense river network. From its source to its mouth, the river takes about 180 tributaries. In terms of their length and catchment area size, the largest tributaries of the Neman River are (in the order of their distance from the mouth): the Berezina, the Shchara, the Zelvianka, the Kotra, the Svisloch, the Merkys, the Vilia / Neris, the Nevezhis, the Dubisa, the Sesupe, the Jura, and the Minija. The Neman River has 7 first-order tributaries over 100 km long: the Vilia, the Shchara, the Berezina, the Zelvianka, the Kotra, the Svisloch, and the Usha.

The main tributaries of the Neman River on the territory of Belarus include the Vilia River, the Shchara River, and the Western Berezina.

The Vilia River is the largest tributary of the Neman. It flows from a small marsh area located 1 km northeast of the village of Velikoe Pole, Dokshitsy rayon, and joins the Neman River on its right bank near the city of Kaunas. The length of the river is 498 km, of which in Belarus – 264 km. The total catchment area is 25,100 km^2, of which in Belarus – 11,050 km^2. The total slope within Belarus is 90.6 m, the average water surface slope is 0.3 %, while the meander ratio is 1.98. The Vilia River and its tributaries are of great environmental value in terms of offering favourable conditions for anadromous, semi-anadromous, and other species of fish, as well as preserving the biological and landscape diversity of their adjacent areas. The Lithuanian part of the Vilia / Neris River is a Natura 2000 area, established to protect salmon, otter, lamprey, bitterling, and other species of fish. The hydrological regime of the Vilia River in the area under consideration was affected due to the creation of the Vileyka-Minsk Water System (VMWS), which includes the Vileyka Reservoir. The Vileyka-Minsk Water System is to ensure the transfer of flow to the Svisloch River to improve its water supply and partially cover the water supply to the city of Minsk.

The Shchara River is the longest tributary of the Neman River within Belarus, ranking the second by its water content. The length of the river is 325 km, while its catchment area is 6,990 km^2. Its main tributaries include: the right bank ones – the Lipnjanka River (20.5 km long), the Myshanka River (109 km), the Lokhozva River (29 km), the Issa River (62 km), and the Podyavorka River (35 km); and the left bank ones – the Vedma River (35 km), the Grivda River (85 km), the Lukonitsa River (32 km), and the Sipa River (26 km).

In terms of the surface area, the largest lakes are Lake Vygonoschanckoye (watershed) and Lake Bobrovichskoye, located in the southern part of the catchment area. The catchment area was subjected to drainage reclamation, as a result of which 12.1 % of the basin area was reclaimed as at 1 January 2008. The network of open hydro reclamation drains is 4,460 km long.

The Western Berezina ranks the third among the tributaries of the Neman River within Belarus in terms of its catchment area and water content. The length of the river is 226 km, the catchment area is 4,000 km^2.

Its main tributaries include: the right bank ones – the Krevlyanka River (20 km long), the Olshanka River (60 km), the Chernitsa River (22 km), and the Chapunka River (38 km); and left bank ones – the Isloch River (102 km), and the Volka River (36 km). Forest tracts account for 30 % of the catchment area, of which about 8 % are swamp forests. The distribution of forests is uneven, the lower part of the catchment area (Nalibokskaya Puscha) is the most wooded. The catchment area was subjected to drainage reclamation, as a result of which 16.1 % of the basin area was reclaimed as at 1 January 2008. The network of open hydro reclamation drains is 2,365 km.

The lake density of the Neman River basin is less than 1 %. There are many medium and small lakes within the river basin, which are very unevenly distributed. The greatest concentration of lakes is found on the right bank of the Vilia River, with up to 300 lakes totalling 200 km^2 located along the stretch to the confluence of the Zeimena River. The lake density of the right bank is 3-4 %. Lake Naroch, Lake Svir, Lake Myastro, Lake Beloye, and others are located on the right bank of the Vilia River. The lake density of the whole catchment area of the Vilia River, including the left bank, is slightly below 2 % within Belarus.[1,2]

The Naroch group of lakes, with its total water surface of up to 100 km^2, is located in Myadel rayon, Minsk oblast. It is drained by a small left bank tributary of the Vilia River – the Naroch River.

The total catchment of all the lakes is 279 km^2. The Naroch group of lakes is characterised by the sub-pond type of basins. Lake Naroch, a typical moraine lake of 79.6 km^2, is the largest lake in the Naroch group. The terrain in its vicinity is a rolling plain at an altitude of 150-200 m above sea level.

Lake Svir is a large and one of the most elongated lakes in the Neman River basin. It is located near Lake Naroch, in a narrow moraine valley, at an altitude of 149.8 m above sea level.

The lakes found in other parts of the Neman River basin are much smaller. The stretch of the right bank of the Neman to the confluence of the Kotra River (Oshmianskaya and Lidskaya Uplands), is almost entirely deprived of lakes. It is only Lake Kroman that lies in this part of the basin, in the catchment area of the Shubino-Neman Canal. The left bank of the Neman River is also characterised by a low density of lakes. The largest of the lakes to be noted – Lake Vygonoschanckoye – is located in the catchment area of the Shchara River, at the watershed of the Shchara River and the Yaselda River, and there is also a group of lakes near the town of Nesvizh, in the upper reaches of the Usha River. The lake density of the Shchara River basin is 0.5 %, that of the Neman River basin to the confluence of the Kotra River is 0.2 %, and that of the Kotra River basin is 1.2 %. The largest lakes of this area are Lake Beloye, Lake Rybnitsa, and Lake Bershtovskoye (Bershtanskoye).

The lake density of the upstream segment of the Neman River basin is low. The area of lakes, concentrated mainly within the basins of the Shchara River and the Usa River, totals 60 km^2.

Lake Svityaz is located on the southern slope of the Novogrudskaya Upland, at the watershed of the Neman River and the Shchara River basins, at an altitude of 258 m above sea level. Its area is 2.24 km^2, its average depth is 3 m, while its maximum depth is 15 m. Just as its upstream section, the lower reaches of the Neman River also have few lakes. Their total area is about 70 km^2.

The largest canals of the Neman River basin are the Oginski Canal and the Augustow Canal.

The Oginski Canal is an artificial water engineering structure that is part of the former Dnieper-Neman waterway. The Oginski Canal is located in Ivatsevichi and Pinsk rayons, Brest oblast. The canal links the basins of the Pripyat River and the Neman River through the Shchara River (a left bank tributary of the Neman) and the Yaselda River (a left bank tributary of the Pripyat). The Oginski Canal was built in 1767-1783 at the initiative of Michal Kleofas Oginski to transport goods, mainly timber. The canal consists of two parts: the first one (3.5 km long) flows into the Shchara River, while the second one (47 km long) – to the Yaselda River. The total length of the canal,

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[1]Блакітны скарб Беларусі: Рэкі, азеры, вадасховішчы, турысцкі патэнцыял водных аб’ектаў / Маст.: Ю.А. Тарэеў, У.І. Цярэнцьеў. – Мінск : БелЭн, 2007. – 480 с.: іл. 280, карт 239, схем 321.
[2]Озёра Беларуси: справочник / Б.П. Власов [и др.] – Минск : БГУ, 2004. – 284 с.

including Lake Vygonoschanckoye, is 54 km. The maximum cargo turnover was achieved in 1847-1848 – in some years, it almost reached the level of turnover of the Dnieper-Bug Canal. There was two-way navigation of vessels along the Oginski Canal. During World War I, the canal was destroyed. Following its rehabilitation, the canal was used until 1941 for navigation and timber floating. During World War II, all its locks and dams were destroyed. Now the canal is used as a flow regulator for reclamation facilities in Ivatsevichi and Pinsk rayons.

The Augustow Canal was built in 1824-1839 at the watershed of the Vistula River and the Neman River basins. Together with the lakes located along its route, the canal links the Netta River (the Vistula River basin), a right bank tributary of the Biebrza River, and the Black Gancha River (a tributary of the Neman River). The canal is of historical value, it has been reconstructed and is an important tourist site, *inter alia* used for recreation.

The most significant canals in the Vilia River basin are the Konchansky Canal and Diagilevsky Canal, built in 1962. The Konchansky Canal is 21 km long. It flows from Lake Diagily into the Uzlianka River 3.0 km north of the village of Nevery.

1.3 General description of land runoff changes and projections with account of climate change

In 2017, there were 17 functioning hydrological stations of the State Institution "Republican Centre for Hydrometeorology, Control of Radioactive Contamination and Environmental Monitoring" (Belhydromet) in the Neman River basin. The results of the international project "Management of the Neman River basin with account of adaptation to climate change" were used to assess land runoff changes and make projections with account of climate change. The project was implemented in 2012-2015 in the framework of a programme of the United Nations Economic Commission for Europe (UNECE) with the support of the International Environment and Security Initiative (ENVSEC) and the United Nations Development Program (UNDP) in the Republic of Belarus[3], taking into account climate change scenarios[4].

In 1961-2010, the trends in land runoff changes were characterized by a slight increase in the average annual runoff (on average by 4.2 % in the river basin), a decrease in spring floods combined with their earlier peak, an increase in runoff during winter periods, and a not very significant decrease of the runoff in summer. The trends identified for the period of 1961-2010 are projected to remain, with an expected greater decrease of the runoff in summer and in autumn (up to 20 %).

[3] The Strategic Framework for Adaptation to Climate Change in the Neman River Basin / United Nations Development Programme in Belarus and United Nations Economic Commission for Europe; V.N. Korneev, A.A. Volchak et al. – Brest, 2015. – 64 p.

[4] Atlas of Global and Regional Climate Projections // IPCC materials, pp. 1350-1353. Electronic resource. – Mode of access: http://www.ipcc.ch/report/ar5/wg1/

2 IDENTIFICATION (DELINEATION) AND TYPOLOGY OF SURFACE WATER BODIES IN THE NEMAN RIVER BASIN ON THE TERRITORY OF BELARUS

In Belarus, the water resource management is exercised both within the boundaries of the country's administrative oblasts and within the boundaries of river basin catchment areas. There are five main river basins identified in the country: the Dnieper and the Pripyat River – the Black Sea basins; the Western Bug, the Western Dvina, and the Neman River – the Baltic Sea basins (Figure 2.1).

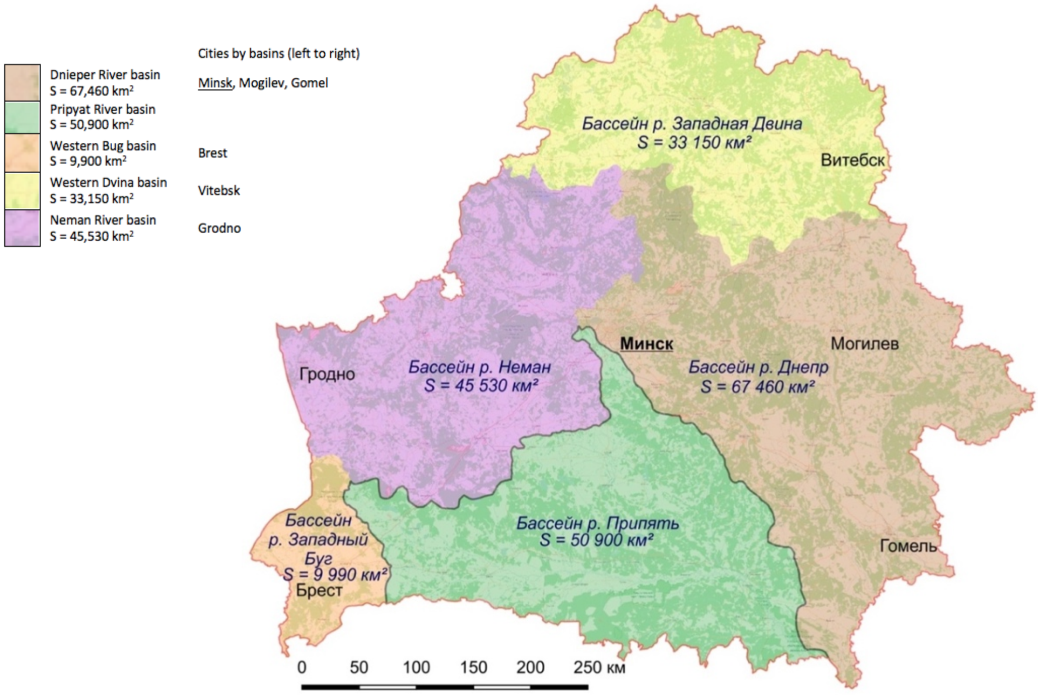

Figure 2.1 – River basins in Belarus

The practice of developing River Basin Management Plans (RBMP) for key river basins was introduced in Belarus in 2015 for the purposes of conservation and rehabilitation of water bodies, as well as for the integrated use of water resources. The RBMP development includes an initial stage of identification (delineation) of surface water bodies and groundwater bodies combined with the identification of the final number of water bodies of a river basin, for which the anthropogenic pressure is to be estimated.

The Republic of Lithuania also prepares River Basin Management Plans in order to improve and maintain the water quality. The water resource planning and management in Lithuania is based on the methodical approach of the Water Framework Directive, the requirements of which are mandatory for the European Union countries. The Water Framework Directive came into force in 2000, and pursuant to its Article 23, Lithuania implemented its provisions and requirements in the national legislation in 2003 by developing and adopting a new version of Republic of Lithuania Law on Water IX-1388 dated 25 March 2003.

Since Lithuania has already developed its first and second Nemunas River Basin Management Plans in line with the Water Framework Directive (WFD)[5] (a six-year cycle is envisaged for the RBMP updates), the same criteria as those used in Lithuania were selected for the delineation of surface water bodies of the Neman River basin on the territory of Belarus. The use of common

[5] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy ("Water Framework Directive")

criteria has enabled comparability of types, baseline ("reference") conditions, status assessments, and water bodies as such.

The proposed scheme for delineation of surface water bodies in the Neman River basin on the territory of Belarus, based on the experience of Lithuania in this field, is presented below:

1. Delineation of surface water bodies by categories:

1) rivers;
2) lakes; and
3) heavily modified and artificial water bodies (bodies, parts thereof).

The criteria of "transition" and "costal" waters are not applicable for Belarus.

2. Further delineation of surface water bodies by types based on the criteria adopted in Lithuania.

The criteria for the river typology include:

1) the size of the catchment area; and
2) the riverbed slope.

The criteria for the lake typology include:

1) the lake size;
2) the average depth; and
3) the maximum depth.

3. Further delineation of surface water bodies based on significant physical (geographical and hydromorphological) factors, such as:

- confluence of rivers,
- multiple river arms,
- hydromorphological modifications, etc.

4. Further delineation of surface water bodies based on changes in their status (ecological and chemical ecological status)

- heavy impact, and
- areas with a special protection status (SPAs, drinking water intake protection zones, recreation areas).

5. Further delineation of surface water bodies in line with the classification of the surface water bodies (parts thereof, "bodies") as heavily modified and artificial based on the following criteria and analysis of the impact of these modifications:

1) river straightening: if a) more than 30 % of the length of the river is straightened; or b) at least 3 km of the river length is straightened;
2) riverbed reservoirs, including ponds with a surface area of over 50 ha (0.5 km^2);
3) river sections with HPP cascades: river sections in the downstream reaches of the cascade, if a) the maximum distance between cascade dams is not more than 12 km and / or b) more than 30 % of the length of the river section between the dams is occupied by a riverbed reservoir;
4) river sections with the natural runoff reduced by 30 % and more; and
5) water bodies with other heavy hydromorphological modifications or a mix thereof, e.g. dredging of inland waterways, daily flow hydrograph in the HPP downstream reaches, water regime changes due to the construction of engineering flood control and irrigation infrastructure, disruption of natural hydraulic riverbed-floodway interconnection, etc.

Stream flows (rivers, streams, canals) with a catchment area of at least 30 km^2 and reservoirs (lakes, water reservoirs, ponds) with a catchment area of at least 0.5 km^2 were selected for the purposes of the delineation of surface water bodies of the Neman River basin on agreement with Lithuanian counterparts.

440 surface water bodies were selected in the Neman River basin for further delineation: 349 stream flows (264 – within the part of the Neman River basin, excluding the Vilia River, 85 –

within the Vilia River basin) and 91 reservoirs (52 – within the part of the Neman River basin, excluding the Vilia River, 39 – within the Vilia River basin).

The selected surface water bodies were digitized using a 1:100,000 scale raster mapping base in the form of linear (for stream flows) and polygonal (for reservoirs) layers of the geographic information system (GIS) in the WGS84 geodesic system (EPSG: 32635, WGS84 / UTM Zone35, encoding: UTF-8). The created GIS layers correlate with the layers of Lithuanian water bodies, integrated through the layer of European surface water bodies of the European Environment Agency, Google maps, Open street maps, CORINE, the digital surface model by the US Geological Survey.

Following that, the selected 440 surface water bodies were divided into water bodies and parts thereof in accordance with the agreed delineation criteria and types of water bodies adopted in Lithuania following the second adjustment (Tables 1.1, 1.2).

In general terms, the adjusted delineation criteria in Lithuania entail the classification of surface water bodies based on the following factors:

– the hydrographic factor (confluence of rivers);
– changed category of the water body (river-lake);
– changed type of the water body (Tables 1.1 and 1.2);
– impact on the water body (point pollution sources);
– worsened ecological status of the water body; and
– hydromorphological modifications (runoff control, HPP, riverbed straightening and reinforcement).

Table 1.1 – Updated river typology of Lithuania used for the delineation of stream flows of the Neman River basin on the territory of Belarus

	River typology following adjustment II (updated)				
Descriptors	1	2	3	4	5
Absolute height, m	< 200				
Geology	calcareous				
Catchment area, km^2	<100	100-1000		> 1000	
Riverbed slope, m/km		<0.7	>0.7	<0.3	>0.3

Table 1.2 – Updated lake typology of Lithuania used for the delineation of reservoirs of the Neman River basin on the territory of Belarus

	Lake typology following adjustment II (updated)			
Descriptors	1		2	3
Average depth, m	≤ 3		3-9	>9
Maximum depth, m	H_{ave}> 3	H_{max}< 11	11-30	> 30
Absolute height, m	< 200			
Geology	calcareous			
Surface area, km^2	>0.5			

Based on the adjusted delineation criteria, 440 selected stream flows and reservoirs of the Neman River basin were divided into **587** surface water bodies. The GIS layer of the delineation results for surface water bodies in the WGS84 geodesic system is presented in Figure 2.2 (EPSG:32635, WGS84/UTM Zone35, encoding: UTF-8).

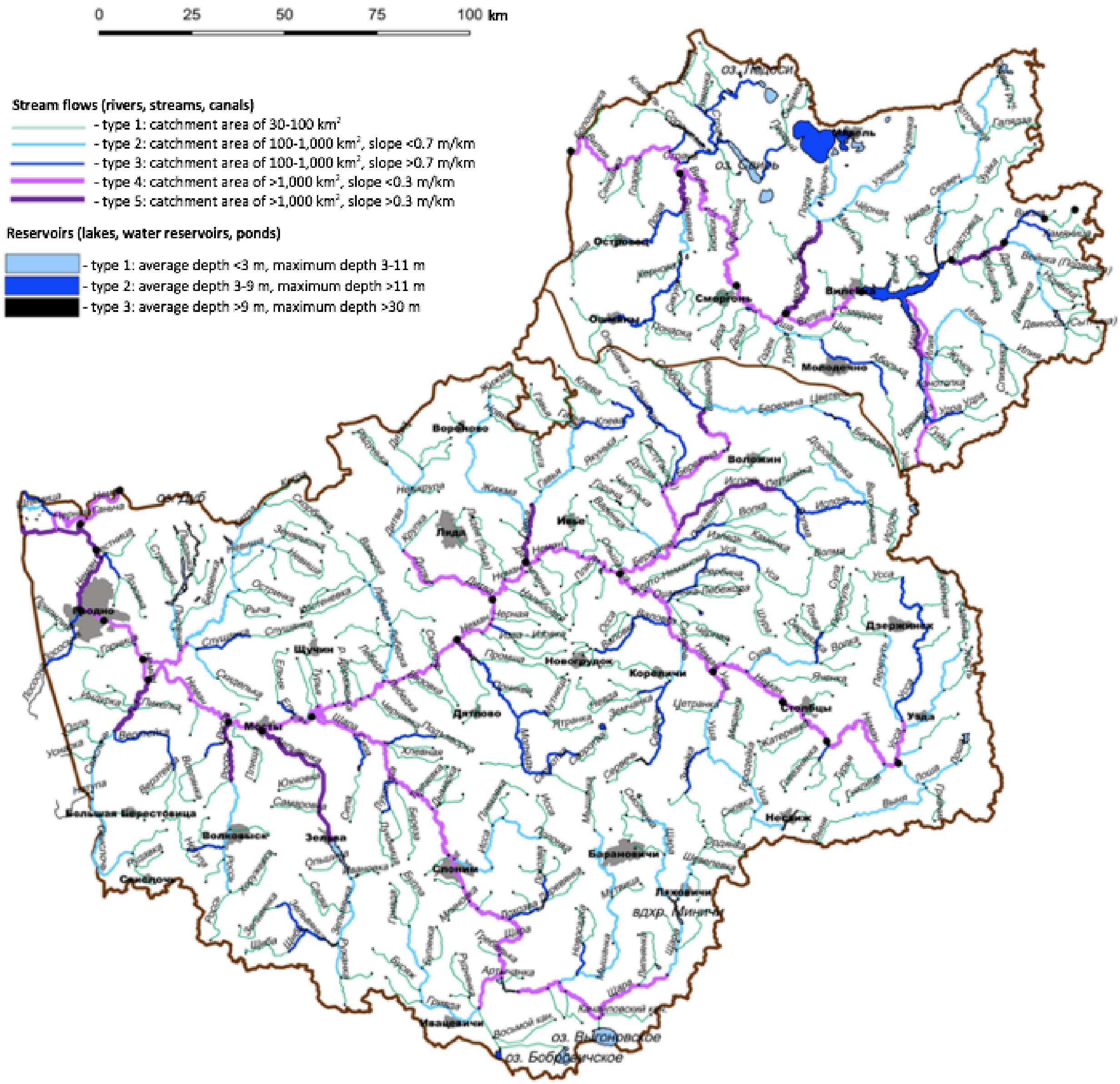

Figure 2.2 – Delineation results for surface water bodies of the Neman River basin

Of those 587 surface water bodies and parts thereof ("water bodies"), 496 are stream flows and parts thereof (379 – within the Neman River basin, excluding the Vilia River, 117 – within the Vilia River basin), and 91 are reservoirs (52 – within the Neman River basin, excluding the Vilia River, 39 – within the Vilia River basin).

The typology of stream flows and parts thereof is as follows: type 1 – 346 stream flows and parts thereof ("water bodies"); type 2 – 48 stream flows and parts thereof ("water bodies"); type 3 – 52 stream flows and parts thereof ("water bodies"); type 4 – 33 stream flows and parts thereof ("water bodies"); and type 5 – 17 stream flows and parts thereof ("water bodies"). The typology of reservoirs is as follows: type 1 – 76 reservoirs ("water bodies"); type 2 – 14 reservoirs ("water bodies"); and type 3 – 1 reservoir ("water body").

3 IDENTIFICATION (DELINEATION) AND MAPPING OF GROUNDWATER BODIES IN THE NEMAN RIVER BASIN

Tectonically, the Neman River basin is mostly located within the Belarusian anteclise, with only a small northern part stretching to the slopes of the Pripyat Trough, the Podlaska-Brest Depression, and the Polesskaya Saddle separating them. The Neman River basin is at the junction of four largest hydrogeological subdivisions: the Baltic, Orsha, Pripyat, and Brest artesian basins, the boundary between which runs along the protrusions of the crystalline basement. The groundwater flows from the centre of the region under consideration to the west – to the central part of the Baltic artesian basin, to the east – to the central part of the Orsha artesian basin, and to the south – to the central parts of the Brest and Pripyat artesian basins.

The upper part of the sedimentary cover is in the zone of active water exchange and contains considerable reserves of fresh groundwater. The thickness of the freshwater zone is 100-150 m, it increases to the east and south reaching 240 m and more.

The groundwater monitoring is performed in Belarus under natural and disturbed conditions.

Natural mode. There are 33 hydrogeological stations (110 active observation wells and 55 inactive ones) for monitoring under natural conditions on the territory of the Neman River basin. 45 observation wells are equipped to observe groundwater, 65 – confined groundwater. Of the total of 33 hydrogeological stations, 15 belong to the national, 15 – to the background, and 3 – to the transboundary levels. The density of the observation well network on the territory of the Neman River basin is 2.35 per 1,000 km^2. The largest number of hydrogeological stations is on the territory of the Vileyskoye Reservoir and Lake Naroch, which is due to the location of numerous health centres, resorts, SPAs, etc.

Disturbed mode. There are currently 28 groundwater intakes on the territory of the Neman River basin. Monitoring observations are conducted at 8 of those groundwater intakes (70 observation wells). Administratively, the intakes are located in Grodno and Minsk oblasts.

The frequency of measurements of the groundwater level and temperature in observation wells is three times per month, with a ten-day periodicity. Groundwater quality test samples are collected once a year.

Data on the groundwater level regime and quality under natural and disturbed conditions are stored in the database “Groundwater of the Republic of Belarus”, where the first observations date back to 1976.

The groundwater monitoring data analysis shows that the quantitative and chemical status of all groundwater bodies is good. The quality of groundwater in the Neman River basin is basically in line with the requirements of the Sanitary Regulations and Standards (SanPiN 10-124 RB 99) applicable on the territory of the Republic of Belarus. Exceptions are the elevated levels of iron and manganese. The fluorine content is lower than normal, which is caused by natural factors. In some wells, elevated levels of ammonia nitrogen are recorded, which indicates the influence of anthropogenic factors (its content does not tend to increase).

The territory of “elevated risk” is the Vitskovschina water intake area, which belongs to the group of water intakes used for the water supply of the city of Minsk. Due to the influence of various natural and anthropogenic factors, elevated levels of ammonia nitrogen, boron, and barium are registered in groundwater here.

13 groundwater bodies were identified in the Neman river basin in Belarus: five in quaternary aquifers and complexes (Figure 3.1), and eight in pre-quaternary aquifers and complexes (Figure 3.2). The groundwater body identification and classification results are summarised in Table 3.1.

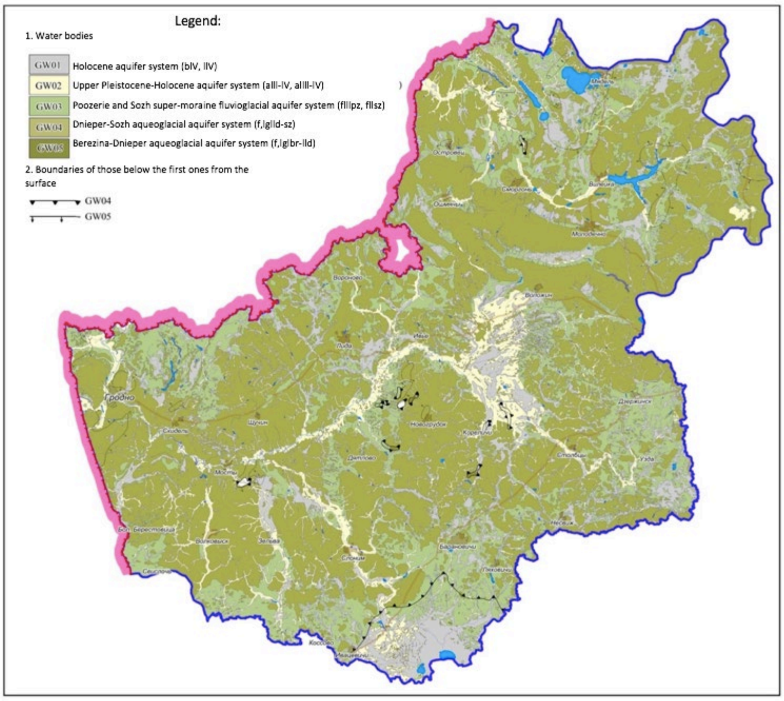

Figure 3.1 – Classification of groundwater bodies of the quaternary period in the Neman River basin on the territory of the Republic of Belarus

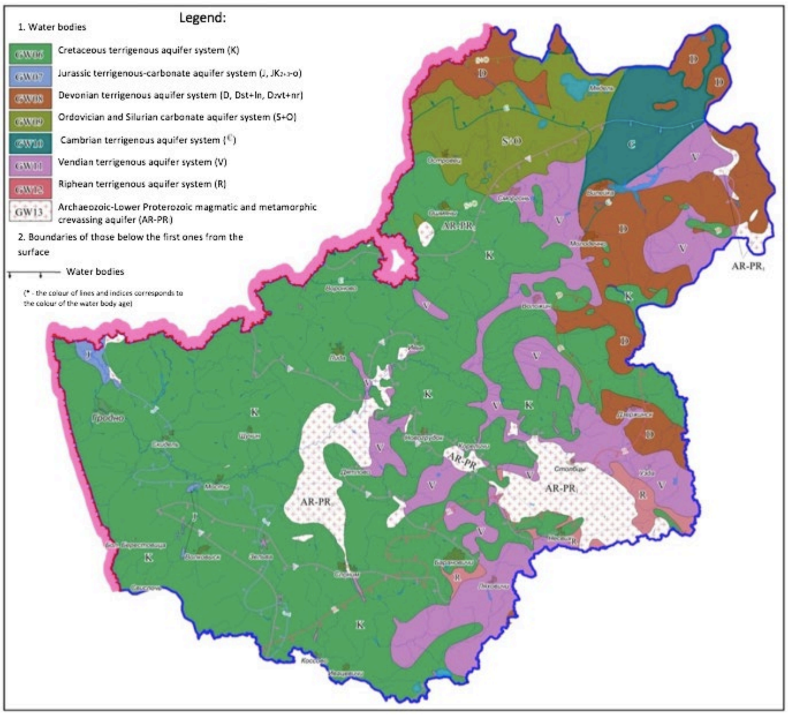

Figure 3.2 – Classification of groundwater bodies of the pre-quaternary period in the Neman River basin on the territory of the Republic of Belarus

Table 3.1 – Classification of groundwater bodies in the Neman River basin on the territory of the Republic of Belarus

Name and general status of ground water body	**Classification criteria for groundwater bodies**					
	1. Saltwater intrusion	**2. Interaction with surface water**	**3. Impact on terrestrial ecosystems**	**4. Underground water protection zone**	**5. General chemical parameters**	**6. Hydrological balance**
The groundwater body in the Holocene bogs and lake-boggy aquifer (bIV; lIV), ground water body code: GW01 **Good status** High data integrity	No saltwater or other intrusions	Groundwater feeds wetlands and bogs	No negative impact on GWDTE	Water intake is very limited, just a few wells. The water intake requires no additional drinking water treatment.	Prevailing ions: Ca^{2+} and HCO_3^-. The ground water is fresh. The concentration of any pollutants does not tend to increase.	The groundwater level has natural seasonal fluctuations; the level does not tend to drop. The water intake is limited to wells
The groundwater body in the Upper Pleistocene-Holocene alluvial and Poozerie lacustrine-alluvial aquifer (aIII-IV, alIII-IV), ground water body code: GW02 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys and flood plains. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	Water intake is very limited, just a few wells. The water intake requires no additional drinking water treatment.	Prevailing cations and anions: Ca, Mg, HCO_3^-. The concentration of any pollutants does not tend to increase.	The groundwater level has natural seasonal fluctuations; the level does not tend to drop. The water intake is limited to wells.
The groundwater body in the Poozerie and Sozh super-moraine fluvioglacial aquifer (fIIIpz, fIIsz), ground water body code: GW03 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is interrelated with surface water. The groundwater discharge has no negative impact on the surface water quality	No negative impact on GWDTE	Water intake is very limited, just a few wells. The water intake requires no additional drinking water treatment.	Prevailing cations and anions: Ca, Mg, HCO_3^-, M 0.3-0.35 g/l. The concentration of any pollutants does not tend to increase.	The groundwater level has natural seasonal fluctuations; the level does not tend to drop. The water intake is limited to wells.
The groundwater body in the Dnieper-Sozh aqueoglacial aquifer (f,lgIId-sz), ground water body code: GW04 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment (iron removal)	Prevailing cations and anions: Ca, Mg, HCO_3^-, M 0.3-0.4 g/l. The concentration of any pollutants does not tend to increase. In some wells, the maximum allowable concentration of ammonia nitrogen is exceeded	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Vitskovschina (Minsk), Dubrovnia (the city of Lida) water intakes.
The groundwater body in the Berezina-Dnieper aqueoglacial aquifer (f,lgIbr-IId), ground water body code: GW05 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment (iron removal)	Prevailing cations and anions: Ca, Mg, HCO_3^-, M 0.3-0.4 g/l. The concentration of any pollutants does not tend to increase.	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Dubrovnia, Borovka (the city of Lida), Ryschitsa (the city of Slonim)

Name and general status of ground water body	Classification criteria for groundwater bodies					
	1. Saltwater intrusion	2. Interaction with surface water	3. Impact on terrestrial ecosystems	4. Underground water protection zone	5. General chemical parameters	6. Hydrological balance
						water intakes.
The groundwater body in the Cretaceous terrigenous aquifer (K), ground water body code: GW06 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment (iron removal)	Prevailing ions: Ca, Mg, HCO_3, M 0.3–0.4 g/l. The concentration of any pollutants does not tend to increase	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Borovka (the city of Lida) water intake
The groundwater body in the Jurassic terrigenous-carbonate aquifer (J, Jk_{3+2}-o), ground water body code: GW07 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment (iron removal)	Prevailing ions: Ca, Mg, HCO_3, Na M 0.3–0.4 g/l. The concentration of any pollutants does not tend to increase	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Gozhka, Pyshka, Chekhovschikhna (the city of Grodno) water intakes.
The groundwater body in the Devonian terrigenous aquifer (D, Dst+ln, D_2vt+nr,), ground water body code: GW08 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires no additional drinking water treatment.	Prevailing ions: Ca, Mg, HCO_3, M 0.2–0.4 g/l. The concentration of any pollutants does not tend to increase.	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Glinny (the city of Vileika) water intake.
The groundwater body in the Ordovician and Silurian carbonate aquifer (O+S), ground water body code: GW09 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment (iron removal)	Prevailing ions: Ca, Mg, Na, Cl, HCO_3, M 0.3–0.5 g/l. The concentration of any pollutants does not tend to increase.	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Ostrovets (the city of Ostrovets), Voigeta (the city of Oshmiany) water intakes.
The groundwater body in the Cambrian terrigenous aquifer (Ꞓ), ground water body code: GW10 **Good status** High data integrity	No saltwater or other intrusions	Groundwater is discharged into river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires no additional drinking water treatment.	Prevailing ions: Ca, Mg, HCO_3, M 0.3–0.5 g/l. The concentration of any pollutants does not tend to increase.	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Glinny (the city of Vileika), Golenovo (the city of Molodechno) water intakes.

Name and general status of ground water body	Classification criteria for groundwater bodies					
	1. Saltwater intrusion	2. Interaction with surface water	3. Impact on terrestrial ecosystems	4. Underground water protection zone	5. General chemical parameters	6. Hydrological balance
The groundwater body in the Vendian terrigenous aquifer (V), ground water body code: GW11 **Good status** **Elevated risk**	There are intrusions from neighbouring aquifers	Groundwater is discharged into large river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment.	Prevailing ions: Ca, Na, Cl, SO_4, B, Ba, HCO_3, M 0.3-0.6 g/l. The concentration of any pollutants does not tend to obviously increase	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Vitskovschina (Minsk) water intake.
High data integrity						
The groundwater body in the Riphean terrigenous aquifer (R), ground water body code: GW12 **Good status**	No saltwater or other intrusions	Groundwater is discharged into large river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment (iron removal)	Prevailing ions: Ca, Na, SO_4, HCO_3, M 0.3-0.6 g/l. The concentration of any pollutants does not tend to increase.	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Vinklerovsky (the city of Nesvizh) water intake.
High data integrity						
The groundwater body in the Riphean terrigenous aquifer ($AR+PR_1$), ground water body code: GW13 **Good status**	No saltwater or other intrusions	Groundwater is discharged into large river valleys. The discharge has no negative impact on the surface water quality	No negative impact on GWDTE	The water intake requires additional drinking water treatment (iron removal)	Prevailing ions: Ca, Na, SO_4, HCO_3, M 0.3-0.6 g/l. The concentration of any pollutants does not tend to increase.	Natural seasonal fluctuations of groundwater. A funnel-shaped depression is generated in the area of the Shchara River 1.2 and Svetilovichi (the city of Baranovichy) water intake.
High data integrity						

4 IDENTIFICATION OF SOURCES OF HEAVY IMPACT AND EFFECTS OF HUMAN ACTIVITY ON SURFACE WATER BODIES WITHIN THE NEMAN RIVER BASIN ON THE TERRITORY OF BELARUS

The factors and sources of heavy impact on the surface water within the Neman River basin, including point and non-point (diffuse) pollution sources, are identified taking into account the characteristics of water and land use based on the data of the State Water Cadastre (SWC), local monitoring (LM), statistical data of the National Statistical Committee of the Republic of Belarus, international projects (NEFCO and Baltic Compass), the degree of change in the hydromorphological indicators, as well as climate change (the impacts are summarised in Table 4.1)

Table 4.1 – Impacts on surface water bodies within the Neman River basin

Type of impact	Impact	Presence of impact
Point pollution sources	Wastewater from industrial enterprises using IPPC[6]	**+**
	Wastewater from industrial enterprises that do not use IPPC[7]	**-**
	Sewage pollution by treatment plants	**+**
	Pollution with untreated wastewater	**-**
	Pollution with rainwater from urban areas	**+**
	Water flow from fields	**+**
	Contaminated facilities of former use	**-**
	Thermal pollution with wastewater by CHP	**-**
	Pollution due to dredging	**-**
	Pollution by fish farms	**+**
Non-point (diffuse) pollution sources	Pollution resulting from agricultural activities	**+**
	Pollution from individual farms not connected to treatment facilities	**+**
	Pollution due to soil erosion	**-**
	Pollution due to the fallout of industrial pollutants with atmospheric precipitation	**+**
	Pollution by transport (accidental leakages and discharges, use of salt solutions, herbicides, automotive engines)	**+**
	Pollution due to navigation	**+**
Quantitative parameters of water resources	Change in the runoff and level due to water intake	**-**
	Change in groundwater levels and stocks due to water intake	**-**
Hydromorphological modifications	Change in the water level and riverbed morphology due to excavation	**-**
	Change in flow parameters and discontinuity of the river due to physical barriers	**+**
	Changes in the flow parameters due to physical changes in water bodies (e.g. riverbed straightening)	**+**
Biological	Fishing and fish farming	**+**
	Introduction of alien species	**-?**

[6] IPPC (integrated pollution prevention and control) is a package of measures of integrated prevention and control of pollution by enterprises with treatment facilities.
[7] Enterprises, which are point pollution sources with no treatment facilities, dump their waste water into the city sewer system for its subsequent treatment.

4.1 Point pollution sources

The analysis of point pollution sources shows that in total there are 103 point pollution sources in the Neman River basin on the territory of Belarus, of which 24 contribute over 90 % of the total wastewater discharge into surface water bodies (Figure 4.1). Moreover, four water users, which are enterprises of the housing and utilities sector, account for over 60 % of the discharge. These include “Grodnovodocanal” city UMPE [unitary municipal production enterprise], “Grodno Azot” OJSC [open joint-stock company] (the city of Grodno), Baranovichi UMPE “Vodocanal” (the city of Baranovichi), Lida Utilities SUE [state unitary enterprise] (the city of Lida).

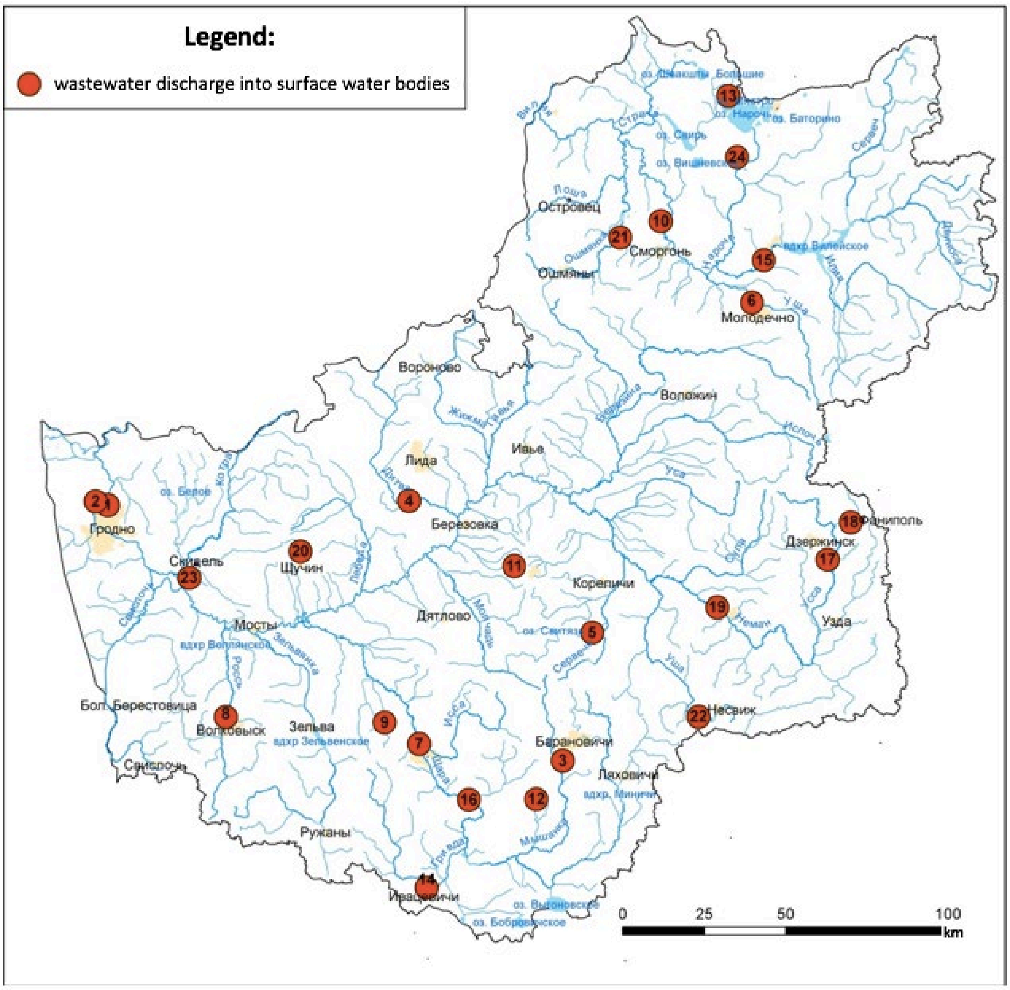

Figure 4.1 – Map of water users, which are point pollution sources in the Neman River basin, responsible for over 90 % of the total wastewater discharge

To identify water bodies under heavy impact resulting from the economic activity (anthropogenic pressure), the following criteria suggested by Lithuanian counterparts were used:

- the mean annual concentration of the biological oxygen demand (BOD) BOD_7 (in Belarus it is BOD_5) in rivers of over 3.0 (3.3 for BOD_5) mg O_2/dm^3;
- the mean annual concentration of ammonia nitrogen NH_4-N in rivers of over 0.2 mg/dm^3;
- the mean annual concentration of nitrate nitrogen NO_3-N in rivers of over 2.3 mg/dm^3;
- the mean annual concentration of total nitrogen N in rivers of over 3 mg/dm^3;
- the mean annual concentration of phosphorus-phosphates PO_4-P in rivers of over 0.09 mg/dm^3;
- the mean annual concentration of total phosphorus P in rivers of over 0.14 mg/dm^3;

– the mean annual concentration of total phosphorus P of over 0.060 mg/dm^3 in water bodies less than 9 m deep; and
– the mean annual concentration of total phosphorus P of over 0.050 mg/dm^3 in water bodies more than 9 m deep.

In total, there are 31 surface water bodies (river segments) under the risk of impact generated by point pollution sources (Figure 4.2).

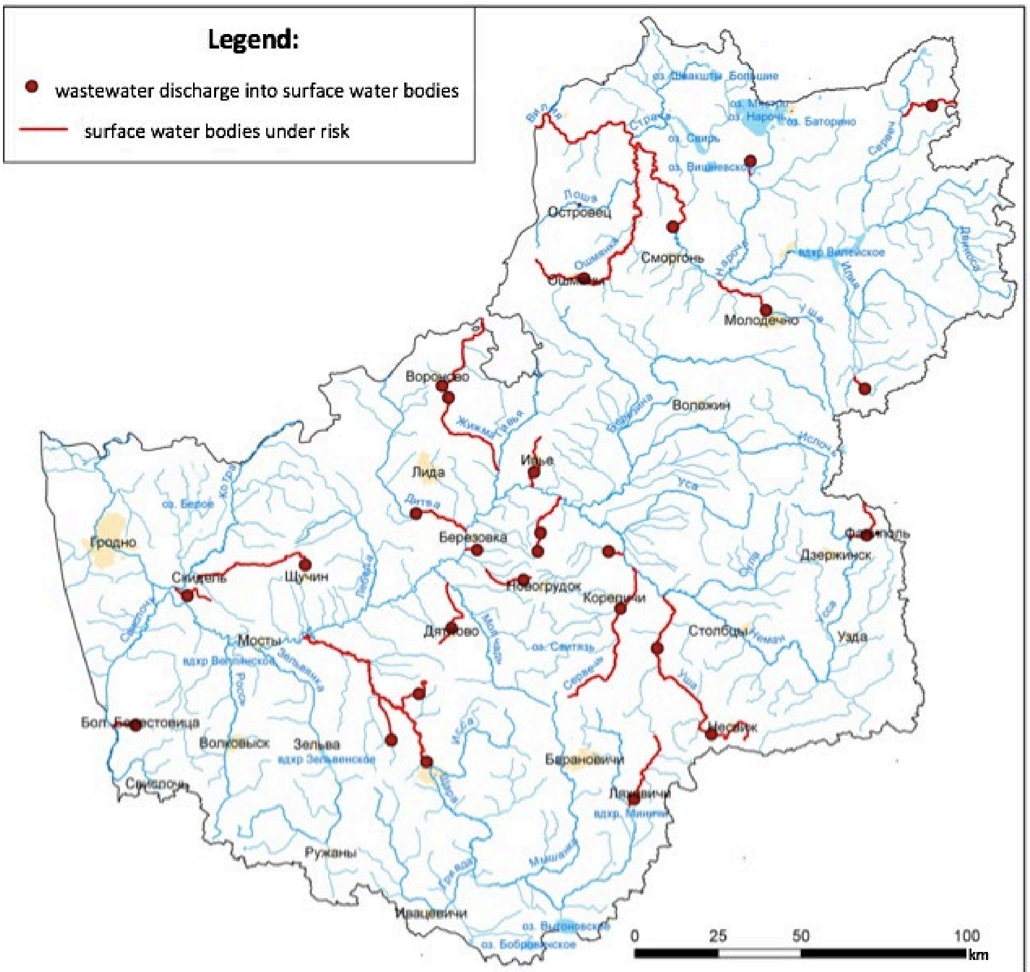

Figure 4.2 – Map of water bodies of the Neman River basin heavily impacted by point pollution sources

4.2 Non-point (diffuse) pollution sources

The main source of such pollution of water bodies is agricultural production and the associated application of mineral and organic fertilisers. In the Neman River basin, as well as throughout Belarus, the highest levels of fertiliser use were observed in the 1980s - early 1990s. At present, as of 2018, the average application of fertilisers per hectare of arable land on most of the river basin territory is 11.1 tons of organic and 184 kg of mineral fertilisers, including 73 kg of nitrogen, 17 kg of phosphorus, and 94 kg of potassium fertilisers.

An assessment of the contribution of point and non-point (diffuse) pollution sources, performed using the balance method, based on the data from the cross-border section of the Neman River, shows that the contribution of point pollution sources to contamination with biogenous elements (total nitrogen and phosphorus) is 35-40 %, while that of non-point (diffuse) sources combined with background content is 60-65 %.

Some further refinement of the analysis of the contribution of diffuse sources, using statistical data on agricultural land and the amount of mineral and organic fertilisers applied, shows that the contribution of non-point (diffuse) sources is estimated at 36-46 %, while the remaining 17-24 % of pollutant content can be attributed to their background content and non-conservative nature of pollutants (their transition to other forms, sedimentation, etc.).

A detailed analysis revealed 222 surface water bodies that are vulnerable to diffuse pollution due to the application of mineral and organic fertilisers on farming lands of the Neman River basin (Figure 4.3). This is 37 % of the total number of surface water bodies and parts thereof and 45 % of the total number of stream flows and parts thereof ("river water bodies") under consideration.

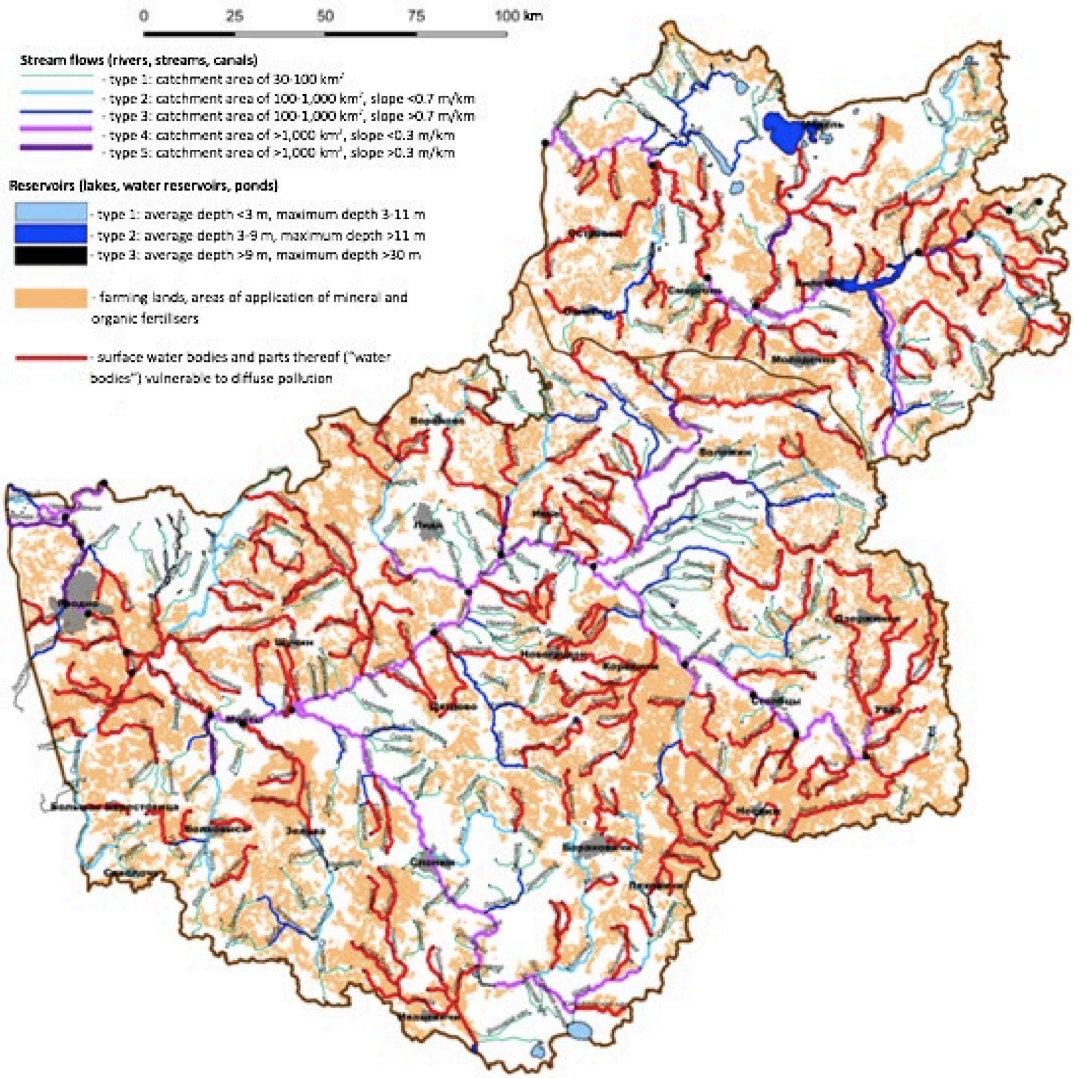

Figure 4.3 – Surface water bodies vulnerable to diffuse pollution with mineral and organic fertilisers applied at farming lands in the Neman River basin

5 COMPARATIVE STUDY OF SYSTEMS OF SURFACE WATER MONITORING IN THE NEMAN RIVER BASIN ON THE TERRITORY OF BELARUS AND LITHUANIA

Surface water monitoring is one of the types of monitoring performed within the National Environmental Monitoring System in the Republic of Belarus (hereinafter referred to as the NEMS). At present, the system of surface water monitoring is supported by a range of regulatory documents, the main ones being: the Water Code of the Republic of Belarus (No. 149-Z of 30 April 2014, last updated on 18 July 2016), which covers the key principles of the EU Water Framework Directive, and the Regulations on the procedure of surface water monitoring performed within the National Environmental Monitoring System in the Republic of Belarus (approved by Resolution of the Council of Ministers of the Republic of Belarus No. 482 of 28 April 2004).

In the Republic of Lithuania, the monitoring of surface water bodies is performed in line with the provisions of:

- the Republic of Lithuania Law on Water;
- the general requirements to monitoring water bodies approved by the Minister of Environmental Protection of the Republic of Lithuania; and
- Resolution of the Government of the Republic of Lithuania No. 315 of 2 March 2011 On Approval of the State Environmental Monitoring Programme for 2011-2017.

The Republic of Belarus operates 64 surface water observation stations in the Neman River basin (39 ones placed at rivers and 25 – at reservoirs), the observation network covers 35 water bodies (22 stream flows and 13 reservoirs). Five observation stations are located at the border, including 2 at the border with the Republic of Lithuania and 3 at the border with the Republic of Poland, on the transboundary segments of the Neman, Vilia, Krynka, Svisloch, and Chernaya Gancha Rivers.

The Republic of Lithuania operates a system of monitoring in the Neman / Nemunas River basin, which includes 675 observation stations (390 ones placed at rivers and 285 – at reservoirs). Depending on the objectives and tasks, different types of monitoring are performed at different intervals. 42 observation stations (35 at rivers and 7 at reservoirs) are used for annual monitoring equivalent to the monitoring performed in Belarus. The remaining 633 stations are used for supervisory, research, and activity monitoring at different intervals.

Belarus and Lithuania are guided by identical principles of the network organisation, the number and location of stations used for regular annual observations.

In the Republic of Belarus, the programme of surface water monitoring (the list of indicators, the observation procedure) is regulated in the part of hydrochemical indicators by the technical code of common practice (TCCP) 17.13-04-2014 and Order No. 44-OD of the Ministry of Natural Resources and Environmental Protection of 30 January 2015 On Some Issues Related to Organisation of Surface and Groundwater Monitoring at Observation Stations of the National Environmental Monitoring System in the Republic of Belarus.

Surface water samples are taken at all national and background observation stations to measure 29 key indicators, and at transboundary stations to measure 31 indicators of common groups. Water transparency is also measured at reservoirs. In 2015-2016, surface water observations were performed at 48 observation stations in the Neman River basin; 403 water samples were collected, and 11,905 tests were made during that period. Sample collection and measurements are carried out by laboratories of the state institution “Republican Centre for Analytical Control in the Area of Environmental Protection”, an organisation under the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus. The laboratories are accredited for compliance with the requirements of international standard STB ISO / IEC 17025-

2007 “General requirements for the competence of testing and calibration laboratories” and confirm their technical competence by participating in interlaboratory comparisons, *inter alia* with Lithuanian laboratories. The laboratories are equipped with analytical equipment appropriate for the monitoring purposes.

In the Republic of Lithuania, three types of monitoring observations are performed, depending on the area of research and the information needed:

- supervisory monitoring: intensive and extensive monitoring respectively performed annually and twice during the period of the river basin management plan;

- activity monitoring: at reservoirs and stream flows, the status of which does not meet the criteria of excellent and good "ecological status"; and

- research monitoring: as needed, to determine the causes and nature of pollution, e.g. in case of accidents and other emergency situations.

All the stations of intensive monitoring are used to measure the general physical and chemical indicators (15 indicators) 12 times a year (monthly), while in the case of rivers flowing into the sea, transboundary rivers and their main tributaries, the main ions (8 indicators) are also measured with the same periodicity.

Specific pollutants (7 metals) are controlled 12 times a year at transboundary rivers, those flowing into the sea, and major rivers, as well as rivers flowing through areas intensively used for farming.

The main administrators of the programme of monitoring surface water bodies are organisations and institutions under the Ministry of Environmental Protection of the Republic of Lithuania.

Thus, the monitoring programmes of Belarus and Lithuania are virtually identical in the part of monitoring the key hydrochemical indicators.

There are some small differences concerning the group of organic substances and heavy metals. In Belarus, the content of organic substances is estimated using BOD_5 (5 days), the content of petroleum products and synthetic surfactants, while in Lithuania – using by BOD_7 (7 days) and the total organic carbon concentrations. In both countries the content of four metals is controlled – Cr, Cu, Zn, As. Another group of four metals (Ni, Pb, Cd, Hg), defined in the programme of monitoring hydrochemical indicators in Belarus, is classified in the EU Water Framework Directive as priority pollutants and is covered by the monitoring of priority substances in Lithuania. Belarus also monitors the content of iron and manganese, while Lithuania measures the content of aluminium, vanadium, and tin (as specific pollutants).

In the Republic of Belarus, there is regular monitoring of the content of hazardous pollutants – persistent organic pollutants (POPs) – in surface water and bottom sediments.

In the Republic of Lithuania, the concentration of priority and hazardous substances is measured at 12 stations. The programme of monitoring priority and hazardous substances covers 45 priority substances defined by the EU Water Framework Directive.

6 COMPARATIVE STUDY AND RESULTS OF ECOLOGICAL STATUS ASSESSMENT OF SURFACE WATER BODIES IN BELARUS AND LITHUANIA

6.1 Assessment of surface water body status for physicochemical parameters and hazardous pollutants

The systems of assessment of surface water body quality for hydrochemical parameters have significant differences in the Republic of Belarus and the Republic of Lithuania. In Belarus, the chemical (hydrochemical) status / status class of surface water bodies is determined using key hydrochemical parameters. In Lithuania, hydrochemical parameters (physicochemical elements) are taken into account along with hydromorphological, hydrobiological, and biological elements to assess the ecological status of water bodies. The assessment of the chemical status is made based on the list of priority hazardous substances and the environmental quality standards set for these purposes by the Environmental Quality Standards Directive (2008/105/EC) in the field of water policies, as amended by Directive 2013/39/EU.

A comparative study of the results of the water body status assessment for physicochemical (hydrochemical) parameters, which were obtained based on the methods applicable in the Republic of Lithuania and the Republic of Belarus, revealed significant differences. For instance, the results for hydrochemical parameters coincided only at 12 of 64 NEMS observation stations in the Neman River basin (at 9 – for the good status, and at 3 – for the excellent status). Of those, 5 stations are located at lakes (Lake Naroch, Lake Vishnevskoe, and Lake Svir) and 7 – at rivers (the Neman, the Svisloch, the Berezina, the Issa, the Gozhka, and the Ross). At the remaining 52 stations, the results of the status (class) assessment differed (Figures 6.1, 6.2).

The differences in the assessment results for hydrochemical parameters are explained by the different ranges of concentrations used for hydrochemical parameters for the 5 classes of quality, primarily for nitrogen- and phosphorus-containing substances. In the Republic of Lithuania, the upper limit of concentrations for hydrochemical parameters set for rivers and lakes of the good class is much lower, i.e. the criteria are more stringent than in the Republic of Belarus. In most cases, the physicochemical class within the assessment system used in Lithuania was downgraded based on the ammonium ion (the worst value).

An assessment of the chemical status for priority hazardous pollutants, performed based on the method used in Lithuania, showed that the condition of all water bodies in the Neman River basin on the territory of the Republic of Belarus meets the criteria for the good chemical status.

In order to harmonise the assessment of the surface water status for hydrochemical parameters in the Neman River basin on the territory of Belarus under international and research projects, an assessment of the chemical status for priority substances and their compliance with the environmental quality standards in terms of the parameters measured under the national monitoring programmes can be proposed. The assessment of the status for physicochemical parameters can be performed relying on either the Belarusian or the Lithuanian system of the surface water quality assessment based on data obtained within the framework of the NEMS.

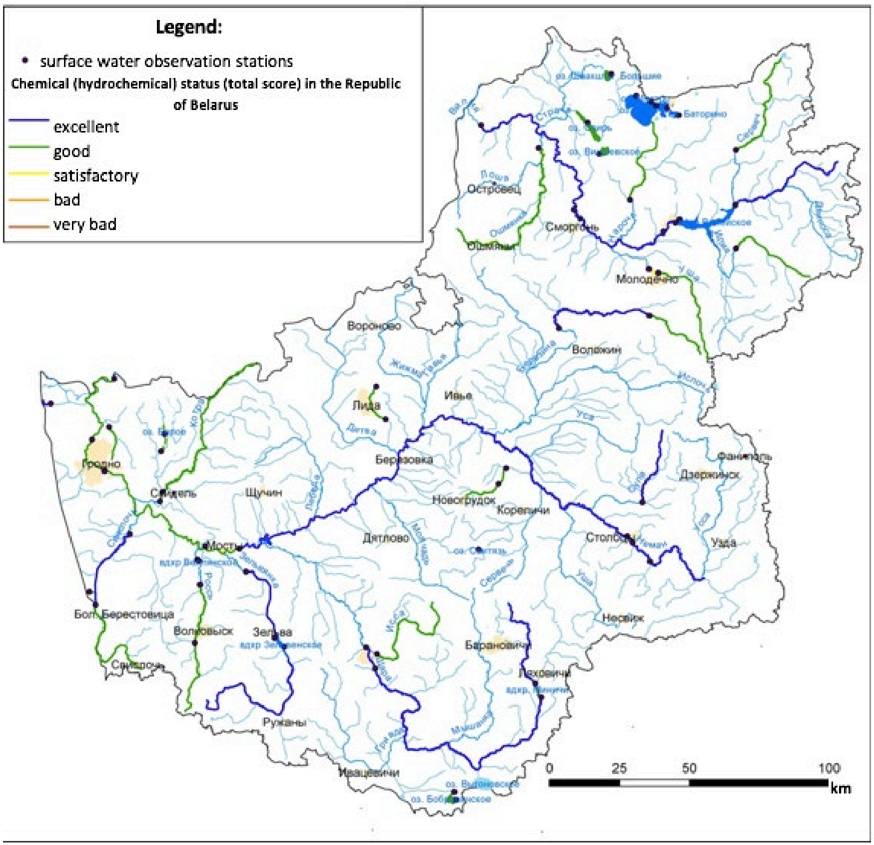

Figure 6.1 – Assessment of the chemical (hydrochemical) status (total score) based on the method used in Belarus

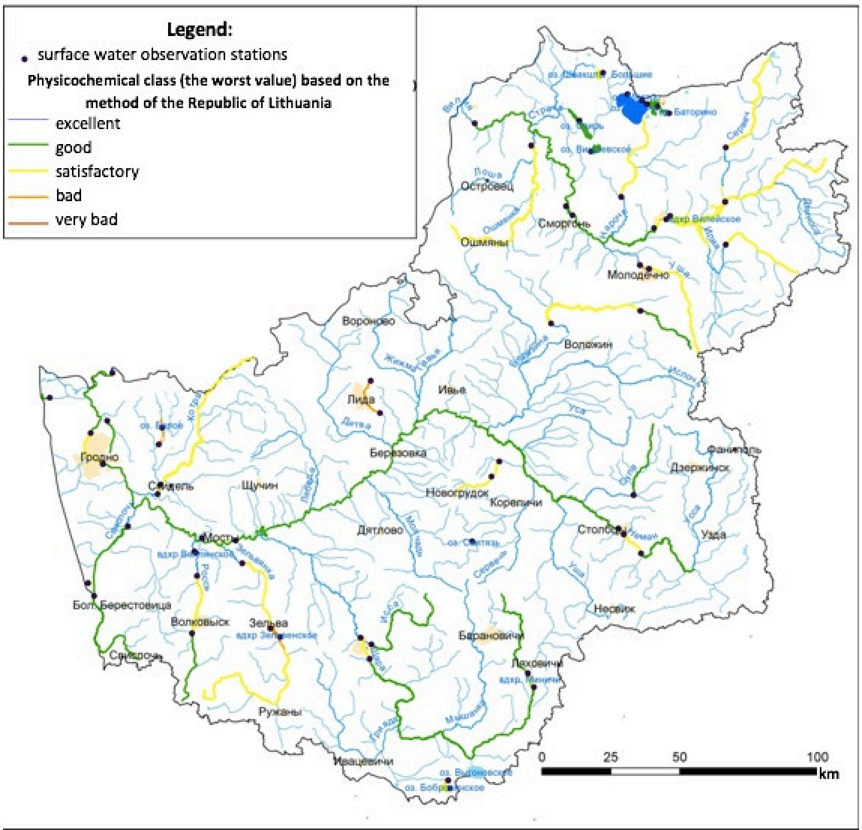

Figure 6.2 – Assessment of the status class for physicochemical parameters (the worst value) based on the method used in Lithuania

6.2 Assessment of status classes of surface water bodies for biological (hydrobiological) parameters of the ecological status

A study of approaches to the assessment of aquatic ecosystem status in the Republic of Belarus and the Republic of Lithuania for biological (hydrobiological) parameters also revealed significant difference. First of all, there were inconsistences discovered in the methods of sampling and determination of hydrobiological parameters used for further assessment of the water body status. Under the Belarusian methodology of phytoperiphyton (phytobenthos) selection, only submerged plant parts are selected as the substrate for sampling, while under the Lithuanian sampling methodology, solid surfaces are preferred, and submerged vegetation is used only in the absence of a suitable substrate with a solid surface.

Even more significant differences are revealed in selection and identification of macrozoobenthos samples. At present, only qualitative sampling methods are used in the hydrobiological practice in Belarus, while in Lithuania, qualitative, semi-quantitative and quantitative samplings methods are applied. The Belarusian sampling method ensures the widest possible coverage of biotopes to achieve the maximum species diversity in collected samples, however, not all organisms are taken from collected samples in the sample preparation process, with the range limited only to those representing the maximum diversity of organisms in the sample (based on a visual evaluation performed by experts). The Lithuanian macrozoobenthos sampling method is more complex, with a composite sample prepared and used for subsequent evaluation, including all organisms collected in the process of sampling using different methods. The assessment criteria also have fundamental differences. The Belarusian assessment method involves the determination of hydrobiological parameters based on the structural characteristics of phytoperiphyton communities by calculating the saprobity index using the Pantle-Bucca saprobiological analysis method in Sladecek’s modification, while in Lithuania, the key biological parameters used for the ecological status assessment are the zoobenthos index (UMI) and phytobenthos index (FBI) for rivers and chlorophyll for lakes.

A comparison of the obtained results of status assessment for hydrobiological indicators based on the assessment systems used in the Republic of Lithuania and the Republic of Belarus revealed significant differences. The results of assessment based on the Lithuanian method showed that the condition of surface water bodies in the Neman River basin is much worse compared to the status assessed using the Belarusian method (Figures 6.3, 6.4). According to the Belarusian assessment, 3 water bodies meet the criteria for the very good status, 23 – for the good status and 19 – for the satisfactory status. According to the Lithuanian assessment, 13 water bodies meet the criteria for the good status, 37 – for the satisfactory and 14 – for the bad status.

The indices calculated for the phytoperiphyton and macrozoobenthos communities turned out to be underestimated, primarily because of the differences in the sampling methodology. Using the parameters of phytoplankton and zooplankton communities, as well as the concentration of chlorophyll within the framework of the joint assessment would be not sufficiently correct at the moment due to the fact that these criteria play a different role in the assessment systems in the Belarus and Lithuania, while the chlorophyll concentration is not used at all to evaluate the status of water bodies in Belarus.

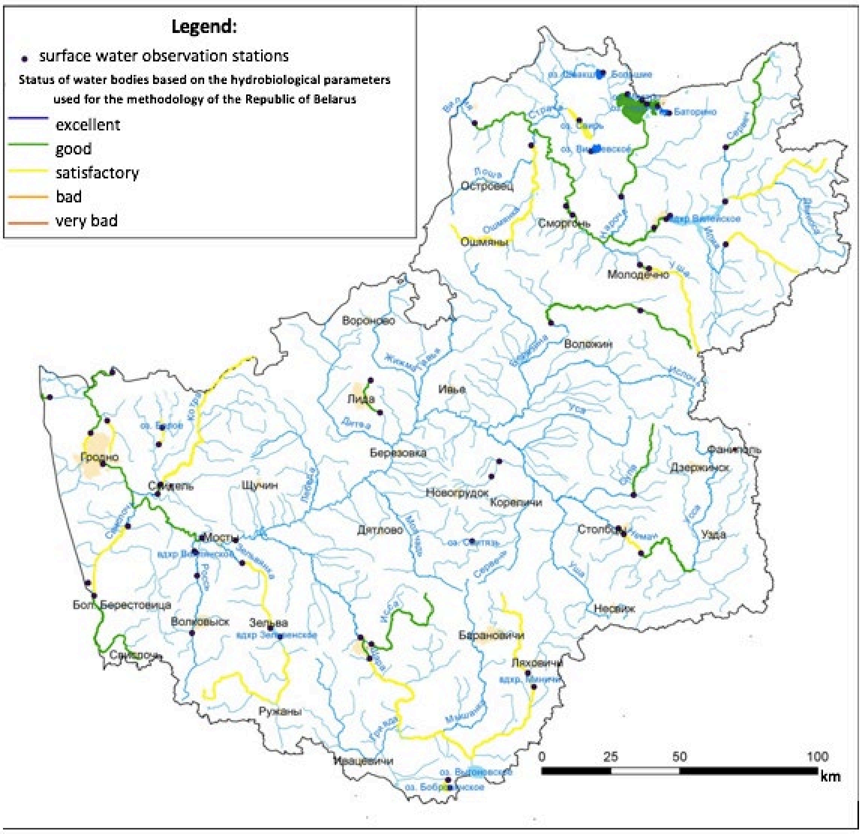

Figure 6.3 – Assessment of classes of surface water bodies for biological (hydrobiological) parameters based on the method used in Belarus

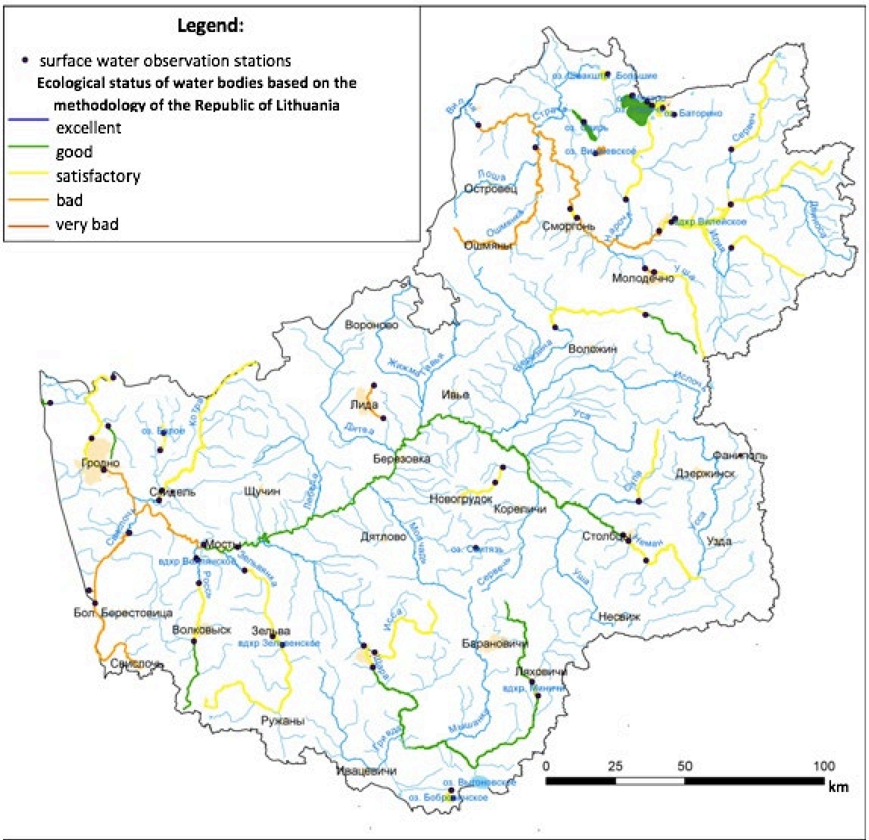

Figure 6.4 – Assessment of the ecological status of water bodies based on the method used in Lithuania

Based on the results of the study of hydrobiological methods of sampling, identification, and subsequent assessment of the status of surface water bodies using the methods of the Republic of Lithuania, the following proposals can be made:

- to consider the option of using Lithuanian sampling methods for all groups of hydrobionts within the hydrobiological part of the system of surface water monitoring of the Republic of Belarus;

- to review and optimize the frequency of sampling in order to improve the assessment of the surface water body status; and

- to introduce into the hydrobiological practice of the Republic of Belarus the indices used in the practice of the Republic of Lithuania to enable adequate joint assessments.

6.3 Hydromorphological modifications

Under the Lithuanian approach, which was used to assess the degree of hydromorphological modifications in the Neman River basin on the territory of Belarus, the hydromorphological modification analysis covers 5 factors, which could result in surface water bodies not reaching at least 'good ecological status':

1. straightening of stream flows: if 1) more than 30 % of the length of the river is straightened; or 2) at least 3 km of the river length is straightened. However, it applies only if the stream flows run through urban or intensively used agricultural areas (otherwise it falls under the category "under the risk of not reaching 'good ecological status'");
2. riverbed reservoirs, including water reservoirs, ponds with a surface area of over 50 ha;
3. river sections with HPP cascades: river sections in the downstream reaches of the cascade, if 1) the maximum distance between cascade dams is not more than 12 km and / or 2) more than 30 % of the length of the river section between the dams is occupied by a riverbed reservoir;
4. river sections with the natural runoff reduced by 30 % and more; and
5. water bodies with other heavy hydromorphological modifications or a mix thereof, e.g. dredging of inland waterways, daily flow hydrograph in the HPP downstream reaches, water regime changes due to the construction of engineering flood control and irrigation infrastructure, disruption of natural hydraulic riverbed-floodway interconnection, etc.

Of the surface water bodies identified in the Neman River basin on the territory of Belarus, only 186 water bodies are not facing heavy hydromorphological modifications—i.e. are in a condition close to the natural one—that makes 31 % of their total number (Figure 6.5).

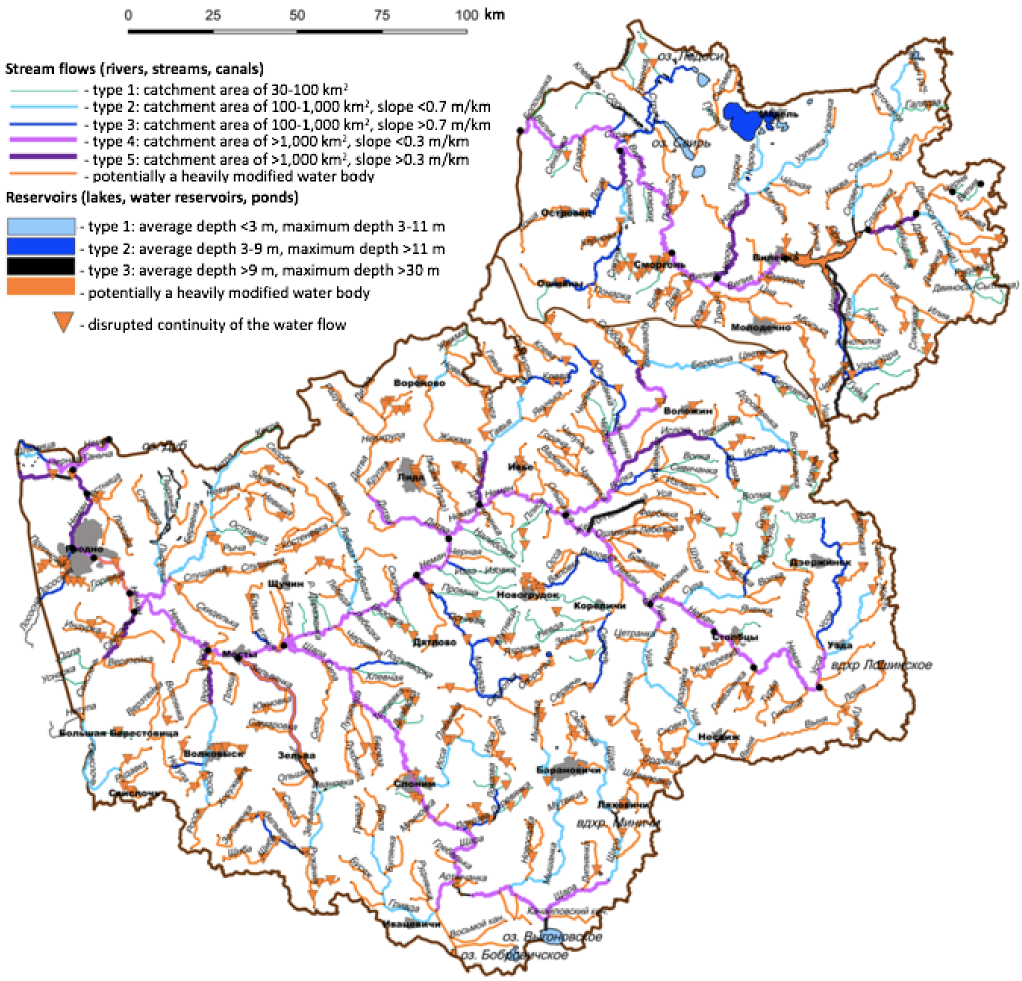

Figure 6.5 – Hydromorphological modifications of surface water bodies and parts thereof ("water bodies") in the Neman River basin on the territory of Belarus

6.4 Assessment of the overall ecological status of surface water bodies

The overall ecological status of surface water bodies is determined in Belarus using a five-grade scale based on the hydrobiological parameters (ecological / hydrobiological ecological status) combined with hydrochemical parameters (chemical / hydrochemical status) and hydromorphological parameters (the degree of their modification). In Lithuania, the overall status class (status) is defined as the overall condition of a water body that meets or fails to meet the criteria for 'good status'.

An assessment of the overall ecological status of the surface water bodies in the Neman River basin on the territory of Belarus, which was based on the approaches used in Belarus and in Lithuania, also revealed significant differences in the results obtained.

According to the Belarusian approach, 10 water bodies meet the criteria for 'excellent ecological status', 32 – for 'good ecological status', and 22 – for 'satisfactory ecological status'. According to the Lithuanian approach, only 12 water bodies meet the criteria for 'good condition (status)', while the remaining 52 fail to meet the criteria for 'good status' (Figures 6.6, 6.7).

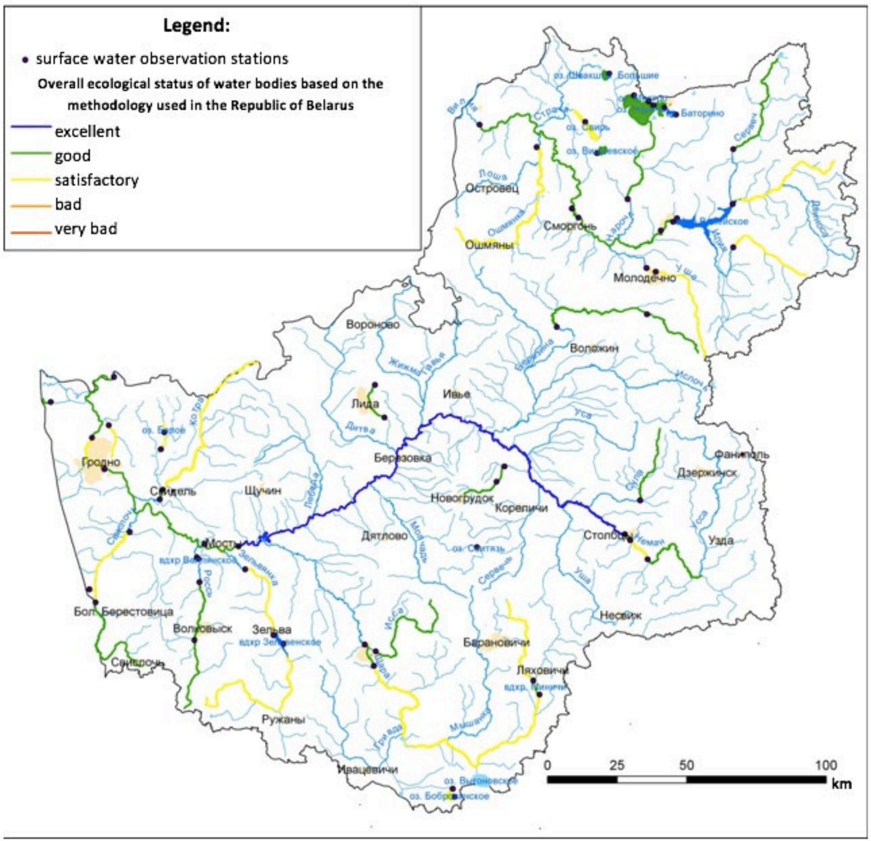

Figure 6.6 – Assessment of the overall status class (status) of surface water bodies based on the methodology used in Belarus

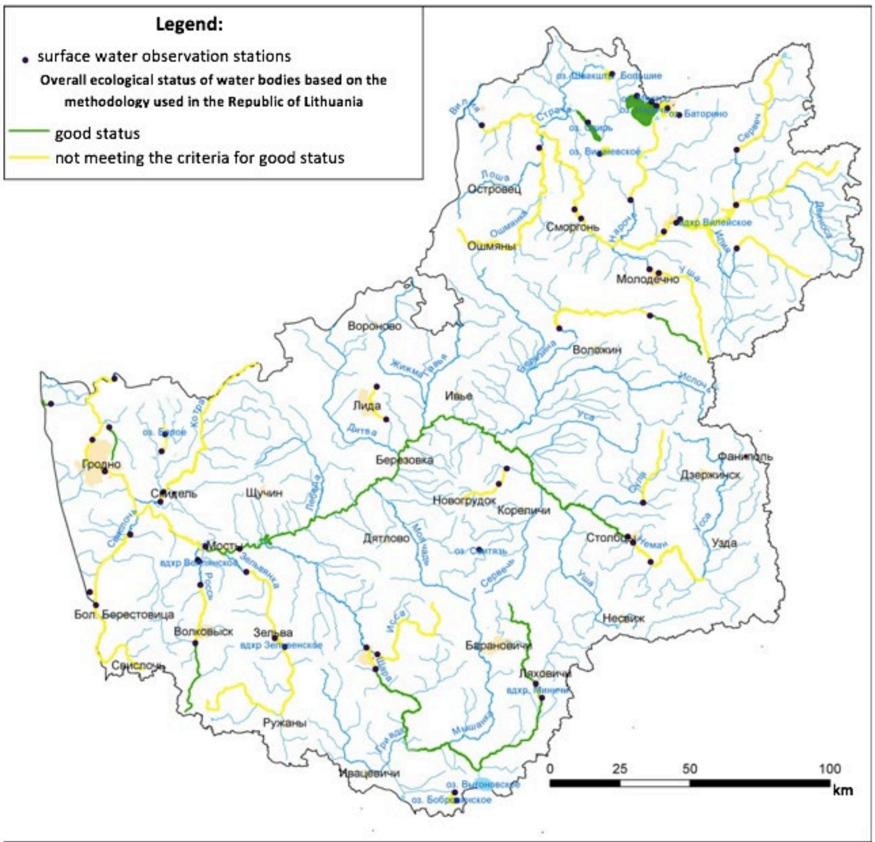

Figure 6.7 – Assessment of the overall status class (status) of surface water bodies based on the methodology used in Lithuania

6.5 Improvement of the definition of surface water bodies under heavy anthropogenic impact and risk of not reaching at least 'good ecological status'

The fact of influence of point pollution sources, which—combined with the assessment of the ecological status based on the data of the NEMS observation network and local monitoring—served as one of the key selection criteria, helped distinguish 65 surface water bodies and parts thereof ("water bodies") under a heavy anthropogenic impact and risk of not reaching at least 'good ecological status' (Figure 6.8).

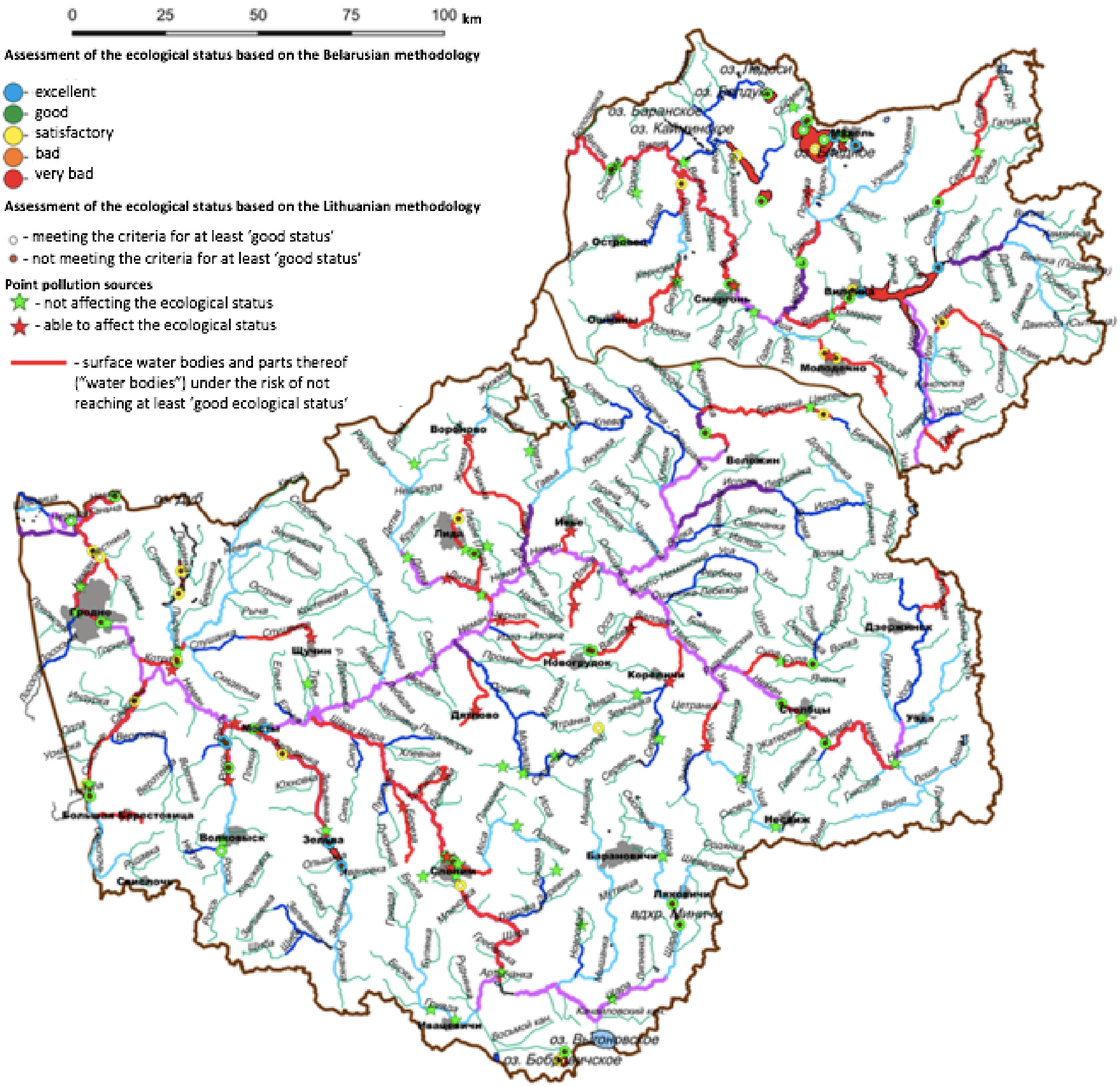

Figure 6.8 – Surface water bodies under the risk of not reaching at least 'good ecological status'

7 ASSESSMENT OF THE QUALITATIVE AND CHEMICAL CONDITION (STATUS) OF GROUNDWATER BODIES IN THE NEMAN RIVER BASIN ON THE TERRITORY OF BELARUS BASED ON THE METHODOLOGY AGREED AT EXPERT LEVEL

When discussing the key criteria for assessing the quantitative and qualitative status of groundwater with EU experts, it was found that identical methodological approaches are used to determine the groundwater status based on some criteria. However, there are significant differences between the systems of groundwater assessment for quantitative and chemical parameters in the Republic of Belarus and the Republic of Lithuania. This is explained by the kind of source data available, which can be used by each of the countries.

7.1 Classification of the qualitative and chemical status of groundwater in the Neman River basin on the territory of Belarus

Groundwater is found across the Neman River basin on the territory of the Republic of Belarus at different depths. It is confined to water-bearing sediments of different lithologic composition. The bottom boundary of the fresh groundwater lies at a depth of 200 to 350 m. There are significant natural and projected useful groundwater resources, the last large-scale assessment of which was carried out in the early 1980s.

The natural (renewable) fresh groundwater resources in the river basin as a whole were estimated at 13.53 million m^3 per day and represent the total flow of groundwater supported with the infiltration of precipitation. The projected useful fresh groundwater resources are estimated at 14.22 million m^3 per day and are determined based on the water consumption that can be reached by the water intake facilities located across the basin area relying on the natural resources and additionally mobilised water from stream flows and reservoirs (natural and artificial ones).

As of January 2017, there were approved reserves of 80 fresh groundwater aquifers in the Neman River basin, located at 43 settlements, of which 53 aquifers at 36 settlements are used. At the same time, groundwater monitoring is carried out for only 8 collective water intakes in 5 cities (Figure 7.1).

According to the data of the State Water Cadastre for 2016, water intakes using groundwater are equipped for 9 main horizons (complexes), which are operated jointly in most cases. Water is mainly taken from quaternary sediments – 43 % and pre-quaternary sediments – 57 %.

There are 33 hydrogeological stations in the Neman River basin, including 110 active observation wells and 55 inactive ones. Observations of groundwater quality were conducted in 2015 at 27 hydrogeological stations (84 observation wells).

To assess the quality of groundwater on the territory of the Neman River basin, the following key criteria are used:

– background (natural) indicators of groundwater quality;

– detection of pollutants exceeding the maximum allowable concentration (MAC) in groundwater established by SanPiN 10-124 RB 99 ("Drinking water. Hygienic requirements for water quality in centralized drinking water supply systems. Quality control"); and

– determination of the frequency of cases, when the content of chemical elements exceeds the maximum allowable concentration in groundwater, relative to the total number of measurements.

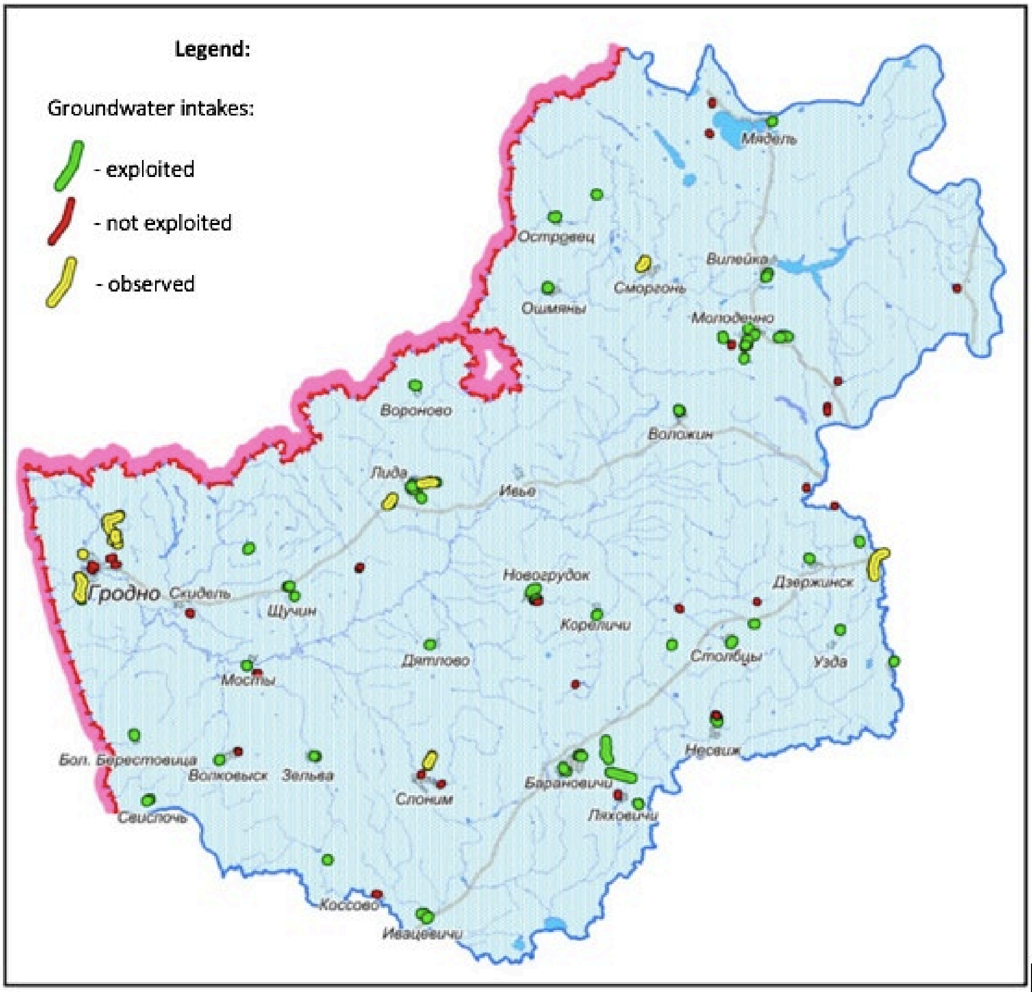

Figure 7.1 – Groundwater intakes with approved reserves in the Neman River basin on the territory of the Republic of Belarus

<u>Groundwater quality analysis (macro elements)</u>

The quality of groundwater in the Neman River basin is largely in line with the established requirements. In 2015, there were no significant changes in the chemical composition of groundwater. The hydrogen index values varied from 5.39 to 10.35 units, which indicates a wide range of changes in the water reaction – from weakly acidic to strongly alkaline. The overall water hardness index ranged from 0.27 to 7.30 mmol / dm^3, which corresponds to groundwater characteristics ranging from very low hardness to moderate hardness.

The groundwater of the Neman River basin is mainly magnesium-calcium hydro carbonate and less often – magnesium-calcium hydro carbonate chloride water. According to the data of routine observations, there were no significant deviations from the established requirements. On the territory of the river basin, there were some isolated cases of the groundwater quality deterioration caused by elevated levels of ammonia nitrogen (Myadel hydrogeological station). In addition, the permanganate oxidizability exceeds the MAC on the territory of the Neman River basin (the hydrological stations at Naliboki, Cheremshitsy, Antoninsberg, Urliki-Shvakshty), which is caused by the influence of both natural hydrogeological factors and municipal pollution. In general, the number of samples with parameters exceeding the MAC level in groundwater decreased in 2015 compared to 2014.

The head water of the Neman River basin is predominantly magnesium-calcium hydro carbonate, more rarely – magnesium-calcium hydro carbonate chloride water. A review of the data for the

2015 showed that the head water quality in terms of the monitored parameters is basically in line with the established requirements. However, in a number of wells (Sheipichi, Myadel, and Vileika hydrogeological stations), the content of ammonia nitrogen exceeded the MAC by the factor of 1-1.8. Such values are explained by both agricultural and municipal pollution, as well as the influence of natural factors.

Groundwater quality analysis (micro elements)

In 2015, a study of the micro-element composition of the groundwater of the Neman River basin was performed at 9 hydrogeological installations (in 9 observation wells). According to the study results, the quality of groundwater in terms of the content of the monitored micro elements met the established requirements. An exception was the lower content of fluorine and the elevated content of manganese.

In 2015, changes in the chemical composition and quality of groundwater at the Neman River basin water intakes were monitored through observation and production wells (203 water production wells and 25 observation wells) at 8 water intakes. In terms of its chemical composition, the groundwater of the used aquifers is magnesium-calcium and calcium-magnesium hydro carbonate, moderately hard, with the dry residue averaging at 311 mg / dm^3. In terms of the monitored parameters, the used groundwater basically meets the established requirements.

However, elevated iron content levels are registered (on average at 1.5-3.5 MAC) both in observation and production wells. In the process of use, the physicochemical composition of the groundwater coming from the utilised aquifers is practically unchanged and its quality does not seem to worsen.

The groundwater of intermorainal aquifers (the Dnieper-Sozh and Berezina-Dnieper aqueoglacial ones) are magnesium-calcium and calcium-magnesium hydro carbonate, with a dry residue at 92-306 mg / dm^3. The water is characterized by an elevated iron content of up to 3.5-25 MAC. In terms of the hydrogen index values, groundwater categories range from neutral to slightly alkaline.

In terms of its chemical composition, the groundwater confined to Poozerie alluvial and Sozh super-moraine fluvioglacial aquifers is magnesium-calcium, calcium-magnesium, and calcium hydro carbonate water with an average mineralisation of 223.0 mg / dm^3. The water is characterised by an elevated iron content of 6-37 MAC, which is explained by natural factors (the confinement of the observation wells to lower wetlands) and the technical condition of the wells.

7.2 Description of the state of groundwater of the Neman River basin based on local monitoring data

The local groundwater monitoring is performed using the observation wells located upstream (background well) and downstream (observation well) from the sources of unfavourable impact along the natural groundwater flow.

The local groundwater monitoring is performed in the Republic of Belarus by 224 natural resource users at 1,419 observation points. In total, observations cover 291 sources of unfavourable impact, of which observed waste storage and disposal sites represent 27 %, solid municipal waste landfills – 54 %, oil product storage facilities – 6 %, filtration fields – 6 %, pesticide disposal sites – 2 %, irrigation fields – 2 %, open pits – 1 %, and industrial sites – 2 %.

The frequency of observations in the framework of the local groundwater monitoring established by the Ministry of Natural Resources and Environmental Protection is once a year at the recession of spring flooding.

The list of parameters to be observed in the framework of local groundwater monitoring is determined by the Ministry of Natural Resources and Environmental Protection, depending on the category of sources of impact. For example, about 20 groundwater parameters are monitored for storage and disposal sites, including general physicochemical parameters and specific pollutants (metals, surfactants, phenols), about 30 parameters are monitored for disposal sites of obsolete pesticides, including priority hazardous substances (organochlorine pesticides).

Observations of the state of groundwater in the vicinity of waste treatment facilities or disposal sites for obsolete plant care products and pesticides are conducted for ten years following liquidation of such sites.

An assessment of the impact of such sites on the groundwater in the Neman River basin was performed in line with the requirement of EcoNiP 17.01.06-001-2017 by comparing the actual concentrations of pollutants in the observation and background wells (W_{obs} / W_{backg}), taking into account the standard MAC according to SanPiN 10 -124 RB 99.

The elevated content of iron and manganese registered in groundwater samples at most sites of the local groundwater monitoring system was mainly due to their high natural background level, and it is not considered as pollution.

According to 2015 observations, compared to other sites covered by the local groundwater monitoring, the greatest impact on groundwater was generated by industrial waste storage and disposal sites. The main pollutants found in groundwater wells at the sites of this group include nitrogen compounds, oil products, heavy metals, and such water is characterised by higher mineralisation. Among all the sites of this group, the maximum exceedance over the background values was recorded in 2015 at certain observation wells at sludge sites and at the industrial waste landfill site of “Grodno Azot” OJSC: up to 4 times for ammonia nitrogen, up to 2 times for oil products, and up to 3 times for heavy metals (cadmium, copper, zinc, aluminium, chromium). At the same time, the MAC was not exceeded.

As to the groundwater collected from observation wells located at filtration fields, the concentration of nitrogen compounds was above the background level, in some cases there were elevated levels of chlorides, sulphates, heavy metals, and mineralisation values. At the same time, all the values for pollutants were within the MAC limits.

Of all the filtration fields covered by the local monitoring, the greatest exceedance over the background values was registered in groundwater samples collected at Skidelsky Sugar Plant OJSC. In the areas where industrial sites are located, there was no heavy groundwater pollution registered.

The local monitoring data indicate that the groundwater quality deteriorates to a certain degree at a significant part of the solid municipal waste landfills. This is mainly associated with higher content values for biogenous elements, primarily ammonia nitrogen and nitrates, as well as sulphates, chlorides, heavy metals (zinc, chromium, nickel) and a high level of water mineralisation.

Of all the solid municipal waste landfills covered by the local monitoring, the most significant groundwater pollution was registered in the area of the solid municipal waste landfill of Baranovichi City Housing and Utilities Complex. According to the local monitoring data for Novogrudok Housing and Utilities Complex RUE, some impact on the groundwater was registered at certain observation wells in terms of the content of phenols, nitrate nitrogen, chlorides, water mineralisation, zinc, copper, surfactants, and petroleum products. But all these values were also within the MAC limits.

An analysis of the local groundwater monitoring data, collected at the location of sources of adverse impact, shows that virtually all the sites covered by the local monitoring have a certain impact on the groundwater quality. The greatest impact is produced by industrial and municipal waste storage and disposal sites, and filtration fields. The deterioration of groundwater quality is mainly caused by an increase in the content of biogenous elements, primarily ammonia nitrogen and nitrates, as well as mineralization (due to sulphates and chlorides) and heavy metals (zinc, chromium, copper). At the same time, all the values for pollutants are within the established limits.

7.3 Identification of significant sources of impact of economic activities on groundwater bodies in the Neman River basin on the territory of Belarus

The significant sources of the impact of economic activities on groundwater bodies in the Neman River basin on the territory of Belarus were Identified and harmonised at the expert level in association with Lithuanian counterparts, taking into account the data of local groundwater monitoring.

The definition of a significant impact of human activities on groundwater in the Neman River basin can be divided into two main parts:

- quantitative – direct water intake from groundwater; and
- qualitative – the impact of anthropogenic activities causing groundwater quality changes.

The highest pressure on groundwater is observed in the cities of Grodno, Baranovichi, Lida, and Molodechno. The high water intake level in the vicinity of the town of Dzershinsk is explained by the close location of one of the large water intakes of the city of Minsk.

An analysis of monitoring observations shows that in the case of most distressed water intakes, the drop in the groundwater level at used aquifers ranged on average from 10.0 to 30.5 m, while the acceptable levels are from 30 to 120 m. The funnel-shaped depression of Grodno water intakes has a radius of about 10 km, and for the rest of the city it does not exceed 3-5 km.

To run a more detailed quantitative analysis of the impact of economic activity on groundwater in the Neman River basin, it is necessary to make an inventory of all exploited water wells, perform their coordinate referencing, and establish a uniform record-keeping system to register data on water intake, special water use, and approved reserves.

The processes of groundwater pollution last for decades.

In terms of the specifics of pollution ingress from the surface to groundwater, two main types of pollution sources can be identified – those related to dry and to liquid waste storage (Figure 7.2).

1) Dry waste (solid municipal waste landfills, industrial waste landfills, pesticide disposal sites, industrial sites of enterprises, etc.); and

2) Liquid waste (sludge collectors, sludge ponds, filtration fields, sedimentation tanks)

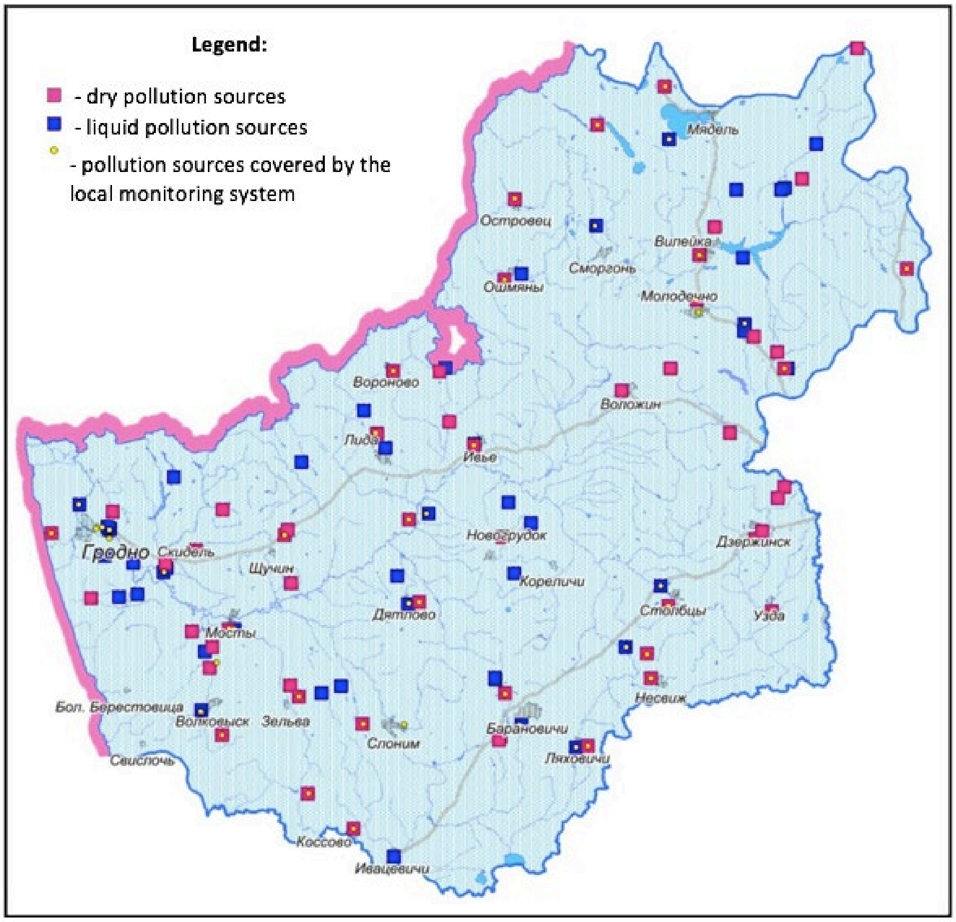

Figure 7.2 – Location of potential pollution sources in the Neman River basin on the territory of the Republic of Belarus

The total area of pollution sources identified in the Neman River basin is 7.75 km^2. Dry wastes occupy a total area of 1.82 km^2 (23.5 %), while the total number of their sources is about 55, liquid wastes take 5.93 km^2 (76.5 %) and the total number of their sources is about 47. The size of dry waste storage sites ranges from 144 to 216,501 m^2, but most often it is 10,000-50,000 m^2. The average size is 35,000 m^2. The size of liquid waste storage sites is from 380 to 1,745,126 m^2, 44 % of them have an area from 2,000 to 10,000 m^2 and 40 % – from 10,000 to 100,000 m^2.

Surface water is under a significant pressure of groundwater pollution, since all groundwater is discharged to surface water.