Climate change, sensitivity to temperature rise and wind data

Sensitivity of the used model to the changes of meteorological conditions was estimated using the following modified input data scenarios:

(1) Air temperature rise +2°C demonstrating climate change with NNPP thermal load of 3 160 $MW_{released}$;
(2) Wind data from INPP meteorological station.

The air temperature rise scenario reflects predicted conditions from year 2040 onwards as the result of climate warming. The air temperature of the warm period (April-October) is predicted (greatest predicted change) to rise 2.2 ^{o}C in Lithuania by 2040–2069 compared to the temperatures in 1961–1990 (*Bukantis and Rimkus, 2005*).

In the INPP wind scenario the measured wind speed and direction from the INPP meteorological station was used instead of the Dukstas station data. This scenario reflects the effect of possible errors in wind data on model results. The wind measured at the INPP station is likely to be more representative of the actual lake conditions than the Dukstas station data. However, the Dukstas station data was used, because data for all required simulation periods was not available from the INPP station.

Figure 7.1-64 shows the time-dependent effect of the climate change scenario compared to the present inlet and outlet 3 160 $MW_{released}$ scenario. The +2°C increase in air temperature warms the lake water about the same amount. The climate change result curve also resembles closely the curve with 5 200 $MW_{released}$ NNPP thermal load scenario at the present climate (see Figure 7.1-54).

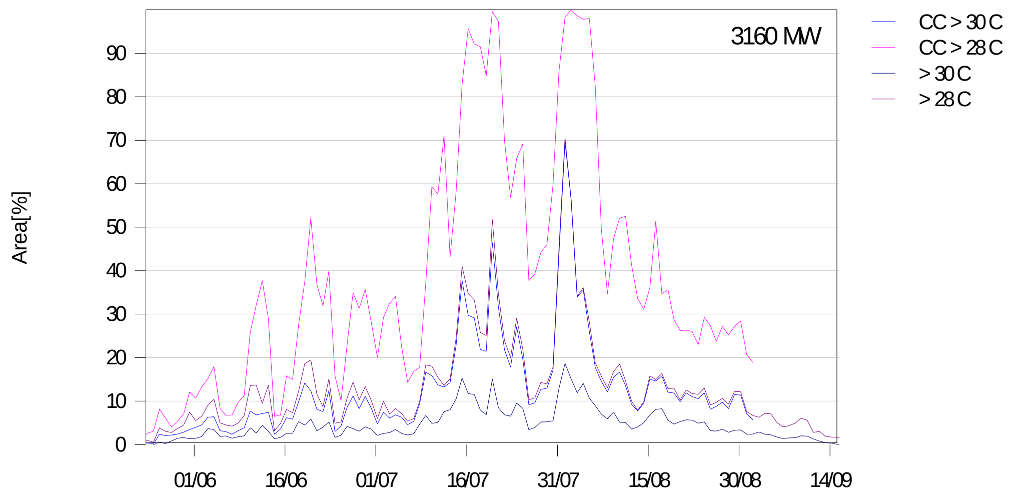


Figure 7.1-64. Proportion of the lake surface area heated to over 28 ^{o}C and 30 ^{o}C by NNPP capacity of 3 160 $MW_{released}$ in year 2002 and in climate change scenario.

Using the INPP wind data causes some changes to the sizes of the areas warmed over 28 and 30 degrees as shown in Figure 7.1-65. There seems to be a period of weaker winds in the beginning of June 2002, that increases the warmed up area size. Peak area size in the beginning of August is somewhat larger than in the simulation using Dukstas station data, but the number of days when the 20 % limit is exceeded is lower. However, the differences caused by using these two wind data sets are generally small.

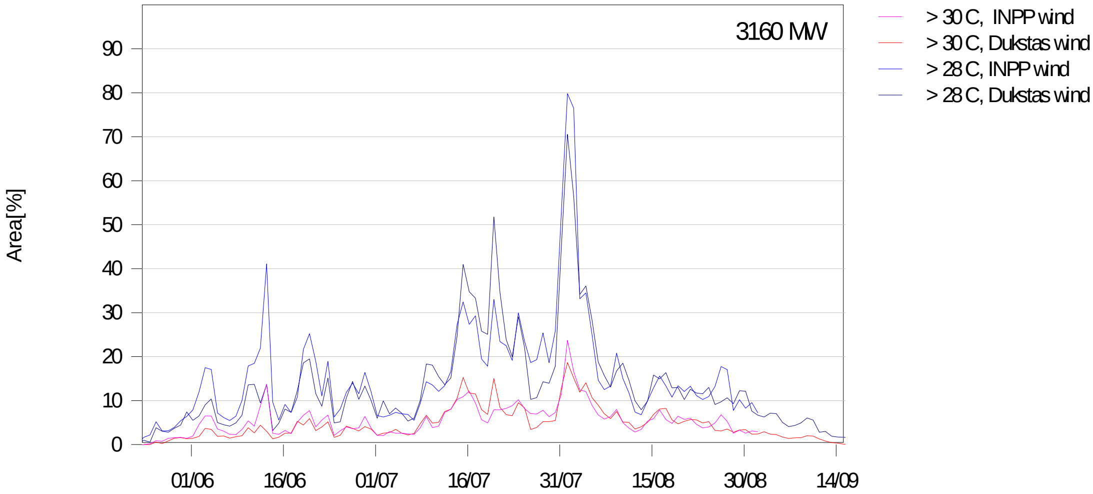


Figure 7.1-65. Effect of using INPP station wind data on the proportion of the lake surface area warming to over 28 °C at NNPP thermal load of 3 160 MW $_{\text{released}}$ in 2002.

Sensitivity to water level change

To investigate the lake temperature response to water level change, a lowered water level scenario was computed. A water level reduction of 0.9 m was used since it is the minimum allowable water level in the lake according to the existing regulation.

The change in the warmed up area for NNPP thermal discharge of 2230 MW was computed for year 2002. The result is shown in Figure 7.1-66. Compared to normal water level scenario, the area warmed over 28°C grows on the average by 1.3 %. Near temperature peaks the raise in warmed up area is larger. The average raise in absolute temperature in the middle of the lake in point P24 was 0.2°C. Thus the impact of water level lowering to the lake temperature is rather small.

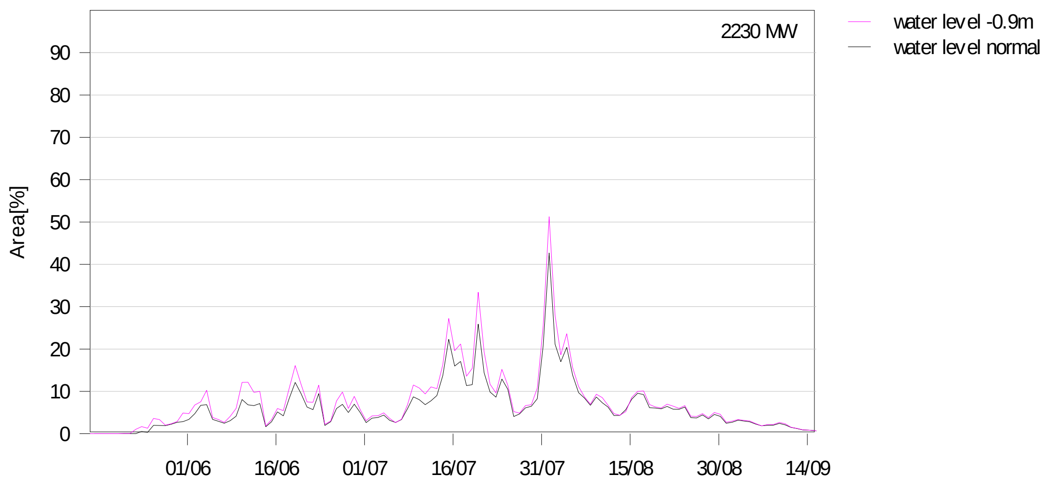


Figure 7.1-66. Effect of lowering the water level in the lake by 0.9m to the proportion of the lake surface area over 28 oC by NNPP discharge of 2230 MW $_{\text{released}}$ on the year 2002.

Conclusions of the thermal modelling

Thermal load levels

It can be concluded, that if the present criterion for lake warming (maximum 20 % of the lake surface layer warming to over 28 degrees) is used the maximum allowable thermal load to the lake during the summer months will be approximately 1 390 $MW_{released}$.

However, by reducing the thermal load during the warmest time in the summer, the maximum allowable thermal load can be essentially bigger. The exemplary modelling results show e.g. that reducing 3 160 $MW_{released}$ thermal load to half during the warmest time would keep lake temperatures below the present criterion, possibly with few days of exception.

The present criterion is relatively rigid and according to exemplary model calculations, already small changes in the criterion would allow relatively big flexibility in the thermal loads. For example, if the criterion for lake warming would be set at 20 % of the lake surface warming over 30 degrees instead of 28 degrees, the maximum allowable thermal load to the lake would be approximately 3 160 $MW_{released}$ even during the warmest summer months. One must however note that these exemplary results are calculated for only one year and in practise the maximum allowable thermal load would vary between years depending on the weather conditions. The ecological aspects of different changes in the criterion (*temperature and its definition depth area, allowed exceeding in time*) are evaluated later in the chapter "ecological impacts of thermal load".

Inlet and outlet locations

The current outlet is the best alternative when the area warmed up is used as criteria. However, the different outlet options do not significantly differ from each other. The present NPP outlet position allows the cooling water to spread efficiently to the main part of the lake, allowing both cooling by heat exchange to atmosphere and mixing to cooler lake water. The southern outlet position is more confined and shallow, which restricts the warm outlet water mixing with cooler lake water thus reducing the surface area where the cooling to atmosphere takes place. Dividing the outlet to two locations was no better than the present outlet option when comparing the average size of warmed up areas. However, the divided outlet option had a small advantage in the warmest day giving a somewhat smaller value for the area exceeding 28 °C, which is explained by higher than 30 °C temperatures near the southern outlet.

Western inlet option had on the average 0.1°C cooler inlet water temperature compared to the present inlet, and the area warmed up was therefore somewhat smaller. Otherwise the behaviour of the scenario was similar to the present inlet option. The temperature difference is explained by a larger distance to the outlet position.

In the deep inlet option simulation, the cold water storage of the deeper part of the lake was depleted in the beginning of the simulation, after which the inlet temperatures did not differ from the present inlet option. Additionally, in the deep inlet option after the thermocline of the lake is destroyed, the mixing of warmer water to deeper layer is increased raising the total heat storage in the lake. As a result, the deep inlet option produces higher surface temperatures during the warmest periods compared to the present inlet option.

<u>*Climate change, sensitivity computations and model accuracy*</u>

Sensitivity analysis computations showed that years 2001 and 2003 had both at least equally warm weather periods compared to year 2002. The climate change scenario with +2.0 °C temperature rise in summer months produced about 2 degree rise in water temperatures.

The possibility of error in the model simulations is mostly related to wind data and surface energy balance computation. Regarding the wind data, the used model does not take into account the possibility that the lake may modify the atmosphere and, for example, generate air movement as a result of warming of the lake. This may give too low values for the lake cooling, especially for situations when the wind speed is low. Therefore the highest peak temperatures, typical for the warm, low wind days, may be somewhat overestimated.

The lake surface energy balance model does not currently take into account the stability of the atmosphere, but uses neutral stability assumption. This may, in case of warm water and cooler air, give smaller values for cooling than in real situations. Also, in the model only one wind speed and direction value is used for the whole lake, whereas in reality the wind is different in different parts of the lake. The representativeness of the meteorological data for Lake Druksiai can also be questioned, as the nearest meteorological station (Dukstas) with weather data available for all the calibration and simulation periods is located 17 km away from the NNPP location.

In year 2002 the overestimation in the modelling is on the average 1ºC, and in year 2003 the overestimation is on the average 2ºC. However, during the warmest periods within each year the overestimation is lower. The model calibration results for years 1989 and 1991 show a similar behaviour.

It should also be noted that during warm summer periods lake water temperatures rise to high values also naturally. For instance 1.8.2002, without the NPP, the average surface temperature of the lake was 26.2 °C, with values ranging from 24.8°C to over 30°C.

To investigate the lake temperature response to water level change, a lowered water level (-0.9 m) scenario was computed. The impact of water level lowering to the lake temperature was observed to be rather small.

7.1.2.7 Impacts on hydrology

The main hydrological impacts of the operation of the new NPP are the evaporative losses created when the heat from the cooling water is transferred to air by evaporation. The total losses depend on the plant effect and the cooling method selection (see Section 4.2. for description of the different cooling alternatives and Sections 7.1.1.2. and 7.1.1.3. for lake hydrology and water balance).

7.1.2.7.1 Water supply

The adequacy of the water supply for the new NPP has been assessed for a normal and a dry hydrological year (with a 1-in-20 year return period i.e. 95 % probability; see Section 7.1.1.3.).

According to the study by Janukiene (*1992*; see Section 7.1.13), raising the INPP electrical effect by 1 000 MW increases evaporation by 14.3 million m^3 per year. This corresponds approximately to evaporation rate of 0.45 m^3 per second.

However, it has to be noticed that extrapolation of the results above 1 500 – 2 200 MW, up to 3 400 MW, and the relatively low number of measurements having their own sources of error, creates insecurity to the calculations. Measurements were carried out mainly for the effects of INPP from 0 to 1 500 MW. One single measurement exists corresponding to effect of INPP of approximately 2 200 MW.

The evaporation via cooling tower is also in the order of 0.45 m^3/s per 1 000 MW of electrical power. Thus it can be estimated that the additional evaporation from the lake for 3 400 MW power plant is approximately 1.5 m^3/s regardless of the cooling system. This corresponds to 48 million m^3 per year.

During a normal hydrological year approximately 85.9 million m^3 of water would be available for additional evaporation caused by a NNPP, assuming that lake level is maintained at normal water level 141.6 m and minimum discharge out of the lake is 0.64 m^3/s. Thus, it can be calculated that during a normal hydrological year there are adequate resources available for cooling evaporation in all the alternative scenarios.

During a dry hydrological year, approximately 33.1 million m^3 of water would be available for additional evaporation (with the same assumptions as above). Additionally the regulating volume of the lake (difference between normal water level and minimum allowable water level) of 43.0 million m^3 would be available. The annual input of 33.1 million m^3 and the regulating volume of 43.0 million m^3 would give adequate water supply in all the evaluated scenarios for about three successive dry years (with a 1-in-20 year return period).

Because water supply generally exceeds demand, as indicated above, it is concluded that the water supply from Lake Druksiai is adequate to the water demands except in the case of more than three successive dry years. However, it is quite unlikely that this kind of drought would occur during the operation period of the new NPP. In this kind of a rare case either the operation of the one or more of the NNPP units should be temporarily limited or the water level of Lake Druksiai allowed to lower below the lowest presently allowed level.

7.1.2.7.2 Lake level

During normal hydrological years the average lake level is not expected to fall below the normal and thus the hydrological effects on the lake and their ecological consequences are considered minor. During dry years (with a 1-in-20 year return period) the lake level would fall below normal, however staying above the minimum allowed regulation level (for approximately three successive dry years). Thus also the consequences of this kind of events can be estimated to be small.

7.1.2.7.3 Downstream river flow

Evaporation of water by cooling the NNPP would reduce the overall volume of water in the lake, thereby impacting the quantity of water discharged to River Prorva. The operation of the new NPP would result in a net decrease of water available to the River Prorva equal to the evaporation caused by the cooling systems.

The present outflow to River Porva has been estimated based on the water balance calculation by subtracting the additional evaporation (0.8 m^3/s), estimated to be caused by the INPP with average production[3] of 1 800 MW electric power output, from the natural average outflow (MQ=3.3 m^3/s). The estimated present mean discharge to the River Prorva is thus 2.5 m^3/s.

Furthermore, the new mean discharge is calculated similarly (by subtracting the

[3] The average production during the operation of the INPP (1 800 MW) has been calculated as a yearly average from period 1993–2004 when both units were in operation.

additional evaporation due to the NNPP from the natural MQ).

The evaporation from the new plant (assuming effect of 3 400 MW) would be approximately 0.7 m^3/s higher than at present (corresponding to the increase of 1 600 MW electric power output). Consequently the present mean annual discharge to River Prorva would decrease approximately by 28 %.

As it is explained in chapter 7.1.1.4, INPP monitors water level in the lake daily. The discharge to river Prorva is calculated based on water level and discharge curves. In this data set covering years 1999-2008 the mean discharge (MQ) to river Prorva has been slightly higher (4.4 m^3/s) than estimated based on the water balance calculations. Consequently, if the decrease in river flow is estimated using this MQ (4.4 m^3/s), the mean discharge to Prorva would decrease only by 16 % due to the NNPP.

These results obtained with two different methods and from two different time periods are well in line with each other. Based on the INPP measurement data, the estimations made of the water adequacy and outflow based on the water balance calculations are even on the conservative side.

The decrease of mean flow would impact the approximately 50 km long stretch of River Prorva, flowing through lakes Obole and Bogino before the confluence of River Dysna (MQ=10 m^3/s, observation point below Druksa rivulet). Reduced flows could alter the riparian vegetation and habitat for riparian and wetland species along the river. They could also have adverse impacts on the river water use for e.g. irrigation or cattle watering. However, the minimum discharge in River Prorva will remain at the present level (0.64 m^3/s) in all of the scenarios.

The decrease in the mean discharge in River Dysna is so small (7 % of the mean discharge 10 m^3/s) that after the confluence with River Dysna the impact of NNPP can be considered negligible.

7.1.2.8 Impacts on aquatic ecology

The impacts on the aquatic ecology were assessed based on the modelling results, the ample available scientific research and monitoring data of the lake and international research of the impacts of thermal discharges.

7.1.2.8.1 Period between closure of the INPP and the commissioning of the new NPP

The second unit of the Ignalina NPP will be shut down in the end of 2009 and the new NPP will start operating in year 2015. During that period the thermal discharges to Lake Druksiai will be minimal. This will impact the lake ecosystem in several ways. Due to eutrophication the lake has high primary production and consequently quite high decomposition rates. This has already at present led to oxygen depletion in the deeper water layers. During the last few years oxygen content has been lowered already at a depth of 10 meters.

When the lake is not anymore warmed by the thermal discharges after 2009, it will be covered by ice during cold periods. As exchange of oxygen between air and water is thus prevented, it may lead to further weakening of oxygen situation during winters, which again contributes to nutrient release from the sediments and thus accelerates eutrophication development. In the worst case, total oxygen depletion under the ice cover might lead to fish kills, but due to quite short and mild winters of Lithuania and consequent short duration of ice cover, this is unlikely.

As the expected period without thermal loading is quite short, 6 – 8 years, no major changes to the present state of the lake can, however be expected. On the other hand the formation of ice cover might accelerate eutrophication development, but on the other, absence of thermal load decelerates it.

It must be noted, that this period resembles to a large extent the changes expected to occur in the T3-scenario (see next chapter). One important difference is naturally that the conditions in T3-scenario would last the next 60 – 80 years instead of 6 – 8 years. This issue is discussed in more detail later.

7.1.2.8.2 Impacts during operation of the new NPP

The amount of waste heat discharged to the lake depends on the electricity produced and the cooling system chosen. In direct cooling system all the excess heat is discharged to the lake, whereas when using cooling towers only a very small part of the heat enters the lake and the major part is transmitted to air. The thermal load to the lake from the cooling towers can in this assessment be considered insignificant.

In order to illustrate the impacts of different thermal loads and cooling technology combinations in a concise and still comprehensive way, three scenarios were created based on the modelling results and hydrological, limnological and biological expert assessment of the probable effects. In all the scenarios the electricity production is assumed to be 3 400 MW_e but the cooling system and consequently the thermal load to the lake varies. The following scenarios were chosen to the assessment:

- Scenario T1 – Thermal load to the lake will be at maximum 3 160 $MW_{released}$. This corresponds to approximately 1 700 MW electric energy produced by using direct cooling for heat dissipation. The remaining 1 700 MW_e will be produced using cooling towers. This scenario resembles roughly the conditions when both units of INPP were in operation.
    - T1*-scenario – A sub-scenario where the thermal load to the lake will be 3 160 $MW_{released}$ (as in T1 scenario) for 11 months but will be reduced by 50 % during the warmest summer month.
- Scenario T2 – Thermal load to the lake will be at maximum 6 310 $MW_{released}$. This corresponds to approximately 3 400 MW electric energy all produced by using direct cooling for heat dissipation. In this scenario the heat load and the temperatures in lake will rise compared to the period of INPP operation and to the scenario T1.
- Scenario T3 – Only cooling towers will be used for cooling and the thermal load to the lake will be negligible. In this scenario the lake water temperatures will decrease compared to the period of INPP operation and to scenarios T1 and T2.

Consequently, this assessment can, from the lake point of view, be considered roughly corresponding to electrical power of 1 700 MW_e (T1), 3 400 MW_e (T2) and 0 MW_e (T3) with direct cooling.

In addition, also impacts of different inlet/outlet combinations were assessed.

General

Thermal discharges raise the temperatures in the receiving water body. The rise in temperature affects organisms differently depending on their preferences. The impacts can be direct (e.g. longer growth period) or indirect (e.g. sufficient food is no longer available or more food is available). In the beginning of the growth period, i.e. in April-May, the ecological impacts of temperatures higher than natural can be significant even though the temperatures as such would not be harmful.

When ambient water temperature rises over 30–32 degrees it is considered harmful to most aquatic organisms. The effects depend on organisms' tolerance as well as the exposure time. Even in natural watercourses water temperature may occasionally rise over 30 degrees. Hence most of the organisms (e.g. fish) are capable to avoid or tolerate high temperatures for short periods (*Langford, 1990*), but will be affected, if the average temperatures are raised for a longer period of time. Consequently, most of the ecosystem changes are realized only within a longer time period, which can vary from days to several years. The detectable ecosystem changes are generally limited to the areas where the water temperature is continuously more than one degree higher than in the natural situation.

Temperature rise accelerates biological activity. The organisms' metabolic activity is higher in warmer temperatures, which leads to faster growth, presuming that conditions are otherwise favourable (e.g. nutrients/food is available). The level of primary production, i.e. growth and reproduction of phytoplankton and vegetation, generally increases as a result of risen temperature and longer growth period. Furthermore, decomposition accelerates and the nutrients are efficiently recycled. High production will increase sedimentation of organic material, which again leads to acceleration of decomposition. Decomposition consumes oxygen in the water layers near the bottom (hypolimnion). Resulting anoxic or low-oxygen conditions are harmful for bottom fauna and fish living or feeding in the hypolimnion.

The described impacts of thermal discharges in the living conditions of species and the production rates are the basic factors behind the significant changes in species composition and diversity observed in Lake Druksiai during the operation of INPP.

In the T1-scenario the thermal load will be approximately as at present. During the last decades the lake has changed from cold and oligotrophic to warm and eutrophic as a result of both the thermal load from INPP and the nutrient load from municipal and other sources. This has led to changes in species composition and abundance. Hence, the organisms habiting the lake at present are adapted to the prevailing conditions. Since the new NPP would in this scenario not significantly alter the thermal conditions from the present, no significant impacts on the present ecosystem can be expected. However, if the nutrient load to the lake can not be significantly reduced in the near future, the eutrophication development will continue and accelerate.

T1-scenario* –impacts are considered to resemble roughly those presented for T1 -scenario. In principle, higher temperatures accelerate primary production. However, during the warmest summer month the lake temperatures are so high that the growth is very likely to be limited by other factors than temperature (nutrient concentrations, light). Thus this decrease in temperature load is not expected to significantly impact the primary production level. The decrease in highest temperatures may have slight positive impacts on cold-preferring species but as the prevailing species consist of organisms tolerant to warm temperatures this impact is not expected to be significant.

In the T2-scenario the thermal load will be higher than it has been during the operation of the INPP. Temperatures will rise almost in the whole lake area. The colder western part of the lake, which at present hosts the species preferring cold water, will also be warmed up to some extent. Temperatures close to the outlet (P38) can rise up to 37–38 degrees, to the levels considered lethal for many aquatic organisms. Also the area where temperatures rise to the harmful levels (over 30 – 32 degrees) is larger than at present. Furthermore, the periods with high average temperature will last longer than at present.

Impacts of this scenario will probably roughly resemble those observed in cooling basins or other limited areas, where temperatures are constantly kept several degrees higher than in the surroundings (e.g. in closed biological research basin at Forsmark NPP on the coast of Sweden; *Sandström & Svensson 1990*). The thermal load will intensify the current eutrophication development. The diversity of species can decrease as the still remaining cold-preferring species disappear from the lake. At the same time the biological production of the lake can, however, increase as the higher temperatures accelerate the growth of the remaining warm water species. Locally the effects can be opposite and biological production can decrease in the area close to the outlet due to the harmfully high temperatures.

In the T3-scenario water temperatures will decrease compared to the period of INPP operation, returning to the level of natural water bodies in the same area. This will improve the conditions for the cold preferring organisms. However, as the eutrophication development has been and still is quite intense, it can be estimated that the lake ecosystem will not start to change significantly towards the previous, more oligotrophic state.

The species typical to the eutrophicated waters will still dominate while the stocks of the clear and cold water preferring species will stay at the present low levels or might even continue to decline. Due to the colder water and shorter growth period the rate of primary production may somewhat decrease, but it is likely to remain on high levels typical to eutrophicated waters. In cold winters the lake will be ice-covered. This together with the eutrophication may lead to worsening oxygen situation, since the exchange of oxygen between air and water will be prevented. This leads to increase of nutrient release from the sediments and contributes to the eutrophication development.

Water quality

The quality of cooling water does not change when it passes trough a direct cooling system, thus the water quality impact does not depend on the thermal load. When cooling towers are used (T1 & T3) the increase of concentrations of substances in the circulating cooling water must be prevented by continuously taking some water in the system ("make-up water") and on the other hand discharging some water out of the system ("blowdown water").

Makeup water will be treated with antifouling chemicals to inhibit growth of organisms on the surfaces within the cooling tower. The amount of added chemicals and quality of the discharged water will be monitored and controlled according to the regulations setting the highest acceptable limits for outlet concentrations and amounts. These limits will be designated in order to protect aquatic communities. Thus concentrations of these chemicals in the blowdown water are not expected have a significant harmful impacts on the aquatic species.

The blowdown water is concentrated lake water. The concentrations of salts and other substances originating from lake water have risen to a level typically about 5–10 times higher than in lake water. Concentrations of the total dissolved solids (TDS) are expected to vary approximately between 1 320-2 640 mg/l. This does not directly increase the TDS concentrations in the lake water since nothing is added, but water is evaporated. This increased evaporation could elevate the concentration of total dissolved solids in the lake water. However, the additional evaporation is relatively small compared to lake volume.

Another mechanism that could cause water quality impacts is the "transport" of lake water from intake area to outlet area when it is used as cooling water. If the water quality in these areas differs, the water quality in both areas may change. This potential impact in various inlet/outlet combinations is evaluated in the following.

Present inlet–Present outlet & Western inlet–Present outlet options: water quality does not significantly differ between the intake and outlet areas. Thus using these combinations will not have an impact on water quality.

Present inlet–Southern outlet & Western inlet–Southern outlet & Present inlet–Divided outlet options: water quality in the western part of the lake is better than in the southern part of the lake where the municipal waste waters are discharged. Leading water from the less nutrient rich western part (*the southern outlet option and the divided option*) could improve water quality somewhat in the southern outlet area. The bay could also benefit from the improved water exchange. Higher temperatures accelerate the denitrification process (nitrogen is released from the lake to the atmosphere) and this natural nitrogen removal could somewhat mitigate the adverse effects of the nutrient load. However, the southern area of the lake is eutrophicated and quite shallow, thus the higher temperatures would probably accelerate the primary production leading to intensification of the eutrophication development. Based on this, the total effects of this option on southern outlet area would most probably be negative.

Deep inlet – Present outlet: at present the water in the deep layers is rich in nutrients, poor in oxygen and would have adverse effects on the water quality in the outlet area. However, as the volume of this deep water area is relatively small and would be totally used in approximately 90 days of power plant operation, the negative water quality impact on the discharge area would be quite short. In addition, the oxygen situation of the deeper areas would improve significantly as a result of the effective water exchange and thus benefit the lake. However, the thermal impacts discussed before make this option worse for the overall state of the lake than other options.

<u>*Plankton and aquatic vegetation*</u>

During the operation of the INPP the diversity of both phytoplankton and aquatic vegetation has decreased. Due to the eutrophication, which has been accelerated by the thermal load, several species have become extinct from the lake (see Section 7.1.1.4 for detailed description). The dominating species are characterised by high tolerance for various environmental hazards (such as high temperature and poor water quality). The primary production, however, has had an increasing trend compared to the time before INPP was in operation. This is likely due to the thermal load and eutrophication which have accelerated growth of the remaining tolerant species. The possible effects on plankton community have most probably been indirect (increase of temperature in receiving water body/ acceleration of eutrophication) since passing trough the power plant has not been observed to impact the plankton communities in the recipient waters (*Langford, 1990, Sandström & Svensson, 1990*).

In the T1-scenario the development of the plankton community and aquatic vegetation would probably resemble the current situation. Eutrophication, which to a large extent does not depend as much on the new NPP as on the external and internal nutrient loads together with the thermal load, would keep the phytoplankton biomass on the levels typical for eutrophicated water bodies. Phytoplankton species composition would probably remain quite similar to what it is at present. Cyanobacteria blooms, which are typical for eutrophicated waters, may still become more common in the future. The aquatic vegetation would probably not change significantly from the present since the most significant changes have already happened during the operation of INPP and the prevailing species are adapted to the warm and eutrophicated conditions. The currently prevailing tolerant species, such as *Myriophyllum spicatum* and *Phragmites australis*, would still be dominating and the total biomass would likely remain roughly on the present level. The zooplankton community is also likely to remain quite similar to what it is at present since the species preferring the cold waters (such as the glacial relict *Limnocalanus marcus*) have already disappeared.

In the T1-scenario* – during the warmest summer month the lake temperature is in this scenario so high that the growth is very likely limited by other factors than temperature (nutrients, light, space). Thus the impacts on plankton and aquatic vegetation are expected to resemble those described in T1-scenario.

In the T2-scenario the currently observed effects of thermal discharges and eutrophication would be accelerated due to the higher thermal load. The higher temperatures may lead to instability of the plankton community and enhance the conditions for mass development (blooms) of single dominating species of e.g. cyanobacteria or diatoms and these may become more common. In the zooplankton community the species tolerant to the higher temperatures would be dominating.

The high temperatures would be likely to increase biomasses of aquatic vegetation as the warming areas would be bigger. Only in the vicinity of the outlet (zone B) could the aquatic vegetation decrease because of the increased erosion and harmfully high temperatures. Also some remaining less tolerant species, such as charophytes, might become less abundant in the lake.

In the T3-scenario temperature would remain on natural level, which is colder than at present. However, eutrophication due to nutrient load is more dominating factor than the thermal load in affecting the phytoplankton production and aquatic vegetation. Therefore species composition would probably not change much compared to the present. Even cyanobacteria blooms would probably be as common as present or even increase if the current shift towards nitrogen limitation would continue. Also composition and biomass of aquatic vegetation would probably remain quite similar as at the present.

However, the conditions for vegetation in the vicinity of the outlet (zone B) would be improved as the strong current and high temperatures would cease. In this area the growth and diversity of vegetation would increase. In the zooplankton community the cold water preferring species would probably have better living conditions and their numbers might increase, but otherwise no significant impact on zooplankton community could be expected.

<u>Bottom fauna</u>

The thermal discharges are mainly warming the lake surface layer, hence the impacts on bottom fauna below the depth of few meters are mainly indirect. The effects of the scenarios (T1, T2 & T3) are considered almost similar, although in scenario T2 the bigger thermal load with stronger eutrophication and in T3 the ice cover would most likely lead to weaker oxygen conditions in larger areas than scenario T1.

In scenarios T1 and T2, the bottom fauna is reduced or completely absent in the vicinity of the cooling water outlet due to the high velocities removing the sediment, like it is at present. In the upper water layers where good oxygen conditions prevail, the biomass of bottom fauna would most probably increase as a result of improved food situation as a result of eutrophication and elevated temperature.

In the deeper bottom sediments the impact would be rather opposite as a result of the weakening oxygen conditions due to e.g. increased production and decomposition and/or ice-cover (in scenario T3). The bottom fauna would disappear or be replaced with few low-oxygen tolerant species in larger areas than at present.

The cold water preferring relict species dwelling on the deep bottom areas have already disappeared or decreased to very low numbers. Therefore significant negative impacts on them are not expected in any of the scenarios.

Fish stocks and fishing

The thermal discharges of INPP and eutrophication have already changed the fish community of the lake quite significantly. The abundance of species preferring cold and clear waters, such as smelt and vendace, has decreased while abundance of e.g. the cyprinids (like roach and silver bream), typical for warm and eutrophied waters, has increased.

At present, there are no professional fishermen fishing on the lake but domestic and recreational fishing is practised. The adverse effects of the proposed activity are mainly related to the changes in species composition towards less valuable species, increased dirtying and fouling of the fishing gear (nets etc.) and restricted possibilities to fish on the ice.

In T1-scenario the fish community would mainly remain similar as at present. The colder western parts of the lake would probably still act as refuge for cold-preferring species, but their future in the lake would still remain uncertain due to the general eutrophication of the lake. The cyprinids as well as e.g. perch would continue to be the dominating species. Since the fish stock has already adjusted to the prevailing temperature conditions, no significant changes compared to the present state are expected.

T1-scenario* –The decrease in highest temperatures may to some extent improve the living conditions of cold-preferring species. However, as the fish fauna mainly consists of species tolerant to the warm temperatures and as the lake temperature also in this scenario resembles most of the year the present situation, the impact is not expected to be significant.

In T2-scenario the fish community would be further altered due to the higher temperatures in the whole lake. It is likely that the currently colder western part of the lake would be warmed so much that the area suitable for cold water species would decrease significantly or even too much for survival of some of them, e.g. vendace and smelt. Vendace spawns to the deeper bottoms during autumn, which makes it also vulnerable to oxygen depletion and increased sedimentation. Cyprinids and other tolerant species would become even more dominating in the fish community. Thus, the total fish biomass is likely to stay at present high level or even decrease. On the other hand, the average temperatures might at least in some parts of the lake be so high that even growth of the more tolerant species might start to decline. The changes would be adverse for fishing due to the decline of the more valuable species and fouling of the fishing gear (nets etc.). Ice fishing would become more restricted due to the shorter ice cover period.

In T3-scenario the water would become permanently cooler which would improve the living conditions of e.g. smelt and vendace. Due to the lower temperatures the species preferring cold and oxygen rich waters might somewhat increase their proportion of the fish stock of the lake. The general eutrophication development of the lake and the changes in the fish community has however been so strong that the fish stock would not be restored to the stage before the INPP commissioning. Species characteristic to the eutrophicated waters would still dominate. Permanent ice-cover during the winters combined with general eutrophication development might lead to anoxic or low-oxygen situations, which are harmful for fish as well as roe. This might lead to decrease of vendace, which spawns to the deeper bottoms.

Inlet and outlet location options

Present inlet option does not demand practically any construction work in the lake area so the effects during the construction period are small. In this option no new areas need to be altered by new structures.

Western inlet option will demand construction of new intake structures. The location of physical structures would naturally be altered permanently. Due to dredging, which is probably needed for the inlet structures and in front of them, the concentrations of particulate matter and nutrients would temporarily increase around the construction area. Bottom fauna and vegetation would temporarily be removed from the dredged area. Locally increased sedimentation and nutrient load can have adverse effects on e.g. fish roe and fry present at the shallow areas. Impacts of the construction works are, however, temporary and very local in nature.

In operation phase, due to decreased recirculation of cooling water, this option would lead to in average 0.1 degrees lower surface water temperatures than using the present inlet. This difference is however so small in practice that no ecological differences compared to using present inlet could be observed.

Deep inlet option would demand construction of a large tunnel (in the order of 100–160 m^2 cross-section area) and an intake structure on the deepest bottom area of the lake. This would cause more turbidity and related impacts than constructing the western inlet alternative, but these can still be considered temporary.

In the operation phase, the cold water reserve of the deep area of the lake would be depleted in about 1 – 2 months and after that the lake would not have a thermocline and intake water temperatures would approach surface water temperatures. Consequently, the thermal energy would spread more evenly in the lake water and the energy exchange to the atmosphere would be reduced. In average, the lake water would be warmer in the later part of the summer than when using surface inlets. This would reinforce the eutrophication development.

A benefit would be that the oxygen conditions in the deep part of the lake would improve as the water would circulate more efficiently. This would benefit the bottom fauna and other biota living in deeper water layers.

Present outlet option does not demand practically any construction work since the existing structures can be used. The area around the present outlet is strongly affected both by the current induced by the cooling water and the thermal load caused by it. Since the area has already changed due to the INPP, using the present channel for the new NPP would not significantly change the present state.

Southern outlet and divided outlet options would demand construction of new southern outlet channel and outlet structures. The impacts for constructing a new outlet channel are similar to the construction of the new inlet structure (see the description above). The major impacts are however related to the operation phase and discharge of the warm waters. The southern area of the lake is currently quite little impacted by the thermal discharges but affected by the waste water nutrient load. Discharging cooling waters to the nutrient-richer southern area would lead to acceleration of the eutrophication of that area. Primary production would increase and cyanobacteria blooms would most probably increase since the shallow, warm and nutrient rich conditions would favour the development.

The temperatures close to the outlet can rise to over 30 degrees in larger area during the warm days, since the mixing of the warm waters is more restricted due to the shallow and confined area. The conditions around the present outlet could improve somewhat as a result of the decreased or removed cooling water discharge, but these positive impacts would remain small compared to the adverse effects of this option. In general, the adverse effects of the option are evaluated more significant than the positive effects.

Conclusions of ecological impacts of thermal load

Thermal load scenarios

The effects of the different scenarios resemble somewhat each other due to the general eutrophication development of the lake, which plays a major role in the ecosystem changes. The magnitude of the impacts, however, varies between the different scenarios. However, the planned new NPP does not significantly affect the trophic state of the lake since nutrient load from the NNPP is small and its impacts can not be distinguished from the general eutrophication development of the lake.

In the T1-scenario the impacts are roughly similar to what they have been while INNP has been operating. During the operation period of INPP the lake ecosystem has been altered to resemble the present thermal and trophic conditions. Consequently no significant changes in the ecosystem are expected in this scenario and it is considered acceptable from environmental point of view.

In the T1-scenario* reduction of the highest temperatures during warmest period of the year may slightly improve the living conditions for the cold preferring fish species. Since the temperature would however mainly resemble both T1-scenario and the present state these impacts are not considered significant.

In the T2-scenario warming would comprise the whole lake area, periods of high temperature would last longer than at present and the area were temperatures exceeds the harmful 30–32 degrees would be larger. In general, it can be assumed that the species diversity would decrease but the total biological production would increase. Hence in this scenario the adverse effects on the lake ecosystem can be significant.

In the T3-scenario the lake temperatures will resemble the natural state more and this can somewhat improve the living conditions of the cold preferring species. However, recovery of the previous conditions or species composition is not expected. If the general intensive eutrophication development continues this alternative may also lead to low-oxygen conditions during periods of ice-cover. From this point of view, moderate warming of the lake can be even environmentally advantageous. This option has somewhat diverse effects on the lake ecosystem. It is the best option when the warming of lake is considered but may result also in adverse effects due to the oxygen depletion.

Inlet and outlet location options

From environmental point of view the present inlet and outlet options are the best alternative. Building a new western surface inlet would only bring marginal benefits from the thermal impact point of view. However, this option can be considered acceptable despite the small construction-time negative impacts.

The relatively small positive impacts achievable by building and operating a new deep inlet or new southern outlet structures can be considered insignificant compared to the adverse effects of these options.

Ecological considerations of the present temperature criterion

The present temperature criterion (28 º / 20 %) is relatively unflexible, since it does not allow any exceedings in temperature, time or area. The phenomenon it is designed to regulate is however varying and quite unpredictable. Also the ecological groundings for the selection of the temperature of 28 ºC and area of 20 % as limits are to some extent artificial.

In practice, the lake surface temperature changes rapidly depending on weather conditions also in natural lakes. During calm periods temperature rise at the surface can be significant in a short time. Then, when even a weak wind again begins to blow, the uppermost water layers mix with cooler deeper layers and dissipation of heat into the air increases. Consequently, the surface temperature drops. The possibilities to prognose the exact temperature behaviour of the lake surface layer in advance are relatively weak.

On the other hand, from the ecological point of view, short and really restricted periods of higher than 28 ºC surface temperatures do not have significant negative impacts. In these situations the deeper water layers remain colder, thus providing suitable conditions even for the organisms sensitive to higher temperatures. It would thus be justified and ecologically acceptable to design the criterion for the new NPP so that it would take into account the natural variation and unpredictability of this phenomenon.

It might be reasonable also from the monitoring and NPP operational points of view to increase the flexibility of the temperature criterion for the new NPP from the present. This could be implemented without significant negative environmental impacts e.g. by applying one or more of the following:

- Allowing some exceeding in time when the lake temperature at certain area exceeds the agreed limit. For example in EU directive 2006/44/EC “Freshwater fish directive” this exceeding is allowed to be 2 % of time.
- Changing the highest allowed temperature from 28 ºC to 29-30 ºC.
- Changing the defined maximum area for a highest allowed temperature.
- Changing the definition of the regulated water layer. The present regulation defines surface layer as the uppermost 10 cms of water. Generally in this thin surface layer biological activity is – regardless of the temperature – limited due to photoinhibition. It would be more relevant to regulate the temperature of the productive layer, ie couple of uppermost meters of the water column.

7.1.2.9 Assessment of radiological impact on waters

Like any other NPP, during the normal operation the new NPP will release a limited, strictly controlled quantity of radionuclides into water. Basing on the information freely distributed on the Internet websites, as well as on data provided by the manufacturers of the reactors, amounts of radioactive waterborne discharges from different types of the reactors are summarized in Table 7.1–39. The data, presented in Table 7.1–39, is compiled based on design documents of different types of reactors DCD (design control documentation), published at the U.S. Nuclear Regulatory Commission Website (www.nrc.gov). In these design documents radionuclide releases are assessed using digital methods, making conservative assumptions and taking into account possible radionuclide release paths (from the SNF management facility, the reactor building, the ventilation systems, the containment, etc.) in case of anticipated operational occurrences. As experience of nuclear power plants in different countries shows, actual radionuclide releases into the environment are much lower than estimated values.

Designers of some reactors provide release data for 60 radionuclides, but the list of radionuclides, given in Table 7.1–39, is compiled on the basis of the legal document LAND 42-2007, which provides dose conversion factors for radionuclides released into the environment, that were applied in the assessment of the population exposure. Section 7.10.2.2 gives estimates of the annual dose received by the population due to releases from various types of reactors. For evaluation of radionuclide releases into the environment the manufacturers of various reactors used computer programs that evaluate a number of nuclides, including radionuclides, which are dominant and constitute the greater part of doses. The nuclide inventory in the normative document LAND 42-2007 was made on the basis of the study "Dose factors for normal operation discharges from Ignalina NPP" (*V. Filistovič, E. Maceika, J. Mažeika et al, 1998*), which in turn had been based on the data on radionuclides produced in light water reactors, presented in the reference book "Radioactive releases in the biosphere" (*Gusev, Belyaev, 1991*). It is mentioned that nuclear reactions in a reactor produce about 600 fission products, the interaction with neutrons generates about 60 actinides; moreover, the activation products are generated as well. From all this extensive list of radionuclides only radionuclides that are dominant and result in the largest and most significant radiological effects are estimated. The lists of airborne and waterborne radioactive releases presented in the normative document LAND 42-2007 include dominant radionuclides, which lead to a significant radiological impact; they are characteristic not only to RBMK, but also to other types as well as models of light water reactors. In case of heavy water reactors, higher tritium releases to the environment are observed, but the dominant fission and activation products are the same as in light water reactors. Therefore the list of nuclides given in the normative document LAND 42-2007 is sufficient for the assessment of releases into the environment from the new NPP. The impact on the water component of the radionuclides not included in the list of LAND 42-2007, but provided in the documentation of some reactor designers, is negligible. As the assessment of the impact on the air component due to the radionuclides not included in the list of LAND 42-2007 shown, in case of ESBWR reactor it was found (this reactor has details on airborne releases of 68 radionuclides), that the annual dose received by the members of the critical group of the population due to the radionuclides not included in the list of LAND 42-2007 is 5.18×10^{-6} mSv. Meanwhile, the dose due to the radionuclides from the list of LAND 42-2007 is 5.84×10^{-2} mSv. Similar results would be obtained in case of the water component, as well.

The waterborne releases of radionuclides presented in Table 7.1–39 are from one corresponding reactor model. It should be noted that at the beginning of the EIA process the Organizer of the planned economic activity applied to the manufacturers of the reactors, which are considered as technological alternatives in the EIA report, asking them to submit information on models of the reactors manufactured by them, as well as on the radionuclide releases into the environment during normal operation. Unfortunately, not all the reactor manufacturers have responded to the request, therefore the detailed data on the radionuclide releases into the environment from the reactor models SWR-1000, WWER/V-392 and WWER/V-448 are not presented in the EIA report. However, based on the data and conclusions presented in the EIA report of the NPP planned to be constructed in Belene (Bulgaria), the assessment summarised the radiological impact of these reactor models as well. The company AECL, the manufacturer of the reactors EC-6 and ACR-1000, presented the data on the radionuclide releases into the environment from CANDU-6 reactor, however, the manufacturer noted that the radionuclide releases from the EC-6 and ACR-1000 reactors would be of comparable level or lower than that of CANDU-6 reactor. The average annual waterborne radionuclide releases from the WWER reactor, presented in Table 7.1–39, are based on the information on releases from the reactor WWER-1000/V320, given in the EIA report of Belene NPP. The latter reactor and the reactor WWER/V-392 being considered in this EIA report have the same electrical power, so it can be stated that the radionuclide releases into the environment are approximately equal. The electric power of WWER/V-448 reactor is 1365 MW_e, therefore the radionuclide releases will be higher. However, at the new NPP the maximum number of units for this model, not exceeding the total planned electric power for the new NPP, is equal to 2, and in case of WWER/V-392 reactor – to 3. Therefore, the total radionuclide releases from the two units of WWER/V-448 or from the three units of WWER/V-392 will be approximately the same.

As already mentioned, the planned economic activity provides for the total electrical capacity of the new NPP units not exceeding 3400 MW. Therefore the number of reactors of certain models may be different. Construction of the reactor units only of one model is envisaged. However, the possibility of selection of combination of different reactor models cannot be completely rejected. Table 7.1–40 provides the release values calculated for the maximum number of units of the same reactor model. Comparison of the releases shows that the total releases are the highest from the four EC-6 units (total electric power of the 4 units – 3000 MW). As it is later shown in Subsection 7.10.2.2 (see Table 7.10–31), the four units of EC-6 also leads to the highest annual dose of the population. In all cases the radiological impact on the population due to different combinations of the reactor models not exceeding the planned electric power of 3400 MW is lower than due to the four EC-6 units.

Table 7.1–39. Estimated annual liquid releases (Bq/year) into environment during normal operation of NPP one unit.

Type	BWR		PWR					PHWR
Model	**ABWR[1]**	**ESBWR[2]**	**EPR[3]**	**APWR[4]**	**AP-600[5]**	**AP-1000[6]**	**WWER[7] (V-392 / V-448)**	**EC-6 / ACR-1000[8]**
Ag-110m	1.22E+07	na	1.63E+07	6.66E+07	3.18E+07	3.89E+07	na	6.60E+05
Ba-140	2.52E+07	3.03E+07	1.55E+08	2.15E+08	1.52E+08	2.04E+08	na	na
C-14	5.92E+06	na	na	na	na	na	4.10E+06	1.40E+07
Ce-141	4.44E+06	2.59E+06	1.85E+06	1.07E+07	2.59E+06	3.33E+06	na	3.90E+05
Ce-144	7.03E+07	na	4.81E+07	2.07E+08	9.62E+07	1.17E+08	na	1.20E+07
Co-58	3.33E+06	1.63E+07	5.55E+07	3.63E+08	1.00E+08	1.24E+08	6.10E+06	4.90E+05
Co-60	3.37E+08	3.33E+07	6.66E+06	5.18E+08	1.37E+07	1.63E+07	4.70E+06	2.50E+08
Cr-51	2.85E+08	4.81E+08	3.70E+07	2.22E+08	5.33E+07	6.85E+07	3.00E+07	1.80E+08
Cs-134	2.26E+08	2.52E+07	9.62E+07	4.44E+08	2.95E+08	3.67E+08	1.30E+07	1.91E+06
Cs-136	1.18E+07	1.52E+07	1.15E+07	8.14E+08	1.70E+07	2.33E+07	na	na
Cs-137	3.29E+08	6.66E+07	1.30E+08	6.66E+08	3.97E+08	4.93E+08	3.10E+07	1.30E+07
Fe-59	3.70E+06	2.59E+06	na	8.51E+07	5.92E+06	7.40E+06	8.40E+05	9.40E+06
H-3	2.22E+12	5.18E+11	7.50E+13	5.92E+13	2.55E+13	3.74E+13	2.00E+13	1.35E+14
I-131	1.18E+08	1.55E+08	1.26E+09	7.40E+07	3.81E+08	5.23E+08	6.30E+07	1.30E+08
I-132	9.62E+07	3.03E+07	4.44E+07	1.15E+07	5.33E+07	6.07E+07	2.80E+06	na
I-133	3.70E+08	7.77E+08	1.30E+09	3.00E+07	1.98E+08	2.48E+08	na	6.49E+06
I-134	6.29E+07	1.48E+06	na	3.29E+06	2.52E+07	3.00E+07	na	na
I-135	2.78E+08	2.00E+08	5.55E+08	2.89E+07	1.65E+08	1.84E+08	na	na
Y-91	4.07E+06	5.18E+06	na	3.33E+06	na	na	na	na
La-140	6.29E+06	na	2.81E+08	2.96E+08	2.03E+08	2.75E+08	na	8.31E+04
Mn-54	9.62E+07	5.92E+06	2.00E+07	1.67E+08	3.96E+07	4.81E+07	6.10E+06	2.61E+07
Mn-56	1.41E+08	4.81E+07	na	na	na	na	na	na
Mo-99	3.07E+07	1.11E+08	na	6.29E+07	2.11E+07	2.11E+07	na	1.10E+06
Na-24	1.04E+08	1.89E+08	2.26E+08	1.74E+08	4.74E+07	6.03E+07	na	na
Nb-95	3.70E+07	7.40E+05	3.70E+06	7.40E+07	7.77E+06	7.77E+06	1.10E+06	3.61E+08
Np-239	1.15E+08	4.07E+08	2.15E+07	1.96E+07	6.29E+06	8.88E+06	na	na
Pr-143	4.81E+04	3.33E+06	1.85E+06	2.92E+06	3.70E+06	4.81E+06	na	na
Ru-103	6.66E+06	1.48E+06	9.25E+07	1.26E+08	1.45E+08	1.82E+08	na	3.70E+06
Ru-106	6.29E+06	na	1.15E+09	1.74E+09	2.24E+09	2.72E+09	na	2.29E+07
Sb-125	na	na	na	na	na	na	na	3.70E+06
Sr-89	4.07E+06	8.14E+06	1.85E+06	5.55E+06	2.96E+06	3.70E+06	3.90E+03	na
Sr-90	1.30E+06	7.40E+05	na	6.66E+05	na	3.70E+05	na	2.79E+05

Type	BWR		PWR					PHWR
Model	**ABWR[1]**	**ESBWR[2]**	**EPR[3]**	**APWR[4]**	**AP-600[5]**	**AP-1000[6]**	**WWER[7] (V-392 / V-448)**	**EC-6 / ACR-1000[8]**
Te-132	1.48E+05	7.40E+05	1.78E+07	1.74E+07	6.29E+06	8.88E+06	5.00E+05	4.61E+05
Zn-65	3.33E+06	1.67E+07	6.29E+06	8.14E+06	1.26E+07	1.52E+07	na	3.11E+06
Zr-95	3.11E+07	7.40E+05	4.81E+06	4.81E+07	8.51E+06	8.51E+06	1.70E+06	1.70E+08
Total (without H-3)	2.83E+09	2.64E+09	5.54E+09	6.5E+09	4.73E+09	5.87E+09	1.65E+08	1.21E+09
Total	**2.22E+12**	**5.21E+11**	**7.50E+13**	**5.92E+13**	**2.55E+13**	**3.74E+13**	**2.00E+13**	**1.35E+14**

na – information about activity of released nuclide is not provided in the freely available reactor suppliers documents or other information sources
[1] - http://www.nrc.gov/reactors/new-reactors/design-cert/abwr.html
[2] - http://www.nrc.gov/reactors/new-reactors/design-cert/esbwr.html
[3] - http://www.nrc.gov/reactors/new-reactors/design-cert/epr.html
[4] - http://www.nrc.gov/reactors/new-reactors/design-cert/apwr.html
[5] - AP600 Design Control Document, Chapter 11, Section 11.2, "Liquid Waste Management Systems." / Accession Number ML003691384 (http://www.nrc.gov)
[6] - http://www.nrc.gov/reactors/new-reactors/design-cert/ap1000.html
[7] - Belene NPP Environmental Impact Assessment Report BNPP-EIA-PEC-NEK-0001-E3
[8] - Belene NPP Environmental Impact Assessment Report BNPP-EIA-PEC-NEK-0001-E3 (data is provided for CANDU-6 reactor, however according to the AECL (producer of this reactor) information releases from EC-6 and ACR-1000 will be similar or smaller)

Table 7.1–40. Annual average waterborne radionuclide releases (Bq/year) during the operation of the maximal number of units of corresponding reactor model.

Type	BWR		PWR					PHWR
Model	ABWR	ESBWR	EPR	APWR	AP-600	AP-1000	WWER (V-392 / V-448)	EC-6 / ACR-1000
Power of Unit, MW_e	1300	1535	1660	1700	600	1100	995 / 1365	750 / 1085
Nb. of Units	2	2	2	2	5	3	3 / 2	4 / 3
Ag-110m	2.44E+07	na	3.26E+07	1.33E+08	1.59E+08	1.17E+08	na	2.64E+06
Ba-140	5.04E+07	6.06E+07	3.10E+08	4.30E+08	7.59E+08	6.12E+08	na	na
C-14	1.18E+07	na	na	na	na	na	1.23E+07	5.60E+07
Ce-141	8.88E+06	5.18E+06	3.70E+06	2.14E+07	1.30E+07	9.99E+06	na	1.56E+06
Ce-144	1.41E+08	na	9.62E+07	4.14E+08	4.81E+08	3.51E+08	na	4.80E+07
Co-58	6.66E+06	3.26E+07	1.11E+08	7.26E+08	5.01E+08	3.72E+08	1.83E+07	1.96E+06
Co-60	6.74E+08	6.66E+07	1.33E+07	1.04E+09	6.85E+07	4.89E+07	1.41E+07	1.00E+09
Cr-51	5.70E+08	9.62E+08	7.40E+07	4.44E+08	2.66E+08	2.06E+08	9.00E+07	7.20E+08
Cs-134	4.52E+08	5.04E+07	1.92E+08	8.88E+08	1.48E+09	1.10E+09	3.90E+07	7.64E+06
Cs-136	2.36E+07	3.04E+07	2.30E+07	1.63E+09	8.51E+07	6.99E+07	na	na
Cs-137	6.58E+08	1.33E+08	2.60E+08	1.33E+09	1.98E+09	1.48E+09	9.30E+07	5.20E+07
Fe-59	7.40E+06	5.18E+06	na	1.70E+08	2.96E+07	2.22E+07	2.52E+06	3.76E+07
H-3	4.44E+12	1.04E+12	1.50E+14	1.18E+14	1.28E+14	1.12E+14	6.00E+13	5.40E+14
I-131	2.36E+08	3.10E+08	2.52E+09	1.48E+08	1.91E+09	1.57E+09	1.89E+08	5.20E+08
I-132	1.92E+08	6.06E+07	8.88E+07	2.30E+07	2.66E+08	1.82E+08	8.40E+06	na
I-133	7.40E+08	1.55E+09	2.60E+09	6.00E+07	9.90E+08	7.44E+08	na	2.60E+07
I-134	1.26E+08	2.96E+06	na	6.58E+06	1.26E+08	9.00E+07	na	na
I-135	5.56E+08	4.00E+08	1.11E+09	5.78E+07	8.23E+08	5.52E+08	na	na
Y-91	8.14E+06	1.04E+07	na	6.66E+06	na	na	na	na
La-140	1.26E+07	na	5.62E+08	5.92E+08	1.01E+09	8.25E+08	na	3.32E+05
Mn-54	1.92E+08	1.18E+07	4.00E+07	3.34E+08	1.98E+08	1.44E+08	1.83E+07	1.04E+08
Mn-56	2.82E+08	9.62E+07	na	na	na	na	na	na
Mo-99	6.14E+07	2.22E+08	na	1.26E+08	1.05E+08	6.33E+07	na	4.40E+06
Na-24	2.08E+08	3.78E+08	4.52E+08	3.48E+08	2.37E+08	1.81E+08	na	na
Nb-95	7.40E+07	1.48E+06	7.40E+06	1.48E+08	3.89E+07	2.33E+07	3.30E+06	1.44E+09
Np-239	2.30E+08	8.14E+08	4.30E+07	3.92E+07	3.15E+07	2.66E+07	na	na
Pr-143	9.62E+04	6.66E+06	3.70E+06	5.84E+06	1.85E+07	1.44E+07	na	na
Ru-103	1.33E+07	2.96E+06	1.85E+08	2.52E+08	7.23E+08	5.46E+08	na	1.48E+07

Type	BWR		PWR					PHWR
Model	**ABWR**	**ESBWR**	**EPR**	**APWR**	**AP-600**	**AP-1000**	**WWER (V-392 / V-448)**	**EC-6 / ACR-1000**
Power of Unit, MW_e	**1300**	**1535**	**1660**	**1700**	**600**	**1100**	**995 / 1365**	**750 / 1085**
Nb. of Units	**2**	**2**	**2**	**2**	**5**	**3**	**3 / 2**	**4 / 3**
Ru-106	1.26E+07	na	2.30E+09	3.48E+09	1.12E+10	8.16E+09	na	9.16E+07
Sb-125	na	na	na	na	na	na	na	1.48E+07
Sr-89	8.14E+06	1.63E+07	3.70E+06	1.11E+07	1.48E+07	1.11E+07	1.17E+04	na
Sr-90	2.60E+06	1.48E+06	na	1.33E+06	na	1.11E+06	na	1.12E+06
Te-132	2.96E+05	1.48E+06	3.56E+07	3.48E+07	3.15E+07	2.66E+07	1.50E+06	1.84E+06
Zn-65	6.66E+06	3.34E+07	1.26E+07	1.63E+07	6.29E+07	4.56E+07	na	1.24E+07
Zr-95	6.22E+07	1.48E+06	9.62E+06	9.62E+07	4.26E+07	2.55E+07	5.10E+06	6.80E+08
Total (without H-3)	5.65E+09	5.27E+09	1.11E+10	1.30E+10	2.37E+10	1.76E+10	4.95E+08	4.84E+09
Total	**4.45E+12**	**1.04E+12**	**1.50E+14**	**1.18E+14**	**1.28E+14**	**1.12E+14**	**6.00E+13**	**5.40E+14**

It should be noted that in the calculations waterborne radionuclide releases are estimated under conservative assumptions and conditions, therefore the estimated values are usually by an order or more higher than the real values, measured during the NPP operation. For example, based on the actual annual average releases during years 2004–2006 from two existing nuclear power plants in Finland (*STUK 2005*, *STUK 2006*, *STUK 2007*) the annual discharges of tritium have been approximately 10 % and the annual discharge of other activation products about 0.002–0.003 % of the site specific discharge limit values (see Table 7.1–41), which are specified taking into account the dose constrain to population, which is 0.1 mSv/year in Finland.

Table 7.1–41. Average annual radioactive releases to water (MBq/year) from two Finnish NPPs during 2004-2006 and site specific limit values.

Liquid radioactive releases (MBq/y)	Loviisa 1 & 2 2x860 MW PWR	Limit	Olkiluoto 1 & 2 2x860 MW BWR	Limit
Tritium (H3)	1.60×10^{13}	1.50×10^{14}	2.17×10^{12}	1.83×10^{13}
Other fission and activation products (total)	8.00×10^{8}	8.90×10^{11}	6.00×10^{8}	2.96×10^{11}

The comparison of the environmental radiological situation, resulting from the operation of Ignalina NPP, with forecasted average annual airborne and waterborne radionuclide releases into the environment reveals that in case a maximum number of units of some certain reactor models are constructed at the new NPP, the releases of some radionuclides into the environment would increase. For example, in case of the PHWR type reactor (EC-6 or ACR-1000), the increase in tritium releases to Lake Drūkšiai would be the most significant. However, even if annual releases of some radionuclides increased, as the results of the calculation of the annual effective dose to the members of the critical population group show (see Subsection 7.10.2.2), the established dose constraint to the population of 0.2 mSv would not be exceeded. The estimated maximum total annual dose received by the members of the critical group of the population due to the radionuclide releases from the four EC-6 units is equal to 0.033 mSv, which is 6 times less than the dose constraint.

Radioactive substances may be released into environment only after the permission to do this has been obtained. This permission is issued by the Ministry of Environment to the operator of the nuclear installation according to the conditions and procedures established in regulations and following the requirements of the normative document LAND 42-2007 “On the Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring” (*State Journal, 2007, No. 138-5693*). In the permission the limits for the liquid radioactive releases will be set. According to the regulations, the protection measures ensuring an adequate safety for human are sufficient to protect both the environment and natural resources.

The radioactivity of the monitored nuclides in the aquatic environment around INPP has been continuously decreasing during the last years (see Section 7.1.1.5 for releases from the INPP). The releases have been and are so small that no negative impacts on environment have been observed. The new NPP will be constructed and operated using the best available techniques and practises to ensure low radioactive releases. Consequently the liquid radioactive releases of the new NPP will not have any negative impacts on public health and environment.

Annual exposure of the critical group members of population due to liquid releases into the environment from different types of power reactors is estimated in chapter 7.10.

Radiological impact of new NPP on downstream water system in terms of effective dose is estimated in chapter 8.

7.1.3 Mitigation measures

7.1.3.1 Mitigation measures for non-radiological impact

7.1.3.1.1 Waste water treatment

Waste water originating from process and technical use will be treated depending on the quality of the waste waters by mechanical, chemical or biological means according to the regulations and laws. Waste waters from process water production will be neutralized. Possible oil traces will be removed. Waste waters from the controlled area will be processed in the liquid waste treatment plant. The impacts of the treated waste waters on the lake are estimated to be minor and acceptable. However, these impacts will be monitored and if unacceptable consequences occur, the treatment of waste waters will be improved.

The household waste waters of the new NPP will be treated at the new waste water treatment plant of Visaginas town. The loads from the new NPP represent only 4–8 % of the loads discharged to the lake from the new waste water treatment plant and naturally even smaller part of the total load to the lake. Thus treatment of the sanitary waste waters at the new waste water treatment plant can be considered adequate.

7.1.3.1.2 Mitigation measures of thermal impact to the lake

When selecting the type or combination of cooling systems for new NPP units, the following issues have to be taken into consideration: the amount of thermal load to the lake, the impacts of the thermal load on the aquatic environment as well as and the hydrological impacts in the lake and watercourse below.

With the present regulation the maximum thermal load to the lake especially during July and August is very limited. During the rest of the year the lake can, however, tolerate substantially higher thermal load. Thus there can be a need to limit the thermal load to the lake more during the warm period than what is sufficient for rest of the year.

The NNPP can be constructed in a way that it relies mainly on direct cooling during the colder periods. When the impacts of the thermal load on the lake are starting to become ecologically significant in spring and summer, the power plant can then switch totally or partially to other cooling techniques.

The environmentally and technically best cooling technology will be selected later in the design phase of the new plant. There are several available technologies and their combinations. For example, the cooling can be carried out by combining direct cooling and wet cooling towers. If additional cooling during the warmest period will be needed it can be carried out e.g. by a helper cooler solution. The different cooling technologies are discussed in more detail in Section 4.2 Cooling water systems.

Thermal impact to the lake can be reduced by timing of the yearly maintenance. The average length of the annual maintenance break is 2 to 6 weeks per one unit. In case of two or more units the maintenance periods are carried out successively. During this period the thermal load is lower than normally since one unit is out of operation. In case of one-unit NPP, the thermal load is practically zero during the maintenance period. Other factors allowing, by timing the maintenance periods to the warmest summer months (July and August) the thermal load could be significantly decreased during this period.

Thermal impact to the lake can be also reduced by utilizing thermal energy for district heating. When using direct cooling the temperature of the water led to the lake has increased about 10°C. The thermal energy led to the lake varies according to the power production (see Table 7.1–31) and cooling technique. For example, in case of a 1 700 MW_e unit running 8 000 hours per year the annual energy amount led to lake is approximately 90 900 TJ = 25 260 GWh. For comparison, this amount is about 4 times the annual district heating energy used in Helsinki (500 000 inhabitants) or about 2.8 times the annual district heat delivery in the country of Lithuania (*Helsingin Energia 2008*, *IEA 2005*) or about 80 times the use of district heat in Visaginas town (compared to year 2004). In order to produce heat or steam in a nuclear power plant, it must be designed for this purpose from the beginning. The heat or steam that the NNPP could produce for heating or industrial purposes can be transported only relatively short distances, some tens of kilometres.

Other possible ways to utilize the excess heat in the cooling water would be to use it to heat the ground like football fields for recreational purposes. Utilization in greenhouses or in fish farming would also be possible. However, only a very small amount of heat could be used for these activities and thus no remarkable reduction in the amount of thermal energy led to Lake Druksiai could be achieved.

7.1.3.2 Regulation of evaporation and water level in Lake Druksiai

The present regulation of Lake Druksiai allows minimum water level to be 140.7 m and the maximum 142.3 m. Usually the lake level varies few tens of centimetres around the mean water level of 141.6 m. The minimum flow out of the lake is defined to be 0.64 m^3/s.

Based on the water balance calculations (see chapters 7.1.1.3 and 7.1.2.7) the water resources will be adequate (water level does not drop below the minimum allowable water level for approximately three successive dry years) for the cooling purposes of the NNPP. However, if in some very unlikely conditions the minimum water level would be approached, evaporation from the lake would be reduced by reducing the output reactor power of the NNPP. This enables maintaining the minimum flow out of the lake even in very unlikely hydrological conditions.

7.1.3.3 Radiological impact mitigation measures

Although the waterborne radioactive releases during the normal operation of a NPP are negligible, technical and administrative measures to reduce releases even more are constantly introduced and improved at nuclear power plants. In order to reduce the radiological impact on the water component at nuclear power plants the following technical measures are commonly used:

- Waste water monitoring system, which performs continuous monitoring of all waste water from a NPP and real-time measurements of activity of representative samples. In case of adverse operating conditions, e.g., increased activity measured, malfunctions of the monitoring system, etc., appropriate drainage valves are closed.
- Liquid radioactive waste is collected in tanks, where their chemical and radiological parameters are measured. After evaluation of the measuring results, collected waste water is transferred either to the radioactive waste treatment facility or discharged to household-process waste water system if clearance levels are not exceeded.

- The design of liquid radioactive waste storage tank (e.g., the wall are double, hermetically sealed and resistant to the impact of liquids being stored in) ensures no leakage from the tanks will occur.
- Additional containment measures (e.g., containment basins for leaked liquid radioactive waste, depressions for leakage collection, the building containment).
- Equipment preventing overfilling of collection tanks (e.g., level meters, independent alarms of increased level, blockers, etc.).
- Periodic inspection and maintenance of tanks, piping and other equipment.

Specific impact mitigation measures will be analyzed and justified in the Safety Analysis Report, where the aspects of the Basic Design will be taken into account.

7.2 CLIMATE AND AIR QUALITY

7.2.1 Present state of the environment

7.2.1.1 Climate

The region concerned is located in the continental East Europe climate area. One of the main features of the climate in the region is the fact that no air masses are formed over this area. Cyclones are mostly connected with the polar front and determine continuous movement of air masses. The cyclones formed over the medium latitudes of the Atlantic Ocean move from the west towards the east through Western Europe and the new NPP region is often located at the intersection of the paths of the cyclones bringing humid maritime air. The variation of maritime and continental air masses is frequent, therefore the climate of the region can be considered as a transient climate from the maritime climate of Western Europe to the continental climate of Eurasia.

In comparison with other Lithuanian areas, the new NPP area is characterized by big variations of air temperature over the year, colder and longer winters with abundant snow cover, and warmer, but shorter summers. Average precipitation is also higher.

7.2.1.2 Precipitation and snow cover

Monthly averages of precipitation for the new NPP region are given in Table 7.2–1. Average annual amount of precipitation in the new NPP region during 1988–2007 is 665 mm. About 65 % of all precipitation takes place during the warm period of the year (April–October), and about 35 % during the cold period (November–March).

Table 7.2–1. Monthly averages of precipitation (mm) for the new NPP region.

Meteorological station and observation period	Month (s)												Total for months		
	01	02	03	04	05	06	07	08	09	10	11	12	01-12	11-03	04-10
Dukstas, 1961–1990	32	25	28	43	58	69	75	66	64	50	42	40	592	167	425
Utena, 1961–1990	39	31	37	47	53	69	73	75	66	50	57	53	650	217	433
Zarasai, 1961–1990	45	36	39	42	59	72	75	66	66	55	60	56	671	236	435
INPP, 1988–1999	41	41	46	33	55	84	60	64	70	66	58	57	676	244	432
INPP, 2000–2007	47	40	37	35	69	78	69	79	38	68	55	38	653	217	436

The snow cover in the region lasts about 100–110 days per year. Average thickness of the snow cover is 16 cm, and the maximum is 64 cm. Density of snow cover gradually increases from 0.2 to 0.5 g/cm^3 in the middle of March. Absolute maximum of recorded weight of snow cover is 120 kg/m^2.

7.2.1.3 Wind

Western and southern winds dominate. The strongest winds blow from west and south-west. The average annual wind speed is about 3.5 m/s, and maximal (gust) speeds can reach 28 m/s. No-wind conditions are observed on, on the average, 6 % of the time and last no more than one day (24 hours) in the summer, and no more than two days in the winter. The wind rose of the new NPP region is based on local wind measurements and is presented in Figure 7.2-1.

Winds with speeds below 7 m/s dominate – recorded events constitute more than 90 % of the total number of observations. Recorded events with wind speeds above 10 m/s are not frequent – less than 10 events per year.

Calculated average wind pressure is 0.18 kPa and pulsation component of wind load is 0.12 kPa. With a reliability coefficient of 1.4 the calculated value of uniform wind load is 0.42 kPa and extreme wind load (with probability 10^{-4} per year) is 1.05 kPa with the reliability overloading coefficient 2.5 (*Almenas et al., 1998*).

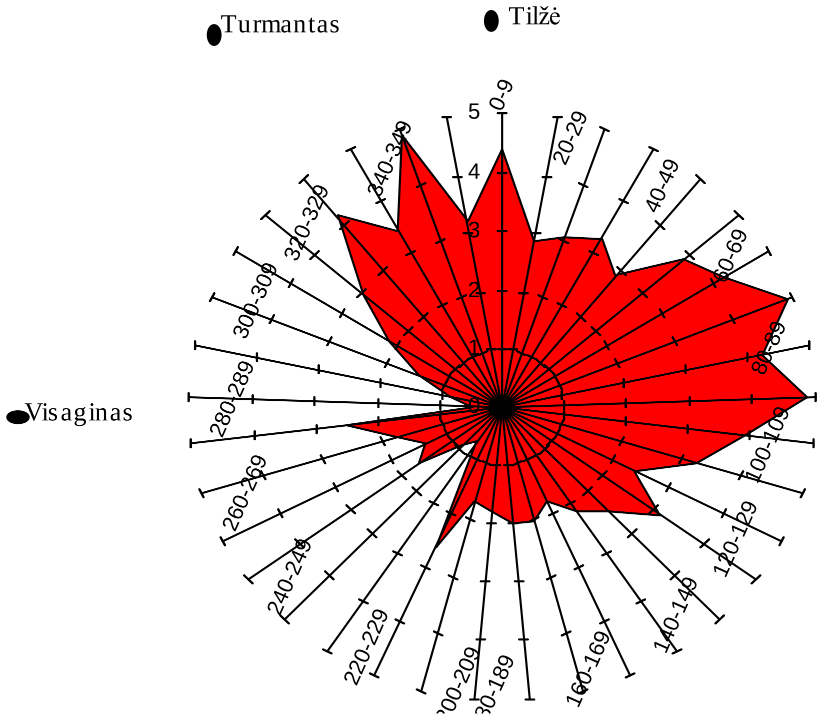


Figure 7.2-1. Wind rose at the new NPP region (wind direction off the new NPP).

Extreme events (spouts) are rare in the vicinity of the Ignalina site. During a storm in 1998 a wind speed of 33 m/s was recorded. Spouts in the vicinity of the new NPP have not exceeded class F-2 according to Fujita classification. The season of spouts begins at the end of April and ends in the first half of September. The direction of spout motion is from south-west to north-east in 75 % of the cases. The average length of spout shift trajectory is 20 km and the length varies from 1 to 50 km. Average width of the spouts is 50 m with variations from 10 to 300 m. Calculated maximum spout velocity with a frequency of 1 in 10 000 years is 39 m/s (*Almenas et al., 1998*).

According to the data of Lithuanian Hydrometeorological Service under the Ministry of Environment (*http://www.meteo.lt*) the maximal wind speed of 40 m/s measured in Utena on June 1986 is a Lithuanian meteorological record. The maximal speed of spout of about 70 m/s has been observed in Sirvintos on May 29, 1981. Spout of such speed is classified as class F-2 according to Fujita classification.

7.2.1.4 Insolation

Average annual duration of sunshine in the region is about 1710 hours (42 % of the maximum possible duration of the earth's surface insolation by the sun). June is the sunniest month: the amount of sunshine in June is about 280 hours (58 % of the possible duration). The shortest period of sunshine because of cloudy weather is observed in December, which is about 20 hours (12 % of possible duration).

Average annual cloudiness in the region is about a force 7. In December it increases to a force 8.5 and in May it decreases to a force 6.5. The average annual amount of cloudy days (175) is considerably larger than the clear ones (*Almenas et al., 1998*).

7.2.1.5 Temperature

Monthly average temperatures in the new NPP region are given in Table 7.2–2.

Average calculated air temperatures of the coldest five-day period are –27 ºC. Absolute maximum of recorded temperature is 36 ºC and absolute minimum is –40 ºC. Absolute maximum of calculated temperature with a probability of 10^{-4} per year is 40.5 ºC and absolute minimum of calculated temperature with a frequency of 1 in 10 000 years is –44.4 ºC (*Almenas et al., 1998*).

Table 7.2–2. Monthly average temperatures (°C) for the new NPP region.

Meteorological station and observation period	Month												01–12
	01	02	03	04	05	06	07	08	09	10	11	12	Average
Dukstas, 1961–1990	-6.8	-5.9	-1.9	5.2	12.1	15.5	16.8	15.9	11.2	6.2	0.9	-3.8	5.5
Utena, 1961–1990	-6.0	-5.2	-1.2	5.5	12.2	15.6	16.8	15.9	11.4	6.6	1.4	-3.2	5.8
INPP, 1988–1999	-2.5	-2.2	0.3	6.6	12.4	16.5	17.9	16.5	11.3	6.0	-0.1	-3.1	6.6
INPP, 2000–2007	-3.3	-5.8	0.1	7.0	12.5	15.7	18.9	17.4	12.3	6.8	1.7	-2.0	6.8

7.2.1.6 Atmospheric pressure

Normal range of atmospheric pressure is 994 hPa. The greatest values of twenty-four-hour atmospheric pressure are usually in winter and vary from 1010 to 1027 hPa. The smallest values of twenty-four-hour atmospheric pressure are observed in summer and vary from 970 to 985 hPa. The oscillations of twenty-four-hour amplitude of atmospheric pressure vary from 15 to 25 hPa.

7.2.1.7 Humidity

Average relative humidity of air reached 80%, and about 90% in winter. A minimum relative humidity (53–63%) is observed in June, and a maximum – in January.

7.2.1.8 The frequency of storms with lightning

The average number of storms with lightning is 11 per year. Four storms monthly are usually observed in July–August and 1–2 storms in other relatively warm months.

Average duration of the storms is 2 hours and the maximum is 4 hours. Average duration of storms with lightning in the course of a year is about 22 hours.

7.2.1.9 Fogs

Fog can be observed any day of the year in the new NPP region. The average number of foggy days is 45. Fog absorbs different impurity (noxious gases, smoke, dust) and, combined with high humidity, increases corrosion intensity, aggravating visibility and impeding transportation. Average duration of fog in the course of a month is from 4 to 29 hours and in the course of year about 173 hours. During the cold period total duration of fog varies between 92 to 106 hours, and during the warm period it is about half of that, which is 49–68 hours.

7.2.1.10 Black ice, hoarfrost, ground freezing

There are about 15 days with glazed frost or ice-crusted ground, 14 days with hoarfrost and 18 days with blizzard per year. The length of hoarfrost threads reaches 50 mm.

The freezing of the ground usually begins in the first part of December and lasts to the middle of April. The average depth of the frost line reaches about 50 cm, and the maximum depth extends to 110 cm depending on the composition of the ground and its humidity.

7.2.1.11 Background contamination of the ambient air and greenhouse gases

Present background contamination

Information on environment background contamination provided in this chapter is based on the reports on the analysis of concentrations of contaminants in the atmosphere presented in the website of the Environment Protection Agency (*http://aaa.am.lt*).

Analysis of concentrations of atmospheric contaminants in Lithuania is performed in the Integrated Monitoring (IM) stations in Aukstaitija (LT01), Zemaitija (LT03), and Preila. Automatic air quality monitoring stations are located in the biggest cities of Lithuania (the closest station is in Panevezys); however, they reflect air situation in the big cities only. Air quality in the region of the NNPP may be evaluated based on measurements of concentration of contamination in the atmosphere at Aukstaitija (LT01) station, which is to the north-west from the INPP at a distance of about 80 km. At this station concentrations of gaseous (SO_2, NO_2), aerosol (SO_4^{2-}) and total ΣNO_3^- (sum of gaseous NO_3 and aerosol particles NO_3^-) and ΣNH_4^+ (sum of gaseous NH_3 and aerosol particles NH_4^+) contaminants are measured. Table 7.2–3 presents values, measured for atmospheric contaminants at Aukstaitija station (LT01) in 2006, and Table 7.2–5 – in 2007.

Table 7.2–3. Statistical values of concentrations of contaminants in air at the station LT01 in 2006 (*Data from Environment Protection Agency*).

Component	Measure-ment unit	Concentrations of contaminants								
		Min.			Max.			Annual average		
		LT01	LT03	Preila	LT01	LT03	Preila	LT01	LT03	Preila
SO_2	$\mu gS/m^3$	0.07	0.04	0.01	5.64	4.10	7.59	0.85	0.89	0.47
NO_2	$\mu gN/m^3$	0.15	0.08	0.23	2.29	2.89	5.33	0.70	1.10	1.30
SO_4^{2-}	$\mu gS/m^3$	0.16	0.26	0.02	2.84	2.76	2.00	0.84	0.79	0.39
ΣNO_3^-	$\mu gN/m^3$	0.14	0.20	0.01	1.49	1.17	3.27	0.52	0.58	0.69
ΣNH_4^+	$\mu gN/m^3$	0.46	0.32	0.17	2.96	3.27	5.06	1.26	1.51	1.71

Limit values for ambient air pollution according to the Lithuanian regulation "Ambient air pollution standards" (*State Journal, 2001, No. 106-3827*) are given in Table 7.2–4.

Table 7.2–4. Limit values for ambient air pollution established for protection of human health, ecosystems and vegetation.

Pollutant	SO_2	SO_2	SO_2	NO_2	NO_2	NO_x	SP_{10}	$SP_{2.5}$	CO
Averaging time-span	1 h	24 h	1 y, ½ y	1 h	1 y	1 y	24 h	24 h	8 h
Limit value, $\mu g/m^3$	350 (24 t)	125 (24 t)	20 E	200 (18 t)	40	30 V	50 (35 t)	40 (14 t)	10 mg/m^3

SP – Solid Particles

(24 t), (18 t), (35 t), (14 t) – allowable overrun per year

E – for protection of ecosystems

V – for protection of vegetation

It can be seen that measured values do not exceed limit values. Comparing the annual average values of concentration of atmospheric contaminants in 2006 in IM stations and Preila, it can be noticed that concentration of SO_2 and SO_4^{2-} in Preila are almost half of the concentrations in IM stations. However, annual average concentration of NO_2 in Preila is almost twice as big as at LT01 and slightly (about 18 %) greater than at LT03. In Aukstaitija (LT01), the annual average values of concentrations of all measured contaminants in 2006 are less than in Zemaitija (LT03). Annual concentrations of NO_2, ΣNO_3^- and ΣNH_4^+ in Zemaitija are by 12–57 % greater than in Aukstaitija.

Change of concentrations of SO_2 and NO_2 has a significant seasonal character. The highest, exceeding several times the average value in every analysis location in 2006, concentrations of sulphur dioxide at LT01 and LT03 stations in Preila occurred in January–March. In Aukstaitija (LT01), from April till the end of the year, the concentration of SO_2 was less than 0.85 $\mu gS/m^3$, with the exception of several weeks in August. In Zemaitija (LT03) and Preila less than average concentrations of SO_2 were measured during April–October 2006, and cases of greater than annual average concentrations of SO_2 were observed in some weeks of November–December. High concentrations of NO_2 (up to 2.5–3.7 $\mu gN/m^3$) at stations LT01 and LT03 were frequent in January–February and December. However, from March till mid-October concentrations of NO_2 were less than average in 2006 both at LT01, and LT03. In Preila, as at IM stations, change of NO_2 concentrations is significant. The greatest concentrations prevailed in January, November and December. From March to November concentrations of NO_2 were usually less than average in 2006. However, also in summertime there were days, when concentration of NO_2 reached 2–3 μgN/m^3. Level of atmosphere contamination with sulphur and nitrogen compounds above Lithuania is conditioned by emissions of these contaminants from local contamination sources and, mostly, from Western and Southern European states.

In change of concentrations of SO_4^{2-} in all locations of monitoring of atmospheric contamination, it is observed that the episodes of the highest concentrations are measured during weeks (IM stations) or days (Preila) of winter months and they co-occur with the episodes of high concentrations of SO_2. In change of concentrations of ammonium compounds ΣNH_4^+ a greater reoccurrence of smaller than in 2006 average concentrations is observed in summer months in comparison to winter months. The episodes of higher and as well lower ΣNH_4^+ concentrations co-occur with the episodes of high and low concentrations of SO_4^{2-}.

At both IM stations and in Preila more frequent reoccurrence of higher concentrations of ΣNO_3^- than average in 2006 was obtained in January–April. Concentrations less than 0.4 μgN/m^3 ΣNO_3^- usually occurred from May till October.

Taking into consideration the change of average annual concentrations of SO_2 during the period of 13 years, their significant decrease can be observed in all monitoring locations from 1994 to 1997: at LT01 it decreased about three times, at LT03 and Preila – about two times. The concentrations of SO_2 in past 10 years changed in a relatively small range with no significant increase or decrease tendency. The concentrations of SO_2 in past 10 years and their standard declinations are as follows: LT01 – 0.74 ± 0.16 μgS/m^3, LT03 – 0.76 ± 0.24 μgS/m^3 and Preila – 0.93 ± 0.26 μgS/m^3.

The average annual concentrations change of SO_4^{2-} is similar to SO_2. The concentrations of SO_4^{2-} in past 10 years changed in a relatively small range and average concentrations of this period and their standard declinations are as follows: LT01 – 0.89 ± 0.15 μgS/m^3, LT03 – 0.83 ± 0.18 μgS/m^3 and in Preila – 1.06 ± 0.28 μgS/m^3.

Annual average concentrations of NO_2 in 1999–2006 in Aukstaitija (LT01) changed from 0.66 to 0.70 μgN/m^3 with no significant increase or decrease tendency, with the average of 0.66 μgN/m^3 at this period and standard declination ±0.03 μgN/m^3, and in Zemaitija (LT03) an insignificant increase of average annual concentrations from 0.69 μgN/m^3 (1999) to 1.1 μgN/m^3 (2006) is observed. In Preila till 2000, average annual concentrations of NO_2 decreased from 2.20 to 1.18 μgN/m^3, and in their further course there is no single change tendency with the average concentration 1.26 μgN/m^3 and standard declination ±0.07 μgN/m^3

Data from the Environment Protection Agency show that at the IM stations annual concentrations of ΣNO_3^- change in a small range and values of average concentrations and standard declinations of the entire period are as follows: LT01 – 0.49 ± 0.07 μgN/m^3, LT03 – 0.56 ± 0.10 μgN/m^3, Preila – 0.75 ± 0.15 μgN/m^3.

Change of concentration of ΣNH_4^+ in the air is quite similar to the change of concentration of SO_4^{2-}: in Aukstaitija it decreases to 1.44 μgN/m^3 (1997), in Zemaitija to 1.56 µgN/m^3 (1998), in the further course of concentrations there is no general tendency for increase or decrease.

Table 7.2–5. Statistical values of concentrations of contaminants in air at the LT and Preila stations in 2007 (*Data from Environment Protection Agency*).

Component	Measure-ment unit	Concentrations of contaminants								
		Min.			Max.			Annual average		
		LT01	LT03	Preila	LT01	LT03	Preila	LT01	LT03	Preila
SO_2	µgS/m^3	0.01	0.02	0.04	3.49	1.55	2.29	0.38	0.34	0.25
NO_2	µgN/m^3	0.05	0.07	0.44	3.05	3.90	4.24	0.61	0.83	1.18
SO_4^{2-}	µgS/m^3	0.02	0.03	0.15	2.98	1.57	3.35	0.63	0.58	0.51
ΣNO_3^-	µgN/m^3	0.06	0.09	0.16	1.39	2.33	1.95	0.42	0.52	0.59
ΣNH_4^+	µgN/m^3	0.02	0.04	0.52	3.37	2.44	6.17	0.95	0.90	1.66

Greenhouse gases emission

Lithuania signed the United Nations Convention on Climate Change (UNFCCC) as an Annex I Party in 1992 and ratified it in 1995. The Kyoto Protocol was signed in 1998 and ratified in 2002. Lithuania undertook to reduce its greenhouse gas emissions by 8 % below 1990 level during the first commitment period 2008–2012. The total emissions in 1990 were about 49 million tonnes equivalent CO_2 so during the years 2008–2012 the annual greenhouse gases (GHG) amount should be at the level 45 million tonnes CO_{2eqv}/year *(National Greenhouse Gas Emission Inventory Report, 2008).*

Aggregated emissions of GHG expressed in CO_2 equivalent (without CO_2 removals and emissions from the LULUCF sector) have decreased by approximately 53 % during the period 1990–2006 (Figure 7.2-2). The abbreviation LULUCF is used for Land Use, Land-Use Change and Forestry.

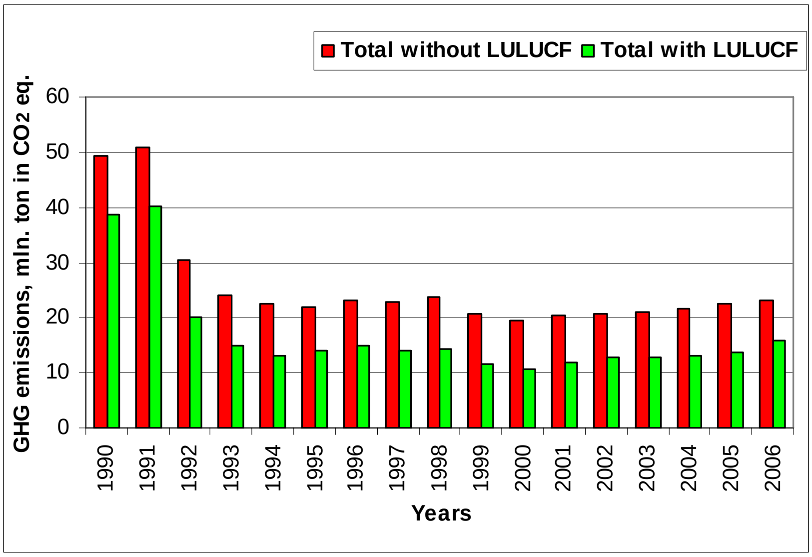


Figure 7.2-2. Emission trends for aggregated GHG (million tonnes in CO_2 equivalent) in Lithuania.

A rapid decrease of GHG emissions has followed the decline of the national economy in the 1990s. The reduction of GHG emissions from 1990 to 2000 was over 60 %. Towards the mid 1990s, Lithuania's GDP began to rise and the reduction in emissions slowed down. The annual increase of GHG emissions in 2000–2006 was approximately 4 % annually.

The decline in the emissions of the main greenhouse gases between 1990 and 2006 is shown in Figure 7.2-3.

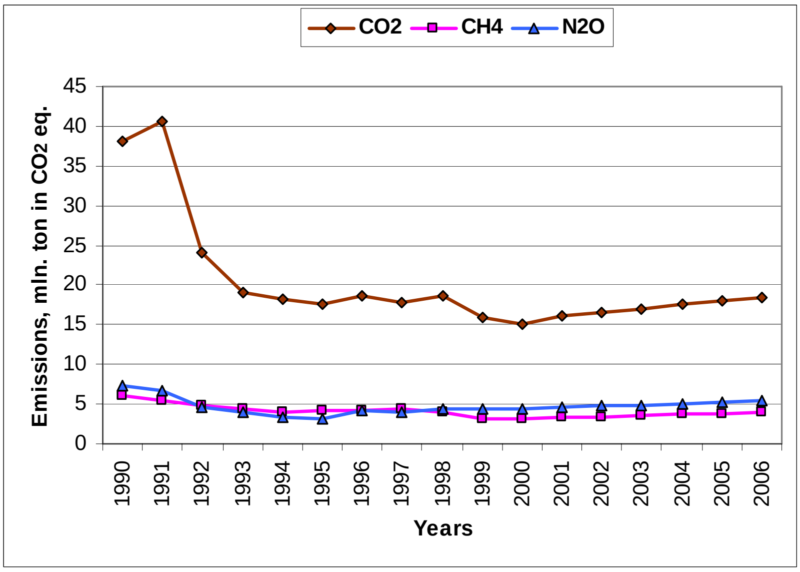


Figure 7.2-3. Trends of GHG emissions by gas in CO_2 equivalent, million tonnes.

Emissions of all three gases were increasing continuously from 2000 to 2006. This increase mainly follows the growth in industrial output as reflected by the growth of GDP. The largest amounts of carbon dioxide emissions resulted from fuel combustion processes in various sectors.

In 1996, CO_2 emissions from transport continued to increase with increasing car fleet. CO_2 emissions from biomass have increased more than 2.5 times since 1990. The government via the promotion of the use of renewable energy sources facilitated consumption of biomass as fuel. It was also regarded as a cleaner and cheaper fuel source. In addition, a number of boiler houses have switched from heavy fuel oil to biomass as a result of a programme of Activities Implemented Jointly mainly with Scandinavian countries *(National Greenhouse Gas Emission Inventory Report, 2008)*

Methane emissions have decreased from approximately 6.1 to about 3.2 mln. tonnes in CO_2 equivalent from 1990 to the year 2000 but remained fairly constant since the year 2000 changing within the limits of approximately 3.2 to 3.4 mln. tonnes in CO_2 equivalent.

The major part of methane emissions is generated in agricultural sector and the decrease was caused mainly by restructuring of agricultural sector after regaining independence resulting in substantial decline in the number of cattle. The second major source of methane emissions is waste management comprising about 40 % of the total where emissions have also decreased but less dramatically. Though methane emissions in energy sector were decreasing continuously throughout the whole 1990–2006 period, emissions from the year 2000 remained stable because of stabilisation of the agricultural sector.

N_2O emissions have decreased roughly by half from 1990 to 1995 but then started increasing again reaching 5.2 mln. tonnes in CO_2 equivalent in 2006 compared to 7 mln. tonnes in CO_2 equivalent in 1990.

From 1990 to 1996 N_2O emissions were decreasing in all sectors (energy, industry, agriculture and waste). The increase in emissions from 1995 was mainly caused by very substantial growth of N_2O emissions in industry – industrial emissions in 2006 exceeded 1990 level approximately 3 times. As a result, the share of industrial emissions in the total N_2O emissions increased from 11 % in 1990 to 42 % in 2006 while the share of agricultural N_2O emissions decreased from 84 % in 1990 to 54 % in 2006 *(National Greenhouse Gas Emission Inventory Report, 2008)*.

The greenhouse emission grows more rapidly than it was foreseen in the National Sustainable Development Strategy. However, this doesn't make cause difficulties for Lithuania to keep the Kyoto protocol requirements. The difficulties may arise after the year 2010, when Ignalina NPP Unit 2 will be shut down and without a new NPP part of the demand of energy would have to be compensated by burning fossil fuels.

Potential changes in background contamination due to shut down of INPP

Unit 2 of Ignalina NPP will be shut down at the end of 2009 and therefore before start up of the new NPP replacement capacity will be needed. The production of unit 2 is about 20 TWh annually. This amount of electricity will be replaced by production of thermal power plants in Lithuania and by imported electricity. Unlike nuclear power plants, thermal power plants produce emissions of pollutants like nitrogen oxide, sulphur dioxide and particles into the air. These pollutants have an impact on the ambient air quality in the vicinity of the power plants. The magnitude of the impact and the area affected depends on the size and type of thermal power plant, and on the mitigation measures applied. The amounts of the different pollutants and thus also their impacts on ambient air quality vary according to the fuel used by the thermal power plants.

If fossil fuels are used for electricity production greenhouse gases will be produced, whereas nuclear power plants, hydropower plants and thermal power plants using biofuels do not produce greenhouse gases.

7.2.1.12 Radionuclide emissions to the atmosphere

Ignalina NPP is the only source of radionuclide emissions to the atmosphere in Lithuania. Permission to release radionuclides from the nuclear installations into the environment is issued by the Ministry of Environment according to the requirements of the normative document LAND 42-2007 "On the Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring" (*State Journal, 2007, No. 138-5693*). According to the existing order, the Ministry of Environment issues permissions for Ignalina NPP for releases of radioactive material into environment. Radioactive emissions from Ignalina NPP to the atmosphere are continuously monitored. The information on radionuclides and activities that have been actually released from existing Ignalina NPP is presented in Table 7.2–6, Table 7.2–7 and Table 7.2–8 (*INPP Report PTOot-0545-15, 2008*). It should be noted that these existing releases of certain radionuclides are 100 or more times less than permissible values indicated in the valid permission of Ministry of Environment.

Table 7.2–6. Activity (10^5 Bq) of aerosol radionuclides released from Ignalina NPP to the atmosphere during 2001–2007 (*INPP Report PTOot-0545-15, 2008*).

Nuclide	Year							Annual limit value
	2001	2002	2003	2004	2005	2006	2007	
Na-24	14.8	15.2	529	1840	0	0	195	463
Cr-51	312	124	190	86.2	0.02	365	215	682000
Mn-54	1790	949	1430	1090	333	560	257	96200
Co-58	98.9	42.0	112	64.4	27.7	39.7	17.4	73400
Fe-59	599	238	318	52.5	105	226	104	491000
Co-60	2990	1920	2260	2320	1030	1020	889	2880000
Zn-65	27.0	4.74	18.5	1.92	160	234	0	8320
As-76	0	0	0	0	0	0	0	103000
Sr-89	332	483	587	618	553	287	543	61100
Sr-90	421	587	453	597	559	592	615	53800
Sr-91	0	0	0	0	0	0	0	25900
Zr-95	325	87.9	120	91.2	0	2.62	15.4	733000
Nb-95	1430	421	458	431	13.4	140	63.2	487000
Mo-99	0	0	0	44.4	44.4	41.2	40.0	146000
Ru-105	0	0	0	0	0	0	0	125000
Sb-122	0	0	0	0	0	0	0	27700
Sb-124	0	0	0	0	0	0	0	147000
I-131*	19500	24900	14200	106000	66700	77000	84900	9870000
I-132	0.40	12.3	0	0.41	0		8.80	9580
I-133	15.2	0.16	342	104	1430	1100	3990	19800
Cs-134	178	279	147	133	12.2	22.7	35.7	13300
I-135	0	0	0	0	0	0	148	86700
Cs-136	0	0	0.40	0.25	0.05	0	0	14800
Cs-137	1770	1170	925	661	1280	1020	316	1390000
Ba-140	0	0	0	0	0	0	0	10800
La-140	2.70	0	0	0	0	0	0	77200
Ce-144	0	0	0	0	0	0	0	78600
W-187	0	0	0	0.04	0	0	0	56400
Total	10500	7010	8030	8420	5590	6910	7822	

* – I-131 taking into account molecular, organic and aerosol fractions.

Table 7.2–7. Activity of noble gas radionuclides (10^{10} Bq) released from Ignalina NPP to the atmosphere during 2001–2007 (*INPP Report PTOot-0545-15, 2008*).

Nuclide	Year							Annual limit value
	2001	2002	2003	2004	2005	2006	2007	
Ar-41	6180	3780	3220	1430	1340	961	1340	900000
Kr-85m	61.1	200	196	90.3	145	49.6	320	45000
Kr-87	25.9	120	22.6	45.1	28.1	0	455	21500
Kr-88	27.4	117	57.4	34.8	24.8	0	518	14700
Xe-133	2640	4550	2740	4090	5110	1780	2930	360000
Xe-133m	2.60	17.4	11.8	15.5	175	0	0	2730
Xe-135m	56.2	143	0	33.7	0	0	818	8000
Xe-135	552	719	470	369	625	332	713	30600
Xe-138	94.7	430	0	45.1	0	0	668	6810
Total	9640	10100	6720	6160	7440	3120	7760	

Radioactive emissions from the existing Ignalina NPP and caused doses to population are summarized in Table 7.2–8 (*INPP Report PTOot-0545-15, 2008*). In order not to exceed the dose constrain (0.2 mSv per year), it is assumed, that annual effective dose form each source of radioactive emissions (airborne and waterborne) from INPP should not exceed 0.1 mSv per year. The actual annual dose to critical group members of the population due to operation of the Ignalina NPP (see Table 7.2–8) is only about 1 % of the 0.1 mSv per year.

Table 7.2–8. Annual dose to critical group members of the population (during 2001–2007) due to radioactive emissions from Ignalina NPP.

	Annual dose to critical group members of the population, μSv			
Year	Noble gases	Aerosols & I-131	Total dose, μSv	% of dose limit (0.1 mSv)
2001	0.065	0.154	0.219	0.22
2002	0.047	0.172	0.219	0.22
2003	0.035	0.110	0.145	0.15
2004	0.017	1.878	1.894	1.89
2005	0.016	1.109	1.126	1.13
2006	0.011	1.377	1.388	1.39
2007	0.034	1.335	1.369	1.37

7.2.1.13 Radionuclide activity in air

This section provides information on the radionuclide activity in the ambient air of INPP (within the sanitary protection and surveillance zones). For comparison, information on the situation in other regions of Lithuania (Vilnius and Utena) is provided. Average annual radionuclide activity concentrations for 2002-2007 within the sanitary protection zone of INPP are presented in Table 7.2–9, and within the surveillance zone of INPP – in Table 7.2–10.

Table 7.2–9. Average annual radionuclide activity concentrations in the ambient air in the sanitary protection zone of Ignalina NPP in 2002-2007 (*INPP report ПТОот-0545-15, 2008*)

Radionuclide	Volumetric activity. μBq/m^3					
	2002	2003	2004	2005	2006	2007
Cs-137	0.73	0.18	0.21	0.21	0.36	0.29
Cs-134	0	0.01	0	0	0	0
Mn-54	0	0.18	0.04	0.01	0.08	0.07
Co-58	0	0	0	0	0	0
Co-60	0	0.03	0.14	0.02	0.10	0.20
Zr-95	0	0	0	0	0	0
Cr-51	0	0	0	0	0.11	0
Nb-95	0	0	0	0	0.01	0
Fe-59	0	0	0	0	0	0
I-131	0	0	0.34	0	0.46	0
Sr-90	<1.00	<1.00	<0.18	<0.05	0.0174	0.0555
Be-7	681	596	589	663	587	938
Total (except for Be-7)	0.73	0.40	0.74	0.23	1.14	0.62

Table 7.2–10. Average annual radionuclide activity concentrations in the ambient air in the surveillance zone of Ignalina NPP in 2002-2007 (*INPP report ПТОот-0545-15, 2008*)

Radionuclide	Volumetric activity. µBq/m^3					
	2002	2003	2004	2005	2006	2007
Cs-137	0.36	0.22	0.23	0.28	0.37	0.25
Cs-134	0	0	0	0	0	0
Mn-54	0	0	0	0	0.0039	0.0017
Co-58	0	0	0	0	0	0.005
Co-60	0.01	0	0	0.10	0.0058	0.11
Zr-95	0	0	0	0	0.0024	0
Cr-51	0	0	0	0	0	0
Nb-95	0	0	0	0	0.0058	0.0033
Fe-59	0	0	0	0	0	0
I-131	0	0	0.08	0	0	0
Sr-90	<1.00	<1.00	<0.18	<0.05	0.0214	0.0134
Be-7	805	815	606	682	1020	957
Total (except for Be-7)	0.37	0.22	0.31	0.39	0.41	0.38

For comparison, information on the situation in other regions of Lithuania is provided. After a more than decade long break, the air radiological studies under the National Environmental Monitoring Program for 2005-2010 were renewed in Vilnius in 2005. Continuing the work execution in the Vilnius city air natural radionuclides Be-7 and Pb-210, as well as technogenic Cs-137 are monitored again. Air samples are taken with the help of an air blowers exposing filters of FPP-15 (Petrianov) type. Air is taken 2 m above the ground surface, exposure time - 2 weeks, filters are replaced once a week. Average values of the radionuclide activity concentrations of 2006-2008 are presented in Table 7.2–11. It can be seen that the change of the average annual values is quite small. Atypical radionuclides brought by long-distance transfer (activation and fissions products) have not been detected.

Table 7.2–11. Average annual radionuclide activity concentrations in the ambient air in the Vilnius city (*Website of the Environmental Protection Agency http://aaa.am.lt/VI/index.php#r/1339*)

Radionuclide	Volumetric activity. µBq/m^3		
	2006	2007	2008
Cs-137	2.0	1.9	1.3
Pb-210	404	437	404
Be-7	2470	2780	3020

The Environmental Protection Agency exercises state environmental radiological monitoring, aerosol samples are collected continuously in Utena, as well. The alternation of activity concentrations of natural radionuclide Be-7 and technogenic radionuclide Cs-137 is monitored. The annual mean values of these radionuclide activity concentrations in 2005-2008 are presented in Table 7.2–12. Occasionally detected increases of activity are not related to the release of radionuclides from the nuclear reactors being operated (including INPP), this is also proved by the fact that iodine and noble gas radionuclides were not detected (they are released in case of emergency incidents).

Table 7.2–12. Annual mean values of radionuclide activity concentrations in aerosol samples in Utena (*Website of the Environmental Protection Agency http://aaa.am.lt/VI/index.php#a/3559 and http://aaa.am.lt/VI/index.php#r/1652*).

Radionuclide	Volumetric activity, μBq/m^3			
	2005	2006	2007	2008
Cs-137	1.3	2.2	1.62	0.77
Be-7	2740	3350	3710	4670

From the comparison of the data above it can be concluded that the radionuclide activity concentrations in the ambient air of INPP (within the sanitary protection and surveillance zones) are very low and often even lower than those in Vilnius and Utena.

7.2.2 Assessment of impacts on air quality

7.2.2.1 Pollutants released to the atmosphere during construction and operation

Amounts of pollutants

During construction of the new NPP the main source of emissions into the air will be traffic which produces exhaust gases and dust. Construction of a nuclear power plant requires a large number of workers and heavy transportation. The need of workers is at its largest during the fourth year of construction when about 1 800 cars and 60 buses are driving daily from Visaginas to Ignalina NPP and back. In addition about 100 trucks will be needed daily.

During construction dust is raised also from land building work, on-site traffic and some separate operations such as concrete mixing stations.

During operation of the new NPP the emissions will mainly be produced from the operation of the back-up engines and from traffic. The amount of cars commuting daily to the new power plant will be about 1 000 and there will also be 30-35 buses. In addition some 40 trucks will drive to the power plant daily.

Exhaust gas emissions from traffic are presented in Table 7.2–13. The figures include the traffic related to the decommissioning project of the INPP.

Table 7.2–13. Estimated traffic emissions during construction and operation stages of the NNPP.

	Construction stage, t/year	Operation stage, t/year
Nitrogen oxides NO_x	30	14
Sulphur dioxide SO_2	0.1	0.1
Particles PM	1	0.2
Carbon monoxide CO	98	44
Carbon dioxide CO_2	3549	1593

Back-up engines are used in emergency situations when connection to the power grid is not available. During normal operation back-up engines are used for monthly functional test only. Emissions from the back-up engines of the NNPP are presented in

Table 7.2–14. In the calculation it is assumed that engines use diesel oil as fuel and that the annual operation time is about 200 hours.

Table 7.2–14. Estimated emissions of back-up engines.

	t/year
Nitrogen oxides NO_x	1
Sulphur dioxide SO_2	0.2
Particles PM	0.5
Carbon dioxide CO_2	500

Heat for the new NPP will most likely be supplied by the existing recently built gas-fired heat boiler which also provides district heat to the city of Visaginas. Steam will most likely be provided by the existing recently built gas-fired steam boiler. The environmental impacts of these boilers have been studied in the EIA's of each boiler (*Ignalina NPP Decommissioning project management unit, 2004a* and *Ignalina NPP Decommissioning project management unit, 2004b*).

Impacts on air quality

Road traffic will increase emissions into the air during the construction of the new NPP. While the number of workers is at it's largest at the fourth year of construction also significant emission produced by traffic are limited to that time. During other time of the construction the traffic emissions into the air are smaller. Thus traffic emissions during construction are not assessed to have significant long-term impacts on the local air quality.

Sources of dust are usually located quite low and the amount is small so the impact is local and dusting will not have significant impact on the air quality outside the construction site.

During operation of the new NPP the traffic amounts are almost the same as they have been during the operation of the INPP so the NNPP project will not have significant negative impacts on the air quality.

The emissions of back-up engines during normal operation are quite low and therefore there will be no significant impact on air quality from these.

As a conclusion the construction and commissioning of the NNPP will not have a significant detrimental impact on the ambient air quality of the Visaginas region taking the background contamination into account. Only very local adverse impacts are expected during the construction phase, mainly at the construction site.

7.2.2.2 Avoided flue gas emissions

Flue gas and green house gas emissions avoided because of the NNPP have been estimated assuming that the amount of electricity equal to the production of the new NPP would be partly produced in Lithuania in thermal power plants and part of it would be imported. According to the zero-option description in chapter 4.4, the majority of energy in Lithuania would be produced with natural gas if the new NPP will not be constructed. As there are targets in the Lithuanian Energy Strategy to increase the use of biomass, also biomass-based electricity production is assumed to be included in the zero-option. Imported electricity is assumed to be produced in thermal power plants using coal and oil as a fuel and in hydro and nuclear power plants as well. In the calculation of the avoided emissions the emission factors used are in accordance with EU directive of the Large Combustion Plants (*2001/80/EC*).

The estimated emissions in the zero-option (energy amount 24 TWh_e) are presented in Figure 7.2-4. These amounts of emissions would be produced in Lithuania (natural gas and biomass) and in the country exporting electricity to Lithuania if the new NPP would not be built.

The estimate of emissions in the zero-option also describes the situation before start up of the new NPP when unit 2 of Ignalina NPP has been shut down. It is possible that in that time the share of import will be higher if new capacity will not be built in Lithuania.

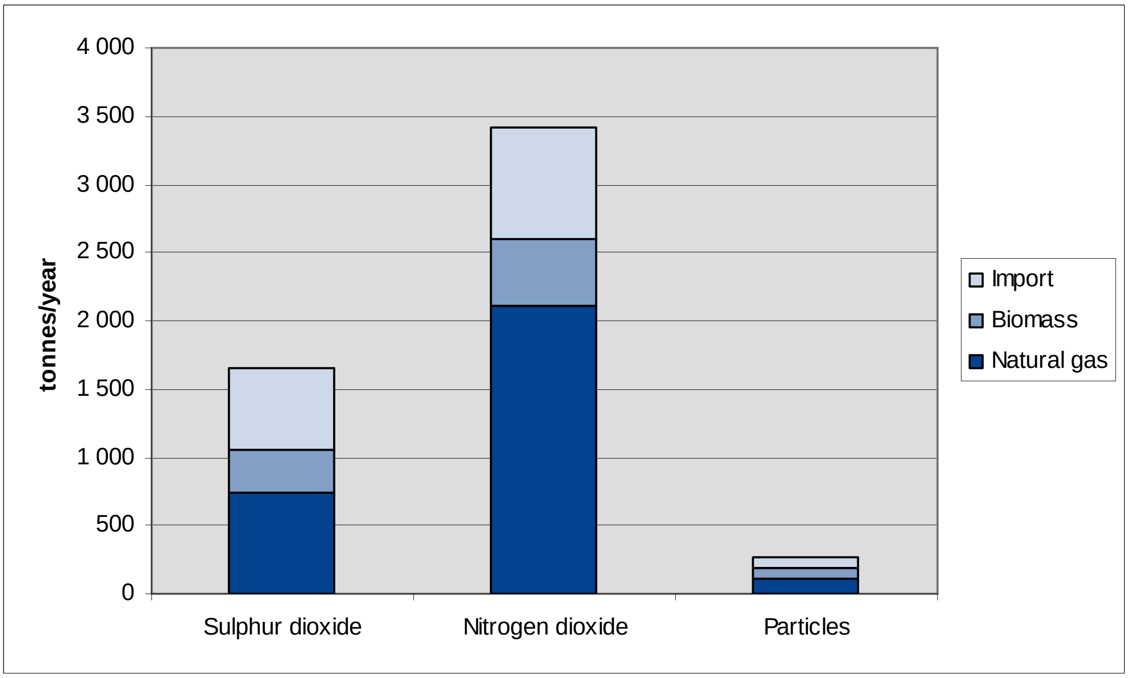


Figure 7.2-4. Avoided emissions (tonnes/year) when NNPP replaces production according to the zero-option (energy amount 24 TWh_e).

Figure 7.2-5 illustrates the carbon dioxide emissions in the zero-option (energy amount 24 TWh_e). Burning of biomass is not considered to produce CO_2 emissions so the emissions from biomass power plants are zero. The total amount of CO_2 produced in the zero-option would be about 5.8 million tonnes of which about 3.8 million would be produced Lithuania. This corresponds to 45 % of Lithuania's total CO_2 emissions from fuel combustion in the energy sector in 2006 (*National Greenhouse Gas Emission Inventory Report, 2008*).

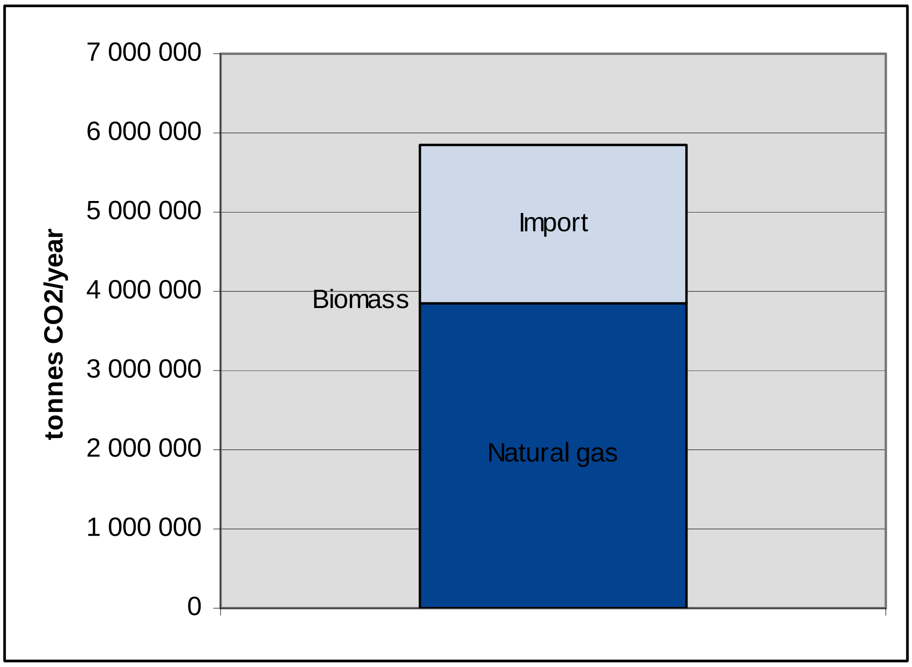


Figure 7.2-5. Carbon dioxide (CO_2) emissions (tonnes/year) in zero-option (energy amount 24 TWh_e).

7.2.2.3 Radiological impact on air

All nuclear power plants during operation cause certain radioactive releases to the atmosphere. Usually, these releases contain noble gases, iodine, aerosols, tritium and carbon-14. According to Lithuanian legislation radioactive materials may be released into the environment only after the permission for discharges of radioactive substances to the environment is obtained. This permission is issued by the Ministry of Environment to the operator of the nuclear installation following the requirements of the normative document LAND 42-2007 "On the Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring" (*State Journal, 2007, No. 138-5693*).

Present radioactive releases into the environment from Ignalina NPP are described in Section 7.2.1.12. Possible gaseous releases from different reactor types are summarized in Table 7.2–15. Data provided in Table 7.2–15 is derived from the design control documentation (DCD) provided for different types of reactors. DCD are freely available on the website of US Nuclear Regulatory Commission (www.nrc.gov). In these design documents radionuclide releases are assessed using numerical methods, making conservative assumptions and taking into account possible radionuclide releases in case of anticipated operational occurrences. As experience of nuclear power plants in different countries shows, actual radionuclide releases into the environment are much lower than conservatively estimated values.

Designers of some reactors provide release data for 70 radionuclides, but the list of radionuclides, given in Table 7.2–15, is compiled on the basis of the document LAND 42-2007, which provides dose conversion factors for radionuclides released into the environment, that were applied in the assessment of the population exposure. The data on the radionuclide releases into the environment used for the development of this EIA report is presented in the appendices of the EIA report. For evaluation of radionuclide releases into the environment the manufacturers of various reactors used computer programs that evaluate a number of nuclides, including radionuclides, which are dominant and constitute the greater part of doses. The nuclide inventory in the normative document LAND 42-2007 was made on the basis of the study “Dose factors for normal operation discharges from Ignalina NPP” (*V. Filistovič, E. Maceika, J. Mažeika et al, 1998*), which in turn had been based on the data on radionuclides produced in light water reactors, presented in the reference book “Radioactive releases in the biosphere” (*Gusev, Belyaev, 1991*). It is mentioned that nuclear reactions in a reactor produce about 600 fission products, the interaction with neutrons generates about 60 actinides; moreover, the activation products are generated as well. From all this extensive list only radionuclides that are dominant and result in the largest and most significant radiological effects are estimated. The lists of airborne and waterborne radioactive releases presented in the normative document LAND 42-2007 include dominant radionuclides, which lead to a significant radiological impact; they are characteristic not only to RBMK, but also to other types as well as models of light water reactors. In case of heavy water reactors, higher tritium releases to the environment are observed, but the dominant fission and activation products are the same as in light water reactors. Therefore the list of nuclides given in the normative document LAND 42-2007 is sufficient for the assessment of releases into the environment from the new NPP. The impact on the air component of the radionuclides not included in the list of LAND 42-2007, but provided in the documentation of some reactor designers, is negligible. As the assessment of the impact on the air component due to the radionuclides not included in the list of LAND 42-2007 shown, in case of the ESBWR reactor it was found (this reactor has details on airborne releases of 68 radionuclides), that the annual dose received by the members of the critical group of the population due to the radionuclides not included in the list of LAND 42-2007 is 5.18×10^{-6} mSv. Meanwhile, the dose due to the radionuclides from the list of LAND 42-2007 is 5.84×10^{-2} mSv.

The airborne releases of radionuclides presented in Table 7.2–15 are from one corresponding reactor model. As already mentioned in the description of the radiological impact on the water component at the beginning of the EIA process the Organizer of the planned economic activity applied to the manufacturers of the reactors, which are considered as technological alternatives in the EIA report, asking to submit information on models of the reactors manufactured by them, as well as on the radionuclide releases into the environment during normal operation. Unfortunately, not all the reactor manufacturers have responded to the request, therefore the detailed data on the radionuclide releases into the environment from the reactor models SWR-1000, WWER/V-392 and WWER/V-448 are not presented in the EIA report. However, based on the data and conclusions presented in the EIA report of the NPP planned to be constructed in Belene (Bulgaria), as well as on the information on the releases from Units 3 and 4 of Cernavoda NPP the assessment summarised the radiological impact of these reactor models as well. The company AECL, the manufacturer of the reactors EC-6 and ACR-1000, presented the data on the radionuclide releases into the environment from CANDU-6 reactor, however, the manufacturer noted that the radionuclide releases from the EC-6 and ACR-1000 reactors would be of comparable level or lower than that of CANDU-6 reactor. It shall also be noted that the data on the airborne releases for inert gas and fission products from CANDU-6 were not presented for a particular nuclide, therefore it was conservatively assumed that total activities of inert gas and fission products is corresponded by Kr-88 and Cs-137, since their dose conversion factors are the highest ones. The average annual airborne radionuclide releases from the WWER reactor, presented in Table 7.2–15, are based on the information on releases from the reactor WWER-1000/V320, given in the EIA report of Belene NPP. The latter reactor and the reactor WWER/V-392 being considered in this EIA report have the same electrical power, so it can be stated that the radionuclide releases into the environment are approximately equal. The electric power of WWER/V-448 reactor is 1365 MW_e, therefore the radionuclide releases will be higher. However, at the new NPP the maximum number of units for this model, not exceeding the total planned electric power of the new NPP, is equal to 2, and in case of WWER/V-392 reactor – to 3. Therefore, the total radionuclide releases from the two units of WWER/V-448 or from the three units of WWER/V-392 will be approximately the same.

The planned economic activity provides for the total electrical capacity of the new NPP units not exceeding 3400 MW. Table 7.2–16 provides the release values calculated for the maximum number of units of the same reactor model. In the discussion of the waterborne releases it was mentioned that the construction of the reactor units only of one model is envisaged. However, the possibility of selection of combination of different reactor models cannot be completely rejected, therefore based on the results of the calculations of the annual doses to the population due to the releases from different reactor models (see Subsection 7.10.2.2), it can be stated that in all cases the radiological impact on the population due to different combinations of the reactor models not exceeding the planned electric power of 3400 MW is lower than due to the four EC-6 units.

Annual exposure of the critical group members of population due to gaseous releases into the environment from different types of power reactors is estimated in Section 7.10.2.2.

Table 7.2–15. Average annual gaseous releases (Bq/year) into environment during normal operation of one reactor Unit.

Type	BWR		PWR					PHWR
Model	ABWR[1]	ESBWR[2]	EPR[3]	APWR[4]	AP-600[5]	AP-1000[6]	WWER[7] (V-392 / V-448)	EC-6 / ACR-1000[8]
Ar-41	2.50E+11	2.85E+08	1.26E+12	1.26E+12	1.26E+12	1.26E+12	1.10E+12	na
Ba-140	1.00E+09	7.82E+08	1.55E+05	1.55E+07	1.55E+07	1.55E+07	na	na
C-14 [9]	3.40E+11	3.54E+11	2.70E+11	2.70E+11	2.70E+11	2.70E+11	7.00E+10	1.05E+12
Ce-141	3.40E+08	2.66E+08	4.81E+05	1.55E+06	1.55E+06	1.55E+06	na	na
Co-58	8.90E+07	3.70E+07	1.78E+07	8.51E+08	8.51E+08	8.51E+08	na	na
Co-60	4.80E+08	3.18E+08	4.07E+06	3.26E+08	3.22E+08	3.22E+08	5.50E+03	na
Cr-51	1.30E+09	7.73E+07	3.59E+06	2.26E+07	2.26E+07	2.26E+07	2.10E+05	na
Cs-134	2.30E+08	1.78E+08	1.78E+06	8.51E+07	8.51E+07	8.51E+07	1.95E+06	na
Cs-136	2.20E+07	1.47E+07	1.22E+06	3.15E+06	3.15E+06	3.15E+06	na	na
Cs-137	3.50E+08	2.69E+08	3.33E+06	1.33E+08	1.33E+08	1.33E+08	4.55E+06	1.50E+07
Cs-138	6.30E+06	8.50E+04	na	na	na	na	na	na
Fe-59	3.00E+07	1.94E+07	1.04E+06	2.92E+06	2.92E+06	2.92E+06	na	na
H-3	2.70E+12	2.80E+12	6.66E+12	6.66E+12	2.85E+12	1.30E+13	1.25E+13	1.18E+14
I-131	9.60E+09	1.51E+10	3.26E+08	1.55E+08	2.44E+09	4.44E+09	3.80E+08	1.90E+08
I-132	8.10E+10	5.89E+10	na	na	na	1.48E+10	8.50E+07	na
I-133	6.30E+10	4.88E+10	1.18E+09	2.37E+09	8.88E+09	1.48E+10	5.50E+08	na
I-134	1.40E+11	1.06E+11	na	na	na	na	4.50E+07	na
I-135	8.90E+10	6.14E+10	na	na	na	na	3.05E+08	na
Kr-85	2.10E+13	4.29E+12	1.26E+15	5.18E+13	8.51E+13	1.52E+14	1.20E+14	na
Kr-85m	7.80E+11	6.50E+11	5.55E+12	na	8.51E+11	1.33E+12	9.50E+11	na
Kr-87	9.30E+11	1.45E+12	1.96E+12	na	3.70E+11	5.55E+11	1.00E+13	na
Kr-88 [9]	1.40E+12	2.18E+12	6.66E+12	na	1.11E+12	1.70E+12	2.50E+13	4.90E+13
Kr-89	8.90E+12	1.40E+13	na	na	na	na	na	na
La-140	6.70E+07	1.29E+06	na	na	na	na	na	na
Mn-54	2.00E+08	1.47E+08	2.11E+06	1.59E+07	1.59E+07	1.59E+07	na	na
Mo-99	2.20E+09	1.66E+09	na	na	na	na	na	na
Na-24	1.50E+08	5.42E+05	na	na	na	na	4.40E+05	na
Nb-95	3.10E+08	2.44E+08	1.55E+06	9.25E+07	9.25E+07	9.25E+07	na	na
Np-239	4.40E+08	8.28E+06	na	na	na	na	na	na
Pr-144	7.00E+05	1.35E+04	na	na	na	na	na	na
Rb-89	1.60E+06	2.01E+04	na	na	na	na	na	na

Type	BWR		PWR					PHWR
Model	**ABWR[1]**	**ESBWR[2]**	**EPR[3]**	**APWR[4]**	**AP-600[5]**	**AP-1000[6]**	**WWER[7] (V-392 / V-448)**	**EC-6 / ACR-1000[8]**
Ru-103	1.30E+08	1.04E+08	6.29E+05	2.96E+06	2.96E+06	2.96E+06	na	na
Ru-106	7.00E+05	1.35E+04	2.89E+04	2.89E+06	2.89E+06	2.89E+06	na	na
Sr-89	2.10E+08	1.48E+08	5.92E+06	1.11E+08	1.11E+08	1.11E+08	na	na
Sr-90	2.60E+06	7.65E+05	2.33E+06	4.44E+07	4.44E+07	4.44E+07	na	na
Sr-91	3.70E+07	6.72E+05	na	na	na	na	na	na
Te-132	7.00E+05	1.41E+04	na	na	na	na	1.55E+06	na
Xe-131m	1.90E+12	1.10E+11	1.30E+14	9.62E+12	4.07E+13	6.66E+13	na	na
Xe-133	8.90E+13	3.11E+13	3.18E+14	na	1.04E+14	1.70E+14	6.00E+14	na
Xe-133m	3.20E+09	8.59E+07	6.66E+12	7.40E+10	1.96E+12	3.22E+12	na	na
Xe-135	1.70E+13	2.43E+13	4.44E+13	7.40E+10	8.14E+12	1.22E+13	9.00E+12	na
Xe-135m	1.50E+13	2.27E+13	5.18E+11	1.48E+11	1.48E+11	2.59E+11	1.25E+11	na
Xe-137	1.90E+13	2.90E+13	na	1.48E+11	na	na	na	na
Xe-138	1.60E+13	2.32E+13	4.44E+11	3.70E+10	1.11E+11	2.22E+11	6.55E+10	na
Zn-65	4.10E+08	2.80E+08	na	na	na	na	na	na
Zr-95	5.90E+07	4.49E+07	3.70E+05	3.70E+07	3.70E+07	3.70E+07	na	na
Total	1.95E+14	1.56E+14	1.78E+15	7.01E+13	2.46E+14	4.23E+14	7.79E+14	1.68E+14
RNG	1.91E+14	1.53E+14	1.78E+15	6.32E+13	2.43E+14	4.09E+14	7.66E+14	4.90E+13
Aerosols	3.48E+11	3.59E+11	2.70E+11	2.72E+11	2.72E+11	2.72E+11	7.00E+10	1.05E+12

na – information about activity of released nuclide is not provided in the freely available reactor suppliers documents or other information sources

[1] - http://www.nrc.gov/reactors/new-reactors/design-cert/abwr.html

[2] - http://www.nrc.gov/reactors/new-reactors/design-cert/esbwr.html

[3] - http://www.nrc.gov/reactors/new-reactors/design-cert/epr.html

[4] - http://www.nrc.gov/reactors/new-reactors/design-cert/apwr.html

[5] - AP600 Design Control Document, Chapter 11, Section 11.3, "Gaseous Waste Management System." / Accession Number ML003691385 (http://www.nrc.gov)

[6] - http://www.nrc.gov/reactors/new-reactors/design-cert/ap1000.html

[7] - Belene NPP Environmental Impact Assessment Report BNPP-EIA-PEC-NEK-0001-E3

[8] - TQ AECL, 2008 (data is provided for CANDU-6 reactor, however according to the AECL (producer of this reactor) information releases from EC-6 and ACR-1000 will be similar or smaller)

[9] – Environmental Impact Assessment Report of Černavoda Unit 3 and 4. http://www.nuclearelectrica.ro/page.php?pid=70

Table 7.2–16. Annual average airborne radionuclide releases (Bq/year) during the operation of the maximal number of units of corresponding reactor model

Model	ABWR	ESBWR	EPR	APWR	AP-600	AP-1000	WWER (V-392 / V-448)	EC-6 / ACR-1000
Power of Unit, MWe	1300	1535	1660	1700	600	1100	995 / 1365	750 / 1085
Nb. of Units	2	2	2	2	5	3	3 / 2	4 / 3
Ar-41	5.00E+11	5.70E+08	2.52E+12	2.52E+12	6.29E+12	3.78E+12	3.30E+12	na
Ba-140	2.00E+09	1.56E+09	3.10E+05	3.10E+07	7.77E+07	4.65E+07	na	na
C-14	6.80E+11	7.08E+11	5.40E+11	5.40E+11	1.35E+12	8.10E+11	2.10E+11	4.20E+12
Ce-141	6.80E+08	5.32E+08	9.62E+05	3.10E+06	7.77E+06	4.65E+06	na	na
Co-58	1.78E+08	7.40E+07	3.56E+07	1.70E+09	4.26E+09	2.55E+09	na	na
Co-60	9.60E+08	6.36E+08	8.14E+06	6.52E+08	1.61E+09	9.66E+08	1.65E+04	na
Cr-51	2.60E+09	1.55E+08	7.18E+06	4.52E+07	1.13E+08	6.78E+07	6.30E+05	na
Cs-134	4.60E+08	3.56E+08	3.56E+06	1.70E+08	4.26E+08	2.55E+08	5.85E+06	na
Cs-136	4.40E+07	2.94E+07	2.44E+06	6.30E+06	1.57E+07	9.45E+06	na	na
Cs-137	7.00E+08	5.38E+08	6.66E+06	2.66E+08	6.66E+08	3.99E+08	1.37E+07	6.00E+07
Cs-138	1.26E+07	1.70E+05	na	na	na	na	na	na
Fe-59	6.00E+07	3.88E+07	2.08E+06	5.84E+06	1.46E+07	8.76E+06	na	na
H-3	5.40E+12	5.60E+12	1.33E+13	1.33E+13	1.42E+13	3.90E+13	3.75E+13	4.72E+14
I-131	1.92E+10	3.02E+10	6.52E+08	3.10E+08	1.22E+10	1.33E+10	1.14E+09	7.60E+08
I-132	1.62E+11	1.18E+11	na	na	na	4.44E+10	2.55E+08	na
I-133	1.26E+11	9.76E+10	2.36E+09	4.74E+09	4.44E+10	4.44E+10	1.65E+09	na
I-134	2.80E+11	2.12E+11	na	na	na	na	1.35E+08	na
I-135	1.78E+11	1.23E+11	na	na	na	na	9.15E+08	na
Kr-85	4.20E+13	8.58E+12	2.52E+15	1.04E+14	4.26E+14	4.56E+14	3.60E+14	na
Kr-85m	1.56E+12	1.30E+12	1.11E+13	na	4.26E+12	3.99E+12	2.85E+12	na
Kr-87	1.86E+12	2.90E+12	3.92E+12	na	1.85E+12	1.67E+12	3.00E+13	na
Kr-88	2.80E+12	4.36E+12	1.33E+13	na	5.55E+12	5.10E+12	7.50E+13	1.96E+14
Kr-89	1.78E+13	2.80E+13	na	na	na	na	na	na
La-140	1.34E+08	2.58E+06	na	na	na	na	na	na
Mn-54	4.00E+08	2.94E+08	4.22E+06	3.18E+07	7.96E+07	4.77E+07	na	na
Mo-99	4.40E+09	3.32E+09	na	na	na	na	na	na
Na-24	3.00E+08	1.08E+06	na	na	na	na	1.32E+06	na
Nb-95	6.20E+08	4.88E+08	3.10E+06	1.85E+08	4.63E+08	2.78E+08	na	na

Model	ABWR	ESBWR	EPR	APWR	AP-600	AP-1000	WWER (V-392 / V-448)	EC-6 / ACR-1000
Power of Unit, MWe	1300	1535	1660	1700	600	1100	995 / 1365	750 / 1085
Nb. of Units	2	2	2	2	5	3	3 / 2	4 / 3
Np-239	8.80E+08	1.66E+07	na	na	na	na	na	na
Pr-144	1.40E+06	2.70E+04	na	na	na	na	na	na
Rb-89	3.20E+06	4.02E+04	na	na	na	na	na	na
Ru-103	2.60E+08	2.08E+08	1.26E+06	5.92E+06	1.48E+07	8.88E+06	na	na
Ru-106	1.40E+06	2.70E+04	5.78E+04	5.78E+06	1.44E+07	8.67E+06	na	na
Sr-89	4.20E+08	2.96E+08	1.18E+07	2.22E+08	5.55E+08	3.33E+08	na	na
Sr-90	5.20E+06	1.53E+06	4.66E+06	8.88E+07	2.22E+08	1.33E+08	na	na
Sr-91	7.40E+07	1.34E+06	na	na	na	na	na	na
Te-132	1.40E+06	2.82E+04	na	na	na	na	4.65E+06	na
Xe-131m	3.80E+12	2.20E+11	2.60E+14	1.92E+13	2.04E+14	2.00E+14	na	na
Xe-133	1.78E+14	6.22E+13	6.36E+14	na	5.18E+14	5.10E+14	1.80E+15	na
Xe-133m	6.40E+09	1.72E+08	1.33E+13	1.48E+11	9.81E+12	9.66E+12	na	na
Xe-135	3.40E+13	4.86E+13	8.88E+13	1.48E+11	4.07E+13	3.66E+13	2.70E+13	na
Xe-135m	3.00E+13	4.54E+13	1.04E+12	2.96E+11	7.40E+11	7.77E+11	3.75E+11	na
Xe-137	3.80E+13	5.80E+13	na	2.96E+11	na	na	na	na
Xe-138	3.20E+13	4.64E+13	8.88E+11	7.40E+10	5.55E+11	6.66E+11	1.97E+11	na
Zn-65	8.20E+08	5.60E+08	na	na	na	na	na	na
Zr-95	1.18E+08	8.98E+07	7.40E+05	7.40E+07	1.85E+08	1.11E+08	na	na
Total	3.89E+14	3.13E+14	3.56E+15	1.40E+14	1.23E+15	1.27E+15	2.34E+15	6.72E+14
RNG	3.82E+14	3.06E+14	3.55E+15	1.26E+14	1.22E+15	1.23E+15	2.30E+15	1.96E+14
Aerosols	6.96E+11	7.17E+11	5.40E+11	5.43E+11	1.36E+12	8.15E+11	2.10E+11	4.20E+12

As in case of the waterborne radionuclide releases, the values of radionuclide activity, estimated by the calculation methods, are usually higher by an order or more than the actual values, measured during the operation of a NPP. For example, based on the actual data for the period of 2004-2006 on the average annual airborne radionuclide releases from two existing nuclear power plants in Finland (*STUK 2005, STUK 2006, STUK 2007*), presented in Table 7.2–17, annual releases of inert radioactive gases and iodine amounted to thousandths of the maximum permitted release values defined for the sites, which were calculated taking into account the dose constraint 0.1 mSv per year adopted in Finland.

Table 7.2–17. Average annual radioactive airborne releases (MBq/year) from two Finnish NPPs during 2004-2006 and site specific limit values

Releases to air	Loviisa 1 & 2 2x860 MW PWR	Limit	Olkiluoto 1 & 2 2x860 MW BWR	Limit
RNG	6.47×10^{12}	2.20×10^{16}	4.00×10^{11}	1.77×10^{16}
Iodine	3.79×10^{6}	2.20×10^{11}	1.35×10^{8}	1.14×10^{11}

7.2.3 Mitigation measures

Non-radiological mitigation measures

Dusting caused by traffic can be reduced by paving the roads that are leading to the site. Also reduction of speed limits on dirty roads and work sites as well as cleaning the roads regularly will reduce dust emissions.

The amount of commuting cars during construction can be reduced by organizing accommodation areas for construction workers near to the site so that they don't need daily transportation.

Radiological mitigation measures

The collection and releases of gaseous radioactive materials is made via the ventilation system of the NNPP. In principle the ventilation system is designed so that the air circulation is carried out from low contamination areas to high contamination areas and finally, after filtering, the air is exhausted through a ventilation stack to the atmosphere. Certain height of the stack provides a better dispersion of the released radioactive isotopes. This results in the reduction of their concentration in the air and the radiation dose for the public due to the releases is less.

Typical technical measures installed in a NPP for the mitigation of radiological impacts due to gaseous releases are as follows:

- Gaseous radioactive releases via stack are continuously monitored for radioactive aerosols, radioactive iodine, noble gases, tritium, carbon-14;
- Filtering of exhaust air. There are different filtering stages:
  - High-efficiency filtering for retaining the contaminant particles;
  - Retention of the radioactive iodine existing in the contaminated air;
  - Retention of the possible active coal particles driven by the air stream.
- Periodical inspection and maintenance of components of the ventilation system.

The actual impact mitigation measures will be analyzed and justified in the Safety Analysis Report considering Technical Design aspects.

7.3 GROUNDWATER

7.3.1 Present state of the environment

7.3.1.1 The new NPP site No. 1

In the new NPP site No. 1 (Figure 7.3-1) the first hydrogeological zone from the earth surface is the unsaturated zone, the thickness of which is up to 8.7 m (*Hidroprojektas Report, 2006a; Hidroprojektas Report 2006b*). This zone is composed of various Quaternary deposits and sediments. The prevailing deposits in the site are sandy and clayey loam (till) characterized by different hydraulic properties (Table 7.3–1).

Figure 7.3-1. Alternative sites (1 and 2) for the new NPP with locations of boreholes. The blue dots represent geological-hydrogeological boreholes and the brown dots represent geotechnical boreholes.

Table 7.3–1. Hydraulic conductivity of unsaturated soil estimated *in situ* (by water level drawdown in infiltrometer).

No	Place	Date	Depth, m	Hydraulic conductivity, m/d
1	Excavation No 1 close to borehole No 1	2006-08-27	0.3	0.14
2	Excavation No 2 close to borehole No 1	2006-08-28	0.3	0.45
3	Excavation No 2 close to borehole No 2	2006-08-28	0.3	0.44
4	Excavation No 1 close to borehole No 3	2006-08-26	0.3	0.24

No	Place	Date	Depth, m	Hydraulic conductivity, m/d
5	Excavation No 1 close to borehole No 4	2006-08-23	0.2	0.06
6	Excavation No 2 close to borehole No 4	2006-08-04	0.5	0.08
7	Excavation No 1 close to borehole No 5	2006-08-25	0.3	0.34

Bog deposits (peat) are distributed locally in lowest landscape depressions close to the north-eastern margin of the site. In this area the groundwater level merges with surface water level in local wetland and the unsaturated zone forms only temporarily in summer dry-time. In general the thickness of the unsaturated zone reduces towards north – north-east.

Other hydrogeological bodies of the site are distinguished and characterized according to the data from borehole No.1, which is located in the central part of the site (Figure 7.3-1).

Unconfined groundwater is spread in the entire area of the site and is related to several lithological layers – peat in small spots, sand and sandy loam in prevailing area of the site. Groundwater is mostly spread in interlayers of glaciofluvial and glaciolacustrine sand and gravel, located in the first from the top till body (marginal till of last glaciation, which is locally named Baltic glacial). These aquiferous layers are in the interval of 0.8 m until 24 meter depth. Groundwater flow direction is to the north and north-east towards Lake Druksiai. Annual amplitude of groundwater level range is 1.5 – 2.0 m, the highest water level is in the months of December-February and the lowest in July–August. Hydraulic characteristics of water permeable layers depend on soil matrix composition. Based on pumping tests the hydraulic conductivity of different deposits is as follows: fine silty sand – $2.3 \cdot 10^{-6}$–$6.9 \cdot 10^{-6}$ m/s; fine sand – $1.9 \cdot 10^{-5}$–$2.8 \cdot 10^{-5}$ m/s; coarse sand with gravel – $5.6 \cdot 10^{-5}$–$1.3 \cdot 10^{-5}$ m/s; gravel – $9.1 \cdot 10^{-5}$–$1.9 \cdot 10^{-5}$ m/s. The groundwater is of calcium-magnesium bicarbonate type, according to carbon acid content weakly aggressive for concrete.

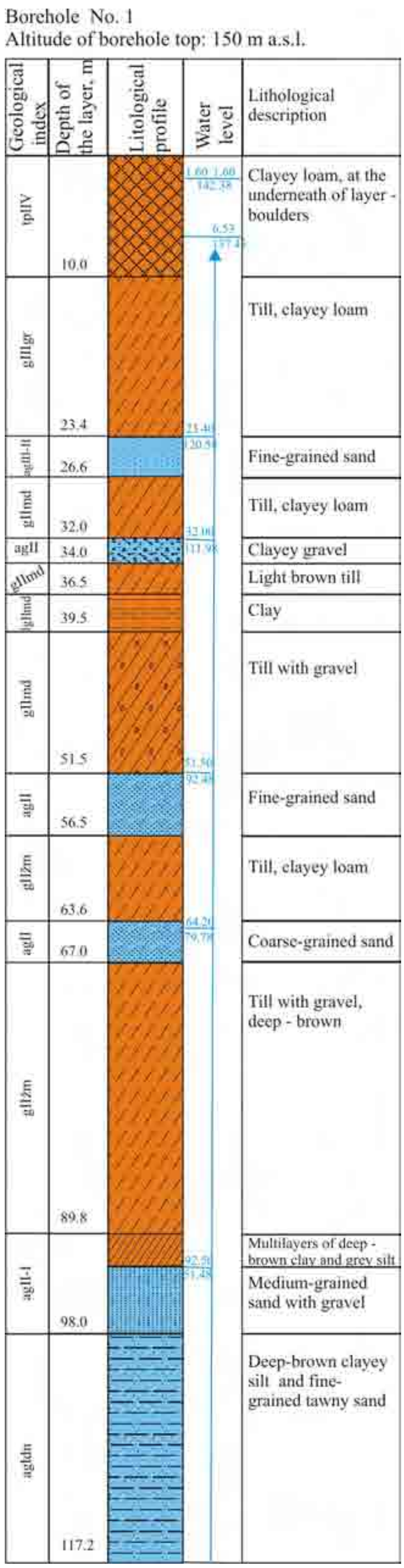


Figure 7.3-2. Generalized (simplified) hydrological section of the new NPP alternative site No. 1 (in blue – confined aquifers, in brown – confining layers).

Confined aquifers are separated from unconfined groundwater by till layers with low and very low permeability. The hydraulic conductivity of confining tills (clayey loam and sandy loam) are varying from $3{\cdot}10^{-9}$ up to $9{\cdot}10^{-9}$ m/s. Therefore, even taking into consideration inhomogeneities of layers, they may be considered as soil of very low permeability (aquitards) with a hydraulic conductivity of 10^{-8} m/s.

At the site a more detailed analysis was carried out for three Quaternary confined aquifers which are from the surface: first aquifer aqIII-II (attributed to intertill deposits that a named in local stratigraphical scheme as Gruda–Medininkai), second aquifer aqII (Medininkai–Zemaitija) and third aquifer aqII-I (Zemaitija–Dainava) (Table 7.3–2).

Table 7.3–2. Hydraulic conductivity of aquifers estimated by pumping tests.

Bore-hole No	Aquifer	Lithology	Aquifer screening interval (filter length), m	Hydraulic conductivity K based on pumping test, m/day		Averaged K value, m/day
				Drawdown of water level	Rise of water level	
1	Devonian	Fine sand	131-136 (5)	19.1	28.0	23.6
2	Quaternary (agII)	Medium coarse sand, silty	62-65 (3)	3.5	4.5	4.0
3	Quaternary (agII)	Medium coarse sand, very clayey	50-53 (3)	0.4	0.5	0.45
4	Quaternary (agII)	Medium coarse sand, silty	54-57 (3)	0.8	0.8	0.8
5	Quaternary (agII)	Medium coarse sand	31-34 (3)	15.1	10.9	13.0

The first confined aquifer (aqIII-II) is spread in the entire site and is attributed to the layers of fine sand with gravel. Prevailing altitude of the aquifer is at about 130 m a.s.l. The hydraulic head is up to 15 m above the top of the aquifer. Main direction of groundwater flow is from south to north; groundwater discharges in Lake Druksiai. Content of TDS in groundwater is 0.2–0.4 g/l. Groundwater is of magnesium-calcium bicarbonate type, according to carbon acid content it is not aggressive to concrete. Yield of pumping wells is 8–9 l/s, specific yield – 0.1–1.2 l/s.

The second confined aquifer (aqII) is spread almost throughout the entire site and is composed of coarse sand. Its thickness is about 3 m. Highest altitude of hydraulic head of this aquifer is in the southern part and the lowest in the northern part of the territory. This shows that the main direction of groundwater flow is from south to north towards Daugava River, which is the discharge area of the aquifer. Hydraulic conductivity of the aquifer ranges from $8.4\cdot10^{-6}$ to $1.5\cdot10^{-4}$ m/day, hydraulic transmissivity ranges from $2.5\cdot10^{-4}$ to $2.9\cdot10^{-3}$ m^2/s. Groundwater is of calcium-magnesium bicarbonate type, content of TDS in groundwater is 0.2–0.4 g/l. The features of other Quaternary confined aquifers are similar. Usually they are spread only in palaeoincisions.

7.3.1.2 The new NPP site No. 2

In the new NPP site No. 2 (Figure 7.3-1) the first hydrogeological zone from the earth surface is the unsaturated zone, the thickness of which is up to 13 m (*Report No. 33978DSP, 1986; Hidroprojektas Report, 2006c*). This zone is composed of various Quaternary deposits and sediments. The prevailing deposits in the site are peat, sandy and clayey loam (till) characterized by different hydraulic properties as indicated in Table 7.3–1.

Bog deposits (peat) occur in the western part of the site and occupy almost half of the site area. In this area the groundwater level merges with the surface water level in local wetland and the unsaturated zone forms only temporarily during dry summer time. In general the thickness of the unsaturated zone reduces to the north – north-west towards

Lake Druksiai and a wetland which in Holocene time was a bay of Lake Druksiai. Surface altitude at the bog area is 143–144 m, and in the other parts 143–153 m.

Other hydrogeological bodies of the site are distinguished and characterized according to the data from boreholes No. 3-R and 20627 (Figure 7.3-3), which are located in the eastern part of the site (Figure 7.3-1).

Unconfined groundwater is spread in the entire area of the site and is related to several lithological layers – peat in the western part, sand and sandy loam in the remaining area of the site. In the bog sediments (bIV) the level of groundwater depends on the amount of precipitation. The peat is well or medium decomposed. The thickness of the peat layer varies from 0.1 to 8.6 m. There is often technogenic soil above the bog sediments. Lacustrine sediments (lIV), the thickness of which is 0.5–2.9 m, are also spread in the western part of the site and occur under bog deposits. Lacustrine sediments consist of sandy loam with organic matter, clayey loam and gray sand.

Groundwater in the site is mostly spread in interlayers of glaciofluvial and glaciolacustrine sand and gravel, located in the first from the top till body (marginal till of last glaciation, which is locally named Baltic glacial). The thickness of these aquiferous layers is from several centimetres to 3 m in the south-eastern part of the site. Groundwater flow direction is to the north and north-west towards Lake Druksiai. Annual amplitude of groundwater level variation is 1.5–2.0 m, the highest water level occurs in the months of December-February and the lowest in July–August. Hydraulic characteristics of water permeable layers depend on soil matrix composition and are similar to that of site No 1. The groundwater is of calcium-magnesium bicarbonate type, according to carbon acid content weakly aggressive for concrete.

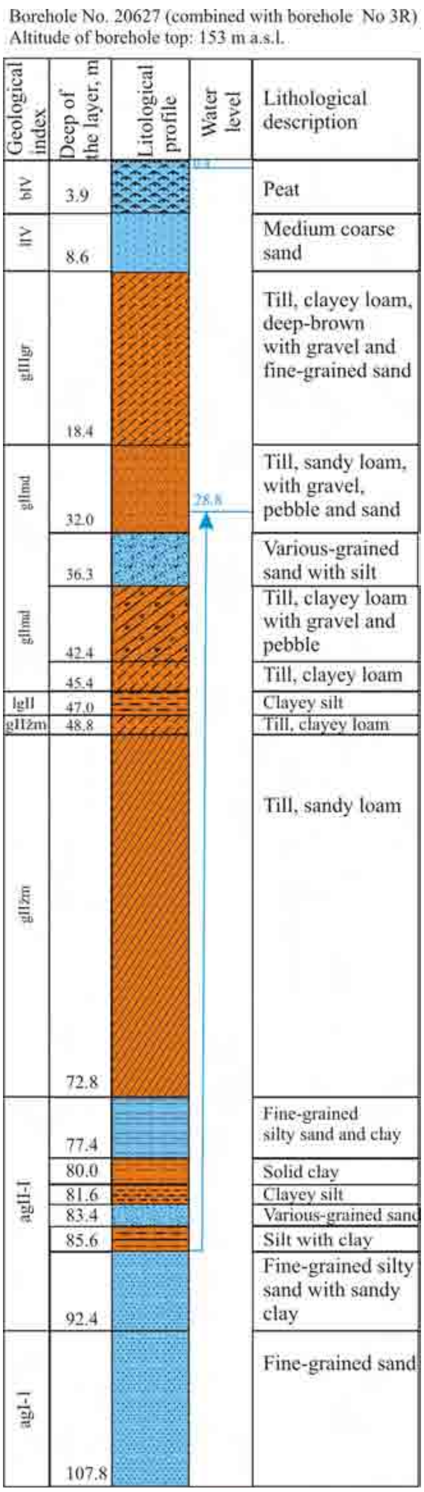


Figure 7.3-3. Generalized (simplified) hydrological section of the new NPP alternative site No. 2 (blue – aquifers, brown – confining layers).

Confined aquifers are separated from unconfined groundwater by till layers with low and very low permeability. The hydraulic conductivity of confining till (clayey loam and sandy loam) varies from $3{\cdot}10^{-9}$ up to $9{\cdot}10^{-9}$ m/s. Therefore, even taking into consideration differences between the layers, they may be considered as soil of very low permeability (aquitards) with a hydraulic conductivity of 10^{-8} m/s.

In the site No 2 the first aquifer (aqIII-II), which was observed in the site No 1, is not present. This aquifer is spread westwards behind the limits of site No 2 and its thickness increases westwards. Three confined Quaternary aquifers are distinguished at the site:

first aquifer aqII (attributed to intertill deposits that a named in local stratigraphical scheme as Medininkai–Zemaitija), second aquifer aqII-I (Zemaitija–Dainava) and third aquifer aqI-1 (Dainava–Dzukija). In palaevalleys, which are spread westward from the site, also the aquifer aqI-2 (underlayered till body Dzukija) occurs.

The first confined aquifer (aqII) is spread in the entire site and is attributed to the layers of sand with gravel. Its thickness is 3–40 m. Prevailing altitude of the aquifer is at about 120 m a.s.l. The hydraulic head is up to 20 m above the top of the aquifer and water level sets up at the depth of 10–12 m from the earth surface. Groundwater flow direction is from south to north; discharge area of the aquifer is the Valley of Daugava River. Hydraulic conductivity ranges from $8.4 \cdot 10^{-6}$ to $3.2 \cdot 10^{-4}$ m/s, hydraulic transmissivity – $2.5 \cdot 10^{-4}$–$2.9 \cdot 10^{-3}$ m^2/s. Content of TDS in groundwater is 0.2–0.4 g/l. Groundwater is of magnesium-calcium bicarbonate type.

The features of other deeper laying aquifers are similar and less characterized. Usually deeper Quaternary aquifers are spread only in palaeoincisions where they may make up to 100–200 m thick aquifer systems composed of various sand, gravel and pebble. Hydraulic conductivity of the aquifer aqII-I ranges from 0.8 to 4.8 m/day. Content of TDS in groundwater is 0.2–0.4 g/l. Groundwater is of magnesium-calcium bicarbonate type.

7.3.2 Assessment of impacts on groundwater

The alternative sites (No. 1 and 2) are practically equal in sense of the groundwater characteristics. Possible impacts will therefore be discussed together for both sites in the following chapters.

Unconfined groundwater: Most important natural factors affecting the shallow unconfined groundwater vulnerability are the following: composition and thickness of the unsaturated zone, hydraulic and sorption properties of unsaturated soil, sources, rate and seasonal distribution of infiltration recharge. It is generally assumed that in the case of lower hydraulic conductivity of unsaturated soil and the deeper groundwater table the shallow groundwater vulnerability is based on surface contamination. Taking this into consideration it may be stated that shallow unconfined groundwater in both sites is weakly protected from surface contamination and has potential risk to be impacted by the new nuclear power plant construction and operation.

However, during the entire INPP operation period no cases of radionuclides originating from INPP spreading in groundwater close to the industrial site have been established. Only the mobile radionuclides ^{3}H and ^{14}C have been recorded in groundwater of the site of INPP (in the closed industrial area). Effective doses due to these events are lower than the dose constraint (*Mazeika, 2002*). Gamma ray emitting radionuclides in groundwater can hardly be detected even in sites close to the radioactive waste storage area. Sometimes traces of ^{137}Cs, ^{60}Co and ^{54}Mn are detected in groundwater. Based on INPP operation there is no expected significant impact even on shallow unconfined groundwater, however, taking into account the high vulnerability of shallow unconfined groundwater a early warning groundwater monitoring system should be installed.

Confined aquifers: Vulnerability of confined aquifers depends on the thickness of confining layers (aquitards) and on the water travel time from recharge point to point of interest.

Within a radius of 15 km from the sites for the new NPP, within the territory of Lithuania, there are five aquifers that could be used for centralized water supply. Two main aquifers for water supply are the Quaternary aquifer aqII (attributed to intertill deposits) and the Devonian aquifer (D_3+D_2).

The most important of them is the Devonian aquifer which is used for centralized water supply for Visaginas town and for the needs of INPP. The average groundwater extraction rate from the Visaginas water field is about 8 800 m^3/day. The new NPP site No. 1 is located at 1 km distance from the 3rd sanitary protection zone of Visaginas water field. The south-western part of the new NPP site No 2 is contiguous with the 3rd sanitary protection zone of Visaginas water field. Besides Visaginas water field, within the radius of 15 km, about 30 separate operational wells for water supply of small settlements and private entities are operated. Groundwater extraction rates from them are mostly only up to 10 m^3/day. All separate operational wells installed in the Quaternary and Devonian aquifers are located further from the surroundings of the new NPP than Visaginas water field.

Within a radius of 10 km from the sites for the new NPP at the territory of Belarus there are no water fields for centralized water supply. Within the radius of 10 km from the sites for the new NPP, in Belarus, seven separate groundwater extraction wells are operated. In the territory within the radius of 30 km from the new NPP sites, about 50 separate operational wells for groundwater extraction are operated.

Within a radius of 10 km from the sites for the new NPP within the territory of Latvia, there are no water fields for centralized water supply; likewise, there are no separate operational wells for groundwater extraction. In the territory of Latvia within a radius of 30 km from the surroundings of the new NPP, about 50 separate operational wells for groundwater extraction are operated.

The groundwater of the Devonian aquifer system, which supplies for the needs of Visaginas town and INPP, is at a distance of 4 km from the sites. This aquifer system is of very low vulnerability from surface contamination. This was assessed by modelling methods (*"Vilniaus hidrogeologija" Report, 2003*) that showed that water particles from the nuclear area could never travel to the aquifer in Visaginas water field in not disturbed (natural) groundwater flow conditions; if the groundwater extraction rate from the aquifer in the water field area is very high (40 000 m^3/day), the particle travel time from the nuclear area takes 300–400 years (*Jakimaviciute et al., 1999*). This period is considerably longer than the time of NNPP operation even based on a conservative approach (very high groundwater extraction rate).

Confined aquifer attributed to Quaternary silty and sandy deposits is well protected from any contamination including chemical one. Potential risk of contamination is peculiar to shallow unconfined groundwater, but it will be excluded by technical means preventing from surface and soil contamination. Groundwater protection will be ensured by an early warning groundwater monitoring system. The groundwater of the Devonian aquifer system which is used for the water supply in the region is very well protected from the surface contamination and can not be affected by any kind of contamination. This was assessed by modelling methods and results were presented in scientific papers.

Based on this all confined aquifers have no risk of being impacted by construction or operation of the new nuclear power plant. This is also supported by the experiences from INPP operation and therefore impacts on confined aquifers are not expected. Both sites are therefore considered suitable for construction and operation of the new NPP from groundwater point of view.

7.3.3 Mitigation measures

The potential risks for contamination of groundwater and water wells will be prevented by applying the technically best practises during both the construction and operation phases of the new plant. This will be done both by minimising the risk for leakages or other contamination as well as by installing an early warning system.

There are several suitable technical solutions for groundwater protection. During the construction and operation of the new NPP all potential sources of harmful substance leaks (e.g. oil containers, transformers etc.) will be constructed into secondary protection basins. The contamination of the groundwater will be prevented by leading all the surface and groundwaters from the constructed area to the drainage system. Also the groundwater level around the deep reaching structures will be permanently lowered to prevent possible contamination of surrounding groundwater.

An early warning groundwater monitoring system can be installed. This system should be implemented according to groundwater monitoring programs for each 3-5 years based on the Lithuanian normative document (*State Journal, 200, Nr. 101-4578*). This system shall include unconfined groundwater aquifer and may be first from top confined aquifer.

7.4 SOIL

7.4.1 Present state of the environment

According to Lithuanian Hygiene Standard HN 60:2004 (*State Journal, 2004, No. 41-1357*) fertile soil is defined as an upper loose layer of earth crust, which is formed from the native rock under influence of soil formation processes (a complex of impacts from water, air, bio organisms) and is characterized by its potential productivity. The territory of the new NPP area has been affected in the past because of industrial activity (INPP). The construction of the INPP Unit 3 was started at the end of the 1980´s. Construction materials and some equipment foreseen for INPP Unit 4 have been stored at Site alternative No. 1. Now the structures of INPP Unit 3 have been dismantled, the uncompleted buildings have been demolished and the stored materials have been taken away. Recently the territory was levelled and covered with man-made soil, thus natural fertile soil in this area is almost totally absent.

According to the Technical Construction Regulation STR 1.04.02:2004 (*State Journal, 2004, No. 25-779*) soil is defined as naturally or artificially compacted or loosened sediments, deposits or other type of the earth particles, and this naturally or artificially formed layer is an object of investigation, evaluation and application for construction purposes – as a foundation for existing or projected building or underground medium of the construction; or as an object of underground construction activities or ground construction; or as medium of the geological events and processes important for construction activities.

The natural fertile soil was not investigated at the alternative sites for the NNPP. It could be described only according to regional mapping and investigations. Eutric podzoluvisoils (PDe) and haplic arenosoils (ARh) are characteristic to the area of Ignalina NPP *(Kadunas et al., 1999)*. Eutric podzoluvisoils have been formed above the glacial loamy and clayey sediments. Haplic arenosoils are sandy. Terric histosoils (HSs) are characteristic for the wet areas. Loamy and clayey soils are about 2 g/cm³ dense. The density of sandy soils is about 1.2 g/cm³. Terric histosoils are looser (density is about 1.1 g/cm³).

Generally the topsoil of Eastern Lithuania is relatively infertile and has low humus content (about 1–2 %). Histosoils are an exception and have higher humus content. The pH value is about 6.4 in sandy soil, 7.4 in loamy soil and about 6.5 in peaty soil. Land and soils have not been used for agriculture in the vicinity of Ignalina NPP. Topsoil usually contains similar chemical components as the sediments of soil matrix. The mineral part comes to the soil from the soil matrix and comprises more than 90 % of soil weight. Chemical elements occur in different compounds in the topsoil. The organic part comprises less than 10 % of soil weight and consists of vegetative and animal leftovers, humus. Humus contains specific groups of organic compounds – humic acid, fulvic acid, humatic melanin acid, bitumen, vax, resin, lipoids. Phosphorus, potassium, nitrogen, sulphur and calcium are the most important elements in the mineral part of the soil. Background content of trace elements according to the Geochemical atlas of Lithuania *(Kadunas et al., 1999)* is presented in Table 7.4–1.

Table 7.4–1. Content of trace elements in the soil of NNPP region.

Trace element	Content in different types of soil, ppm		
	Sandy	Loamy	Peaty
Ag	0.065	0.064	0.058
As	2.8	3.7	1.7
B	27.2	32.7	19.8
Ba	291	370	231
Co	4.4	6.0	3.3
Cr	24.2	42.5	20.5
Cu	6.5	11.3	8.7
Ga	5.1	7.5	4.0
Y	20.7	28.8	16.4
Yb	2.5	2.4	2.5
La	18.2	26.5	19.2
Li	10.7	16.3	7.5
Mn	502	600	466
Mo	0.65	0.8	0.71
Nb	14.5	13.6	9.8
Ni	10.1	16.9	11.9
P	598	527	680
Pb	14.8	14.6	18.1
Rb	58	76.6	38.5
Sc	2.5	7.7	4.2
Sn	1.3	2.3	1.1
Sr	68.3	91.2	67.6
Th	4.2	7.5	3.8
Ti	1916	3075	1870
U	1.7	3.0	1.4
V	27.5	45.3	31.4
Zn	24.7	32.9	29.4
Zr	282	363	192

Water in the topsoil can occur in 4 forms. The first form is hygroscopic water which is caged by soil particles and can be removed only by heating (till 100 °C). The second form is filmy water (semi combined). It occurs around the soil particles and migrates very slowly. Plants can hardly reach this water. The third form is capillary water which occurs in very thin cracks of the soil. The last fourth form is gravitational water which can fill all the openings in the soil and which migration is affected by gravitation. Vertical moisture migration in the soil causes the possibility for different substances from the land surface to reach the underground. Moisture content in the soil and its plasticity is presented in the Table 7.4–2.

The new NPP sites are almost totally covered by man-made soil (tplIV). There are only a few locations at Site No. 2 where the natural fertile soil still remains. At locations of former buildings there are a lot of technogenic formations (tIV) consisting of construction scrap and abandoned underground communication cables. Man-made soil consists of clayey loam with pebble and gravel, sand at places with organic remains. Layer thickness is 2–10 m (*UAB "Hidroprojektas", 2006*).

Table 7.4–2. Moisture content and plasticity of man made soils at the proposed sites.

Lithology	Moisture content	Liquid limit	Plastic limit	Plasticity index	Liquidity index
	w_n	wL	wp	Ip	I_L
Silty clay	0.166	0.316	0.147	0.169	0.112
Clay loam	0.151	0.263	0.133	0.130	0.138
Clay loam	0.151	0.265	0.130	0.135	0.156
Sandy and clayey silt	0.174				
Clay loam	0.159	0.262	0.138	0.124	0.169

Man-made soil was poured here from the beginning of the construction of the Ignalina NPP. Soil was poured from trucks, without compaction. This soil represents a mix of clay loam, sandy loam, sand, and construction scrap. At certain places of the sites the thickness of the man made soil reaches 9 meters. The soil was poured in place of excavated peat and often into lower places of the relief without excavation of peat. Hence, there are places, where peat lays under a layer of man made soil.

The man-made soil is in most places without vegetation. Some parts of Site No. 2 (wet places between the knolls) are scrubby. Chemical composition of the man-made soil depends on the sediments it is made from. Man-made soil of the 2 proposed sites for the new NPP is made most of all from silty and clay loam. These sediments contain silicates, carbonates, spars, plagioclases and clay minerals (montmorilonite, kaolinite, hydromica). Permeability and hydraulic conductivity of the soil depends on particle size. The bigger the particles are the higher the permeability is. The share of silt and clay particles reaches 20–30 % in the loamy soil of the proposed sites.

If the loamy soil has no cracks or fissures its permeability is quite low. In natural conditions many small fissures occur in the loamy soil. Hydraulic conductivity, the parameter that characterises soil permeability, could be evaluated during field tests. The hydraulic conductivity of the man-made soil at the particular sites has been evaluated during the geological mapping and applied investigations. Hydraulic conductivity of clay loam determined by field tests varies in the ranges of 0.14–0.24–0.34 meters per day. Hydraulic conductivity of silty and sandy soils is about 0.45 m/d (*Marcinkevicius et al., 1995; Kerasevicius & Kropas, 2006).*

Hydraulic conductivity characterises the saturated flow. However the upper part of the soil is not fully saturated by water and forms the vadose (unsaturated) zone above the shallow groundwater level. Water or moisture migration goes on according to the laws of capillary and soil pressure. Many scientific investigations *(Klimas, 1988; Mazeika, 1993)* prove that the velocity of moisture migration is between 1 and 2 meters per year in unsaturated zone. The lower velocity (1 m/y) is characteristic to clayey soils and the higher one to sandy soils. The thickness of the unsaturated zone varies from 1 to 5 meters at the proposed sites.

The sorption capacity of the soil depends on the amount of clay particles and organic material. This parameter was not investigated at the proposed sites. However it is known from the results of many former investigations of Lithuanian soils that sorption capacity of glacial loamy deposits is quite high. For example, loam sorption capacity for oil (petrol) products is about 15 mg/kg.

Usually soil pollution is detected in the upper part of the topsoil (0–10 cm deep) or in the arable layer (0–25 cm deep). Natural purification of the soil varies depending on the soil type, climate conditions and the kind of pollutant. Pollutants quickly migrate through the sandy soils and clayey soils sorb them. In wet and warm climate the pollutants leach from the soil quicker than in cold and dry conditions. Some toxic heavy metals will never degrade and can only be accumulated in soil, water, stream sediments, plants and animals.

According to the Ignalina NPP monitoring program, samples of the soil in the region of Ignalina NPP are continuously monitored. Radionuclide concentrations in soil is monitored in the INPP territory, which also accommodates the alternative sites of the NNPP, in the sanitary protection zone and in the surveillance zone, at 7 stations of constant monitoring in total (Building 438, warehousing zone, Visaginas city hospital, Tilze, Turmantas, Cepukai, Ignalina). Data on the average concentrations of radionuclides in the region's soil is provided in Table 7.4–3 (*INPP Report PTOot-0545-15, 2008*).

Table 7.4–3. Specific activity of the radionuclides in the soil of Ignalina NPP region.

Year	Specific activity in the soil, Bq/kg								Total (except Ra, Th, K)	
	Cs-137	Cs-134	Mn-54	Co-60	Sr-90*	Ra-226	Th-228	K-40	Bq/kg	Bq/m^2
1999	7.89	1.28	0.17	0	<20.0	21.9	33.1	807	9.35	170
2000	5.10	1.50	0.10	0	<20.0	31.4	30.2	618	6.70	339
2001	4.89	1.36	0.08	0	<20.0	42.6	31.9	606	6.34	320
2002	7.02	1.65	0	0	<20.0	45.9	45.2	850	7.36	154
2003	3.70	1.03	0	0	<1.53	22.9	29.3	596	6.26	131
2004	4.98	0.43	0.08	0	2.08	34.2	26.8	549	7.47	158
2005	3.38	0	0	0	1.49	13.8	18.6	462	4.87	31.3
2006	3.38	0	0	0.05	0	22.0	25.6	613	3.43	74.8
2007	2.77	0	0	0	0	19.6	21.5	631	2.77	76.7

* since 2003 detection methodology of Sr-90 has been improved

The specific activity of radionuclides in grassland and forest plants and in soil of their growth analyzed in the INPP region is presented in Section 7.6.1.8.

The specific activity of radionuclides in the soil of Ignalina and other Lithuanian districts can be compared. In 1996–1998 when investigating the soil of the complex background monitoring stations (forest ecotope) of Ignalina, Plunge and Varena districts it was found that the highest average value of the specific activity of ^{137}Cs was measured in the soil of Plunge district (340 Bq/kg). In the soil of Varena district the highest average value of the specific activity of ^{137}Cs was found in 1996 (103 Bq/kg), but in 1997 it declined to 13 Bq/kg, and in 1998 and 2002 it was equal to 25 and 10 Bq/kg correspondingly. In the soil of Ignalina district the highest average value of the specific activity of ^{137}Cs in 1997 reached 115 Bq/kg, and in 1996, 1998 and 2000 this value varied from 49 to 79 Bq/kg. In 1996 and 1997 ^{134}Cs was recorded as well, its average value of the specific activity in the soil did not exceed 4 Bq/kg in Plunge district, 0.9 Bq/kg in Varena and Ignalina districts (*Radiation Protection Centre Project Report, 2007*).

7.4.2 Assessment of impacts on soil

The proposed sites for the new NPP are located in the industrial area of the operating Ignalina NPP. The soil surface and natural soil of the sites have been changed during the

Ignalina NPP construction period. This is why substantial impacts on soil already took place about 30 years ago and the current state of the soil is not natural.

The main impacts on soil will occur during the construction stage and will be typical to any construction project. These include excavation works, relocation of soil, generation of dust from the movement of heavy vehicles and also from soil movements (dust clouds can develop especially during dry periods). These impacts will be mainly temporary. However, some of the soil needs to be permanently relocated.

The depth of the NNPP construction site will vary from 8 to 16 meters and a large volume of soil needs to be removed from the site. The area of the construction works of the NNPP is about 30–32 ha. About 1 400 000 m^3 of soil will be excavated from the NNPP construction site in case two large NPP units will be built. The excavated soil will be transported to soil dumping areas. The preliminary locations of these dumping areas are presented in Figure 7.4-1. The soil dumping area A will be used in case of site 1 and the soil dumping area B in case of Site No. 2. The soil will be transported by road vehicles via a gravel access road from the construction site to the dumping site. Both of the soil dumping sites have the same area, about 24 ha, and their storage capacity is 700 000 m^3 of soil each. The soil will be stored in piles. Some of the removed soil will be moved back to the NNPP construction site and the rest will be left for final storage. It is estimated that about 1 300 000 m^3 of different soil material is needed as fill materials at the construction site in case of two NPP units. The soil that now covers the sites and will be excavated is not valuable and does not contain humus or plants.

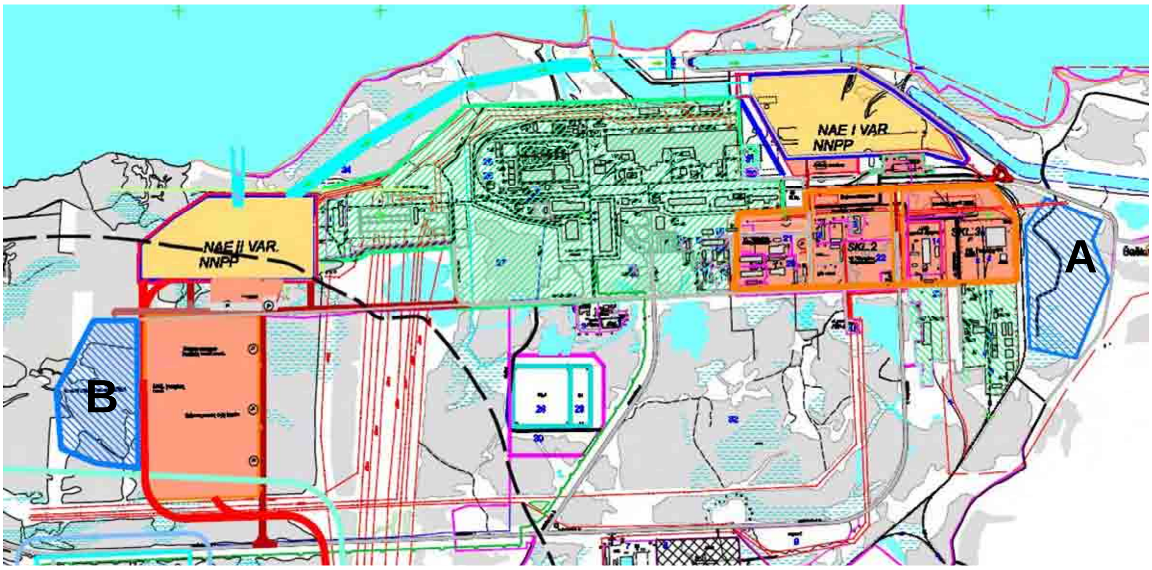


Figure 7.4-1. Preliminary locations of the soil dumping areas during construction of the NNPP: area A for Site No. 1 and area B for Site No. 2.

Cars and other vehicles, materials used for construction and sewage from the temporary buildings could be identified as sources of minor soil pollution during the construction stage of the new NPP. Content of zink, lead and oil products in the soil at the site can increase during the construction stage of the new NPP. However, the duration of the construction stage is about 5–7 years, which is too short a period for significant changes to occur in the soil chemical composition. Possible soil pollution caused by polluted air will be very small during the construction stage and neglible during operation. The new NPP will be designed so that soil pollution during normal operation will be negligible. Any leaks from the chemical storages or sewage collection will be prevented. Thus no significant accumulation or migration of pollutants can occur. In case of some soil pollution its migration will be prevented by soil properties described above.

During construction some of the excavated soil will be replaced with more suitable materials. The fill materials will be chosen according to their suitability for the construction site. The chemical composition of the man-made soil to be used will depend on the sediments it is made from. Permeability and hydraulic conductivity of the man-made soil will depend on particle size.

The proposed sites for the new NPP are located in the industrial area of the operating Ignalina NPP, where the natural soil of the sites has been changed already earlier. Thus constructing the new NPP will not have a significant impact on the biological activity of the soil of the sites.

After the removal of weak soils the deeper natural soils will occur at the land surface. Deeper soils are clayey and relatively clean. Due to the static load of buildings these soils will be compacted. The value of the compaction is predictable and can be calculated according to the soil compression test results to be conducted at a later stage.

The radiological impact of the new NPP on the soil on the site is expected to be insignificant during normal operation. It is expected that during normal operation of the new NPP the radiation doses due to radionuclides in the soil will be negligible.

The planned economic activity will not cause soil erosion or other negative processes.

Until the beginning of the operation of the new NPP a comprehensive environmental monitoring program shall be prepared. During the development of this program ecogeological investigation shall be carried out and the existing soil contamination with radionuclides shall be assessed. If the investigation determines radionuclide contamination of the soil or filling materials, which will be removed during the NNPP construction and will be stored on the sites during the operation, the NNPP environmental monitoring program will provide additional monitoring of those removed grounds before the start of the NNPP operation.

7.4.3 Mitigation measures

Construction will be performed using techniques designed to minimize the potential erosion of the topsoil and to prevent leaking of harmful substances like fuel and oils from the machines. Materials used for the construction will be stored in buildings or on the ground (for example on concrete blocks) isolated from the environment. Sewage from the temporary buildings will be collected and transported to the waste water treatment plant.

Removed soil will be stored for a relatively short period. The storage area will be as small as possible to decrease the physical impact on the environment. After the construction stage, the removed soil that is not used as filling material in the NNPP site can be used to improve the scenery of the new NPP area. Small hills can be formed using the removed soil. The landscape will be designed according to the special project.

To prevent possible soil pollution the new NPP site will be covered by impermeable material where needed. Other open areas will mainly be covered by grasslands. Small amounts of pollutants could be taken from the soil by plants.

The new NPP will be designed to avoid chemical and radiological pollution of the environment. All technological units and objects for sewage removal will be constructed using appropriate materials. All the chemicals used will be stored in a correct manner to prevent any leaks to the environment. All the sewage from the buildings during operation will be collected and transported to the waste water treatment plant. During normal operation significant pollution of soil will be impossible.

For the mitigation of possible changes in the quality of the environment comprehensive monitoring of the new NPP site will be carried out. Soil quality will be monitored during the new NPP operation. If some changes will be detected the suitable technical measures will take part. Possibly polluted soil will be changed mechanically to clean soil material. Polluted soil will be treated in situ using specific physical processes (electrolysis, etc.) or materials (sorbents).

7.5 GEOLOGY

7.5.1 Present state of the environment

The last comprehensive geological mapping performed in 1995, at a scale of 1:50 000, also covered part of the territory of the Latvian Republic and part of the Republic of Belarus. The geological structure, described below, characterizes also the geology of these neighbouring countries.

7.5.1.1 Precambrian crystalline basement in the region

The new NPP area is located in the western margin of the East European Platform. It is located in the junction zone of two major regional tectonic structures: the Mazur-Belarus Rise and the Latvian Saddle that makes the structural pattern of the area rather complicated. The contemporary relief of the crystalline basement reflects movements over a period of 670 million years. Several tectonic structures (blocks) of the lower order are distinguished in the surface of the Precambrian crystalline basement: the North Zarasai Structural terrace, the Anisimoviciu Graben, the East Druksiai Uplift, the Druksiai Depression (Graben) and the South Druksiai Uplift. The North Zarasai Structural terrace, the Anisimoviciu Graben and the East Druksiai Uplift are related to the Latvian Saddle. The South Druksiai Uplift belongs to the Mazur-Belarus Rise and the Druksiai Depression (Graben) is located within the junction zone of the two aforementioned regional structures (*Marcinkevicius et al. 1995*).

The crystalline basement is buried at a depth of about 720 m from the Earth's surface. It is comprised of the Lower Proterozoic rocks predominantly of biotite and amphibole composition: gneisses, granite, migmatite, etc. The thickness of the sedimentary cover in the region of the new NPP varies in a range of 703–757 m. Pre-Quaternary succession is represented by the Upper Proterozoic Vendian complex, overlain by sediments of the Palaeozoic systems. The Vendian deposits are represented by a succession of gravelstone, feldspar-quartz sandstone of different grain size, siltstone and shale. The Palaeozoic section comprises the successions of the Lower and Middle Cambrian, the Ordovician, the Lower Silurian and the Middle and Upper Devonian sediments (Figure 7.5-1 and Figure 7.5-2).

The Lower Cambrian is represented by quartz sandstone with inconsiderable admixture of glauconite, siltstone and shale. The sandstone is of different grain size with the fine-grained and especially fine-grained sandstone predominating. The Middle Cambrian comprises the fine-grained and especially fine-grained sandstone. The Ordovician is composed of interbedded marlstone and limestone. The Lower Silurian is composed of dolomitic marlstone and dolomite. The Middle Devonian – of gypsum breccia, dolomitic marlstone and dolomite as well as interbeds of fine-grained and very fine-grained sand and sandstone, siltstone and claystone; the Upper Devonian – of fine-grained and very fine-grained sand and sandstone, interbeds of siltstone and claystone. The Vendian deposits vary in thickness from 135 to 159 m; the total thickness of the Lower and Middle Cambrian succession reaches 93–114 m, the thickness of the Ordovician varies in a range of 144–153, the Silurian in a range of 28–75 m and the total thickness of the Devonian sediments reaches 250 m (*Marcinkevicius et al., 1995*).

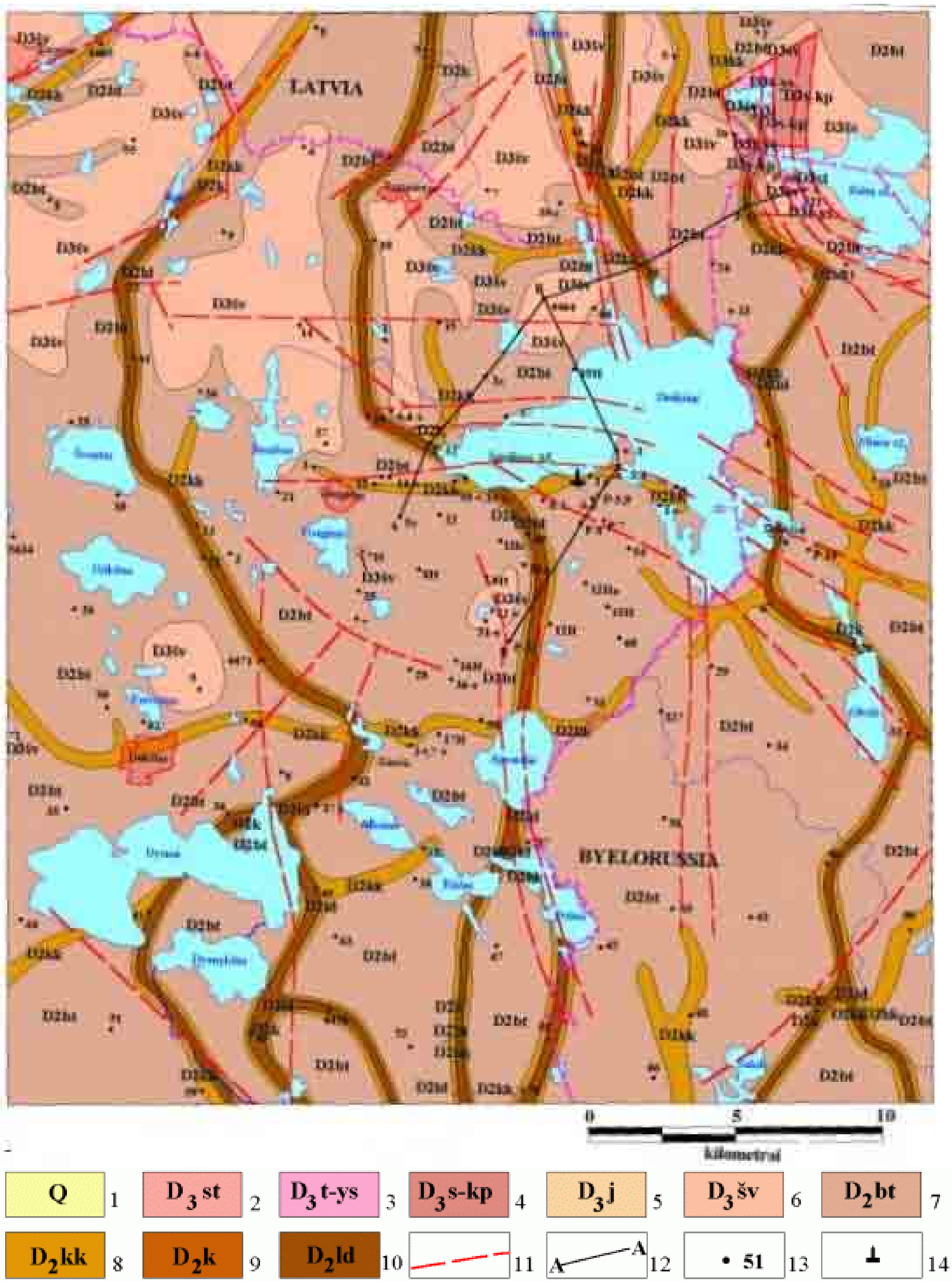


Figure 7.5-1 Pre-Quaternary geological map of the new NPP region (*Marcinkevicius at al., 1995*): 1 – Quaternary deposits (on the sections); Upper Devonian formations: 2 – Stipinai; 3 – Tatula–Istra; 4 – Suosa–Kupiskis; 5 – Jara; 6 – Sventoji; Middle Devonian formations: 7 – Butkunai; 8 – Kukliai; 9 – Kernave; 10 – Ledai; 11 – Fault; 12 –Line of geological-tectonical cross-section; 13 – Borehole; 14 – INPP and the new NPP.

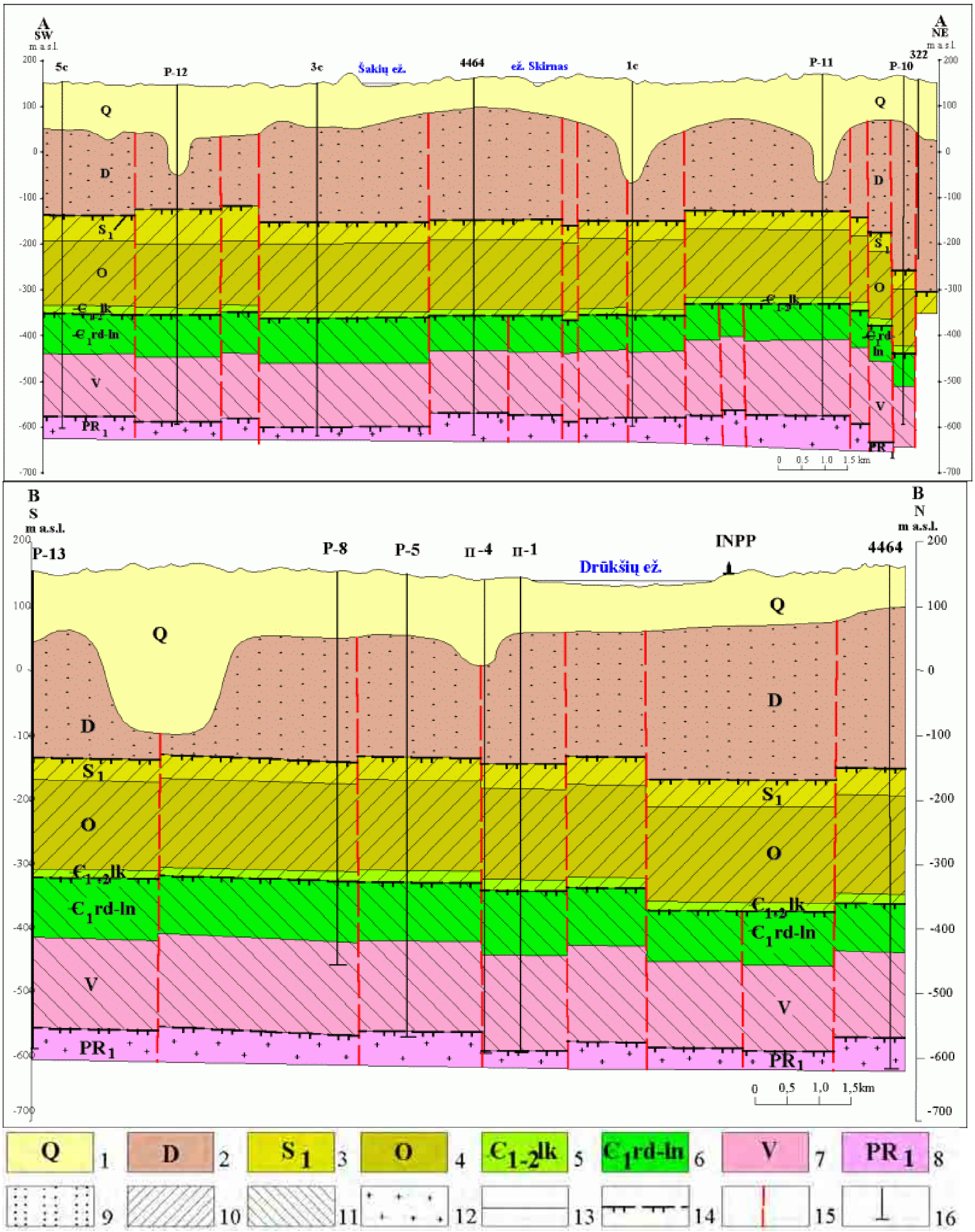


Figure 7.5-2. Geological-tectonic cross-sections of the new NPP region (*Marcinkevicius at al., 1995*): 1 – Quaternary: till, sand, silt and clay; 2 – Middle and Upper Devonian: sand, sandstone, siltstone, clay, domerite, dolomite, breccia; 3 – Lower Silurian: domerite, dolomite; 4 – Ordovician: limestone, marl; 5 – Lower and Middle Cambrian Aisciai Series Lakajai Formation: sandstone; 6 – Lower Cambrian Rudamina–Lontova Formations: argillite, siltstone, sandstone; 7 – Vendian: sandstone, gravelite, siltstone, argillite; 8 – Lower Proterozoic: granite, gneiss, amphibolite, mylonite; Structural complexes: 9 – Hercynian; 10 – Caledonian; 11 – Baikalian; 12 – Crystalline basement; 13 – Border between systems; 14 – Border between complexes; 15 – Fault; 16 – Borehole.

7.5.1.2 Quaternary cover of the region

The Sub-Quaternary relief of the area is highly dissected by paleoincisions (Figure 7.5-3). The thickness of the Quaternary cover varies from 62 to 260 m.

The Quaternary deposits are of Pleistocene and Holocene age. The area is made up of glacial deposits (till) of the Middle Pleistocene Dzukija, Dainava, Zemaitija and Medininkai Formations, and of the Upper Pleistocene Upper Nemunas Formation (Gruda and Baltija). Intertill glaciofluvial (sand, gravel, cobble, pebble) and glaciolacustrine (fine-grained sand, silt, clay) sediments are detected in the area. The thickness of the intertill deposits varies from 10–15 m to 25–30 m (Figure 7.5-4). The interstadial deposits are composed of very fine-grained and fine-grained sand, silt and peat (Figure 7.5-6 and Figure 7.5-7). The Holocene deposits are represented by alluvial, lacustrine and bog sediments. Alluvial sediments are variously grained sands with 1–1.2 m thick organic layers. The lacustrine sediments (fine-grained sand, clay, silt) reach a thickness of 3 m. The thickness of the peat is 5–7 m (*Marcinkevicius et al. 1995*).

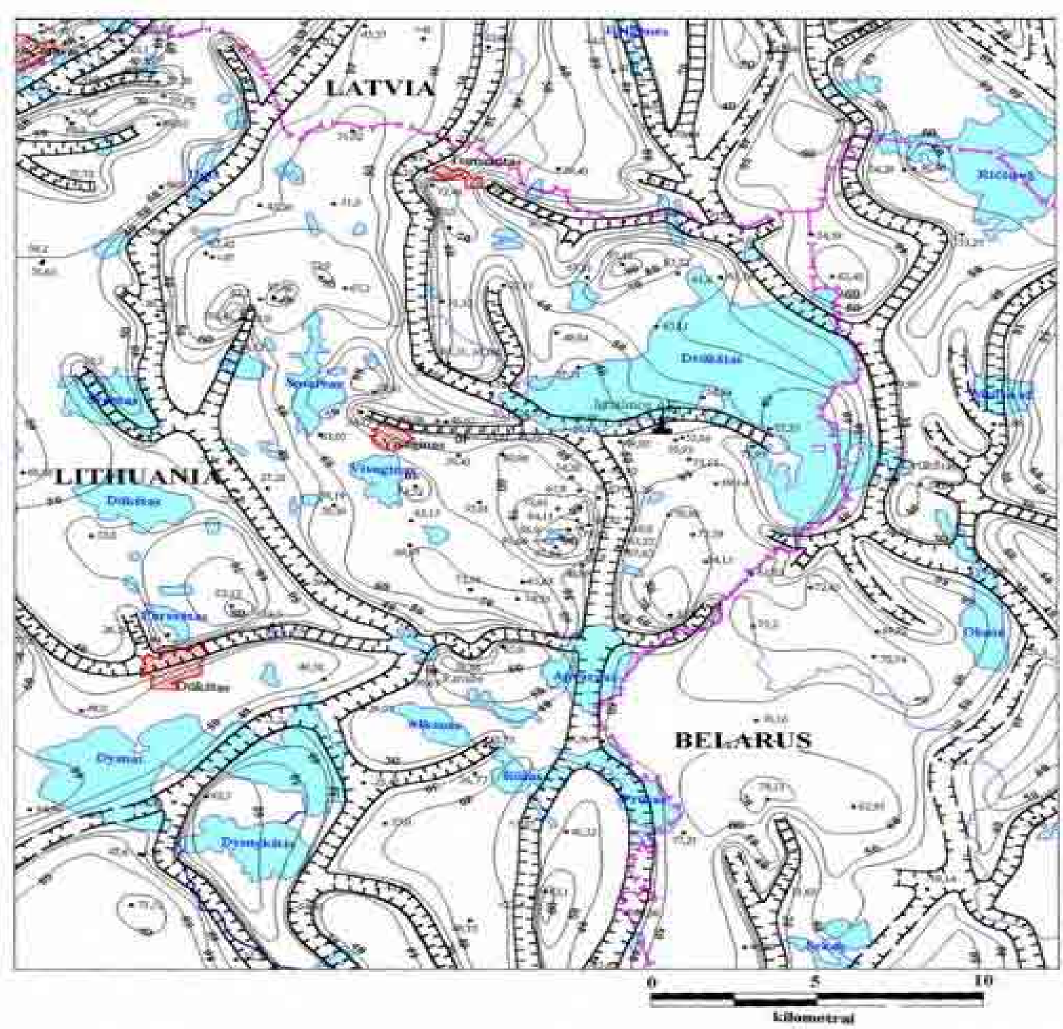


Figure 7.5-3. Scheme of sub-Quaternary surface of the new NPP area (*Marcinkevicius at al., 1995*): 1 – Paleoincision; 2 – Isohypse of pre-Quaternary surface, m; 3 – Boreholes and the absolute depth of the pre-Quaternary surface: 4 – INPP and the new NPP.

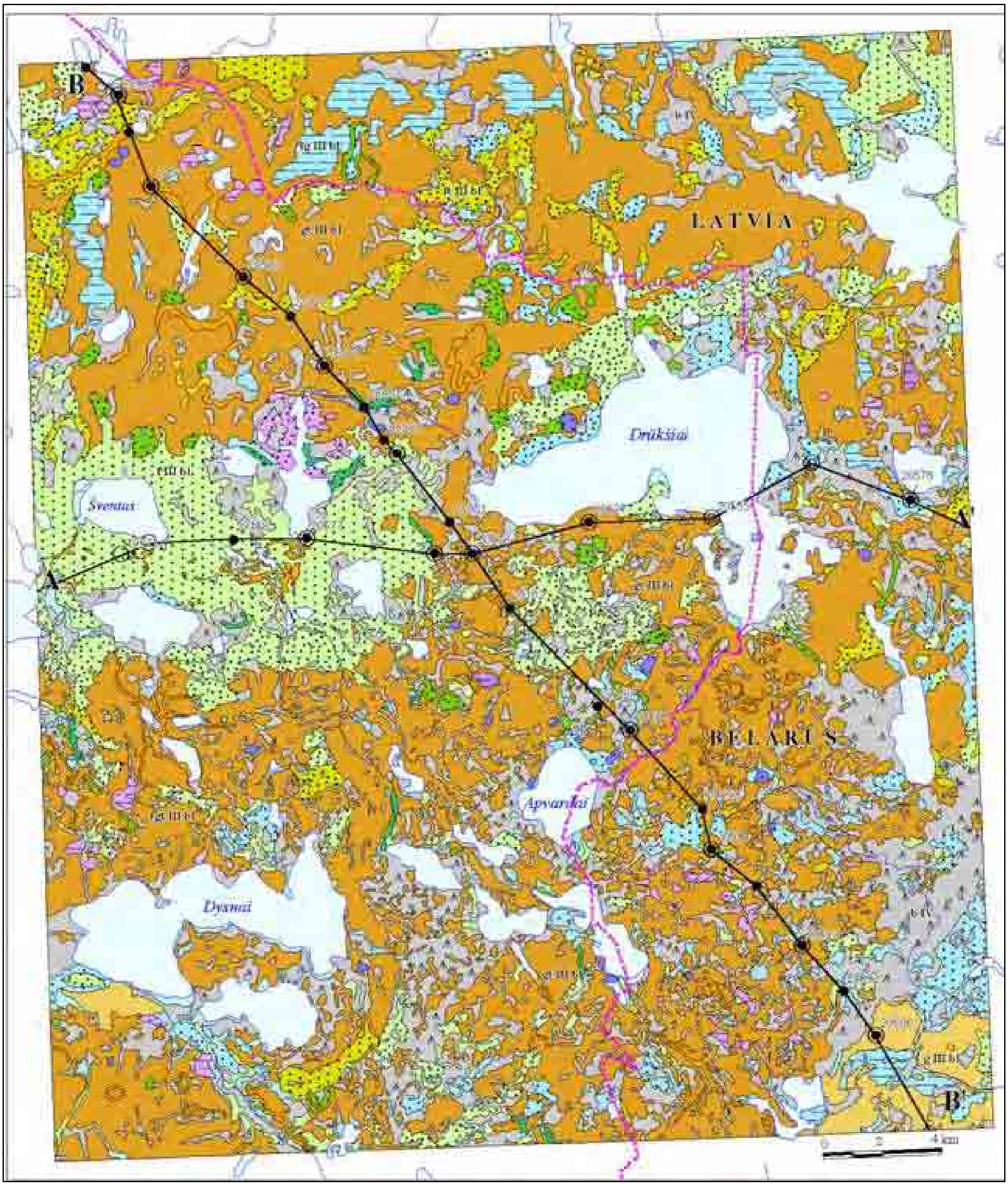


Figure 7.5-4. Quaternary geological map of the new NPP area (original scale 1:50 000, author: R. Guobyte (*Marcinkevicius et al. 1995*)); legend see in Figure 7.5-5.

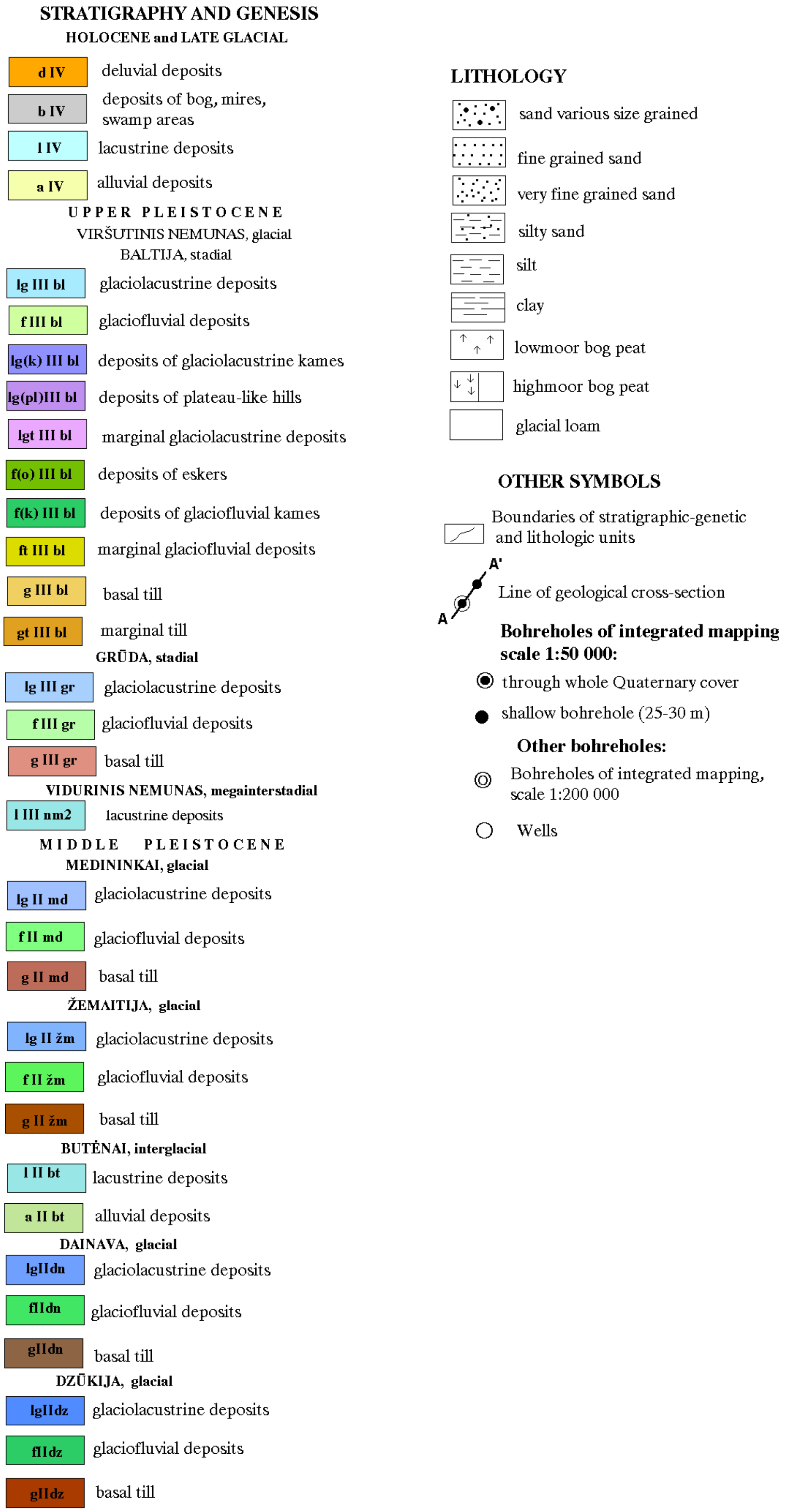


Figure 7.5-5. Legend for Quaternary geological map and geological cross-sections of the new NPP region.

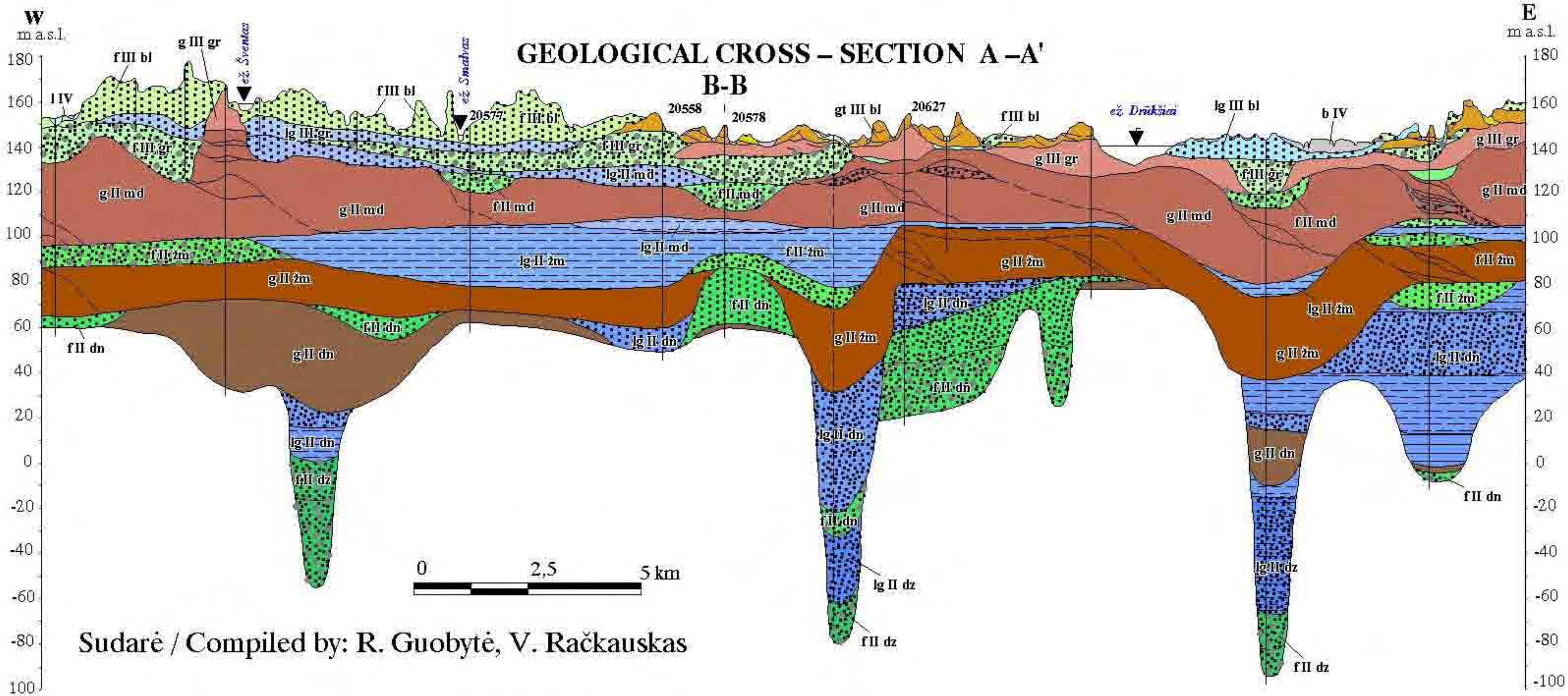


Figure 7.5-6. Quaternary geological cross-section A-A of the new NPP area (original scale 1:50 000, authors: R. Guobyte, V. Rackauskas (*Marcinkevicius V. et al., 1995*)); legend see Figure 7.5-5.

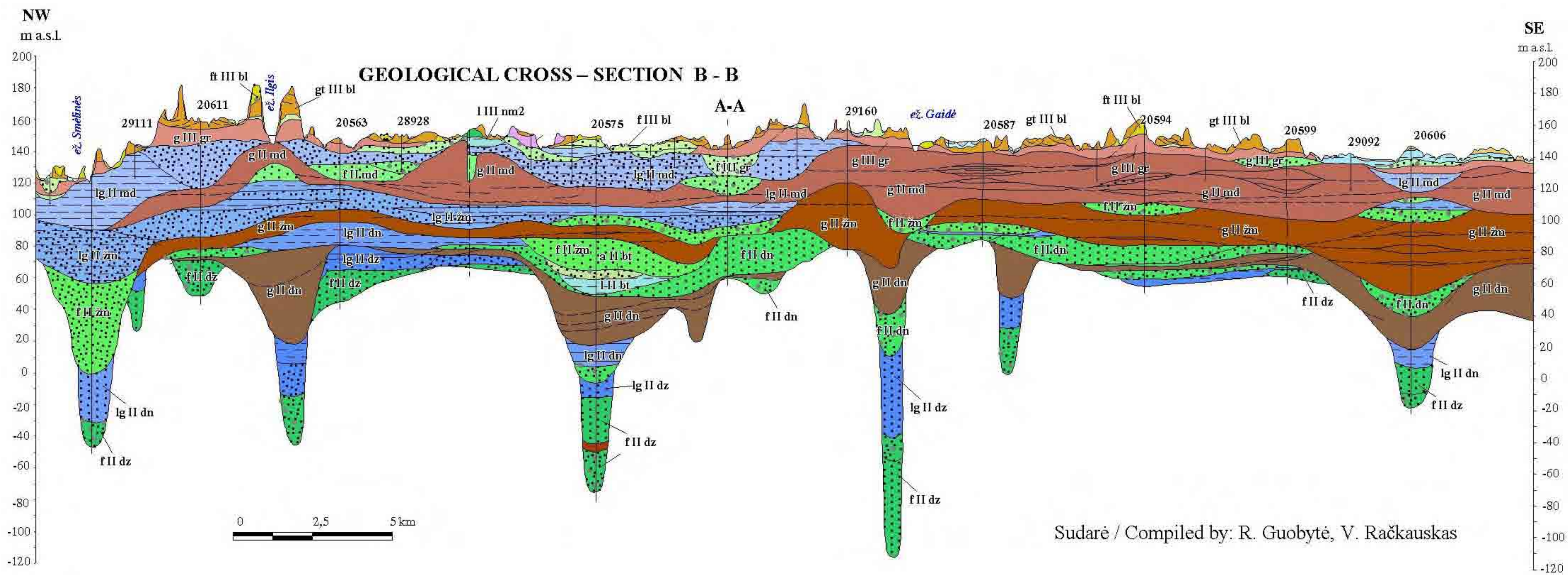


Figure 7.5-7. Quaternary geological cross-section B-B of the new NPP area (original scale 1:50 000, authors: R. Guobyte, V. Rackauskas (*Marcinkevicius V. et al., 1995*)); legend see Figure 7.5-5.

7.5.1.3 Geologic structure of the new NPP sites

Geological composition of the whole industrial site of the Ignalina NPP and the proposed sites for the NNPP has been sufficiently well investigated. In 1975–1976 the 25th Hydrogeologic Expedition of the Second Geological Board of the former USSR have drilled as many as 5 bore holes in the immediate vicinity of the surveyed site, with a bore depth from 720 to 745 m. Data obtained from later boring works and used in cartography reports of the sites allow for specification of deep layer stratification conditions in the area of the sites (*Vaitonis et al., 1975; Marcinkevicius et al., 1995*). Data obtained during these boring works provide for reliable distinction of three parts of the geological cross-section of the sites – crystalline basement, sedimentary rock layer, and Quaternary cover formed by shifts of continental glaciers.

Crystalline basement

Ignalina NPP industrial site, where the two sites for the new NPP are located, is in the area of junction of the large regional geological structures of the Eastern European platform. This is a junction between so-called Latvian Saddle and the Mazurian-Byelorussian Rise. The crystalline rock basement is stratified here at very uneven level of 550 to 750 m from the earth surface. This is because the crystalline basement (Figure 7.5-8) is divided into structural blocks of uneven size with different relative elevations. The difference in amplitude of elevation of these blocks in the environs of the Ignalina NPP is up to 55 m. Within the Ignalina NPP industrial site the surface altitude of the crystalline basement is from minus 561.2 m (bore P6) to minus 581.4 m while the absolute height isoline running across the INPP industrial site is minus 575 m.

In the surveyed sites there are no boreholes deeper than 130 m, the deeper layers may only be described on the basis of regularities of geological composition of adjacent territories and the Ignalina NPP industrial site.

Crystalline basement rocks are of Lower-Middle Proterozoic geological age. The deep bore bored near Lake Druksiai, slightly to the north of the first surveyed site (site 1), had reached rocks of the crystalline basement in the depth of 732 m (*Vaitonis et al., 1975; Juozapavicius, Juodkazis, 1987*). These rocks had been bored into up to a depth of 781 m. At this stretch between 781 and 732 m crystalline basement rocks consist of granite gneiss, amphibole, and shale.

Sedimentary rocks

On the surface of the dislocated crystalline basement there is a layer of sedimentary rocks with rocks from Vendian, Cambrian, Ordovician, Silurian, and Devonian geological systems.

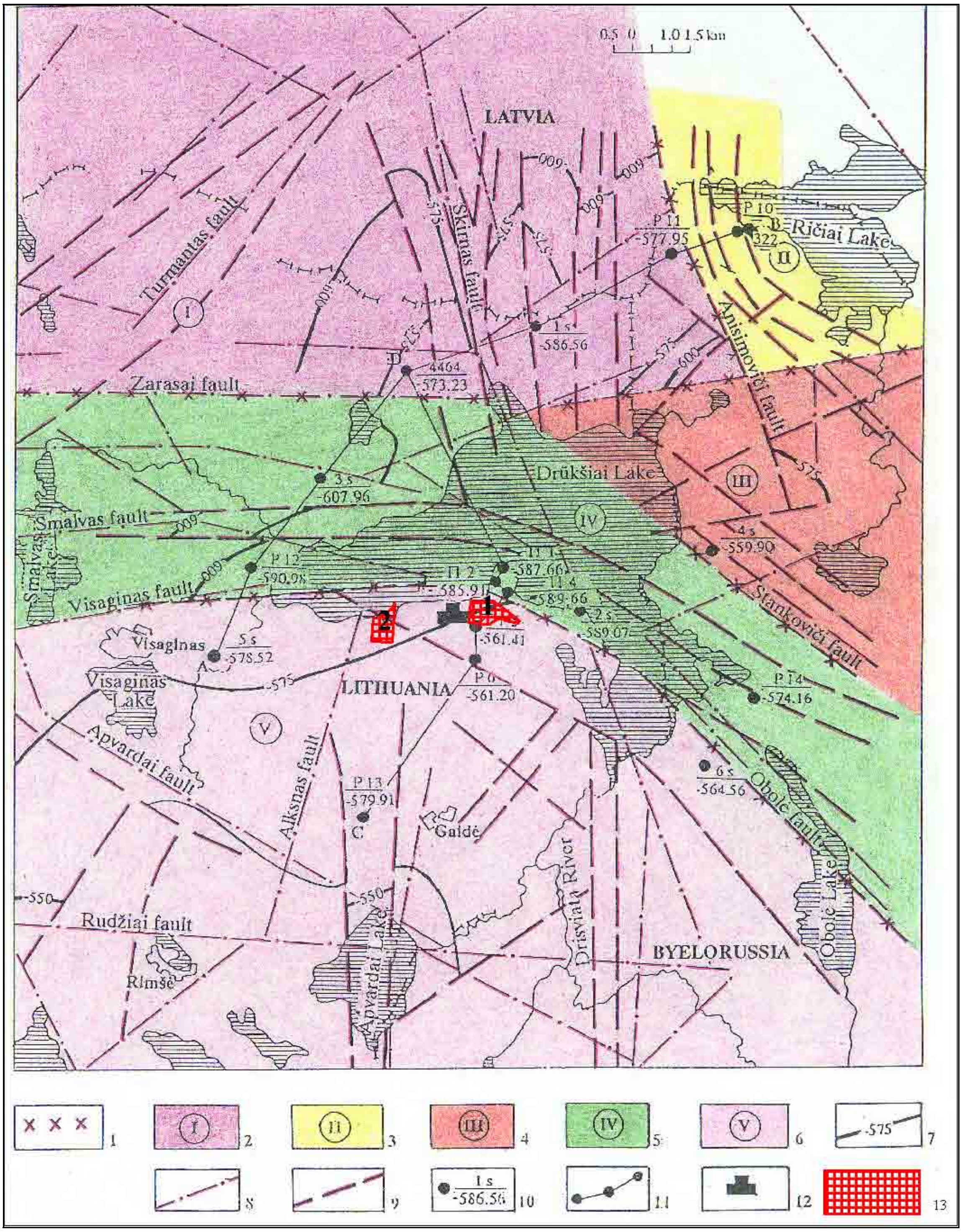


Figure 7.5-8. Structural scheme of the surface of crystalline basement of Ignalina NPP area: 1 – Border of the main structural elements (blocks) of the crystalline basement; Structural elements (blocks): 2 – North Zarasai bench; 3 – Anisimovici graben; 4 – East Druksiai uplift; 5 – Druksiai trough (graben); 6 – South Druksiai uplift; 7 – Isohypses (m) of the surface of the crystalline basement; 8 – Faults established by aeromagnetic and gravity data; 9 – Faults established by seismic data; 10 – Borehole: in numerator – number of borehole, in denominator– the absolute depth of the surface of the crystalline basement (m); 11 – Line of geological-tectonical section; 12 – Ignalina NPP; 13 – NNPP alternative sites No. 1 and No.2 (according to *Marcinkevicius et al., 1995*).

Data obtained from the deep bores made in the adjacent areas indicate that the crystalline basement of block composition is divided by tectonic deformations and covered by the rocks of the Vendian complex of Upper Proterozoic geological age, while the dislocated and degraded surface of the Vendian layer is covered with terigenous rocks of the Lower Cambrian complex. The Vendian complex is stratified 732 to 596 m deep. It consists of quartz sandstone and siltstone.

The argillite and sandstone layer with lytified clay layers occurring above the Vendian complex in the depth of 598 to 585 m is attributed to the Lower Cambrian complex. Fine-grained quartz sandstone is stratified at a depth from 585 to 570 m. This Middle Cambrian layer is in places covered by rocks of the Caledonian complex.

In the geological cross section of the first site, light-gray limestone and sandstone of the Lower Ordovician geological age is stratified above the Middle Cambrian rocks at a depth of 570–507.2 m, limestone and marl of the Middle Ordovician is stratified at a depth of 507.2–496.3, while light-gray limestone of the Upper Ordovician is stratified at a depth of 496.2 to 440.1 m.

Rocks of the Ordovician system are in places covered with light-gray dolomitic marl of the Lower Silurian geological age, the layer of which lies at a depth of 440.1–354.0 m. Dolomite, limestone, and marl of the Upper Silurian lay at a depth of 354.0–220 m.

On the degraded surface of the Silurian system rocks the Hercynian complex rocks are stratified. These include light-gray siltstone, sandstone, and dolomite of the Middle Devonian. In the surveyed site these rocks are stratified very unevenly and it may only be predicted that the bore should reach this layer at a depth of 220–119.5 m. In some boreholes (*Vaitonis et al., 1975; Marcinkevicius et al., 1995; Juozapavicius, Juodkazis, 1987*), which had been bored in the area of the first surveyed site a bit southwest from Lake Druksiai, the sandstone and siltstone layers of the Devonian system reach up to 76–77 m, while in other places this layer is either completely degraded in palaeoincisions or remains thin.

Rocks of Narva horizon of the Middle Devonian in the Ignalina NPP area comprise a regional aquitard. At the places where degraded rocks of the Devonian system have been eroded by palaeoincisions (Figure 7.5-1) the Narva aquitard horizon is much thinner; in some places its thickness is barely 5 m. Middle-Upper Devonian Sventoji–Upninkai sandstone layer is at places completely degraded in the area of the Ignalina NPP, while in other places only the lower part of the eroded layer remains. In the surveyed site, sandstone and siltstone of the Kukliai and Butkunai formations of the Upninkai series form erosion etched pre-Quaternary surface, which is covered by sediments formed during Quaternary glacial periods.

Quaternary cover

This layer of Quaternary geological age has a very complex composition and is very uneven. However this is the most important component of the engineering geological conditions of the sites. It consists of sediments and deposits formed during glacial periods. This layer also includes both current Holocene sediments (peat, sapropel, and peaty deposits) and technogenic grounds. A layer of Quaternary sediments and deposits at the sites reaches up to 120 m. Thickness of the sediments depends on the relief and absolute heights of the pre-Quaternary surface.

From a geomorphological point of view the new NPP sites are located in the Gaide glaciodepression of the Baltija Highland to the south of Lake Druksiai. The sites are surrounded by hummocky moraine landscape of the marginal zone of the last (Nemunas) glaciation. The hummocky landscape of this depression is interspersed with numerous individual glacial forms such as kames, eskers, glaciofluvial hills and other ice-crevice forms (*Marcinkevicius et al., 1995*).

Geological structure of site No. 1

NNPP Site No. 1 is located on the north-eastern side of the Ignalina NPP industrial site. The southern border is close to the west-east transport strip, the western border matches the strip of ruins of the Third Unit of the INPP, while in the north and north-west the investigated site is delimited by a stretch of channels constructed on the shore of Lake Druksiai.

From a geomorphological standpoint, the surveyed site No. 1 is a part of the Baltic Highland. Its surface relief has formed at the edge of the last Baltic glacier. It is a typical relief of moraine formations. On the southern side the relief belongs to the Cebarakai massive of the so-called Gaide glaciodepression (*Vaitonis et al., 1975*), the surface of which in many places is covered by a thin cover with a thin sand layer. The surface of the Cebarakai geomorphological massive is flat, hilly in some places, with many thermosinkholes.

The relief of the northern part is characterized by flat transition of the waterlogged undulate plain to a marshy shore of Lake Druksiai. Absolute altitudes of surfaces of the northern and eastern parts are several meters above the absolute altitude of the water level of Lake Druksiai.

The natural relief at the southern part of the site has been completely changed during the construction of the Third Unit of the Ignalina NPP. In former places of marshes peat has been completely or partially removed and covered with sand, gravel or other soil. Mounds have been formed for access roads. On the northern and north-eastern part adjacent to the hydrotechnological channels, the original natural relief has been damaged by excavations. However, the declination of both southern and northern part of the current levelled surface has the northern and north-eastern direction, towards the shore of Lake Druksiai.

Prequaternary rocks occur at a depth of 129.2 m (altitude +14.8 m) in the territory of site No. 1. These rocks belong to the Butkunai formation of Upninkai series of the Middle Devonian (D_2bt) that consists of siltstone, fine grained sand and clay. Above these sandy layers glaciolacustrine deposits of Middle Pleistocene Dzukija formation (lgIIdz) occur and consist of silty sand. The upper part of Dzukija formation consists of glaciofluvial deposits (fIIdz) that are also sandy and silty. The top of Dzukija formation occurs at the altitude of +46.0 m (Figure 7.5-9).

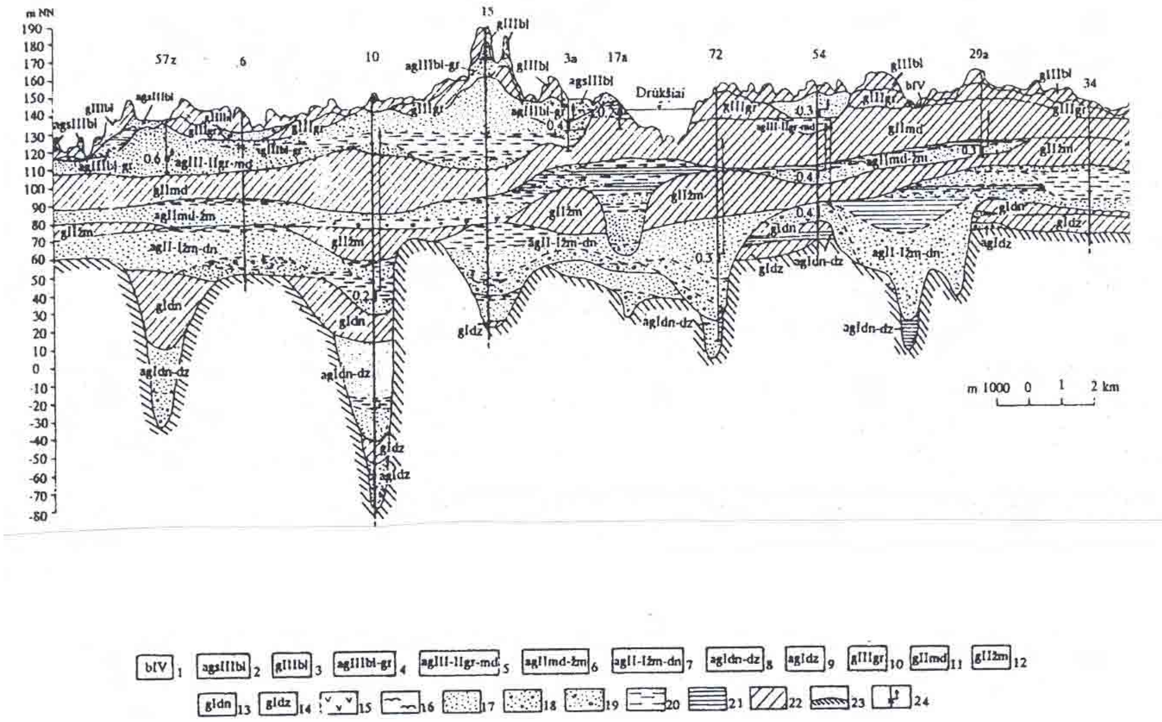


Figure 7.5-9. Schematic geological cross-section of the site No 1 with hydrogeological information. Genesis of layers: 1 – bog, 2 – glaciofluvial, 3 – glacial; intermorainic confined aquifers: 4 – Baltija–Gruda, 5 – Gruda–Medininkai, 6 – Medininkai–Zemaitija, 7 – Zemaitija–Dainava, 8 – Dainava–Dzukija, 9 – Dzukija fliuvioglacial deposits; low permeable beds – relative aquitards: 10 – Gruda, 11 – Medininkai, 12 – Zemaitija, 13 – Dainava, 14 – Dzukija glacial deposits; 15 – peat, 16 – sapropel; 17 – sand, very fine and fine; 18 – various – grained sand; 19 –gravel; 20 – silt; 21 – clay; 22 – loam; 23 – pre-Quaternary rocks; 24 – well tested and piesometric level of the aquifer tested (modified from *Kerasevicius and Kropas, 2006*).

Above the Dzukija formation the aquaglacial intertill deposits (agIIdn-dz) occur. This layer is distributed locally and consists of different sand, gravel and silt. The thickness of this intertill layer is about 8.2 m. In some places the basic till of the Dainava formation of Middle Pleistocene (gIIdn) was drilled. This layer consists of hard clayey till with gravel, sometimes with interbeds of silt or sand. The thickness of this till reaches 33.3 m (top altitudes +78.2–88.5 m). Above the basic till glaciofluvial sands of the Dainava formation (fIIdn) occur. The thickness of this layer varies from 1–5 to 8–18 m. Altitudes of the top layer are +83.6–100.6 m.

At the altitudes from +95.6 to +105.5 m the glacial deposits (basic till) of the Zemaitija formation (gIIžm) occur. These consist of clayey loam with gravel. Glaciolacustrine deposits of the Zemaitija formation (lgIIžm) occur above the basic till and consist of clay and silt. The thickness of glaciolacustrine deposits varies from 3 to 13 m. The upper part of Middle Pleistocene is formed by the Medininkai formation which consists of glacial basic till (gIImd) – clayey loam with gravel, and locally of glaciofluvial (fIImd) fine grained sand. The thickness of glacial deposits reaches 14–18 m at the altitudes from +132.2 to +143.2. Glaciofluvial deposits are only 0.5–13 m thick.

Glacial deposits of Gruda sub-formation of Upper Pleistocene (gIIgr) occur only in the southern part of site No. 1. The thickness of the layer is about 10 m, and altitudes of the top are from +144.5 to +148.4 m (*Jonusas et al., 2006*).

The most recent layers of Quaternary system belong to Holocene. These are lacustrine sediment (l IV) and biogenic sediments of bogs (b IV) and occur below the man made soils (tpl IV).

Geological structure of site No. 2

The site is located in the western part of Ignalina NPP industrial area. From a geomorphological standpoint, the surveyed site No. 2 is also a part of the Baltic Highland regionally called Aukstaiciai highland. The site belongs to the local geomorphologic unit of Gaide morainic rise. Its surface relief was formed at the margin of the last Baltic glacier.

There are several knolls of 3–6 m. height at the site. The surface of the territory has a slight decline (altitudes 153.1–152.2) towards the north. Absolute altitudes of the surface are several meters above the absolute altitude of the water level of Lake Druksiai. The land surface has been changed during the construction works of Ignalina NPP. There are several structures which were built for the distribution of electricity remaining at the site.

Pre-Quaternary rocks of the site have only been mapped during the last geological mapping at a scale of 1:50 000 in 1995. More detailed geological investigations reached a maximum of 20 meters. According to the results of several investigations the Quaternary cover up to a depth of 20 m consists of glacial (g III) and glaciofluvial (f III) deposits of Upper Pleistocene and recent sediments (Holocene) of bogs (b IV), lacustrine deposits (l IV) and man made (t IV) soil (Figure 7.5-10). Man made soil that consists of natural soils from surrounding area forms several mounds.

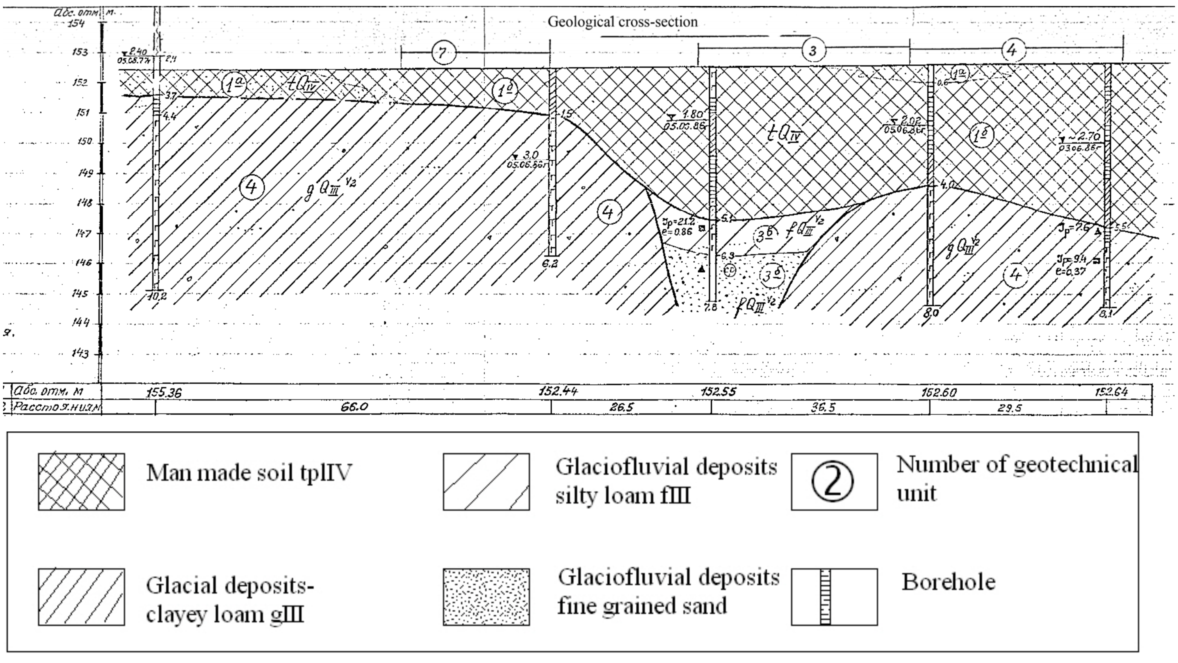


Figure 7.5-10. Geological cross-section of site No 2.

Glacial deposits are represented by clayey and silty loam that occurs at a depth of 0.5–1.0 m in the southern part of the site and at a depth of 5.5–11.0 m in the northern part. Average thickness of all glacial deposits is about 20–25 m. Glacial deposits belong to marginal till of the Baltija subformation (gtIII bl) of Upper Pleistocene and to basal till of the Medininkai formation (gII md) of Middle Pleistocene. Loamy deposits of the Medininkai formation occur at the altitudes 137.0–151.2. In some places glaciofluvial differently grained sands occur above the glacial loam. The layer of sand is quite thin. It belongs to marginal glaciofluvial deposits of the Baltija subformation (ftIII bl). Its thickness varies from 0.5 m in the middle part to 5 m in the small incisions in the southern part of the site. The depth of the sandy layer varies from 1.0 to 9.2 m. The most part of the site is covered by man made soil that is represented by silty and clayey loam of low density and in some places peat. The thickness of the man made soil varies from 0.5 to 11.0 m. The largest layers of man made soil occur in the northern part of the site (*Krainiukov et al., 1986*).

7.5.1.4 Tectonic faults

Two types of faults can be distinguished in the new NPP area, i.e. the oldest pre-platform and younger platform features. The faults detected in the sedimentary cover are oriented N-S, W-E, NW-SE and NE-SW. The faults of the Druksiai Depression (Graben) and Anisimoviciu Graben are the most distinct tectonic features recognized in the study area. The Druksiai Depression (Graben) is as wide as 3–5 km; it consists of 0.5–1.5 km wide structural domains. The middle part of the graben is uplifted, representing the horst. The bounding faults exceed 20 km in length. The amplitude of the faults separating the horst is in the range of 25–55 m, the amplitude of the faults bounding the depression in the south and the north is about 10–20 m. The Anisimoviciu Graben is dissected by arcuate-shaped (in plan view) faults spaced at 0.5–0.7 km; the blocks stepping down to the northeast.

The length of the faults is of about 10 km; the amplitude reaches 15–60 m. Total amplitude of the faulting with respect to the top of the Silurian is about 180 m. The faults striking N-S are common in the North Zarasai Structural terrace and eastern part of the South Druksiai Uplift. The eastern part of the North Zarasai Structural terrace is fragmented by faults bounding the narrow (0.5–1.5 km) horsts and grabens of sub-longitudinal orientation. The faults are as long as 5–9 km, and the amplitude is in the range of 10–20 m. The Apvardai–Prutas and Macionys Grabens, bounded by 3–15 km long and 10–25 m amplitude faults, have been mapped in the South Druksiai Depression.

The faults striking northeast and northwest have been recorded in all tectonic structures (blocks) of the new NPP area. Their length varies from 3–5 km to 15–18 km; the offset is of 15–20 m (*Marcinkevicius et al., 1995*).

North Zarasai Terrace block, Anisimovitch Graben block to the east and East Druksiai Graben block belong to a large regional tectonic structure – the so-called Latvian Saddle, while the South Druksiai block belongs to another regional tectonic structure – the Mazury-Byelorussian Rise. The Druksiai Depression block (graben) is located within the junction zone of the two aforementioned regional tectonic structures (*Marcinkevicius et al., 1995*).

The North Zarasai Terrace block is located north to Lake Druksiai. It is separated from the Druksiai Depression block by a latitudinal Zarasai tectonic fault. The Skirnas tectonic fault crosses the middle of Lake Druksiai in the sub-longitudinal direction cutting the North Zarasai Terrace block into two.

The East Druksiai Uplift block is located in the southern and north-eastern part of Lake Druksiai and its shore. In the southwest it is bordered by the Stankoviciai fault, while in the west it is bordered by the Zarasai fault.

The Druksiai Depression block forms an arch-shaped strip stretching from west to southwest across the whole area of the INPP. The block is broken by lower order faults and forms a neotectonically active graben-horst-graben structure. In the north the

Druksiai Depression block borders with Zarasai and Stankoviciai faults, while in the south and southwest it borders with the Druksiai (Visaginas) and Obole faults.

The South Druksiai block covers the southern part of the Ignalina NPP area. In the north and northeast it is separated from the Druksiai Depression by Druksiai (Visaginas) and Obole faults. In the south this block borders with the Rudziu fault, while in the west it borders with the longitudinal Smalva fault.

The South Druksiai block is crossed by several local faults of sub-longitudinal orientation, which break the block into several graben-type structures of small amplitude (Apvardai–Prutas, Macionys, etc.) (*Marcinkevicius et al., 1995*).

The territory of the first surveyed site is also affected by platform faults crossing the sedimentary rocks layer. The nearest such faults are the Druksiai (Visaginas) fault bounding the Druksiai Depression (Graben) from the south and Oboles fault bounding the same block from the southwest. The length of these faults is up to 20 km and the amplitude of the Druksiai (Visaginas) fault bounding the Druksiai block in the south is up to 10–20 m. In the eastern part of the South Druksiai Uplift block there are local faults of sub-longitudinal orientation with length of 5–9 km and amplitude of 10–29 m. The South Druksiai Uplift block has local faults, the amplitudes of which in the Apvardai–Prutas and Macionys grabens are up to 10–25 m. Intersection of the regional faults is in the Lake Druksiai, where deep faults of various orientations intersect (Figure 7.5-11).

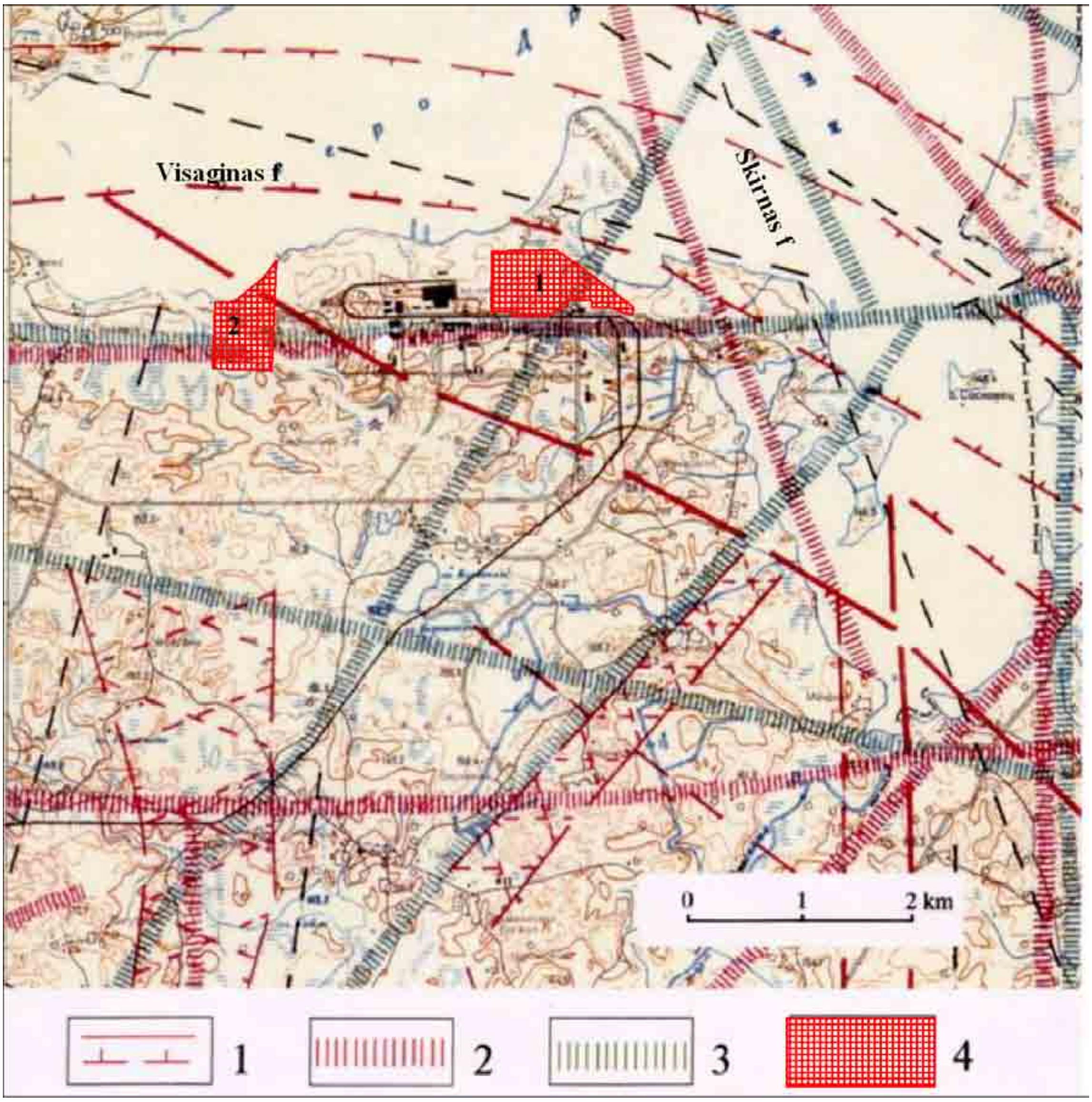


Figure 7.5-11. Tectonical scheme of the Ignalina NPP area: 1 – Tectonical faults; 2 – Neotectonical zones by morphometrical analysis; 3 – Neotectonical zones by morphostructural analysis; 4 – NNPP alternative sites No. 1 and No.2 (*Marcinkevicius et al., 1995*).

In the area of the Ignalina NPP there are neotectonically active zones, which may be locally related to the tectonic fault zones, but are somewhat displaced with regard to fault lines.

Skirnas and Druksiai (Visaginas) faults are neotectonically active. Neotectonic activity of these fault zones is confirmed by measurements of vertical and horizontal earth surface shifts in the Druksiai Geodynamic Ground (*Zakarevicius, 1999*).

The surveyed NNPP sites adjacent to the buildings of the Ignalina NPP are situated in the north-eastern part of the South Druksiai structural block. This part of the block is 4–5 km away from the intersection of Skirnas and Druksiai (Visaginas) regional faults. The zone of Druksiai (Visaginas) regional fault is approximately 0.5 km away from the northern boundary of the surveyed site. The surveyed site is about 5–6 km away from the longitudinally oriented Skirnas fault (Figure 7.5-8). Local deep faults forming Apvardai–Prutas and Macionys grabens do not reach the surveyed site. The neotectonically active zone crossing the Ignalina NPP industrial site is to the south of the surveyed site No. 1.

Site No 2 is crossed by a tectonic fault from the north-west to the south-east. Neotectonically active zones cross site No 2 from west to east (Figure 7.5-8 and Figure 7.5-11).

Conclusions

- regional deep tectonic faults dissecting the crystalline basement and penetrating the sedimentary rock layers divide the Ignalina NPP area into four structural blocks;
- the surveyed NNPP sites are on the South Druksiai structural block, in a relatively stable solid monolithic part of this block;
- site No 1 is approximately 1.0 kilometre away from the zone of Druksiai (Visaginas) regional fault and about 5–6 kilometres away from the regional Skirnas fault; site No 2 is crossed by a tectonic fault, established according to seismic data during the mapping, from northwest to southeast;
- the detailed technical feasibility study of the new NPP should include investigation (at least one borehole) of the Ledai Subformation of the Upninkai Formation, because the absolute depth of the ridge of these rocks will provide the data for estimation of the probability of a local tectonic fault in a specific location of the projected buildings.

7.5.1.5 Neotectonics

It can be shown using morphometric, morphostructural and the interpretation of satellite image data that most of the faults, penetrating the crystalline basement and sedimentary cover, are active neotectonically. As a rule, neotectonically active zones coincide with fault lines or are displaced near it. The faults system of the Druksiai trough, Anisimoviciu graben, and Skirnas fault are the most active. The paleoincisions are connected with neotectonically active zones. Their depth sometimes reaches 200 m (from the pre-Quaternary surface) (*Marcinkevicius et al., 1995*).

On a regional scale, the Ignalina NPP area is in the region of a neotectonic vertical change of the earth surface. This region measures 120 × 230 km. In this region the rate of rising of the earth surface is about 2 mm per year (*Preliminary evaluation ..., 1981*). Compared to the fundamental Vilnius benchmark, the regional rate of rising of the earth surface at the Ignalina NPP territory is up to 2.5 mm per year.

In the general background of the neotectonic vertical rise of the Ignalina NPP area, differential shifts of structural blocks take place due to tectonic faults. These shifts – both vertical and horizontal – are measured in the Geodynamic Ground.

On the basis of the complex investigation data processed for reports in 1988 it was found (*Voskresenskaia et al., 1988*; *Conclusions of working group ..., 1988*), that the whole industrial site of the Ignalina NPP is located on a solid structural block; however, due to activity of deep faults, differential shifts of the earth surface take place at the junction of the Druksiai Graben and the South Druksiai block.

Assessing seismic conditions at the Ignalina NPP industrial site, the State Commission of the former USSR formed in 1988 stated that there was a lack of studies (including geodetic studies) conducted in the INPP area for analysis of the current activity of tectonic faults. Data of such geodetic studies were the qualitative indices for assessment of the geodynamic risk degree of the Ignalina NPP. Objectives for the studies were formulated as follows: to establish whether deep tectonic faults in the area of the Ignalina NPP were active, whether shifts of the earth surface caused by activity of tectonic faults posed any threat to active nuclear power objects and their operational safety.

A geodynamic ground has been equipped for measurement of current vertical shifts of the earth surface (*Juknelis et al., 1990*). The Geodynamic Ground of the Ignalina NPP consists of a precise levelling network (*Zakarevicius, 1999*), covering an area of 110 km^2 located at the depression of Lake Druksiai and including the Ignalina NPP industrial site. Precise geodetic measurements were conducted in 1989, 1990, 1991, 1992, and 1994. Graphic representation of the vertical earth surface shift measurement data is presented in Figure 7.5-12.

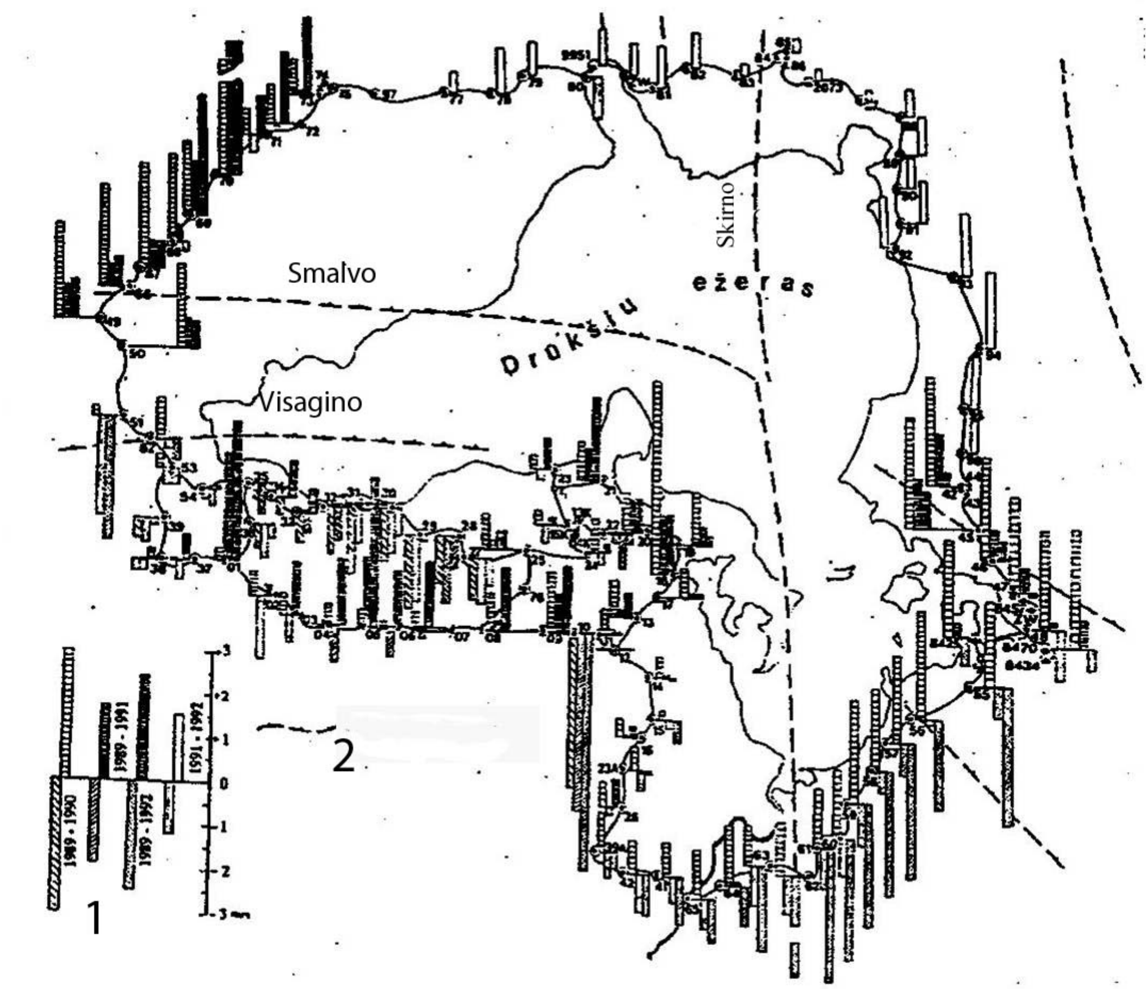


Figure 7.5-12. Measurement results from the Geodynamic Ground. 1 – diagrams of shift amplitudes in surveillance point; 2 – tectonic faults (*Zakarevicius, 1994*).

Vertical shifts of benchmarks of the Geodynamic Ground reveal that vertical shifts of the earth surface are differentiated according to blocks. Shifts of benchmarks are clearly differentiated according to tectonic blocks along the tectonic fault of Druksiai. During the investigation period between 1989 and 1994 the amplitude of relative vertical shift of the northern and the southern blocks has been about 5 mm (*Zakarevicius, 1999*). The northern block is rising relatively to the southern block. Inversion of direction of vertical shifts has been noted – one year measurement cycle data indicate a rise of a certain location, while the next year measurement cycle data indicate downward shift of the benchmark in that location (*Zakarevicius, 1999*). As different structural blocks of the area are bound by deep tectonic faults, it may be assumed that tilting of individual blocks is taking place. Measurement results indicate that differentiation of earth surface shifts in the Ignalina NPP district is related to structural blocks bound by tectonic faults. Shifts found by means of precise geodetic measurements are an expression of not only vertical shifts of the earth surface but also differential vertical shifts of the crystalline basement blocks.

This provides for a conclusion (*Voskresenskaia et al., 1988*; *Zakarevicius, 1999*), that active tectonic processes take place in the area of the Ignalina NPP at the present time. However, absolute values of shifts amounting to the amplitude of 5 mm in three years and changing direction of shift vector are infinitely small in practice. Maybe the more important conclusion of studies of these geodynamic shifts is that the industrial site of the Ignalina NPP area located at the junction of two regional tectonic structures in Lake Druksiai is located at an increased sensitivity zone from the seismic point of view.

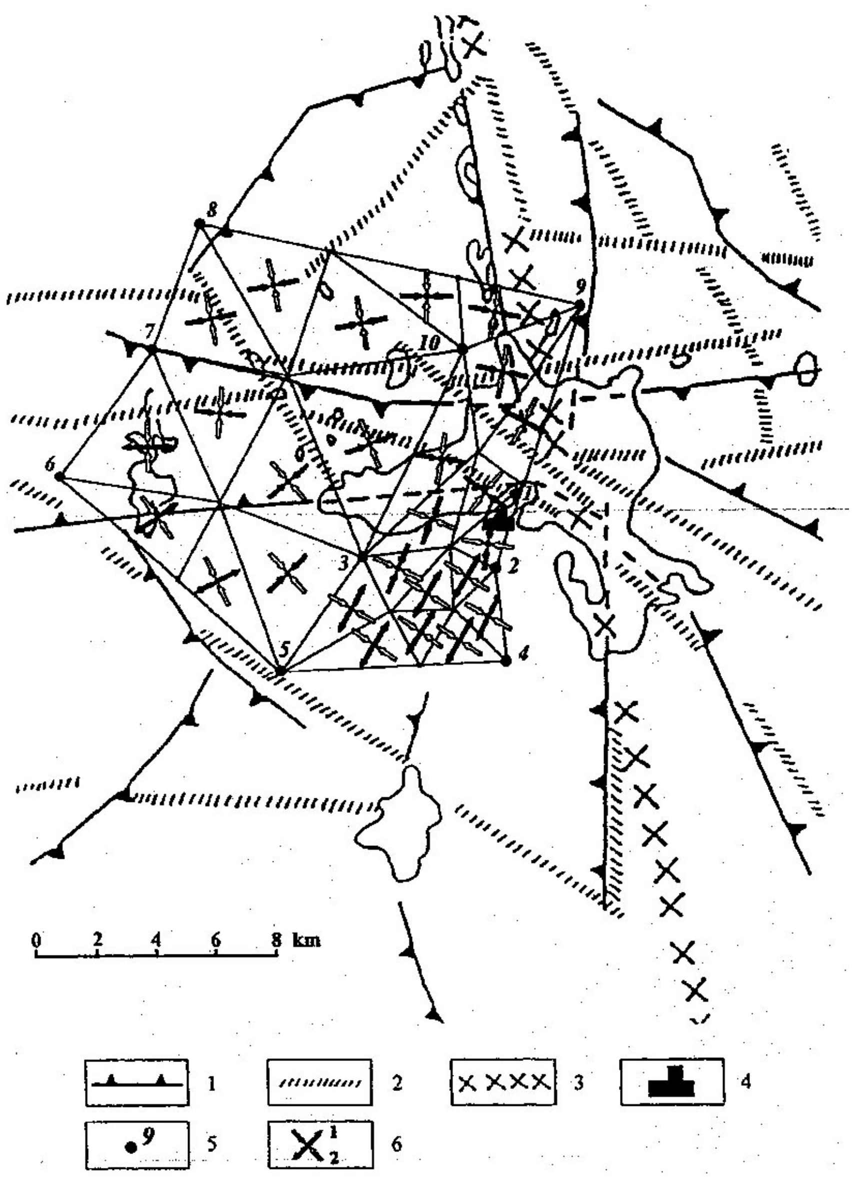
The presented data indicates that intensity of vertical neotectonic shifts of the earth surface at the first surveyed site is best represented by measurements conducted at some points. It may be seen that data of measurement cycles indicates a tendency for consistent rise of one point. The amplitude of the rise amounted to plus two mm for the period between 1989 and 1993. Inversions of vertical shift of another point were established for the period between 1989 and 1991 and amounted to an amplitude of almost half a millimetre, while in 1989–1992 the total amplitude of the vertical shift vector did not exceed one millimetre. Such absolute values of the measured shifts indicate that the area is not in a zone of active tectonic faults and the differentiated rise of infinitely small amplitude of the earth surface is caused by geodynamic processes taking place in the adjacent graben of the Druksiai Depression.

During recent years the measurement of horizontal differential shifts of the earth surface in the area of the Ignalina NPP was completed using precise geodetic methods. Studies of horizontal shifts indicated conformation of the block composition of the Ignalina NPP area with a very high probability.

Measurements indicate that in the Geodynamic Ground equipped in the area of the Ignalina NPP and around Lake Druksiai directions of the largest relative horizontal shifts coincide with directions of tectonic faults determined using geological methods (*Stanionis, 2005*).

Precise geological measurements conducted in 1992–1994 indicated that annual values of the largest elongation in the Ignalina NPP area amount to a tenth million part and going from southwest to northeast a compression zone turns into an extension zone. All territory of the industrial ground of the Ignalina NPP is within the general tectonic compression zone (*Stanionis, 2005*).

Therefore, precise measurements of horizontal shifts of the earth surface indicate that the first surveyed NNPP site (Site 1) (Figure 7.5-13) is affected by tectonic compression. The direction of the biggest and the most important stress almost coincides with the longitudinal direction; hence the compression stress is perpendicular to the Druksiai (Visaginas) regional fault crossing Lake Druksiai.



1 – seismic survey, 2 – aeromagnetic survey, 3 – morphostructural analysis. Others: 4 – Ignalina Nuclear Power Plant, 5 – GPS points, 6 – principal stresses (1 – maximal principal stress variation, 2 – minimal principal stress variation)

Figure 7.5-13. Pattern of Earth crust principal tectonic stress variations. Modified from (*Juknelis et al., 1990*).

Conclusions

- data of precise geodesic measurements of earth surface shifts confirm the conclusion of geological studies concerning block composition of tectonic structures in all Ignalina NPP area;
- these studies and measurements confirm the assumptions concerning activity of the Druksiai (Visaginas) and Skirnas tectonic faults; precise measurements revealed that in the proposed site No 1 earth surface shifts are infinitely small and that in certain periods the vertical shift vector changes its direction – the earth surface rises and then sinks;
- precise measurements have not been performed at site No 2;
- measurements of horizontal shifts indicate infinitely small relative deformations and infinitely small deformation gradients;

- the nature of the present earth surface movements indicates that the both NNPP sites are at sufficient distance from the junction between the Druksiai(Visaginas) tectonic fault and the Skirnas tectonic fault and belongs to the compressive stress area to the south of the Druksiai (Visaginas) tectonic fault zone.

7.5.1.6 Seismic activity

The Lithuanian territory is traditionally considered as a non-seismic or low-seismic zone. This is due to the geological structure of the territory and the long distance from tectonically active regions. Historical and recent instrumental data prove that seismic events of low or medium intensity have happened in territories of the Baltic States (Figure 7.5-14).

The most recent seismic events with magnitude of 4.4 and 5.0 on the Richter scale took place in the Kalingrad region of Russia in September 21, 2004. These were registered by seismological networks worldwide as well as by the seismological station of INPP.

Nineteen historical earthquakes took place within a radius of 250 km around the new NPP sites between 1616 and 1965 (*PNIIIS, Moscow, 1988*). In the new NPP region 4 seismological observation stations were installed in 1999 (Figure 7.5-14). Since then the Geological Survey of Lithuania according to agreement with INPP processes and analyses the data gathered at these stations.

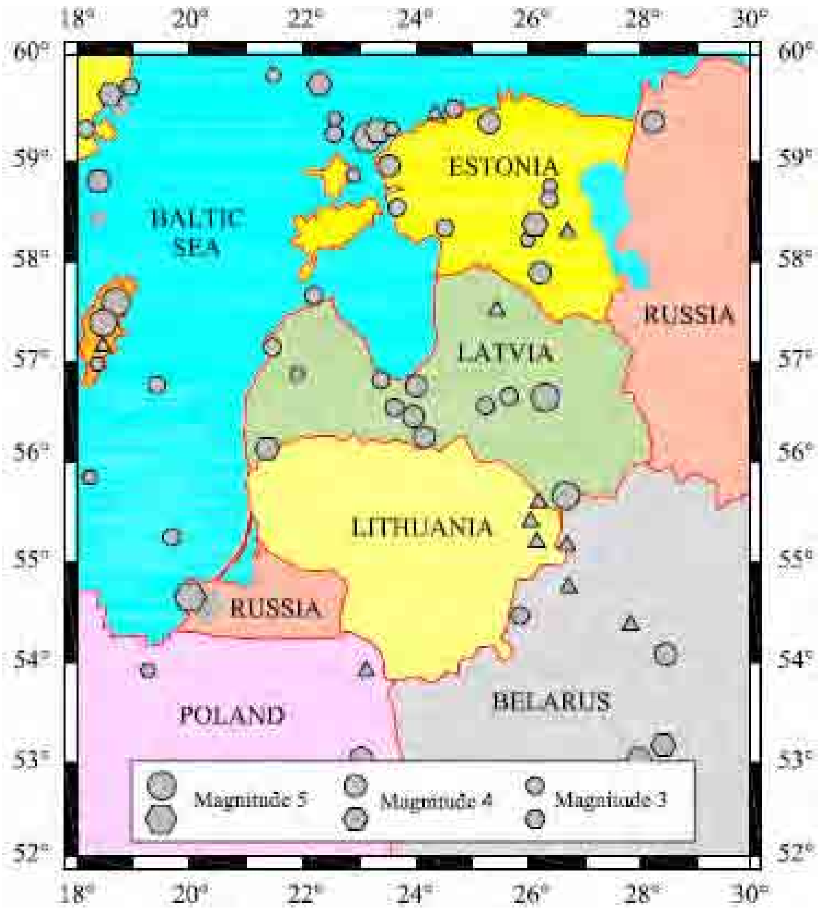


Figure 7.5-14. Seismicity of Baltic States: circles – historical events from 1616 to 1965; hexagons – instrumental data from 1965 to 2004; triangles – operative seismic stations.

A new VATESI regulation P-2006-01 “Requirements for Analysis of Seismic Impact on Nuclear Installations” (*State Journal, 2006, No. 87-3447*) provides requirements and recommendations for the seismic design and impact analysis of the structures, systems and components of nuclear installations.

IAEA Safety Standards (*IAEA Safety Guide No. NS-G-3.3, 2002; IAEA Safety Requirements No. NS-R-3, 2003; IAEA Safety Guide No. NS-G-1.6, 2003*) set the requirements for evaluation of seismic properties of construction sites of nuclear power plants and other nuclear installations and for quantitative description of project parameters of earth tremors and seismic categories of soils.

IAEA Safety Standards (*IAEA Safety Requirements No. NS-R-3, 2003* and *IAEA Safety Guide No. NS-G-1.6, 2003*) assume that during an earthquake a nuclear power plant is shaking together with the geological basis, i.e. totality of the ground supporting the plant building. Therefore, assessment of seismic properties is conducted for the whole "building-basement" system. However, there are two aspects to discuss.

The first aspect is how the shaking basement affects seismic displacement of the building during an earthquake. Displacement of splits in the tectonic basement may cause destruction of NPP buildings. It is prohibited to construct nuclear power plants directly above splits in the tectonic basement (*IAEA Safety Series No. 110, 1993*). Other effects on NPP buildings also depend on construction, arrangement, and dynamic characteristics of the buildings. Composition, structure, water content, and physical properties of basement soils describing seismic categories of grounds are also very important.

The second aspect is evaluation of the basement soils capacity and settlement caused by permanent and seismic stresses. The essential principle for designing seismically durable NPP buildings and plant is strict observance of provisions of the IAEA Safety Standards to avoid radiation accidents, which may be caused by destruction of nuclear energy objects as a result of earthquakes.

As a NPP represents a potentially dangerous nuclear installation with regard to radiation safety, it is necessary to ensure its protection from seismic effects. However, there is no point in infinite improvement of seismic durability of the buildings and plant, the destruction of which would not cause radiation accident. Therefore the safety philosophy of the IAEA presumes different levels of safety requirements for each element of a NPP. Different durability categories are defined for buildings and plant in relation to radiation safety. Buildings of the nuclear reactor must be of the highest category.

Therefore, different levels of dangerous intensity of tremors and probability of shifts are set for each seismic durability category of buildings. These levels may become manifested during a possible earthquake at the specific NPP site.

IAEA Safety Standards provide that for each NPP site selected, two levels of seismic shifts, which may be caused with a certain probability at the NPP site by an earthquake, must be assessed:

- SL-1 (Seismic Level 1), corresponding to the seismic level PZ (Design Earthquake) of the Russian Federation standards, to the American OBE (Operating Basis Earthquake), and the British DBE (Design Basis Earthquake);
- SL-2 (Seismic Level 2), corresponding to the seismic level MRZ (Maximum Estimated Earthquake), of the Russian Federation standards, to the American SSE (Safe Shutdown Earthquake), and the British SSE or BDBE (Beyond Design Basis Earthquake).

Seismic Level 1 (SL-1) is such a probable highest level of ground seismic shift at the NPP site, which allows for termination of production of electric or heat power without shutting down a reactor, but rather only by changing its operation mode. The IAEA provides that probability for a repeat of an earthquake of this level is 10^{-2} 1/years. That is, ground seismic shifts of this level may be caused by an earthquake, which may take place at any time, but only once in 100 years. Therefore, possibly highest intensity of seismic shifts at the NPP site, which may be caused by the SL-1 earthquake, has a set probability that it may take place within the operating period of a specific NPP.

Seismic Level 2 (SL-2) is such a probable highest level of ground seismic shift at the NPP site, which still allows for a safe shut-down of the nuclear reactor. According to the VATESI document P-2006-01 (*State Journal, 2006, No. 87-3447*) SL-2 corresponds to a level with a probability of being exceeded in the range 1×10^{-3} to 1×10^{-4} (mean values) or 1×10^{-4} to 1×10^{-5} (median) per reactor per year. Therefore, the SL-2 sets the highest possible intensity of seismic shifts, which may be caused at the NPP site by an earthquake of such magnitude, the probability of which may not be rejected even if it is infinitely small.

Like intensity of earthquakes, seismic levels SL-1 and SL-2 are described by points according to the international 12-point scale MSK-64 (Medvedev–Schponhoyer–Karnik scale of 1964) or according to equivalent 12-point European Macro seismic Scale of 1998, EMS-98.

A risk of seismic deformations of NPP plant and buildings is increased by poor seismic characteristics of basement soils, which depend on composition, water content, and physical condition. The most dangerous from the seismic point of view are soils of the third seismic category (*STR 1.04.02: 2004; List of Regulations, SP 11-105-97, 1989; SNiP II-7-81, 1995*). If half or more of the 10-meter soil layer at the NPP site is of the third seismic category, seismic levels of the NPP site are increased by one point. This is a so-called assessment of the seismic level of the NPP site taking into account soil conditions.

Current assessment of seismic properties of the Ignalina NPP site is based on the official conclusion prepared by a task force for evaluation of the seismic conditions at the NPP site formed by resolution No. 1886 P adopted by the USSR Council of Ministers on September 22nd, 1989 (*Conclusions of working group ..., 1988*). Following requirements of the IAEA Safety Standards, a thorough analysis of data obtained during geological, tectonic, geophysical, geodetic, seismological, hydrogeological, engineering geological, and engineering seismic studies was conducted. On the basis of analysis of these data, seismic levels PZ (SL-1) and MRZ (SL-2) were determined for the Ignalina NPP site according to the MSK-64 scale taking into account the condition of soils (i.e. taking into account presence of grounds of the 3rd seismic category under buildings of the NPP).

Taking into account that the top 10-meter part of the basement layer under buildings of the Ignalina NPP site consists of grounds of the 3rd seismic category, the task force has determined the PZ seismic level of 6 points (in the MSK-64 scale), which corresponds to the 6-point level SL-1 in the MSK-64 or EMS-98 scale. The task force has determined the MRZ seismic level of 7 points (in the MSK-64 scale), which corresponds to the 7-point level SL-2 according to the MSK-64 or EMS-98 scale (*Conclusions of working group ..., 1988*).

In June–October of 1988 specialists of the Moscow Industrial and Scientific Research Institute conducted instrumental seismic studies and seismic micro-zoning of the Ignalina NPP site (*Voskresenskaia et al., 1988*). On the basis of the data obtained during instrumental studies, quantitative seismic parameters were evaluated and seismic micro-zoning, which also covered the area of the first surveyed NNPP site (Site 1), was performed.

On the basis of the seismic micro-zoning data it was established that the PZ (SL-1) level of the surveyed site is 6 points in the MSK-64 scale, taking into account that the top 10-meter part of the soil layer consists of grounds of the 3rd seismic category. The MRZ (SL-2) levels of the surveyed site is 7 points in the MSK-64 scale, taking into account, that there are grounds of the 3rd seismic category in the top 10-meter part of the soil layer (*Voskresenskaia et al., 1988; Mikhailitchenko et al., 1995*). Using abbreviations used in the IAEA Safety Standards, the seismic level SL-1 of the surveyed site is 6 points in the MSK-64 scale (or EMS-98 scale), while seismic level SL-2 is 7 points in the MSK-64 scale (or EMS-98 scale).

Assessment of seismic characteristics using instrumental measurements and modelling of seismic data of the Ignalina NPP site and its particular parts has been performed (*Voskresenskaia et al., 1988; Mikhailitchenko et al., 1995*). According to the data presented, parameters of seismic movements in the new NPP sites may be described by the following values (*Voskresenskaia et al., 1988*):

- Critical acceleration a_{max}=0.0375 g for seismic level PZ (SL-1);
- Critical acceleration a_{max}=0.075 g for seismic level MRZ (SL-2).

In the analytic report prepared by the National Projection and Scientific Research Complex Power Technology Institute in 1989 the 3rd seismic model was applied to the surveyed site. This model assumes an average ground density of ρ=2.2 Mg×m^{-3}, transversal wave propagation speed of v_s= 400 m×s^{-1} and a longitudinal wave propagation speed v_p=1400 m×s^{-1} (*Mikhailitchenko et al., 1995*).

Dynamic characteristics of the ground layer stratified at a depth of up to 10 meters:

- Transversal wave propagation speed v_s= 250–270 m×s^{-1};
- Longitudinal wave propagation speed v_p= 1080–1125 m×s^{-1};
- Dynamic Puason's number v_d= 0.45–0.46;
- Dynamic Jung's modulus E_d= 365–450 MPa;
- Dynamic Kulon's modulus G_d= 125–160 MPa;
- Relative dissipation D_p= 0.5–0.85.

Averaged dynamic characteristics of the ground layer stratified deeper than 10 meters:

- Transversal wave propagation speed v_s= 380 m×s^{-1};
- Longitudinal wave propagation speed v_p= 1140 m×s^{-1};
- Dynamic Puason's number v_d= 0.43;
- Dynamic Jung's modulus E_d= 800 MPa;
- Dynamic Kulon's modulus G_d= 300 MPa;
- Relative dissipation D_p= 0.60.

Thus, when assessing deformation of basements under the NPP buildings as a result of seismic effects, a geological composition of ground layers is simplified: it is assumed that the base of the NPP buildings consists of an infinite continuum of horizontal layers, grounds are analyzed as viscous elastic medium with linear deformation, while deformation characteristics of grounds are taken to be the same within boundaries of the same layer.

Conclusions:

- seismic conditions at the Ignalina NPP industrial area have been thoroughly researched using complex methods such as seismic micro-zoning, the data of which may be used for determination of seismic levels of the proposed sites;

- the measured seismic parameters of ground layers correspond to the requirements of the IAEA Safety Standards for seismic research methods;
- it has been found that a part of the top 10-meters layer of the ground consists of low-strength grounds of the 3rd seismic category;
- taking into account domination of soils of the 3rd seismic category in the upper part of the geological cross-section at the sites, seismic micro-zoning works and research data provided the determination of the 6 point seismic level PZ (SL-1) and 7 points seismic level (SL-2) in the MSK –64 (or EMS-98) macro-seismic scale;
- results of the instrumental seismic studies conducted in the industrial area of Ignalina NPP provides the description of general seismic characteristics of soil layers at the proposed NNPP sites.

7.5.2 Assessment of impacts on the underground

Direct impacts on the underground include the possible changes in chemical composition of soil and shallow groundwater and changes of soil porosity under the planned buildings.

The geological conditions of the alternative sites are quite equal. The land surface of site No 1 has been flattened, peat has been removed from the lowerings which are filled with man made soil. The surface of site No 2 is quite flat except for a few knolls. At this site the soil has not been removed and man made soil occurs in former sags of the natural land surface. The volume of man made soil is larger at site No 2. Man made soil is too weak for the building foundation and has to be removed.

The construction and operation is not expected to affect the deeper geological layers or the confined groundwater. The possible impacts on soil are discussed in more detail in the Section 7.4 and impacts on groundwater in Section 7.3.

Faulting and the vertical movements of the earth surface can potentially cause cracking of foundations and other constructions which in turn could increase the risks of accidents. Therefore the new NPP has to be built on a stable foundation which is not located on a tectonic fault.

The structural tectonic conditions at the new NPP sites are rather complicated. The area of the selected sites is located in the region of a neotectonic vertical change of the earth surface where both vertical and horizontal movements of the tectonic blocks occur. According to the studies the tectonic movements change direction and relative vertical shift of the blocks can reach amplitude of 2 mm per year. The largest relative horizontal shifts coincide with directions of tectonic faults determined using geological methods. The elongation of the area reaches only a tenth million part. The compression zone turns into an extension zone from the southwest to northeast. All the territory of the Ignalina NPP industrial area is located within a general tectonic compression zone.

Both sites are located on the same tectonic block which is quite stable. The absolute values of shifts at the sites are infinitely small in practice and negative impact due to the tectonic movements on the construction or operation of the new NPP is not expected. According to the currently available data, the both sites are equally acceptable and appropriate with regards to the tectonic and seismic conditions. More detailed assessment of the sites under these conditions requires accurate instrumental measurements and additional investigation. It is necessary to carry out more detailed investigations at both sites. The detailed technical feasibility study of the new NPP should include investigation (at least one borehole) of the Ledai Subformation of the Upninkai Formation, because the absolute depth of the ridge of these rocks will provide the data for estimation of the probability of a local tectonic fault in a specific location of the projected buildings.

7.5.3 Mitigation measures

The most important mitigation measure is the appropriate technical design. The technical design of the new NPP will meet all the safety standards required by IAEA recommendations and Lithuanian legislation and regulations.

The reactor as well as other buildings will be designed and constructed to remain stable in case of earthquakes of predicted intensity. The risk for negative impacts of the tectonic movements will be further diminished by layout design.

All possible changes of the environmental quality will be monitored. The NPP environmental monitoring program will include hydrogeological, geochemical and geodetic measurements of the new NPP site. If some changes of the environmental components exceed the permitted level, for example in an emergency case, the environmental component will be handled using technical measures.

7.6 Biodiversity

7.6.1 Present state of the environment

7.6.1.1 General description of the biodiversity and main values

When accessing impact of the new nuclear power plant (new NPP or NNPP) on biodiversity mainly the territory of the Lithuanian Republic with a radius of 30 km from village Tumelina (western edge of Lake Druksiai) has been analysed in this work. Further in this work the analysed territory will be named as the NNPP region. The region is located in Aukstaitija eminence, which is a part of the Baltic Eminencies physical geographical region. Higher and drier areas of the region are overgrown with forests. The relief is very undulating and rich in lakes.

The NNPP region belongs to the Boreal region of Mixed Forest Biome. In Lithuania it belongs mostly to Eastern Lithuania Laky Channels and Northern Nalsia Highlands units of the Eastern Baltic Province.

From the biodiversity point of view there are a few very important ecological complexes in the NNPP region: Lake Druksiai, the Smalvas and Smalvykstis lakes with adjoining wetlands, Antaliepte wetlands (Antaliepte Hydro-power water reservoir on Sventoji River), Pusnis mire and some others.

The climate of the region is continental. Yearly fluctuations are largest in the country. Transitions between seasons are fastest, winters are longest and coldest, and summers and the vegetation period are shortest.

The following biodiversity values have been discussed and taken into consideration in this EIA Report:

- NATURA 2000 areas and other areas of biodiversity protection
- Qualifying bird species (Annex I species of the Council Directive 79/409/EEC, which population protection the SPAs have been designated for);
- Other bird species covered by Annex I of the Council Directive 79/409/EEC);
- Qualifying plant and animal species (Annex II species of the Council Directive 92/43/EEC, which population protection the SCI have been proposed (designated) for);
- Other plant and animal species covered by Annex II of the Council Directive 92/43/EEC);
- Qualifying natural habitats (Annex I habitats of the Council Directive 92/43/EEC, which protection the SCI have been proposed (designated) for);
- Other natural habitats covered by Annex I of the Council Directive 92/43/EEC;
- Species covered by Annex IV of the Council Directive 92/43/EEC);
- Species included into the Lithuanian Red Data Book;
- Aggregated species (colonial, making aggregation on stop-over sites, etc.);
- Game species.

Thus in this work animal and plant species, habitat types of community interest, whose conservation requires the designation of special areas of conservation according to the Council Directives 79/409/EEC and 92/43/EEC; rare and threatened species included into the Lithuanian Red Data Book (LRDB) and other species of community interest in need of strict protection, were considered as biodiversity values.

7.6.1.2 Summary of NATURA 2000 conservation areas

NATURA 2000 implementation and designation values

The European ecological network “NATURA 2000” is a network of protected areas of the European Community, designated when implementing the Directives of the Council of the European Communities 79/409/EEC and 92/43/EEC. The main objective of the NATURA 2000 network is to ensure the survival of species and habitats that are threatened or rare throughout Europe.

Based on the Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (further – Birds Directive), for conservation of Annex I species the most suitable areas have been designated as “Special Protection Areas” (SPAs). Annex I of the Directive lists bird species in danger of extinction, species, which are vulnerable to specific changes in their habitats, species, which are rare and other species, which deserve particular attention due to the specifics of their habitat.

With respect to the regularly occurring migratory bird species, which are not listed in Annex I, similar measures shall be taken, on the grounds of Article 4 (clause 2), whereby special attention shall be paid to the protection of wetlands. Regarding the SPAs, the member states are obliged to implement appropriate measures in order to prevent pollution and deterioration of the areas and to avoid disturbance of birds.

When implementing the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (further – Habitat Directive) Special Areas for Conservation (SACs) are to be established. Prior to establishment of SACs, based on scientific research, potential SACs (or Sites of Community Importance, SCIs) are to be selected and the list is to be presented to the European Commission (EC). After the potential SAC is approved by EC, the member state has to commence its establishment.

Potential SAC (SCI) territories are areas meeting the established criteria for selection of Special Areas for Conservation and indicated in the list, approved by the Order of the Minister of the Lithuanian Ministry of Environment No D1-302, dated June 15, 2005 (*State Journal, 2005, No. 105-3908*). According to the Directive the member states shall introduce measures in order to ensure that the quality of the natural habitats and the habitats of species in the NATURA 2000 network does not deteriorate and that no factors arise which might disturb the species for which the areas have been designated.

According to the requirements stated in Article 24 of Paragraph 2 of the Lithuanian Law on Protected Areas (*State Journal, 1993, No. 63-1188; 2001, No. 108-3902*), first a national protected area is to be established with the purpose to grant them the status of Special Protection Area or/and Special Areas for Conservation. The European Commission has already approved the list of potential SAC territories in Lithuania.

The basis for legal establishment of all mentioned SCIs is Order of the Minister of the Lithuanian Ministry of Environment No. D1-302, dated June 15, 2005 (*State Journal, 2005, No. 105-3908*).

NATURA 2000 areas within the NNPP region

There are 8 NATURA 2000 network Sites of Community Importance (SCIs), valuable for habitat, plant and animal species protection in the NNPP region (Figure 7.6-1 and Table 7.6–1).

Based on literature data most of the biodiversity values in the NNPP region are concentrated to the NATURA 2000 network sites. Thus special attention has been paid to the NATURA 2000 network areas in this assessment.

Most of the territories covered by SCIs are located in the western part of the region being situated on axis East–West. The NNPP region covers the areas of Grazute regional park and Dietkauscizna meadows SCIs only partly.

Table 7.6–1. NATURA 2000 network areas of importance for habitat and species protection (SCI) in the NNPP region and key information on their boundaries.

Site name: official / English	Area of the site, ha	Comments on site boundaries	Site code in NATURA 2000 network data base
Druksiu ezeras / Lake Druksiai	3611	The SCI has been established according to the special map. The border is nearly the same as for Druksiu ezeras SPA.	LTZAR0029
Smalveles upe ir slapzemes / River Smalvele and adjacent limy fens	547	The border is the same as for Smalva hydrographical reserve and nearly the same as for Smalvos slapzemiu kompleksas SPA.	LTZAR0026
Smalvos ir Smalvykscio ezerai ir pelkes / Lakes and wetlands Smalva and Smalvykstis	2225	The border is the same as for Smalvas landscape reserve.	LTZAR0025
Grazutes regioninis parkas / Grazute regional park	26125	The border is nearly the same as for Grazute regional park (with the exception of the zones for recreational, agriculture and other (residential) purposes). It comprise Siaures rytine Grazutes regioninio parko dalis SPA.	LTZAR0024
Pusnies pelke / Pusnis wetland	779	The border is the same as for Pusnis thelmological reserve.	LTIGN0001
Ruzo ezeras / Ruzas lake	205	Border has been established according to the special map.	LTIGN0026
Gerveles pelke / Gervele wetland	373	Border has been established according to the special map.	LTIGN0017
Dietkausciznos pievos / Dietkauscizna meadows	147	The SCI is a part of Dysna hydrographical reserve. Border has been established according to the special map.	LTIGN0004

* The official (Lithuanian) name, code of the protected area, area of the site are indicated as they are used in the NATURA 2000 Standard Data Form (”NATURA 2000” Network Database) for Special Protection areas (SPA) and for sites eligible for identification as Sites of Community Importance (SCI) and for Special Areas of Conservation (SAC).

Sakeliskes meadows SCI is bordering the NNPP region. Aukstaitija National park is located to the south-east from the NNPP (in Figure 7.6-2 indicated in red), and is a few kilometres outside the border. These two protected areas, which are outside the NNPP region, have not been analysed in detail in this work.

Out of 8 NATURA 2000 network Sites of Community Importance (SCIs), 3 sites are of international importance for bird conservation (SPAs), 5 sites are fully or partly protected by national laws (are protected territories of national importance), two sites are water body protection zones (site protection regulation is based on surrounding terrestrial areas and targeted on achievement or maintenance of good water quality) and one site is still non-protected territory.

Presented qualifying (most important) values in SCIs (Table 7.6–3) show that SCIs of the NNPP region are of international importance for protection of biodiversity mostly related with wetland and woodland habitats: European otter (*Lutra lutra*), several species of plants, invertebrates and many types of habitats.

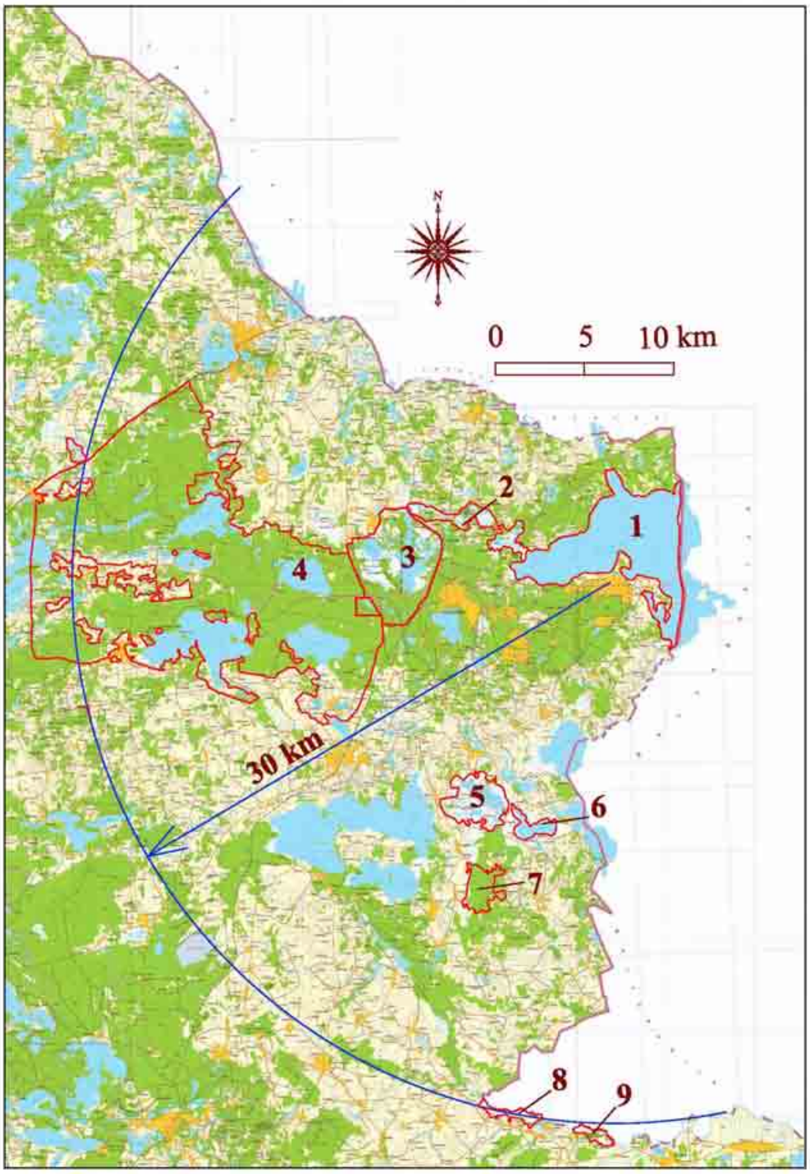


Figure 7.6-1. The NATURA 2000 network Sites of Community Importance (SCIs), valuable for habitat and animal species protection in the NNPP region. Perimeter of the region is indicated in blue). Sites of Community Importance: 1 – Lake Druksiai; 2 – River Smalvele and adjacent limy fens; 3 – Lakes and wetlands Smalva and Smalvykstis; 4 – Grazute regional park; 5 – Pusnis wetland; 6 – Ruzas Lake; 7 – Gervele wetland; 8 –- Dietkauscizna meadows; 9 – Sakeliskes meadows.

There are 4 NATURA 2000 network Special Protection Areas (SPAs), valuable for bird protection in the NNPP region (Figure 7.6-2 and Table 7.6–2).

A legal basis for establishment of the mentioned SPAS is Resolution of the Government of the LR No. 399, dated April 8, 2004 (amended resolution of the Lithuanian Government, dated September 25, 2006 No. 819) (*State Journal, 2006, No. 92-3635*).

Most of the territories covered by SPAs are located in the western part of the region being situated on axis East–West. The NNPP region covers part of the North-eastern part of Grazutes Regional Park SPA territory only. Aukstaitija National Park is located to the South-east from the NNPP, and is a few kilometres outside the border.

Table 7.6–2. Natura 2000 network areas of importance for protection of birds (SPAs) in the NNPP region and key information on their boundaries*.

Site name: official / English	Area of the site, ha.	Comments on site boundaries	Site code in NATURA 2000 network data base
Druksiu ezeras / Lake Druksiai	3612.33	The SPA covers part of national protected area. The border of the SPA has been defined according to the plan.	LTZARB003
Dysnu ir Dysnykscio apyezeriu slapzemiu kompleksas / The complex of Dysnai and Dysnykstis lakes surrounding wetland areas	4016.56	The SPA covers part of protected area. The border of the SPA has been defined according to the plan.	LTIGNB004
Smalvos slapzemiu kompleksas / The complex of Smalva wetlands	538	The border of the SPA is the same as for Smalva hydrographical reserve and nearly the some as for Smalveles upe ir slapzemes SCI	LTZARB002
Siaures rytine Grazutes regioninio parko dalis / North eastern part of Grazute regional park	5699.85	Siaures rytine Grazutes regioninio parko dalis SPA comprises a part of the Grazute Regional Park and part of the Grazutes regioninis parkas SCI territory. The border has been defined according to the plan.	LTZARB004

*The official (Lithuanian) name, code of the protected area, area of the site are indicated as they are used in the NATURA 2000 Standard Data Form (NATURA 2000 Network Database) for Special Protection Areas (SPA) and for sites eligible for identification as Sites of Community Importance (SCI) and for Special Areas of Conservation (SAC).

Out of 4 NATURA 2000 network Special Protection Areas (SPAs), 3 sites are of international importance for habitat and species conservation (being as potential Sites of Community Importance (SCI), and 2 sites are fully protected by national laws (are protected territories of national importance). Two territories are water body protection zones (site protection regulation is based on surrounding terrestrial areas and targeted on achievement or maintenance of good water quality).

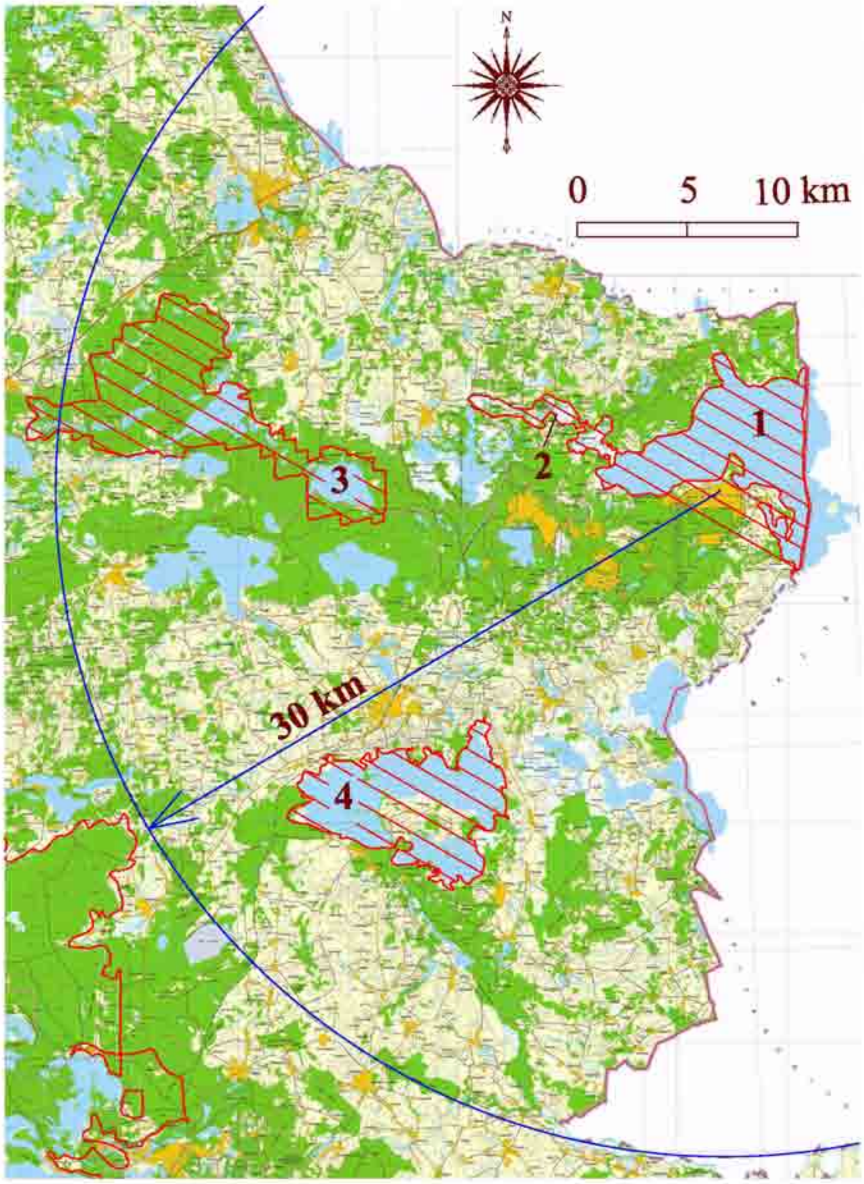


Figure 7.6-2. The NATURA 2000 network Special Protection Areas (SPAs), valuable for bird protection in the NNPP region. Perimeter of the region is indicated in blue. Special Protection Areas: 1 – Lake Druksiai; 2 – The complex of Smalva wetlands; 3 – North eastern part of Grazute Regional Park; 4 – The complex of wetland areas, surrounding Dysnai and Dysnykstis lakes.

Presented qualifying (most important) values in SPAs (Table 7.6–4) show that the SPAs of the NNPP region are of international importance for protection of populations of birds, representing various ecological groups, whose main breeding and feeding habitats are water bodies (e.g., Great Bittern (*Botaurus stellaris*) and Black-throated Diver (*Gavia arctica*)), forests (Pygmy owl (*Glaucidium passerinum*)), open agricultural landscape (Corncrake (*Crex crex*)) and a mixture of water body-wetland and meadow areas (Black Tern (*Chlidonias niger*)).

Table 7.6–3. Most important values in NATURA 2000 network areas designated for protection of habitats (SCI) in the NNPP region.

Site name: official / English[1]	Site code in NATURA 2000 data base	Most important values [2]	Amount of values[1] (local population; area)
Druksiu ezeras / Lake Druksiai	LTZAR0029	European otter (*Lutra lutra)*	6–10 ind.
Smalveles upe ir slapzemes / River Smalvele and adjacent limy fens	LTZAR0026	European otter (*Lutra lutra)*	1–5 ind.
Smalvos ir Smalvykscio ezerai ir pelkes / Lakes and wetlands Smalva and Smalvykstis	LTZAR0025	3140, Hard oligo-mesothrophic waters with benthic vegetation of *Chara* formations	354.59 ha
		9010* Western taiga	265.94 ha
		7140 Transition mires and quaking bogs	265.94 ha
		91D0 Bog woodland	88.7 ha
		9080 Fennoscandian deciduous swamp woods	88.7 ha
		7230 Alkaline fens	88.7 ha
		7210 Calcareous fens with *Cladium mariscus* and *Carex davaliana*	88.7 ha
		3160 Dystrophic lakes	53.2 ha
		Fen orchid *(Liparis loeselii), Drepanocladus vernicosus*	251–500 ind.
Grazutes regioninis parkas / Grazute Regional Park	LTZAR0024	3130 Oligothrophic waters in medio-European and perialpine area with amphibious vegetation: *Littorella* or *Isoetes* or annual vegetation on exposed banks (Nanocyperetalia)	105 ha
		7140 Transition mires and quaking bogs	69.6 ha
		7120 Degraded raised bogs, (still capable of natural regeneration)	27.2 ha
		3140 Hard oligo-mesothrophic waters with benthic vegetation of *Chara* formations	18.4 ha
		91D0 Bog woodland	10.9 ha
		6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco brometalia; important orchide sites*)	1.0 ha
		6120* Xeric sand calcareous grasslands (*Koelerion glaucae*)	6.4 ha
		Large copper (*Lycaena dispar)*	
		Eastern pasque-flower *(Pulsatilla patens)*	251–500 ind.
Gerveles pelke / Gervele wetland	LTIGN0017	7120 Degraded raised bogs, (still capable of natural regeneration)	50 ha
		91D0 Bog woodland	95 ha
Pusnies pelke / Pusnis wetland	LTIGN0001	6230* Species-rich *Nardus* grasslands, on silicious substrates in submountain areas in Continental Europe	7.9 ha
		6430 Hydrophilous tall herb fringe communities of plains and of the mountain to alpine levels	39.7 ha
		7140 Transition mires and quaking bogs	237.9 ha
Ruzo ezeras / Ruzas lake	LTIGN0026	*Dytiscus latissimus*	
		Vesicular aldrovanda *(Aldrovanda vesiculosa)*	>10 000 ind.
Dietkausciznos pievos / Dietkauscizna meadows	LTIGN0004	6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)	4 ha
		6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	4 ha
		6450 Northern boreal alluvial meadows	14 ha
		6510 Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)	1 ha
		7230 Alkaline fens	21 ha
		9080* Fennoscandian deciduous swamp woods	4 ha
		Fen orchid (Liparis loeselii)	51–100 ind.

1 – The official (Lithuanian) name and amount of values are indicated as they are used in the NATURA 2000 Standard Data Form ("NATURA 2000" Network Data Base) for Special Protection areas (SPA) and for sites eligible for identification as Sites of Community Importance (SCI) and for Special Areas of Conservation (SAC).

2 – Most important values are indicated according to the legal acts of designation of the SCIs. In some cases list of most important values in the NATURA 2000 Standard Data Form ("NATURA 2000" Network Data Base) for Special Protection areas (SPA) and for sites eligible for identification as Sites of Community Importance (SCI) and for Special Areas of Conservation (SAC), in comparison with the legal act of their designation is longer (a new data/information available is included).

Table 7.6–4. Most important values in NATURA 2000 network areas designated for protection of birds (SPA) in the NNPP region*.

Site name: official / English	Site code in NATURA 2000 network data base	Most important values[1]	Amount of values (local population)
Druksiu ezeras / Lake Druksiai	LTZARB003	Great Bittern (*Botaurus stellaris*)	10 males
Dysnu ir Dysnykscio apyezeriu slapzemiu kompleksas / The complex of Dysnai and Dysnykstis lakes surrounding wetland areas	LTIGNB004	Corncrake (*Crex crex*)	30 males
Smalvos slapzemiu kompleksas / The complex of Smalva wetlands	LTZARB002	Black Tern (*Chlidonias niger*)	40 breeding pairs
Siaures rytine Grazutes regioninio parko dalis / North eastern part of Grazutes Regional Park	LTZARB004	Black-throated (Diver *Gavia arctica*), Pygmy owl (*Glaucidium passerinum*)	3 breeding pairs 4-5 breeding pairs

* – The official (Lithuanian) name and amount of values are indicated as they are used in the NATURA 2000 Standard Data Form ("NATURA 2000" Network Data Base) for Special Protection areas (SPA) and for sites eligible for identification as Sites of Community Importance (SCI) and for Special Areas of Conservation (SAC).

[1] – Most important values are indicated according to the legal acts of designation of the SCIs. In some cases list of most important values in the NATURA 2000 Standard Data Form ("NATURA 2000" Network Data Base) for Special Protection areas (SPA) and for sites eligible for identification as Sites of Community Importance (SCI) and for Special Areas of Conservation (SAC) in comparison with the legal act of their designation is longer (a new data/information available is included).

Black-throated Diver (*Gavia arctica)* and Pygmy owl (*Glaucidium passerinum*) are very rare in Lithuania, therefore protection of their populations is of great importance on national scale as well. According to the data available (*Kurlavicius & Raudonikis 2001*) national minimum population of Black-throated Diver (*Gavia arctica)* consists of 3 pairs only. The NNPP region (particularly the North eastern part of Grazutes Regional Park SPA) is most important area from point of view the species conservation in Lithuania. Breeding population of the Pygmy Owl (*Glaucidium passerinum*) is also rather small (minimum 50 pairs; *Kurlavicius & Raudonikis, 2001*) in the country. Thus the breeding local population of the species in some years can make up to 10 % of the national population. Regional populations of other mentioned species do not present so large a portion of the whole country's population.

7.6.1.3 Individual descriptions of NATURA 2000 areas in the NNPP area

In the following the individual NATURA 2000 sites are described more in detail. First the SCI-areas are described and thereafter the SPA-areas. The focus is on Lake Druksiai NATURA 2000-areas (SCI and SPA) because most of the essential impacts are presumed to be limited to Lake Druksiai and its immediate vicinity.

SCI site: Lake Druksiai (LTZAR0029)

The lake is the biggest one in Lithuania. Area of the site is about 3611 ha. Part of the lake belongs to Belarus. The total area of the lake is 4480 ha. A centre of the territory is defined by E 26 34 57 longitude and 55 37 19 latitude (W/E Greenwich). Water bodies are predominating in the site (Table 7.6–5). The maximum depth of the lake is 31 m.

As the main possible impact is presumed to focus on Lake Druksiai area, this NATURA-site is described here more in detail compared with other NATURA –sites further away from the new nuclear power plant location.

Table 7.6–5. General habitat structure of the Druksiu ezeras SCI according to the NATURA 2000 DB* (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Inland water bodies (Standing water, Running water)	58
Bogs, Marshes, Water fringed vegetation, Fens	3
Extensive cereal	4
Other arable land	6
Broad-leaved deciduous woodland	6
Mixed woodland	16
Other land (Including Towns, Villages, Roads, Waste places, Mines, Industrial sites)	7
Total habitat cover	100

* In this and other similar tables information is from the NATURA 2000 DB Chapter 4 (Site description). It is helpful to better understand habitat structure of the protected site.

Connections to other NATURA–sites: The Druksiu ezeras SCI borders on other NATURA 2000 sites such us the Complex of Smalva wetlands SPA (LTZARB002) and the River Smalvele and adjacent limy fens SCI (LTZAR0026). At the same time the Druksiu ezeras SCI has nearly the same border as the Druksiu ezeras SPA (LTZARB003).

NATURA 2000 – designation values: The Druksiu ezeras SCI is designated with the main goal to protect the local population of qualifying species European otter (*Lutra lutra*), which is listed in Annex II of the Habitat Directive. Its population consists of 6–10 individuals. According to the recent data (*Svazas et al., 2008)* 8 sub-areas where European otter (*Lutra lutra*) has been registered most frequently (Figure 7.6-3). Based on common behaviour of the European otter (*Lutra lutra*) it can be concluded that when moving between habitats (sub-areas) and during dispersion the animal uses mostly the shore of a big water body and watercourses. The population dynamics of the European otter (*Lutra lutra*) in Lake Druksiai is not known in more detail.

According to the NATURA 2000 DB the fish species Spined Loach (*Cobitis taenia*) is the other important value of the site. It is considered as a common species here.

Other species / Mammals: Three other mammal species inhabiting Druksiu ezeras SCI are also listed in Annex II of the Habitat Directive. Wolf (*Canis lupus*) is an occasional visitor of the territory. In 2006-2008 single individuals of lynx (*Lynx lynx*) were counted in Zarasai district and one individual was registered in Ignalina district. It can be concluded that the NNPP is made a conclusion that INPP region is not very important for this animal (*Svazas et al., 2008*). Similarly to the whole Lithuania, in the NNPP region beaver (*Castor fiber*) is a very common mammal. The population of the region consists of 1100–2700 individuals (2006–2008).

The surroundings of the lake are the habitat of the rare mammal ermine (*Mustela erminea*), which is included in the LRDB. Three other mammal species, also included into the LRDB, have been registered in the territory. European otter (*Lutra lutra*), included into the Annex II of the Directive, is a focal, qualifying species. Mountain hare (*Lepus timidus*) is rare but is being observed regularly. Birch mouse (*Sicista betulina*) is a rare species in the meadows of surrounding forests (*Svazas et al. 1999*). A breeding colony of Noctule Bat (*Nyctalus noctula*) was found in Tilze village. The bat Nathusius' pipistrelle (*Pipistrellus nathusii*) has been observed in the region several times. Both these species are listed in the LRDB.

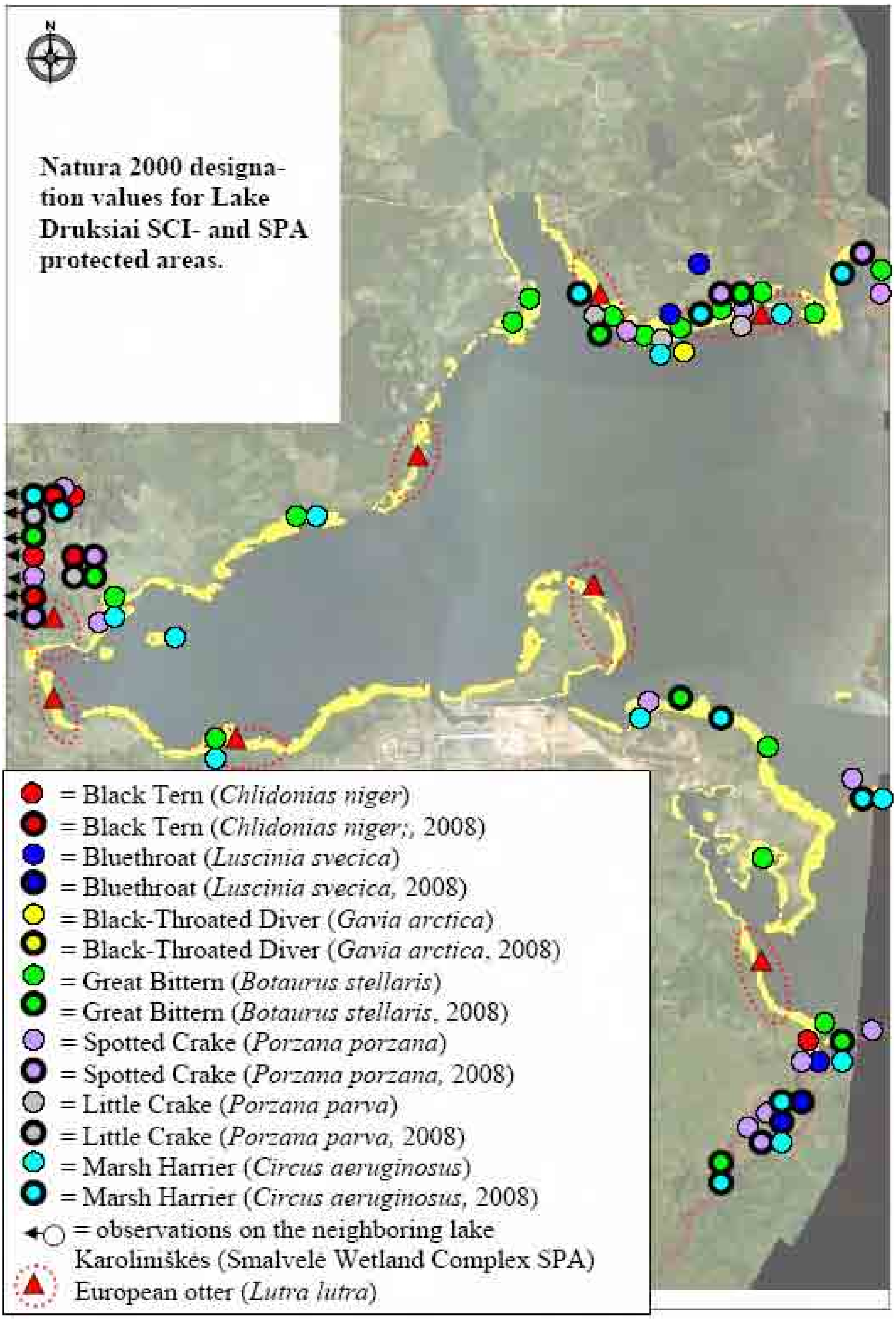


Figure 7.6-3. NATURA 2000 designation values for the Lake Druksiai SCI and Lake Druksiai SPA protected areas, Lithuania. The coloured dots and figures show approximate location of the Natura 2000 designation values (calling males (breeding sites), recorded individuals, and most frequently used habitats). The Spined Loach (Cobitis taenia) is not indicated in the figure. Yellow colour shows associations of Phragmitetea and Potamogenetea (Nymphaea) plants (*Institute of Ecology of the Vilnius University, 2006-2007 and data of L. Raudonikis, 2008*).

Other species / Amphibians and reptiles: A total of 10 species of amphibians and 5 species of reptiles have been registered in the NNPP region (*Rana temporaria, R. arvalis, R. lessonae, R. esculenta, Bufo bufo, B. calamita, Pelobates fuscus, Bombina bombina, Triturus vulgaris, T. cristatus; Lacerta vivipara, L. agilis, Anguis fragilis, Vipera berus* and *Natrix natrix; Svazas et al., 2008*).

In 2006 two rare amphibian species (*Triturus cristatus* and *Bombina bombina*) listed in Annex II of the Habitat Directive were found within a radius of 3 km from the INPP (*Svazas et al., 2008*). These two species as well as *Bufo calamita* are also included into the LRDB. 5 species (*Triturus cristatus, Bombina bombina, Rana arvalis, Rana lessonae, Pelobates fuscus* and *Lacerta agilis*) are listed in Annex IV of the EU Habitat Directive. *Bombina bombina* inhabits water bodies heavily disturbed by humans near the INPP. *Triturus cristatus* has been found in Tumelina forest in a very typical habitat very close to the INPP (*Svazas et al., 2008*).

Other species / Insects: More than 1500 species of insects have been found at Lake Druksiai and in its surroundings in total. During entomological studies some rare terrestrial insect species included in the LRDB have been registered here. *Leucorrhinia pectoralis* and *Lycaena dispar* are listed in Annex II of the EU Habitat Directive. *Lycaena dispar* and *Leucorrhinia albifron* (Odonata) are listed in Annex IV of the EU Habitat Directive. All three species are included in the LRDB. Odonata species are ecologically related to water bodies; in the surroundings of the NNPP mostly with Lake Druksiai. Single individuals have been registered in the south-western part of the lake near Yliske. Single individuals of *Lycaena dispar* (Lepidoptera, Lycaenidae) have been found in the entire region in meadows close to water bodies (*Svazas et al., 2008*).

Carabus coriaceus (Coleoptera, Carabidae) is also included in the LRDB. A small population has been discovered in the Tilze forest. Single individuals of *Papilio machaon* (Lepidoptera, Papilionidae) are registered annually in the surroundings of the villages Tilze and Visaginas. Occasionally *Aricia eumedon* (Lepidoptera, Lycaenidae) is found in wet meadows in the entire region. *Coenonympha tullia* (Lepidoptera, Nymphalidae) inhabits a meadow near Visaginas settlement. All these mentioned species have been listed in the LRDB (*Svazas et al., 2008*).

Rhyssella obliterata and *Phytodietus geniculatus* (Hymenoptera, Ichneumonidae) have been found in a meadow of the Smalvele river valley near Lake Druksiai. This is the only site in the country where these species have been recorded (*Svazas et al., 2008*).

Some other rare insect species have been recorded in the surroundings of Lake Druksiai as well. *Carabus convexus* (Coleoptera, Carabidae) is a rare species in Lithuania. It usually inhabits forest edges near water bodies. It has been found in woodland near the Smalvele River. *Sospita vigintiguttata* (Coleoptera, Coccinellidae) has been found in woodland near the Smalvele River. *Stenoptinea cyaneimarmorella* (Lepidoptera, Tineidae) and *Parornix traugotti* (Lepidoptera, Gracilariidae) have been found in Visaginas. This is the only known site in the country where these species have been recorded. *Caryocolum tischeriella* (Lepidoptera, Gelechiidae) has been found in Tilze village. This is the only site in Lithuania where this species has been recorded. It is now considered extinct. A large local population of *Buckleria paludum* (Lepidoptera, Pterophoridae) was discovered in Mistautai village near Bedugnis lake. *Melitaea phoebe* (Lepidoptera, Nymphalidae) has been found in a meadow of the Smalvele River valley near Lake Druksiai and very close to the main building of the INPP. *Temelucha arenosa* (Hymenoptera, Ichneumonidae) has also been found in a meadow of the Smalvele river valley near Lake Druksiai (*Svazas et al., 2008*).

Several rare species have been registered very close to the INPP. For example, *Aricia eumedon* has been found on the shore of Lake Druksiai about 2 km to the west from the INPP. *Lycaena dispar* has been observed in a meadow about 2.5 km to the south from the INPP.

***Other species / Crustaceans*:** It has been pointed out (*Svazas et al. 1999; Raudonikis & Kurlavicius, 2000*), that Druksiu ezeras SCI inhabits several relict animal species. Some rare, relict crustaceans, such as *Mysis oculata relicta* and *Pallasiola quadrispinosa*, have been recorded here. They are included in the LRDB.

Other species / Flora: Some rare plant species, included in the LRDB, have been found in the area (*Baleviciene, Sinkeviciene et al., 1997*), such as *Scolochloa festucacea* (species included in the LRDB), *Zanichelia palustris, Alisma gramineum* and *Nitella opaca* (rare species; to be protected). These species except *Alisma gramineum* are dominating in the communities of macrophytes of the lake. Some rare terrestrial plant species included in the LRDB have been registered in the surroundings of Lake Druksiai (*Svazas et al., 2008*): Fen orchid (*Liparis loeselii*), *Dactylohiza baltica*, *Dactylohiza incarnata*, *Eriophorum gracile*, *Gentiana cruciata*, *Juncus stygius*, *Cladium mariscus* and *Carex heleonastes. Hamatocaulis vernicosus* is not only listed in the LRDB but also in Annex II of the EU Habitat Directive. Most of the rare plants have been found on the shores of the lake and in shore wetlands as well as meadows (Figure 7.6-4).

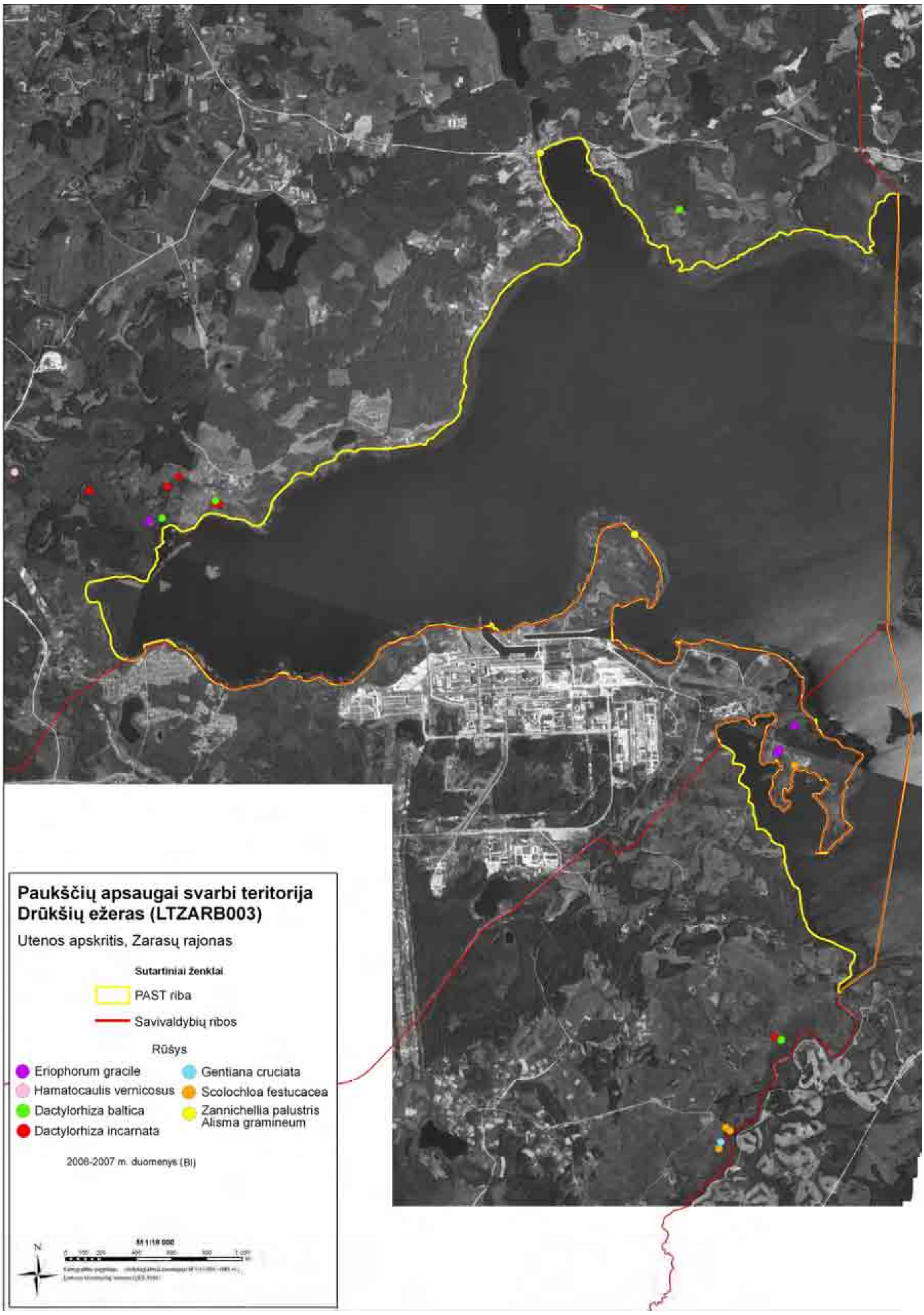


Figure 7.6-4. Distribution of some rare plants in the Druksiu ezeras SCI (*Svazas et al., 2008*). Dots show location of sites where listed plants have been mapped.

During long term detailed botanical studies some changes in plant life have been discovered. E.g., before the INPP started operating (studies of 1979–1983) the flora of the lake consisted of 95 water plant species. It was pointed out that *Nitella flexilis*, *Chara filiformis*, *Scolochloa festucaceae* were rare species (*Svazas et al., 2008*).

Other species / Fungi, lichens: Some rare macromycet species, included in the LRDB, have been found in the surroundings of Lake Druksiai (*Svazas et al., 2008*): *Russula aurata*, *Melanoleuca turrita* and *Tricholoma inocyboides*.

The NNPP region is rich in biodiversity which is known much better in comparison with other places of the country. During long-term complex studies (1979–1983) in the surroundings of Lake Druksiai (a zone of 0.5 km around the lake) in total 213 species of agaricoidic macromycets (*Agaricales*), 120 species of *Aphyllophorales*, 33 species of dyscomycets, 29 species of lichens and related fungus species, and 31 species of water fungus species were registered (*Svazas et al., 2008*).

Habitats: In the surroundings of Lake Druksiai some valuable habitats listed in Annex I of the EU Habitat Directive have been mapped: meadow habitats of 4 types (*6210* Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco brometalia; important orchide sites*), *6410 Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*), *6450* Northern boreal alluvial meadows, *6510* Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*); forests of type *9080** Fennoscandian deciduous swamp woods; two types of bog (*7140* Transition mires and quaking bogs and *7230* Alkaline fens) and two types of water bodies habitat (*3140* Hard oligo-mesothrophic waters with benthic vegetation of *Chara* formations and *3150* Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* – type vegetation). Meadow habitats are concentrated to the valley of the Duksta and the Smalvele rivers. Boggy habitats are concentrated to the valley of the Smalvele River and near lakes Druksiai and Karoliniskes (Figure 7.6-5 and Figure 7.6-6). Results of mapping of valuable habitats listed in Annex I of the EU Habitat Directive in the surroundings of the Druksiu ezeras SCI (Svazas et al., 2008) were available for this assessment.

Recent changes: Botanical surveys of 1993–1997 (when two units of the INPP were operating), revealed some changes in plant communities of the lake. It was concluded that *Cladophora* species have prospered very much under influence of thermal pollution of the lake by the INPP. These species were covering all other submersed plants. At a depth of 6–7 m they were nearly fully growing over submersed plants. A belt of helophytes of 10–500 m width has developed on the lake shore. In most of the lake the belt is still fragmented (especially in northern, eastern, southern and north-western parts where waves are most heavy and active).

During special botanical investigations of the lake in 1996–1997 (*Baleviciene, Sinkeviciene et al., 1997*) 69 water plant species were registered. A total of 27 types of plant associations mostly belonging to predominating community classes *Potamogetonetea pectinati, Phragmitetea australis* and *Charetea fragilis* were found.

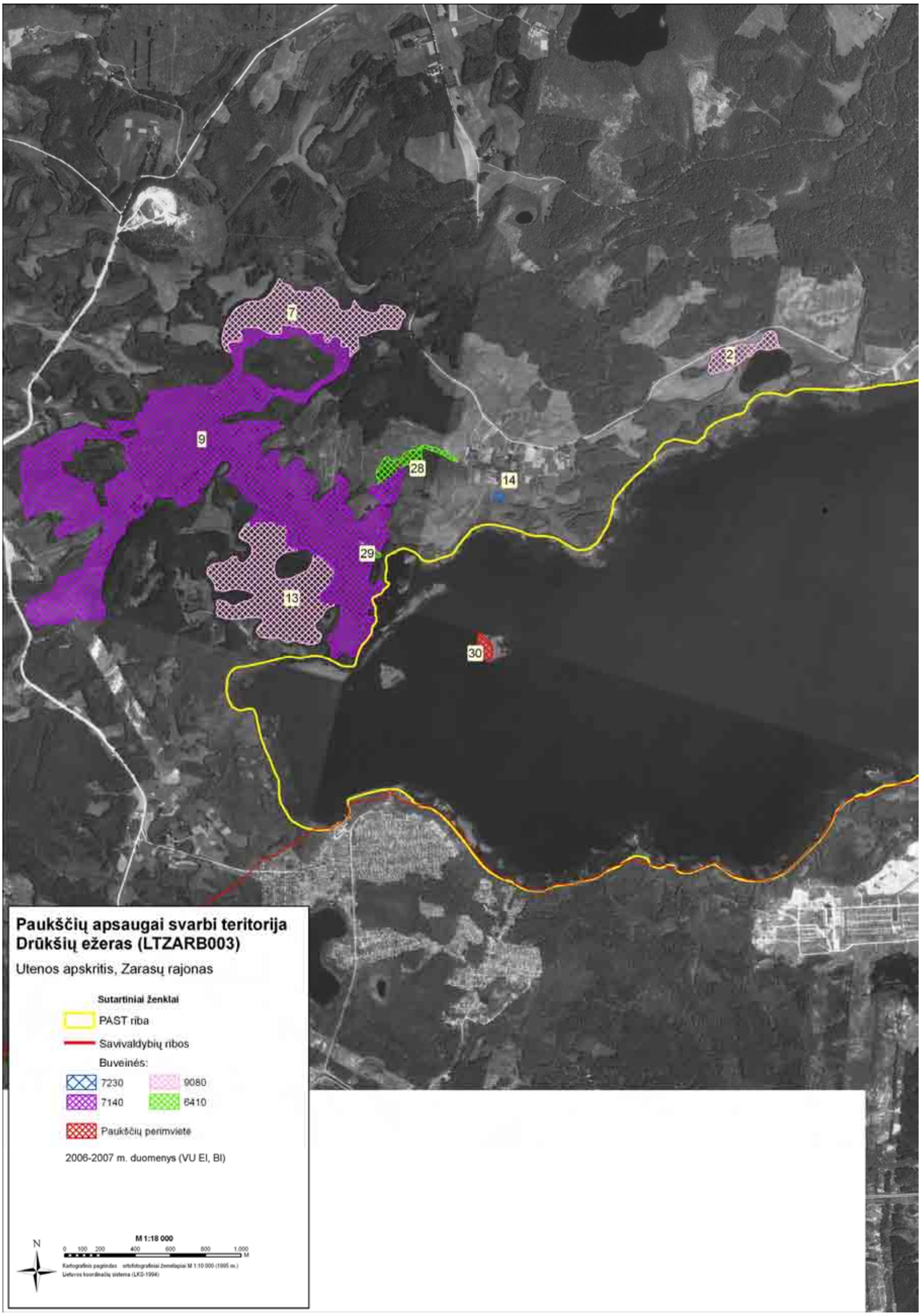


Figure 7.6-5. Some valuable habitats listed in the Annex I of the EU Habitat Directive (squared; codes are indicated in the legend). Areas squared in red are important breeding (aggregation) sites of birds in the Druksiu ezeras SCI (*Svazas et al., 2008*).

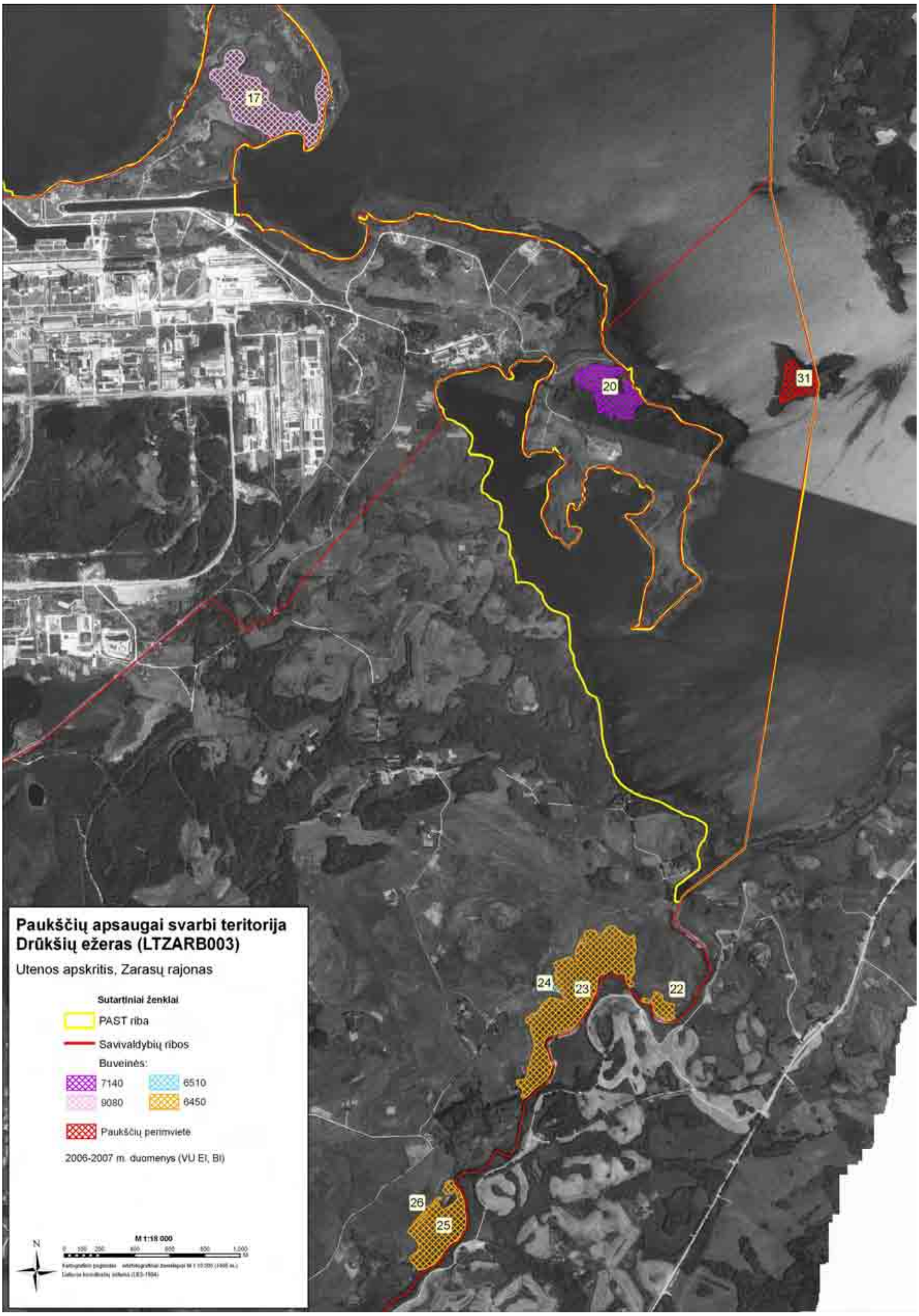


Figure 7.6-6. Some valuable habitats listed in Annex I of the EU Habitat Directive (squared; codes are indicated in the legend); Areas squared in red are important breeding (aggregation) sites of birds in the Druksiu ezeras SCI (*Svazas et al., 2008*).

The NNPP region is important for some game animals. The population of elk (*Alces alces*) of the Ignalina and Zarasai districts covers about one sixth of the country's population (and about 4.4 % of the area of the country). In comparison with all the country populations of other game mammal species, such as red deer (*Cervus elaphus*), rot deer (*Capreolus capreolus*), wild boar (*Suc crofa*), the populations of the NNPP region are not big.

SCI site: River Smalvele and adjacent limy fens (LTZAR0026)

The border is the same as for Smalvas hydrographical reserve and nearly the same as for Complex of Smalva wetlands SPA (LTZARB002). The area of the site is about 547 ha. A centre of the territory is defined by E 26 27 20 longitude and 55 38 09 latitude (W/E Greenwich). Wetlands and forests are predominating in the site (Table 7.6–6). The Smalveles upe ir slapzemes SCI is directly related to other NATURA 2000 sites, such as: the Druksiu ezeras SCI (LTZAR0029), Smalvos ir Smalvykscio ezerai ir pelkes SCI (LTZAR0025), Druksiu ezeras and Smalvos slapzemiu kompleksas SPAs (LTZARB003 and LTZARB002, respectively).

Table 7.6–6. Habitat structure of the Smalveles upe ir slapzemes SCI according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Bogs, Marshes, Water fringed vegetation, Fens	43
Extensive cereal	5
Improved grassland	2
Other arable land	1
Broad-leaved deciduous woodland	12
Mixed woodland	37
Total habitat cover	100

The Smalveles upe ir slapzemes SCI has been designated with the main goal to protect the local population of qualifying species European otter (*Lutra lutra*). Based on the NATURA 2000 DB it can be pointed out that the European fire-bellied toad (*Bombina bombina*), which is listed in Annex II of the Directive, is the other important value of the site. It is considered as a common species here.

SCI site: Lakes and wetlands Smalva and Smalvykstis (LTZAR0025)

The border is the same as for Smalvas landscape reserve. The area of the site is about 2225 ha. A centre of the territory is defined by E 26 22 55 longitude and 55 37 07 latitude (W/E Greenwich). Water bodies and forests are predominating in the site (Table 7.6–7).

Table 7.6–7. Habitat structure of the Smalvos ir Smalvykscio ezerai ir pelkes SCI according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Inland water bodies (Standing water, Running water)	24
Bogs, Marshes, Water fringed vegetation, Fens	15
Other arable land	4
Broad-leaved deciduous woodland	2
Coniferous woodland	29
Mixed woodland	26
Total habitat cover	100

The Smalvos ir Smalvykscio ezerai ir pelkes SCI is directly related to other NATURA 2000 sites, such as: the Grazutes regioninis parkas (LTZAR0024) and Smalveles upe ir slapzemes SCIs (LTZAR0026).

The Smalvos ir Smalvykscio ezerai ir pelkes SCI has been designated with the main goal to protect qualifying habitats of EU importance, such as: Hard oligo-mesothrophic waters with benthic vegetation of *Chara* formations (3140), Western taiga (9010*), Transition mires and quaking bogs (7140), Bog woodland (91D0), Fennoscandian deciduous swamp woods (9080), Alkaline fens (7230), Calcareous fens with *Cladium mariscus* and *Carex davaliana* (7210) and Dystrophic lakes (3160), which are listed in Annex I of the Directive, and qualifying plant species Fen orchid (*Liparis loeselii*) and *Drepanocladus vernicosus*, which are listed in Annex II of the Directive.

According to Svazas et al. (*1999*), the territory hosts the rare mammal ermine (*Mustela erminea*), which is included in the LRDB. Mountain hare (*Lepus timidus*), listed in the LRDB as well, is not numerous here. European otter (*Lutra lutra*) and two families of beaver (*Castor fiber*), both species included in Annex II of the Directive, live in the lake complex. Wolf (*Canis lupus*), listed in Annex II of the Directive, has been observed only in some years. Two rare species of butterflies have been recorded here: Swallowtail (*Papilio machaon;* species included in the LRDB) and *Stigmella lediella* (the second record in the country).

Some rare plant species, included in the LRDB, have been found in the territory (*Svazas et al. 1999*): downy willow (*Salix lapponum*), European cutsedge (*Cladium mariscus*), slender cotton-grass (*Eriophorum gracile*), narrow-leaved marsh orchid (*Dactylorhiza russowii*), dwarf birch (*Betula nana*) and fen orchid (*Liparis loeselii*). Hollyleaved naiad (*Najas marina*) was recorded in Berzinis lake, while *Hydrilla verticillata* has been found in several lakes of the protected area.

SCI site: Grazute Regional Park (LTZAR0024)

The border is partly the same as for Grazute Regional Park. The area of the site is 26 125 ha. A centre of the territory is defined by E 26 08 23 longitude and 55 37 19 latitude (W/E Greenwich). Woodland and water bodies are predominating in the site (Table 7.6–8). The Grazutes regioninis parkas SCI is bordering another NATURA 2000 site Smalvos ir Smalvykscio ezerai ir pelkes SCI. It also covers the Siaures rytine Grazutes regioninio parko dalis SPA.

Table 7.6–8. Habitat structure of the Grazutes regioninis parkas SCI according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Inland water bodies (Standing water, Running water)	19
Extensive cereal	10
Improved grassland	2
Other arable land	7
Broad-leaved deciduous woodland	6
Coniferous woodland	31
Mixed woodland	25
Total habitat cover	100

The SCI has been designated with the main goal to protect qualifying habitats, plant and butterfly species, such as: Oligothrophic waters in medio-European and perialpine area with amphibious vegetation: *Littorella* or *Isoetes* or annual vegetation on exposed banks (Nanocyperetalia) (3130), Transition mires and quaking bogs (7140), Degraded raised bogs, (still capable of natural regeneration) (7120), Hard oligo-mesothrophic waters with benthic vegetation of *Chara* formations (3140), Bog woodland (91D0), Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco brometalia; important orchide sites 6210*), Xeric sand calcareous grasslands (*Koelerion glaucae*)

(6120*); Large copper butterfly (*Lycaena dispar*) and Eastern pasque-flower (*Pulsatilla patens*).

NATURA 2000 DB shows that the Grazutes regioninis parkas SCI is also valuable for protection of other habitat types, such us: Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation (3150), Active raised bogs (7110*), Fennoscandian mineral-rich springs and spring fens (7160), Petrifying springs with rufa formation (*Cratoneurion*) (7220), Western taiga (9010*), Fennoscandian hemiboreal natural old broad-leaved deciduous forests (*Quercus, Tilia, Acer, Fraxinus or Ulmus*) rich in epiphytes (9020*), *Tilio–Acerion* ravine forests (9180*) and Fennoscandian deciduous swamp woods (9080), which are listed in Annex I of the Directive. The site is also important for protection of local populations of European otter (*Lutra lutra*), great crested newt (*Triturus cristatus*), European fire-bellied toad (*Bombina bombina*) and *Thesium ebracteatum*, which are listed in Annex II of the Directive.

Other important species of flora of the site are *Betula humilis* and downy willow (*Salix lapponum*), which are included in the LRDB.

According to earlier references (*Svazas et al., 1999*), in Antaliepte hydrographical reserve, which is a part of the Grazutes regioninis parkas SCI, some other species listed in the Lithuanian RDB have been recorded. Heath spotted orchid (*Dactylorhiza maculata*) grows in wet meadows along the reservoir bank. *Hydrilla verticillata* grows in the Antaliepte reservoir near Azuolyne village. Yellow marsh saxifrage (*Saxifraga hirculus*) has been found in a marsh near Deguciai village. Fen orchid (*Liparis loeselii*) and single-leaved bog orchid (*Malaxis monophyllos*) grow nearby on a raised bog. Cross gentin (*Gentiana cruciata*) and green-winged orchid (*Orchis morio*) grow in meadows on bank slopes. Fir clubmoss (*Huperzia selago*) is found in a bogged forest (*Svazas et al., 1999*).

SCI site: Pusnis mire (LTIGN0001)

The border is the same as for Pusnis thelmological reserve. The area of the site is about 779 ha. A centre of the territory is defined by E 26 26 67 longitude and 55 29 52 latitude (W/E Greenwich). Water bodies, bogs, marshes, water fringed vegetation and fens are predominating in the site (Table 7.6–9).

According to Svazas et al. (*1999*) the Pusnis mire complex consists of transitional mires, fens and 5 lakes. Habitat diversity is very high. Former drainage ditches are dammed by beavers (*Castor fiber*).

Table 7.6–9. Habitat structure of the Pusnies pelke SCI according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Inland water bodies (Standing water, Running water)	27
Bogs, Marshes, Water fringed vegetation, Fens	36
Humid grassland, Mesophile grassland	7
Other arable land	8
Broad-leaved deciduous woodland	4
Mixed woodland	1
Other land (Including Towns, Villages, Roads, Waste places, Mines, Industrial sites)	17
Total habitat cover	100

The Pusnies pelke SCI is an isolated (directly not related with other analogous sites) NATURA 2000 site. It has been designated with the main goal to protect qualifying habitats of EU importance, such as: Transition mires and quaking bogs (7140), Eutrophic tall herbs (6430) and Species rich Nardus grasslands on siliceous substrates (6230), which are listed in Annex I of the Directive.

According to Svazas et al. (*1999*), the mire complex hosts the rare mammal ermine (*Mustela erminea*), which is included in the LRDB. European otter (*Lutra lutra*) and several families of beavers (*Castor fiber*), both species included in Annex II of the Directive, have been found in the area or live in the mire complex, respectively. Two species of butterflies have been recorded here: *Papilio machaon* (species included in the LRDB) and *Leucospilapteryx omisella* (the first record in the country).

In 1996-1999, during a special Lithuanian wetland survey (*Svazas et al., 1999*), it was concluded that Pusnies mire with some surrounding territories is valuable for many rare bird species, included in Annex I of the EU Bird Directive 79/409/EEC. Solitary females of Great Snipe (*Gallinago media*) breed in the mire. Black Grouse (*Lyrurus tetrix*) breeds here, leks have been found in the bog. One pair of Wood Sandpiper (*Tringa glareola*) breeds in the territory. Black Stork (*Ciconia nigra*) feeding individuals were recorded in the bog. Honey Buzzard (*Pernis apivorus*) is a possible breeder in the area. Annually 1–2 pairs of Montagu's Harrier (*Circus pygargus*) breed here as well. A minimum of 5 pairs of Crane (*Grus grus*) breed in the mire complex and 10-15 of immature individuals stay in the bog during the breeding season. Up to 100 staging individuals were found in the area during the autumn bird migration season. Courtship calls of 6–7 males of Spotted Crake (*Porzana porzana*) have been recorded in the territory. 11 territories of Corncrake (*Crex crex*) have been registered. At least 2 pairs of Short-eared Owl (*Asio flammeus*) breed in the bog. Bluethroat (*Luscinia svecica*) is considered as a possible breeder in the territory. Several other rare species have been registered in the mire, for instance Whiskered Tern (*Chlidonias hybridus*) breeds here.

During the Lithuanian wetland survey (*Svazas et al., 1999*), it was also stated that Pusnies mire and some surrounding territories form an important site for rare bird species included in the LRDB. About 5 pairs of Redshank (*Tringa tetanus*), 2–3 pairs of Curlew (*Numenius arquata*), more than 1 pair of Black-tailed Godwit (*Limosa limosa*) and one pair of Green Woodpecker (*Picus viridis*) breed in the mire complex in favourable years. Also breeding White-winged Black Tern (*Chlidonias leucopterus*) and Citrine Wagtail (*Motacilla citreola*) have been found here.

The Pusnis mire is one of a few sites in Lithuania, where Jack Snipe (*Lymnocryptes minimus*) possibly breeds. One pair was observed during the breeding season (*Svazas et al., 1999*).

The mire is a regionally important site for migrating goose. Up to 500 staging White-fronted Geese (*Anser albifrons*) and Bean Geese (*Anser fabalis*) have been recorded in the mire during spring migration (*Svazas et al., 1999*).

Some rare plant species, included in the LRDB, have been found in the mire (*Svazas et al., 1999*): downy willow (*Salix lapponum*), Single-leaved bog orchid (*Malaxis monophyllos*), green-winged orchid (*Orchis morio*) and *Dactylorhiza longifolia*.

SCI site: Ruzas Lake (LTIGN0026)

The area of the site is about 205 ha. A centre of the territory is defined by E 26 29 39 longitude and 55 29 03 latitude (W/E Greenwich). Water bodies are predominating in the site (Table 7.6–10). The Ruzo ezeras SCI is an isolated NATURA 2000 site. It has been designated with the main goal to protect the local population of qualifying species of invertebrates and plants: *Vertigo angustior*, *Dytiscus latissimus* and Vesicular Aldrovanda (*Aldrovanda vesiculosa*), which are listed in Annex II of the Directive.

Table 7.6–10. Habitat structure of the Ruzo ezeras SCI according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Shingle, Sea cliffs, Islets	100
Total habitat cover	100

<u>SCI site: Gervele wetland (LTIGN0017)</u>

The area of the site is about 373 ha. A centre of the territory is defined by E 26 26 51 longitude and 55 27 13 latitude (W/E Greenwich). Woodland and water bodies, bogs, marshes, water fringed vegetation and fens are predominating in the site (Table 7.6–11). The Gerveles pelke SCI is not directly related with other NATURA 2000 sites (is an isolated protected area). It has been designated with the main goal to protect qualifying habitats of EU importance: Degraded raised bogs, (still capable of natural regeneration) (7120) and Bog woodland (91D0), which are listed in Annex I of the Directive.

Table 7.6–11. Habitat structure of the Gerveles pelke SCI according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Bogs, Marshes, Water fringed vegetation, Fens	8
Other arable land	3
Broad-leaved deciduous woodland	24
Mixed woodland	65
Total habitat cover	100

<u>SCI site: Dietkauscizna meadows (LTIGN0004)</u>

The area of the site is about 147 ha. A centre of the territory is defined by E 26 27 56 longitude and 55 20 19 latitude (W/E Greenwich). Extensive cereal cultures and other arable land as well as woodland are predominating in the site (Table 7.6–12).

Table 7.6–12. Habitat structure of the Dietkausciznos pievos SCI according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Extensive cereal cultures	29
Mixed woodland	41
Other arable land	17
Broad-leaved deciduous woodland	13
Total habitat cover	100

The Dietkausciznos pievos SCI is an isolated NATURA 2000 site. The SCI is a part of the Dysna hydrographical reserve. It has been designated with the main goal to protect the qualifying habitat of EU importance *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) (6410), which is listed in Annex I of the Directive.

Based on NATURA 2000 DB the Dietkausciznos pievos SCI is also valuable for protection of habitats Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) (91E0), and the plants fen orchid (*Liparis loeselii*) (51–100 individuals) and common butterwort (*Pinguicula vulgaris*).

SPA site: Lake Druksiai (LTZARB003)

Lake Druksiai is a cooler of the Ignalina NPP and is the nearest big water body as well as the nearest NATURA 2000 site to the NNPP sites. Other protected areas are located much further away from the NNPP sites (e.g. lakes and wetlands Smalva and Smalvykstis – about 5 km from the site, complex of Dysnai and Dysnykstis lake area – about 13 km, see Figure 7.6-1 and Figure 7.6-2). Human access is limited because of the border regime.

The area of the site is about 3612.33 ha. A centre of the territory is defined by E 26 33 43 longitude and 55 36 59 latitude (W/E Greenwich). Water bodies and arable land are predominating in the site (Table 7.6–13).

Table 7.6–13. Habitat structure of the Druksiu ezeras SPA according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Inland water bodies (Standing water, Running water)	71
Bogs, Marshes, Water fringed vegetation, Fens	5
Extensive cereal	3
Improved grassland	3
Other arable land	10
Broad-leaved deciduous woodland	3
Mixed woodland	5
Total habitat cover	100

NATURA 2000 designation values: The SPA has been designated with the main goal to protect the local population of qualifying species of Great Bittern (*Botaurus stellaris*), which is listed in Annex I of the EU Bird Directive. According to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*) local breeding population of the species is one of the biggest in the country (10 calling males). A very high density of the species has been recorded in the SPA (Figure 7.6-3).

The lake is also an important site for other bird species listed in Annex I of the EU Bird Directive. One pair of Black-throated Diver (*Gavia arctica*), 5 pairs of Marsh Harrier (*Circus aeruginosus*), 6 males of Spotted Crake (*Porzana porzana*), one male of Little Crake (*Porzana parva*), 10 pairs of Black Tern (*Chlidonias niger*) and one pair of Bluethroat (*Luscinia svecica*) have been observed breeding in the area (*NATURA 2000 DB; Ministry of Environment of the Republic of Lithuania*). According to Svazas et al. (*1999*), some years ago Black-throated Diver (*Gavia arctica*), an endangered species in Lithuania, was considered as a possible breeder in the lake. At the end of the previous century Black-throated Diver (*Gavia arctica;* especially immature individuals) were observed here annually.

Other bird species: There is some information available about other rare species, listed in Annex I of the EU Bird Directive and included in the Lithuanian RDB. White-tailed Eagle (*Haliaeetus albicilla*) also used to be considered as a possible breeder. According to later references (*Svazas et al., 2008*), this species breeds here. Up to 7 individuals have been recorded in winter. The site is especially valuable for the species during cold winters, when all other water bodies of the region suitable for feeding are covered by ice. Fragmentary visits show concentration of White-tailed Eagle (*Haliaeetus albicilla*) on Lake Druksiai in winter in cold periods. According to later studies (*Svazas et al., 2008*) Ferruginous Duck (*Aythya nyroca*) has been considered as a breeding species as well.

One pair of Montagu's Harrier (*Circus pygargus*) breeds in a bogged meadow in the valley of the Duksta rivulet. One – two pairs of Crane (*Grus grus*) breed on the northern bank of the lake. Single pairs of Dunlin (*Calidris alpine*) used to breed on Pilies Island, which belongs to Belarus. Islands of the lake are important staging areas for migratory birds.

According to latest references (*Svazas et al., 2008*) in Lake Druksiai and its surroundings in total 140 bird species have been found. A total of 33 species listed in the LRDB and 31 species included in Annex I of the EU Bird Directive have been registered.

Lake Druksiai and Druksa rivulet are valuable for some regionally rare species of birds (*Svazas et al., 1999*). Short-toed Eagle (*Circaetus gallicus*) is an extinct species in Lithuania, however occasionally it has been recorded in the territory. Two territories of Quail (*Coturnix coturnix*) have been registered in the valley of the Duksta rivulet. Red-breasted Merganser (*Mergus serrator*) breeds on the lake. A brood with fledglings was registered in 1999. Staging flocks of up to 350 individuals occur on the lake during bird migration periods. The species is also regularly recorded in the free from ice Lake Druksiai in January-February. Two pairs of Redshank (*Tringa totanus*) breed in the valley of the Duksta rivulet. Two–three pairs of Curlew (*Numenius arquata*) and several pairs of Black-tailed Godwit (*Limosa limosa*) breed on the Pilies Island (belongs to Belarus) and in the valley of the Duksta rivulet. One pair of Oystercatcher (*Haematopus ostralegus*) breeds along the eastern bank of the lake, belonging to Belarus. Single pairs of Gadwall (*Anas strepera*) have been annually recorded in recent years. Shoveler (*Anas clypeata*) breeds in some years in the surroundings of the lake. Goosander (*Mergus merganser*) is a rather common breeding species. More than 10 males were counted during one census. Lake Druksiai is an important staging and wintering site of this species in eastern Lithuania. Up to 900 staging birds have been recorded in autumn. The site regularly supports up to 500 wintering Goosanders. Kingfisher (*Alcedo atthis*) is considered as a possible breeder because it has been recorded regularly on the lake and along the Duksta rivulet. Citrine Wagtail (*Motacilla citreola*) has been registered breeding in the valley of the Duksta rivulet. The species is very rare in the country (*Svazas et al., 1999*).

In the period 1985–2000 in the surroundings of village Tilze (northern part of the lake) nearly annually the following territorial (very likely breeding) species were recorded: Eurasian Hobby (*Falco subbuteo*), Black Grouse (*Tetrao tetrix*), Grey-headed Woodpecker (*Picus canus*), Green Woodpecker (*Picus viridis*), White-backed Woodpecker (*Dendrocopos leucotos*), Goosander (*Mergus merganser*), Ortolan Bunting (*Emberiza hortulana;* species included in the LRDB). White Stork (*Ciconia ciconia*), Red-backed shrike (*Lanius collurio*), Wood Lark (*Lullula arborea*) and European Nightjar (*Caprimulgus europaeus;* species listed in Annex I of the EU Bird Directive). At the time they were common here (*Kurlavicius, unpublished data*).

A mixed colony of Cormorant (*Phalacrocorax carbo*), with about 500 nests registered, Grey Heron (*Ardea cinerea*), with about 150 nests, and Great White Egret (*Egretta alba*), with a few nests, is located on the western bank of the lake close to the Ignalina NPP. Recently colonies of Cormorant (*Phalacrocorax carbo*) have been under influence of strong control throughout the country, especially in the Aukstaitija National Park (about 30 km from the NNPP). Most likely due to this activity the colony of Cormorant (*Phalacrocorax carbo*) of Lake Druksiai is rather stable. The Great White Egret (*Egretta alba*) is a new breeding bird species in Lithuania. It is listed in Annex I of the EU Bird Directive.

Lake Druksiai is important for the regional population of Great Crested Grebe (*Podiceps cristatus*). The breeding population of this species in the lake is the largest known in the region. Several colonies have been found on the lake. White-winged Black Tern (*Chlidonias leucopterus*) has been registered breeding in the valley of the Duksta rivulet (*Svazas et al. 1999*). The species is very rare in the country (*Raudonikis & Kurlavicius, 2000*).

In 1996-1999, during a special Lithuanian wetland survey (*Svazas et al., 1999*), it was concluded that large staging flocks of migratory waterfowl concentrate on the lake in spring and autumn, with up to 700 Mallards (*Anas pratyhynchos*), 550 Coots (*Fulica atra*), 480 Goldeneyes (*Bucephala clangula*), 120 Mute Swans (*Cygnus olor*) and numerous flocks of other species.

The western part of the lake and especially the site with a regular influx of warm water provides a suitable habitat for various species of waterfowl during cold winter periods. This area regularly supports numerous wintering mergansers (*Mergus merganser*), Goldeneyes (*Bucephala clangula*), Mallards (*Anas pratyhynchos*), Mute Swans (*Cygnus olor*) and Coots (*Fulica atra*)(*Svazas et al., 1999*).

Changes in bird communities and populations: In some recent references (*Svazas et al., 2008*) it has been pointed out that the bird fauna of Lake and its surroundings has undergone remarkable changes. The reasons for these changes have been reported as well. They are caused mainly by the lake eutrophication processes and field abandonment: overgrowing of open habitats with woody vegetation and expansion of reedbeds on the shore of the lake. Due to these reasons populations of some rare species have decreased in numbers or they have even turned locally extinct: Black-throated Diver (*Gavia arctica*), Oistercatcher (*Haematopus ostralegus*), Redshank (*Tringa totanus*), Black-tailed Goodwit (*Limosa limosa*), Eurasian Curlew (*Numenius arquata*), Dunlin (*Calidris alpine*), Ruff (*Philomachus pugnax*) and Common Tern (*Sterna hirundo*). Contrary, since the INPP was built, due to the mentioned habitat changes populations of birds of reedbeds, Great Bittern (*Botaurus stellaris*) and Little Crake (*Porzana parva*), have increased and a new species Bearded Tit (*Panurus biarmicus*) has occurred.

SPA site: Complex of wetlands on surroundings of Dysnu and Dysnykscio lakes (LTIGNB004)

The Area of the site is about 4016.56 ha. A centre of the territory is defined by E 26 19 56 longitude and 55 28 05 latitude (W/E Greenwich). Water bodies are predominating in the site (Table 7.6–14).

Table 7.6–14. Habitat structure of the Dysnu ir Dysnykscio apyezeriu slapzemiu kompleksas SPA according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Inland water bodies (Standing water, Running water)	95
Extensive cereal	1
Other arable land	1
Mixed woodland	3
Total habitat cover	100

The Dysnu ir Dysnykscio apyezeriu slapzemiu kompleksas SPA is an isolated NATURA 2000 site. The SPA has been designated with the main goal to protect local populations of qualifying species Corncrake (*Crex crex*).

The SPA is also important for the protection of the national population of Great Bittern (*Botaurus stellaris*), Marsh Harrier (*Circus aeruginosus*), Montagu's Harrier (*Circus pygargus*) and Spotted Crake (*Porzana porzana*). These species are listed in Annex I of the EU Bird Directive. According to the NATURA 2000 DB (*Ministry of Environment of the Lithuanian Republic*) the local breeding population of Great Bittern (*Botaurus stellaris*) is 7 calling males, of Corncrake (*Crex crex*) – 30 calling males, of Marsh Harrier (*Circus aeruginosus*) – 11 pairs, of Montagu's Harrier (*Circus pygargus*) – 2 pairs and of Spotted Crake (*Porzana porzana*) – 8 calling males.

Lake Dysnu ir Dysnykscio apyezeriu slapzemiu kompleksas SPA is valuable for some regionally rare species of birds (*Raudonikis, 2004*). 11 breeding bird species are listed in the LRDB.

SPA site: Smalva wetland complex (LTZARB002)

The border is nearly the same as for Smalvas hydrographical reserve and River Smalvele and adjacent limy fens SCI. The area of the site is about 538 ha. A centre of the territory is defined by E 26 28 34 longitude and 55 37 34 latitude (W/E Greenwich). Wetlands and forests are predominating in the site (Table 7.6–15).

Table 7.6–15. Habitat structure of the Smalvos slapzemiu kompleksas SPA according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Bogs, Marshes, Water fringed vegetation, Fens	80
Extensive cereal	1
Other arable land	2
Mixed woodland	17
Total habitat cover	100

The Smalvos slapzemiu kompleksas SPA is directly related with another NATURA 2000 site the Smalveles upe ir slapzemes SCI (LTZAR0026). The SPA has been designated with the main goal to protect the local population of qualifying species Black Tern (*Chlidonias niger*). The species is included in Annex I of the EU Bird Directive. According to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*) the local breeding population of the Black Tern is 40 pairs.

The site is also an important site for other bird species listed in Annex I of the EU Bird Directive. Their breeding populations are however not big. According to the NATURA 2000 DB two males of Great Bittern (*Botaurus stellaris*), two pairs of Marsh Harrier (*Circus aeruginosus*), one pair of Montagu's Harrier (*Circus pygargus*), three calling males of Spotted Crake (*Porzana porzana*), two pairs of Common Crane (*Grus grus*) and five pairs of the Red-backed Shrike (*Lanius collurio*) have been observed. Black Grouse (*Tetrao tetrix*) and White Stork (*Ciconia ciconia*) occur in the Smalvos slapzemiu kompleksas SPA, but data on their numbers is not available.

SPA site: North-eastern part of Grazute regional park (LTZARB004)

The area of the site is about 5699.85 ha. A centre of the territory is defined by E 26 09 32 longitude and 55 39 17 latitude (W/E Greenwich). Water bodies and coniferous woodland are predominating in the site (Table 7.6–16).

Table 7.6–16. Habitat structure of the Siaures rytine Grazutes regioninio parko dalis SPA according to the NATURA 2000 DB (*Ministry of Environment of the Republic of Lithuania*).

Habitat classes	Coverage, %
Inland water bodies (Standing water, Running water)	23
Extensive cereal	1
Broad-leaved deciduous woodland	1
Coniferous woodland	64
Mixed woodland	11
Total habitat cover	100

The Siaures rytine Grazutes regioninio parko dalis SPA is related with another NATURA 2000 site, the Grazutes regioninis parkas SCI, and with the national protected area Grazute Regional Park. The SPA has been designated with the main goal to protect local populations of qualifying species of Pygmy Owl (*Glaucidium passerinum*) and Black-throated Diver (*Gavia arctica*). These species are listed in Annex I of the EU Bird Directive. According to the NATURA 2000 DB the local breeding population of the Black-throated Diver (*Gavia arctica*) is 3 pairs and of Pygmy Owl (*Glaucidium passerinum*) 4–5 pairs.

The site is also important for other bird species listed in Annex I of the EU Bird Directive. Three pairs of Black Kite (*Milvus migrans*), 4–5 pairs of Tengmalm's Owl (*Aegolius funereus*), 7 pairs of White-backed Woodpecker (*Dendrocopos leucotos*), 3 pairs of Three-toed Woodpecker (*Picoides tridactylus*), 3 pairs of Lesser Spotted Eagle (*Aquila pomarina*), 7–8 pairs of Honey-buzzard (*Pernis apivorus*), 7–8 calling males of Great Bittern (*Botaurus stellaris*), 5 pairs of Black Woodpecker (*Dryocopus martius*) and 6 pairs of Wood Lark (*Lullula arborea*) as well as several pairs of Osprey (*Pandion haliaetus*), Hazel Grouse (*Bonasa bonasia*), Common Crane (*Grus grus*), European Nightjar (*Caprimulgus europaeus*) and Pied Flycatcher (*Ficedula parva*) have been monitored breeding in the area (*NATURA 2000 DB of the Ministry of Environment of the Republic of Lithuania*).

According to earlier references (*Svazas et al., 1999*), in Antaliepte hydrographical reserve, which is a part of the Siaures rytine Grazutes regioninio parko dalis SPA, some other species listed in Annex I of the EU Bird Directive and included in the Lithuanian RDB were recorded. 24 bird species, included in the Lithuanian RDB, have been registered in the reserve, for instance single individuals of White-tailed Eagle (*Haliaeetus albicilla*) have been frequently recorded in the territory. One pair breeds in adjacent forests. Single individuals of Black Stork (*Ciconia nigra*) have been recorded in the reserve. The species probably breeds in the surrounding forests. One pair of Montagu's Harrier (*Circus pygargus*) breeds in the southern part of the reserve. Several calling males of Spotted Crake (*Porzana porzana)* and Corncrake (*Crex crex)* have been registered in the territory (*Svazas et al., 1999*).

Antaliepte hydrographical reserve is valuable for some other rare species of birds, included in the Lithuanian RDB (*Svazas et al., 1999*). Single calling males of Quail (*Coturnix coturnix*) have been recorded in the reserve. Redshank (*Tringa tetanus*) is a possible breeder. It has been recorded during the breeding season. 1–2 pairs of Curlew (*Numenius arquata*) possibly breed as well. Red-necked Grebe (*Podiceps grisegena*) is also a possible breeder. Flocks of Greylag Goose (*Anser anser*) of up to 40 individuals have been recorded in the fields of the reserve. 1–3 pairs of Shoveler (*Anas clypeata*) possibly breed in the reserve. Up to 15 pairs of Goosander (*Mergus merganser*) breed in the territory. Large staging flocks (up to 380 individuals) have been recorded here. 2-3 pairs of Kingfisher (*Alcedo atthis*) breed in the reservoir (*Svazas et al., 1999*).

The reserve is regionally important site for migrating birds. Up to 120 staging Red-breasted Merganser (*Mergus serrator*) were recorded in the reserve in autumn (*Svazas et al., 1999*).

7.6.1.4 Other protected and important biodiversity areas

There are 7 national protected areas valuable for nature protection in the NNPP region (Figure 7.6-7).

A legal basis for establishment of national protected areas, other key information about size of the areas, site code and main goals of their establishment are presented in Table 7.6–17.

Most of the territory covered by national protected areas is concentrated to the western part of the region. The national protected areas are mostly located on axis east–west. The NNPP region covers part of the territory of the Grazute Regional Park and Dysna hydrographical reserve. Pratkunai geomorphological reserve is just bordering the NNPP region. Aukstaitija National Park is located to the south-east from the NNPP, and is a few kilometres outside the border. Due to this reason the Aukstaitija National Park protected area has not been analysed more in detail here.

Out of 7 national protected areas, 5 sites are of international importance for habitat and/or species conservation (being as Sites of Community Importance (SCI) and/or Special Protection Areas (SPA)). Two Sites of Community Importance (SCI) are still non-protected by national laws.

Territories, which according to national legislation are considered as protection zones of water bodies, have not been analysed more in detail. They are both not indicated neither in the map of national protected areas (Figure 7.6-7), nor in the summary of key information (Table 7.6–17).

Figure 7.6-7. Protected areas, established according to the national legislation in the NNPP region (according to the Cadastre for the State protected areas; State Protected Area Service at the Environment Ministry of the Lithuanian Republic). Perimeter of the region is indicated in blue. The protected territories: 1 – Tilze geomorphological reserve; 2 – Smalva hydrographical reserve; 3 – Smalvas landscape reserve; 4 – Grazute Regional Park; 5 – Pusnis thelmological reserve; 6 – Dysna hydrographical reserve; 7 – Pratkunai geomorphological reserve; 8 – Aukstaitija National Park.

Information available (Table 7.6–17) shows that national protected areas in the NNPP region are multifunctional. They have been established mostly with the goal to protect landscape with valuable valleys of natural small rivers, picturesque relief. One protected area is designated with the goal to protect a complex of fen and one partly to protect not only nature but also cultural values.

Table 7.6–17. Key information about protected areas, established according to national legislation, in the NNPP region.*

Site name: official / English*	Area of the site, ha	Legal establishment basis	Main goal	Site code (ID)	International importance
Tilzes geomorfologinis draustinis / Tilze geomorphological reserve	43.68	Decision No. I-2913 of the Parliament of 24-09-1992 (*State Journal, 1992, No. 30-913*)	To protect unique complex of limnoglacial relief	0210200000010	Not known
Smalvos hidrografinis draustinis / Smalva hydrographical reserve	547.44	Decision No. 342 of the Ministerial Council of the Lithuanian SSR of 14-12- 1983 (*State Journal*, *1983, No. 36-383; 22-244*)	To protect natural valley of the Smalva rivulet	0210300000009	Important. Area is near the some as for Smalvos slapzemiu kompleksas SPA and the some as for Smalveles upe ir slapzemes SCI
Smalvo krastovaizdzio draustinis / Smalvas landscape reserve	2225.28	Decision No. 517 of the Ministerial Council of the Lithuanian SSR of 27-09- 1960 (*State Journal*, *1960, Nr. 27-244*)	To protect characteristic landscape with Smalvas and Smalvykstis lakes of the Aukstaitija highland	0230100000014	Important. Area is the some as for Smalvos ir Smalvykscio ezerai ir pelkes SCI
Grazutes regioninis parkas / Grazute Regional Park	29471	Decision No. I-2913 of the Parliament of 24-09-1992 (*State Journal*, *1992, Nr. 30-913*)	To protect characteristic landscape in the Sventoji river outflow and cultural values	0700000000012	Important. Part area is covered by Grazutes regioninis parkas SCI and by Siaures rytine Grazutes regioninio parko dalis SPA
Pusnies telmologinis draustinis / Pusnis thelmological reserve	779.4	Decision Nr. 1486 of the Government of 29-12-1997. (*State Journal*, *1998, Nr. 1-9*)	To protect complex of fen	0210900000027	Important. Area is the some as for Pusnies pelke SCI
Dysnos hidrografinis draustinis / Dysna hydrographical reserve	586.63	Decision Nr. 1486 of the Government of 29-12-1997 (*State Journal*, *1998, Nr. 1-9*)	To protect valley of the Dysna river on limnoglacial lowland	0210300000013	Important. Part of area is the some as for Dysnu ir Dysnykscio apyezeriu slapzemiu kompleksas SPA
Pratkunu geomorfologinis draustinis / Pratkunai geomorphological reserve	623.47	Decision No. I-2913 of the Parliament of 24-09-1992 (*State Journal*, *1992, Nr. 30-913*)	To protect highest morenic complex of Seliai highland with Pratkunai hill	0210200000011	Not known

* Source: the Cadastre for the State protected areas; State Protected Area Service at the Environment Ministry of the Republic of Lithuanian.

The official (Lithuanian) name, code of the protected area, area of the site are indicated as they are used in Cadastre for the State protected areas *http://stk.vstt.lt/stk/default2.jsp?bs=1&lang=lt&jsessionid=E00C236D64073306E6A695C978F8110E*.

7.6.1.5 Biodiversity values outside protected areas

There are only few literature sources dealing with the biodiversity values outside the protected area network of the NNPP region. Information available is not detailed enough. According to the LRDB *Hirudo medicinalis* has been recorded in Ignalina and Zarasai districts (*Rasomavicius, 2007*), *Papilio machaon*, *Bufo calamita* and *B. viridis*, Honey Buzzard (*Pernis apivorus*), White-tailed Eagle (*Haliaeetus albicilla*), Montagu's Harrier (*Circus pagargus*), Northern Goshawk (*Accipiter gentilis*), Lesser Spotted Eagle (*Aquila pomarina*), Osprey (*Pandion haliaetus*), Eurasian Hobby (*Falco subbuteo*), Black Grouse (*Lyrurus tetrik*), Quail (*Coturnix coturnix*), Spotted Crake (*Porzana porzana*), Corncrake (*Crex crex*), Crane (*Grus grus*), Stock Dove (*Columba oenas*) and Mountain hare (*Lepus timidus*) are rare species but distributed in all the districts of the country (*Rasomavicius, 2007*). Plants *Nitela syncarpa*, *Neckera pennata*, *Calliergon trifarium*, *Lycopodiela inundata*, *Huperza selago*, *Botrychium matricariifolium*, *Nymphaea alba*, *Myriophyllum alterniflorum*, *Thesium ebracteatum*, *Callitriche hermaphroditica*, *Alisma gramineum*, *Hydrilla verticillata*, *Najas minor*, *Gymnadenia conopsea*, *Dactylorhiza fuchsii*, *D. incarnate*, *D. longifolia*, *D. maculate*, *D. ochroleuca*, *D. traunsteineri*, *Hammarbya paludosa*, *Malaxis monophyllos*, *Corallorhiza trifida*, *Juncus stygius*, *Carex heleonastes* and *Scolochloa festucacea* have been recorded in the NNPP region (*Rasomavicius, 2007*). *Meesia triquetra* has been found in Zarasai district.

Based on available references it can be concluded that the most important biodiversity values are concentrated to the protected areas of the NNPP region. At the some time some biodiversity values do exist outside the protected areas. They are less known and most likely less important.

7.6.1.6 Biodiversity values outside Lithuania

Latvia

Protected areas of the NNPP region

In the 30 km zone and territory crossing the 30 km zone from the planned nuclear power plant in the territory of Latvia, the following particularly protected nature reserves are located: protected landscape area "Augsdaugava", which includes the nature park "Daugavas loki", protected landscape area "Augszeme", which includes the nature park "Meduma ezeraine" and the nature park "Svente", as well as nature reserves "Bardinska ezers" (lake), "Skujines ezers" (lake), and the nature park "Silene", which includes the nature reserves "Ilgas" and "Glusonkas purvs" (bog)(Table 7.6–18, Figure 7.6-8). Protection and use of the territories is established by the regulations No. 415 of July 22, 2003 of the Council of Ministers "Provisions of general protection and use of particularly protected nature territories". Within the 30 km zone in the territory of Latvia, there are also 9 micro-reserves with a total area of 126.8 ha, however in compliance with the legal enactments of the Republic of Latvia (Regulations No. 45 of the Council of Ministers "Regulations of establishment, protection, and management of micro-reserves"), more extensive information on micro-reserves must be requested at the State Agency "Latvijas Vides, geologijas un meteorologijas agentura" (Latvian Environmental, Geology, and Meteorology Agency). The territory also includes natural monuments: Medumu alley, Medumu park (dendrology plantations), as well as 74 protected trees (Law of April 7, 1998 of the Republic of Latvia "Law on Particularly Protected Natural Territories").

All of the aforementioned territories are particularly protected territories of European importance, i.e. NATURA 2000 areas.

List of particularly protected areas of the NNPP region in Latvia:

Augszeme
Protection category: protected landscape area (includes nature parks – Medumu ezeraine (Lakeland), Svente, nature reserves – Bardinska Lake, Skujines Lake), NATURA 2000 area.
Administrative division: Medumu, Sventes, Kalkunes, and Sederes rural municipalities.
Area: 20 828 ha.
Year of establishment: 1977.
Natural values: Valuable landscape territory includes Sventes and Medumu lakes with islands as well as several small lakes in the vicinity. The territory includes high-elevation territory of Augszeme, as well as several biologically valuable territories. 12 habitats of Annex 1 of the EU Habitat Directive and 8 species of Bird Directive can be found here.

Bardinska Lake
Protection category: nature reserve (included into the area of protected landscapes – Augszeme), NATURA 2000 area
Administrative division: Sederes rural municipality
Area: 5 ha
Year of establishment: 2004
Natural values: The territory was established for protection of EU Habitat Directive **–** transition bog and marshlands. There are 3 EU Habitat Directive species in the lake. One of the few Lapland hamatocaulis moss specimens that can be found in Latvia is located here.

Skujines Lake
Protection category: nature reserve (included in the protected landscape area – Augszeme), NATURA 2000 area
Administrative division: Sēderes rural municipality
Area: 10 ha
Year of establishment: 2004
Natural values: The territory was established for protection of EU Habitat Directive **–** transition bog and marshlands. There are 3 EU Habitat Directive species in the lake. One of the few Lapland hamatocaulis moss specimens that can be found in Latvia is located here.

Medumu ezeraine (Lakeland)
Protection category: nature park (included in the protected landscape area – Augszeme, the nature park includes the nature reserve – Medumu Lake islands), NATURA 2000 area
Administrative division: Medumu rural municipality
Area: 1484 ha
Year of establishment: 1977
Natural values: There are various types of forests in the territory, not forming extensive complexes, as well as transition bogs near the lakes, where EU directive species – Yellow Widelip Orchid has been found. The lakes are an excellent source of feeding for several rare bat species. Many rare and protected vascular plant, moss, and lichen species can be found here.

Medumu Lake Islands
Protection category: nature reserve (included in the nature park – Medumu ezeraine (Lakeland)), NATURA 2000 area
Administrative division: Medumu rural municipality
Area: 3 ha
Year of establishment: 1987
Natural values: The territory was established for protection of the islands in Medumu Lake. The main value of the territory is its forests on the islands, which are mainly broad-leaved tree forests, where linden, aspen, and wild birches, as well as oak trees and ash-trees dominate the habitat.

Medumu Park
Protection category: natural monument
Administrative division: Medumu rural municipality
Area: 12.5 ha
Year of establishment: 1977

Meduma Alley
Protection category: natural monument
Administrative division: Medumu rural municipality
Area: 0.4 ha
Year of establishment: 2005

Svente
Protection category: nature park (included in the protected landscape area – Augszeme, the nature park includes the nature reserve – Sventes Lake islands), NATURA 2000 area
Administrative division: Medumu, Sventes, Kalkunes, Sēderes rural municipality
Area: 2225 ha
Year of establishment: 1977
Natural values: Exquisitely scenic lake. Includes Sventes Lake, which is one of the clearest lakes in Latvia. There are 3 forest-covered islands in the lake. Excellent territory for protection of eutrophic lakes. Such biotopes as transition bogs and marshes, wet black alder woods have been found at the territory; particularly protected plant species: Enchanter's nightshade (*Circaea lutetiana*), Yellow widelip orchid (*Liparis loeselii*), Acute-leaved pondweed (*Potamogeton acutifolius*) etc.

Sventes Lake Islands
Protection category: nature reserve (included in the nature park – Svente), NATURA 2000 area
Administrative division: Sventes rural municipality
Area: 3 ha
Year of establishment: 1987
Natural values: Particularly scenic islands of Svente Lake, the largest island is the Visku island (1.7 ha). There are predominantly broad-leaved trees on the islands: black alder – birches – ash-trees.

Silene
Protection category: nature park (includes natural reserves – Ilgas, Glusonkas bog), NATURA 2000 area
Administrative division: Lidumnieku, Skrudalienas rural municipality
Area: 3825 ha
Year of establishment: 1977

Natural values: Excellent territory for protection of various forest types (especially bog-type forests) and eutrophic lakes. The lakes are a great source of grazing for bats. 2 large bat colonies have been observed. Particularly large number of rare and protected plant and animal species.

Ilgas
Protection category: nature reserve (included in the nature park – Silene), NATURA 2000 area
Administrative division: Skrudalienas rural municipality
Area: 157 ha
Year of establishment: 1999
Natural values: A large number of particularly protected species of Latvia have been established here: the plants Early marsh orchid (*Orchis palustris*), Northern running-pin, Stiff clubmoss (*Lycopodium annotinum*), Ground pine (*L. clavatum*), White adder's mouth, Green-winged orchid (*Orchis morio*), Shetland pondweed (*Potamogeton rutilus*), and bird species Lesser spotted eagle (*Aquilla pomarina*), White-backed woodpecker (*Dendrocopos leucotos*), Black woodpecker (*Dryocopus martius*), Grey-headed woodpecker (*Picus canus*), Honey buzzard (*Pernis apivorus*), Black stork (*Ciconia nigra*).

Glusonkas purvs
Protection category: nature reserve (included in the nature park – Silene), NATURA 2000 area
Administrative division: Skrudalienas rural municipality
Area: 155 ha
Year of establishment: 1977
Natural values: The territory has 2 diseutrophic lakes (Glusņas and Glusonkas), which are surrounded by poor grassy and transition bogs, marshes. In the periphery there are boggy pinewoods and fir-tree forests.

Augsdaugava
Protection category: protected landscape area (includes nature park – Daugavas loki (The River-bends of Daugava)), NATURA 2000 area
Administrative division: Naujenes, Salienas, Vecsalienas, Tabores, Skrudalienas rural municipality. The territory is included also in the district of Kraslava.
Area: 52 325 ha
Year of establishment: 1990

Natural values: The territory was established to maintain exquisite values of cultural sceneries and natural sciences in the Daugava river valley and vicinity. A large number of protected plant and animal species can be found at the territory. In the territory, there are such EU Habitat Directive biotopes as river overfalls, open inland dunes with Grey club grass (*Corynephorus canescens*) meadows, springs and spring bogs rich in mineral substances, hillside and ravine forests, dry fields in calcareous soils, etc.

Daugavas loki (The River-bends of Daugava)
Protection category: nature park (included in the protected landscape area – Augsdaugava), NATURA 2000 area
Administrative division: Naujenes, Salienas, Vecsalienas, Tabores, and Skrudalienas rural municipality. The territory is included also in the district of Kraslava.
Area: 12372 ha
Year of establishment: 1990

Natural values: The territory was established to maintain the unique landscape of the medium courses of the Daugava River valley, the valuable natural areas, versatility of nature therein, as well as the monuments of local history. The nature park includes 8 large bends of the River Daugava from Kraslava to the Naujene ravine.

Table 7.6–18. Protected areas of the NNPP region in Latvia and their area.

No	Name of Protected Nature Territory	Area (ha)
1.	Protected landscape area “Augsdaugava”	52 325
1.1.	Nature park “Daugavas loki”	12 372
2.	Protected landscape area “Augszeme”	20 828
2.1	Nature Park “Medumu ezeraine”	1484
2.1.1.	Nature reserve “Meduma ezera salas”	3
2.2.	Natural monument “Medumu parks”	12.5
2.3.	Natural monument “Medumu aleja”	0.4
2.4	Nature Park “Svente”	2225
2.4.1.	Nature reserve “Sventes ezera salas”	3
2.5.	Nature reserve “Skujines ezers”	10
2.6.	Nature reserve “Bardinska ezers	5
3.	Nature Park “Silene”	3825
3.1.	Nature reserve “Glusonkas purvs”	155
3.2.	Nature reserve “Ilgas”	157

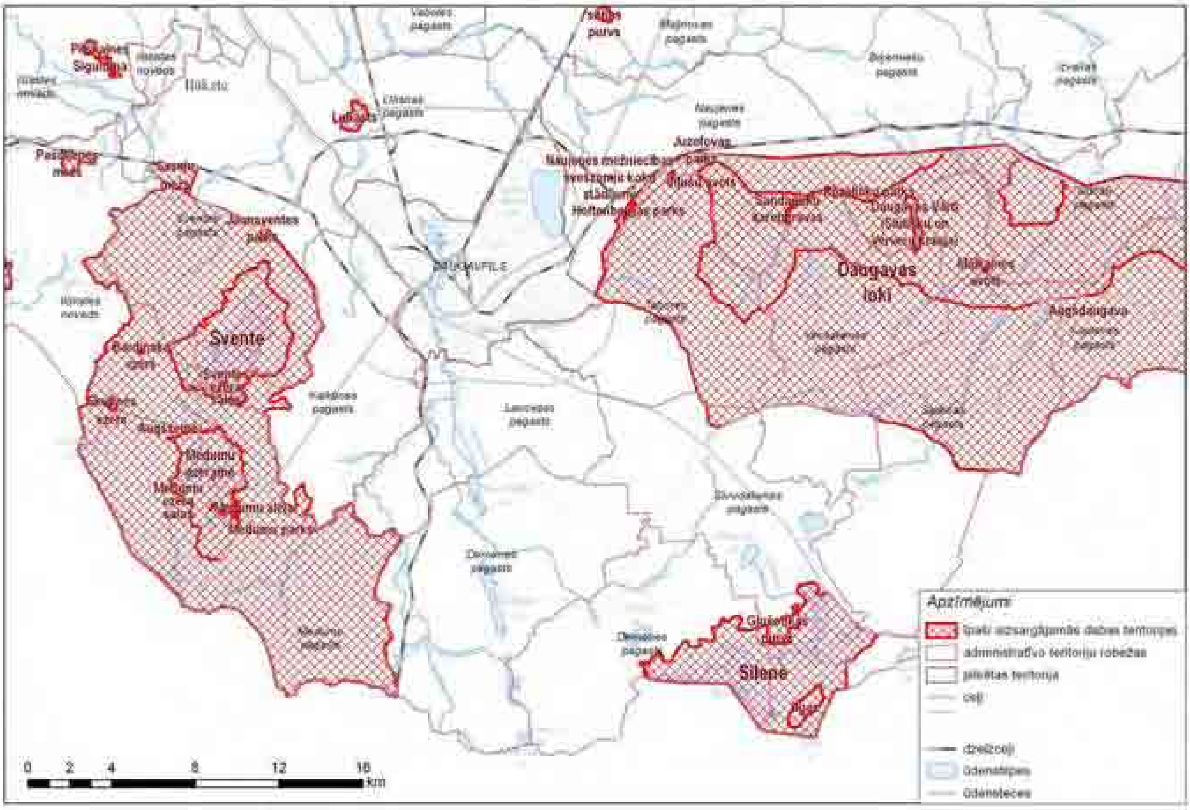


Figure 7.6-8. Protected areas of the NNPP region in Latvia.

Belarus

Protected areas of the NNPP region

All territory in the 30 km zone from the planned nuclear power plant in the territory of Belarus belongs to Braslav administrative district. In the territory some protected areas are located. The nearest and probably best known one is the Braslav Lakes National Park.

Braslav Lakes National Park

The objectives of the Braslav Lakes National Park are: conservation of the natural complex of Braslav lakes group, its unique ice age landscape, biodiversity (especially plant and animal) typical for Belorussian Poozerye; organization of environmental education of the population; conservation of cultural heritage; organization of recreation and tourist activities. The Braslav Lakes National Park was established in 1995.

The park occupies a territory of 71.5 thousand hectares or more than a third of the Braslav administrative district (Figure 7.6-9). From north to south the park stretches for 56 km. Width of the park fluctuates from 7 to 29 km. Depending on predominating values functional zones of the park have been identified. 27 746 ha (39 %) belongs to regulated usage zone. Territory of the zone is a subject for study, restoration, development and sustainability of the ecosystems undisturbed by human economic activities. Economic zone covers 25 815 ha (36.3 %). It is established for the location of the facilities for servicing park's visitors and administration, recreation and living buildings. Recreation zone occupies 12 103 ha (17.0%). It is meant for the location of recreation and tourist facilities necessary for the population recreation, organization of cultural activities. Nature reserve zone covers 3 452 ha (4.9 %). It is identified in the most valuable and the least loaded part of Boguinsky forest land in order to conserve untouched typical and unique ecosystems.

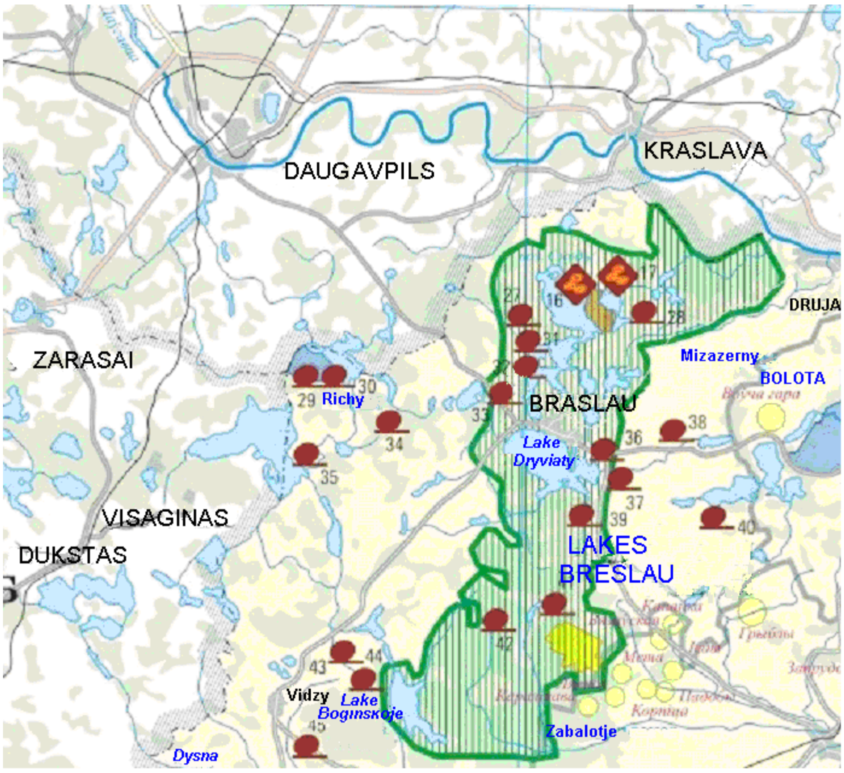


Figure 7.6-9. The national park "Braslav Lakes" of the Republic of Belarus

The park is rich in forest and lake. The forests occupy 46 % of the park. There are 60 lakes occupying 17 % of the territory in the park. The biggest lakes are, Drisvyaty (Lake Druksiai), Snudy, Strusovo, Boguinskoye. Volos Yuzhny is a deepest lake (40.4 m) of the park.

The relief here was shaped in the result of the last ice shelf. The Braslav upland is one of the most unique natural complexes in Belarus. The combination of chains, hills, lakes, wetlands and rivers makes this territory very mosaic. In the park there are a lot of huge stones (up to 10 m long), which are remarkable in geological and historical respects. The Braslav upland is characterized by sod-podzol more rarely sandy loam soils.

The modern fauna is represented by species typical to mixed forests of Middle Europe. The lakes are inhabited by 29 species of fish. There are 189 bird species including 45 rare and threatened ones. Breeding Black Stork (*Ciconia nigra*), Willow Grouse (*Lagopus lagopus*), Dunlin (*Calidris alpina*) here are of greatest value. Big animal species inhabiting the park are elk (*Alces alces*), brown bear (*Ursus arctos*), wolf (*Canis lupus*), lynx (*Lynx lynx*). About 500 species of flora (20 of them are rare for Belarus) have been registered here. Volos Yuzhny Lake is the only one in Belarus where relict Crustacea of the ice age can still be found.

Other protected areas

There are some other protected territories of international value in the Vitebsk region located a little bit outside the 30 km zone from the NNPP in Lithuania. They are as follows (*Kozulin et al., 2002*): Bolota Elnia (E 27 55 and N 55 34; 23200 ha), Azerna-bolotny Kompleks “Asveiski” (E 28 01 and N 56 06; 22600 ha); Lesa-bolotny Kompleks “Cervony bor’ (E 28 30 and N 56 00; 34234 ha); Servatc (E 27 30 and N 55 00; 9268 ha).

Bolota Elnia is a national hydrographical nature reserve (zakaznik), established in 1968. In 1998 it was designated as an Important Bird Area (IBA) of international value. Azerna-bolotny Kompleks “Asveiski” is a national landscape nature reserve (zakaznik), established in 2000. In 1998 it was designated as an Important Bird Area (IBA) of international value. Lesa-bolotny Kompleks “Cervony bor’ is a national landscape nature reserve (zakaznik), established in 1995. It is considered as a potential Important Bird Area (IBA) of international value. Servatc is a national hydrographical nature reserve (zakaznik). It is considered as a potential Important Bird Area (IBA) of international value.

7.6.1.7 Summary of biodiversity values (in Lithuania only)

There are 8 NATURA 2000 network Sites of Community Importance (SCI), valuable for habitat, plant and animal species protection according to the EU Habitat Directive in the NNPP region in Lithuania. There are 23 habitat types of international importance protected in the NATURA 2000 network Sites of Community Importance (SCI). Those habitats and 12 species of animals as well as plants of international importance are considered as designation values according to the EU Habitat Directive in the NNPP region in Lithuania.

There are 4 Special Protection Areas (SPAs) valuable for bird protection in the NNPP region in Lithuania. In those areas there are 26 breeding bird species of international importance, which are considered as NATURA 2000 network designation values.

From the point of view of biodiversity impact assessment most important values in this work were considered to be those, which are designation values of the Lake Druksiai

SCI and the Lake Druksiai SPA. They are as follows: European otter (*Lutra lutra;* 6–10 individuals), Spined Loach (*Cobitis taenia;* a common species here), Great Bittern (*Botaurus stellaris;* local breeding population of 10 calling males), Black-throated Diver (*Gavia arctica;* 1 pair), Marsh Harrier (*Circus aeruginosus;* 5 pairs), Spotted Crake (*Porzana porzana;* 6 males), Little Crake (*Porzana parva;* 1 male), Black Tern (*Chlidonias niger;* 10 pairs) and Bluethroat (*Luscinia svecica;* 1 pair).

Biodiversity values within the immediate vicinity of the two proposed sites

Several biodiversity values of international importance are located in the immediate vicinity of the INPP and the two proposed sites of the NNPP. Two important habitats of European otter (*Lutra lutra*), one of Great Bittern (*Botaurus stellaris*), one of Spotted Crake (*Porzana porzana*) and one of Marsh Harrier (*Circus aeruginosus*) are on the shore of Lake Druksiai close to the proposed sites of the NNPP. All these species are designation values of the Druksiai SPA and the Druksiai SCI (Figure 7.6-10).

Some other species, listed in Annex II of the EU Habitat Directive and Annex I of the EU Bird Directive have been registered in the immediate vicinity of the INPP and the two proposed sites of the NNPP. During bird breeding period Tawny Pipit (*Anthus campestris*) inhabits a disturbed territory used as a site for excavating of gravel. The species is listed in Annex I of the EU Bird Directive. Spotted Crake (*Porzana porzana*) and Tawny Pipit (*Anthus campestris*) are included in the LRDB.

Two rare amphibian species, listed in Annexes II and IV of the EU Habitat Directive and included in the LRDB (*Triturus cristatus* and *Bombina bombina*), occur very close to the INPP (Figure 7.6-10). *Bombina bombina* inhabits water bodies heavily disturbed by humans. *Triturus cristatus* inhabits small water bodies in Tumelina forest.

A mixed colony of Cormorant (*Phalacrocorax carbo*), with about 500 nests registered, Grey Heron (*Ardea cinerea*), with about 150 nests, and of Great White Egret (*Egretta alba*), with a few nests, is located on the Lake Druksiai shore close to the Ignalina NPP. The Great White Egret (*Egretta alba*) is a new breeding bird species in Lithuania. It is listed in Annex I of the EU Bird Directive.

In close vicinity of the INPP the rare habitat "Fennoscandian deciduous swamp woods" (9080) is located. This valuable habitat is listed in Annex I of the EU Habitat Directive.

Large copper butterfly (*Lycaena dispar*) has been observed in a meadow about 2.5 km to the south from the INPP. This species is listed in the Annex II of the EU Habitat Directive.

Some rare plant species, included in the LRDB have been found close to the INPP (e.g., *Scolochloa festucacea, Eriophorum gracile*).

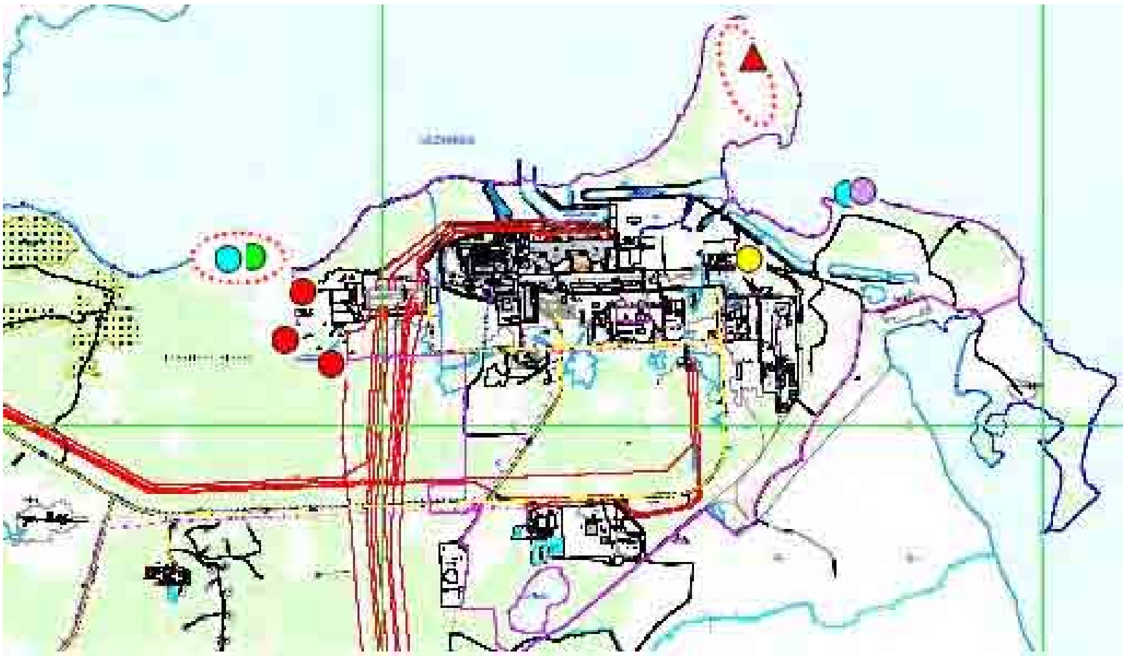


Figure 7.6-10. Location of most important biodiversity values in the immediate vicinity of the INPP and the two proposed sites. Legend: red pointed line – most frequently used habitat of European otter (*Lutra lutra*); sky blue spot – breeding habitat of Marsh Harrier (*Circus aeruginosus);* green spot – habitat of Great Bittern (*Botaurus stellaris);* yellow spot – breeding habitat of Tawny Pipit *(Antus campestris*); violet spot – breeding habitat of Spotted Crake (*Porzana porzana);* red spot – habitat of great crested newt *(Triturus cristatus);* red triangle – breeding colony of Great White Egret (*Egretta alba*).

Some rare invertebrate species have been registered close to the INPP. E.g., *Melitaea phoebe* (Lepidoptera, Nymphalidae) inhabits a meadow of the Smalvele river valley near Lake Druksiai close to the main building of the INPP. *Temelucha arenosa* (Hymenoptera, Ichneumonidae) has also been found in a meadow of the Smalvele river valley near the Lake Druksiai. *Aricia eumedon* has been found on the shore of Lake Druksiai about 2 km to the west from the INPP.

7.6.1.8 Terrestrial radioecological status of biodiversity

General issues about radioecology

Radioecology is a scientific discipline which studies how radioactive substances interact with nature, how different mechanisms affect the substances migration and uptake in food chain and ecosystems and what are aspects of the environmental impact of radioactive substances. Radioactivity originates from natural and anthropogenic sources, including radioactive materials used in industry and power generation.

It is known that modern nuclear power plants pollute the environment very little. Nevertheless, it is important to monitor radioactive pollution in relation to operating of NPPs and to study dispersion and transfer of radioactive materials in nature. An in international interest in the topic of protection of the environment from radiation is increasing.

Results of monitoring

Researches of radionuclides specific activities in plants of various ecotopes have been started in 1996 in the frame of state scientific research program “Atomic Energy and the Environment” and after these researches were finished, the researches have been continued in 1998, 2000 and 2001 (*Radiation Protection Centre Project Report, 2007*). It has been established that in 1996–2001, maximal values of ^{137}Cs activity in plants of forest ecotope ranged from 71 to 174, and in their soil it was up to 109 Bq/kg (Table 7.6–19). In forest ecotope the highest activity of this radionuclide was detected in *Hiloconium splendens* and *Pteridium aquilenium* (respectively 164 and 174 Bq/kg). In analyzed indicator sorts of plants highest values of ^{137}Cs activity ranged respectively from 102 up to 130 Bq/kg, and in their soil it was up to 108 Bq/kg (Table 7.6–19). In plants of meadow ecotope and in their soil the highest values of ^{137}Cs activity were the lowest and were respectively 26 and 30 Bq/kg (Table 7.6–19). In plants and soil the highest ^{137}Cs activity is detected in the forest and swamp ecotopes at the closets to Ignalina NPP Grikiniskiu reference site and in Tilze, located on the opposite side of INPP, on the other shore of the Lake Druksiai. In 2003–2005 and 2007 in INPP region values of ^{137}Cs specific activity in forest, swamps and meadow plants in most cases were similar or less than in 1996–2001 (Table 7.6–19).

Table 7.6–19. Values of specific activity of radionuclides (Bq/kg, d.w.) in tested species of plants in various ecotopes of the Ignalina NPP region.

Ecotope	Plant species	Range of radionuclides activity: minimal – maximal values							
		^{137}Cs			^{60}Co			^{90}Sr	
		1996–2001	2003–2005	2007	1996–2001	2003–2005	2007	1996–2005	2007
Forest	Lichenies	50–71	–	–	15	3	–	8–15	–
	Hilocomium splendens	30–164	29–80	31±4	3–28	<mdl–3	<mdl	6–26	6
	Vaccinium myrtillus	17–75	32–64	26±3	2–3	<mdl	<mdl	3–16	11
	Pteridium aquilinum	82–174	158–174	50±4	<mdl	<mdl	<mdl	31	–
	Dryopteris filix-mas	26–37	–	–	<mdl	–		–	–
	Calamagrostis arundinacea	7–43	34	14±1	–	<mdl	<mdl	6–8	6
	soil	22–109	29–46	–	<mdl–7	–		16–28	–
Swamp	*Sphagnum* sp.	28–104	27–76	70±5	2–4	<mdl	<mdl	6–12	7
	Calluna vulgaris	25–130	20–78	100±6	1	<mdl	<mdl	15	–
	Calla palustris	15–102	35–110	83±7	<mdl–10	<mdl	<mdl	10–30	20
	soil	20–108	25–47	–	<mdl–2	–		10–32	–
Meadow	meadow plants	4–26	–	–	3–9	–		6–83	–
	meadow moss	–	1	4±1	–	<mdl	1±0.3	–	1
	soil	11–30	–	–	<mdl	–		–	–

<mdl: under minimal detectable level

In 1996–2007, activities ^{134}Cs and ^{54}Mn of all examined plants at reference sites in forest, swamp and meadow, and the soil of their ecotopes were less than the minimal detectable level.

In 1996–2001, the greatest activity of ^{60}Co was detected in plants, at the closest to INPP Grikiniskiu reference site. From tested species of plants the greatest activity of this radionuclide was detected in *Hiloconium splendens* (up to 28 Bq/kg) (Table 7.6–19). In other tested species of plants, activity values of this radionuclide ranged from 1 to 10

Bq/kg or were less than minimal detectable level (Table 7.6–19). In the soil, ^{60}Co is detected only at the closest to INPP Grikiniskiu reference site. Activity of this radionuclide in the soil ranged from 2 to 7 Bq/kg or was less than minimal detectable level. In 1996–2007, activity values of ^{60}Co in the analyzed plants were less than minimal detectable level (Table 7.6–19).

In 1996–2005, highest values of ^{90}Sr activity in the forest and swamp plants were 12–30 Bq/kg, and in their soil 28–32 Bq/kg, and were less than ^{137}Cs (Table 7.6–19). The highest ^{90}Sr activity values are detected in meadow plants (up to 83 Bq/kg), in which values of this radionuclide were far higher than ^{137}Cs. At Tilze and Grikiniskiu reference sites ^{90}Sr activity in the tested plants was higher than in other reference site plants, located further from INPP. In 2007 ^{90}Sr activity values in plants were similar to those in 1996–2005 (Table 7.6–19).

The comparison of activity of radionuclides in the same species of tested plants in the region of Ignalina NPP and other regions of Lithuania demonstrates that after accidents at the Chernobyl NPP average values of activity ^{137}Cs in plants most contaminated with radionuclides were far higher in Varena region than in Ignalina NPP region (Figure 7.6-11). Values of ^{90}Sr activity in plants in Plunge and Varena regions differ very little or were higher than in Ignalina NPP region. During the analysis period (from 1994 till 2002), in plants of Plunge and Varena regions, the tendency of ^{137}Cs and ^{90}Sr activity decrease is observed (Figure 7.6-11). However, in the tested species of plants in Ignalina NPP region values of ^{137}Cs and ^{90}Sr specific activity during the entire analysis period (1996–2007) ranged in similar limits, i.e. the tendency of activity decrease in these radionuclides has not been observed (Figure 7.6-11).

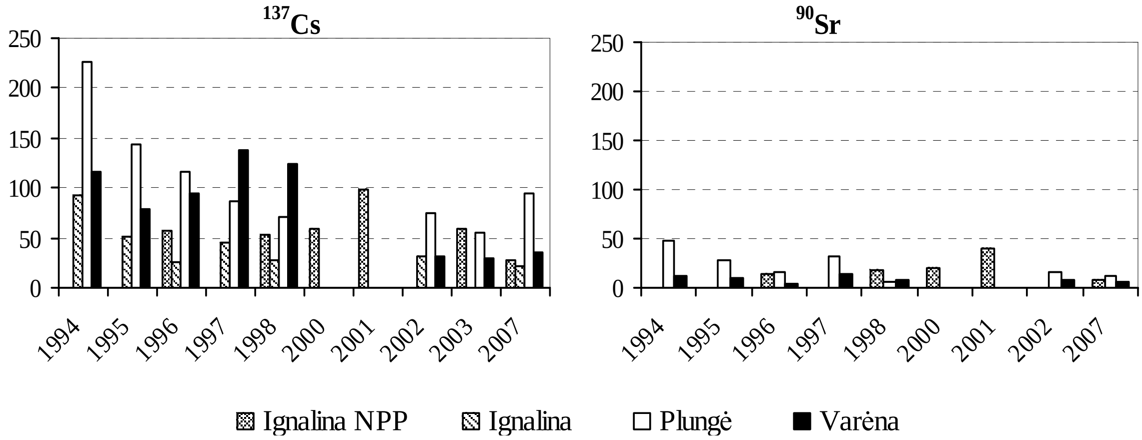


Figure 7.6-11. Average values of specific activity of ^{137}Cs and ^{90}Sr (Bq/kg d.w.) in plants at background monitoring stations in the INPP region, Ignalina, Varena, and Plunge regions.

7.6.2 Assessment of impacts on vegetation, fauna and protected areas

It is evident that there will be several factors which can have diverse impacts on biodiversity by various means. Furthermore, there may be impacts which will emerge in very long-term perspective and these impacts will depend on many factors which most probably cannot be foreseen today. Therefore it is worth mentioning that this assessment of impacts is based on factors that can be predicted at the time of this assessment – such phenomena as global warming or climate change cannot be taken into consideration with much emphasis. It is more reasonable to concentrate on the most evident and probable, foreseeable impacts in order to produce as clear and accurate assessment as possible and not include all possible long-term future situations which will not depend on this project.

As there are NATURA 2000 protected areas near by the project area, the impacts towards the NATURA 2000 designation values are assessed separately. Thereafter the impacts on terrestrial fauna, flora and habitats are assessed. The impacts on aquatic nature values (apart from NATURA 2000 values) are assessed in Section 7.1 and are therefore not repeated here.

Relevant impact factors

The construction, and further, the operation of a new nuclear power plant is presumed to influence the natural environment mainly through i) traffic, ii) noise and vibration, iii) direct construction impacts, and iv) aquatic environmental characteristic change in Lake Druksiai (water temperature, eutrophication, water flow, ice coverage). Later in the assessment these factors will be referred as i, ii, iii and iv and they include the following features:

i) The traffic during construction and operation is presumed to happen mainly through now existing routes and this traffic is not expected to create major impacts if compared to existing situation. During construction it can be expected that the traffic amounts will increase compared with power plant operation time (now or future), but this effect must be considered, however, relatively temporary (even though the construction will take for example 5 years).

ii) The noise and vibration levels will mostly affect the Lake Druksiai environment – this is supposed to be valid both for the construction period and operation period. In total the noise level is not assumed to rise significantly from the present situation.

iii) Direct construction impact is hereby defined to be immediate destruction of habitats, vegetation and possible populations of sessile fauna within the new power plant exact area and other operational areas which will be built. Both options for new locations are taken into consideration as well as areas intended for other use relating to the NNPP.

iv) Changes in aquatic environment are here assumed to be the most essential impact factors. The main impact issue is considered to be the thermal effect of the NNPP. Naturally also other aquatic characteristics may change directly or indirectly (such as eutrophication depending from e.g. waste water treatment systems), but the thermal effect is here considered to be the main impact (upon which the other changes to some proportion depend on). Changing the present situation (warmer or cooler) will most probably have the clearest effects on the surrounding natural environment of the NNPP. There will be three (3) impact options considered here (they are described more in detail in the aquatic environment impact assessment chapter and therefore not repeated here in details).

In order to illustrate the impacts of different thermal loads and cooling technology combinations in a concise and still comprehensive way, three scenarios were created based on the modelling results and hydrological, limnological and biological expert assessment of the probable effects. In all the scenarios the electricity production is assumed to be 3 400 MW_e but the cooling system and consequently the thermal load to the lake varies. The following scenarios were chosen to the assessment:

- Scenario T1 – Thermal load to the lake will be at maximum 3 160 $MW_{released}$. This corresponds approximately 1 700 MW electric energy produced by using direct cooling for heat dissipation. The remaining 1 700 MW_e will be produced using cooling towers. This scenario resembles roughly the conditions when both units of INPP were in operation.

- Scenario T2 – Thermal load to the lake will be at maximum 6 310 $MW_{released}$. This corresponds approximately 3 400 MW electric energy all produced by using direct cooling for heat dissipation. In this scenario the heat load and the temperatures in lake will rise compared to the period of INPP operation and to the scenario T1.
- Scenario T3 – Only cooling towers will be used for cooling and the thermal load to the lake will be negligible. In this scenario the lake water temperatures will decrease compared to the period of INPP operation and to scenarios T1 and T2.

Consequently, this assessment can, from the lake point of view, be considered roughly corresponding to production of 1 700 MWe (T1), 3 400 MWe (T2) and 0 MWe (T3) with direct cooling.

Due to the above explained issues the main focus of biodiversity impact assessment will be on Lake Druksiai water temperature change – other areas around Lake Druksiai (whether NATURA 2000 areas or other important areas) are not given much attention since it is rather evident that clearly the main effects of the NNPP will fall on Lake Druksiai (the most important effect, water temperature, cannot affect other water bodies further away and up-stream of Lake Druksiai). The above mentioned water temperature option will be later referred as T1, T2 and T3.

7.6.2.1 NATURA 2000 impact assessment

Assessment justification and values to be assessed

The NATURA 2000 network has been established to protect and maintain various, important biodiversity values. These so called *designation values* are nature values, which are the reason why the certain area has been selected to be part of the NATURA-protection network. There are two different types of NATURA 2000 areas and they have different designation values. Special Areas for Conservation (SACs, or Sites of Community Importance SCIs) are selected to protect habitats and animal species which are listed in official NATURA 2000 standard data form in chapters 3.1. (habitat types) and 3.2.c-3.2.g. (mammals, amphibians, fishes, invertebrates and plants of Annex II of the EU Habitat Directive). Special Protection Areas (SPAs) are selected to protect bird species which are listed in official NATURA 2000 standard data form in chapters 3.2.a (EU Bird Directive, Annex I species) and 3.2.b (regularly occurring migratory birds not listed on Annex I of the EU Bird Directive).

It should be noted that the NATURA 2000 impact assessment will concentrate strictly on these values, which are the designation values for each NATURA 2000 area. Other possible biodiversity values are discussed separately.

As it has been shown previously, there are many NATURA 2000 areas in the nearby NNPP region. However, as the main impacts of the NNPP are determined to link strongly to the possible alterations in water temperature (see above, Section 7.6.2), the emphasis should be focused on Lake Druksiai NATURA 2000-area since no reasonable, significant direct or relevant indirect effect will concern the areas nearby under normal power plant operation or construction (some indirect effects may arise such as increasing volume of people moving around the protected areas, but these factors are here considered to be marginal and also uncertain to predict). Also it is to be noted that there were no other projects indicated or identified which would be now ongoing or planned and would have relevant meaning as cumulative or summarizing factor to interact with the NNPP project in relation towards the NATURA 2000 designation values.

The assessment is concentrated on the favourable conservation status (hereafter FCS) of the designation values. FCS can be simply described to be a situation where a habitat type or species is doing sufficiently well in terms of quality and quantity and has good prospects of continuing to do so in the (predictable) future. Species must remain as viable component of their natural habitats on long-term basis, the natural range of the species (or habitats) is not reduced or is not likely to be reduced in the foreseeable future and there will be sufficient conditions to maintain habitats or populations on long-term basis. Any significant negative impact (changing the above mentioned factors) by the NNPP project (project alone or the sum of influences with any other project in progress now or now in planning) must not be caused to any designation value. It is not clearly or simply clarified what can be interpreted as significant negative impact and therefore FCS is used to measure this.

Within this NATURA 2000 assessment it is also taken into consideration what is valid for the precautionary principle in NATURA 2000 assessments. This means that if a certain risk cannot be excluded, according to the so called precautionary principle, such risk that the plan or project will have a significant effect, is considered to exist.

Impact assessment in detail

Traffic: The NATURA 2000 assessment has revealed (Table 7.6–20) that if the traffic during construction and operation would be organised through now existing routes, and if during construction it can be expected that the traffic amounts will increase compared with power plant operation time (now or future), this would not have a relevant negative impact on designation values. This conclusion will be valid, if no new roads would be built out of nowadays devastated (urban) territory (especially closer to Lake Druksiai, because the designation values are more or less ecologically related with the water ecosystems).

Noise, vibration and construction: Noise and vibration as well as construction of the NNPP could have a moderate negative impact on three species. No negative impact from those factors is expected on the remaining 5 species (designation values)(see Table 7.6–20).

Change in aquatic environment: Depending on water maximum temperature in Lake Druksiai, very different NNPP impacts on the NATURA 2000 area of Lake Druksiai are expected. The maximum temperature of the water will depend on NNPP thermal load. Three scenarios were analysed in this work: T1, T2 and T3. The highest negative impact on NATURA 2000 network values would occur if T2 scenario would be selected (thermal load to lake would be at maximum 6 310 $MW_{released}$ and the temperature would rise significantly). Option T2 has the greatest potential to have negative impact of almost all the species in question. The main impact factor would be the decrease of food resources (fish, insects and other aquatic animals). This would be the case in the very extreme conditions – most probably it is evident that even with rather high temperatures it is probable that there would be enough fish, insects, other aquatic animals and plants to maintain the favourable conservation status (FCS) of all the species. However, when taking precautionary principle into account, T2 must be considered to be an option, which can pose a threat of significant negative effect towards one or more Natura 2000 designation values (see Table 7.6–20). The species in question are ecologically fully dependent on the ecosystem of the lake. On the other hand, operation of the NNPP according to T1 or T3 scenarios would not have any significant negative impact on NATURA 2000 network values.

Table 7.6–20. Presumed essential impacts on NATURA 2000 protected areas (Lake Druksiai) relevant designation values, depending on construction site and cooling water scenario.*

DESIGNATION VALUE / NATURA-AREA	Traffic	Noise and vibration	Direct construction	T1	T2	T3
European otter (*Lutra lutra*) / Lake Druksiai LTZAR0029	No relevant impact, since traffic is directed mainly through present roads.	The present situation of noise intensity will not essentially change in long-term. If Site No. 2 would be selected for construction of the NNPP, a risk of disturbance could occur because the source of noise, in comparison with present situation, would be ten times closer to one of priority sites (most frequently used habitat which very likely is the breeding habitat) of the European otter *(Lutra lutra)*. Possible relevant negative impact in case of the second proposed site.	No known breeding or resting places of the species will be destroyed directly through construction. If Site No. 2 would be selected for construction of the NNPP, a risk of human disturbance could occur (noise, presence of people, blocking of dispersal/migration roads, etc). Especially big threat for the local population would occur because it is expected that construction work and new NPP could block dispersal and migration route of the local population. The otter is a shore species with large territories whose individuals are controlling when moving along the shore. Built and in other way disturbed territory is almost unsuitable habitat for the species, even for migration. Thus direct construction in case of Site 2 would decrease FCS of the species, if no mitigation measure would be implemented.	The present situation does not change significantly, there will be conditions equivalent to present conditions for the species to breed and use the area.	The significant warming of the lake does pose a potential risk of changes in composition of the fish community (fish is main food of the species). According to the predictions, even though the species composition of fish will most probably change, the biomass or amount of fish would not decrease and thus there would be enough food for the species to keep the FCS.	Since the temperatures will resemble the natural temperatures no significant negative impacts are expected.
Spined Loach (*Cobitis taenia)*/ Lake Druksiai LTZAR0029	No impact, not relevant (the Spined Loach is a fish).	No impact, not relevant.	Construction of the cooling water intake and outlet structures and the possible dredging may negatively affect the Spined loach population in the immediate vicinity of the site.	Because the present situation does not change considerably, any significant effects on the population are not expected.	Spined loach is tolerant for high water temperature and relative low oxygen concentrations. It is dwelling in the littoral zone were permanent anoxic conditions are unlikely. It also spawns in densely	The littoral zone habitats will not be significantly altered from the present. Therefore no significant impacts

DESIGNATION VALUE / NATURA-AREA	Traffic	Noise and vibration	Direct construction	T1	T2	T3
			The impacts are, however, considered local and temporal and will not affect survival of the spined loach population and FCS of the species.		vegetated areas. Based on the habitat preferences it is considered quite tolerant to the eutrophication and warming affects and no significant adverse effects are expected.	on spined loach population are expected.
Black-throated Diver (*Gavia arctica)/* Lake Druksiai LTZARB003	No impact, not relevant (the Black-throated Diver is a waterfowl).	Because the present situation of noise intensity will not essentially change in long-term, no relevant impact on the species is foreseen.	No nesting or resting places of the species will be destroyed through construction. No relevant impact on the species is foreseen.	Because the present situation does not change significantly, no relevant changes in temperature, there will be conditions equivalent to present situation for the species to breed and use the area.	The significant warming of the lake does pose a potential risk of decrease of fish diversity. Possible negative impact on habitat quality (mainly feeding conditions and development of helophytes) of the species. Thus relevant negative impact. Even though the species composition of fish will most probably change, the biomass or amount of fish would not decrease and thus there would be enough food for the species. Development of helophytes in the lake could decrease the FCS of the species in the nearest future.	Since the temperatures will resemble the natural temperatures no significant negative impacts are expected.
Marsh Harrier (*Circus aeruginosus)/* Lake Druksiai LTZARB003	No relevant impact, since traffic is directed mainly through present roads.	The present situation of noise intensity will not essentially change in long-term. Independently which of the two proposed sites would be selected for construction of the NNPP, a risk of disturbance of the species could occur because the source of noise, in comparison with present situation, would be critically close to the breeding site of at least one pair.	No nesting or resting places of the species will be destroyed through construction. A risk of human disturbance could occur (noise, presence of people, etc) for one pair. FCS of the species would not change, if special mitigation measures would be implemented.	Because the present situation does not change significantly, no relevant changes in temperature, there will be conditions equivalent to present situation for the species to breed and use the area.	Possible negative and positive impact on population of the species. Amount of a breeding habitat (helophytes – mostly *Phragmitetum australies* associations) would increase. Feeding conditions of the species could become worse. Because surroundings of the lake are mostly non-agricultural areas (very small part of agricultural areas are meadows or grazing areas), the main feeding areas of the species are located in the lake and	Since the temperatures will resemble the natural temperatures no significant negative impacts are expected.

DESIGNATION VALUE / NATURA-AREA	Traffic	Noise and vibration	Direct construction	T1	T2	T3
		Possible relevant very local (one pair) negative impact. However, equivalent amount of pairs compared to the present situation can breed in the future (FCS would not change) in case special mitigation measures would be implemented.			adjoining wetlands. In spite of this most likely there will be enough food resources for the species to maintain FCS.	
Spotted Crake, (*Porzana porzana)/* Lake Druksiai LTZARB003	No relevant impact, since traffic is directed mainly through present roads.	In case Site No. 1 would be selected for construction of the NNPP, a risk of disturbance could occur because the source of noise, in comparison with present situation, would be much closer to one of the breeding sites. Possible relevant impact in case of Site No. 1. In spite of this the FCS of the species would not change, if special mitigation measures would be implemented.	No nesting places of the species will be destroyed through construction. If Site No. 1 would be selected for construction of the NNPP, a risk of human disturbance could occur (noise, presence of people, etc) for one breeding site. If special mitigation measures would be implemented, the FCS of the species would not change.	Because the present situation does not change significantly, no relevant changes in temperature, there will be conditions equivalent to present situation for the species to breed and use the area.	The significant warming of the lake does pose some risk of habitat change where species composition of plant community and water level could change causing a decrease of the shore terrestrial habitat suitability and quality for the species. However, the food resources for the species can be assumed to be adequate (insects and aquatic animals) to maintain the FCS.	Since the temperatures will resemble the natural temperatures no significant negative impacts are expected.
Little Crake (*Porzana parva)/* Lake Druksiai LTZARB003	No impact, not relevant, because breeding habitat of the species is mainly a shore reedbed.	Because the present situation of noise intensity will not essentially change in long-term, no relevant impact on the species could be foreseen.	No nesting or resting places of the species will be destroyed through construction. No relevant impact on the species is foreseen.	Because the present situation does not change significantly, no relevant changes in temperature, there will be conditions equivalent to present situation for the species to breed and use the area.	Possible negative and positive impact on population of the species. Amount of a breeding habitat (helophytes – mostly *Phragmitetea australlis* associations) would increase. Feeding conditions of the species would become worse. However, it can be assumed that still it would be enough food (insects and other small animals) to maintain the FCS for the species.	Since the temperatures will resemble the natural temperatures no significant negative impacts are expected.

DESIGNATION VALUE / NATURA-AREA	Traffic	Noise and vibration	Direct construction	T1	T2	T3
Black Tern (*Chlidonias niger)/* Lake Druksiai LTZARB003	No relevant impact, since traffic is directed mainly through present roads.	Because the present situation of noise intensity will not essentially change in long-term, no relevant impact on the species is foreseen.	No nesting, resting places and feeding sites of the species will be destroyed through construction. No relevant impact on the species is foreseen.	Because the present situation does not change significantly, no relevant changes in temperature, there will be conditions equivalent to present situation for the species to breed and use the area.	Possible potential risk of oxygen lost, changes in habitat structure and damage of biodiversity. This might have both negative and positive impact on population. Amount of a breeding habitat would increase due to faster eutrophication of the lake. Feeding conditions of the species in the lake could become worse in very extreme case. However, it can be assumed that the will be enough food (mostly insects) to maintain the FCS.	Since the temperatures will resemble the natural temperatures no significant negative impacts are expected.
Bluethroat (*Luscinia svecica)/* Lake Druksiai LTZARB003	No relevant impact, since traffic is directed mainly through present roads.	Because the present situation of noise intensity will not essentially change in long-term, no relevant impact on the species is foreseen.	No nesting, resting places and feeding sites of the species will be destroyed through construction. No relevant impact on the species is foreseen.	Because the present situation does not change significantly, no relevant changes in temperature, there will be conditions equivalent to present situation for the species to breed and use the area.	Possible risk of habitat change (in case, if species would breed in lake shore wetland) where species composition of plant community and water level could change causing a decrease of the shore terrestrial habitat suitability, quality for the species. However, it can be assumed that the FCS will still be maintained here.	Since the temperatures will resemble the natural temperatures no significant negative impacts are expected.

* “Traffic”, “Noise and vibration” include the disturbance during construction and future operation. “Direct construction” means direct impacts of construction. “T1”, “T2” and “T3” mean different water temperature options explained in Section 7.6.2.

7.6.2.2 Assessment of impacts on terrestrial fauna

An initial conclusion is that impact of the NNPP on biodiversity would be focused on the cooling area (Lake Druksiai) and on the construction site. Thermal releases to Lake Druksiai and direct as well as direct damage of the NNPP construction site as a habitat would be the biggest threats for biodiversity. The noise levels and vibration levels are not expected to increase in comparison with the present situation and thus any other relevant impact of the NNPP on other territories and on other NATURA 2000 sites is not expected.

Impact of the thermal releases of the NNPP on the NATURA 2000 network sites Lake Druksiai SPA and Lake Druksiai SCI have been analysed above (see Section 7.6.2.1 for details). It was concluded that the thermal releases to Lake Druksiai will not have any significant direct negative impact on local terrestrial or semi-aquatic animals on territory covered by construction of the NNPP and on the lake, if special mitigation measures are be implemented. The animal species depending on the fish as food resource would have enough food also in the future with all the scenarios (T1, T2, T3) mentioned above since the amount of fish is not predicted to decrease – only the species composition can be expected to change in scenario T2.

Direct NNPP construction impact on terrestrial or semi-aquatic fauna could be relevant in the territory covered by construction and in its immediate vicinity. The impact will depend on the proposed sites for construction. Biodiversity values inhabiting or using the territory of the INPP and its surroundings were listed above in Section 7.6.1.7. Analyses of possible impact of the direct construction on these values allowed making a conclusion that noise and vibration, in relation with construction of the NNPP, will not have any negative impact on local terrestrial animal populations, provided certain mitigation measures are implemented (Table 7.6–21).

Increase of traffic intensity within the construction period could have a negative impact on local rare amphibians Great crested newt (*Triturus cristatus*) and European fire-bellied toad (*Bombina bombina*) mainly during their migrations and dispersal.

If the proposed Site 1 would be selected for construction of the NNPP, this could fully destroy the breeding habitat of the Tawny Pipit (*Anthus campestris*) and the species would become locally extinct.

In case Site 2 would be selected for construction of the NNPP, this could destroy part of the habitat of great crested newt (*Triturus cristatus)* and there is a risk that the isolated local population could decrease.

In both cases site 1 or 2, there will be a negative impact on local population of European fire-bellied toad (*Bombina bombina*). Part of the species habitat and part of the population would disappear.

Table 7.6–21. Presumed essential impacts of the NNPP on terrestrial fauna depending on proposed construction site.*

FAUNA SPECIES INHABITING IMMEDIATE VICINITY OF THE NNPP	Traffic	Noise and vibration	Direct construction
Tawny Pipit (*Anthus campestris*). 1-2 pairs.	No relevant impact in case of proposed Site No. 2, since traffic is directed mainly through present roads.	The present situation of noise intensity will not essentially change in the long-term. No relevant impact in case of proposed Site No. 2.	No nesting or resting places of the species will be destroyed through construction in case of proposed Site No. 2. If Site No. 1 would be selected for construction of the NNPP, than the breeding habitat of the species would be destroyed.
Great crested newt (*Triturus cristatus*). Numbers of population is not known.	A negative impact in case of proposed Site No. 1. Though traffic is directed mainly through present roads, an increase of intensity could damage population of the species.	The present situation of noise intensity will not essentially change in the long-term. No relevant impact.	No nesting or living places of the species will be destroyed through construction in case of proposed Site No. 1. If Site No. 2 would be selected for construction of the NNPP, then part of living and breeding habitat of the species would be destroyed.
European fire-bellied toad (*Bombina bombina*). Numbers of population is not known.	Though traffic is directed mainly through present roads, an increase of intensity would damage the population of the species.	The present situation of noise intensity will not essentially change in the long-term. No relevant impact.	In both cases of Site No. 1 or No. 2 part of living and breeding habitat of the species would be destroyed.
A mixed colony of Cormorant (*Phalacrocorax carbo*), Grey Heron (*Ardea cinerea*) and of Great White Egret (*Egretta alba*). About 500, 150 and few nests respectively.	No relevant impact, since traffic is directed mainly through present roads.	The present situation of noise intensity will not essentially change in the long-term. No relevant impact.	No nesting or resting places of the species will be destroyed through construction. A risk of human disturbance could occur (presence, visits of people, etc).
Lycaena dispar. Numbers of population is not known.	No relevant impact, since traffic is directed mainly through present roads.	The present situation of noise intensity will not essentially change in the long-term. No relevant impact.	No living places of the species will be destroyed through construction.

* Main definitions (“Traffic”, “Noise and vibration” and “Direct construction”) are as in Table 7.6–20.

There is a risk that when constructing the NNPP a mixed colony of Cormorant (*Phalacrocorax carbo*), Grey Heron (*Ardea cinerea*) and of Great White Egret (*Egretta alba*) would be damaged due to human disturbance (very likely visits of people, recreation, etc).

No negative impact of the NNPP on the Large copper butterfly (*Lycaena dispar*), inhabiting a meadow about 2.5 km to the south from the INPP, is expected.

7.6.2.3 Impact assessment on terrestrial flora and habitats

Direct NNPP construction impact on terrestrial flora and rare habitats in the territory covered by construction and in its immediate vicinity was analysed. Biodiversity values inhabiting or using the territory of the INPP and its surroundings were listed above in Section 7.6.1.7 Analyses of possible impact of the direct construction on these values allowed to make a conclusion that the traffic, noise and vibration as well as direct construction of the NNPP, will not have any negative impact on local terrestrial plants and protected habitats (Table 7.6–22).

Table 7.6–22. Presumed essential impacts of the NNPP on terrestrial flora and rare habitats, depending on proposed construction site.*

PROTECTED FLORA SPECIES AND HABITATS IN IMMEDIATE VICINITY OF THE NNPP	Traffic	Noise and vibration	Direct construction
Scolochloa festucacea	No relevant impact, since traffic is directed mainly through present roads.	No relevant impact.	Independently on which proposed site would be selected, no habitat of the species will be destroyed through construction of the NNPP.
Eriophorum gracile	No relevant impact, since traffic is directed mainly through present roads.	No relevant impact.	Independently on which proposed site would be selected, no habitat of the species will be destroyed through construction of the NNPP.
Habitat 9080, Fennoscandian deciduous swamp woods	No relevant impact, since traffic is directed mainly through present roads.	No relevant impact.	Independently on which proposed site would be selected, the area covered by the habitat 9080 would not be destroyed through construction of the NNPP.

* Main definitions (“Traffic”, “Noise and vibration” and “Direct construction”) are as in Table 7.6–20.

7.6.2.4 Summary of biodiversity impacts

It can be concluded that impacts of the NNPP project on biodiversity focuses quite strictly on Lake Druksiai and its immediate vicinity. The aquatic biodiversity impacts are described and assessed in Section 7.1. This assessment concentrates on terrestrial biota and Natura 2000-values. The most important impacts can be summarized as follows.

Impacts on NATURA 2000 values

There will be no significant negative impact of the traffic on NATURA 2000 designation values (Table 7.6–23).

The negative impact of the noise would be caused by increase of a risk of disturbance. The risk would increase because the source of noise, in comparison with present situation, would be critically close to breeding sites of some pairs (individuals) of the Natura designation species and could disturb them. The negative impact of the ”direct construction” would be caused by increase of a risk of human disturbance (during the construction) of designation species by expected increase of visits, presence of people, which could disturb them (especially within their breeding period).

Table 7.6–23. Severity of presumed essential impacts of the NNPP on NATURA 2000 designation values, depending on proposed construction site and water cooling scenario.*

DESIGNATION VALUE / NATURA-AREA	Traffic	Noise and vibration	Direct construc tion	T1	T2	T3
European otter (*Lutra lutra*) / Lake Druksiai LTZAR0029	-	2x	2x	-	x (<70%)	-
Spined Loach (*Cobitis taenia)*/ Lake Druksiai LTZAR0029	-	-	-	-	x (<30%)	-
Black-throated Diver (*Gavia arctica)/* Lake Druksiai LTZARB003	-	-	-	-	x	-
Marsh Harrier (*Circus aeruginosus)/* Lake Druksiai LTZARB003	-	1, 2x(20%)	1, 2x(20%)	-	x (<30%)	-
Spotted Crake (*Porzana porzana)/* Lake Druksiai LTZARB003	-	1x(20%)	1x(20%)	-	x (<30%)	-
Little Crake (*Porzana parva)/* Lake Druksiai LTZARB003	-	-	-	-	x	-
Black Tern (*Chlidonias niger)/* Lake Druksiai LTZARB003	-	-	-	-	x	-
Bluethroat (*Luscinia svecica)/* Lake Druksiai LTZARB003	-	-	-	-	x	-

* Main definitions are as in the Table 7.6–20. Symbols used: “-“ – no negative impact; “x” – negative impact; “xx” – very big negative impact; “1” and “2” – proposed construction site. Percents mean part of the local (of Lake Druksiai) population under negative impact.

Impact of water temperature changes in Lake Druksiai, depending on the thermal load to the lake from the NNPP (scenarios T1, T2, and T3; see Section 7.6.2 for details), would have different impact predictions on NATURA 2000 values. Scenarios T1 and T3 are not likely to cause negative impacts on NATURA 2000 designation values. However, the effects on the ecology should be constantly monitored and mitigation measures implemented if applicable.

Scenario T2 has the largest potential to cause significant negative impacts. All species (perhaps with the exception of the Bluethroat) are dependent on the lake ecosystem. Possible impacts could be significant decrease in populations if the temperatures would rise so high that the relevant food resources would become scarce. It is however likely that even if the changes in species composition would be significant the amount of fish and other relevant food resources (insects) would not decrease in biomass meaning that the lake would have sufficient amount of suitable food for the above mentioned species. Taking the precautionary principle into consideration, it cannot be ruled out that scenario T2 can cause significant negative impacts. This could be caused by decrease of quality of their feeding conditions (amount or quality of food) on habitats of the lake ecosystem or in sites ecologically dependant on the lake ecosystem; and by decrease of quality of their habitat (mostly breeding: vegetation amount, species composition, horizontal and vertical structure, etc.).

Depending on the species, up to 70 % members of population (four biggest populations were analysed only) would be influenced by this negative impact. If no mitigation measures would be implemented, in the long-term the negative impact of the T2 scenario could lead to decrease of the FCS of local populations of the European otter (*Lutra lutra*) and Black-throated Diver (*Gavia arctica*).

Impacts on terrestrial fauna

Noise and vibration, in relation with construction of the NNPP, will not have any negative impact on local terrestrial animal populations (Table 7.6–24).

Increase of traffic intensity within the construction period would have a negative impact on great crested newt (*Triturus cristatus*) and European fire-bellied toad (*Bombina bombina*). It is expected that this would cause a higher (in comparison with present situation) mortality rate of the populations of these two species (more of these amphibians would be run over by cars).

Table 7.6–24. Severity of presumed essential impacts of the NNPP on terrestrial fauna depending on proposed construction site.*

TERRESTRIAL FAUNA SPECIES IN IMMEDIATE VICINITY OF THE NNPP	Traffic	Noise and vibration	Direct construction
Tawny Pipit (*Anthus campestris*).	-	-	1xx
Great crested newt (*Triturus cristatus*).	2x	-	2x
European Fire-bellied Toad (*Bombina bombina*)	1,2x	-	1,2x
A mixed colony of Cormorant (*Phalacrocorax carbo*), Grey Heron (*Ardea cinerea*) and of Great White Egret (*Egretta alba*)	-	-	1,2x

* Definitions and symbols are as in Table 7.6–23.

If the proposed Site No. 1 would be selected for construction of the NNPP, this would fully destroy the breeding habitat of the Tawny Pipit (*Anthus campestris*) and the species would locally extinct. If the proposed Site No. 2 would be selected for construction of the NNPP, this could destroy part of habitat of great crested newt (*Triturus cristatus)* and there is a risk that the population could decrease or even disappear in the long-term.

Both sites 1 and 2 will have a negative impact on the local population of European fire-bellied toad (*Bombina bombina*). Part of the species habitat will be destroyed and part of the population would disappear. A mixed colony of Cormorant (*Phalacrocorax carbo*), Grey Heron (*Ardea cinerea*) and of Great White Egret (*Egretta alba*) could be damaged due to visits of people, recreation, etc.

Any negative impact of the NNPP on other conservation values (species included in the Annex I of the EU Bird Directive, Annex II of the EU Habitat Directive and listed in the LRDB), is not expected.

Impacts on terrestrial flora and habitats

Traffic, noise and vibration as well as direct construction of the NNPP will not have any significant negative impact on local terrestrial plants and protected habitats.

7.6.2.5 Summary of radioecological impacts

Many years' tests (1994–2007) of radionuclide activity in terrestrial flora and its soil in the Ignalina NPP region have shown that the greatest impact on the radioecological state of flora of this region and its soil is due to ^{137}Cs, the activity of which in these components during the entire period of testing has not decreased, but ranged in similar limits. However, in terrestrial flora of Ignalina NPP region activity of ^{137}Cs and also ^{90}Sr, was similar or lower than in flora of other regions of Lithuania (Plunge, Varena and Ignalina). Main amount of ^{137}Cs, penetrated into terrestrial ecosystem, accumulates in soil (thickness 10-15 cm), where characteristically for this radionuclide, as opposite to ^{90}Sr, a so-called aging process occurs, i.e. the longer ^{137}Cs stays in solid, the stronger it is tight into it. In soil, due to increased ^{137}Cs fixation, flow of this radionuclide from the soil may decrease up to ten times. Therefore, processes of natural cleaning of this soil contaminated by this radionuclide are processed much slower than of other radionuclides. Plants play a great part in the process of cleaning of soil, contaminated by radionuclides, especially ^{137}Cs.

Based on data of the performed analysis, it may be stated that the radioecological state of flora and its soil at Ignalina NPP region is quite good; however, assessing natural possibilities of soil cleaning of ^{137}Cs, impact of new NPP to the radioecological state of the region should be lower than of existing Ignalina NPP.

7.6.3 Mitigation measures

7.6.3.1 NATURA 2000 issues

In case the project or plan will cause significant negative impact on NATURA 2000 designation values, it is still possible to proceed with the project or plan. However, certain requirements must be met, and they are explained in Habitat Directive 92/43/EEC Article 6(4).

It must be shown that the alternative which is selected to put forward for approval, damages least the designation values and no other feasible alternative with less impacts exists. There must also be imperative reasons of overriding public interest. This imperative reason of overriding public interest is, however, not defined within the Directive even though such things as human health, safety and beneficial consequences for the environment are mentioned as examples. Services of general interest have been described by the European Commission as *"activities of commercial service fulfilling missions of general interest, and subject consequently by the member states to specific obligations of public service. It is the case in particular of services in transport, energy, communication networks"*. Also the reason must be genuinely overriding and therefore must be also a long-term interest. The NNPP would, based on what is said above, seem to fulfil the qualifications for this imperative overriding reason as the effects on global warming can be interpreted to be beneficial and energy production is essential for Lithuania's economy as well as local economy and society. The outlet and inlet solutions as well as cooling systems can be selected so that a least damaging situation is reached meaning that for NATURA values (as well as many other biodiversity values) it is important that the lake water temperature would remain at the present level. Unless the mitigation measures and application of other safeguards is not sufficient, compensatory measures must be considered. The compensatory measures adopted must always be communicated to the European Commission (*European Commission, 2007*).

An impact assessment (see Section 7.6.2) analysis shows that negative impact of the NNPP should be minimised for three designation values. If Site 2 will be selected for construction of the NNPP, mitigation measures should be implemented for European otter (*Lutra lutra*) and for Marsh Harrier (*Circus aeruginosus*; see Table 7.6–25). In order to assure (enforcing the precautionary principle) the FSC of these two species, it is recommended to establish a buffer zone on the lake shore to be managed out of development. The zone would decrease a negative effect of disturbance of the species and would be used as a migration and dispersal corridor for European otter (*Lutra lutra*) and many other species ecologically related to the lake ecosystem.

Noisy construction work impact can be minimised if it is not performed in the main breeding period of the designation species. The main breeding period of the Marsh Harrier (*Circus aeruginosus*) in Lithuania lasts from April to the end of June.

Table 7.6–25. NNPP negative impact mitigation measures for the designation values in the proposed construction Site 2.*

DESIGNATION VALUES	Noise and vibration	Direct cons-truction	Mitigation measures
European otter (*Lutra lutra*)	x	x	Moving proposed Site 2 a minimum of 200 m from the Lake Druksiai shore (to the south) would form a buffer zone between the NNPP (as disturbance source for animals) and the lake shore, as an ecologically very important area – a migration corridor for various animals, especially for the European otter (*Lutra lutra*). The buffer zone should be out of urbanization and development. It should remain as natural as possible. Forming the buffer zone of Site 2 would decrease the effect of noise and vibration on important nearest habitat of the European otter (*Lutra lutra*) in the lake. The measure would allow maintaining FCS of the species because the main migration and dispersal corridor of the species (as well as of many other animal species, ecologically related to the lake ecosystem), would be secured in long-term.
Marsh Harrier (*Circus aeruginosus*)	x(20%)	x(20%)	Moving proposed Site 2 a minimum of 200 m from the Lake Druksiai shore (to the south) would form a buffer zone between the NNPP (as disturbance source for animals) and the lake shore. Performing loud construction works outside the main breeding period of the species (April – June) would diminish noise and vibration disturbance towards the species thus saving favourable conservation status of one pair (roughly about 20 % of the total population) breeding close to the proposed second construction site.

* Definitions and symbols are as in Table 7.6–23.

If Site No. 1 will be selected for construction of the NNPP, mitigation measures should be focused on Marsh Harrier (*Circus aeruginosus*) and Spotted Crake (*Porzana porzana*) which have been registered here. They are considered as nearest designation values breeding on the lake shore wetland and in the reedbed. In order to maintain FSC of these two species it is recommended to establish a buffer zone on the lake shore to be managed out of development (Table 7.6–26). The zone would decrease a negative impact of disturbance of the species and would be used as a migration and dispersal corridor for European otter (*Lutra lutra*) and many other species ecologically related to the lake ecosystem. Most of the area to the east from Site No. 1 and potentially suitable as a buffer zone is already narrower than 200 m. Nevertheless, this migration corridor is recommended and beneficial for various animal species considered.

Loud construction works are recommended to be carried out outside the main breeding period. Main breeding period of the Marsh Harrier (*Circus aeruginosus*) in Lithuania lasts from April until late June, and Spotted Crake (*Porzana porzana*) breeds from early May to late June.

Table 7.6–26. NNPP negative impact mitigation measures for the designation values in the proposed construction Site No. 1.*

DESIGNATION VALUES	Noise and vibration	Direct cons-truction	Mitigation measures
Marsh Harrier (*Circus aeruginosus*) Spotted Crake (*Porzana porzana)*	x(20%) x(20%)	x(20%) x(20%)	If the proposed Site No. 1 would be selected for construction of the NNPP, it is recommended to save the existing buffer zone between the channel and the lake. The buffer zone is recommended to remain as natural (present state) as possible. Loud construction works are recommended to be carried out outside the main breeding period of these species (breeding period of the Marsh Harrier (*Circus aeruginosus*) in Lithuania: April – June; of the Spotted Crake (*Porzana porzana*): May – June). This mitigation measure would separate the NNPP (source of the disturbance), and the nearest habitats of the Marsh Harrier (*Circus aeruginosus*) as well as the Spotted Crake (*Porzana porzana*), and decrease a negative impact of noise and vibration. It would most probably ensure the successful breeding of the pairs located not far from the proposed Site No. 1.

* Definitions and symbols are as in Table 7.6–23.

Independently of which site will be selected for construction of the NNPP, it is recommended to minimise potential negative impacts of the NNPP for European otter (*Lutra lutra*). In order to assure (enforcing the precautionary principle) the FCS of the species, it is suggested to take special measures in the buffer zone of the NNPP. As it was described above, it is recommended to manage the zone out of development. It is assumed that the zone would decrease a negative effect of disturbance of the species and would be used by European otter (*Lutra lutra*) and also by other species ecologically related with the lake ecosystem as a migration and dispersal corridor.

It could be that due to unnaturally high water temperature the cooling water discharge channel of the NNPP is an obstacle for the otter (*Lutra lutra*) and other terrestrial animals when using their migration corridor (the buffer zone). This means that the FCS of the European otter (*Lutra lutra*) in the area close to the INPP may even now not be assured, and it would not be assured in the future, after the NNPP would have been constructed. The status of the FCS of the otter is today not known as there is no data about population trend of the species at all. In order to re-establish the blocked migration corridor for the otter (*Lutra lutra*) it is recommended that a closed "bridge" (like a water-pipe of a rather great diameter) is constructed to be placed on the very shore of the lake across the channel. The western border of the buffer zone/otter migration corridor next to the NNPP and to the cooling water discharge channel should be fenced. Fences will direct the migrating mammals to the shore and to the "bridge".

It is well known that otters are using underground openings when crossing highways or roads. In many European countries there is a good practice when protecting otters where their migration roots and human roads cross. Similar experience could be applied when constructing the NNPP in Lithuania.

7.6.3.2 Other issues

It is recommended that negative impact of the NNPP would be minimised for also other biodiversity values next to Natura 2000 designation values. If Site No. 2 will be selected for construction of the NNPP, mitigation measures are recommended to be focused on European fire-bellied toad (*Bombina bombina*) and on great crested newt (*Triturus cristatus*) (Table 7.6–27).

The total colony is recommended to be protected since all the birds in the colony are ecologically related. If necessary, some populations (e.g. Cormorant (*Phalacrocorax carbo*)) could be controlled.

The only possible mitigation measure towards the Tawny Pipit within the construction site of the new nuclear power plant would be constructing new wasteland areas within the vicinity of the construction area. However, considering the undoubted negative effects towards other values of biodiversity and the general insignificance of this one pair resident in the area, this mitigation measure can not be recommended. Moreover, the site area can not be regarded as best possible habitat for the species in any case.

Table 7.6–27. NNPP negative impact mitigation measures for the biodiversity Habitat Directive annex IV species and a valuable bird colony.*

DESIGNATION VALUES/ PROPOSED SITES FOR CONSTRUCTION	Traffic	Direct construction	Mitigation measures
European fire-bellied toad (*Bombina bombina*) Proposed construction Sites No. 1 or No. 2 Great crested newt (*Triturus cristatus*). Proposed construction	x	x	In relation with new construction activities traffic in the NNPP area and its surroundings would increase. Therefore it is recommended to minimize significantly the risk of the European fire-bellied toad (*Bombina bombina*) and great crested newt (*Triturus cristatus*) to be run over by road traffic on existing and new roads. A species management plan is recommended to be prepared, and it is recommended to be confirmed and implemented by the project developer of the NNPP. Detailed studies of ecology of the species in selected construction site and its immediate vicinity are recommended. This should include mapping breeding habitats, wintering sites, main migration

DESIGNATION VALUES/ PROPOSED SITES FOR CONS-TRUCTION	**Traffic**	**Direct const-ruction**	**Mitigation measures**
Site No. 2.			and dispersal routes. Based on this data it is possible to get adequate data on the species. In the management plan should be indicated: - ranges where roadsides are to be blocked (fence) in order to prevent crossing of the road by those amphibians; - sites where special animal migration underground openings (if necessary; co-ordinating with water management measures; to be used not only by European fire-bellied toad (*Bombina bombina*) but also by other amphibians, small mammals (including even single individuals of the European otter (*Lutra lutra*), etc.); - wintering sites to be saved or/and created; - small breeding waterbodies to be saved and/or created., etc. The management plan should be integrated into right development and construction plans and implemented together with the NNPP construction works.
A mixed colony of Cormorant (*Phalacrocorax carbo*), Grey Heron (*Ardea cinerea*) and of Great White Egret (*Egretta alba*). Proposed construction Sites No. 1 or No. 2	-	x	A possible risk that when constructing the NNPP the colony would be damaged due to very likely visits of people and local recreation. Territory of the colony and rest part of the peninsula is recommended to be included into above mentioned buffer zone between the NNPP and Lake Druksiai. The main goal of the buffer zone should be securing the long-term functioning of migration and dispersion of the terrestrial and semi-terrestrial animals (including European otter (*Lutra lutra*)) on the lake shore and protection of breeding habitats of other valuable species. The buffer zone should be closed for visitors but open for terrestrial species moving along the lake shore.

* Definitions and symbols are as in Table 7.6–23.

Concerning all the species which are listed in the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora annex IV (a) the following regulations are valid:

- Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV (a) in their natural range, prohibiting:

  (a) all forms of deliberate capture or killing of specimens of these species in the wild;
  (b) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;
  (c) deliberate destruction or taking of eggs from the wild;
  (d) deterioration or destruction of breeding sites or resting places.

The prohibition referred to in (a) and (b) shall apply to all stages of life of the animals to which Article 12 applies.
(Extract of relevant issues concerning the NNPP from *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, Article 12*)

- Provided that there is no satisfactory alternative and the derogation is not detrimental to the maintenance of the populations of the species concerned at a favourable conservation status in their natural range, Member States may derogate from the provisions of Articles 12, 13, 14 and 15 (a) and (b):

  (a) in the interest of protecting wild fauna and flora and conserving natural habitats;
  (b) to prevent serious damage, in particular to crops, livestock, forests, fisheries and water and other types of property;
  (c) in the interests of public health and public safety, or for other imperative reasons of overriding public interest, including those of a social or economic nature and beneficial consequences of primary importance for the environment;
  (d) for the purpose of research and education, of repopulating and re-introducing these species and for the breedings operations necessary for these purposes, including the artificial propagation of plants;
  (e) to allow, under strictly supervised conditions, on a selective basis and to a limited extent, the taking or keeping of certain specimens of the species listed in Annex IV in limited numbers specified by the competent national authorities.

Member States shall forward to the Commission every two years a report in accordance with the format established by the Committee on the above mentioned derogations applied.

(Extract of relevant issues concerning the NNPP from *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora,* Article 16.

7.7 Landscape and land use

7.7.1 Present state of the environment

The proposed new NPP will be constructed and operated within the INPP industrial area. The landscape of the sites is industrial and is characterized by power production units and buildings connected to power production operation (ancillary facilities, operative spent fuel storage facility, household wastewater treatment plant, ducts for the district heating system of Visaginas and the electricity transmission lines), see Figure 7.7-1. The most visible part of the existing power plant is the ventilation stacks.

Figure 7.7-1. Present landscape of the INPP industrial area and NNPP sites.

The landscape around the nuclear power plant is mainly composed of forests and wetlands. Residential areas consist of small villages with traditional houses. Lake Druksiai is a major natural landscape element with associated activities (fishing, recreational use).

The landscape of the Lake Druksiai watershed is characterised by a relief formed during glacial periods, consisting of picturesque mountain ridges, ravines, lakes, and plains as well as by pine forests and vast water meadows (Figure 7.7-2) (*Pauliukevicius G. et al., 1997*).

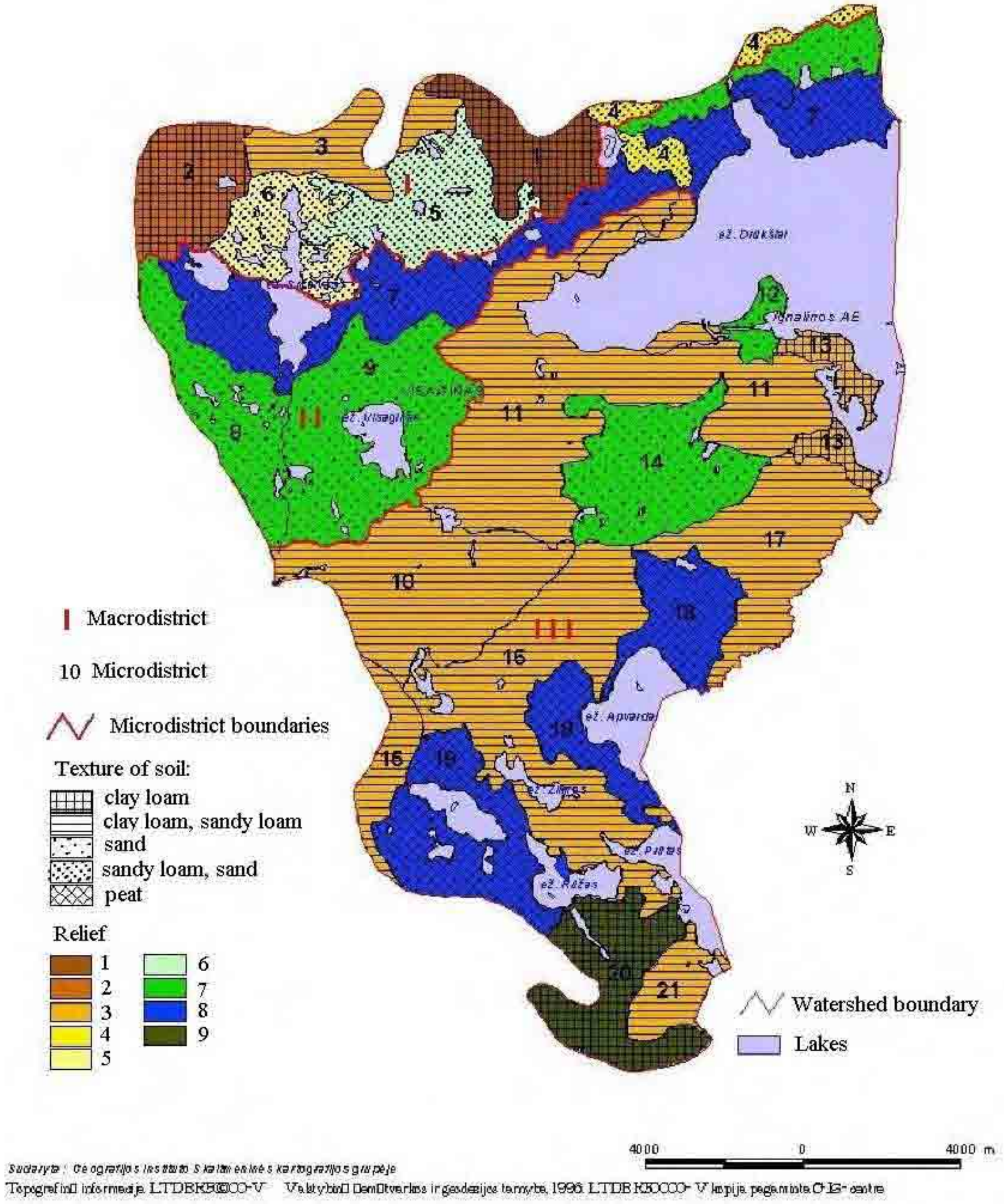


Figure 7.7-2. Landscape types in the Lake Druksiai watershed (*Pauliukevicius G. et al., 1997*).

The most valuable landscape areas are located far away from the new NPP. Smalvos hydrological reserve, Smalvos landscape reserve and Tilzes geomorphological reserve are protected territories within a radius of 10 km from the new NPP (see Figure 7.8-1 in the next Section 7.8). Pusnies protected territory is located about 13 km from the new NPP sites. Grazutes Regional Park is located about 15 kilometres from the proposed site alternatives for the new NPP.

Grazutes Regional Park covers 29 471 hectares and is aimed at preserving the landscape of the Sventoji river basin with its lakes, forests, its natural ecosystem as well as the cultural heritage values, maintaining them and rationally using them. Pine forests (72 %) and birch forests (17 %) prevail in the Park. The average forest age is 65 years.

The Smalvos protected hydrographical territory also presents landscape values with its undulated relief and particular ecological formations.

7.7.2 Assessment of impacts on landscape and land use

The landscape in the Lake Druksiai watershed has degraded because of the building and operation of INPP, Visaginas town and related infrastructure. According to the State Research (*Pauliukevicius G. et al., 1997*), it was determined that 1.43 % of the watershed (not taking the lake into account) was damaged irreversibly. There are abandoned farming lands (1.56 %) and a reduction of the forest area (3.83 %). Figure 7.7-3 illustrates damages to the initial landscape in the lake Druksiai watershed.

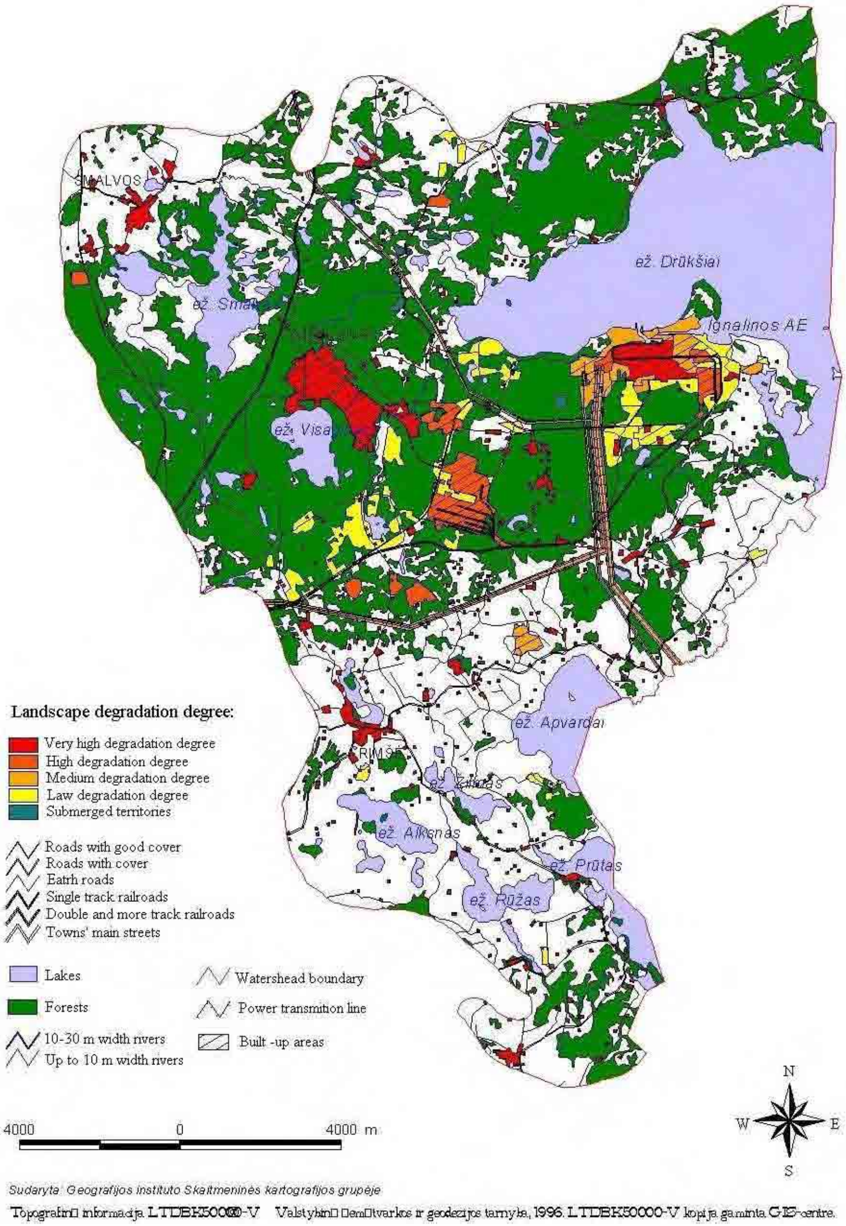


Figure 7.7-3. Landscape degradation degree in the Lake Druksiai watershed (*Pauliukevicius G. et al., 1997*).

The ratio between the natural and semi-natural territories and technogenic-urbanized areas in the Lake Druksiai watershed is 21.4. Natural and semi-natural areas also prevail in the whole 30 km area around the INPP. Though the building of INPP and Visaginas town has considerably (twice) reduced this ratio, it remains a few times higher than elsewhere in Lithuania (7.9) (Utena county – 10.6, Ignalina district – 10.9). Thus, it may be concluded that the Lake Druksiai watershed is predominated by comparatively natural and poorly culturalized landscape with a hotbed of intensive technogenization. The mentioned ratio is changing in the territory of Visaginas and INPP due to deserted farmlands and renaturalization of recultivated areas (*Environmental Impact Assessment Report U1DP0, 2007*).

The shores of Lake Druksiai are predominantly forested, thus significantly reducing the view over the lake from near-shore areas. There are only a few points where larger amounts of people occur by the lake shore. The view from two such points has been presented in photomontages prepared. Additionally photomontages using the aerial photograph of Figure 7.7-1 have been prepared. The photomontages show the landscape after the new nuclear power plant has been built. Photomontages for two units and two units with cooling towers at site 1 and site 2 are presented in this EIA Report as these represent the greatest impact on landscape. The viewing points for ground-level photomontages are presented in Figure 7.7-4. From Viewpoint 2 the NNPP at Site 2 will not be visible. The photomontage pictures showing the impact of the NNPP on existing landscape are presented in Figure 7.7-5 to Figure 7.7-14.

The natural draft type wet cooling towers are shown in the photomontage pictures. Estimated diameter for a natural draft wet cooling tower capable for cooling 850 MW (electrical energy) plant is approximately 120 meters - respectively 1700 MW power plant demands two cooling towers of this size. Their estimated height is 150 m. Especially in cool and moist climate conditions a visible plume is formed above the tower due to saturation of the exiting air. These cooling towers represent the greatest impact on landscape, since forced draft type wet cooling towers are significantly smaller in size.

Figure 7.7-4. Location of viewing points in ground-level photomontages.

Figure 7.7-5. Aerial photograph – Site 1 with two NNPP units.

Figure 7.7-6. Aerial photograph – Site 1 with two NNPP units and cooling towers.

Figure 7.7-7. View 1 – Site 1 with two NNPP units.

Figure 7.7-8. View 1 – Site 1 with two NNPP units and cooling towers.

Figure 7.7-9. View 2 – Site 1 with two NNPP units.

Figure 7.7-10. View 2 – Site 1 with two NNPP units and cooling towers.

Figure 7.7-11. Aerial photograph – Site 2 with two NNPP units.

Figure 7.7-12. Aerial photograph – Site 2 with two NNPP units and cooling towers.

Figure 7.7-13. View 1 – Site 2 with two NNPP units.

Figure 7.7-14. View 1 – Site 2 with two NNPP units and cooling towers.

The following conclusion can be made: construction of the new NPP near the INPP will produce no greater effect of landscape degradation and will not disrupt the ratio between the natural and anthropogenic territories. Only at a few places by the lake shore will the NNPP be visible to larger amounts of people. The impacts on landscape will therefore not be significant.

7.7.3 Mitigation measures

Landscaping, selection of proper design, materials and construction types and planting of greenery will be used to enhance the appearance of the new NPP.

During the necessary improvement and possible restoration of the road network in the new NPP region, road culverts will be repaired or additionally installed were necessary. Therefore the existing flooded areas will be drained and restored to forest or agriculture.

7.8 Cultural heritage

7.8.1 Present state of the environment

The following territories are protected inside a radius of 10 km from the new NPP: Smalvos hydrological reserve, Smalvos landscape reserve and Tilzes geomorphological reserve (Figure 7.8-1). Pusnies protected territory is located about 13 km from the new NPP.

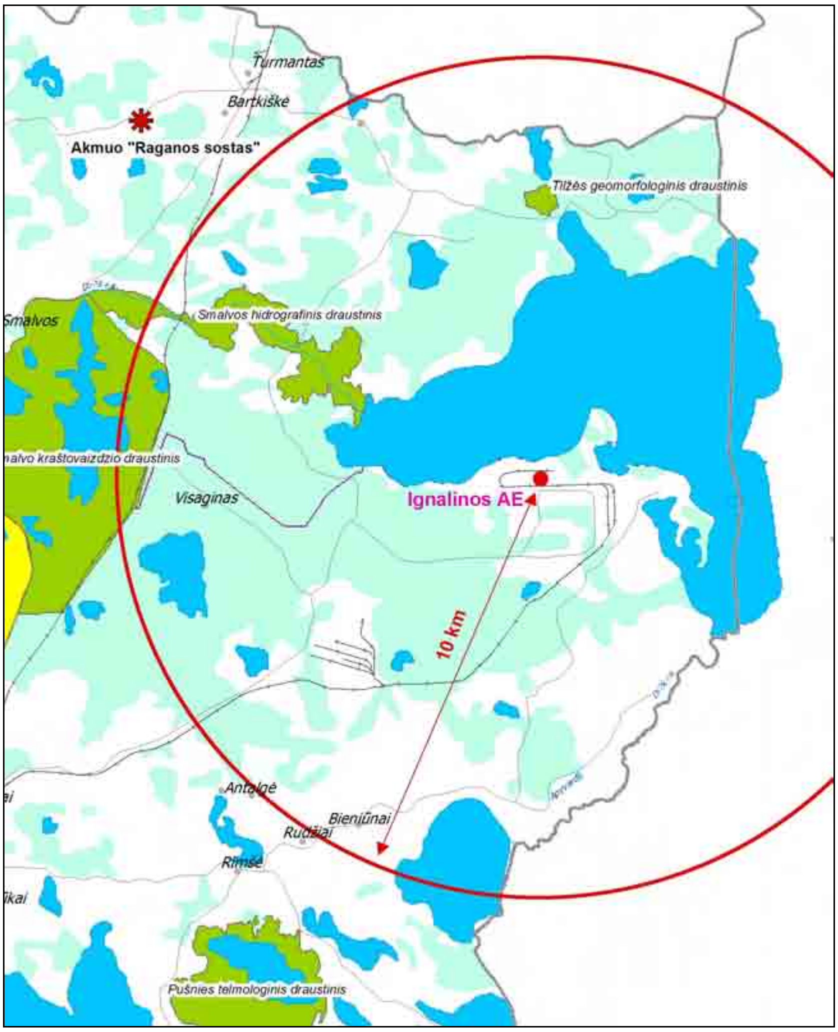


Figure 7.8-1. Protected territories (indicated in green) at a distance of 10 km from the new NPP.

There are seven cultural heritage sites in the vicinity of the new NPP: Petriskes settlement antiquities I, Petriskes mound, Petriskes settlement antiquities II, Grikiniskes settlement antiquities III, Grikiniskes settlement antiquities II, Grikiniskes settlement antiquities I and Stabatiskes manor site (Figure 7.8-2).

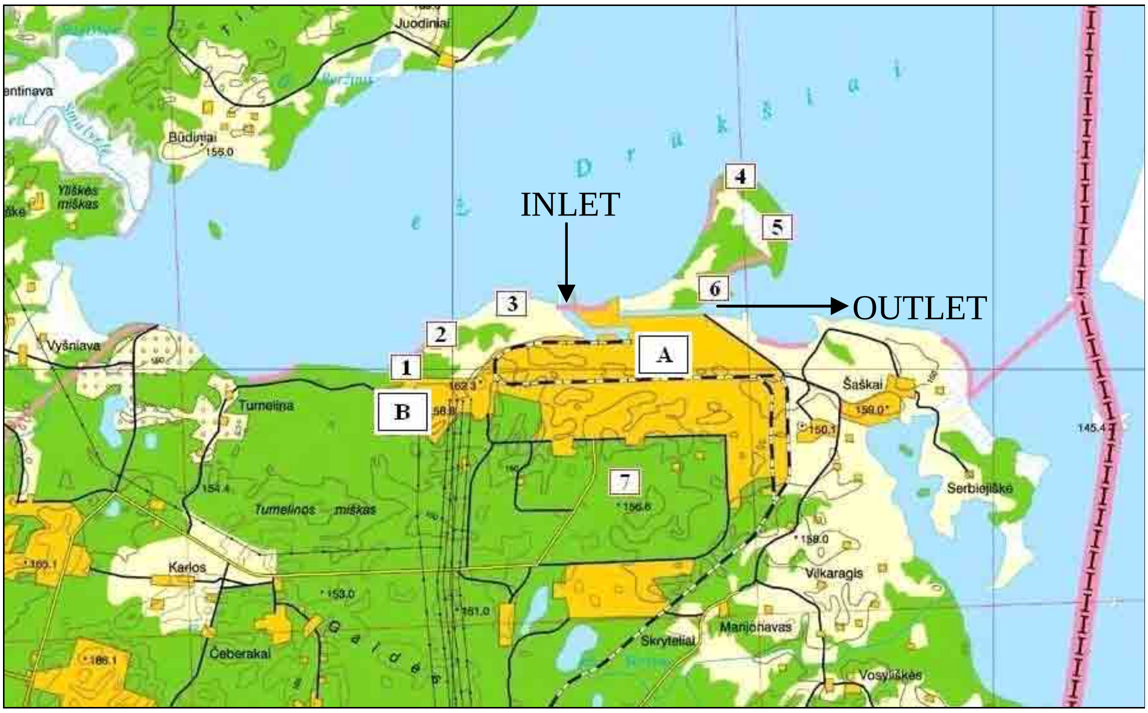


Figure 7.8-2. Cultural heritage sites in the vicinity of the new NPP sites A and B: 1 – Petriskes settlement antiquities I; 2- Petriskes mound; 3 – Petriskes settlement antiquities II; 4 – Grikiniskes settlement antiquities III; 5 – Grikiniskes settlement antiquities II; 6 – Grikiniskes settlement antiquities I; 7 – Stabatiskes manor site.

The distance from Stabatiskes site for the planned INPP near surface repository for low and intermediate level radioactive waste to Lake Druksiai is about 2 km. The INPP industrial area separates the site from the lake (see Figure 7.8-2). In June 2006 on Stabatiskes site during exploratory archaeological investigations a destroyed Stabatiskes manor place (settlement) was found. During the investigation in the central part of the manor place a cultural layer (up to 0.5 m thick) with construction waste and individual ceramics, metal and bone findings was found. According to the primary data the territory of the former manor place covers an area of about 1.95 ha (*EIA Report of the Near Surface Repository, 2007*). During the additional exploratory archaeological investigation in the territory of Stabatiskes manor place (settlement) cultural layers of two periods (the second half of the XV century – the XVI century and the second half of the XVIII century – the XX century) were discovered – 20–80 cm thick layer of soil and clay loam with construction and household ceramics, metal, glass, osteologic archaeological findings (*Working Report of the Society of Lithuanian Archaeology, 2006*). It was found that this was the residues of a homestead that existed in the second half of the XV century – the XVI century. In the XVII century people did not live here anymore.

From the end of the XVIII century to the middle of the XIX century Druksiai Manor changed hands, until finally it was gradually sold off. At the time Stabatiskes location was re-populated as well (the village was mentioned in written sources from the end of the XVIII century). A small manor was there. The investigation has clarified the territory of the object (*Working Report of the Society of Lithuanian Archaeology, 2006*). It occupies an area of 1.5 ha.

The surroundings of the site accommodate supposed or unidentified real heritage monuments. In most cases, they are natural hills that were called mounds by the local population. No long-lived cultural layer is found there. Adjacent to the site, there was Montvila manor place. Other past objects have been destroyed or damaged during the construction of the NPP and its infrastructure, some of them (barrows) – even before. Their restoration and reconstruction is not linked to the planned economic activity (*EIA Report of the Near Surface Repository, 2007*).

On some hills of the region, there are several mounds possibly used for timbered fortresses such as Rimses, Ceberaku, Pasamanes (so called Baznyciakalnis A1537) Svegzdziunu, Rapusiskiu etc. (*Pauliukevicius G. et al., 1997*). These mounds and other cultural heritage sites are located far from the new NPP sites.

7.8.2 Assessment of impacts on cultural heritage

During the construction of INPP, the area located within the boundaries of the plant underwent large excavation works and no outstanding elements of archaeological value were found.

The identified cultural heritage sites will not be affected by the new NPP construction as they are located outside the proposed sites. New access roads, the soil dump and other new infrastructure will not affect cultural values. There are no other sites of cultural heritage, ethnic or cultural values that could be negatively impacted by the new NPP.

7.8.3 Mitigation measures

Temporary construction and storage sites will be located away from cultural heritage sites.

During the additional exploratory archaeological investigations Stabatiskes manor place (village place) has been discovered. In case of the construction of the planned INPP near surface repository for low and intermediate level radioactive waste, the manor place would be destroyed (*EIA Report of the Near Surface Repository, 2007*). The following ways are proposed for impact mitigation (*Working Report of the Society of Lithuanian Archaeology, 2006*):

1. The technical parameters of the designed repository shall be changed so that Stabatiskes manor place (village place) would remain intact during the construction; in this case the eastern part of the repository could be increased instead of the western part of the site, leaving the territory of the manor place free. In this case, the free area of the site holds 50 vaults, but no reserve territory remains.

2. If the location of the construction and the work extent did not change, in this case a complete scientific archaeological survey of Stabatiskes manor place (village place) would be required. In this case it would be necessary to examine an area of 0.6 hectares (*Working Report of the Society of Lithuanian Archaeology, 2006*).

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7.9 SOCIO-ECONOMIC ENVIRONMENT

7.9.1 General information

The location of the new NPP (NNPP) will not substantially change the sanitary and monitoring zones or the concept of the boundaries of the region under consideration. For this reason, there is no need to include new territorial administrative subjects into the scope of the project. They should remain the same: the Ignalina district, Visaginas town and Zarasai district municipalities of the Republic of Lithuania, Daugavpils town and Daugavpils district municipalities of the Republic of Latvia and Braslav district municipalities of the Republic of Belarus. The NNPP localization will not virtually change the 30 km radius of monitoring zone. For this reason, the study of social impacts of NNPP in the Ignalina NPP region can be used as a territorial comparative basis.

For acquisition of new comparative data, an EIA model for subjects has been worked out (a special questionnaire has been handed out to local governmental institutions, largest enterprises, administrations of preserved territories, and other institutions; the data has been collected and generalized).

It should be pointed out that only parts of the territories of all territorial administrative units (except the Visaginas municipality) are included in the 30 km radius of monitoring zone. The sanitary protection zone of the NNPP will not be larger than the existing INPP sanitary protection zone with a 3 km radius, and will thus be located within the limits of Visaginas municipality.

7.9.1.1 Population and demography

The economic activity is planned to be performed in a sparsely populated territory of a transborder zone of long-lasting depopulation. The following major aspects of population distribution and demographic processes should be pointed out:

- The region is predominated by very small (1–10 residents) settlements (about 17 % of formal settlements in the Lithuanian segment are settlements without permanent residents); the local rural Rimse administrative unit is marked by the lowest relative portion of children up to 15 years of age in Lithuania;
- The Lithuanian segment includes three towns with a population from 900 to 29 000 people and about 12 settlements with a population between 200 and 900. The Latvian segment includes the southern part of Daugavpils town, 4 settlements with a population over 1000 and 19 settlements with a population between 100 and 1000. In the Belarusian segment, about 10 settlements have populations of more than 100 each. The regional centre Braslav is situated at the border of the monitoring zone (30 km);
- The number of non-permanent residents (i.e. land owners) from Daugavpils and Visaginas towns is increasing in the Lithuanian and Latvian segments. This phenomenon demonstrates rapid reduction of the isolation of Visaginas from the surrounding areas. In some territorial functional units (e.g. Rimse local rural administrative unit of Ignalina District), the numbers of registered permanent residents and non-permanent residents are comparable;
- A long-lasting depopulation of rural areas has been taking place in the all three segments of the NNPP region;
- The Lithuanian and Latvian segments include large settlements (Visaginas and Daugavpils towns) where after rapid depopulation in the last decade of the 20th

century the demographic situation stabilized and approached the average national values. The sub-regional centre Braslav of the Belarusian segment is of low demographic potential still showing signs of depopulation.

According to data for 2005 the total population of the new NPP region, which includes the municipality of Visaginas (59 km^2), Ignalina district (1 496 km^2) and the Zarasai district (1 334 km^2) was 71 700 (in Visaginas 28 700 people and in Ignalina and Zarasai districts 21 400 and 21 600 people, respectively). Even if the NNPP region comprises 4.3 % of Lithuanian territory the population number is only about 2 % of the total Lithuanian population. Therefore, the NNPP region is a rather sparsely populated region of the Lithuania. During recent years, a decrease of population in the new NPP region has been observed. From 1999 to 2005 the total population of the region has decreased by 11 500 (~14 %) The information about the main demographic indicators and population distribution in the region within a radius of 30 km is presented in Table 7.9–1, Table 7.9–2 and Figure 7.9-1.

Inhabitants, living in the territories of Latvia and Belarus, which fall inside the 30 km radius zone around the INPP have been taken into account (Figure 7.9-1). Within a 30 km radius the density of population is about 48 people per km^2. This is lower than the average density of population in Lithuania (56.7 people per km^2). In fact, population density in the new NPP region is one of the lowest in Lithuania.

Within the current sanitary protection zone of INPP (radius = 3 km) there are neither farms nor settlements. Also economic activities are restricted (see Figure 7.9-2). The closest town is Visaginas, which is situated 8 km from the nuclear power plant.

Table 7.9–1. Demographic indicators of Ignalina NPP region in 2005.

Factor	Ignalina district	Zarasai district	Visaginas	INPP region
% of population < 15 years	14.58	15.81	12.70	14.36
% of population 15-44 years	34.83	36.66	48.75	40.08
% of population 45-64 years	24.62	23.92	28.74	25.76
% of population >=65 years	23.45	20.85	7.35	17.22
% of population >=75 years	10.23	9.46	1.87	7.19
Birth rate per 1000 pop.	7.45	8.49	8.16	8.03
Death rate per 1000 pop.	22.46	20.22	6.73	16.47
Natural increase per 1000 pop.	-15.04	-11.73	1.45	-8.44

Table 7.9–2. Estimated population distribution (thousands) in 2005.

Radius of circle	N	NE	E	SE	S	SW	W	NW	Amount of inhabitants	
									in the ring	cumulative within the radius
30 km	33.5	0.7	7.6	1.2	1.5	2.1	2.0	0.8	49.3	116.9
25 km	1.2	0.9	2.2	2.2	4.0	1.4	1.2	7.5	20.6	67.6
20 km	0.4	0.3	1.2	1.1	1.1	2.5	0.8	0.6	8.1	47.0
15 km	0.5	0.7	0.9	0.8	0.8	1.1	0.3	0.9	5.9	38.9
10 km	0.4	0.5	0.6	0.4	0.9	0.4	29.2	0.3	32.8	33.0
5 km	-	-	-	-	0.1	-	-	0.1	0.2	0.2
3 km	-	-	-	-	-	-	-	-	-	-
Total in the segment	36.0	3.2	12.4	5.8	8.4	7.5	33.5	10.1	Total 116.9	

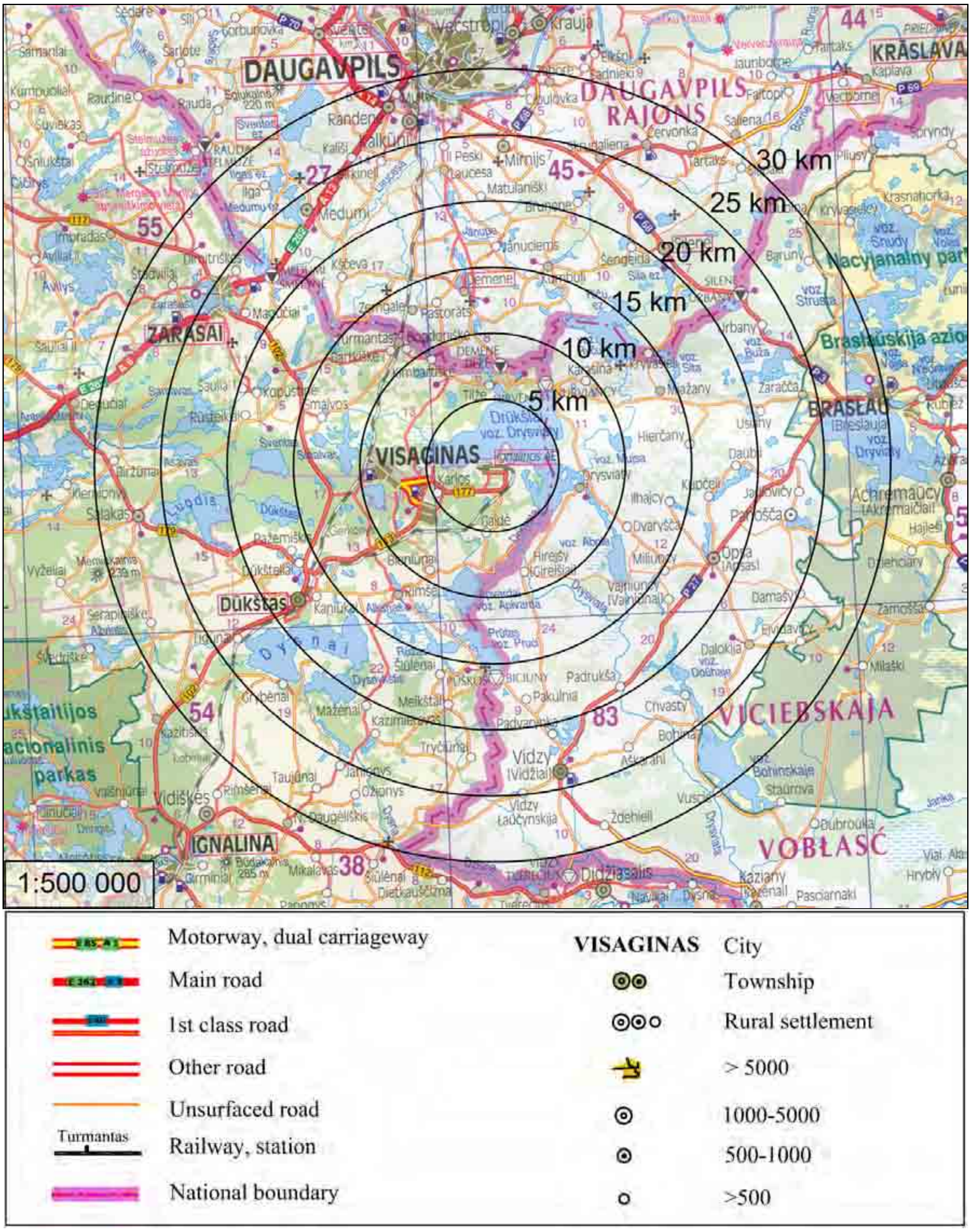


Figure 7.9-1. Population distribution within 5, 10, 15, 20, 25 and 30 km radiuses around the new NPP.

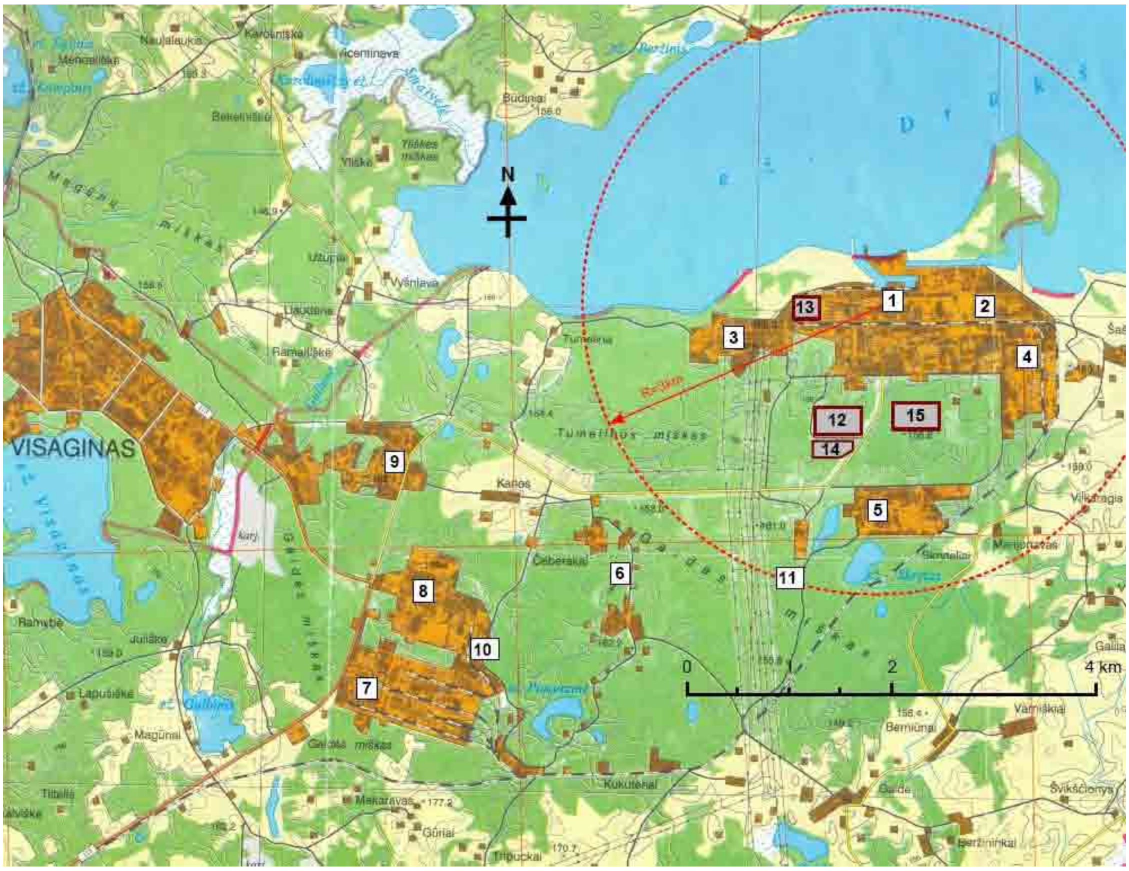


Figure 7.9-2. Existing sanitary protection zone of the INPP and facilities in the vicinity; 1 – Power Units, 2 – existing Spent Nuclear Fuel Storage Facility, 3 – open distributive system, 4 – supply base, 5 – sewage purification constructions, motor transport department, 6 – Visaginas waterworks (city artisan well site), 7 – construction base, 8 – industrial construction base, 9 – military base, health clinic, 10 – heat boiler station, 11 – Visaginas dump site, 12 – SWTSF and ISFSF site, 13 – SWRF site; 14 – site of the planned very low level radioactive waste near surface disposal facility, 15 – site of the planned low and intermediate level short-lived radioactive waste near surface disposal facility. The existing sanitary protection zone of INPP within a 3 km radius is also indicated.

7.9.1.2 Economic activities

From the economic point of view the new NPP region, except for the town of Visaginas, is a less developed region in Lithuania. Agriculture and forestry of low intensity dominate in the region. For example the intensity of cattle breeding is about 1.4 times lower than on the average in Lithuania. No important minerals with the exception of quartz sand are found in the region. The turnover of the retail trade in the region is 1.5, and the volume of services is more than 2.5 times lower than on the average in the country.

The town of Visaginas has an urban type labour force, which means a younger age structure (residents under 41 years of age is 67 %), more educated people and greater variety of professional training. Ignalina and Zarasai districts have a rural type labour force, which means an older age structure, lower education and a small variety of professional training. The number of people in working age is 66 % of population (22 200 people) in Visaginas, 52 % in Ignalina district (12 900 people) and 53 % in Zarasai district (13 000 people). Visaginas' unemployment rate is a bit higher than the average unemployment level in Lithuania.

There are 980 employers in the region (including public institutions), of which about 700 are small to medium sized enterprises with have less than 250 workers.

Main features of the economy in the region under consideration can be described as follows:

- According to the employment of population service sector, industry and energetics are the main economic activities – the majority of residents are employed there. However the most important activities from the land use point of view are extensive agriculture, forestry and development of rural tourism and ecological agriculture;
- The economy in Visaginas, which previously was a very narrowly specialized town, is becoming more and more diverse. The relations with the surrounding region and rest of the country are continuously increasing and most of Visaginas economy is now not based on INPP;
- The region and surroundings are more and more intensively used for recreation and tourism, which is starting to play one of the key roles in its economy.

It is expected that the most important impact on business expectations in this region in the context of construction of the new NPP can be caused by these factors:

- The decommissioning of the INPP and as a consequence:
  - The drop of employment in the town of Visaginas;
  - The decrease of purchasing power of the population and drop of demand for goods and services in the town of Visaginas;
  - The increase of electricity prices;
  - The demand for services and labour force needed for the process of decommissioning of Ignalina NPP;
- The construction of the new NPP and demand for goods, services and labour force related to this;
- EU support for rural and regional development and international collaboration;
- Peripheral location of the region in the conjunction of borders of three states, far from main economic centres;
- Further expansion of business relations with Latvia related to decreasing limiting impact of state borders.

The questionnaires of targeted requests were delivered to foreign subjects: to eight Latvian local municipalities, municipalities of Daugavpils region and Daugavpils town, Belarus Braslav region council, Braslav national park and other foreign institutions, which can possibly be interested in the NNPP region.

7.9.1.3 Traffic and noise

The nearest motorway passes 12 km to the west of the new NPP location. This motorway joins the city of Ignalina with those of Zarasai and Dukstas, and has an exit to the highway connecting Kaunas and St. Petersburg. The entrance of the main road from the new NPP sites to the motorway is near the town of Dukstas (Figure 7.9-3). There is another exit to Vilnius–Zarasai motorway. The length of the road from the new NPP to Dukstas is about 20 km.

The main railroad from Vilnius to St. Petersburg passes 9 km to the west of the new NPP location (Figure 7.9-3).

Figure 7.9-3. Road and railway network.

There are 3 zones where flights are prohibited in Lithuania, one of which is the territory 10 km around INPP (Figure 7.9-4).

There are about 30 000 flights per year (in 2005) from Vilnius airport, which is located 130 km from new NPP sites. About 125 000 airplanes per year cross the Lithuanian air space. Altogether 30 airports of civil, military and mixed purpose are located in the country.

The number of aircrafts that passed the Vilnius Flight Information Region in 2000–2005 is presented in Figure 7.9-5.

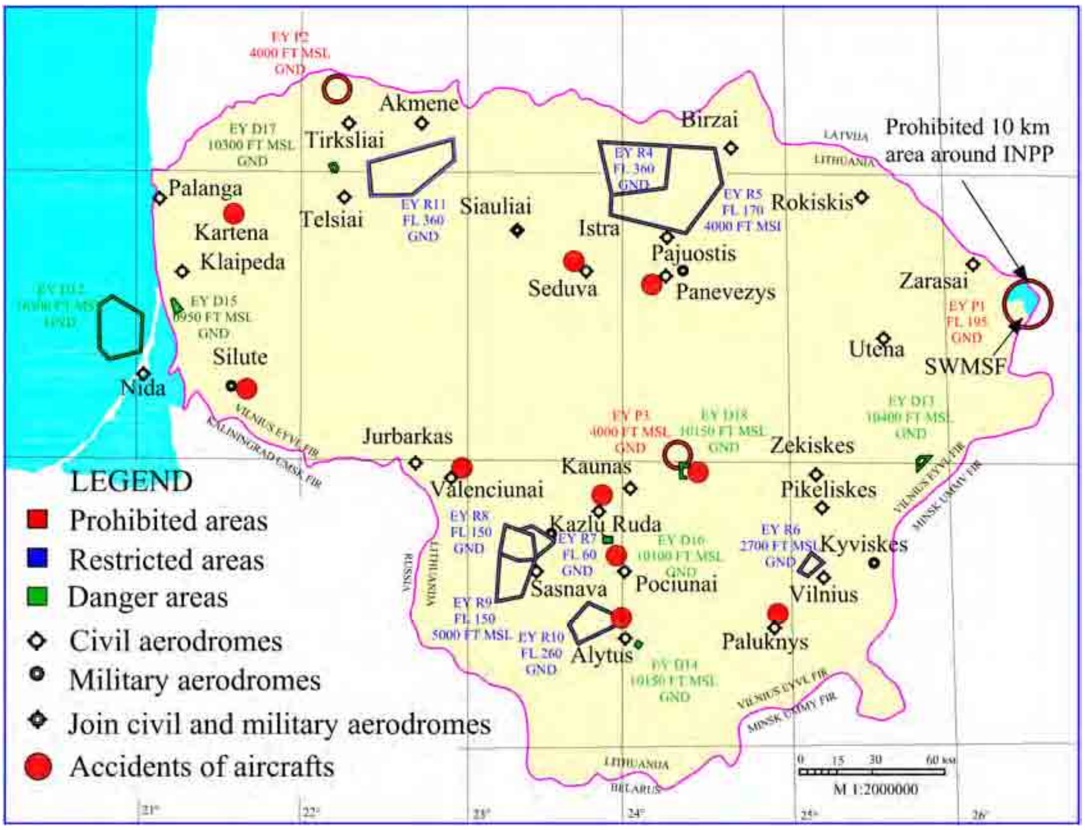


Figure 7.9-4. Airports, forbidden, restricted and dangerous areas in Lithuania.

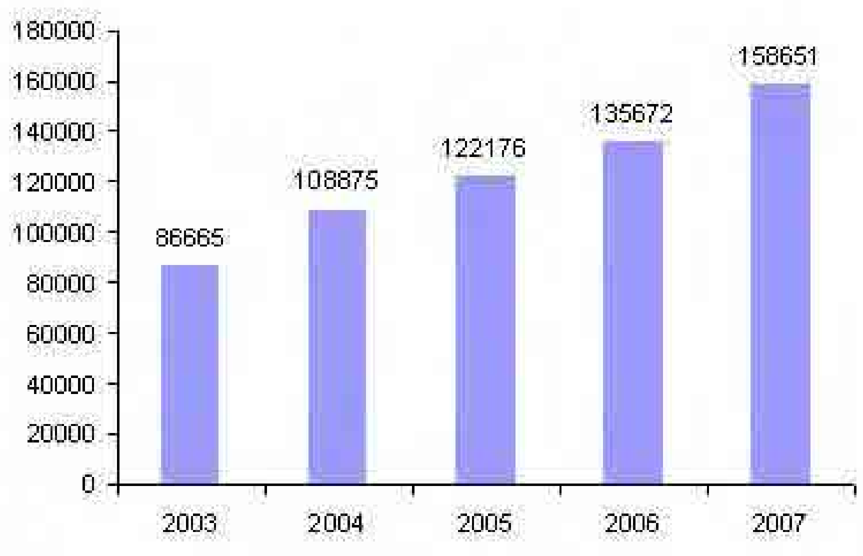


Figure 7.9-5. The number of aircrafts that passed the Vilnius Flight Information Region in 2003–2007 (*www.caa.lt*).

7.9.1.4 Noise and vibrations

The sources of highest noise levels at an NNPP include steam ejection equipment, turbine generators, steam collectors and feeding and condenser pumps. Individual workstations with noise levels above the norms may also be found in auxiliary facilities. The noise modelling results, presented in next Section 7.10, indicate that the noise level will not exceed 55 dB during normal operation outside the immediate vicinity of the NNPP.

7.9.1.5 Existing staff prequalification and utilization possibilities

According to the information provided by potential suppliers and the experience of the EIA Consortium, the average number of staff required to operate all units of a new NPP is about 500 people. The exact number depends on the final organization and it will be determined when the decision on the type of plant has been taken. As soon as the organization becomes clear the individual functions within the structure are given. Each function requires an appropriate qualification, which can be acquired by defined training within the necessary time.

The following charts show the age structure of the existing INPP personnel by May 2008. General age structure of existing INPP personnel is presented in Figure 7.9-6.

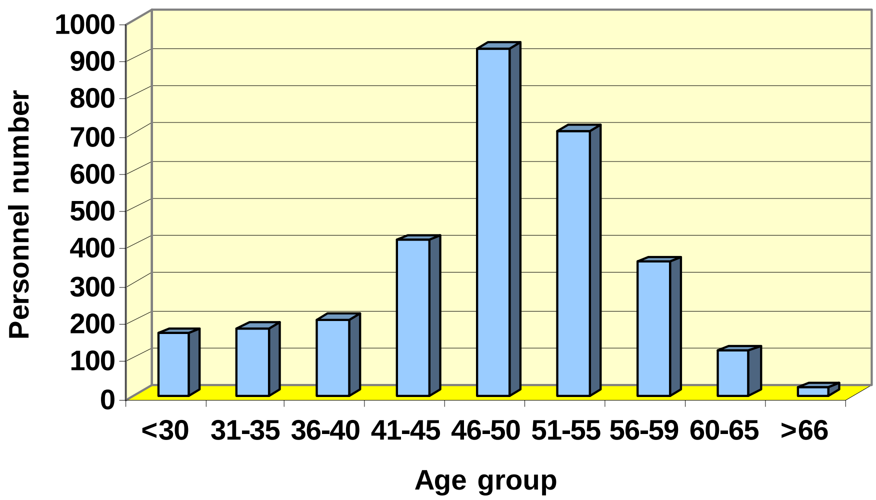


Figure 7.9-6. General age structure of existing INPP personnel.

The new NPP will most likely start commercial operation between 2015 and 2020, as it will take 7 to 12 years from now for designing, constructing, commissioning, licensing, testing and start-up. The official age for retirement in Lithuania is 62.5 for men and 60 for women. Therefore, almost all existing personnel of age 46 and older will have retired by the time the new NPP is commissioned.

Assuming that trained personnel should be able to work for at least another 5 years before retiring, this leaves about 500 people younger than 41 year (see Figure 7.9-6), who have to be examined in relation to actual position, education, training and qualification in order to decide who could be transferred to the new organization and under which prerequisites (additional education, training, retraining and other qualification programs). It is too early for detailed statements about this, but some information on existing personnel structure is presented in Figure 7.9-7.

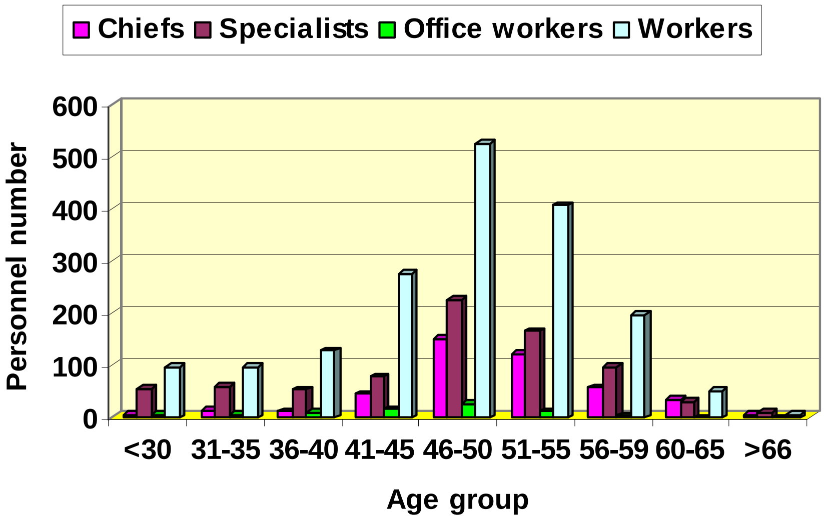


Figure 7.9-7. Personnel structure in different age groups of INPP staff in 2008.

7.9.2 Assessment of impacts on socioeconomic environment

7.9.2.1 Population and demographic processes

The preliminary observations in terms of labour force taking into consideration the planned economic activity are the following:

- The long-term demographic forecasts for the NNPP region (in the Lithuanian segment) have not come true: for the Utena County they were minus 5 % and for Visaginas city about minus 15 % and the depopulation rates exceeded the expected ones;
- The demographic situation in the cities of the region has been stabilizing whereas in rural areas it has been changing qualitatively and quantitatively: the number of owners of real estate rather than the number of residents increases. The factual density of rural population has been reducing in all territorial segments (Lithuania, Latvia and Belarus). In the cities, the population has stabilized;
- There are no premises for assumption that geodemographic processes in the Latvian and Belarusian segments follow another pattern because previous investigations have shown similar trends in these countries;
- Long-term (for 60 coming years as requested) demographic forecasts are formally not prepared on a regional level. They would require a special study;
- According to preliminary forecasts, the local resources of labour force are insufficient not only due to the scheduled scope and kind of works and demographic trends but also because diversification of economic activity and changes of lifestyles have taken place which have detracted part of the population from direct activities at the NPP. This is especially well reflected in the attitudes and expectations of the young residents of Ignalina NPP region;
- The potential of labour force in the Belarusian segment is small and prospectless due to the age structure. Participation in the first stages of construction and operation of the NNPP is also limited by political reasons;
- When evaluating the resources of labour force it is necessary to take into account the plans of the Republic of Latvia to build a large oil processing plant, waste handling

and other industrial enterprises in the monitoring zone of 30 km in radius. They may become a highly requested labour market for the regional population, in the Latvian segment in particular.

7.9.2.2 Economic activities

In a small country, the shutdown of a large NPP means a major reduction in the national electricity supply capacity, leading to higher prices, lower exports or higher imports with consequent implications for the national economy. Such situation increases the pressure to replace lost generation from a site by other nuclear means. The existing infrastructure and workforce make this particularly attractive, and such investment is likely to reduce the socioeconomic impacts of the shutdown of INPP.

Generally the construction and operation of the new NPP will have a positive impact on the social environment in the region, though some negative aspects can be expected.

The main expected positive impacts are:

- The increase of demand for labour force, maximum 3 500 persons during various stages of construction can be expected during 5 to 7 years;
- Impact of additional income due to the construction of NPP can be expected to amount to some EUR 20 million per year;
- Operation of the NPP is expected to need about 500 employees;
- Development of infrastructure and especially the housing sector in Visaginas and surrounding areas;
- Social and political stabilization of the town of Visaginas in the context of decommissioning of INPP. Positive psychological impact on Visaginas society;
- Multiplication of economic impact through increasing local demand for goods and services;
- The improvement of investment attractiveness of the region.

Main expected negative impacts are:

- A positive impact on the social environment in the foreign parts of NNPP region is hardly expected. Its possible that some minimal negative impact on attractiveness of the region for tourism and recreation can appear, though having in mind present operation of INPP and decrease of pollution after its closure this impact is not highly expected;
- New demand for land needed for the NNPP can raise some conflicts because the land use reform is not finished in the Lithuanian part of the region. Nevertheless, both alternative sites of the new NPP are within INPP SPZ which means no other economic activities are allowed there at least until the end of INPP decommissioning.

The socioeconomic impact of the new NPP on tourism and recreation sectors in the Lithuanian part of the region is not one-sided. The planned activity can cause some negative impact on attractiveness of the region but on the other hand increasing economy and incomes can generate substantial new demand for such services.

7.9.2.3 Transport and noise

Existing road and railways, which could be used for the new NPP, are located far from residential areas. The main transportation hub in the region is Dukstas. From there all roads and railways go to the NNPP through unpopulated areas though quite close to the collective gardens of Visaginas. Possible intensive transportation flows, related to the construction and operation of the NNPP, would take place in a very scarcely populated area.

Dukstas settlement would play hub role in this situation, which is a historically common phenomenon. The main communications, which at present are used for transit transportation, are mostly surrounded by industrial or similar non residential areas (except for a few houses and a school).

There is no need for impact on air transportation while this is a zone of no flights (except flights of military police and border control helicopters).

No premises of the NNPP are expected to generate noise and vibrations, which could exceed existing norms and limits.

7.9.2.4 Resident survey

A survey of the residents of the town of Visaginas and surrounding areas (*Resident Survey Report, 2008*) forms the constituent part of the evaluation of impacts on the environment that serves in evaluation of the socio-economic impact of the planned economic activity. During the assessment the attitude and opinion to the new NPP and its possible impacts on the social and economic environment of residents of the town of Visaginas and surrounding areas were surveyed.

The main survey objectives were to find out the attitude of residents living nearby the current INPP to the impact of the new NPP on the living environment, communication and transport, leisure activities, livelihood and professional life, migration attitudes of residents, value of real estate in the region, employment of the population, the most significant impacts during construction and operation of the new NPP and personal awareness of the new NPP project.

In order to implement the objectives of the survey, a representative survey of the inhabitants of the region was carried out: 518 residents of the town of Visaginas and surrounding areas in the range of 20 km were interviewed. The survey was carried out by interviewing respondents at their homes according to a standardized questionnaire, where the answers were registered. A representative probability sampling routine was used for the selection of the respondents by evaluating the distribution of the 18 years and older residents of the town of Visaginas and surrounding areas by age, sex, education and place of residence. “RAIT Ltd.” surveys are performed according to the European Society for Opinion and Marketing Research (ESOMAR) requirements.

The main results of the survey

<u>The residents of the town of Visaginas and surrounding areas evaluated a positive potential impact of the new NPP on the following aspects of the socioeconomic environment:</u>

For the living environment after the construction of the new NPP: (“How would you evaluate your living environment, where the new power plant is constructed?”: very attractive – 42.4 %, attractive – 41.6 %: total – 84.0 %, Figure 7.9-8).

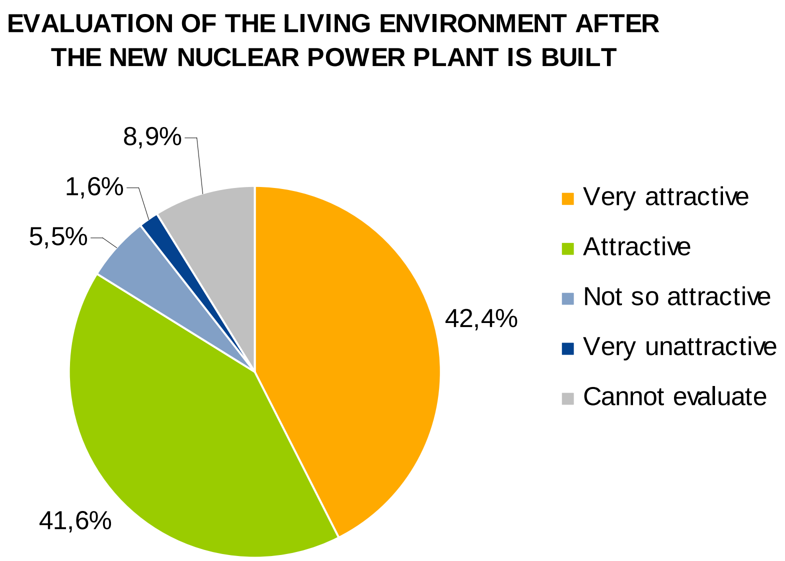


Figure 7.9-8. Residents answer to the question "How would you rate your living environment after the new nuclear power plant has been built?" (N=518).

The present living environment is evaluated notably favourable and somewhat more favourable than it would be after the construction of the new NPP ("How would you evaluate your living environment at the moment?": very attractive – 36.0 %, attractive – 55.1 %: total – 91.2 %).

For the family livelihood and professional life: ("What is your opinion about the impact of the new power plant on your and your family's livelihood or professional life?": very positive – 22.9 %, positive – 43.7 %: total – 66.6 %, Figure 7.9-9).

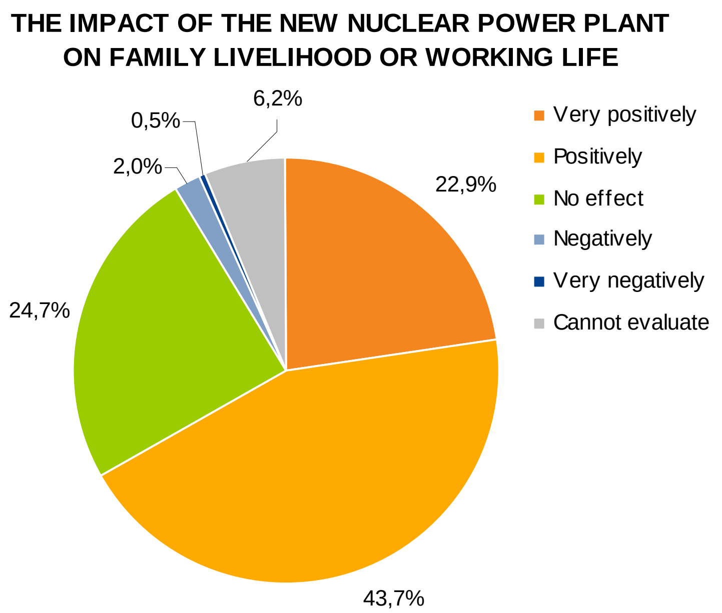


Figure 7.9-9. Residents answer to the question "How would you think the new nuclear power plant affects your and your family's livelihood or working life?" (N=518).

For the value of accommodation: ("How will the new atomic power plant influence the value of your permanent residence in your opinion?": value will increase – 49.0 % permanent residents of the region, Figure 7.9-10).

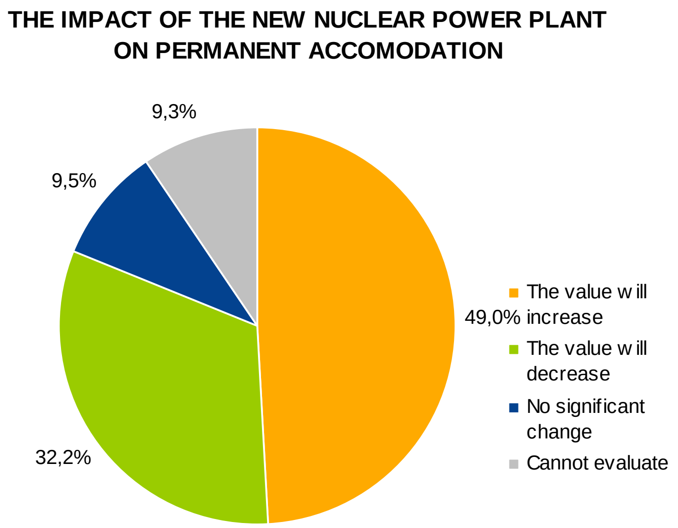


Figure 7.9-10. Residents answer to the question "How do you think the new nuclear power plant affects the value of your holiday residence?" (N=508).

For the level of employment of the population during the construction and operation: ("How do you evaluate the impact of the new power plant on the employment of population (employment situation) during construction?": employment will increase greatly – 46.7 %, employment will increase – 42.8 %: total – 89.5 %, Figure 7.9-11); ("How do you evaluate the impact of the new nuclear power plant on the employment of population (employment situation) during operation?": employment will increase greatly – 26.6 %, employment will increase – 38.7 %: total – 65.4 %).

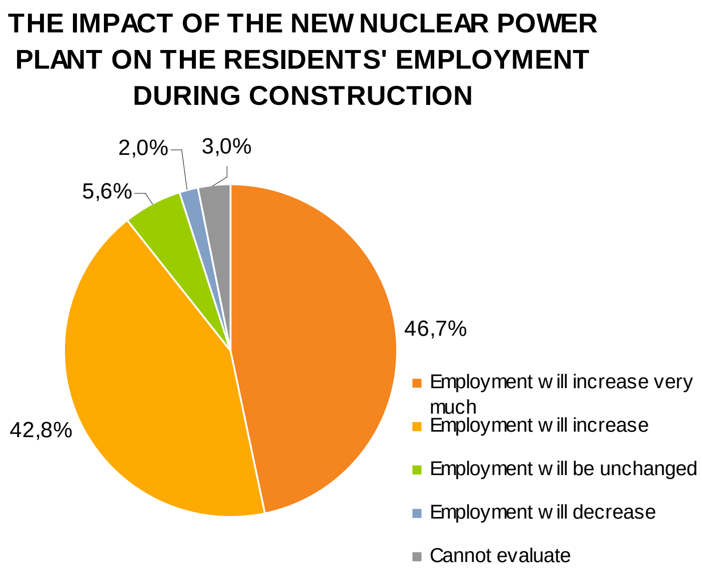


Figure 7.9-11. Residents answer to the question "How significant do you rate the effects of the new nuclear power plant on the employment during the construction?" (N=518).

When evaluating the communication and transport: ("How will the new nuclear power plant influence means of communication/transport (buses, automobiles, etc.) you use?": very positively – 13.9 %, positively – 35.9 %: total – 49.7 %, no effect – 41.6 %). The residents of the region divided into two quite equal groups: one a slightly larger group agrees with the positive impact of the new NPP on the means of transport, and another slightly smaller group thinks that will not have any impact.

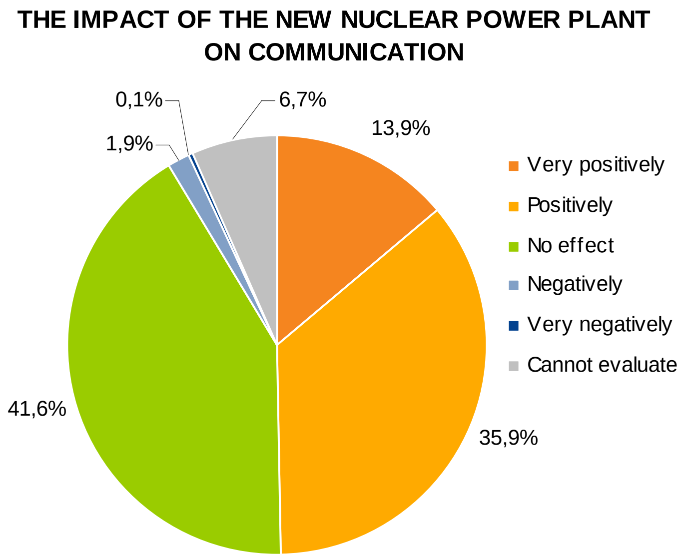


Figure 7.9-12. Residents answer to the question "How would you think the new nuclear power plant affects the means of communication you use?" (N=518).

<u>According to the opinion of the majority of residents of the town of Visaginas and surrounding areas, the new NPP will not impact the following aspects in any way:</u>

Recreation and leisure opportunities: ("How do you think the new nuclear power plant affects your opportunities of recreation or other leisure activities?": will have no effect – 61.5 %).

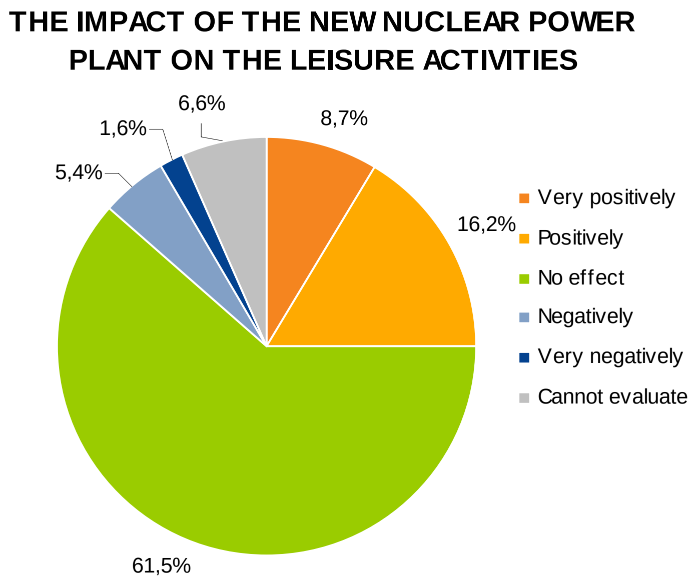


Figure 7.9-13. Residents answer to the question "How would you think the new nuclear power plant affects your opportunities of recreation or other leisure activities?" (N=518).

One quarter (24.9 %) of respondents think that the impact of the new nuclear power plant will have the positive influence on leisure sphere, i.e. they have rated the influence of the power plant as very positive (8.7 %) or positive (16.2 %) for the leisure activities. Six questioned people of ten (61.5 %) think that the new nuclear power plant will have no impact on the potential leisure activities and 7.0 % think, that the new nuclear power plant will have the negative impact on the potential leisure activities. 6.6 % of respondents have not expressed their opinion on this question. When reviewing the distribution of the answers, one may notice, that thinking about the impact of the new NPP on recreation and leisure activities, the bigger part of the region thinks that the new NPP won't change this part of their life in any way.

When asked, what particular leisure activities the new NPP would influence, people were more intended to philosophize than to mention the particular types of activities. From the potential specific ways of leisure, the ones who claimed, that the new NPP will generally effect the leisure more positively, said that there would be more possibilities of spending the days off and will be more resting places (7.3 %), the fishery would be effected (5.3 %), there would be changes in tourism sector (4.5 %), Figure 7.9-14. Those who think that the new NPP would influence the leisure negatively, claimed that it would effect the fishery (32.1 %), the recreation in the forest (14.3 %), swimming, boating (6.3 %), also there were some claiming that all ways of spending the leisure time would be effected (6.3 %).

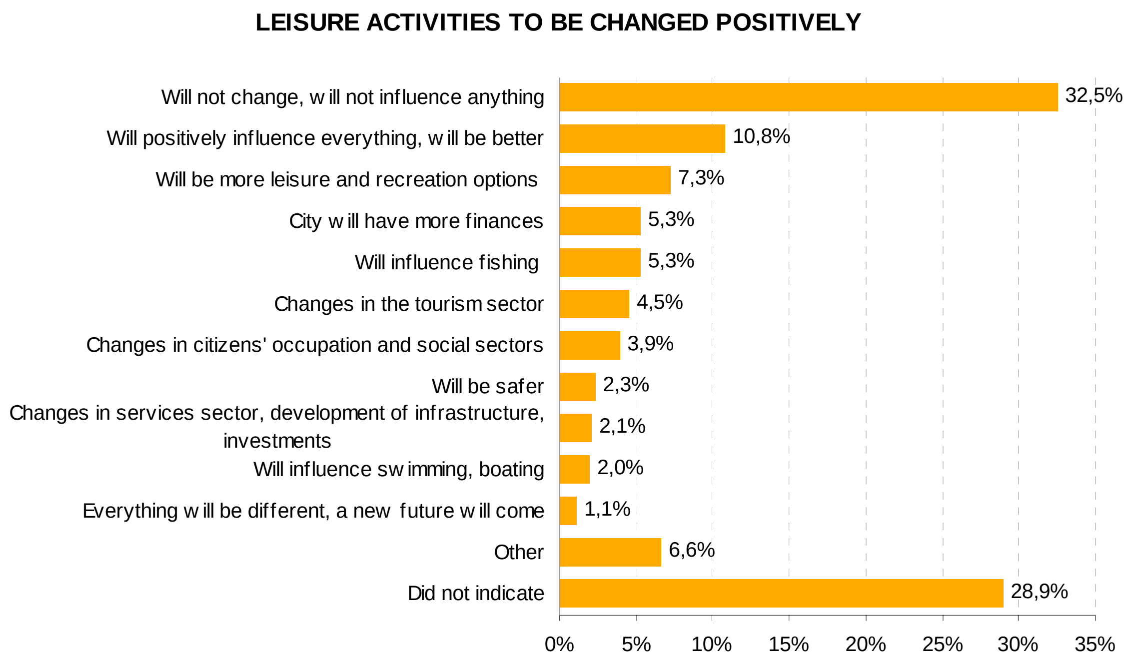


Figure 7.9-14. Residents answer to the question "Which leisure activities do you think the new nuclear power plant would affect (for example fishing, boating, other outdoor activities)?" % is counted from those who evaluate NNPP impact on leisure activity positively (N=129).

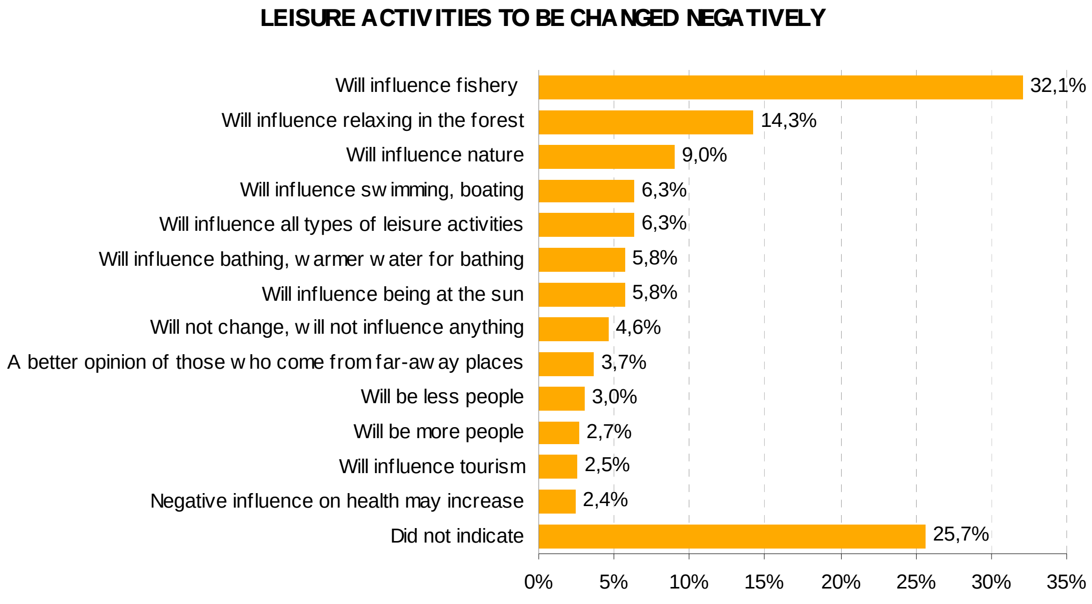


Figure 7.9-15. Residents answer to the question "Which leisure activities do you think the new nuclear power plant would affect (for example fishing, boating, other outdoor activities)?". % is counted from those who evaluate NNPP impact on leisure activity negatively (N=36).

When analyzing the answers to this question under the social-demographic characteristics, there are no statistically significant differences, though one might notice the trend that the citizens of Visaginas are keener to think that the new NPP would have the positive impact on the recreational and leisure activities.

Desire to move out: ("How do you think the new nuclear power plant will affect your desire to move away from the area?": will not influence the desire of moving – 70.4 %). A fifth part (21.9 %) of the residents claimed that the wish of moving will decrease due to the new NPP, therefore, the region would become more attractive for this part of residents, Figure 7.9-16.

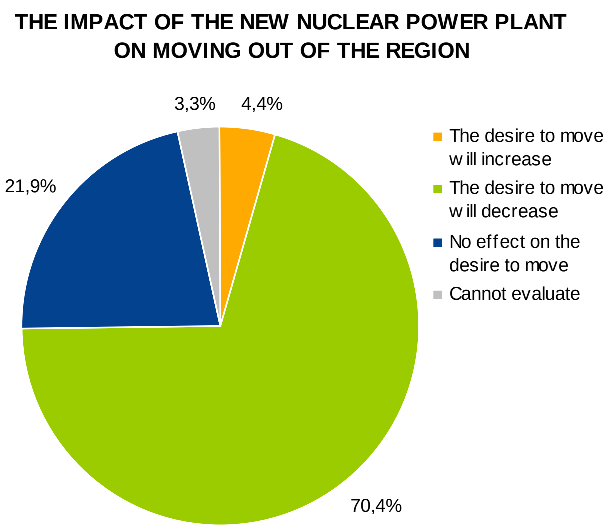


Figure 7.9-16. Residents answer to the question "How do you think the new nuclear power plant will affect your desire to move away from the area?" (N=518).

Though there are no statistically significant differences under the social–demographic characteristics, one might notice the trend that for the citizens of Visaginas town the desire to move out would become smaller (25.3% of Visaginas residents and 1.3% of residents of surrounding areas claimed, that their desire to move out would decrease). The residents of the surrounding villages and small towns have more often said that the construction of the new NPP would have no impact on their intentions to leave the region.

In the opinion of the residents of the region, the most important impact during the construction of the new NPP would be observed on the employment of population (37.7 %). In the opinion of the residents, the other important impacts are the feeling of safety (28.6 %), impacts for Lake Druksiai (26.5 %) and for the traffic (23.8 %), Figure 7.9-17.

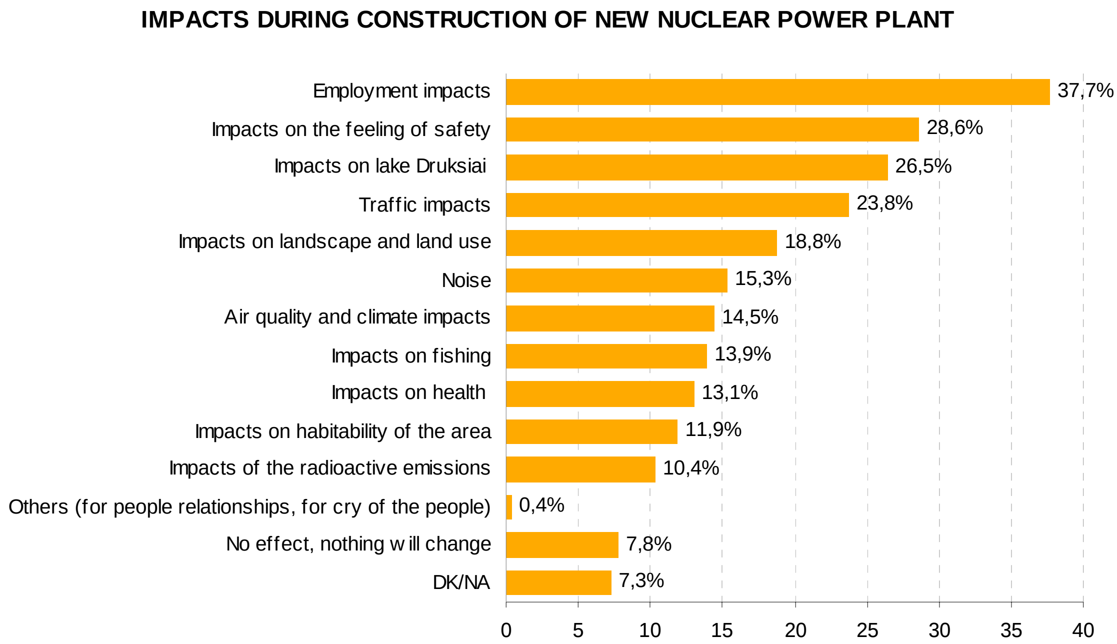


Figure 7.9-17. Residents answer to the question "Which environmental impacts do you consider the most important during the construction of the plant?" (N=518).

In the opinion of the residents of the region, the most important impact during the operation of the new NPP would be observed for the energy market (41.0 %). In the opinion of the residents, the other important impacts are impact for the employment of population (29.0 %), impact for Lake Druksiai (26.3 %) and impact for the feeling of safety (23.8 %), Figure 7.9-18.

The impact on the employment of population was often mentioned by residents of Visaginas town and the impact on the lake Druksiai and on air quality and climate – was mentioned by the residents of the surrounding areas. Respondents with the vocational education more often mentioned that the biggest impact would be on air quality and climate. The proposition about the impact on radioactive emissions and the impact on health and fishery more often was mentioned by respondents of 18–25 years and residents of Visaginas town. The impact on landscape and land interest was more often mentioned by respondents of 36–45 years and the ones with the university education.

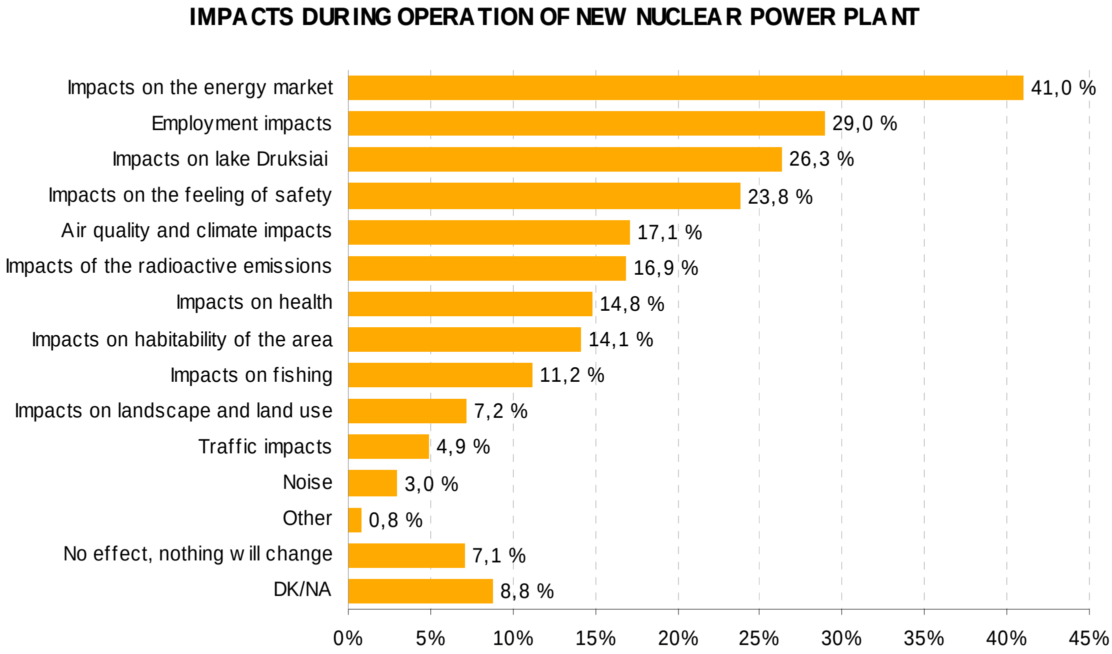


Figure 7.9-18. Residents answer to the question "Which environmental impacts do you consider the most important during operation of the plant?".

A summary reveals that besides the energy market, in the opinion of the residents the most important impact would be observed on the same aspects: for the employment, safety feeling and Lake Druksiai. The impact on the other aspects would be different during construction and maintenance. The respondents assume that the traffic, landscape, land-tenure and noise would be affected, but such an impact will not be observed during operation. The respondents envisaged impact on the air quality, climate and emission of radioactive materials more often during operation, and such impacts will not be observed during construction in their opinion.

The residents of the town of Visaginas and surrounding areas are not very well informed about the project of the new nuclear power plant: ("*Have you received enough information about the nuclear power plant project?": have little information – 52.9 %, have not heard anything about the project – 15.7 %: total – 68.6 % poorly informed or uninformed residents of the region*). The opinion of the residents of the town of Visaginas and surrounding areas is slightly different on this question. More residents of Visaginas feel informed enough and do not request more information in comparison to residents of surrounding areas, but generally, both parts of the residents are too little informed about the project of the new NPP, Figure 7.9-19.

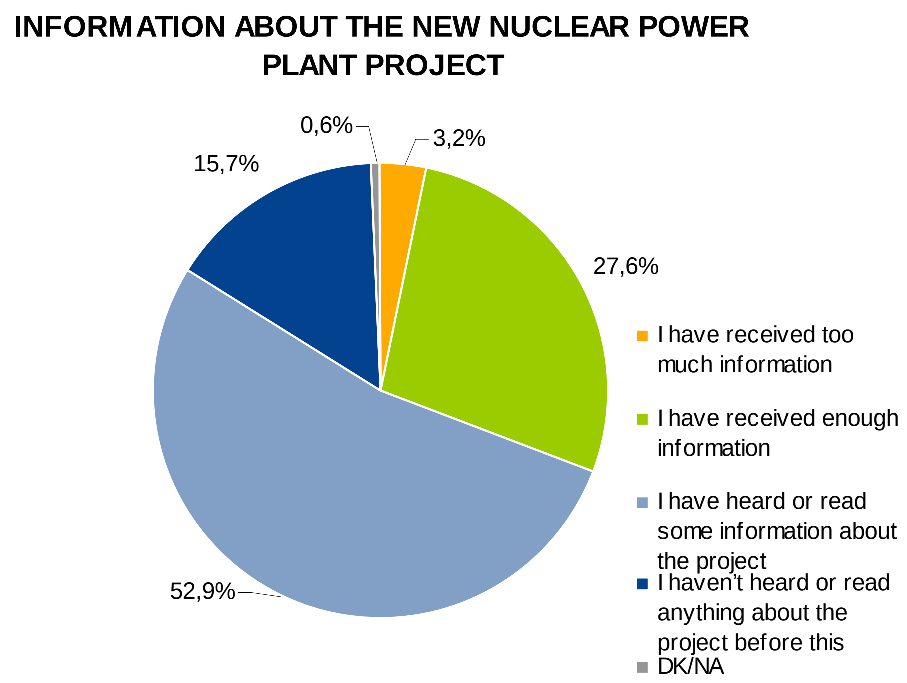


Figure 7.9-19. Residents answer to the question "Have you received enough information about the nuclear power plant project?" (N=518).

The residents of the region would like to get more information on the topics shown in Figure 7.9-20.

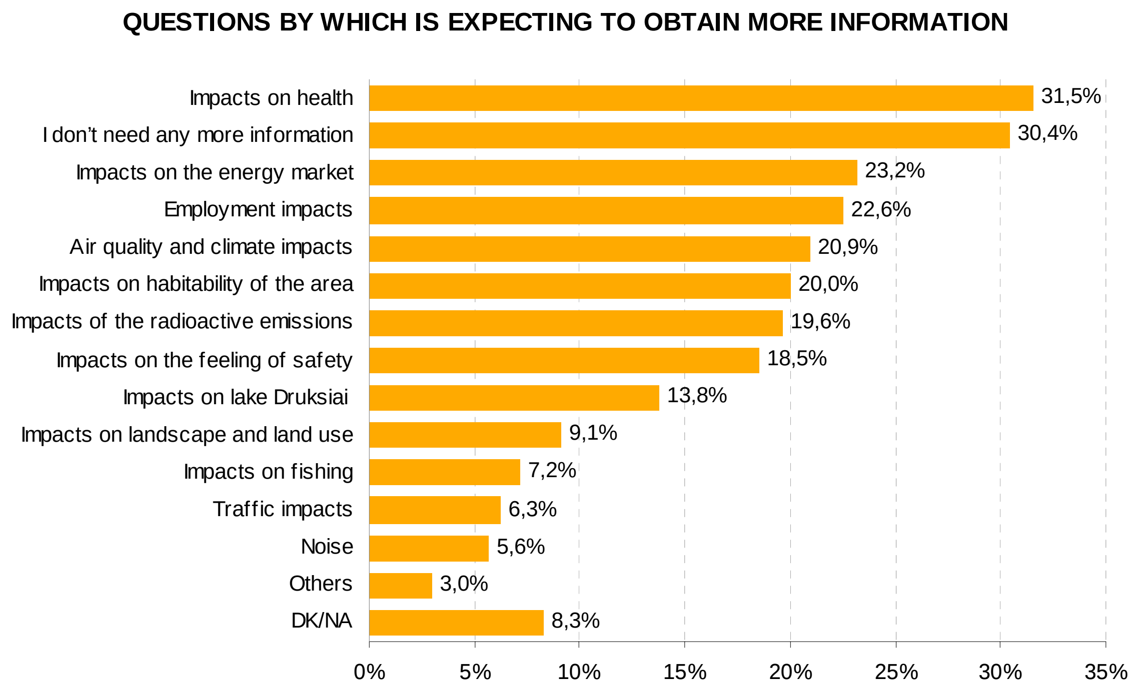


Figure 7.9-20. Residents answer to the question "About which matters would you like to get more information?" (N=518).

According to the opinion of the vast majority of residents in the region, the new nuclear power plant in Lithuania should be constructed (91.9 % agree). A vast majority agrees with the construction of the new nuclear power plant in one of the planned sites (82.8 % agree), but they do not feel able to influence which impacts on the environment are evaluated and how they are evaluated. Six residents out of ten (63.4 %) did not agree with the statement that they can influence which impacts on the environment are evaluated and how they are evaluated. Regardless of the fact that the residents do not feel able to influence the assessment process, they believe that possible impacts on the environment will be assessed comprehensively (66.3 % agree), Figure 7.9-21.

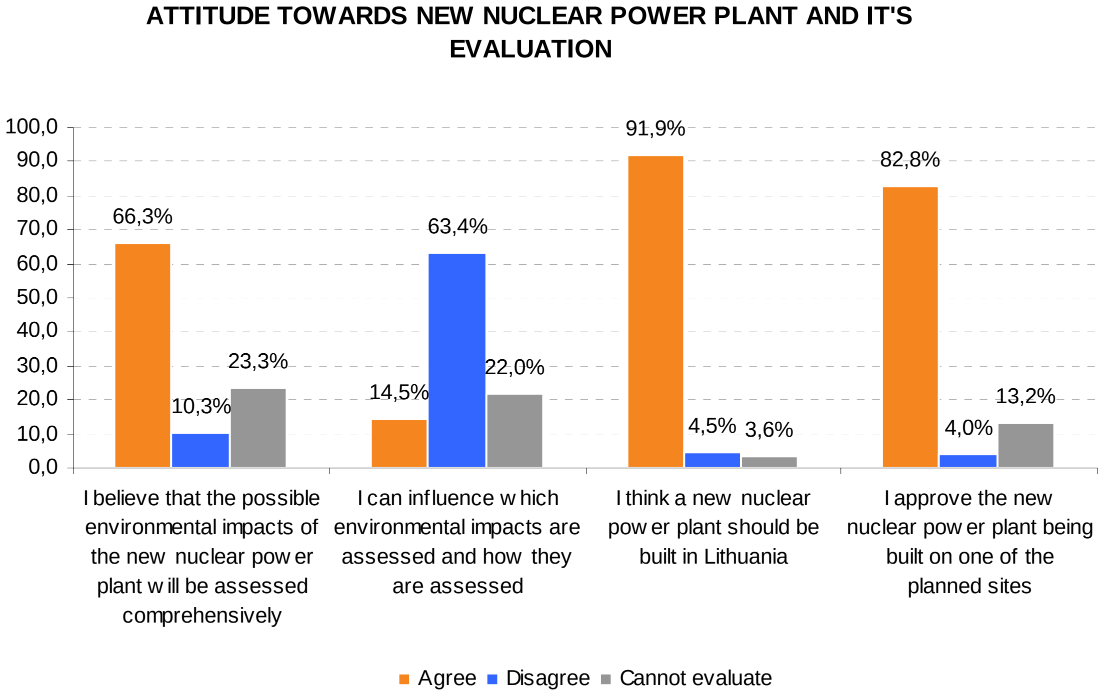


Figure 7.9-21. Residents answer to the question "How well do the following statements represent your opinion or view on the matter?" (N=518).

It was quite difficult for the residents to state their requests to the planners and evaluators of the project, but those who had their opinion stated the following requests for the planners ("*Which matters would you like to be taken into consideration in the planning of the nuclear power plant What are your requests for the planners?*"):

- To pay attention to the safety of the NNPP and safety of its operation (16.6 %);
- To pay attention to the employment of population (9.4 %);
- To pay attention to the conservation of landscape and nature (5.5 %);
- To make an effort for faster course of the construction works (5.1 %).

And for the evaluators ("*Which matters would you like to be taken into consideration in the environmental impact assessment of the nuclear power plant. What are your requests for the evaluators?*"):

- To pay attention to the safety of the NNPP and safety of its operation (17.4 %);
- To pay attention to the air quality, climate and control how ecological norms are observed (12.6 %);
- To pay attention to the conservation of landscape and nature (9.9 %).

Consequently, the main request for the planners and evaluators is to pay attention to the safety of the NNPP and its maintenance.

Conclusion

When summarizing results received during the assessment, a statement can be made that the residents of the town of Visaginas and surrounding areas evaluate the impact of the new NPP to the investigated spheres of socioeconomic life positively, and agree with the construction of the new NPP in one of planned sites. When planning and evaluating impacts of the new NPP, they require that attention is paid to the safety of the new NPP and its operation firstly. Because of the fact that half of the residents are too little informed or not informed at all about the NNPP project, they should get more information about planned works and impacts by receiving information about the opportunities of presenting opinions to the planners and evaluators at the same time, because the majority of the regions residents do not think that they can influence such a process.

7.9.3 Mitigation measures

7.9.3.1 Population and demography

The proposed measures for mitigation of adverse impacts are as follows:

- Promotion of diversification of activities related to construction and operation of the NNPP; in the sphere of long-term services to constructors and operators in particular. This would encourage trade in the neighbourhood and would stabilize the demographic situation in it in long-term activity perspective;
- Maximal recruiting of Visaginas labour forces which would contribute to avoidance of mass immigration from other countries and regions (except high class experts and special services).

When planning a long-term activity like construction and operation of the NNPP, it is necessary to take into account this important aspect. The current demographic and labour force situation is based on the census of population and housing of 2001 and current data provided by municipal structures.

In view of the scheduled construction of the NNPP, the data obtained during the population census of 2012–2013 in all the countries of the region will be very relevant while they will allow specification of demographic trends, labour force potential, etc. It would be expedient to carry out a targeted study of human potential in the NNPP region after the mentioned population census.

7.9.3.2 Economic activities

Potential measures for mitigation of negative impact are:

- The town of Ignalina and some other settlements in the district gained the status of resort only recently and they are not located in the zone of surveillance of the NNPP. However due to the name of the Ignalina NPP they can be related to the INPP and this can cause a negative impact on their attractiveness. New measures for improving the image of NNPP are needed, which could not only improve the awareness of its safety but would psychologically detach the NNPP from the surrounding region (Ignalina district municipality first of all), which depends on tourism and recreation very much;

- Zarasai city was granted the status of resort territory by the resolution No. 875 of the Republic of Lithuania Government of September 10, 2008. Zarasai city is in 25 kilometres from the existing Ignalina NPP, and this has not disturbed its recreational, tourism, and cultural activities so far. However, when creating the NNPP image it is necessary to stress out that the out-of-date INPP RBMK reactors do not meeting the Western standards will be dismantled, the most modern and secure technology will be used in the new plant, and the NNPP positive effect on the region‘s socio-economic development due to rebound of the labour market, increase of the attractiveness of the investment, and development of service industries can attract further investment into the region's recreational, resort and tourist sites, as well;
- Tackling this contradiction of interests a new specialised research, devoted to the wider impact of NNPP of socioeconomic environment in the context of the General plan of the Lithuania, could be carried out;
- Siltation in the part of Lake Druksiai near Tilze, Raipole, Padrukse villages of Zarasai district is caused not by INPP radiological impact, but by the inadequately treated household waste water released into Lake Druksiai from the household waste water treatment plants operated by the state enterprise “Visagino energija”. These waste water treatment facilities must be reconstructed. The reconstruction project was launched in May, 2008. The capacity of the new Visaginas waste water treatment plant will be 5500 m^3/d, it will be equipped with activated sludge plant and it will meet all current Lithuanian and EU requirements on waste water management. The reconstruction project is funded by the State of Lithuania and the EU Cohesion Fund, it is expected that the renovation will be completed by 2010. The potential impact of the planned economic activity on the coast of Lake Druksiai will be concentrated on the chosen construction site, as well as on the locations of intake and discharge of cooling water. This effect will be short-termed, and the impact on the farther lake coast, recreational areas, beaches and other recreational activities is not expected. If such an unplanned impact is detected on more remote coastlines, the NNPP operator will take the appropriate impact mitigation measures.

The performed public opinion survey has shown that the majority of the residents of Visaginas town and the surroundings (61.5 %) think that the NNPP will have no impact on their recreation and leisure possibilities, one quarter (24.9 %) of the respondents think that the impact of the NNPP will have the positive influence on leisure and recreation sphere, i.e. they have rated the influence of the power plant as very positive (8.7 %) or positive (16.2 %), and only 7.0 % of the residents think, that the NNPP will have the negative impact on their potential leisure activities.

The public opinion survey has also shown that the majority of the residents of Visaginas town and its surroundings (84.0 %) have rated positively their living environment after the construction of the new nuclear power plant, i.e., half of them (42.4 %) said it would be very attractive and half of them (41.6 %) said it would be attractive. The living environment would seem unattractive after the construction of the new power plant to only 7.1 % of the respondents (unattractive – 5.5 %, very unattractive – 1.6 %). Further on, when asked about their estimation of the impact of the new nuclear power plant on the employment of residents during the construction works, the absolute majority (89.5 %) has stated that the employment of the population would increase (increase very much – 46.7 % or increase – 42.8 %). 5.6 % of the population think that the employment rate during the construction of the NPP will not increase, 2.0 % think that it will decrease.

7.9.3.3 Transport and noise

The construction works will be carried out in an unpopulated area so the main mitigation measure is strong observance of safety requirements. The timetable of cargo transportation and transhipment in Dukstas town could be adjusted. Noise reducing fences should be constructed along main roads at least in some residential areas.

An effective measure according to the opinion of the local population would be the construction of new roads and modernisation of existing ones.

7.9.3.4 Working language

Miscellaneous studies in the nuclear field, the aviation and the medical field in the past have analyzed the influence of the working language on the job performance in high risk environments. The results show in general a distinctly better performance when using the native language. Especially under stress condition such as disturbance or emergency conditions, the number of mistakes due to misunderstandings, which will lead to an accident or disastrous condition, is significantly lower when using the native language instead of any other foreign language.

Therefore all training programs as well as the operation of the NPP should be executed by using the native language. All instruction documents and operating procedures should be issued in Lithuanian language. In case the supplier delivers descriptions and procedures in any other language, they should be translated into Lithuanian language. The original documentation should be kept as reference in the original language, but not be used in the daily work.

Article 4 of the Republic of Lithuania Law on Official Language No. I-779 (*State Journal, 1995, No. 15-344, 2002, No. 68-2760*) settles that "all institutions, agencies, companies and organizations operating in the Republic of Lithuania carry out the documentation of filling work, accounting, reporting, as well as financial and technical documents in the official language". Article 24 of this Law stipulates that "any actions against the status of the national language set out by the Constitution of the Republic of Lithuania are not allowed" (*State Journal, 1995, No. 15-344, 2002, No. 68-2760*).

7.10 PUBLIC HEALTH

7.10.1 Health status of population of Belarus, Latvia and Lithuania

7.10.1.1 Demographical indicators

The new NPP (NNPP) sites are located in the north-eastern part of Lithuania, close to the borders of Belarus and Latvia. The closest inhabitants are located about 3 km to the south-west from NNPP Site No. 2.

Data on population of the neighbouring countries and annual growth as given in World Health Organization’s database “Core Health Indicators” is provided in Table 7.10–1. Data is available only for the year 2005.

Belarus’ population is more than three times as great as Lithuania’s and more than 4 times greater compared to Latvia.

Table 7.10–1. Population (in thousands) total.

Country	2005
Belarus	9755
Latvia	2307
Lithuania	3431

Population annual growth rate is negative in all three countries with the highest negative rate in Latvia and the lowest in Belarus. Annual growth per year 2005 is given in Table 7.10–2.

Table 7.10–2. Population annual growth rate (%).

Country	2005
Belarus	-0.5
Latvia	-0.8
Lithuania	-0.6

As seen from Table 7.10–2, all three neighbouring countries have reduced population growth and thus will generally face no such problems as increased need for food, infrastructure and services. On the other hand, negative growth, in a way, represents tense social environment, which, in turn, has negative impact on health indicators.

7.10.1.2 Population health indicators

In this chapter health status of the population of the three neighbouring countries are represented by crude mortality, standardized mortality rates and life expectancy indicators.

These indicators will only present the existing health status. Evaluation of the causes of differences in health indicators of the countries has not been carried out as it would require evaluation of relation of mortality rates with specific co-founders (e.g. radiation, smoking, social factors and similar). Such evaluation has not been included in the scope of the EIA.

Health status of the residents in proximity of the existing INPP was not assessed for the above mentioned reasons. Collection of the health data of the representative sample for all three countries would require access to crude statistics and explicit epidemiological study that is not the scope of this EIA.

Crude death rate per 1 000 of population of the three mentioned countries is presented in Table 7.10–3. As seen from this table the death rate per 1 000 of population has grown in 20 years period from 10 (1990) to 12 (2005) in Lithuania, from 12 (1990) to 14 (2005) in Latvia and from 10 (1985) to 14 (2005) in Belarus per 1000. The highest growth is observed in Belarus and the smallest in Lithuania. The highest average death rate (1985-2005) per 1 000 of population is observed in Latvia (13.4) and the lowest in Lithuania (11.4).

The source of information is the United Nations statistics division, which provides mortality rate statistics for every 5th year only.

Table 7.10–3. Crude Death Rate per 1 000 (Source: United Nations statistics division).

Country or Area	Population projections variants	1985	1990	1995	2000	2005
Belarus	Estimates (on the past)	10	10	12	14	14
Average	12					
Latvia	Estimates (on the past)	13	12	14	14	14
Average	13.4					
Lithuania	Estimates (on the past)	11	10	12	12	12
Average	11.4					

Available information on age standardized mortality statistics is extracted from World Health Organization database “Core Health Indicators”. The available indicator is age-standardized mortality rate for non-communicable diseases (per 100 000 population) and standardized mortality rate for cancer (per 100 000 population) for the year 2002.

Age-standardized mortality rate for non-communicable diseases is highest in Belarus and lowest in Lithuania (Table 7.10–4).

Table 7.10–4. Age-standardized mortality rate for non-communicable diseases (per 100 000 population).

Country	2002
Belarus	839.0
Latvia	733.0
Lithuania	640.0

On the other hand age-standardized mortality rate for cancer is highest in Lithuania and lowest in Belarus (Table 7.10–5).

Table 7.10–5. Age-standardized mortality rate for cancer (per 100 000 population).

Country	2002
Belarus	143.0
Latvia	156.0
Lithuania	161.0

Life expectancy at birth reflects the overall mortality level of a population. It summarizes the mortality pattern that prevails across all age groups – children and adolescents, adults and the elderly. It estimates average number of years that a newborn is expected to live if current mortality rates continue to apply. The database provides the indicator for the years 2004 and 2005.

The highest life expectancy at birth for both males and females is anticipated in Lithuania while the lowest is anticipated in Belarus (Table 7.10–6).

Table 7.10–6. Life expectancy at birth (years).

Males:

Country	2004	2005
Belarus	63.0	63.0
Latvia	66.0	65.0
Lithuania	66.0	65.0

Females:

Country	2004	2005
Belarus	74.0	75.0
Latvia	76.0	76.0
Lithuania	78.0	77.0

The indicator of healthy life expectancy or health-adjusted life expectancy (HALE), which is based on life expectancy at birth, but includes an adjustment for time spent in poor health, is not yet available in the WHO database.

7.10.1.3 Comparison of health indicators of the new NPP region and Lithuanian population

This subchapter presents the comparison of health indicators of the new NPP region, whole Utena County and Lithuanian population. Mortality data is extracted from the database of the Lithuanian Department of Statistics. Mortality rates are not standardized by age therefore the rates are compared among municipalities only for approximate analysis.

It has to be emphasized that detailing of mortality by specific causes (e.g. thyroid cancer) may be biased by the events at Chernobyl NPP in 1986. Only special investigation could unveil if the activity of the existing Ignalina NPP influenced heath of surrounding inhabitants.

Visaginas municipality is young with the lower number of old people. For the year 2008 the prevailing age groups with the distinctively higher level of residents compared to the municipalities were 20–29 and 45–54. While the lower level of residents is observed in age group from 60 to 85 and older, Table 7.10–7.

Table 7.10–7. Amount of residents by age groups at the beginning of 2008 (*Statistics Department under the Government of the Republic of Lithuania, http://db1.stat.gov.lt/statbank*).

Age group	Republic of Lithuania		Utena county		Visaginas municipality		Ignalina district municipality		Zarasai district municipality	
	Resident amount	%	Resident amount	%	Resident amount	%	Resident amount	%	Resident amount	%
0–4	153653	4.56	6690	3.88	1205	4.22	754	3.74	830	4.03
5–9	164108	4.87	7549	4.37	1011	3.54	891	4.42	1011	4.91
10–14	199237	5.92	9615	5.57	1249	4.37	1123	5.57	1159	5.63
15–19	261469	7.77	13639	7.90	2215	7.75	1489	7.39	1721	8.36
20–24	273337	8.12	14728	8.53	3277	11.5	1487	7.38	1729	8.40

Age group	Republic of Lithuania		Utena county		Visaginas municipality		Ignalina district municipality		Zarasai district municipality	
	Resident amount	%	Resident amount	%	Resident amount	%	Resident amount	%	Resident amount	%
25–29	230019	6.83	9425	5.46	2201	7.70	899	4.46	915	4.44
30–34	222989	6.62	9067	5.25	1811	6.34	931	4.62	915	4.44
35–39	246077	7.31	11288	6.54	1803	6.31	1219	6.05	1279	6.21
40–44	251161	7.46	12881	7.46	2400	8.40	1363	6.77	1459	7.08
45–49	266562	7.92	14546	8.43	3520	12.32	1468	7.29	1550	7.53
50–54	214653	6.38	11758	6.81	2837	9.93	1247	6.19	1230	5.97
55–59	192278	5.71	10387	6.02	1853	6.48	1252	6.21	1223	5.94
60–64	157658	4.68	8412	4.87	903	3.16	1118	5.55	1113	5.40
65–69	164157	4.88	9526	5.52	1008	3.53	1339	6.65	1215	5.90
70–74	142750	4.24	8546	4.95	669	2.34	1302	6.46	1150	5.58
75–79	116095	3.45	7157	4.15	376	1.32	1164	5.78	1020	4.95
80–84	72243	2.15	4874	2.82	183	0.64	770	3.82	710	3.45
85 and older	37911	1.13	2492	1.44	61	0.21	331	1.64	364	1.77
Total	3366357	100	172580	100	28582	100	20147	100	20593	100

Visaginas municipality is a rather closed community mainly comprising of employees of the Ignalina NPP and their families. Therefore mortality rates of this municipality is of a special interest as certain heath effects could be expected in this community as a result of a higher probability of influence of radiation.

Death rate per 1000 inhabitants in Utena County is higher than the country average (Table 7.10–8, Figure 7.10-1). Visaginas mortality rate is the lowest among the County municipalities and nearly twice as low compared to County average.

Table 7.10–8. Death rate per 1000 of inhabitants (*Statistics Department under the Government of the Republic of Lithuania, http://db1.stat.gov.lt/statbank*)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Republic of Lithuania	11.5	11.5	11.3	11.1	11.6	11.8	11.9	12.0	12.8	13.2	13.5
Utena county	14.4	14.5	13.5	13.5	13.7	14.5	14.7	14.8	15.8	15.8	16.8
Visaginas municipality	4.9	4.2	5.6	5.5	6.2	5.2	6.0	6.8	6.7	7.6	8.0
Ignalina district municipality	19.4	19.6	19.2	17.1	17.8	21.4	20.2	19.4	22.5	19.9	22.5
Zarasai district municipality	19.0	19.2	18.0	18.9	16.2	18.0	19.4	19.7	20.2	19.5	20.2

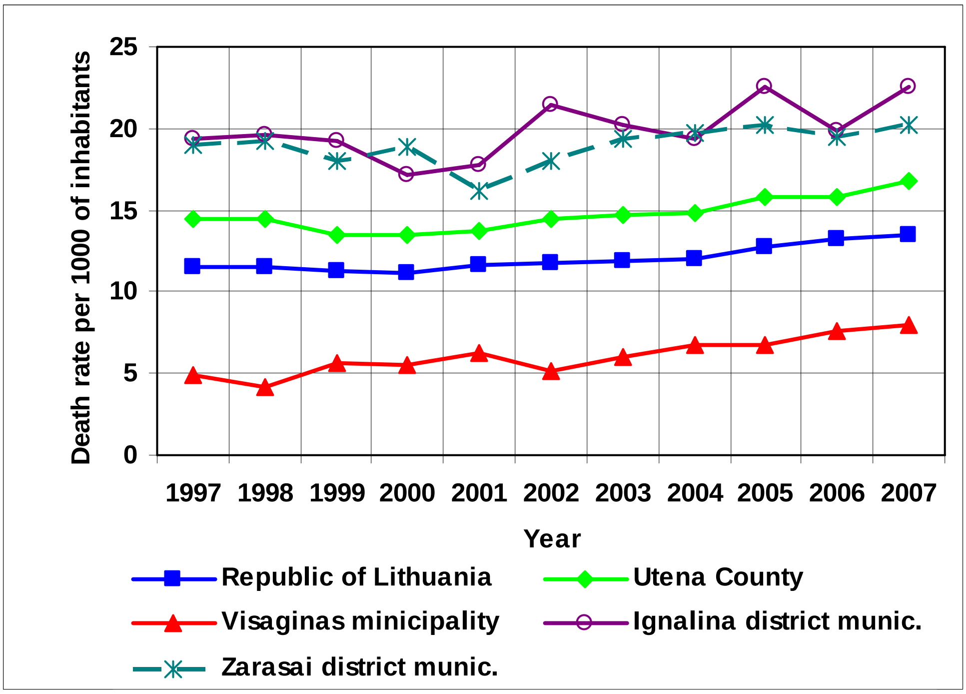


Figure 7.10-1. Death rate per 1000 of inhabitants during 1997–2007.

Correlation between the population at the age of 65 and more and crude mortality rate is strong – above 0.8. Yet is has to be emphasized that Visaginas municipality death rate should be lower as correlated to the population age than eventually it is (Figure 7.10-2).

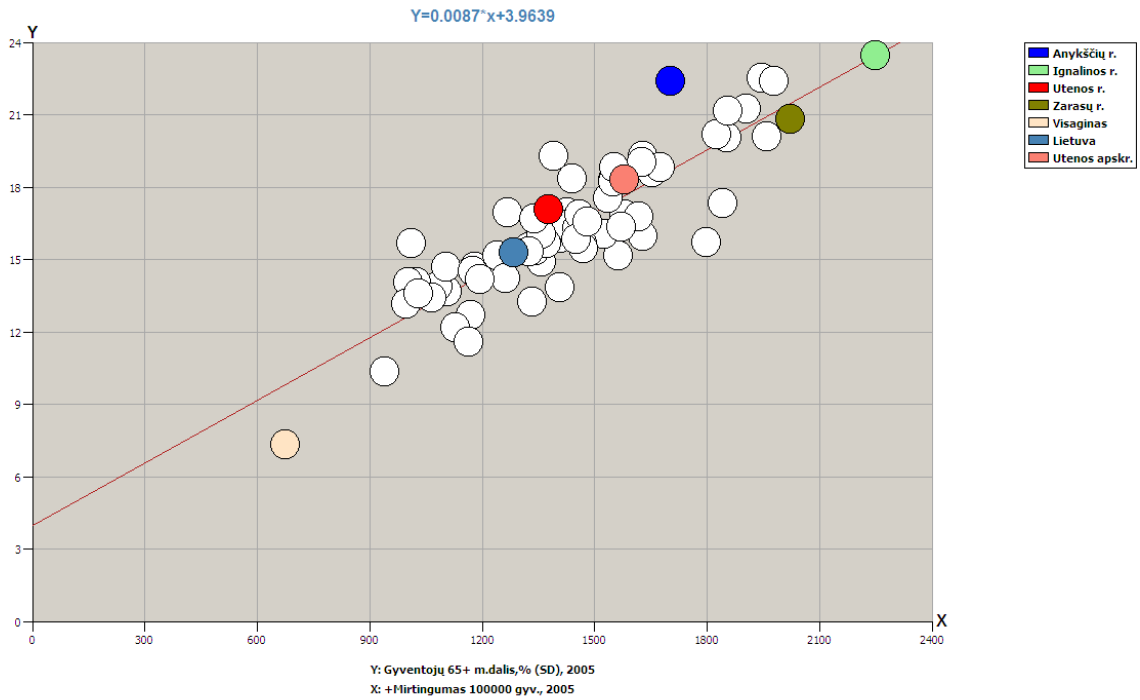


Figure 7.10-2. Correlation between the overall mortality rate and resident amount of 65 and older: X – death rate per 100000 of inhabitants; Y – percent of inhabitants of 65 years and older.

Mortality rate from cancer in Utena County is as well higher than the country average. And again Visaginas municipality inhabitants die not as often from cancer as in other bordering municipalities (Table 7.10–9, Figure 7.10-3).

Table 7.10–9. Mortality rate from cancer (C00C9) per 1000 of inhabitants (*Statistics Department under the Government of the Republic of Lithuania, http://db1.stat.gov.lt/statbank*)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Republic of Lithuania	2.00	2.05	2.10	2.21	2.24	2.27	2.27	2.32	2.36	2.40	2.45
Utena county	2.15	2.44	2.14	1.22	2.45	2.64	2.63	2.66	2.64	2.79	2.83
Visaginas municipality	0.89	0.80	1.07	2.80	1.02	1.22	1.29	1.39	1.26	1.57	1.51
Ignalina district municipality	2.47	2.53	2.37	2.66	3.39	3.81	3.09	3.30	3.65	3.45	4.02
Zarasai district municipality	2.90	2.91	2.56	2.11	2.32	2.87	3.26	2.73	3.57	3.35	3.41

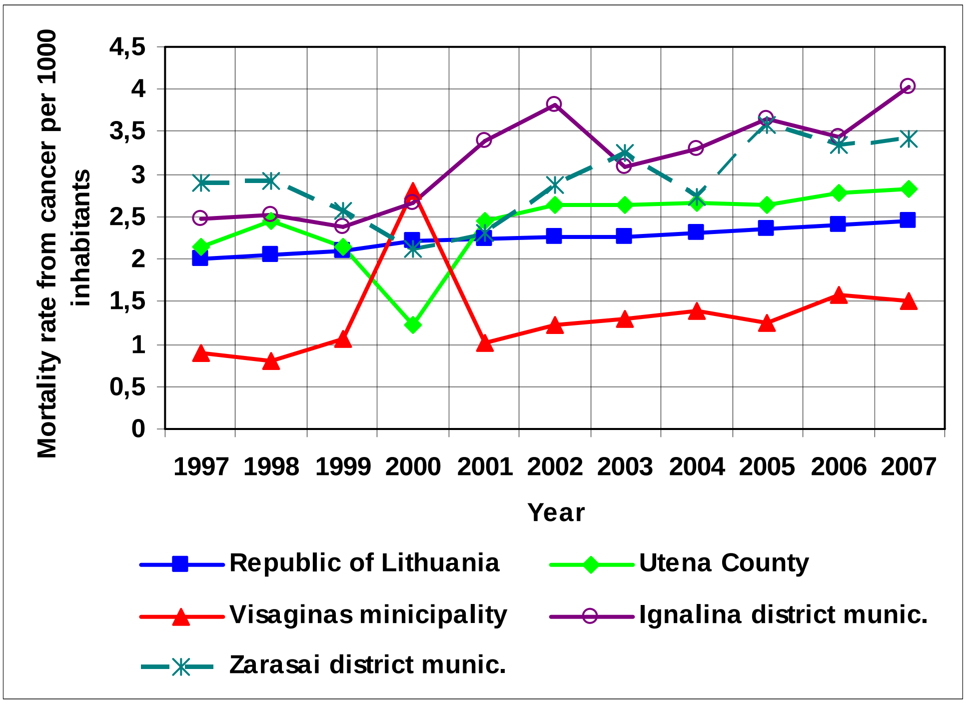


Figure 7.10-3. Mortality rate from cancer (C00C9) per 1000 of inhabitants during 1997–2007.

There is peak of Visaginas municipality mortality from cancer rate in 2000 during 11 year period. At the Republic of Lithuania and Utena County levels the tendency is growth of mortality from cancer (Figure 7.10-3).

In the period of last 6 years the Utena County average mortality rate from diseases of circulatory system is increasing and is higher than the country average. Visaginas municipality mortality rate is lower compared to other bordering municipalities almost in all years of observation (Table 7.10–10, Figure 7.10-4).

Table 7.10–10. Mortality rate from circulatory system diseases (I00I99) per 1000 of inhabitants (*Statistics Department under the Government of the Republic of Lithuania, http://db1.stat.gov.lt/statbank*)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Republic of Lithuania	6.14	6.02	5.92	5.98	6.28	6.44	6.45	6.56	6.98	7.17	7.20
Utena county	8.34	8.07	7.42	2.71	7.96	8.33	8.37	8.54	8.73	9.09	9.39
Visaginas municipality	2.02	2.46	2.35	8.88	3.17	2.26	2.79	3.09	3.03	3.18	3.81
Ignalina district municipality	11.7	11.9	10.8	8.34	9.87	11.6	11.8	11.3	12.4	11.5	11.9
Zarasai district municipality	11.9	11.4	10.3	5.48	10.5	10.8	12.2	12.5	11.0	11.1	10.4

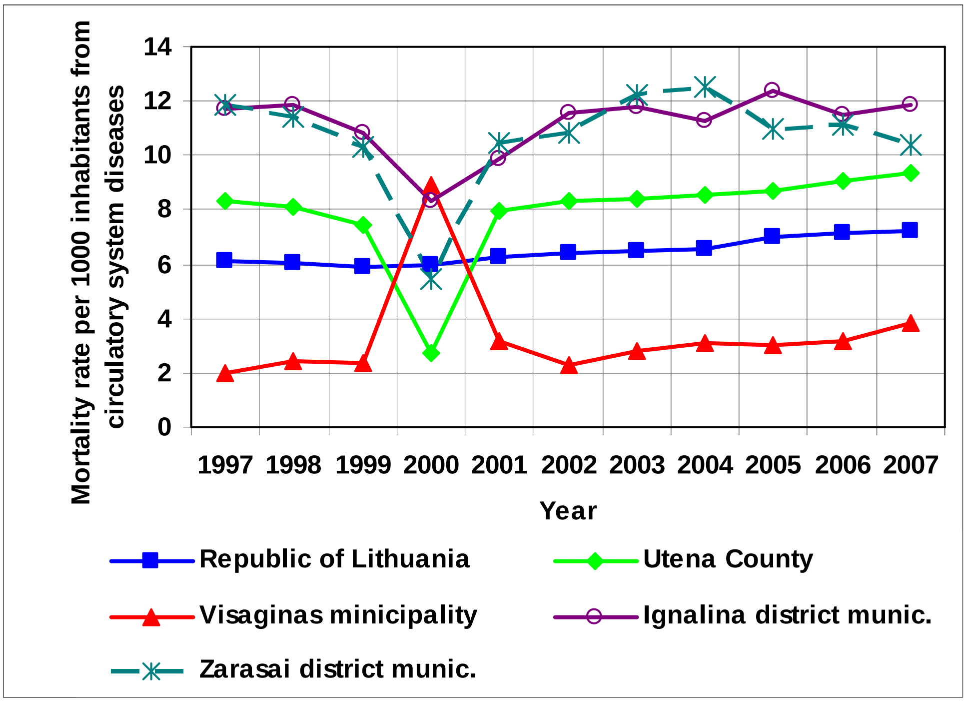


Figure 7.10-4. Mortality rate from circulatory system diseases (I00I99) per 1000 of inhabitants during 1997–2007.

As can be seen from Figure 7.10-4, mortality rate from circulatory system diseases in Visaginas municipality has been increased in 2000, while mortality rate in other municipalities has even been decreased in this year.

Mortality from diseases of respiratory system in Utena County is higher than the Lithuanian average. Visaginas municipality mortality rate is lower compared to other municipalities of the County with the exception of the year 2000 (Table 7.10–11, Figure 7.10-5).

Table 7.10–11. Mortality rate from respiratory system diseases (J00J98) per 1000 of inhabitants (*Statistics Department under the Government of the Republic of Lithuania, http://db1.stat.gov.lt/statbank*)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Republic of Lithuania	0.43	0.45	0.41	0.45	0.42	0.47	0.47	0.47	0.51	0.50	0.58
Utena county	0.69	0.75	0.56	1.26	0.68	0.64	0.78	0.78	0.84	0.81	0.89
Visaginas municipality	0.18	0.18	0.12	3.39	0.10	0.10	0.14	0.10	0.17	0.32	0.21
Ignalina district municipality	0.99	0.80	0.76	4.27	0.78	0.83	1.48	1.19	1.27	1.34	1.72
Zarasai district municipality	0.44	0.97	0.65	2.48	0.70	0.57	0.58	1.00	1.02	1.04	1.35

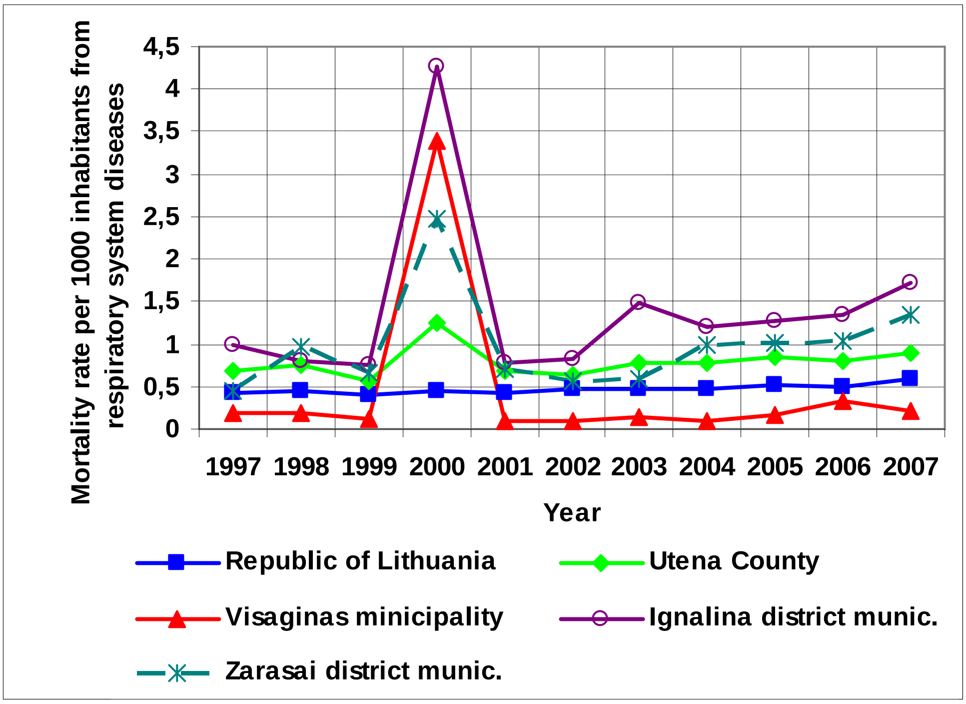


Figure 7.10-5. Mortality rate from respiratory system diseases (J00J98) per 1000 of inhabitants during 1997–2007.

As can be seen from Figure 7.10-5, there was distinctive peak of mortality in the year 2000 for all the municipalities of the county. Other raises of mortality are not so pronounced. The causes for the increase of mortality in the year 2000 are not investigated. National level of the mortality has no such sharp increase in the year 2000.

Death rate from external causes in Utena County is higher than the country average indicator with the exception of the year 2000 (Table 7.10–12, Figure 7.10-6).Visaginas municipality has a lower mortality rate from external causes with the exception of year 2000 also.

Table 7.10–12. Mortality rate from external causes (V01Y89) per 1000 of inhabitants (*Statistics Department under the Government of the Republic of Lithuania, http://db1.stat.gov.lt/statbank*)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Republic of Lithuania	1.47	1.45	1.42	1.46	1.58	1.52	1.52	1.48	1.63	1.57	1.55
Utena county	1.81	1.72	1.72	0.93	1.82	1.84	1.81	1.62	2.04	1.70	1.81
Visaginas municipality	1.13	1.07	1.19	1.78	1.47	1.04.	0.94	1.01	0.98	1.08	1.16
Ignalina district municipality	2.35	2.25	2.98	1.96	2.70	3.29	2.33	2.06	2.72	2.11	2.06
Zarasai district municipality	1.81	2.19	2.16	1.46	1.84	2.47	1.97	2.05	2.78	2.13	2.50

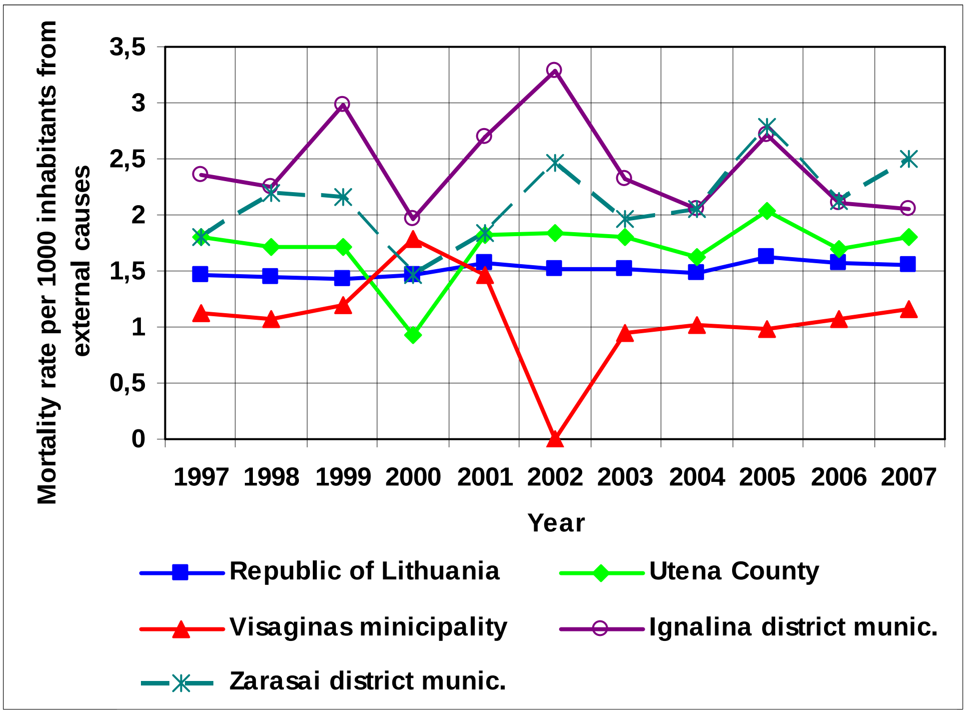


Figure 7.10-6. Mortality rate from external causes (V01Y89) per 1000 of inhabitants during 1997–2007.

7.10.2 Assessment of the impact on public health

7.10.2.1 Non-radiological impact

Major non-radiological population health risks

The proposed economic activity will be conducted within the INPP industrial site and within the existing 3 km radius sanitary protection zone of INPP. The shortest distance from the planned NNPP to the boundary of the existing sanitary protected zone is about 1.5–2 km. There is no permanently living population within the existing sanitary protection zone of INPP and the economic activity is limited as well. The proposed economic activity will be distant from permanently living population.

The potential public health impact sources of conventional (i.e. non-radiological) nature are presented in the tables below. Table 7.10–13 presents the risks of the construction phase and Table 7.10–14 the risks of the operation phase.

Table 7.10–13. Risks of the construction stage (duration 5–7 years).

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
1. Factors of behaviour and lifestyle (nutrition habits, alcohol consumption, smoking, consumption of narcotic and psychotropic drugs, safe sex and other)	0	National	Minor impact on national alcohol consumption.

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
	-	Regional	Construction workers coming from other areas may add to consumption of alcohol in the region as a result of isolation from families.
2. Factors of physical environment			
2.1. Air quality	0	National	National levels of air pollution will practically not be affected.
	-	Regional	Construction dust, welding fumes, transport emissions. Transport emissions that may affect settlements along roads are presented in Section 7.10.2.1.
2.2. Water quality	0	National	No impact on water quality on national level is anticipated.
	0	Regional	No impact on quality of potable groundwater is anticipated as underground contamination from containers of construction chemicals will be avoided as a result of proper container sealing and spill prevention. Minor impact on surface water is anticipated as a result of household water discharge and rainwater runoff. Effluent treatment such as mechanical and biological wastewater treatment and rainwater runoff oil separation is planned. Effluent amount, pollution level and receiving surface waters are detailed in Section 7.1. Amounts and quality of drinking water are presented in Section 7.1.
2.3. Food quality	0	National	No impact on food quality on national level is anticipated.
	0	Regional	Increase of traffic and transport emissions as well as contaminated road rainwater runoff will have minor negative effect on crops planted near roads. Quality of fish in adjacent lakes and rivers will not deteriorate as a result of wastewater and surface runoff treatment.
2.4. Soil	0	National	No impact on soil on national level is anticipated.
	0	Regional	Earthworks (excavation) will comprise 1 400 000 m^3 while earthworks with fill materials will comprise 1 300 000 m^3. Soil contamination from containers of construction chemicals will be avoided as a result of proper container sealing and spill prevention. Impacts on soil are assessed in Section 7.4.
2.7. Noise	0	National	No specific road connection between the site of the plant and distant regions of the country will be established therefore noise is minor hazard on national level.
	-	Regional	Existing access road may be renovated or expanded. Increase of traffic may increase noise in the settlements located along access roads. Noise assessment is presented in the Section 7.10.2.1.
2.8. Home conditions	0	National	No impact on home conditions is anticipated on national level.

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
	+	Regional	If a large number of employees from distant areas are employed, apartment rental prices may rise in surrounding areas. It will benefit the local residents. The flat area may be insufficient for the construction employees and certain number of temporary living houses will have to be constructed.
2.9. Safety	0	National	No impact is anticipated.
		Regional	Increase of traffic and big machines may add to road accidents and injury.
2.10. Means of communication	0		Communication network is already established.
2.11. Territory planning	0	National	No impact is anticipated.
	0	Regional	Except for site planning no other territorial planning is anticipated. NNPP will be constructed at the existing INPP site and therefore the land use of the surrounding areas will not be altered.
2.12. Waste management	0	National	No impact is anticipated.
	0	Regional	Paper, glass, packaging waste, metal scrap, electronic scrap, used tires, end-of-life vehicles, sewage sludge and concrete sludge will be utilized at regional licensed waste management companies. The amounts of waste generated during the construction stage are presented in Chapter 6.
2.13. Power appliance	0	National	Construction will demand power and that will increase the national power consumption.
	0	Regional	Connection to the existing network is available. Increase of regional power consumption is anticipated.
2.14. Risk of accidents	0	National	No impact is anticipated.
	-	Regional	Construction and traffic accidents may increase. Mainly employees and areas along roads may be affected.
2.15. Passive smoking	NA		
3. Social and economic factors			
3.1. Cultural heritage	NA		Impact on cultural heritage or protected areas is not anticipated as construction will take place at the existing INPP site (Section 7.8).
3.2. Discrimination	NA		Construction activity has no discriminative elements.
3.3. Property	NA		NNPP will be constructed within the boundaries of the existing INPP site and therefore no impact on property is anticipated.
3.4. Income	0	National	Construction will have a positive impact on tax income. Also some of the electricity will be sold abroad. These will have a strong positive impact on the national income.

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
	+	Regional	Rise of regional income is anticipated as a result of increase in sales of goods and services.
3.5. Education possibilities	NA		No impact on education possibilities is anticipated. Education network is already established. Immigration of families of constructors, which may demand education facilities, is not anticipated.
3.6. Employment, labour market, business opportunities	0	National	Minor increase in labour market on national level is expected.
	+	Regional	In the construction activity approx. 3 500 people at the maximum will be employed. This will temporarily develop regional labour market as a certain number of construction employees will be contracted from local labour market. Therefore positive impact on employment rate and reduction of unemployment (given in Section 7.9.1.2) is anticipated.
3.7. Criminality	0	National	Minor impact on the national criminality level is anticipated.
	-	Regional	In case a large number of construction workers will come from distant regions, criminal situation may worsen in the region. The cause may be social isolation related to distancing the workers from their families.
3.8. Leisure, recreation	NA		Leisure and recreation conditions will not alter.
3.9. Movement	NA		Construction activity will not affect free movement
3.10. Social security (social contact and welfare)	NA		Construction is a temporary activity and therefore the impact on social security will be minor.
3.11. Sociality, sociability, cultural contact	NA		Construction is a temporary activity and therefore the impact on sociality will be minor.
3.12. Migration	0	National	Minor impact on national migration levels is anticipated.
	-	Regional	Regional migration level may be affected in case of immigration of a number of construction specialists from other countries. Aspects of emigration of the existing population involved in Ignalina NPP operation and closure is evaluated in a special state programme of the termination of activity of the first and second units of INPP (*State Journal, 2005, No. 17-536*).
3.13. Family constitution	NA		
4. Professional risk factors (chemical, physical, biological, ergonomic, psychosocial, manual work)	Given in the next Section		
5. Psychological factors			

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
5.1. Aesthetical appearance	0		NNPP will be constructed within the boundaries of the existing INPP site therefore no impact on aesthetical appearance is anticipated. Impact of the NNPP on the landscape is assessed in Section 7.7.
5.2. Comprehensibility	NA		
5.3. Capability to hold the situation	NA		
5.4. Significance	+		Construction of the facility is significant for the economy of the entire country and region.
5.5. Possible conflicts	0		NNPP will be constructed within the boundaries of the existing INPP site. Therefore conflicts with the adjacent population are not anticipated.
6. Social and health services (acceptability, suitability, succession, efficiency, protection, availability, quality, self-help technique)	0		A network of social and health services is already developed and will be sufficient for the construction period. The nearest facilities are: ▪ The Centre of Primary Health Care of the town of Visaginas, Taikos av. 15 LT-31139 Visaginas ▪ „Ambulansas" – Ambulance branch of the town of Visaginas, Taikos av. 15 LT-31139 Visaginas ▪ Hospital of the town of Visaginas, Taikos av. 15 A LT-31107, Visaginas

Table 7.10–14. Risks of the operation stage (duration 60 years).

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
1. Factors of behaviour and lifestyle (nutrition habits, alcohol consumption, smoking, consumption of narcotic and psychotropic drugs, safe sex and other)	+	National	Increase of electrical power production and consequently reduction of costs of electrical power and consumer goods will result in increase of accessibility of quality consumer goods and services
	+	Regional	Better labour prospects increase social status, reduce social exclusion and shall reduce consumption of drugs and alcohol given that the workers of the existing INPP are not discriminated in terms of employment.
2. Factors of physical environment			
2.1. Air quality	+	National	Reduction of air pollution and related diseases resulting from cutting of combustion of fossil fuel.
	-	Regional	Boiler and steam plant, traffic air pollution and other industrial emissions will be discharged to ambient air.

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
			As a result of big distance to the nearest settlements air pollution will not exceed allowable levels in the surrounding close to access roads settlements. The Section below presents emission rates and impact on air quality.
2.2. Water quality	+	National	Reduction of the use of fossil fuel will result in decrease of soil and underground pollution and consequently will ensure quality of groundwater.
	0	Regional	No impact on quality of potable groundwater is anticipated. Underground contamination from containers of chemicals will be avoided as a result of proper container sealing and spill prevention. Drinking water will be used for household consumption, process water production and maintenance. Water will be supplied from Visaginas municipal water supply network. Cooling and service water will be supplied from Lake Druksiai. Detailed information of water consumption is presented in Section 7.1. Wastewater will be discharged to Visaginas waste water treatment plant from which, after treatment, to Lake Skripku, then Lake Druksiai. Waste water treatment and discharges as well as effluent pollution are presented in Section 7.1. Rainwater and industrial water, after local treatment as given in Section 7.1, will be discharged to Lake Druksiai.
2.3. Food quality	+	National	Reduction of the use of fossil fuel will result in decrease of air and soil pollution and consequently level of toxic compounds in crops or fruits and vegetables.
	+	Regional	Contamination of fish in Lake Druksiai will not alter compared to the present situation (see Section 7.1).
2.4. Soil	+	National	Reduction of the use of fossil fuel will result in decrease of soil pollution.
	0	Regional	Soil contamination from containers of chemicals will be avoided as a result of proper container sealing and spill prevention.
2.7. Noise	0	National	No impact is anticipated on national level.
	-	Regional	NPP is not noisy industry: noise emitting machines and facilities are as a rule located inside of buildings in the area. Ventilation system mounted on the exterior wall or roofs will not cause increase of noise in adjacent settlements as a result of long distance and considerably low noise emission levels. Increase of traffic as a result of operation of the new NPP is not anticipated given existing INPP is dismantled by the start of the operation of the new plant. At certain periods when dismantling works are not finished traffic may increase and consequently noise as well.
2.8. Home conditions	0	National	Not impact on home conditions is anticipated.
	+	Regional	If a large number of employees from distant areas

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
			will be employed, apartment rental price may raise in surrounding areas. It will benefit local residents.
2.9. Safety	+		Accidents, external and internal events, including terrorism, can pose a threat to the safe operation of a nuclear power plant. However, the potential accidents and internal and (or) external threats are taken into account in the design of the power plant (see Chapter 5 and 10). It is provided that the safety of the nuclear power plant will be ensured by the introduction of advanced physical, nuclear and radiation safety measures.
2.10. Means of communication	0		Communication network is already established.
2.11. Territory planning	0	National	Except for site planning no other territorial planning is anticipated.
	0	Regional	Except for site planning no other territorial planning is anticipated. NNPP will be constructed at the existing INPP site and therefore the land use of the surrounding areas will not be altered.
2.12. Waste management	0	National	Different non-radioactive waste types and their amounts are presented in Chapter 6. Management of non-radioactive waste will have minor impact on national level as will be disposed of or utilized in the regional waste management system. Radioactive waste generation and management are presented in Section 6.2.2.
	0	Regional	Different non-radioactive waste types and their amounts are presented in Chapter 6. Waste will be utilized or disposed of in regional waste management system. Hazardous waste will be delivered to national system. Radioactive waste generation and management are presented in Section 6.2.2.
2.13. Power appliance	0	National	Electrical power network is already laid in the course of construction of the existing nuclear power plant.
	+	Regional	Certain electrical cables or lines will be laid connecting the new NPP with the existing network. Operation of the new NPP will require energy in a form of electrical power, natural gas, diesel fuel and nuclear fuel. Sources of supply and annual amounts are given in Chapter 1.
2.14. Risk of accidents	0	National	National level negative impact of non-radiological accidents is hardly possible.
	-	Regional	Minor non-radiological accidents may be anticipated related to technological issues, failure of treatment facilities, failure of operation of equipment or machines, fires or explosions. As a result of not less than 2 km distance to the nearest living areas, negative impact on public health from minor non-radiological accidents is not anticipated with the exception of transportation accidents.

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
2.15. Passive smoking	NA		
3. Social and economic factors			
3.1. Cultural heritage	NA		NNPP will be constructed within the boundaries of the existing INPP site therefore no impact on existing cultural heritage and other objects is anticipated (Section 7.8).
3.2. Discrimination	NA		Projected activity has no discriminative elements.
3.3. Property	NA		NNPP will be constructed within the boundaries of the existing INPP site and therefore no impact on property is anticipated.
3.4. Income	0	National	Increase of gross national product (GDP) on national level is expected.
	+	Regional	Increase of GDP is anticipated for the region (Section 7.9).
3.5. Education possibilities	NA		Education network is developed already. In case foreign personnel will be employed, local education capacities for education of foreign children may be required.
3.6. Employment, labour market, business opportunities	+	National	Minor labour market increase on national level is expected.
	+	Regional	The NNPP will employ approx. 500 people. Income will increase for this group. Raise of income will increase income indicator for the region (Section 7.9).
3.7. Criminality	0	National	No effect on national criminality level is anticipated.
	+	Regional	As a result of increase of social security criminal situation should improve in the region with the precondition that the population living in the region is given worth labour opportunities.
3.8. Leisure, recreation	NA		No recreation or leisure facilities are planned. NNPP will be constructed within the boundaries of the existing INPP site therefore no impact on the existing network is anticipated.
3.9. Movement	NA		Planned activity will not affect free movement.
3.10. Social security (social contact and welfare)	0		No impact on national level is anticipated.
3.11. Sociality, sociability, cultural contact	NA		Operation activity will have no effect on these issues.
3.12. Migration	0	National	Minor impact on national migration levels is anticipated.
	0	Regional	Regional migration level may be affected in case of employment of a number of nuclear specialists from other countries. Large number of such specialists is not anticipated as there are local nuclear professionals that have competence to operate the NNPP (Section 7.9).

Factors influencing health	Positive (+); negative (-); minor (0)	Scale	Comments
3.13. Family constitution	NA		
4. Professional risk factors (chemical, physical, biological, ergonomic, psychosocial, manual work)	Given in the next Section		
5. Psychological factors			
5.1. Aesthetical appearance	0		NNPP will be constructed within the boundaries of the existing INPP site. Impact of the NNPP on landscape is assessed in Section 7.7.
5.2. Comprehensibility	NA		
5.3. Capability to hold the situation	NA		
5.4. Significance	+		The facility is significant for the economy of the entire country.
5.5. Possible conflicts	0		NNPP will be constructed within the boundaries of the existing INPP site and therefore conflicts with the population are not anticipated with the exception of interest groups that are against nuclear power (Section 7.9).
6. Social and health services (acceptability, suitability, succession, efficiency, protection, availability, quality, self-help technique)	0		Network of social and health services is developed already and will be sufficient for the planned NNPP.

As given in the tables above, certain risks are quantitative while other could be qualitative. Among those that could be predicted in detail are those related to measurable environment pollution, e.g.:

- Air pollution;
- Noise.

Major occupational non-radiological risks

As required by Lithuanian public health impact assessment legal acts, including Law of public health care of the Republic of Lithuania (*State Journal, 2002, No. 56-2225*), Rules of assessment of the cases of public impact not included in the law of environment impact assessment of the planned economic activity (*State Journal, 2004, No. 109-4091*) and Methodical guidelines for the public impact assessment (*State Journal, 2004, No. 106-3947*), a public health impact report shall cover occupational risks, which have to be assessed within the scope of Occupational risk assessment, which is a responsibility of the employer.

Table 7.10–15 below presents the main occupational non-radiological risks during construction stage.

Table 7.10–15. Main occupational risks during construction stage.

Risk factor	Risk
Uncomfortable working posture resulting from level of working environment and repeated movements	Risk of injury
Motion over barriers, motion on slippery, uneven surface very close to sharp edges	Risk of injury
Delivery of instruments and materials	Risk of fall, crush, joint loading, injury of palm, injury of back
Motion of high and unsteady surfaces	Risk of fall from height
Cleaning with high pressure devices	Risk of dust, noise impact, eyes inflammation, risk of injury
Fall of stored items or materials	Risk of crush, compression or fall down
Polishing, levelling	Dust, vibration, noise and repeated movements
Work in poorly illuminated area	Risk of injury, sight disorders
Motion in areas with traffic of machines, transport and similar	Risk of injury
Excavation works	Risk of fall
Work close to sharp objects, armature, metal elements of constructions and similar	Risk of injury or punching
Work in sewage wells or confined areas	Risk of suffocation, contamination with gems
Work close to electrical power lines and installations	Risk of electrical shock
Work along or at roads and streets with traffic	Risk of accidents and injuries
Work in warm rooms or outside area	Risk of heat impact
Contact with concrete, cement, lime, glues, paints, varnishes, solvents and other chemicals	Risk of skin impairment, intoxication
Driving trucks and machines	Accident and injury risk
Storage of chemicals and gases	Risk of explosion and fire
Cutting with oxygen	Risk of burn and intoxication with fumes
Cutting, drilling and grinding of concrete, bricks and other construction materials	Dust, thermal impact, injury risk, vibration
Welding	Risk of electrical shock, burn, intoxication with welding fumes, UV, IR radiation
Use of lifting equipment	Risk of injury
Use of portable cutting, drilling, perforating machines	Noise, vibration, risk of injury
Responsibility, work intensity	Stress

The listed impacts will be avoided by the use of collective and personal safety and protection measures. Quantitative evaluation of the occupational environment impact will be evaluated by the employer according to national Occupational Risk Assessment Regulations (*State Journal 2003, No. 100-4504*).

Main occupational non-radiological risks during the operation of the NNPP are presented in Table 7.10–16.

Table 7.10–16. Main occupational risks during operation stage.

Risk factor	Risk
Responsibility, work intensity	Stress
Unergonomic working posture	Risk of injury
Delivery of instruments and materials	Risk of fall, crush, injury of joints, palm, injury of back
Work at high levels	Risk of fall, injury
Work in poorly illuminated areas	Risk of injury, sight disorders
Motion in areas with traffic of machines, transport and similar	Risk of injury
Work close to electrical power lines and installations	Risk of electrical shock
Storage of chemicals and gases	Risk of explosion and fire
Use of chemicals	Risk of intoxication, chemical burns, working area air pollution
Use of lifting equipment	Risk of injury
Work with computer	Risk of sight problems, health problems due to sedentary work

The listed impacts will be avoided by the use of collective and personal safety and protection measures. Quantitative evaluation of the occupational environment impact will be evaluated by the employer according to national Occupational Risk Assessment Regulations.

The main chemicals to be used at the NNPP and their health risks to the employees are presented in Table 7.10–17. Chemicals are used so that the Material Safety Data Sheet instructions are followed and the risk to the employees is minimized. Detailed information on quantities and use of the chemicals is presented in Chapter 1.

Listed health risks will be avoided by the use of collective and personal protection measures.

The chemical discharges from the NNPP are collected and treated so that they pose no risk to public health. Detailed information on the discharged chemicals is presented in Chapter 6.

Table 7.10–17. The main chemicals to be used at the NNPP and their health risks to the employees.

Chemical	Health risks
Boric acid (in PWR)	Inhalation: Causes irritation to the mucous membranes of the respiratory tract. May be absorbed from the mucous membranes and have toxic impact on nervous and other systems. Ingestion: Symptoms parallel with absorption via inhalation. Skin contact: Causes skin irritation. Readily absorbed through damaged or burned skin. Symptoms of skin absorption parallel with inhalation and ingestion. Eye contact: Causes irritation, redness, and pain. Chronic exposure: Prolonged absorption causes weight loss, vomiting, diarrhea, skin rash, convulsions and anaemia. Liver and particularly the kidneys may be susceptible.
Hydrazine	Potential acute health effects: Very hazardous in case of skin contact (irritant) and of ingestion. Hazardous in case of skin contact (corrosive), eye contact (irritant) and inhalation. Inhalation of the spray mist may produce severe irritation of respiratory tract. Potential chronic health effects: The substance is toxic to blood, kidneys, lungs, the nervous system, mucous membranes. Carcinogenic.

Chemical	Health risks
Ammonia	Ammonia is very alkaline and reacts corrosively with all body tissues. Inhalation: Corrosive. Extremely destructive to tissues of the mucous membranes and upper respiratory tract. Ingestion: Corrosive. Swallowing can cause severe burns of the mouth, throat, and stomach, leading to death. Skin contact: Dermal contact with alkaline corrosives may produce pain, redness, severe irritation or full thickness burns. May be absorbed through the skin with possible systemic effects. Eye contact: Corrosive. Can cause blurred vision, redness, pain, severe tissue burns and eye damage. Chronic exposure: Prolonged or repeated skin exposure may cause dermatitis. Prolonged or repeated exposure may cause eye, liver, kidney, or lung damage.
Lithium hydroxide	Potential acute health effects: Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion and of inhalation. Hazardous in case of eye contact (corrosive). Inhalation of dust will produce irritation to gastro-intestinal or respiratory tract, characterized by burning, sneezing and coughing. Potential chronic health effects: Hazardous in case of ingestion, of inhalation. The substance may be toxic to kidneys, gastrointestinal tract, upper respiratory tract, skin, eyes, central nervous system (CNS).
H_2SO_4	Potential acute health effects: May cause irreversible eye injury. Causes eye irritation and burns. Skin: Causes severe skin irritation and burns. Ingestion: Causes gastrointestinal tract burns. Inhalation: May cause severe irritation of the respiratory tract. Causes chemical burns to the respiratory tract. Potential chronic health effects: Prolonged or repeated skin contact may cause dermatitis. Prolonged or repeated inhalation may cause nosebleeds, nasal congestion, chest pain and bronchitis. Prolonged or repeated eye contact may cause conjunctivitis.
NaOH (50 %)	Inhalation: Severe irritant. Effects from inhalation of dust or mist vary from mild irritation to serious damage of the upper respiratory tract, depending on severity of exposure. Ingestion: Corrosive. Swallowing may cause severe burns of mouth, throat, and stomach. Skin contact: Corrosive. Contact with skin can cause irritation or severe burns and scarring with greater exposures. Eye contact: Corrosive. Causes irritation of eyes, and with greater exposures it can cause burns that may result in permanent impairment of vision, even blindness. Chronic exposure: Prolonged contact with dilute solutions or dust has a destructive effect upon tissue.
NaOH (10-30 %) (20 %)	Same as above. As a result of lower concentration health risks are less.
Lubricating oil	Health hazard acute and chronic. Inhalation: may cause anaesthesia, headache, dizziness, nausea and upper respiratory irritation. Skin: may cause drying of skin and/or irritation. Eyes: may cause irritation, tearing and redness. Ingestion: may cause irritation, nausea, vomiting and diarrhea. Aspiration hazard: if swallowed can enter respiratory system.

Air pollution

The main air pollution sources during construction stage are the following contaminants:

- Carbon monoxide;
- Oxides of nitrogen;
- Sulphur dioxide;
- Suspended particulate matter;
- Carbon dioxide.

Estimated emissions from traffic during the construction stage are presented in Table 7.10–18 below. The figures in the table include emissions from both the traffic of the new NPP as well as the decommissioning of INPP.

Table 7.10–18. Annual amounts of emissions from traffic during construction stage, tonnes.

	Amount, units	CO	NO_x	SO_2	Solid particles	CO_2
Traffic of the new NPP as well as the decommissioning of INPP (mobile sources)	tonnes/year	97.8	30.3	0.11	0.55	3549

During construction dust is raised from land building work, soil transport and dumping, site traffic and some separate operations such as concrete mixing stations. Sources of dust are usually located quite low and the amount is small so the impact is local and dusting will not have impact on the air quality outside the construction site.

The main air pollution sources during operation are emissions from traffic, heat and steam boilers, and back up diesel generators. The estimated emissions are presented in Table 7.10–19 below. The figures in the Table 7.10–19 include emissions from both the traffic of the new NPP as well as the decommissioning of INPP. Dust is mainly raised from traffic and does not have any significant impact.

Table 7.10–19. Annual amount of emissions from traffic during operation stage, tonnes.

	Amount, units	CO	NO_x	SO_2	Solid particles	CO_2
Traffic of the new NPP as well as the decommissioning of INPP (mobile sources)	tonnes/year	43.6	13.6	0.05	0.25	1593

The annual emissions from the steam only boiler, the heat only boiler and diesel generators are presented for different periods of time in Table 7.10–20. It should be noted that only a minor part of the heat only boiler production goes to the NNPP so the emissions from the heat only boiler can not be considered as NNPP emissions.

Table 7.10–20. Annual emissions from stationary sources, steam only boiler, heat only boiler and diesel generators, in tonnes/year.

Pollutant	Steam Boiler		Heat boiler		Diesel generators
	2005–2009	2010–2025	2005–2009	2010–2025	2015–>
SO_2	0	0	0	0	0.2
NO_x	16	33	39	116	1
CO	6	12	14	41	
CO_2	21 300	44 620	524 500	157 046	500
Solid particles	0	0	0	0	0.5

As seen from the Table 7.10–18, Table 7.10–19 and Table 7.10–20 the emission of air pollutants is rather small. Pollution will increase about 9 % in the Visaginas municipality and tenth parts of the present in the whole country. It can be concluded that the influence of the planned economical activity in terms of emissions will be minor both on County and municipal level.

Given the importance of the planned activity for reduction of both national and regional emissions of air pollutants from fossil fuel combustion, emissions from the planned activity will be insignificant.

Noise

The construction of the NNPP will take approximately 5–7 years. Local noise increase might be expected during construction works. Such impact, conventional for any construction activity, could be relevant only in the close vicinity of the NNPP where no population lives permanently. Since the construction machines operate intermittently and the types of machines in use at the construction site change with the stage of the project, the noise emitted during construction will be variable. However, since the nearest residential properties are located at least 2 km away from the NNPP sites, it is expected that noise from the construction will rarely exceed the existing levels.

The main sources of noise during construction stage are construction machines and traffic. Noise power of the construction machines may average as follows:

- Pneumatic equipment – 115 dBA;
- Metal equipment – 105;
- Electric engines – 85 dBA;
- Air compressors – 105 dBA.

Predicted levels of environmental noise from traffic and machines during construction are presented in Figure 7.10-8 and Figure 7.10-9. The corresponding noise levels for the colours of the maps are given in Figure 7.10-7.

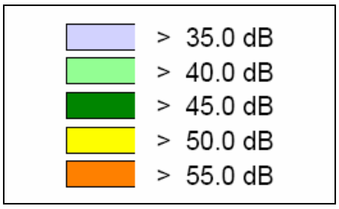


Figure 7.10-7. The colours and corresponding noise levels.

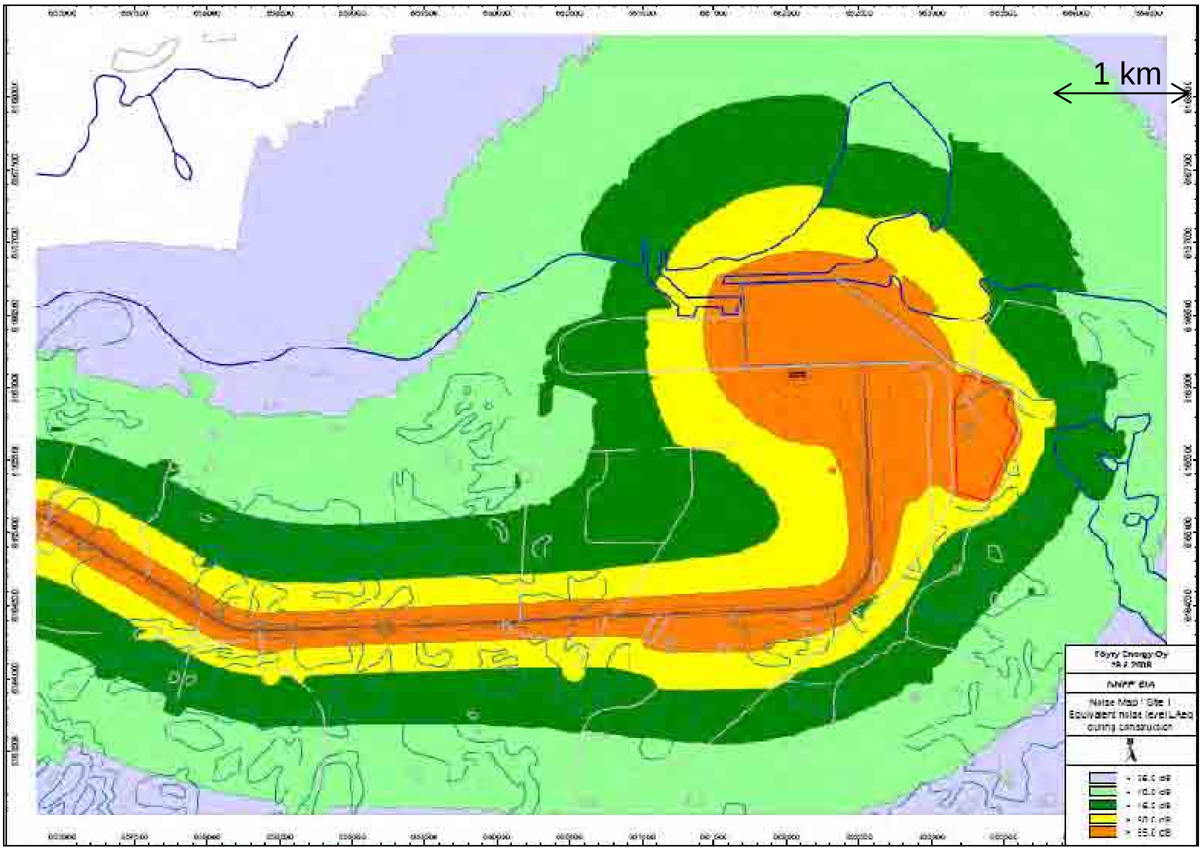


Figure 7.10-8. Noise map for Site No. 1 during construction phase.

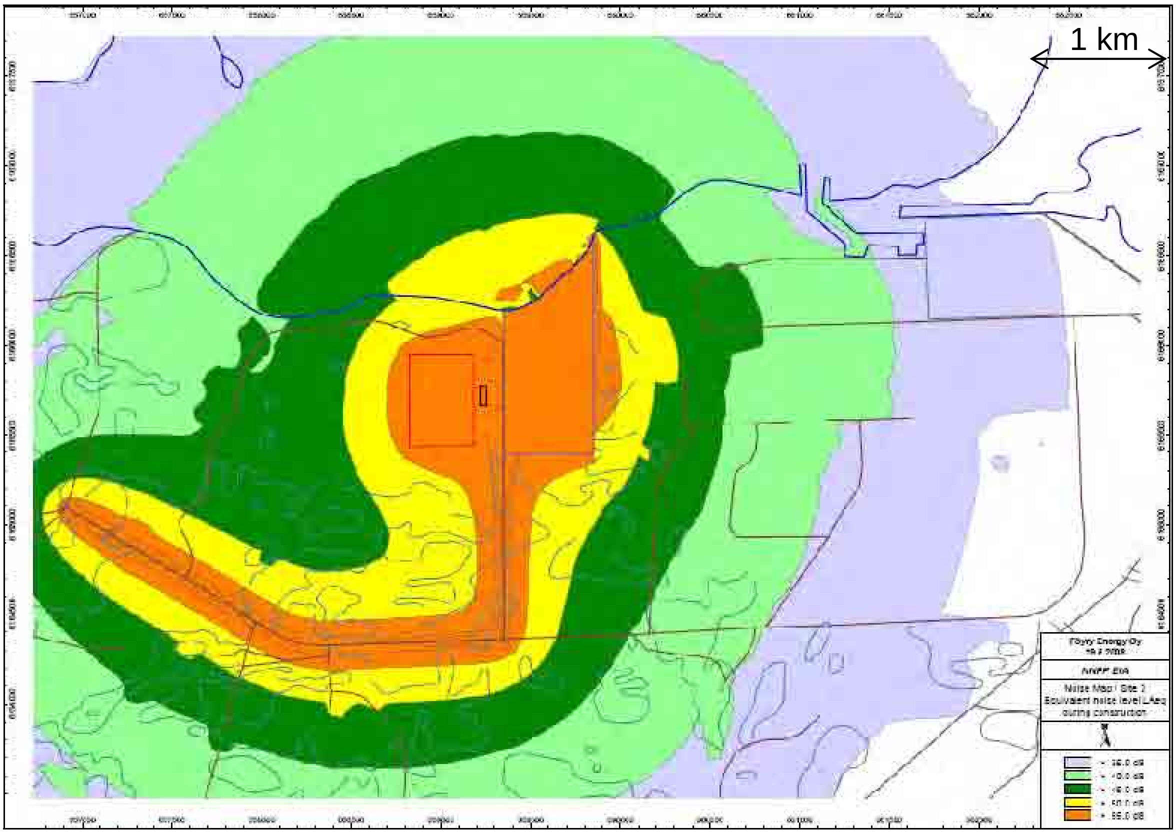


Figure 7.10-9. Noise map for Site No. 2 during construction phase

The main sources of noise during operation stage are ventilation equipment, diesel back up generators, turbines and traffic. Noise power of equipment may average as follows:

- Power generators – 90 dBA;
- Fan equipment – 100 dBA;
- Turbo generators – 92 dBA (they will be mounted inside the building, which will be shielded from noise).

What is heard outside of the plant during operation is a continuous faint humming noise around the clock. The noise is easily covered by other sources of noise like the wind. If the new plant will use a pressurized water reactor, the steam circuit will have safety valves, which will be tested during annual maintenance. When tested, the valves release high pressure steam and loud but short noise will emerge above the general noise level of the plant area. If cooling towers will be used these will also emit noise. The noise from natural draft wet cooling towers, the most likely cooling tower solution for the NNPP, is due to falling water inside the tower.

Predicted levels of environmental noise from traffic and equipment, including natural draft cooling towers, during operation are presented in Figure 7.10-10 and Figure 7.10-11. The corresponding noise levels for the colours of the maps are given in Figure 7.10-7.

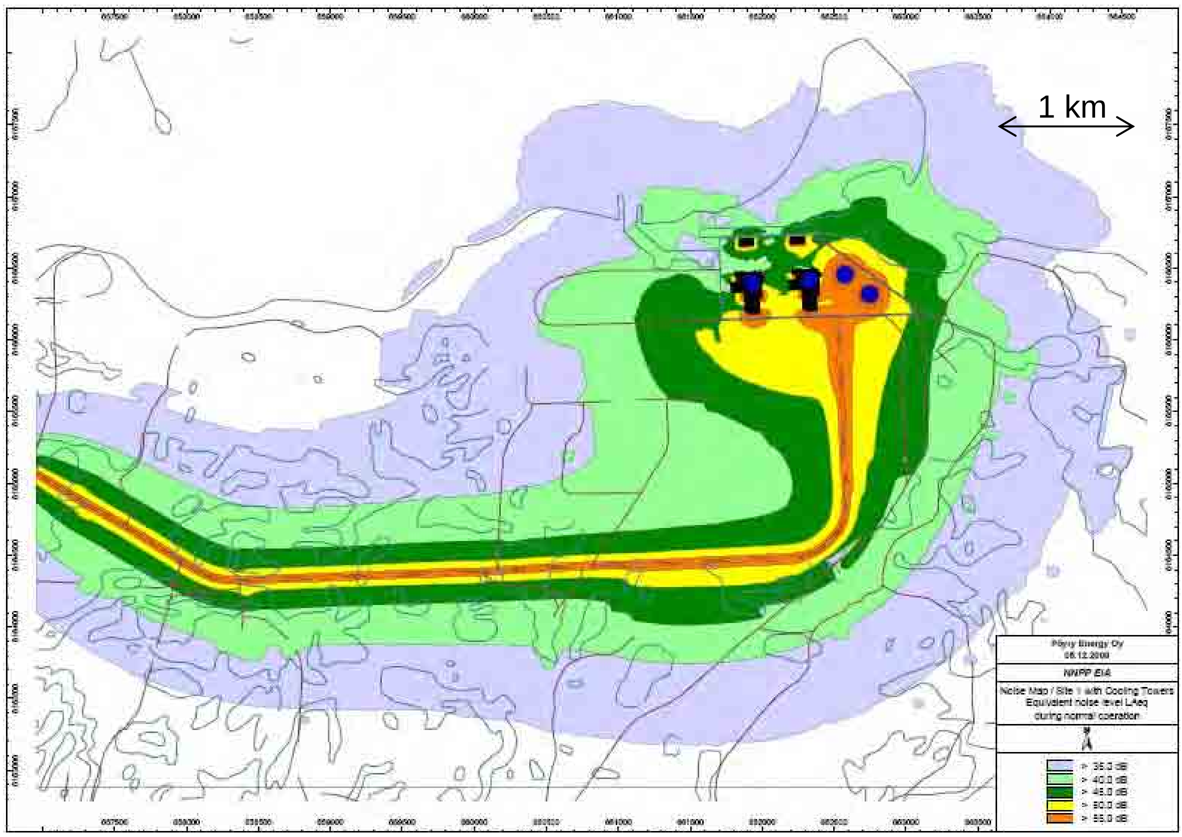


Figure 7.10-10. Noise map for Site No. 1 during operation phase.

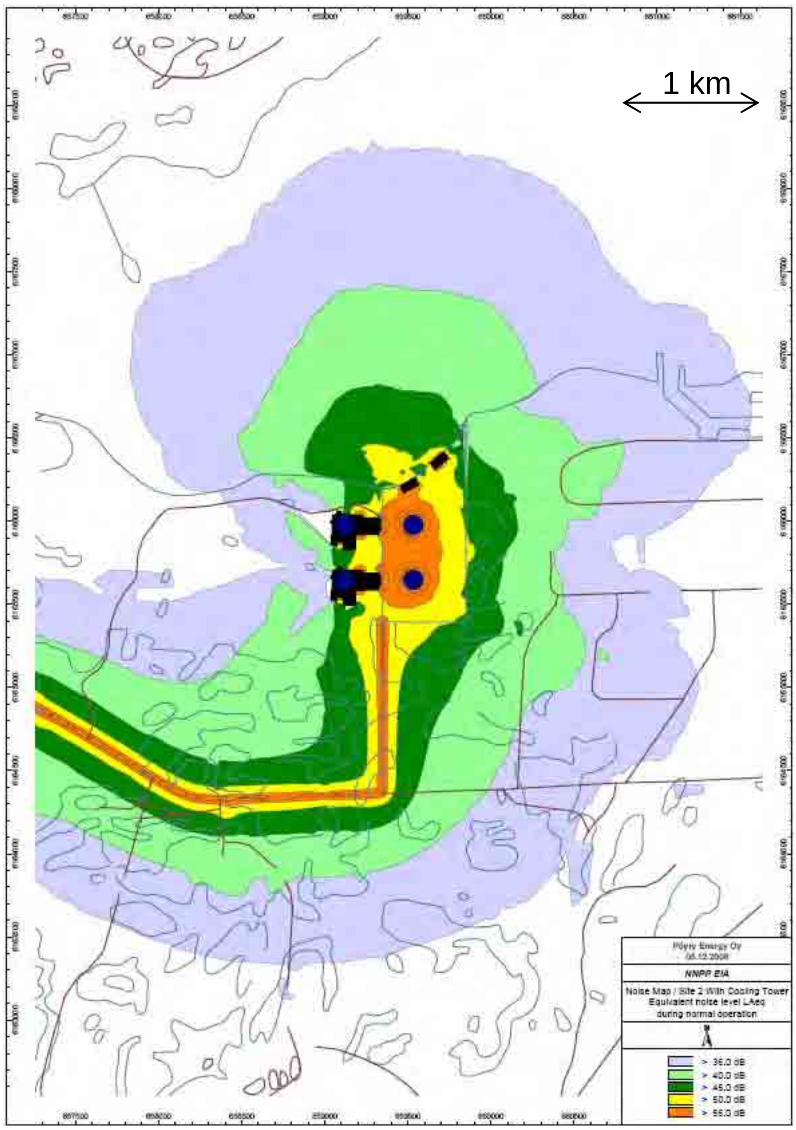


Figure 7.10-11. Noise map for Site No. 2 during operation phase.

Lithuanian Hygiene Standard HN 33:2007 (*State Journal, 2007, No. 75-2990*) requires noise not to exceed the levels presented in Table 7.10–21.

Table 7.10–21. Noise limit values (*HN 33:2007*).

Facility	Equivalent noise level, dBA	Maximal noise level, dBA	Time of day, hour	Noise levels applicable for noise mapping			
				L_{av}	L_{6-18}	L_{18-22}	L_{22-6}
007 Immediate environment of living and public buildings	65 60 55	70 65 60	6–18 18–22 22–6	65	66	61	55

As can be seen from the above presented maps, noise levels during the construction stage (including transport) will not exceed 55 dBA (night time level in urban areas) at a distance of 80-100 m from the centre of road. Noise at the construction site does not exceed 55 dBA at a distance of approx. 850 m from the centre of the area of construction.

Noise levels during operation stage (including transport) will not exceed 55 dBA (night time level in urban areas) at a distance of 30–40 m from the centre of road. Noise at the operation site does not exceed 55 dBA at a distance of approx. 250 – 300 m from the centre of the area of operation.

Obviously construction works or transportation activity during the operation stage will not be carried out at night time and therefore the zones of excess noise will not be as wide as given above.

Noise can cause hearing impairment, interfere with communication, disturb sleep, cause cardiovascular and psycho-physiological effects, reduce performance, and provoke annoyance responses and changes in social behaviour. The main social consequence of hearing impairment is the inability to understand speech in normal conditions, which is considered a severe social handicap.

Hearing impairment is mostly restricted to the work setting. Non-industrial noise is referred to as community noise, also known as environmental, residential or domestic noise.

For most people, life-time's continuous exposure to an environmental average noise level of 70 dB will not cause hearing impairment. An adult person's ear can tolerate an occasional noise level of up to 140 dB, but for children such an exposure should never exceed 120 dB. *(WHO, Occupational and community noise)*

The main health effects linked to high levels of noise are presented in Table 7.10–22 below.

Table 7.10–22. The main health effects linked to high levels of noise (*– Source: WHO, Occupational and community noise).

Environment	Critical health effect	Sound level dB(A)*	Time hours
Outdoor living areas	Annoyance	50–55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	Sleep disturbance	30	8
School classrooms	Disturbance of communication	35	During class
Industrial, commercial and traffic areas	Hearing impairment	70	24
Music through earphones	Hearing impairment	85	1
Ceremonies and entertainment	Hearing impairment	100	4

As can be seen from the maps of environmental noise (Figure 7.10-8, Figure 7.10-9, Figure 7.10-10, Figure 7.10-11), the levels of noise will not exceed the allowable levels set out for residential areas both in settlement along roads and settlement next to the sanitary protection zone of the planned sites. Therefore negative health effects from noise are not anticipated.

If necessary, the noise level in open air will be measured at locations in which such noise is perceived most clearly. If necessary, the works will be stopped and means for noise reduction will be implemented. Consequently, the construction activities will have minimal and temporary impacts on the levels of environmental noise at the locations of the nearest residential receptors.

When the construction works are finished, the amount of potential sources of noise will be reduced. The construction machines will be removed from the site and the transport of construction materials will be terminated.

Equipment mounted inside the buildings will be shielded by the building structure. Therefore NNPP interior equipment and machines will produce no noise that will be perceptible at the nearest residential receptors.

Premises of operators can be adequately isolated from noise.

Summary of non-radiological impact

The main qualitative non-radioactive impacts are presented in table format above. Most of the effects are minor.

Then main positive impacts are in the areas of economy and social security, while negative non-radiological effects are mainly related to environmental pollution and accidents as given in Table 7.10–23. Negative impacts can be mitigated and therefore they will be minor.

Table 7.10–23. Impacts of the proposed economic activity on factors influencing the health.

Factors influencing the health	Kind of activity or means, contamin. sources	Impact on factors influencing the health	Impact on health	Forecasted changes of the analyzed indicators	Possibilities to mitigate (eliminate) the negative impact	Comments and remarks
Construction phase						
1. Air pollution	Transport	CO, NOx, SO_2, solid particle emissions	Minor	Not estimated as a result of small emissions		Impacts are applicable for residents. Impact on employees will be assessed within the scope of occupational risk assessment.
2. Noise	Traffic, construction machines and equipment	Annoyance	Increase of noise level	Noise from traffic will not exceed 55 dBA at a distance of 80-100 m from the centre of road. Noise from the construction site will not exceed 55 dBA at a distance of approx. 850 m from the centre of the area of construction. Noise will not exceed allowable levels outside the existing sanitary protection zone of INPP.	Noise control of construction machines and equipment	Impacts are applicable for residents. Impact on employees will be assessed within the scope of occupational risk assessment.
3. Risk of accidents	Traffic	Construction and traffic accidents may increase.	As a result of increase of traffic more	Qualitative assessment	Traffic control and new roads	

Factors influencing the health	Kind of activity or means, contamin. sources	Impact on factors influencing the health	Impact on health	Forecasted changes of the analyzed indicators	Possibilities to mitigate (eliminate) the negative impact	Comments and remarks
		Mainly employees and areas along roads may be involved	transport accidents are expected			
4. Migration	Construction	Immigration of highly qualified NPP construction foreign employees	Minor	Qualitative assessment	Employment of the existing construction labour force when possible	
Operation phase						
1. Air pollution	Transport, steam boiler, heat boiler and diesel generators	CO, NOx, SO_2, solid particle emissions	Minor	Increase of emissions equalling 0.1-8.93 % on municipal level and substantially less on county level	Paving of roads, treatment of flue gases	
2. Noise	Traffic, fan equipment, turbogenerators, power generators	Annoyance	Minor	Noise from traffic will not exceed 55 dBA (night time level in urban areas) at a distance of 30-40 m from the centre of road. Noise from the operation site does not exceed 55 dBA at a distance of approx. 80 m from the centre of the area of operation. Noise will not exceed allowable levels outside the existing sanitary protection zone of INPP	Noise shielding	
Risk of accidents	Minor non-radiological technological accidents may be anticipated	Fire, release of untreated exhaust	Minor	Qualitative assessment	More than 2 km distance to the nearest living areas will ensure that negative impact will not be noticeable	

Factors influencing the health	Kind of activity or means, contamin. sources	Impact on factors influencing the health	Impact on health	Forecasted changes of the analyzed indicators	Possibilities to mitigate (eliminate) the negative impact	Comments and remarks
Migration	Operation of nuclear installations	Immigration	Minor	Qualitative assessment	Employment of local nuclear professionals	Large number of nuclear specialists is not anticipated as there are local nuclear professionals that have competence to operate NPP.

Anticipated negative impacts are summarized in Table 7.10–24 and Table 7.10–25.

Table 7.10–24. Possible impact of proposed economic activity on public groups.

Public groups	Kind of activity or means, contamination sources	Group size	Impact	Comments and remarks
1. Public groups (local population) outside the existing sanitary protection zone of INPP	Construction and operation	There is no permanently living population in the sanitary protection zone of INPP. Economical activity is limited.	0	Impact within the sanitary protection zone of INPP will be minimal. Outside the sanitary protection zone, the impact can be considered as insignificant.
2. Personnel	Operation	500–1000	(-)	Personnel exposure due to the proposed economic activity can be controlled and limited using, where appropriate, shielding, remote-controlled equipment, proper operational procedures etc. Personnel exposure will be optimized during the Technical Design and will not exceed the limits prescribed by occupational health and safety requirements.
3. Other	Not relevant			

Table 7.10–25. Assessment of features of quantitative impacts.

Impact induced by factor	Impact features								
	Number of persons under the impact			Evidence (possibility), strength of the evidentiary material			Duration		
	< 500	501–1000	> 1001	Clear	Probable	Possible	Short (< 1 y)	Medium (1–3 y)	Long (> 3 y)
1. Noise		+				+			+
2. Air pollution		+				+			+

7.10.2.2 Radiological impact

Assessment of the radiological impact on the population during the normal operation of the new NPP, assuming the radionuclide releases described in Sections 7.1 and 7.2, is provided in this section. Also the annual doses, received by the members of the various critical groups of the population, stipulated by the impact not only of the new NPP, but also of the existing and planned nuclear facilities of Ignalina NPP are assessed. The construction of the new NPP is one of the stages of the planned economic activity. During the construction there will be no radiological impact of the new NPP to the population, but the builders of the power plant will be exposed to the radiological impact from the nuclear facilities of Ignalina NPP, which is also evaluated in this section. Potential radionuclide releases in case of Design Basis Accident and Severe Accident, as well as the resulting impact on the population are analysed in Chapter 10.

Radiation Protection Requirements for Members of Personnel

The Republic of Lithuania hygienic norm HN 73:2001 (*State Journal, 2002, No. 11-388; 2003, No. 90-4080*) defines dose limits for workers:

- The limit for effective dose – 100 mSv in a consecutive 5 year period;
- The limit for annual effective dose – 50 mSv;
- The limit on equivalent dose for the lens of the eye – 150 mSv in a year;
- The limit on equivalent dose for the skin, limbs (hands and feet) – 500 mSv in a year. This limit has to be averaged over 1 cm2 area of skin subjected to maximal exposure.

The normal practice for NPPs is to supplement regulatory requirements by internal procedures on radiation protection. These procedures foresee additional requirements for assurance of permanent control and optimization of radiation impact on personnel. The implementation of principle of ALARA is also considered. For example, annual exposure of personnel members are controlled to be below 20 mSv as not to exceed yearly average for consecutive 5 year period dose limit and thus do not impose special limitations on working activities during subsequent years.

Radiation Protection Requirements for Members of General Public

The Republic of Lithuania hygienic norm HN 73:2001 (*State Journal, 2002, No. 11-388; 2003, No. 90-4080*) defines dose limits for members of the public:

- The limit for effective dose – 1 mSv in a year;
- In special circumstances limit for effective dose – 5 mSv in a year provided that the average over five consecutive years does not exceed 1 mSv in a year;
- The limit on equivalent dose for the lens of the eye – 15 mSv in a year;
- The limit on equivalent dose for the skin – 50 mSv in a year. This limit has to be averaged over 1 cm2 area of skin subjected to maximal exposure.

According to requirements of the Republic of Lithuania hygienic norm HN 87:2002 (*State Journal, 2003; No. 15-624, 2008, No. 35-1251*) the exposure of population shall be limited by application of dose constraint during design, operation (both normal operation conditions and anticipated operational occurrences) and decommissioning of nuclear facilities. If more than one nuclear facility contributes to the exposure of the population, the total sum of annual effective doses to members of the public from all contributing nuclear facilities shall not exceed the dose constraint. The established dose constraint for members of the public is 0.2 mSv per year. This value is relatively low, for example, the annual effective dose received by the Lithuanian population from natural ionising radiation sources, in average is 2.1 mSv (*RSC 1997-2007 years* *activities report*). The average values of the doses received from the main natural radiation sources are as follows: indoor radon - 1 mSv, cosmic radiation - 0.35 mSv, construction materials indoors - 0.45 mSv, natural radionuclides in the human body - 0.34 mSv. The average dose of the world's population, received due to the natural radiation, is 2.4 mSv per year. It can be noted that the annual effective dose to a member of the critical population group received due to the radionuclide release into the environment from the currently operated Ignalina NPP was 0.0033 mSv in year 2007.

According to requirements of the Republic of Lithuania normative document LAND 42-2007 (*State Journal, 2007, No. 138-5693*), if radionuclides are dispersed into the environment by several pathways (e.g. by atmospheric and water paths) and the members of the same or different critical groups of population are impacted, the particular pathway resulting dose shall be limited in such a way that the total sum of doses from all pathways shall not exceed the dose constraint. The impact due to direct external ionizing irradiation shall be taken into account and the total dose (due to radioactive emissions and due to direct irradiation) to the critical group member of population shall not exceed the dose constraint.

Radiological impact during normal operation of the NNPP

It is planned that the first unit of the new NPP will start to operate no later than year 2015. Construction and start up of additional units necessary to reach the full design capacity will depend on the project implementation schedule (see Chapter 1).

The radiological impact on the environment during normal operation of a NPP may arise from radioactive airborne and liquid effluents. The buildings and structures of a NPP, which contain radioactive materials, may be sources for external ionizing irradiation.

Radiological impacts from existing and planned Ignalina NPP facilities (interim spent fuel storages, solid radioactive waste management and storage facilities, and others) which shall be considered in the evaluation of total impact (from the new NPP and from Ignalina NPP) are discussed in Section 7.11.

<u>Annual releases of radioactive effluents</u>

Evaluation of the radionuclide releases into the water (into Lake Druksiai) is given in Section 7.1. The annual releases of radionuclides into Lake Druksiai are summarized for different reactor types, which are considered as technological alternatives.

Evaluation of the releases into the atmosphere is given in Section 7.2. The annual releases of radionuclides into the atmosphere are summarized for different reactor types, which are considered as technological alternatives.

These data serve as a basis for calculation of potential exposure of the population.

<u>Method for calculation of annual exposure of the critical group members of population</u>

Dose Assessment using the Dose Conversion Factors Presented in the Normative Document LAND 42-2007

The potential exposure of the population due to the radionuclide releases into the air and Lake Druksiai from the new NPP was calculated using dose conversion factors given in the Annex of the document LAND 42-2007 (*State Journal, 2007, No. 138-5693*). These dose conversion factors represent a relationship between the activity of the constant long-term radionuclide releases into the environment and the dose received by a member of the population in the point of the maximum foreseen exposure. The dose conversion factors were derived after a scientific study had been carried out (*V. Filistovič, E. Maceika, J. Mažeika et al, 1998*), using the location-specific model, taking into account the specific environmental components, peculiarities of radionuclide spread in the environment, as well as location-specific lifestyle and nutrition habits of the members of the critical group of the population together with all relevant external and internal exposure pathways. Although the LAND 42-2007 dose conversion factors are submitted for Ignalina NPP, they can also be applied to the assessment of the new NPP impact, since the dose conversion factors are given for the radionuclides characteristic to the RBMK-1500 reactor, which are dominant and causing the maximum radiological impact in other reactor types and models as well. Moreover, the proposed sites of the new NPP are adjacent to Ignalina NPP, so it can be assumed that the peculiarities of radionuclide spread and human lifestyle will be similar or the same. However, in the subsequent stages of the new NPP project, when the specific technology will be chosen, the model and assumptions for the definition of the dose conversion factors given in LAND 42-2007 will be subject to review and update by the Organizer of the planned activities. The Organizer of the planned activities will also have to assess the limits of activities of the radionuclides released from the new NPP into the ambient air and water.

- The radionuclide specific conversion factors, which are provided in the annex of the normative document LAND 42-2007, are supported by several references, one important among these being *Nedveckaite, et al. 2000*. This document describes the mathematical models implemented to assess the behaviour of the released radionuclides in the components and trophic chains and habits of the critical group members. When choosing critical groups of the population it was found that the greatest negative impact due to airborne radionuclide releases will be felt by farmers, and in case of waterborne radioactive releases – by fishermen or gardeners (in case of transuranic radionuclides). It is assumed, that habits of the critical group members and lake water usage during the operation of the new NPP will not change, therefore there will be no other exposure pathways. In order to avoid exceeding the dose constraint, it was assumed that the annual effective dose due to the flow of radionuclides (airborne and waterborne) should not exceed 0.1 mSv per year.

Dose factors, which are provided in the annex of the normative document LAND 42-2007, were determined taking into account the following assumptions and methods:

- In case of atmospheric releases, the atmospheric dispersion has been evaluated using the Gaussian plume model, which accounts for reflection from the earth's surface and from the top of the mixing layer. Gaussian plume model is widely used in the dispersion modelling and impact estimations of releases from NPP during normal operation. The detailed description of this model is provided in IAEA Safety Standard Series No. 19 "Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment" (*IAEA SSS No. 19*). The State-approved, long-term meteorological data (wind speed and direction, air temperature, cloudiness, cloud height and precipitation) from the nearest meteorological station with similar terrain (15 km from the Ignalina NPP) has been used. Corrections have been made for the influence of wind velocity at the stack height and plume rise.
- The accumulation of radionuclides over a time period of 40 years on an originally uncontaminated ground surface is considered. The new NPP is planned to operate for 60 years. The accumulation balance of many radionuclides, which are assessed in this EIA report, stabilizes in less than 40 years. As shown by the preliminary dose calculations according to the methodology described in IAEA Safety Standards Series No. 19, assuming accumulation of radionuclides of 40 and 60 years, the difference of the results obtained is less than 0.1%. Radionuclide concentrations in

agricultural and animal products, for the most unfavourable conditions, have been calculated using a linear transfer model. The following exposure pathways are the most significant when estimating the annual external and internal dose from atmospheric releases for the critical group of farmers: immersion in the plume, inhalation, external exposure from ground deposition, and ingestion of contaminated food. This critical group was assumed to reside in the most unfavourable conditions in the near vicinity of the INPP.

- In the case of releases into water, the highest radionuclide concentration is expected in the mixing zone of heated effluent water in Lake Druksiai. Thus, the radionuclide specific releases to dose conversion factors have been calculated for the fishermen fishing in this zone or the gardeners using the water of Lake Druksiai for the irrigation of their gardens. The annual exposure of the critical group of fishermen was estimated considering the following exposure pathways: external exposure resulting from the radionuclides in the lake water and in the coastal zone sediments, as well as internal exposure caused by the fish used for food (radionuclide intake and inhalation with water spatter is insignificant).. Exposure of gardeners in small suburban gardens, situated close to Lake Druksiai and using its water for irrigation, has also been estimated. In the case of gardeners, external exposure resulting from the radionuclides deposited in the irrigated soil, as well as internal exposure due to consumption of the food from the irrigated garden and the inhalation of re-suspended particles was taken into account. For most radionuclides, the dose conversion factors for the exposure of fishermen is greater compared to the exposure of gardeners.

The evaluation of the radionuclide volumetric activity in the air took into account the secondary rise of radionuclides - resuspension (resuspension factor - 10^{-6} m^{-1}). The impact of the airborne radionuclide release due to inhalation was assessed for two age groups – for 10 year old children and adults. It was assumed that the children's respiratory rate is 15 l/min. and the adult respiratory rate is 30 l/min.

The critical group of fishermen is constituted of professional fishermen, working 8 h/day, i.e. about 2000 h/year. During the calculation of the dose conversion factors it was assumed that due to adverse weather conditions the fishing time is shortened about 25%, i.e. up to 1500 h/year. Assessing the exposure due to fish consumption, two age groups were taken into account, assuming the same quantity of fish eaten. One age group is made up of 7-12 year old children, and another of residents older than 17 years.

The basic parameters used in the evaluation of the annual dose received by the gardeners are provided in Table 7.10–26.

Table 7.10–26. The basic parameters used in the evaluation of the annual dose received by the gardeners

Parameter	Value
Time spend in the watered territory, hours/year	4500
Water amount used for irrigation, l/m^2	300
Resuspension factor, m^{-1}	10^{-6}
Breathing rate (adult person), m^3/hour	1.2

Since there is no exact data about food consumption in Ignalina region, average food consumption rates in Lithuania, except fish consumption, were multiplied twice and used for dose estimation. Fish consumption rate was assumed to be 100 kg per year, which is about ten times higher than average fish consumption in Lithuania. The food consumption rates used for the definition of dose factors are provided in Table 7.10–27.

Table 7.10–27. Average food consumption in Lithuania *(V. Filistovič, E. Maceika, J. Mažeika et al, 1998)*.

Food product	Consumption rate, kg/d
Meat and meat products	0.26
Milk and milk products	1.29
Cereals	0.3
Potatoes	0.37
Root vegetables	0.18
Fruits	0.077
Green vegetables	0.05
Eggs	0.068
Fish	0.03

Resulting doses from different radionuclides were evaluated in (*V. Filistovič, E. Maceika, J. Mažeika et al, 1998*) and dose factors, i.e. ratio between annual effective dose and activity of released radionuclides, have been determined for above mentioned members of the critical group. Since in case of releases of radionuclides into water two critical groups were assessed, dose factors were selected which have higher values. Therefore, dose factors provided in LAND 42-2007 are not specifically defined for certain critical group, but these dose factors are conservative values for various radionuclides.

Dose Assessment using Appropriate Models as Recommended by the IAEA

Dose factors, which are provided in normative document LAND 42:2007 (*State Journal, 2007, No. 138-5693*), allow to estimate public exposure in the specific environment of the release source. However, using these dose factors it is not possible to estimate dose variation with distance between the release source and the member of the critical group of the population. Therefore additional dose calculations due to radionuclide releases in air for justification of the SPZ size have been performed according to recommendations of IAEA Safety Standard Series No. 19 “Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment” (*IAEA SSS No. 19*) which allow to estimate dose variation with distance from the release source to the member of the critical group, see Subsection 7.10.3.2.

The impact assessment models of IAEA Safety Standards Series No. 19 include and consider all main airborne activity migration and exposure pathways. These are:

- The calculation of atmospheric dispersion and the resulting near-ground concentration of the released airborne activity at the sites specific exposure locations;
- The calculation of the external exposure annual effective dose to the human due to the submersion into a radioactive cloud and the internal exposure dose due to the inhalation of the air containing radioactive material;
- The calculation of the deposition of radioactivity on the ground and the calculation of the external exposure annual effective dose to the human from the soil contaminated by the deposited activity;
- The calculation of the deposition of radioactivity on the pasture field. The calculation of the activity accumulation in the pasture grass, transfer of activity into animal feed and calculation of the internal annual effective dose to the human due to consumption of the main animal products – milk and meat;
- The calculation of the deposition of radioactivity on the pasture field. The calculation of the activity accumulation in the crop field, transfer of activity into

crop products and calculation of the internal annual effective dose to the human due to the consumption of crop products.

When evaluating the impact on the population due to the airborne radioactive releases two separate critical groups of the population are considered:

- *The 1st group*: a member of this group is a local resident living at the border of the SPZ and self-employed in agriculture (livestock farming, vegetable growing). The total annual effective dose E, caused by external and internal radiation exposure, is calculated using the following formula:

$$E = \sum_j H_j + \sum_j e(g)_{j,ing} I_{j,ing} + \sum_j e(g)_{j,inh} I_{j,inh} \text{ ,}$$

here:

H_j is the critical group member dose equivalent due to the external exposure from radionuclide *j*;

$e(g)_{j,ing}$ and $e(g)_{j,inh}$ are the committed effective doses per unit intake by ingestion or inhalation for radionuclide *j* by a member from the age group g (according to the Lithuanian Hygiene Standard HN 73:2001);

$I_{j,ing}$ and $I_{j,inh}$ are the annual intake via ingestion or inhalation of radionuclide *j*.

- *The 2nd group*: a member of this group is a local resident who passes the SPZ of the new NPP twice per day (up to the point of destination and backwards). It is assumed that a human moves with a speed of 5 km/h in average (in case of 1 km SPZ radius this would constitute around 290 hours per year). The total annual effective dose E for the member of this critical group of the population resulting from external and internal exposure pathways is calculated according to the following formula:

$$E = (\sum_j H_j + \sum_j e(g)_{j,inh} I_{j,inh})k \text{ ,}$$

here:

H_j is the critical group member dose equivalent due to the external exposure from radionuclide *j*;

$e(g)_{j,inh}$ is the committed effective doses per unit intake by inhalation for radionuclide *j* by a member from the age group *g* (according to the Lithuanian Hygiene Standard HN 73:2001);

$I_{j,inh}$ is the annual intake via inhalation of radionuclide *j*;

k is a fraction of a year spent within the INPP SPZ.

The Gaussian plume model is applied to assess the dispersion of long-term atmospheric releases. This model is widely accepted for use in radiological assessment activities. The model is considered appropriate for representing the dispersion of either continuous or long-term intermittent releases within a distance of a few kilometres from the source. The main parameters used for airborne dispersion, activity migration and human exposure calculation are summarized in Table 7.10–28. Since there is no exact statistical data about the habits of population in Ignalina region, the general parameters, which are recommended in IAEA safety standard (*IAEA SSS No. 19*), are used. Details on the mathematical models can be found also in this IAEA safety standard.

Table 7.10–28. Main parameters used for assessment of critical group member exposure due to release of airborne radioactivity

Parameter	Value	Comment
The fraction of the time during the year that the wind blows toward the receptor of interest in 30º sector, dimensionless	0.25	Generic value, also conservative respect to local conditions
The geometric mean of the wind speed representative of one year, m/s	4	At the height of 10 m, local conditions
Forage grass exposure period (growing season), d	30	Generic value
Food crops exposure period (growing season), d	60	Generic value
Delay (hold-up) time between harvest and consumption of forage in the pasture, d	0	Generic value
Delay (hold-up) time between harvest and consumption of forage stored in the store, d	90	Generic value
Delay (hold-up) time between harvest and consumption of food crops, d	14	Generic value
Average time between collection and human consumption of milk, d	1	Generic value
Average time between slaughter and human consumption of meat, d	20	Generic value
Amount of feed consumed by milk produced animal (large animal), kg/d	16	Generic value
Amount of feed consumed by meat produced animal (large animal), kg/d	12	Generic value
Fraction of the year that animals consume fresh vegetation, dimensionless	0.7	Generic value
Surface dry weight of the pasture soil (10 cm depth), kg/m^2	130	Generic value
Surface dry weight of the plough land (ploughshare depth of 20 cm), kg/m^2	260	Generic value
Adult breathing rate, m^3/s	2.66×10^{-4}	Generic value
Infant (1-2 a) breathing rate, m^3/s	4.44×10^{-5}	Generic value
Annual crop (fruit, vegetables and grain, including potatoes) intake for adult, kg/a	410	Generic value
Annual crop (fruit, vegetables and grain, including potatoes) intake for infant (1-2 a), kg/a	150	Generic value
Annual milk intake for adult, L/a	250	Generic value
Annual milk intake for infant (1-2 a), L/a	300	Generic value
Annual meat intake for adult, kg/a	100	Generic value
Annual meat intake for infant (1-2 a), kg/a	40	Generic value

<u>Annual effective doses to population</u>

Dose Assessment using the Dose Factors from LAND 42-2007

Annual exposures of population due to releases of radionuclides into the atmosphere for different types of reactors are summarized in Table 7.10–29.

LAND 42-2007 (*State Journal, 2007, No. 138-5693*) provides dose conversation factors from releases from stacks of 150, 75 and 10 m height. Since the heights of the ventilation stacks for the types of reactors being considered in this EIA Report will be at least 60 meters, basing on the values of dispersion factors for different release heights given in IAEA SSS No. 19 (for heights of 46–80 m dispersion factors are the same), dose conversion factors for radionuclide releases from the height 75 meters have been taken. In case of release from the height of 150 meters, the values of dose conversion factors are lower.

Annual exposure of critical group members of the population due to release of radioactive liquids into the water for different types of reactors are summarized in Table 7.10–30.

Table 7.10–29. Annual effective doses (mSv/year) to population due to release of radionuclides into the atmosphere from one Unit.

Type	BWR		ESBWR					PHWR
Model	**ABWR**	**ESBWR**	**EPR**	**APWR**	**AP-600**	**AP-1000**	**WWER** (V-392 / V-448)	**EC-6 / ACR-1000**
Ar-41	8.50E-10	9.69E-13	4.28E-09	4.28E-09	4.28E-09	4.28E-09	3.74E-09	-
Ba-140	3.23E-09	2.53E-09	5.01E-13	5.01E-11	5.02E-11	5.01E-11	-	-
C-14	5.10E-07	5.31E-07	4.05E-07	4.05E-07	4.05E-07	4.05E-07	1.05E-07	1.58E-06
Ce-141	8.44E-11	6.60E-11	1.19E-13	3.85E-13	3.86E-13	3.85E-13	-	-
Co-58	3.33E-10	1.38E-10	6.66E-11	3.18E-09	3.18E-09	3.18E-09	-	-
Co-60	9.32E-08	6.17E-08	7.90E-10	6.33E-08	6.25E-08	6.25E-08	1.07E-12	-
Cr-51	7.07E-11	4.21E-12	1.95E-13	1.23E-12	1.23E-12	1.23E-12	1.14E-14	-
Cs-134	6.49E-08	5.03E-08	5.03E-10	2.40E-08	2.40E-08	2.40E-08	5.51E-10	-
Cs-136	3.14E-10	2.10E-10	1.74E-11	4.50E-11	4.49E-11	4.50E-11	-	-
Cs-137	1.43E-07	1.10E-07	1.36E-09	5.43E-08	5.43E-08	5.43E-08	1.86E-09	6.12E-09
Cs-138	6.22E-14	8.39E-16	-	-	-	-	-	-
Fe-59	1.33E-10	8.57E-11	4.60E-12	1.29E-11	1.29E-11	1.29E-11	-	-
H-3	1.65E-08	1.71E-08	4.08E-08	4.08E-08	1.74E-08	7.96E-08	7.65E-08	7.22E-07
I-131	1.83E-06	2.88E-06	6.21E-08	2.95E-08	4.65E-07	8.46E-07	7.24E-08	3.62E-08
I-132	6.60E-09	4.80E-09	-	-	-	1.21E-09	6.92E-12	-
I-133	4.08E-07	3.16E-07	7.64E-09	1.53E-08	5.75E-08	9.58E-08	3.56E-09	-
I-134	3.38E-09	2.56E-09	-	-	-	-	1.09E-12	-
I-135	4.56E-08	3.14E-08	-	-	-	-	1.56E-10	-
Kr-85	3.21E-09	6.56E-10	1.93E-07	7.93E-09	1.30E-08	2.33E-08	1.84E-08	-
Kr-85m	3.18E-10	2.65E-10	2.26E-09	-	3.47E-10	5.43E-10	3.88E-10	-
Kr-87	2.06E-09	3.21E-09	4.34E-09	-	8.18E-10	1.23E-09	2.21E-08	-
Kr-88	8.09E-09	1.26E-08	3.85E-08	-	6.42E-09	9.83E-09	1.45E-07	2.83E-07
Kr-89	2.48E-08	3.90E-08	-	-	-	-	-	-
La-140	1.37E-11	2.63E-13	-	-	-	-	-	-
Mn-54	2.18E-09	1.60E-09	2.30E-11	1.73E-10	1.73E-10	1.73E-10	-	-
Mo-99	3.22E-10	2.43E-10	-	-	-	-	-	-
Na-24	6.63E-11	2.40E-13	-	-	-	-	1.94E-13	-
Nb-95	3.81E-10	3.00E-10	1.90E-12	1.14E-10	1.14E-10	1.14E-10	-	-
Np-239	2.54E-11	4.79E-13	-	-	-	-	-	-
Pr-144	3.09E-16	5.97E-18	-	-	-	-	-	-
Rb-89	9.79E-15	1.23E-16	-	-	-	-	-	-
Ru-103	3.40E-10	2.72E-10	1.65E-12	7.75E-12	7.75E-12	7.75E-12	-	-

Type	BWR		ESBWR					PHWR
Model	**ABWR**	**ESBWR**	**EPR**	**APWR**	**AP-600**	**AP-1000**	**WWER** (V-392 / V-448)	**EC-6 / ACR-1000**
Ru-106	1.86E-11	3.58E-13	7.66E-13	7.66E-11	7.65E-11	7.66E-11	-	-
Sr-89	8.57E-10	6.04E-10	2.42E-11	4.53E-10	4.53E-10	4.53E-10	-	-
Sr-90	6.19E-10	1.82E-10	5.55E-10	1.06E-08	1.06E-08	1.06E-08	-	-
Sr-91	2.14E-12	3.88E-14	-	-	-	-	-	-
Te-132	6.90E-13	1.39E-14	-	-	-	-	1.53E-12	-
Xe-131m	4.20E-11	2.43E-12	2.87E-09	2.13E-10	8.99E-10	1.47E-09	-	-
Xe-133	7.28E-09	2.54E-09	2.60E-08	-	8.47E-09	1.39E-08	4.91E-08	-
Xe-133m	2.39E-13	6.43E-15	4.98E-10	5.54E-12	1.47E-10	2.41E-10	-	-
Xe-135	1.04E-08	1.49E-08	2.72E-08	4.53E-11	4.98E-09	7.47E-09	5.51E-09	-
Xe-135m	1.28E-08	1.93E-08	4.40E-10	1.26E-10	1.26E-10	2.20E-10	1.06E-10	-
Xe-137	5.68E-09	8.67E-09	-	4.42E-11	-	-	-	-
Xe-138	3.75E-08	5.44E-08	1.04E-09	8.68E-11	2.60E-10	5.21E-10	1.54E-10	-
Zn-65	1.14E-07	7.80E-08	-	-	-	-	-	-
Zr-95	1.29E-10	9.78E-11	8.06E-13	8.06E-11	8.06E-11	8.06E-11	-	-
Total	**3.36E-06**	**4.24E-06**	**8.19E-07**	**6.60E-07**	**1.14E-06**	**1.65E-06**	**5.04E-07**	**2.62E-06**

Table 7.10–30. Annual effective doses (mSv/year) to population due to release of radioactive liquids into the water from one Unit.

Type	BWR		PWR					PHWR
Model	ABWR	ESBWR	EPR	APWR	AP-600	AP-1000	WWER (V-392 / V-448)	EC-6 / ACR-1000
Ag-110m	3.05E-10	-	4.08E-10	1.67E-09	7.96E-10	9.73E-10	-	1.65E-11
Ba-140	1.94E-10	2.33E-10	1.19E-09	1.66E-09	1.17E-09	1.57E-09	-	-
C-14	1.84E-08	-	-	-	-	-	1.27E-08	4.34E-08
Ce-141	7.10E-12	4.14E-12	2.96E-12	1.71E-11	4.14E-12	5.33E-12	-	6.24E-13
Ce-144	2.46E-09	-	1.68E-09	7.25E-09	3.37E-09	4.10E-09	-	4.20E-10
Co-58	8.66E-11	4.24E-10	1.44E-09	9.44E-09	2.61E-09	3.22E-09	1.59E-10	1.27E-11
Co-60	4.04E-07	3.99E-08	7.98E-09	6.21E-07	1.64E-08	1.95E-08	5.63E-09	3.00E-07
Cr-51	3.42E-11	5.77E-11	4.44E-12	2.66E-11	6.39E-12	8.22E-12	3.60E-12	2.16E-11
Cs-134	1.67E-06	1.86E-07	7.12E-07	3.29E-06	2.18E-06	2.72E-06	9.62E-08	1.41E-08
Cs-136	2.36E-09	3.04E-09	2.30E-09	1.63E-07	3.40E-09	4.66E-09	-	-
Cs-137	7.90E-07	1.60E-07	3.12E-07	1.60E-06	9.52E-07	1.18E-06	7.44E-08	3.12E-08
Fe-59	6.29E-11	4.40E-11	-	1.45E-09	1.01E-10	1.26E-10	1.43E-11	1.60E-10
H-3	7.77E-08	1.81E-08	2.63E-06	2.07E-06	8.94E-07	1.31E-06	7.00E-07	4.73E-06
I-131	2.36E-09	3.10E-09	2.52E-08	1.48E-09	7.63E-09	1.05E-08	1.26E-09	2.60E-09
I-132	4.52E-12	1.42E-12	2.09E-12	5.41E-13	2.50E-12	2.85E-12	1.32E-13	-
I-133	5.55E-10	1.17E-09	1.95E-09	4.50E-11	2.97E-10	3.72E-10	-	9.74E-12
I-134	1.07E-12	2.51E-14	-	5.59E-14	4.27E-13	5.10E-13	-	-
I-135	5.00E-11	3.60E-11	9.98E-11	5.20E-12	2.96E-11	3.31E-11	-	-
Y-91	2.48E-11	3.16E-11	-	2.03E-11	-	-	-	-
La-140	1.07E-11	-	4.78E-10	5.03E-10	3.45E-10	4.68E-10	-	1.41E-13
Mn-54	7.89E-09	4.85E-10	1.64E-09	1.37E-08	3.25E-09	3.94E-09	5.00E-10	2.14E-09
Mn-56	1.41E-11	4.81E-12	-	-	-	-	-	-
Mo-99	1.01E-11	3.66E-11	-	2.08E-11	6.96E-12	6.96E-12	-	3.63E-13
Na-24	4.58E-11	8.32E-11	9.94E-11	7.66E-11	2.08E-11	2.65E-11	-	-
Nb-95	5.18E-08	1.04E-09	5.18E-09	1.04E-07	1.09E-08	1.09E-08	1.54E-09	5.05E-07
Np-239	2.99E-11	1.06E-10	5.59E-12	5.10E-12	1.64E-12	2.31E-12	-	-
Pr-143	9.14E-14	6.33E-12	3.52E-12	5.55E-12	7.03E-12	9.14E-12	-	-
Ru-103	5.73E-12	1.27E-12	7.96E-11	1.08E-10	1.24E-10	1.57E-10	-	3.18E-12
Ru-106	2.01E-10	-	3.68E-08	5.57E-08	7.17E-08	8.70E-08	-	7.33E-10
Sb-125	-	-	-	-	-	-	-	1.18E-10
Sr-89	6.11E-11	1.22E-10	2.78E-11	8.33E-11	4.44E-11	5.55E-11	5.85E-14	-
Sr-90	2.47E-09	1.41E-09	-	1.27E-09	-	7.03E-10	-	5.30E-10

Type	BWR		PWR					PHWR
Model	**ABWR**	**ESBWR**	**EPR**	**APWR**	**AP-600**	**AP-1000**	**WWER** (V-392 / V-448)	**EC-6 / ACR-1000**
Te-132	6.81E-11	3.40E-10	8.19E-09	8.00E-09	2.89E-09	4.08E-09	2.30E-10	2.12E-10
Zn-65	4.66E-09	2.34E-08	8.80E-09	1.14E-08	1.76E-08	2.13E-08	-	4.35E-09
Zr-95	1.65E-10	3.92E-12	2.55E-11	2.55E-10	4.51E-11	4.51E-11	9.01E-12	9.01E-10
Total	**3.04E-06**	**4.40E-07**	**3.75E-06**	**7.96E-06**	**4.17E-06**	**5.38E-06**	**8.93E-07**	**5.63E-06**

Table 7.10–31. Total dose to the critical group members of population due to release of radioactive effluents into the environment.

Type	BWR		PWR					PHWR
Model	**ABWR**	**ESBWR**	**EPR**	**APWR**	**AP-600**	**AP-1000**	**WWER** (V-392 / V-448)	**EC-6 / ACR-1000**
Power, MW_e	**1300**	**1535**	**1660**	**1700**	**600**	**1100**	**995 / 1365**	**750 / 1085**
Nb. of Units	**2**	**2**	**2**	**2**	**5**	**3**	**3 / 2**	**4 / 3**
Annual effective dose, mSv								
Due to releases in water	6.08E-03	8.80E-04	7.50E-03	1.59E-02	2.09E-02	1.61E-02	2.68E-03	2.25E-02
Due to releases in air	6.71E-03	8.48E-03	1.64E-03	1.32E-03	5.70E-03	4.94E-03	1.51E-03	1.05E-02
Total	**1.28E-02**	**9.36E-03**	**9.14E-03**	**1.72E-02**	**2.66E-02**	**2.11E-02**	**4.19E-03**	**3.30E-02**

Total annual exposure of the population due to release of radioactive effluents (both airborne and liquid) into environment calculated according to the methodology presented in normative document LAND 42-2007 for different reactor types with total power of 3 400 MW_e maximum are summarized in Table 7.10–31. Depending on reactor type, capacity and total number of units, annual doses vary in the range from 0.004 to 0.033 mSv and do not exceed the dose constrain of 0.2 mSv/year. As already mentioned not all the reactor manufacturers have responded to the planned economic activity organizer's request to present the data on the radionuclide releases into the environment for particular models of the reactors. Therefore the annual doses stipulated by the reactors WWER/V-392, WWER/V-448, EC-6, ACR-1000 and SWR-1000 were estimated based on the impact of similar models of the reactors or the data given in other assessment reports. The company AECL, the manufacturer of the reactors EC-6 and ACR-1000, presented the data on the radionuclide releases into the environment from CANDU-6 reactor. However, the manufacturer noted that the radionuclide releases from the EC-6 and ACR-1000 reactors would be of comparable level or lower than from CANDU-6 reactor. Therefore Table 7.10–31 includes the annual dose, received by the population from four EC-6 units, since the number of ACR-1000 units, not exceeding the planned electric capacity of the new NPP, would be equal to three and their total impact would be lower. The assessment of the impact of the reactors WWER/V-392 and WWER/V-448 is based on the data for the reactor WWER-1000/V320 given in the EIA report of a NPP planned to be constructed in Belene (Bulgaria). The reactors WWER/V-392 and WWER-1000/V320 have the same electrical power, so it can be stated that the impacts will be similar. The electric power of WWER/V-448 reactor is higher, therefore the radiological impact of one unit will be higher, as well. However, at the new NPP the maximum number of units for this model, not exceeding the total planned electric power for the new NPP, is equal to 2, and in case of WWER/V-392 reactor to 3. Therefore, the total radiological impact of the two units of WWER/V-448 or of the three units of WWER/V-392 will be approximately the same. The EIA report of the planned Belene NPP estimated that the annual dose of the population of Belene NPP region due to one WWER-1000 reactor unit would be 0.0012 mSv per year, and due to SWR-1000 0.0015 mSv per year. In case of the Lithuanian population, the estimated annual dose from one WWER reactor unit is 0.0014 mSv per year. It can be roughly estimated that the annual dose caused by releases from the two maximum permissible SWR-1000 reactor units will be about 0.004 mSv per year.

Exposure forecast of all existing and planned NF is presented in chapter 7.11.1. Doses during normal operation of the new NPP will be about 6 times less than the dose constraint. Also it should be noted, that annual releases of radioactive effluents into the environment have been calculated using computer codes and making conservative assumptions. Actual releases from operating NPP are usually smaller than the calculated values.

Dose Assessment using Methodology Recommended by IAEA

The results of calculation of doses to the members of the 1st critical group due to airborne radionuclide releases from four EC-6 units and two ESBWR units are presented on Figure 7.10-12. Calculation results are provided for members of critical group (for adults and infants). As seen from Figure 7.10-12, in case of EC-6 reactor the difference between doses for adults and infants is rather small (difference is about 2 % therefore curves in Figure 7.10-12 cover each other). However, in case of releases from ESBWR dose received by infant of 1.11×10^{-1} mSv/year at 1 km distance is about 4 times higher than dose to adult. Dose to infant due to release from ESBWR reactors is determined by I-131, which forms about 82 % of total dose. This is due to the fact that milk and milk products consumption rate for infant is higher than for adult. Dose to adult caused by I-131 does not exceed 50 % of total dose. In both EC6 and ESBWR cases, the maximum doses are observed within an area of 800 m radius around the release source. Radiation dose decreases with the increase in the distance, and at a point 1 km away from the source it is equal to 7.87×10^{-2} / 8.06×10^{-2} mSv/year (adult / infant) for EC-6 reactors and to 2.88×10^{-2} / 1.11×10^{-1} mSv/year (adult / infant) for ESBWR reactors.

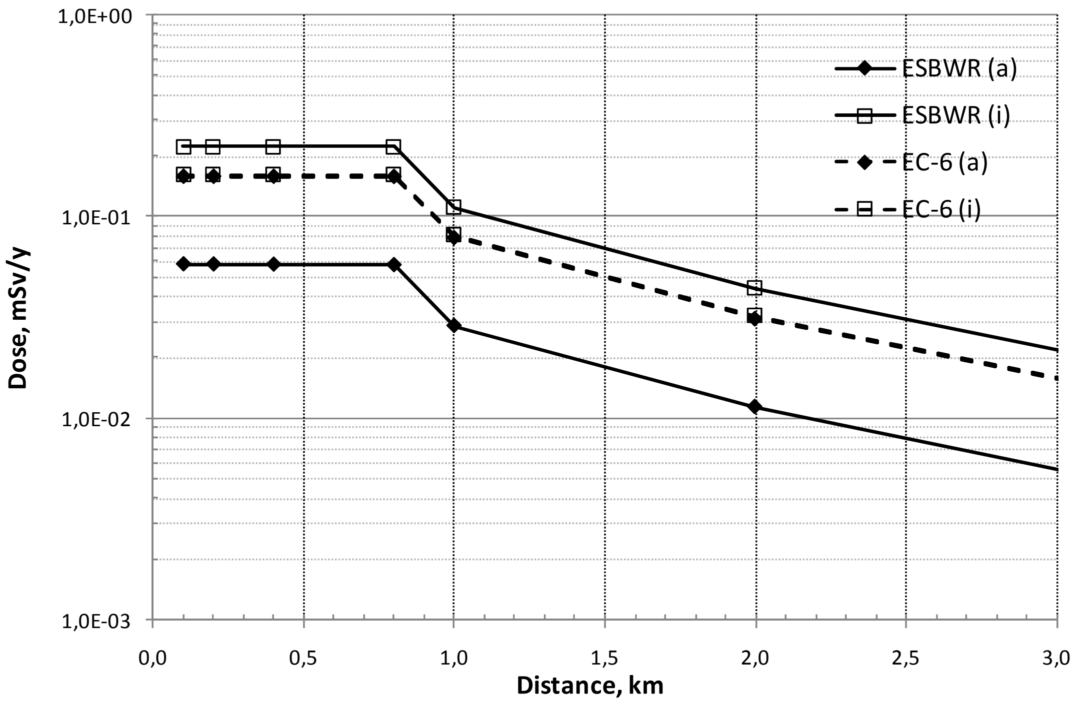


Figure 7.10-12. Dependence of dose to the member of population of 1st critical group on distance (a – adult, i – infant).

Only two types of reactors, EC-6 and ESBWR, are being considered for dose estimations to the members of the 2nd critical group, because according to Table 7.10–29 these reactors cause the maximum doses to the members of the critical group of the population. The results of calculations of the doses due to the airborne radionuclide releases for the members of the 2nd critical group (adult which stay 290 hours in SPZ) are presented in Table 7.10–32. The evaluation of the dose to the member of the population did not take into account the alternation of the volumetric activity of the released radionuclides within the sanitary protection zone, instead the largest estimated value of the volumetric activity in the SPZ was conservatively assumed. Table 7.10–32 shows the values of the dose for the adults of the 2nd critical group. The difference between the annual effective dose received by the child and the adult for both of the type of reactors is insignificant (<1 %).

Table 7.10–32. Annual effective dose to the 2nd critical group member of population due to release of airborne radioactive effluents into the environment.

Reactor type	Annual effective dose, mSv/year
EC-6 (4 Units)	2.69×10^{-3}
ESBWR (2 Units)	3.15×10^{-4}

Impacts of direct ionising radiation

The impact of direct radiation on the member of the 2nd critical group of the population has been estimated taking into account the measuring data of the sensors of "Skylink" system, presented in Ignalina NPP monitoring report of 2007 (*INPP, PTOot-0545-15*). According to the measurements of this system it is apparent that the doses registered within the Ignalina NPP SPZ do not differ from the natural radiation exposure, which is essentially due to natural radionuclide K-40. This is confirmed by measurements performed in the environments of power plants of other countries, where fixed doses do not differ from the natural radiation background. Therefore the impact of direct ionizing radiation is insignificant and hardly separated from the natural background. Even if conservatively assuming that the average dose rate at the existing INPP SPZ is equal to 0.115 μSv/h and assuming that the members of the 2nd critical group of the population will be affected by such dose rate, the annual effective dose received by the member of this group due to the direct exposure, depending on the time spent within the SPZ, will be less than dose constraint (see Table 7.10–33). Since the impact of direct radiation is insignificant to the 1st critical group as well, this impact is not considered further (see also subsection "*Impacts of direct ionising radiation*" of section 7.11.1)

Table 7.10–33. Annual effective dose to the 2nd critical group member of population due to direct irradiation.

Time spent in SPZ, hours per year	Annual effective dose, mSv/year
290	0.03

Dose to workers temporary working in SPZ of INPP

The Paragraph 89 of the updated Lithuanian Hygiene Standard HN 87:2002 (*State Journal, 2003, No. 15-624, 2008, No. 35-1251*) states that persons who are permanently or temporarily employed at a nuclear facility or other objects related to operation or maintenance of a nuclear facility, as well as located within the sanitary protection zone of a nuclear facility, and who are not assigned to workers of either category A or category B shall be subject to the dose limit of 1 mSv per year, set out by the Hygiene Standard HN 73:2001 (*State Journal, 2002, No. 11-388, 2003, No. 90-4080*). During the new NPP construction the workers who will carry out construction works within the territory of current Ignalina NPP, fall within this category. Adjacent to the alternative site No. 1 is the interim Ignalina NPP spent nuclear fuel storage facility, so it is conservatively assumed that the workers on this site will suffer from the highest exposure. The annual effective dose received by the workers working on site No. 2 will be lower. Based on the data of the route gamma dose rate measurements, presented in Ignalina NPP monitoring report of 2007 (*INPP, PTOot-0545-15*), the measured dose rate on site No. 1 is 0.152 μSv/h. As it was mentioned above, dose to member of 2nd critical group due to direct radiation is mainly determined by natural radiation background. However, even if conservatively assuming that workers are exposed by this natural radiation and they work 2000 hours per year in SPZ, also taking into account average measured radionuclide concentrations in air and soil of SPZ, the calculated exposure of the workers is 0.3 mSv per year and this is less than the annual dose limit of 1 mSv.

Summary of occupational exposure based on operational experience of existing NPPs

Probably the largest amount of information on occupational doses at various nuclear power plants is gathered in the Information System on Occupational Exposure (ISOE) programme of the Nuclear Energy Agency (NEA). Thus the information given in this chapter generally is a short summary of the most recent ISOE programme report (*OECD, 2008*).

Since 1992 ISOE, jointly sponsored by the OECD/NEA and IAEA, has supported the optimisation of worker doses in nuclear power plants through an information and experience exchange network for radiation protection professionals of nuclear power plants and national regulatory authorities worldwide, and through development and publication of relevant technical resources.

A key aspect of the ISOE programme is the tracking of annual occupational exposure trends from nuclear power facilities worldwide for benchmarking, comparative analysis and experience exchange amongst ISOE members. Using the ISOE database, which contains annual occupational exposure data supplied by all participating utilities, ISOE members can perform various benchmarking and trend analyses by country, by reactor type, or by other criteria such as sister-unit grouping. The summary below provides highlights of the general trends in occupational doses in nuclear power plants.

At the end of 2006, the ISOE programme included 71 participating utilities in 29 countries (336 operating units; 42 shutdown units), as well as the regulatory authorities of 25 countries. The ISOE occupational exposure database itself included information on occupational exposure levels and trends from 401 operating reactors in 29 countries, covering about 91 % of the world's operating commercial power reactors. Table 7.10–34 summarises the participation by reactor type and status.

Table 7.10–34. Number of reactors included in the ISOE database.

	PWR	BWR	PHWR	GCR	LWGR	Other	Total
Number of operating reactors included in the ISOE database	262	88	28	22	1	0	401
Number of definitively shutdown reactors included in the ISOE database	26	15	2	31	4	2	80
Total number of reactors included in the ISOE database	**288**	**103**	**30**	**53**	**5**	**2**	**481**

A summary of average annual collective dose in 2006 by reactor type for operating reactors is provided in Table 7.10–35.

Table 7.10–35. Summary of average collective doses for 2006.

Radioactive effluents	2006 average annual collective dose (man•Sv)	For 2004-2006 (man•Sv) 3-year rolling average
Pressurised water reactors (PWR/WWER)	0.71	0.75
Boiling water reactors (BWR)	1.32	1.41
Pressurised heavy water reactors (PHWR/CANDU)	1.15	1.06
All reactors, including gas cooled (GCR) and light water graphite reactors (LWGR)	0.85	0.88

Exposure trends over the past three years for all reactor types, expressed as average annual and 3-year rolling average annual collective doses are shown in Table 7.10–36 and in Table 7.10–37 respectively. These results are based primarily on the data reported and recorded in the ISOE database during 2007, supplemented by the individual country reports.

Table 7.10–36. Average annual collective dose per unit by reactor type, 2004-2006 (man·Sv).

PWR, WWER			BWR			PHWR			GCR			LWGR			Global Average		
2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006	2004	2005	2006
0.77	0.77	0.71	1.46	1.47	1.31	0.84	1.19	1.15	0.04	0.06	0.12	3.41	2.11	3.06	0.89	0.91	0.85

Table 7.10–37. 3-year rolling average annual collective dose per unit by reactor type, 2002-2006 (man·Sv).

PWR, WWER			BWR			PHWR			GCR			LWGR			Global Average		
'02-'04	'03-'05	'04-'06	'02-'04	'03-'05	'04-'06	'02-'04	'03-'05	'04-'06	'02-'04	'03-'05	'04-'06	'02-'04	'03-'05	'04-'06	'02-'04	'03-'05	'04-'06
0.84	0.80	0.75	1.64	1.57	1.41	0.96	1.05	1.06	0.07	0.06	0.07	4.03	3.49	3.00	0.99	0.95	0.88

Figure 7.10-13 shows the 2006 data in a bar-chart format, ranked from the highest to the lowest average dose for different reactor types. Figure 7.10-14 shows the trends in the average collective dose per reactor type for 1992-2006, with the average annual doses for 2006 maintaining at fairly low level. In Figure 7.10-13, the “number of units” refers to the number of units for which the data has been reported for the year in question.

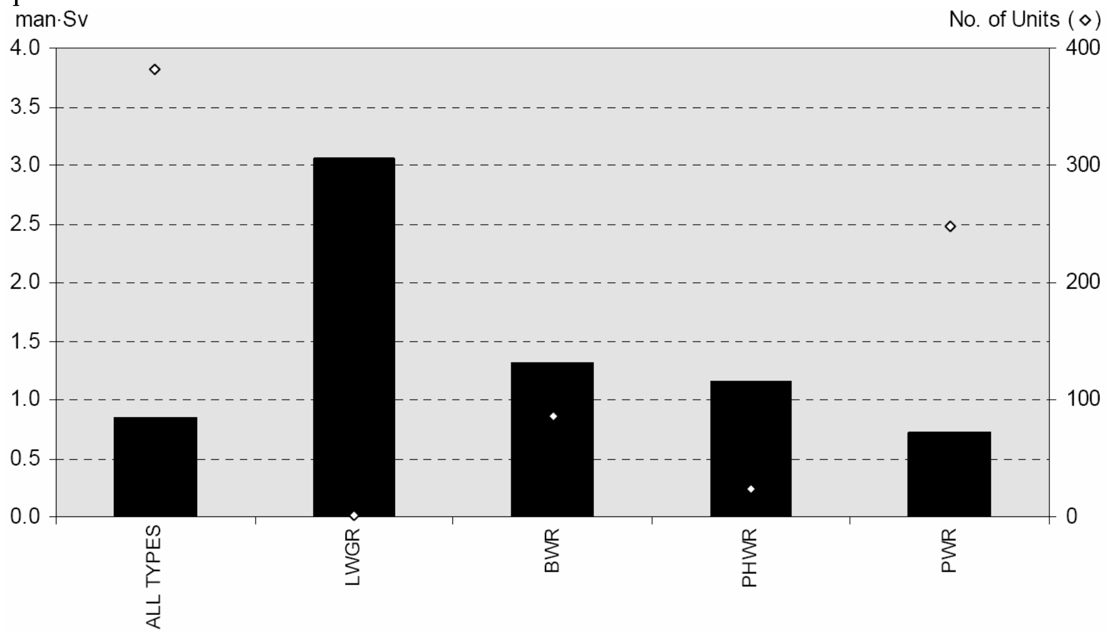


Figure 7.10-13. Average collective dose per reactor type in 2006.

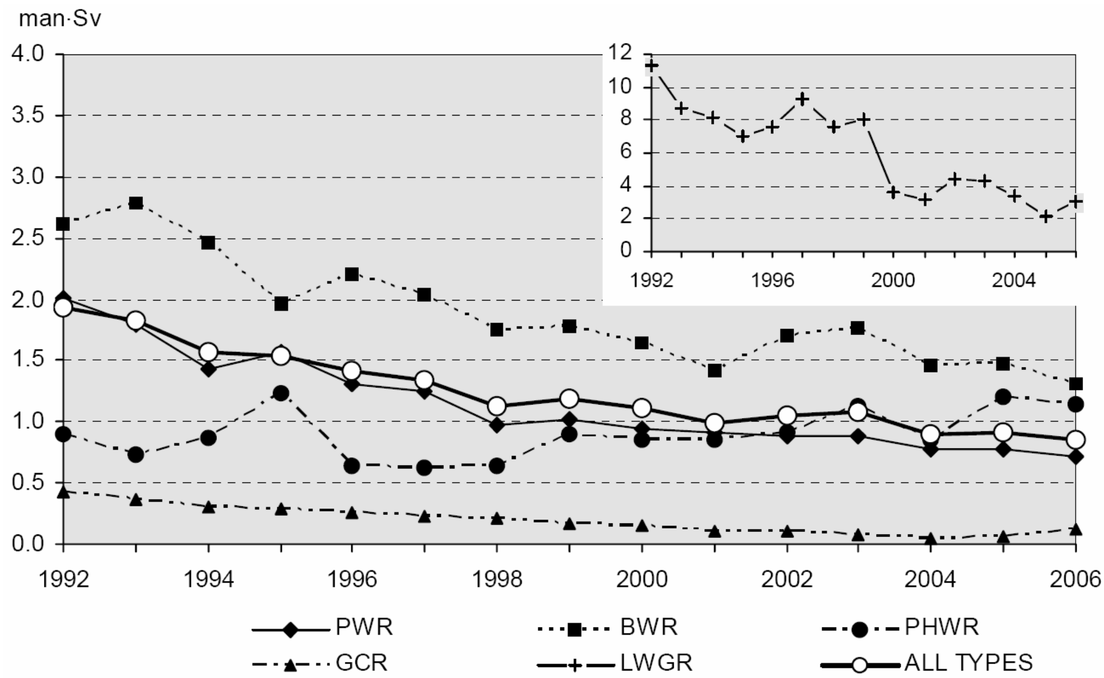


Figure 7.10-14. Average collective dose per reactor for all operating reactors by reactor type, 1992-2006 *(Note: Inserted chart shows average collective dose for LWGRs).*

In Europe, the average collective dose per reactor for PWRs and WWERs in 2006 was around 0.58 man·Sv per reactor, with most countries showing a stable or decreasing trend over the last three years. The average collective dose per reactor for BWRs in Europe in 2006 was around 1.00 man·Sv. The trend of the 3-year rolling average annual collective dose, which provides a better representation of the general trend in dose, shows a slight decrease for PWRs and WWERs, going from 0.74 man·Sv per reactor for 2002-2004 to 0.65 man·Sv per reactor for 2004-2006. The trend for BWRs appears to be more stable, with 1.01 man·Sv per reactor for 2002-2004 and 1.00 man·Sv per reactor for 2004-2006. The 3-year rolling average annual collective doses per reactor for BWRs are quite similar in all European countries, the minimum being in Sweden (0.91 man·Sv) and the maximum in Switzerland (1.08 man·Sv).

In general, the annual average collective dose per operating reactor unit has consistently decreased over the time period covered in the ISOE database, with the 2006 averages maintaining the levels reached in the last few years. In spite of some yearly variations, a clear downward trend in the levels of collective dose in most reactors has been maintained.

More detailed discussion and analyses of dose trends in various countries can be found in (*OECD, 2008*). However, it is noted that due to the complex parameters driving the collective doses and the varieties of the contributing plants, the above discussion and figures do not support any conclusions as regards to the quality of radiation protection performance in the countries addressed above.

7.10.3 Mitigation measures

7.10.3.1 Mitigation of non-radiological impacts

The new nuclear power plant will be designed so that it complies with all health and safety regulations of authorities. The previous Sections 7.10.2.1 and 7.10.2.2 list all the different types of impacts of the NNPP on public health and for some types also the possibilities to mitigate them. Many of the actions and technical solutions for the prevention and mitigation of the adverse impacts will be determined in more detail during the design of the NNPP.

The factors influencing public health, on which the NNPP can have an adverse impact either during the construction or operation stage, are air quality, noise, risk of accidents (construction and traffic), migration, alcohol consumption and criminality.

The mitigation measures of the impacts of the NNPP on air quality are described in Section 7.2.3. It discusses also the mitigation measures of the impacts of traffic to and from the NNPP. Since the heat and steam boilers are not part of the economic activity assessed in this EIA, their impacts and mitigation measures are described in the EIAs concerning them (*Ignalina NPP Decommissioning project management unit, 2004a* and *Ignalina NPP Decommissioning project management unit, 2004b*).

The noise impacts of the construction activities of the NNPP can be mitigated by timing particularly noisy or distracting actions to be carried out during weekdays and in the daytime. Heavy traffic to the construction site can also be timed similarly if necessary. The noise levels can be reduced also by using noise barriers.

The noise made by machinery and equipment during the operation of the NNPP can be effectively reduced with the choice of construction techniques and materials of the buildings. Sources of noise can also be isolated with a casing or they can be equipped with sound dampers if necessary. Noise resulting from vibration can be reduced by placing the vibrating equipment on a flexible base.

The impacts of the NNPP on traffic safety can be mitigated with appropriate traffic planning and control. The amount of traffic can be reduced by organizing bus transports for the employees of the NNPP during both the construction and the operation stage. During construction special accommodation facilities can be built near the construction site to reduce traffic. Special transport, especially during the construction stage, can be scheduled to take place outside the peak hours of everyday traffic.

Occupational risk factors and ways to reduce them are described separately in Sections 7.10.2.1 and 7.10.2.2.

The mitigation of adverse social impacts, such as any social problems caused by temporary construction labour moving to the area, should be taken into account in advance when planning the project. The adverse impacts can be minimized with the co-operation between the organizer of the NNPP and the nearby municipalities. Different leisure activities can be coordinated for the employees and the foreign employees can be provided with guidance on the local culture and practices.

7.10.3.2 Mitigation of radiological impacts

Around the new NPP site, a sanitary protection zone (SPZ) will be established, where there are no permanent inhabitants and where economic activities are limited. Radiological impact on public health within the sanitary protection zone is minimal and will not exceed the limits prescribed by radiation protection requirements. Outside the sanitary protection zone the impact can be considered as insignificant. Regulations for SPZ establishment are described in document “On the approval of regulations for establishing of boundaries and requirements for sanitary protected zones” (*State Journal, 2004, No. 134-4878*). It should be emphasized that the terms used for area name around the NPP and criteria for determination of size of this area differs in various countries. The term “Sanitary protection zone” used in Lithuanian legislation was used in former Soviet Union and typically this zone around a nuclear power plant in former

Soviet Union countries is 3 km in radius. Existing Ignalina NPP also has a SPZ of 3 km in radius. Other terms such "exclusion area" or "plant site" are used in US and Finnish legislation. A summary of requirements and criteria for establishment of the areas around a NPP in various countries is presented in Table 7.10–38.

The size of the SPZ of the new NPP is proposed under the assumption that the annual dose due to releases into atmosphere from the new NPP should be about 0.1 mSv per year. This is a conservative assumption, since if the value of the dose constraint (0.2 mSv per year) was accepted the SPZ size would be smaller. It should be noted that the proposed size of the new NPP SPZ is preliminary and is intended only for the assessment of the size of the new NPP SPZ. The current territory of the SPZ of Ignalina NPP accommodates nuclear facilities, both operated and planned, which are enveloped by the total SPZ of 3 km radius. However, after the final shutdown of Ignalina NPP and the reduction of radionuclide releases into the environment, the SPZ can be revised, i.e., either the current SPZ will be left, or every nuclear facility, including the new NPP, will have its own SPZ.

The size of the sanitary protection zone is determined by the dose received by the member of the 1st critical group. As it can be seen from Figure 7.10-12, the radiation dose decreases with the increase of the distance, and at a point 1 km away from the source the dose for adults and infants makes about 0.08 mSv/year for EC-6 reactors, and about 0.11 mSv/year for infants in case of ESBWR reactors. The dose caused by airborne releases for the reactors of other models is even lower.

The size of the SPZ of the new NPP proposed in the EIA report is preliminary, and during the subsequent project phases the SPZ boundaries and activities will be determined in accordance with the provisions of the document "On the approval of regulations for establishing of boundaries and requirements for sanitary protection zones" (*State Journal, 2004, No. 134-4878*).

On the basis of dose estimates for members of 1st critical group, the size of the new NPP SPZ to all types of reactors should be about 1 km radius. It should be noted that the estimated annual maximum exposure of the members of the critical group of the population (using dose factors provided in LAND 42-2007) due to the waterborne radionuclide releases from four EC-6 reactors is about 0.023 mSv (see Table 7.10–31). This value conservatively adding to annual effective dose, which is received by members of 1st critical group (infants) due to airborne releases from two ESBWR reactors, the total dose value would be about 0.13 mSv/year and this is less than dose constraint 0.2 mSv/year.

The proposed sites for the NNPP are within the existing INPP industrial site and sanitary protection zone. The shortest distance from the proposed sites to the boundary of the existing sanitary protection zone is about 1.5 km. Thus for New NPP (for any reactor type) proposed SPZ will be within the existing INPP SPZ and the need for new restrictions or relocation of people is not required.

Table 7.10–38. Area around nuclear power plant.

Sanitary protection zone (*State Journal, 1996, No. 119-2771*)	**Exclusion area (*10 CFR*)**	**Plant site (*YVL 1.10*)**
Sanitary protection zone – a special territory or a site of radioactive contamination where the irradiation level may exceed the prescribed norms under the normal operational conditions of a nuclear facility. Prior to the commissioning of the facility, all the population shall be resettled from the sanitary protection zone in the manner prescribed by the Government. Activities as well as construction of installations and buildings unrelated to the operation or service of the facility shall be prohibited therein. Land, woods and water bodies in the territory of the sanitary protection zone may be used for economic purposes only subject to an approval of the facility operator and authorizations from the Ministry of the Environment and the Ministry of Health. According to (*State News, 2004, No. 134-4878*) dose constraint for members of the public (0.2 mSv/year) shall not be exceeded at the boundary of SPZ during normal NPP operation.	**Exclusion area** means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result. An exclusion area shall be of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.	A nuclear power **plant site** extends to about a kilometre's distance from the facility. It is defined as an area where only power plant related activities are allowed as a rule. Permanent settlement is prohibited and only very limited employee accommodation or recreational settlement is allowed. The licensee responsible for the operation of the nuclear power plant shall have authority of decision over all activities in the area and shall be able to remove unauthorised individuals from the site, if necessary, or prevent such individuals from entering it. The plant site may contain other non-facility related activities provided that they do not pose a threat to plant safety. A traffic lane may traverse the site if the volume of traffic is small and if traffic can be directed elsewhere, if necessary. Visits onsite are allowed provided that the licensee has the possibility to control the movement of visitors.

Additionally, administrative and technical measures will be implemented to mitigate radiological impacts. These measures include:

- Control of radioactive sources. The measures and activities necessary for radioactive material confinement will be implemented. Multiple barriers will be provided to prevent the radioactive material releases to environment.

- Control of radioactive releases. This covers the measures and activities that will be installed at new NPP to control the radioactive releases into environment to comply with specified limits.
- Monitoring of radioactive releases. The measures and activities necessary for measurings of radioactive releases in certain emission points will be implemented.
- Environment Monitoring. The measures and activities necessary for measuring of environmental radioactivity levels, to assess the radiological impact on public health and environment due to radioactive releases from the new NPP will be available.

The more detailed impact mitigation measures will be analyzed and justified in Safety Analysis Report considering Technical Design aspects.

7.11 SUMMARY OF RADIOLOGICAL IMPACTS AND IMPACTS ON LAKE DRUKSIAI UNDER NORMAL OPERATIONAL CONDITIONS

7.11.1 Summary of radiological impacts

As stated in the EIA Program, this Section summarizes the assessment of radiological impacts on different components of the environment due to normal operation of the new NPP. Also other existing and planned nuclear facilities located in the Ignalina NPP sanitary protection zone are taken into consideration.

The radiological impact on the environment during normal operation of the NNPP arises from radioactive airborne and liquid effluents. Evaluation of the liquid and airborne releases into the environment for different types of power reactors is given in Sections 7.1.2 and 7.2.2, respectively. LAND 42:2007 (*State News, 2007, No. 138-5693*) provides principles for how assessment of radiological impact on the environment shall be performed. One of the principles states that protection measures ensuring an adequate safety for humans are sufficient to protect both the environment and natural resources. Therefore, based on data of liquid and airborne releases, the calculation of potential exposure of the population has been performed and is presented in Section 7.10. Depending on reactor type, capacity and total number of units, annual doses of the critical group members of population due to release of radioactive effluents (both airborne and liquid) into the environment vary in a range from 4.19 to 33.01 µSv (from 0.004 to 0.033 mSv). The established dose constraint for members of the public is 0.2 mSv (200 µSv) per year. Therefore, doses during normal operation of the new NPP will be about 6 times less than the dose constraint. This means that the new NPP will not cause detrimental health effects (e.g. reduction in length and quality of life from exposure to ionizing radiation, somatic effects, cancer or genetic disorder).

Overview of existing and planned Ignalina NPP facilities

Both potential sites for the new NPP are located within the INPP industrial site with the existing 3 km radius sanitary protection zone (SPZ). The INPP will be completely shut down by the end of 2009. An immediate dismantling concept has been selected for the decommissioning of the INPP. In the course of decommissioning, new nuclear facilities will be constructed on the INPP industrial site and nearby with the purpose of management, interim storage and disposal of existing operational and decommissioning produced radioactive waste (only of certain types of waste) together with spent nuclear fuel.

Decommissioning of the existing INPP and the operation of these new nuclear facilities may last for several decades and even more. These existing and new nuclear activities may stipulate radiological impact at the sites of the new NPP during performance of construction works. Once becoming operational, radiological impact from the new NPP may be contributed by additional radiological impacts from the existing and new nuclear activities.

According to the INPP Final Decommissioning Plan (*INPP DPMU, 2004*) the INPP decommissioning process is split into several decommissioning projects (DP). Each of these DP is a process covering a particular field of activity, defining scope of works and their peculiarities and providing input for organization of the specific activity, safety analysis and environmental impact assessment. In order to ensure that environmental impact assessment is based on reliable and detailed information, which becomes available along the progress of the particular DP, the EIA Program of INPP decommissioning (*INPP DPMU, 2004*) provides to develop EIA reports separately for each DP. Every EIA report of a subsequent DP shall take into account results of previous reports. Thus the overall environmental impact due to the INPP decommissioning will be assessed and controlled on the basis of the latest information, and environmental impact mitigation measures will be adequate for the real situation.

In addition to the decommissioning activities at the Ignalina NPP existing nuclear facilities, the decommissioning project foresees construction of:

- Interim Spent Nuclear Fuel Storage Facility (ISFSF);
- Solid Radioactive Waste Management and Storage Facility (SWMSF);
- Disposal Units for Very Low-level Radioactive Waste (*Landfill* repository);
- Low and Intermediate Level Radioactive Waste Near-Surface Repository.

Future activities foresee conversion of the presently operated Bituminized Waste Storage Facility into a disposal facility. A Liquid radioactive waste Cement Solidification Facility (i.e., for grouting of spent ion-exchange resins and filter aid deposits) began operation in the year 2006. Solidified waste will be temporarily stored in a new Temporary Storage Facility, constructed on the INPP industrial site. Later on, the waste will be disposed of in a Short Lived Low and Intermediate Level Radioactive Waste Near-Surface Disposal facility. The decision on extension of the existing Spent Nuclear Fuel Storage Facility has already been made. In the year 2006 VATESI appended the license conditions and allowed storage of additionally 18 CONSTOR RBMK-1500 casks in the storage facility. One more modification is planned, which would increase the storage capacity by an additional 10 CONSTOR RBMK-1500 casks.

Existing and planned nuclear facilities, located in the Ignalina NPP existing sanitary protection zone of 3 km radius are shown in Figure 7.11-1. Main activity phases (operation, decommissioning, institutional surveillance, etc.) of the nuclear facilities are summarized in Figure 7.11-2.

Figure 7.11-1. Existing and planned nuclear facilities, located in the INPP existing sanitary protection zone of 3 km radius.

In Figure 7.11-1 indicated nuclear facilities are as follows:

1 – bld. 158 (planned repository of bituminised RAW) and new interim storage facility for solidified radioactive waste (bld. 158/2); 2 – Reactor Units of the Ignalina NPP; 3A, 3B – alternative sites for construction of new NPP; 4 – existing SNF storage; 5 – new ISFSF; 6 – new SWMSF; 7 – disposal units of the *Landfill* facility; 8 – near-surface repository for low and intermediate level RAW; 9 – buffer storage of the *Landfill* facility.

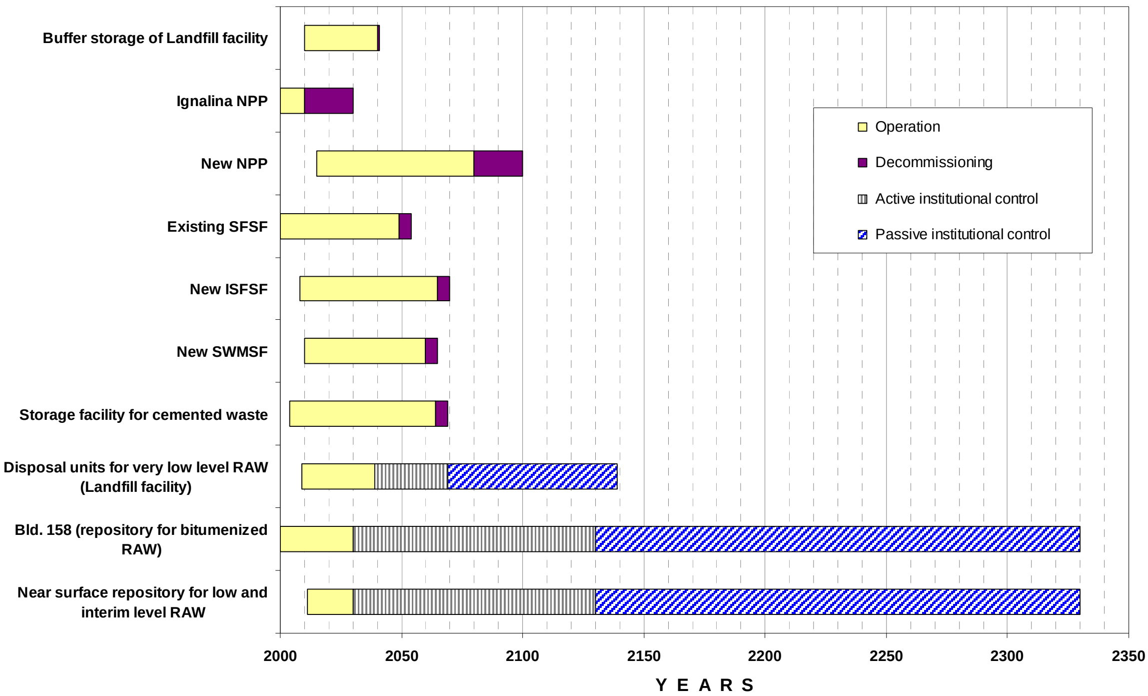


Figure 7.11-2. Main activity stages of the existing and planned nuclear facilities, located in INPP existing sanitary protection zone of 3 km radius.

It has been planned that the first unit of the new NPP will start operation no later than 2015. Therefore, total radiological impact from new NPP and existing and planned Ignalina NPP facilities located within INPP industrial site are estimated for 2015. During operation of the new NPP radiological impact from Ignalina NPP facilities due to radioactive decay of stored radioactive waste and SNF will only decrease.

Radioactive releases from the existing facilities in the SPZ of INPP

According to the data in the monitoring report (*INPP*, *PTOot-0545-15*), doses due to the actual waterborne release and airborne emission from the INPP site are presented in Figure 7.11-3. It can be concluded that the doses due to the actual releases from the INPP site are far below the dose constraint (0.2 mSv per year (*HN 87:2002*)). Starting from 1995 the dose due to waterborne releases gradually decreases. The dose due to airborne releases in general is considerably lower. The dose increase in 2004 is due to the increase of the release of I-131 from the INPP liquid radioactive waste treatment facility (building 150).

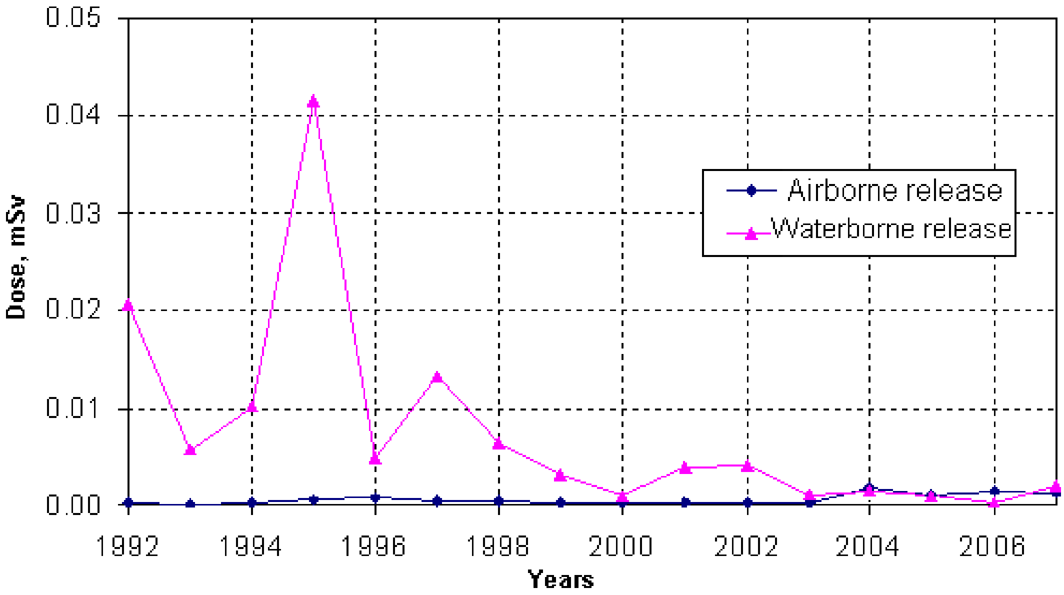


Figure 7.11-3. Annual effective dose to the critical group member of population due to radioactive releases (airborne emissions and liquid releases) from the nuclear facilities located in the SPZ of INPP for time period 1992 – 2006 (*INPP, PTOot-0545-15*)

It has been planned that INPP will be in operation till the end of 2009. To forecast future doses the last years' (1999 – 2007) observed dose maximum is selected as a conservative estimation of the impact due to the operation of INPP till the year 2010. The assumed annual effective dose to a member of the population due to airborne emissions is 1.9×10^{-3} mSv (year 2004 dose), and due to liquid releases is 4.19×10^{-3} mSv (year 2002 dose).

A forecast of the impact from the existing nuclear facilities in the SPZ of INPP also includes the dose forecast due to the emissions and discharges from the following planned activities:

- INPP Reactor Unit 1 reactor final shutdown, de-fuelling and in-line decontamination phase of the INPP Decommissioning Project (i.e. U1DP0 activities). The U1DP0 activities are planned to be implemented in the years from 2005 to 2012;
- The start-up of the operation of the new Cement Solidification Facility for liquid radioactive waste solidification and of the Interim Storage Building for the storage of solidified waste in the year 2006. The Cement Solidification Facility will operate for about 14 years. The Interim Storage Building is designed for operation of approximately 60 years.

The forecast for the dose to the population due to airborne emissions and liquid releases from the existing nuclear facilities in the SPZ of INPP is summarized in Figure 7.11-4. It can be seen that the doses due to airborne emissions and liquid releases from the existing nuclear facilities in the SPZ of INPP are low. The observed dose maximum (9.69×10^{-3} mSv per year) in year 2009 is mainly due to the planned start up of the in-line decontamination activities at the Reactor Unit 1 and the assumption that the doses resulting from the operation of INPP (6.09×10^{-3} mSv) are still relevant.

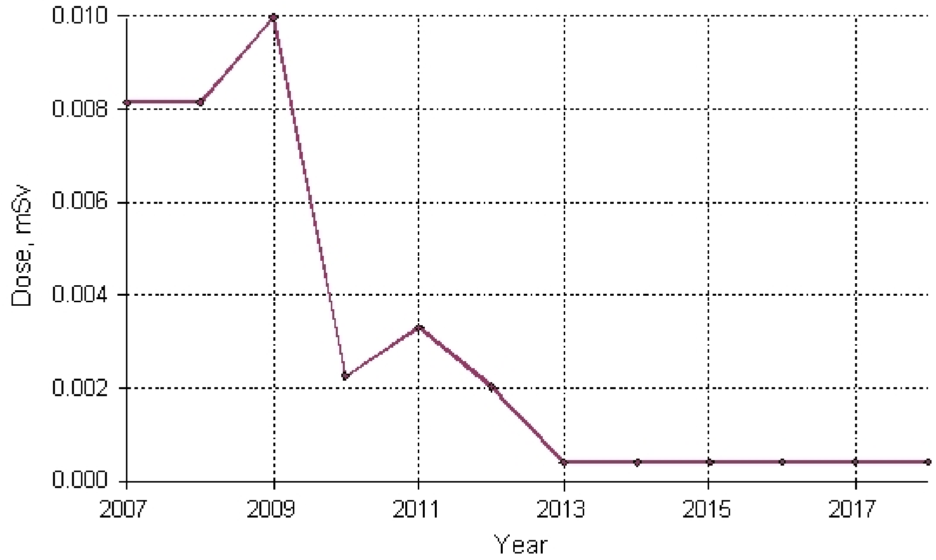


Figure 7.11-4. Forecast for the dose to the critical group member of population due to radioactive releases (airborne emissions and liquid releases) from the nuclear facilities located in the SPZ of INPP.

The dose forecast as presented in Figure 7.11-4 does not include similar in-line decontamination activities at the Reactor Unit 2. A separate project (U2DP0) will be prepared for these activities. The estimation of the doses due to activity releases is not available at the moment. Therefore only approximate assessment is possible. Considering availability of ISFSF it is planned to finish the de-fuelling of Reactor Unit 2 in several years after the final reactor shutdown. In comparison to activities at Reactor Unit 1, the equipment in-line decontamination at Reactor Unit 2 could start within a shorter time period after the final reactor shutdown. Therefore the activity of radioactive releases (short-lived Mn-54, Fe-55, Co-58, Co-60, Cs-134, etc.) will be higher and could result in higher doses as compared to the doses from the similar U1DP0 activities. It is anticipated that equipment in-line decontamination at Reactor Unit 2 can stipulate approximately two times higher annual dose to the critical group member of population (i.e. up to 8.0×10^{-3} mSv in a single year). Therefore it is forecasted that after 2015 the annual effective dose due to airborne emissions and liquid releases from the existing nuclear facilities in the SPZ of INPP will be below 1×10^{-3} mSv.

No dose estimations due to activity releases during further decommissioning projects for existing INPP facilities are available at the moment. The EIA Program of INPP decommissioning provides that every subsequent environmental impact assessment shall take into account the results of previous reports.

Impact due to radioactive releases from the newly planned facilities in the INPP SPZ

Based on SWTSF EIA Report (*SWTSF EIAR*), conservatively estimated annual effective dose to the critical group member of population from the SWTSF, dose due to radioactive airborne emissions during the waste retrieval and treatment phase is equal to 7.79×10^{-3} mSv. With finishing of waste retrieval the radioactive airborne emissions and subsequently the exposure of the population will decrease.

The conservatively estimated annual effective dose to the critical group member of population due to radioactive airborne emissions from ISFSF activities will not exceed 4.15×10^{-4} mSv, as presented in ISFSF SAR. It is planned that by the year 2016 all spent nuclear fuel from INPP will be loaded into the leak-tight storage casks and will be isolated from the environment. Later on the radioactive airborne emissions due to the

SNF handling activity could be possible only in the case of fuel reloading in the Fuel Inspection Hot Cell (FIHC) of ISFSF. In case of SNF reloading additional exposure of up to 1.67×10^{-4} mSv is possible. However, it is not anticipated that a cask will fail during its storage life. The necessity for occurrence of a fuel repacking operation is low in probability. The cask will be designed as a double-barrier welded system for a safe operation time of at least 50 years. Therefore the operation of the FIHC should not be considered as a part of normally expected ISFSF operations.

Disposal units of the *Landfill* facility are planned for solid and solidified radioactive waste packages disposal. Before that, these waste packages will be temporary stored in *Landfill* Buffer storage. The repository will have no radioactive waste treatment installations. The conditioned, packaged and ready for disposal waste packages will be delivered to the repository. Packages shall meet the Waste Acceptance Criteria for *Landfill* repository. No release of activity into the atmosphere either in aerosol or gas form is expected under normal operation conditions. During the waste disposal phase disposal units of the repository will be equipped with a temporary drainage system. No radioactive liquid releases into the environment will occur.

Environmental impact assessment for the planned *Landfill* repository is ongoing. According to preliminary estimates, the annual effective dose of the member of the critical group of the population due to radioactive releases from the Buffer Storage of the *Landfill* facility would be about 2.54×10^{-6} mSv, and due to radioactive releases from the disposal units of the *Landfill* facility it would not exceed 6.00×10^{-7} mSv.

The estimations of maximum exposure doses caused by near-surface repository for low and intermediate level radioactive waste to a member of the critical group, i.e. to a local inhabitant (the farmer), are provided in the document (*RATA*, *2007*). The estimation of the maximum value of the common exposure dose should be approx. 0.009 mSv/year in case of the consumption of contaminated water from the lake Druksiai and also ingestion of fish caught in the lake, or 0.0015 mSv/year in case of consumption of contaminated water from a well installed at a distance of 150 m from the near-surface repository. The expected time of the maximum total dose in both cases is approximately 9000 years after repository closure, however conservatively it can be assumed that this maximal annual dose of 0.009 mSv will occur in 2015 also.

Forecast of the maximal annual effective dose to the critical group member of population due to radioactive releases (airborne emissions and liquid releases) from the existing and planned nuclear facilities located in the SPZ of INPP in 2015 is summarized in Table 7.11–1.

Table 7.11–1. Forecast of the impact from radioactive releases (for 2015).

Facility	Dose due to releases, mSv/year
Ignalina NPP existing facilities	1.00×10^{-3}
SWTSF	7.79×10^{-3}
ISFSF	4.15×10^{-4}
FIHC (during SNF reloading at ISFSF)	1.67×10^{-4}
Landfill Buffer Storage	2.54×10^{-6}
Landfill Disposal Units	5.60×10^{-7}
Low and Intermediate Level Radioactive Waste Near-Surface Repository	9.00×10^{-3}
New NPP	3.30×10^{-2}
TOTAL	$\mathbf{5.14\times10^{-2}}$

It can be seen from Table 7.11–1 that in 2015 the greatest contribution to the dose is due to radioactive releases from the new NPP.

Impacts of direct ionising radiation

The monitoring of radiation fields performed in the INPP industrial site and its surroundings shows that increase in direct radiation dose rates is observed locally and only close to some of radioactive material handling facilities. The dose rate measurements performed at the proposed SWTSF and ISFSF sites, which are approximately at 1.5 km distance from Ignalina NPP Reactor Units, existing dry SNF storage facility, and other facilities, demonstrate that gamma radiation background at these sites does not distinguish from gamma radiation background outside the border of the existing SPZ of INPP. The mean of measured dose rates corresponds to the mean of dose rates measured in the INPP region.

This means that impacts due to direct exposure from existing Ignalina NPP nuclear facilities do not create exceptional impacts at distances greater than approximately 1 km. The impact stipulated by the direct radiation of the new NPP will be similar. For instance, the EPR safety analysis report (U.S. EPR Final Safety Analysis Report) shows that the annual dose to the population at the boundary of the restricted zone (at the distance of ~800 m from a NPP) is lower than 0.01 mSv. The manufactures of other reactors do not even estimate the impact of direct radiation, stating that this impact is insignificant. Therefore the conclusion is that the radiological impact to population due to direct radiation is insignificant and does not need to be considered further.

Conclusions on radiological impacts

Depending on reactor type, capacity and total number of units of the NNPP, annual doses of the critical group members of population due to releases of radioactive effluents (both airborne and liquid) into the environment vary in a range from 4.19 to 33.01 µSv (from 0.004 to 0.033 mSv). The radiological impact to population due to direct radiation at the boundary of existing SPZ is insignificant.

It is forecasted that in 2015 (when the new NPP is planned to be built) the total annual effective dose to the critical group members of population due to airborne emissions and liquid discharges from the new NPP and existing and new nuclear facilities of Ignalina NPP at the boundary of the existing SPZ (with 3 km radius) will be below 0.0514 mSv. The established dose constraint for members of the public is 0.2 mSv per year. Therefore, total annual dose in 2015 to population during normal operation of the facilities in the existing SPZ will be about 4 times less than the dose constraint.

7.11.2 Summary of impacts on Lake Druksiai

7.11.2.1 Impacts of NNPP cooling

The amount of waste heat discharged to Lake Druksiai from the NNPP depends not only on the electricity produced but also on the cooling system chosen. In direct cooling system all the heat is discharged to the lake when in case of cooling towers only a minor part of the heat enters the lake and the major part is transmitted to air.

Based on modelling results and expert assessments it can be concluded that the ecologically acceptable thermal load to the lake will be approximately 3 160 $MW_{released.}$, With this thermal load no significant impacts on the lake ecosystem are expected compared to the present state of the lake. With higher thermal load the impacts on the lake ecosystem start to be clear and significant.

However, with the present criterion for lake warming (maximum 20 % of the lake surface layer warming to over 28 degrees) the maximum allowable thermal load to the lake during the summer months is approximately 1 390 $MW_{released}$. Due to this additional thermal load reduction might be needed during the warmest month. Reducing the thermal load of 3 160 $MW_{released}$ to half during the warmest month would keep the lake temperatures below the present limit, possibly with few days of exception. Consequently the environmentally and economically best option may be to limit the thermal load to the lake mainly during the warmest months. There are several available technologies and their combinations. The environmentally and technically best cooling technology will be selected later in the design phase of the new plant.

If the thermal load will be negligible (cooling solely by cooling towers), the lake temperatures will return to the natural level and this can somewhat improve the living conditions of the species preferring cool water. However, recovery of the conditions or species composition before commissioning of INPP is not expected. If the general intensive eutrophication process continues, this alternative may also lead to low-oxygen conditions during periods of ice-cover. From this point of view, moderate warming of the lake can even be environmentally advantageous. Thus this option has somewhat diverse impacts on the lake ecosystem: it is the best option when the warming of lake is considered, but may result in partly adverse effects due to oxygen depletion if the eutrophication of the lake will continue.

The current outlet is the best alternative when the area warmed up is used as criteria. However, the different outlet options do not significantly differ from each other. The present NPP outlet position allows the cooling water to spread efficiently to the main part of the lake, allowing both cooling by heat exchange to atmosphere and mixing to cooler lake water. The southern outlet position is more confined and shallow, which restricts the warm outlet water mixing with cooler lake water thus reducing the surface area where the cooling to atmosphere takes place. Thus the southern outlet would lead to more distinct warming and eutrophication impacts in the southern part of the lake than other outlet options.

Dividing the outlet to two locations is not a significantly better solution than the present outlet option when comparing the average size of warmed up areas.

In the deep inlet option simulation, the cold water storage of the deeper part of the lake was depleted at the very beginning of the simulation, after which the deep inlet water temperature did not differ from the temperatures in the present inlet option. Additionally, in the deep inlet option, after the thermocline of the lake is destroyed, the mixing of warmer water to deeper layers is increased, raising the total heat storage in the lake. As a result the deep inlet option would produce higher surface temperatures in the whole lake during the warmest periods compared to the present inlet option.

The main hydrological impacts of the operation of the new NPP are the evaporative losses created when the heated cooling water will transfer the heat load to air by evaporation. The total losses depend on the plant effect and the cooling method selection.

During normal hydrological years the average lake level is not expected to fall below the normal because of the NNPP and thus the hydrological effects on the lake and their consequences are considered minor. During rare periods of three successive dry years the lake level would fall below normal, possibly reaching the minimum allowable level. As the water volume and surface area of the lake decrease only relatively little even in this case, the hydrological impacts on the lake can be estimated to be small also in this kind of rare event.

The impact of the cooling water releases on wintertime ice conditions was also simulated using three different NNPP thermal load levels. At a thermal load of 2 230 $MW_{released}$ the ice free area would be located close to the NNPP outlet. At times, depending on winter temperature in general, the impact on the ice cover would be significant, especially with thermal loads of over 3 160 $MW_{released}$. Thermal loads of 4 460–6 310 $MW_{released}$ would keep the main part of the lake open longer from the start of the winter. In general the impact on the ice cover would be smaller in the southern and western part of the lake compared to the rest of the lake.

7.11.2.2 Impacts of NNPP waste waters

The nutrient load from the new NPP will comprise only 4 to 8 % of the total nutrient load to be discharged from the Visaginas new waste water treatment plant. The nutrient load from the NNPP is thus small compared to the total load to Lake Druksiai coming from the other sources (e.g. Visaginas municipality and natural runoff). Thus the impacts of the new NPP to water quality and eutrophication are considered insignificant and they can not be distinguished from the general eutrophication development of the lake.

Waste water originating from process and technical use will be treated depending on the quality of the waste waters by mechanical, chemical or biological means according to the regulations and laws. Waste waters from process water production will be neutralized. Possible oil traces will be removed. Waste waters from the controlled area will be processed in the liquid waste treatment plant. The impacts of the treated waste waters on the lake are estimated to be minor and acceptable. However, these impacts will be monitored and if unacceptable consequences occur, the treatment of waste waters will be improved.

7.11.2.3 Landscape

The landscape in the Lake Druksiai watershed has degraded because of the building and operation of INPP, Visaginas town and related infrastructure.

Construction of the new NPP near the INPP will produce no greater effect of landscape degradation and will not disrupt the ratio between the natural and anthropogenic territories. The impacts on the landscape of Lake Druksiai and its surroundings will therefore not be significant.

7.11.2.4 Cultural heritage

No impacts on cultural heritage sites or objects related to Lake Druksiai are expected.

7.12 COMPARISON OF ALTERNATIVES

7.12.1 General

The following implementation alternatives of the new nuclear power plant in Lithuania have been assessed in this EIA Report:

- Technological alternatives for nuclear power reactors (all are generation III or III+ reactors)
    - pressurized water reactor (PWR)
    - boiling water reactor (BWR)
    - pressurized heavy water reactor (HWR)

- Power level alternatives
    - Power generation up to max. 3400 MW_e
- Location alternatives
    - Site No. 1 – east of INPP
    - Site No. 2 – west of INPP
- Cooling alternatives
    - Direct cooling
        - Different inlet and outlet alternatives
            - Present inlet
            - Deep inlet
            - Western inlet
            - Present outlet
            - Southern outlet
    - Indirect cooling
        - Wet cooling towers
        - Dry cooling methods
        - Hybrid cooling towers
    - Combination of direct and indirect cooling

The differences in environmental impacts between these alternatives are summarized in the following Sections.

7.12.2 Comparison of alternatives

7.12.2.1 Environmental impact comparison tables

In Table 7.12–1 and Table 7.12–2 the most essential environmental impacts, taking the different alternatives that have been assessed into account, are summarized. In the Sections after that different site and technical alternatives are discussed and compared.

Table 7.12–1. Summary of the most essential environmental impacts of different alternatives during the construction phase.

CONSTRUCTION PHASE	State of waters	Climate and air quality	Groundwater, geology and soil	Biodiversity	Landscape, land use and cultural heritage	Socio-economic environment	Public health
Construction of the nuclear power plant	Slight increase in wastewater load but capacity of rehabilitated WWTP sufficient.	Temporary local dust impact. Dusting will not have significant impact on the air quality outside the construction site.	Significant earth-moving works but ground already heavily altered by man in both sites. No adverse impacts on groundwater.	Potential significant adverse impact on European otter (*Lutra lutra*) and Marsh harrier (*Circus aeruginosus*) populations (designation values for the Natura 2000 –area, European otter listed in Annex IV of the EU Habitat directive) if Site No. 2 is chosen can be mitigated to an acceptable level. Potential significant adverse impacts on Marsh harrier (*Circus aeruginosus*) and Spotted crake (*Porzana porzana*) populations (designation values for the Natura 2000 –area) if Site No. 1 is chosen can be mitigated to an acceptable level. Other adverse impacts at both sites on biodiversity are not significant or can be mitigated to an acceptable level.	Only small change to landscape, no significant difference between alternative sites. No changes in land use limitations at either site.	Significant positive impact on regional economy and society in both Lithuania and Latvia: - Significant employment impact. - Increased demand for long-term accommodation and services. Immigration of foreign NPP construction employees, diverse impacts on local society.	Noise from the construction site will not exceed 55 dBA at a distance of approx. 850 m from the centre of the area of construction. Noise will not exceed allowable levels.
Construction of the associated infrastructure	No impact.	Temporary local dust impact, not significant.	Construction of new access roads and other required infrastructure will cause impacts on soil through	No significant impact.	No significant impact as new transmission line routes and pylons are not required.	Significant positive impact on regional economy and society in both Lithuania and Latvia.	Noise will not exceed allowable levels.

CONSTRUCTION PHASE	State of waters	Climate and air quality	Groundwater, geology and soil	Biodiversity	Landscape, land use and cultural heritage	Socio-economic environment	Public health
			required earthworks.				
Construction of the required cooling structures	Construction of new inlet at Site No. 2 may cause temporary clouding of water in immediate vicinity. If a new outlet is required in either site alternative the construction may cause temporary clouding of water. No significant impacts.	No impact.	No significant impact.	Potential significant adverse impacts on European otter (*Lutra lutra*) and Marsh harrier (*Circus aeruginosus*) populations (designation values for the Natura 2000 –area, European otter listed in Annex IV of the EU Habitat directive) if Site No. 2 is chosen can be mitigated to an acceptable level.	No significant impact.	Significant positive impact on regional economy and society in both Lithuania and Latvia.	Noise will not exceed allowable levels.
Raw water and waste water	No impact.	No impact.	Groundwater amount sufficient. No major new facilities or piping required.	No impact.	No impact.	No impact.	No impact.
Transportation and traffic	No impact.	Road traffic will increase emissions into the air during the construction of the new NPP. Traffic emissions during construction are not assessed to	No impact.	Potential adverse impacts on the European fire-bellied toad (*Bombina bombina*) and the great crested newt (*Triturus cristatus*) need to be mitigated if Site No. 2 is chosen. If Site No. 1 is	No impact.	Local/regional impact of increased traffic.	Noise from traffic will not exceed 55 dBA at a distance of 80-100 m from the centre of road. Noise will not exceed allowable levels.

CONSTRUCTION PHASE	State of waters	Climate and air quality	Groundwater, geology and soil	Biodiversity	Landscape, land use and cultural heritage	Socio-economic environment	Public health
		have significant long-term impacts on the local air quality.		chosen mitigation measures for European fire-bellied toad are required. These species are strictly protected on an EU level (listed in Annex IV of the EU habitat directive).			As a result of increase of traffic more transport accidents are expected. No significant impact from traffic emissions is expected.

Table 7.12–2. Summary of the most essential environmental impacts of different alternatives during the operational phase.

OPERATIONAL PHASE	State of waters	Climate and air quality	Groundwater, geology and soil	Biodiversity	Landscape, land use and cultural heritage	Socioeconomic environment	Public health
Operation of new nuclear power plant	Lake Druksiai utilized for cooling and as raw water source.	No significant impacts.	No significant impacts.	Cooling water discharge potentially impacts biodiversity.	Will be visible only from some points of the lake shore. Only small change to landscape, no significant difference between alternative sites. No extension of existing sanitary protection zone and no changes to land use restrictions or regulations in the surrounding area are expected at either site.	Employment impact for about 500 people. Significant positive impact on regional economy and society in both Lithuania and Latvia.	No significant impacts.
Releases of radioactive	No significant impact.	No significant impact.	No impact.	No impact.	Not relevant.	No impact.	No significant impact. Fear of

OPERATIONAL PHASE	State of waters	Climate and air quality	Groundwater, geology and soil	Biodiversity	Landscape, land use and cultural heritage	Socioeconomic environment	Public health
substances		Releases a fraction of the permissible limits.					significant radioactive releases may cause concern and affect sense of safety, no great change to current situation.
Cooling water and waste water	Thermal load to Lake Druksiai if direct cooling is used. The lake can not tolerate significantly greater thermal load than caused by INPP so far from an ecological point of view. The tolerable thermal load is estimated to be about 3 160 $MW_{released}$. However, with the present criterion for lake warming (maximum 20 % of the lake surface layer warming to over 28 degrees) the maximum allowable thermal load to the lake during the summer months is approximately 1 390 $MW_{released}$. Due to this additional thermal load reduction might be needed during the warmest month. A new deep inlet will not bring any significant benefits. A new western inlet at Site No. 2 brings only small benefits. A new southern outlet will	No impact.	No impact.	Potentially significant adverse impacts on designation values of the Lake Druksiai Natura 2000 –area and other biodiversity values can not be excluded if a thermal load significantly exceeding 3 160 $MW_{released}$ is discharged to the lake. Positive impact on especially bird fauna biodiversity as parts of the lake would be kept continuously ice-free in wintertime.	No significant impact.	Change in ice conditions may affect possibilities of fishing on ice at certain places. Fishing still possible, no changes in total catches expected. Species composition may change if large amounts of cooling water are discharged to the lake. No significant impact.	No significant impact.

OPERATIONAL PHASE	State of waters	Climate and air quality	Groundwater, geology and soil	Biodiversity	Landscape, land use and cultural heritage	Socioeconomic environment	Public health
	cause more warming of the southern and eastern parts of Lake Druksiai and will accelerate eutrophication there. Divided outlet will not bring any significant benefits. Water amount will be sufficient in all cooling solutions. The maximum of 3400 MW electric power generation is possible by combining direct cooling and cooling towers. Treated process waters containing salts will be discharged to Lake Druksiai but no significant impact is expected.						
Noise	No impact.	No impact.	No impact.	No impact.	No impact.	No significant impact.	No significant impact.
Handling and disposal of radioactive waste	No impact.	No impact.	No impact when properly handled and disposed of. Will undergo separate EIA procedures.	No impact.	No impact.	No impact when properly handled and disposed of. Will undergo separate EIA procedures.	No impact when properly handled and disposed of. Will undergo separate EIA procedures.
Other wastes and chemicals	No impact.	No impact.	No impact when properly handled and disposed of.	No impact.	No impact.	No impact when properly handled and disposed of.	No impact when properly handled and disposed of.
Traffic and	No impact.	No significant	No impact.	Potential adverse impacts	No impact.	Local/regional	Noise from traffic

OPERATIONAL PHASE	State of waters	Climate and air quality	Groundwater, geology and soil	Biodiversity	Landscape, land use and cultural heritage	Socioeconomic environment	Public health
transportation		impact.		on the European fire-bellied toad (*Bombina bombina*) and the great crested newt (*Triturus cristatus*) need to be mitigated if Site No. 2 is chosen. If Site No. 1 is chosen mitigation measures for European fire-bellied toad are required. These species are strictly protected on an EU level (listed in Annex IV of the EU habitat directive).		impact of increased traffic.	will not exceed 55 dBA at a distance of 80-100 m from the centre of road. Noise will not exceed allowable levels. No significant impact from traffic emissions is expected.

7.12.2.2 Technological alternatives for nuclear power reactors

The reactor type or types to be chosen for the NNPP in Lithuania shall be safe, employ proven technology and be in line with the most recent developments in nuclear technology. The reactor type to be chosen has to comply with the safety and other requirements of Lithuanian regulations and regulators and international standards.

Safety requirements set for the pressurized water reactors (PWR), boiling water reactors (BWR) and pressurized heavy water reactors (HWR), their safety level, environmental impacts and socioeconomic impacts do not significantly differ from each other. Nor are there very significant differences in impacts in transportation, storage of fresh fuel and the handling, storage and final disposal of radioactive waste. The pressurized heavy water reactor (PHWR) requires substantially larger amounts of fuel, and thus produces larger amounts of spent nuclear fuel (SNF). PHWR also requires heavy water, which has to be imported. Pressurized water reactors discharge boron to the environment in small quantities.

7.12.2.3 Power generation level alternatives

The smallest reactor included in the environmental impact assessment has an output of 600 MW_e and the largest an output of 1 700 MW_e. A maximum generation capacity of 3 400 MW_e has been defined based on future power demand scenarios and limitations set by the available sites and infrastructure. The exact size and capacity of the NNPP to be built is dependent on the reactor type and supplier chosen, and on for instance technical and environmental limitations of the available sites.

The targeted maximum power generation level of 3 400 MW_e influences, depending on the reactor to be chosen, the number of reactors and also the cooling solutions as the only environmental load which in practice changes in a significant way with the power generation capacity, directly proportional to this, is the required cooling water amount. As there is an upper limit to the amount of warmed cooling water which Lake Druksiai can tolerate from an ecological point of view (as discussed in Section 7.1), it would be necessary to implement other cooling solutions in combination with direct cooling utilizing Lake Druksiai.

The power generation level and thus the size of the NNPP affects the amount of materials transported and used during construction and operation of the NNPP, the waste amounts generated, the amounts of workers and thus the traffic amounts, and the socioeconomic impacts of the project. The NNPP size will not significantly affect the transmission lines as the existing pylons have originally been dimensioned for four RBMK reactor units, nor other required infrastructure.

The NNPP size impacts the amounts of radioactive releases during normal operation, but this impact can not be considered significant as the caused doses will be significantly smaller than the defined dose constraints even at the maximum size of the NNPP.

7.12.2.4 Location alternatives

There are two site alternatives for the NNPP. Site No. 1 is located directly to the east of the existing Ignalina NPP. Site No. 2 is located directly to the west of the Ignalina NPP. Both sites border to the INPP site. In the feasibility study of the new NPP, which was accomplished before EIA process of the new NPP has started, it was identified that areas of sites where new NPP is planned to be built are sufficient for reactor units and all auxiliary facilities that are necessary for NPP operation.

This section includes comparison of the conditions of the site alternatives, and comparison of the impacts of the site alternatives.

Comparison of conditions of site alternatives

Possible impacts from the new NPP are assessed in this EIA Report. However, analysis on how environment of sites (geological and seismic conditions, meteorological characteristics, human activity and etc.) can influence the design features and safety of NNPP is outside the scope of EIA. Therefore, the separate project "Site evaluation of potential sites for the new NPP" is going to be initiated. The aim of this separate project is to evaluate the suitable of potential sites for construction of new NPP according to IAEA Safety Requirements NS-R-3 „Site evaluation for nuclear installations". During this evaluation the detailed description of the site will be prepared and the set of parameters (soil characteristics, seismicity, ambient temperatures, etc.) important for designing will be identified.

During the site evaluation, the following external factors, which can affect the safety of NPP and design decisions, shall be considered:

- seismicity;
- geotechnical parameters;
- meteorological events;
- flooding possibility;
- external human induced events.

Generally, the evaluation of these external factors is performed according to IAEA safety guides, where applicable evaluation methodologies, initial data collection and processing, and other relevant information are provided.

Also it is planned to perform ecogeological investigations (environmental audit) of the potential sites for the new NPP. The aim of this investigation is to identify the consequences of former activities at the site, i.e. ground contamination, underground conditions, etc. Results of this investigation are important in evaluation of suitability of the site and in planning of project risks.

The scope of this comparison presented in EIA Report is to identify advantages or disadvantages of the environmental conditions according to available data at alternative sites and possible environmental impacts. The technical measures how to eliminate disadvantages or how the site conditions can influence the safety of NPP are not addressed in EIA. These issues will be considered during NNPP technical design and in safety analysis report. The alternative sites have been compared, assigning them ranks according to every analyzed factor (0 – not acceptable, 1 – medium and 2 – acceptable). Summarized comparison of the alternative sites No. 1 and No. 2 of the new NPP and references to the detail information given in appropriate chapters are presented in Table 7.12–3

Table 7.12–3. Comparison of the environmental conditions of alternative sites.

Characteristic	Site No 1		Site No 2	
	Description	Rank [4)]	Description	Rank [5]
1. Geology				
1.1. Engineering geology condition	Man made soil that consists of glacial loam of medium plasticity occurs at the land surface of the 1st site. The site is investigated in detail and the properties of soil are predictable. Man made soil is quite weak and should be removed. Glacial soils of sufficient density and strength occur below the man made soils at a depth of 1–6 meters (see Section 7.5). Occurrence of high density soils provides a stable base for building foundations.	2	Man made soil that consists of glacial silty loam of medium plasticity occurs below the fertile soil layer at the 2nd site. Soil properties are investigated up to the depth of 20 meters. Thickness of man made soil layer reaches 10 m in some places of the site. In some places glaciofluvial differently grained sands occur above the glacial loam with the thickness of 0.5–5 meters (see Section 7.5). Glacial soils of sufficient density and strength that provide the stability of foundations occur below the man made soils, which have to be removed.	1
1.2. Geomorphology	Relief of the site had been changed during former construction works. Land surface had been flattened with slight declination to the North-West. Altitude of the land surface vary between +143 and 149 m.	2	There are several knolls of 3–6 m height at the site. The land surface had been changed during the construction works of Ignalina NPP. The surface of the territory has a slight decline (altitudes 153.1–152.2) towards the north. Some wet places of the surface are swamped.	1
1.3. Geotechnical condition	Unfavourable geological processes do not take place at the site. Geotechnical properties of the soils are suitable for the stable foundations.	2	Unfavourable geological processes except the swamping at the small areas do not take place at the site. Geotechnical properties of the soils are suitable for the stable foundations.	2
<u>Conclusion</u>: Based on available information geological, tectonic, seismic and geomorphological conditions are more favourable on site No. 1.				
2. Hydrogeology				
2.1. Shallow groundwater	Groundwater level is seasonally high, following heavy storms and after snow melting, the level of groundwater comes very close to the earth surface (especially at the north-east part of the site). During the dry season, it drops to 4 m, in other places down to 9 m. This unconfined groundwater occurs in inhomogeneities of till body filled by sand and gravel. Groundwater flow is of low intensity and does not form integral aquifer. During construction and operation of NPP reduction of the groundwater level will be necessary (see Section 7.3).	2	Groundwater level is seasonally high, following heavy storms and after snow melting, the level of groundwater comes very close to the earth surface (almost at the third part of swampy area at the north-west part of the site). During the dry season, it drops to 3 m, in other places down to 13 m. This unconfined groundwater occurs in inhomogeneities of till body filled by sand and gravel. Groundwater flow is of low intensity and does not form integral aquifer. During construction and operation of NPP reduction of the groundwater level will be necessary (see Section 7.3).	1

4) 2 – acceptable, 1 – medium, 0 – not acceptable, * – not relevant to the existing case
5) 2 – acceptable, 1 – medium, 0 – not acceptable, * – not relevant to the existing case

Characteristic	Site No 1		Site No 2	
	Description	Rank [4)]	Description	Rank [5]
2.2. Confined groundwater	The first aquifer (aqIII-II) confined from the surface lies at a depth of 25 m. The aquifer is about 3–5 m thick. Confining layer from above is a clayey loam (till) of about 20 m thickness. Due to the low permeability the aquifer has very low risk of being contaminated by the planned activity.	2	The first aquifer (aqII) confined from the surface lies at a depth of 32 m. The aquifer is about 4–5 m thick. Confining layer from above is a clayey loam (till) of about 23 m thickness. Due to the low permeability the aquifer has very low risk of being contaminated by the planned activity.	2
2.3. Basic points of discharge	The site belongs to the watershed of Lake Druksiai; unconfined groundwater is discharged to the relief depressions of neighbouring areas to the site, ditches and Lake Druksiai. Groundwater of the first confined aquifer from the surface (aqIII-II) is discharged to Lake Druksiai.	2	The site belongs to the watershed of Lake Druksiai; unconfined groundwater is discharged to the swampy relief depressions, ditches and Lake Druksiai. Groundwater of the first confined aquifer from the surface (aqII) is discharged toward north in the valley of Daugava River.	2
2.4. Direction of water pathway, velocity of groundwater flow	Groundwater flow in confined aquifer is directed to northeast toward Lake Druksiai, water flow (Darcy velocity) is 5.2 10^{-6} cm/s (see Section 7.3).	2	Groundwater flow in confined aquifer is directed to northeast toward Daugava River, water flow (Darcy velocity) is 2.3 10^{-5} cm/s (see Section 7.3).	1
2.6. Feeding of groundwater	Infiltration recharge rate ranges from 10 to 100 mm/year, based on the model evaluations in the neighbouring areas, the infiltration recharge rate, integrated in the entire area, is about 30 mm/year.	2	Infiltration recharge rate ranges from 10 to 100 mm/year, based on the model evaluations in the neighbouring areas, the infiltration recharge rate, integrated in the entire area, is about 30 mm/year.	2
Conclusion: Hydrogeological conditions of site No. 2 are slightly more complicated than those of the first site: the conditions of unconfined groundwater are more complex due to the presence of swamp deposits and greater groundwater flow rate in confined aquifer. Both sites are suitable for the planned economical activity, but the conditions at site No 1 are slightly more favourable.				
3. Hydrology				
Cooling water channels	Existing (in the 1st site) location of cooling water input and output are in favourable places, since almost the whole lake surface area takes part in the cooling process. Existing input and output channels may be used, however they should be extended.	2	New cooling water input channel must be constructed (in the 2nd site) and the output channel must be way longer than input, in order to avoid recirculation of cooling water (see Section 4.2).	1
Conclusion: Considering the usage of lake water for cooling purposes, the Site No. 1 can use existing INPP inlet and outlet channels. In the Site No. 2 a new intake and a long cooling water channel has to be constructed to prevent recirculation of cooling water and the site is therefore considered as less favourable.				

Characteristic	Site No 1		Site No 2	
	Description	**Rank** [4)]	**Description**	**Rank** [5]
4. Geochemistry				
4.1. Sorption/ solubility of radionuclides	Based on lithological characteristics of the soil and chemical analysis of groundwater, the conclusion may be drawn that impact of colloids and organic materials is possible for migration of radionuclides.	1	Based on lithological characteristics of the soil and chemical analysis of ground water, the conclusion may be drawn that impact of colloids and organic materials is possible for migration of radionuclides.	1
4.2. pH of the groundwater	Shallow unconfined groundwater is attributed to the category of bicarbonate water type; pH changes from 7.2 to 7.7 (see Section 7.3).	2	Shallow unconfined groundwater is attributed to the category of bicarbonate water type; pH changes from 6.8 to 7.3 (see Section 7.3).	2
4.3. Natural colloids and organic materials	Clayey soil predominates at the site. Existing colloid and organic materials can affect the characteristics of radionuclide migration.	1	Clayey soil predominates at the site. Existing colloid and organic materials can affect the characteristics of radionuclide migration.	1
4.4. Corrosiveness of groundwater towards the concrete	Groundwater is low corrosive towards concrete.	2	Groundwater is low corrosive towards concrete	2
Conclusion: According to geochemistry, both sites are favourable and equally acceptable.				
5. Tectonics and seismicity				
5.1. Tectonics	According to the currently available data the site is acceptable and appropriate pursuant the tectonic conditions. More detailed assessment of the sites under these conditions requires accurate instrumental measurements and additional investigation.	2	According to the currently available data the site is acceptable and appropriate pursuant the tectonic conditions. More detailed assessment of the sites under these conditions requires accurate instrumental measurements and additional investigation.	2
5.2. Estimation of seismicity	Taking into account domination of soils of the 3rd seismic category in the upper part of the geological cross-section at the site, seismic micro-zoning works and research data provided the determination of the 6 point seismic level (SL-1) and 7 points seismic level (SL-2) in the MSK –64 (or EMS-98) macro-seismic scale.	2	The site is located in the Ignalina NPP industrial zone. According to the results of investigations from surrounding area the seismic levels could be estimated. The 6 point seismic level (SL-1) and 7 points seismic level (SL-2) in the MSK-64 (or EMS-98) macro-seismic scale are characteristic to the site.	2
5.3. Neotectonic processes	There is a junction of neotectonically active zones below Lake Druksiai. Absolute values of the measured shifts indicate that the area is not in the zone of active tectonic faults and the differentiated rise of infinitely small amplitude of the earth surface is caused by geodynamic processes taking place in the adjacent graben of the Druksiai Depression (see Section 7.5).	2	Neotectonically active zones cross the site No. 2 from the west to the east. These zones were defined during the mapping according to the morphometric and morphostructural data. Precise instrumental measurements were not performed (see Section 7.5).	1

Characteristic	Site No 1		Site No 2	
	Description	**Rank [4)]**	**Description**	**Rank [5]**
5.4. Liquefaction of soil	Water bearing soils of silty or fine grained sand (geologic indices tpIIV; IIV; gIImd; fIImd; lgIIžm; gIIdn) could have high liquefaction potential. Those soils are of the 3rd seismic category (see Section 7.4).	1	Water bearing soils of silty or fine grained sand (geologic indices tpIIV; ftIIIbl) could have high liquefaction potential. Those soils are of the 3rd seismic category (see Section 7.4).	1
Conclusion: According to the currently available data, the both sites are equally acceptable and appropriate with regards to the tectonic and seismic conditions. More detailed assessment of the sites under these conditions requires accurate instrumental measurements and additional investigation. The detailed technical feasibility study of the new NPP should include investigation (at least one borehole) of the Ledai Subformation of the Upninkai Formation, because the absolute depth of the ridge of these rocks will provide the data for estimation of the probability of a local tectonic fault in a specific location of the projected buildings.				
6. Surface processes				
6.1. Flooding	Altitudes of the land surface are between +143 and 149 m. There are no possibilities for flooding of the site. Dominant incline of ground surface creates very favourable conditions for surface run-off. Probabilistic estimation of the external flooding due to the increase of water level of Lake Druskiai was performed in the Safety Analysis Report of Ignalina NPP Unit 2. It was calculated that probability of lake level increase above 143.0 m is less than 8.6×10^{-5} per year, above 143.5 m – 2.1×10^{-8} per year.	2	Altitudes of the land surface are between +153.1 and 152.2 m. There are no possibilities for flooding of the site. Dominant incline of ground surface creates very favourable conditions for surface run-off. Probabilistic estimation of the external flooding due to the increase of water level of Lake Druskiai was performed in the Safety Analysis Report of Ignalina NPP Unit 2. It was calculated that probability of lake level increase above 143.0 m is less than 8.6×10^{-5} per year, above 143.5 m – 2.1×10^{-8} per year.	2
6.2. Landslides	Land surface of the site is almost flat, landslides do not occur.	2	Land surface of the site is almost flat, landslides do not occur.	2
6.3. Erosion	Soil or ravine erosion was not observed. Fertile soil is absent and geomorphology is unfavourable for ravine erosion.	2	Fertile soil is covered by vegetation and soil erosion has not been observed. Geomorphology is unfavourable for ravine erosion.	2
Conclusion: Both sites are equally suitable.				
7. Meteorology				
7.1. Extreme winds	The distance between the sites is only about 1 km therefore the same meteorology conditions are for the both sites. Detailed analysis how the meteorological conditions of the site can influence the operation of the NNPP will be estimated in technical design and safety analysis report according to Lithuanian legislation and IAEA safety guides (i.e. IAEA Safety Guide No. NS-G-3.4 “Meteorological Events in Site Evaluation for Nuclear Power Plants”, etc.).			
7.2. Precipitation				
7.3. Extreme snow pack				
7.4 Extreme temperatures				
7.5. Spouts (Tornadoes)				

Characteristic	Site No 1		Site No 2	
	Description	Rank 4)	Description	Rank 5
7.6. Lightning				
Conclusion: Meteorological conditions are the same for both sites. Analysis of how meteorological events can influence the safety of NNPP will be performed in the safety analysis report.				
8. External man-induced events				
8.1. Explosion (wave and projectiles impacts)	Since the distance between the sites is only about 1 km the same external man-induced events are relevant for both sites. Detailed analysis what hazards can cause external man-induced events and influence on safety will be performed in technical design and safety analysis report according to Lithuanian legislation and IAEA safety guides (i.e. IAEA Safety Guide No. No. NS-G-3.1 “External Human Induced Events in Site Evaluation for Nuclear Power Plants”, etc.).			
8.2. Fire				
8.3. Release of flammable, explosive, asphyxiant, corrosive, toxic or radioactive substances				
8.4. Aircraft crash				
8.5. Ground collapse				
8.6. Blockage or damage to cooling water intake structures				
8.7. Electromagnetic interference				
Conclusion: The same external man-induced events are relevant for both sites. Analysis of how external man-induced events can influence the safety of NNPP will be performed in the safety analysis report.				
9. Land use				
9.1. Jurisdiction over the land or ownership	The considered sites for the new NPP are within an industrial land area allocated for State Enterprise Ignalina NPP. The legal analyses of both sites, which may be needed for a NNPP construction, are under preparation. After analyses are ready, the changes and amendments of legal acts will be done and detailed planning will be initiated (see Section 1.7).	2	The considered sites for the new NPP are within an industrial land area allocated for State Enterprise Ignalina NPP. The legal analyses of both sites, which may be needed for a NNPP construction, are under preparation. After analyses are ready, the changes and amendments of legal acts will be done and detailed planning will be initiated (see Section 1.7).	2

Characteristic	Site No 1		Site No 2	
	Description	**Rank 4)**	**Description**	**Rank 5**
9.2. Foreseeable development of land in the area of interest	The land usage purpose is defined as “of other special purpose (production and distribution of electric energy, operation of nuclear power units, nuclear fuel storage, supervision and maintenance of energy installations and other)”. Due to the proposed economic activity the land usage will not need to be changed.	2	The land usage purpose is defined as “of other special purpose (production and distribution of electric energy, operation of nuclear power units, nuclear fuel storage, supervision and maintenance of energy installations and other)”. Due to the proposed economic activity the land usage will not need to be changed.	2
Conclusion: Both sites are favourable and equally acceptable.				
10. Population distribution				
10.1. Population exposure	There are no residents in the sanitary protection zone. Distance between the alternative sites is only about 1 km. therefore the population exposure due to NNPP will be the same.	2	There are no residents in the sanitary protection zone. Distance between the alternative sites is only about 1 km. therefore the population exposure due to NNPP will be the same.	2
10.2. Population density	The proposed site for the new NPP is within the existing INPP industrial site. A 3 km radius sanitary protection zone has been defined for Ignalina NPP site. There is no permanently living population within the existing sanitary protection zone and the economic activity is limited as well. The site is distant from residential areas (see Section 7.9).	2	The proposed site for the new NPP is within the existing INPP industrial site. A 3 km radius sanitary protection zone has been defined for Ignalina NPP site. There is no permanently living population within the existing sanitary protection zone and the economic activity is limited as well. The site is distant from residential areas (see Section 7.9).	2
Conclusion: Both sites are favourable and equally acceptable.				
11. Protection of the environment				
11.1. Biodiversity	There are endangered species at or close to the site. Special mitigation measures for protection of biodiversity are necessary (see Section 7.6).	2	There are endangered species at or close to the site. Special mitigation measures for protection of biodiversity are necessary (see Section 7.6).	1
11.2. Protected areas and ecological networks	There are no protected areas or ecological networks at the site. In a radius of 30 km from the site, there are eight NATURA 2000 network Sites of Community Importance (SCI), valuable for habitat and animal species protection and four NATURA 2000 network Special Protection Areas (SPAs), valuable for bird protection, as well as 5 protected territories of national importance and two water body protection zones (protection regulation is based on surrounding terrestrial areas and targeted on achievement or maintenance of good water quality) (see Section 7.6).	2	There are no protected areas or ecological networks at the site. In a radius of 30 km from the site, there are eight NATURA 2000 network Sites of Community Importance (SCI), valuable for habitat and animal species protection and four NATURA 2000 network Special Protection Areas (SPAs), valuable for bird protection, as well as 5 protected territories of national importance and two water body protection zones (protection regulation is based on surrounding terrestrial areas and targeted on achievement or maintenance of good water quality) (see Section 7.6).	2

Characteristic	Site No 1		Site No 2	
	Description	Rank 4)	Description	Rank 5
11.3. Areas of significant public values	There are no areas of significant public value at the site. There are seven cultural heritage sites in the vicinity of the new NPP site (see Section 7.8).	2	There are no areas of significant public value at the site. There are seven cultural heritage sites in the vicinity of the new NPP site (see Section 7.8).	2
11.4. Social economic sphere	The site is located in a sparsely populated territory of trans-border zone of long-lasting depopulation. From the economic point of view the new NPP region, except the town of Visaginas, is a less developed region in Lithuania. Agriculture and forestry of low intensity dominate in the region. There are 980 employers in the region (including public institutions), about 700 of whom are small to medium sized enterprises, which have no more than 250 workers. No important minerals (with the exception of quartz sand) are found in the region (see Section 7.9).	2	The site is located in a sparsely populated territory of trans-border zone of long-lasting depopulation. From the economic point of view the new NPP region, except the town of Visaginas, is a less developed region in Lithuania. Agriculture and forestry of low intensity dominate in the region. There are 980 employers in the region (including public institutions), about 700 of whom are small to medium sized enterprises, which have no more than 250 workers. No important minerals (with the exception of quartz sand) are found in the region (see Section 7.9).	2
11.5. Infrastructure	There is good infrastructure of roads and railway connection at the site. The nearest motorway passes 11 km to the west of the site. This motorway joins the city of Ignalina with those of Zarasai, Dukstas and has an exit to the highway connecting Kaunas and St. Petersburg. The entrance of the main road from the site to the motorway is near the town of Dukstas. There is another exit to Vilnius–Zarasai motorway. The extension of the road from the site to Dukstas is about 20 km. The main railroad from Vilnius to St. Petersburg passes 8 km to the west of the site. There is a 10 km zone of no flights around the site (except flights of military police and border control helicopters).	2	Better road connection and new railway connection have to be built to the site. The nearest motorway passes 12 km to the west of the site. This motorway joins the city of Ignalina with those of Zarasai, Dukstas and has an exit to the highway connecting Kaunas and St. Petersburg. The entrance of the main road from the site to the motorway is near the town of Dukstas. There is another exit to Vilnius–Zarasai motorway. The extension of the road from the site to Dukstas is about 20 km. The main railroad from Vilnius to St. Petersburg passes 9 km to the west of the site. There is a 10 km zone of no flights around the site (except flights of military police and border control helicopters).	1
11.6. Landscape	The landscape of the site is industrial and is characterized by power production units and buildings connected to power production operation. The landscape around the site is mainly composed of forests and wetlands. Residential areas consist of small villages with traditional houses. Lake Druksiai is a major natural landscape element with associated activities (fishing, recreational use) (see Section 7.7).	2	The landscape of the site is industrial and is characterized by switchyard and buildings connected to power production operation. The landscape around the site is mainly composed of forests and wetlands. Residential areas consist of small villages with traditional houses. Lake Druksiai is a major natural landscape element with associated activities (fishing, recreational use). (see Section 7.7)	2

Conclusion: Both sites are suitable but Site No. 1 is more favourable because of less important biodiversity values and better infrastructure of local roads.

Characteristic	Site No 1		Site No 2	
	Description	**Rank 4)**	**Description**	**Rank 5**
12. NNPP erection conditions				
12.1. Place and features of surroundings	The site is situated east of Unit 2 of the present power plant and comprises the area, which was previously planned for Units 3 and 4. The site area is approximately 0.493 km^2 and ends at its northern side (length 0.6 km) directly at the cooling water discharge channel common for existing INPP Units 1 and 2. To the south of Units 1 and 2, the area is limited by the road from west to east. The length of the western border is approximately 0.58 km. The perimeter of this site is approximately 3.5 km. At its southern border (length of 1.255 km) the interim spent nuclear fuel storage facility is located. The new NPP feasibility study, which had been prepared before the start of the EIA process of the new NPP, has found that the site area is sufficient for construction of the new NPP and auxiliary installations.	2	The site is situated in an area west of the existing switchyard and it is currently unbuilt area (swamp, bushes). Its size is approximately 0.424 km^2. Its northern border is the shoreline of Lake Druksiai (length approximately 0.75 km). The other three borders are straight, forming a rectangular area, the eastern side of which is 1.1 km and the western 0.66 km long. The existing Building No. 106 (open switchyard) is in the area. Better road connection and new railway connection have to be built to the site. The new NPP feasibility study, which had been prepared before the start of the EIA process of the new NPP, has found that the site area is sufficient for construction of the new NPP and auxiliary installations.	1
12.2. Peculiarity of subsurface	Subsurface of the assessed site and its surroundings do not have specific features according to present knowledge and data. There are no solid minerals and valuable protected geological objects. Groundwater (confined) is well protected from possible contamination. The site is located at a distance of about 1 km from the third level limit of sanitary protection zone of well-field of the Visaginas town (see Section 7.3).	2	Subsurface of the assessed site and its surroundings do not have specific features according to present knowledge and data. There are no solid minerals and valuable protected geological objects. Groundwater (confined) is well protected from possible contamination. Southwest part of the site boarders with the third level limit of sanitary protection zone of well-field of the Visaginas town. (see Section 7.3).	1
12.3. Underground peculiarities	There are no deposits of mineral resources at the site and it's closest vicinities. According to existing data valuable properties of the underground have not been observed. Groundwater has not been used for drinking purposes at the site territory.	2	There are no deposits of mineral resources at the site and it's closest vicinities. According to existing data valuable properties of the underground have not been observed. Groundwater has not been used for drinking purposes at the site territory. More detailed investigations are needed.	1
12.4. Exploration level of the site and demand on extra data	Many geological investigations have been performed at the site (see Section 7.5). Demand of extra data (soil, geotechnical characteristics) will be clarified before the design.	2	More detailed geological investigations of the site are needed (see Section 7.5). Demand of extra data (soil, geotechnical characteristics) will be clarified before the design.	1

Characteristic	Site No 1		Site No 2	
	Description	**Rank 4)**	**Description**	**Rank 5**
12.5. Melioration importance	Level of surface water will depend on the depth of building foundations. Unconfined groundwater is discharged to the underground areas next to the site, ditches and Lake Druksiai.	2	Level of surface water will depend on the depth of building foundations. Unconfined groundwater is discharged at the swampy descents, ditches and Lake Druksiai.	2
12.6. Change of land usage	The land usage purpose is defined as “of other special purpose (production and distribution of electric energy, operation of nuclear power units, nuclear fuel storage, supervision and maintenance of energy installations and other)”. Due to the proposed economic activity the land usage will not need to be changed (see Section 1.7).	2	The land usage purpose is defined as “of other special purpose (production and distribution of electric energy, operation of nuclear power units, nuclear fuel storage, supervision and maintenance of energy installations and other)”. Due to the proposed economic activity the land usage will not need to be changed (see Section 1.7).	2
12.7. Public evaluation	The residents of the town of Visaginas and surrounding areas have a positive attitude towards construction of the new NPP at the site No. 1.	2	As a result of the currently ongoing process of the public participation in the discussion of the environment impact assessment of the new NPP, the site No. 2 has got negative feedback due to vicinity of the sanitary protection zone to the garden-plots.	1
Conclusion: Conditions for construction and operation of the new NPP at the first site are favourable. At the second site, conditions are less favourable.				

The following conclusions were drawn from the comparison of the suitability of the location alternatives for construction and operation of the new NPP:

- Conditions of geochemistry, surface processes, meteorology, man induced events, land use and population distribution are equally favourable for both sites.
- According to the currently available data, the both sites are equally acceptable and appropriate with regards to the tectonic and seismic conditions. More detailed assessment of the sites under these conditions requires accurate instrumental measurements and additional investigation.
- Hydrogeological conditions of the site No. 2 are slightly more complicated than those of the site No. 1 and therefore the first site is considered more favourable.
- Considering the hydrological conditions for heated water cooling in the lake, the site No. 1 is more favourable. At the site No. 2 an efficient direct cooling system would demand construction of a long cooling water channel. However, in case of the first site means shall be provided to ensure that during the NNPP construction neither the existing INPP surface water management systems, nor the system of the future near surface radioactive waste repository on Stabatiskes site is damaged.

The final conclusion of the site evaluation is that both of the sites are suitable for construction and operation of the new NPP.

Comparison of environmental impacts of location alternatives

Site No. 1 was originally intended for the third and fourth Ignalina NPP reactors. Some foundation structures were constructed in the 1980's and have since then mostly been removed. The whole site has been totally altered by man and now consists of a large open and empty area with bare man-made soil. The direct impacts if construction at Site No. 1 will thus be small.

Site No. 2 mainly consists of scrubland altered by man during the construction of the INPP. Some forest needs to be cleared as part of site preparation.

The NNPP will at Site No. 1 be able to utilize the existing cooling water inlet and outlet structures, only minor extensions of these will be required. At Site No. 2 a new inlet and a significant extension of the outlet channel have to be constructed.

Both sites will potentially cause some impacts on biodiversity due to the direct construction measures and to disturbance of habitats of valuable species. As Site No. 1 has already been prepared the impacts of this site will be slightly less compared to Site No. 2.

Both sites are located in the immediate vicinity of the existing INPP. Construction of the NNPP will thus not change the landscape very much in either site alternative.

Site No. 2 will be located closer to settlements and Visaginas town. The distance to the nearest settlements will however still be at least 2 km, and the distance to Visaginas town centre will be 6-8 km. Thus this factor can not be considered very significant.

From an environmental point of view Site No. 1 is preferable as it has already been prepared, and as it is more or less surrounded by technological structures of the INPP. The difference between the two sites from an environmental point of view is however not very significant.

7.12.2.5 Cooling alternatives

The most essential factor in the cooling system selection process is the availability of sufficiently large body of water and the environmental impact of the thermal releases on the ecology of the body of water. If there is sufficient cooling capacity and if the environmental impacts are acceptable, direct cooling is the preferred solution. The wet cooling tower solution is the second choice, if the impacts of water evaporation and discharge of blow-out waters on the body of water utilised are acceptable. If these criteria are met size of available sites, impact on efficiency and investment cost considerations are the main determining factors.

Direct cooling

The direct cooling system is the most efficient cooling system but it requires a relatively large watercourse with adequate water supply and cooling capacity. Its advantages are the usually lower investment costs and higher plant efficiency. In the once-trough cooling (direct cooling) the receiving water body acts as a heat sink from where the heat is transferred to air by evaporation. The discharge of heated water can have various environmental impacts on the receiving water body. In direct cooling the cooling water does not necessarily need any other treatment than mechanical removal of larger particles.

The location of the cooling water inlet and outlet may influence the environmental impacts significantly. The impacts on Lake Druksiai water temperature of different direct cooling water inlet and outlet alternatives and combinations at different power levels have been assessed. Six alternative NNPP inlet and outlet location combination scenario sets were computed using a three-dimensional (3D) hydrodynamic lake model specifically constructed for surface water modelling. The following inlet and outlet combinations were used:

- PP – present inlet and present outlet
- DP – deep inlet and present outlet
- PS – present inlet and southern outlet
- WP – western inlet and present outlet
- WS – western inlet and southern outlet
- PD – present inlet and divided outlet

Of the different outlet options the current outlet is the best when the warmed up water area of the lake is used as a criteria. However, the different outlet options do not significantly differ from each other. The present INPP outlet position allows the cooling water to spread efficiently to the main part of the lake, allowing both cooling by heat exchange to atmosphere and mixing to cooler lake water. The southern outlet position is more confined and shallow, which restricts the warm outlet water mixing with cooler lake water thus reducing the surface area where the cooling to atmosphere takes place. Dividing the outlet to two locations would be no better than the present outlet option when comparing the average size of warmed up areas. However, the divided outlet option has a small advantage in the warmest days giving a somewhat smaller value for the area exceeding 28 °C, which is explained by higher than 30 °C temperatures near the southern outlet.

Of the simulated inlet options, using the warmed area as a criteria, the western inlet is marginally better that the present inlet and both are better than the deep inlet option. The western inlet option had on the average 0.1°C cooler inlet water temperature compared to the present inlet, otherwise this option was similar to the present inlet option in the modelling. The temperature difference is explained by a larger distance to the outlet. In the deep inlet option simulation, the cold water storage of the deeper part of the lake was depleted in the beginning of the simulation, after which the inlet temperatures were no different from the present inlet option. Additionally, in the deep inlet option after the thermocline of the lake is destroyed, the mixing of warmer water to deeper layer is increased raising the total heat storage in the lake. As a result the deep inlet option produced higher surface temperatures during the warmest periods compared to the present inlet option.

The different power levels do not significantly change the behaviour between different inlet and outlet location alternatives.

Direct cooling also causes evaporation of lake water and thus may affect the water level and water amount of the lake. The hydrological effects on the lake and their consequences are considered minor. During rare periods of several successive dry years the lake level would fall below normal, however staying above the minimum allowable level. Evaporation of water by cooling the NNPP would periodically reduce the overall volume of water in the lake somewhat, thereby impacting the quantity of water discharged to River Prorva in Belarus.

Based on the 3D modelling and assessment it is clear that because of ecological reasons only part of the planned maximum total power generation level of 3 400 MW_e can be generated utilising Lake Druksiai for direct cooling. The ecologically acceptable thermal load to the lake is estimated to be approximately 3 160 $MW_{released}$.

Indirect cooling

Indirect cooling should be considered when the thermal load to the lake exceeds 3 160 $MW_{released}$.

Possible indirect cooling solutions are:

- Wet cooling towers
- Dry cooling methods
- Hybrid cooling towers

Wet cooling towers utilise lake water for cooling through evaporation, convection and radiation. Wet cooling tower is the commonly used system at locations with restricted water resources or special needs to limit the thermal load to the watercourse. It is the second most efficient cooling system after the direct cooling system. It also has higher investment costs. Its power consumption as well as demand for area depends on the design type. The natural draft towers consume more energy but demand less space than the forced draft towers. Cooling towers usually need treatment of cooling water for biofouling, scaling and suspended matter, with acceptable biocides, antiscalants, and dispersants, respectively. Since most of the heat is evaporated to the atmosphere and not discharged to the water systems, the impacts on the receiving watercourse remain smaller than in direct cooling.

Wet cooling towers can also be used as a part of the direct cooling system to decrease thermal discharge to the receiving body of water. With this solution, condenser cooling water discharge is led (entirely or partly) through this so called “helper cooler” which cools down the exiting water.

Wet cooling towers cause visible steam plumes at certain weather conditions.

Dry-cooling systems can be air-cooled condensers or so called Heller-systems. In the dry-cooling systems the cooling efficiency is lower than in the wet cooling systems but also the demand of water is lower. Specific features of an air-cooled condenser (ACC) and Heller system are insignificant make-up water consumption but also rather ineffective cooling. In ACC the cooling occurs with convection and radiation. Due to relatively low heat transfer efficiency, ACC also requires a large area to be placed. Heller is an indirect dry cooling method. There's a closed circulation between the condenser and the dry cooling tower whose structure is very similar to ACC's. The condenser is jet type which sprays the cooled water directly to the boiler water circulation. Therefore the cooling water has to be demineralised water.

The dry cooling systems are not regularly used as a primary cooling system in large (> 1 000 MW) power plants since they demand a relatively large area (up to ten times as large as wet cooling towers) and decrease the plant efficiency significantly. The electricity demand is also high due to the fans, which are required for air circulation. The investment costs of dry cooling systems are substantially higher than those of wet cooling. Also, the dry tower system alone can be unable to produce the needed performance required during periods of ambient high temperature. The advantage of the dry cooling systems is that they barely consume water at all, thus there are typically no evaporation losses. Since it does not produce any thermal discharges it does not cause any heat impacts on the surrounding water systems.

In conditions where water can be a limiting factor for some time periods it can be favourable to combine both dry and wet cooling methods. It is possible to use separate wet and dry towers or to incorporate both wet and dry cooling sections into the same tower design (hybrid). The construction of a hybrid tower may vary significantly along the various manufacturers. The basic idea is, however, that the wet cooling part is located at the bottom of the tower and the dry cooling at the top. The cooling system can be operated based on the prevailing conditions. When sufficient amount of water is available the dry cooling, which consumes more electricity, is turned off and heat removal relies on wet tower cooling. During times of limited water resources the heat or, depending of the design, some proportion of it, would then be dissipated by the dry towers.

However, with the present temperature regulation (20 % / 28 ºC) the maximum thermal load to the lake especially during July and August is limited. During the rest of the year the lake can, however, tolerate substantially higher thermal load without exceeding limits set in the criterion. The results from thermal load reduction scenarios show that reducing 3 160 $MW_{released}$ thermal load to half during the warmest, ecologically most critical month would keep lake temperatures below the present limit of 20 % / 28 ºC degrees (possibly with few days of exception). Consequently the environmentally and economically best option may be to limit the thermal load to the lake mainly during the warmest months.

7.12.2.6 Comparison of non-implementation of the project

The most significant impact of non-implementation of the project is of socio-economic character. Considering the planned shutdown of Unit 2 of Ignalina NPP in 2009 the non-implementation situation will not be the same as today. After shutdown of Ignalina NPP the socioeconomic situation of the Visaginas region will change for the worse due to unemployment. The new nuclear power plant would counter-effect this adverse change as it would offer employment and other economical benefits. If the NNPP is not constructed its significant positive impact on employment and the socioeconomics of the NNPP region, including Latvian territory, would not be realised.

After shutdown of Ignalina NPP the thermal load currently discharged to Lake Druksiai will be absent, which will have impacts on lake ecology and biodiversity changing it from what it is today. This may very well have significant impacts also on biodiversity such as the designation values of the Lake Druksiai Natura 2000 –area, especially on the birdlife. It is difficult to exactly predict how the lake will develop during decades after stopping the thermal load, but it can be assumed that it will not return to the situation before commissioning of the Ignalina NPP because of other factors influencing the development of the lake to another direction. The thermal load from the NNPP would make it possible for some of the biodiversity values of today to continue existing or, should they disappear after the shutdown of INPP, make it possible for them to return to the lake after commissioning of the NNPP. This is especially true for certain bird species.

If the project is not executed the electricity that would have been produced by the NNPP will be produced by alternative forms of electricity generation. Substituting the amount of electricity with fossil fuels will cause substantially more emissions of sulphur dioxide, nitrogen oxides, carbon dioxide and particles. The immediate impacts of these emissions will not be realized in the Visaginas region, but instead in the areas close to the power plants generating this alternative electricity and close to the fuel sources in Lithuania and abroad. The impacts of carbon dioxide releases on climate change are global.

7.12.3 Conclusion on the environmental and social feasibility of the planned activity

Utilization of Lake Druksiai for direct cooling is for ecological reasons only possible approximately up to a thermal load level of 3 160 $MW_{released}$. By combining direct cooling with wet cooling towers and/or dry or hybrid solutions the planned maximum power generation level of 3 400 MW_e is achievable from an environmental point of view.

It is conservatively forecasted that in 2015 (when the new NPP is planned to be built) the total annual effective dose to the critical group members of population due to airborne emissions and liquid discharges from the new NPP and existing and new nuclear facilities of Ignalina NPP at the boundary of the existing SPZ (with 3 km radius) will be about 0.05 mSv. The established dose constraint for members of the public is 0.2 mSv per year. Therefore, total annual dose in 2015 to population during normal operation of the facilities in the existing SPZ will, at a maximum, be about 4 times less than the dose constraint (see Table 7.11–1).

Based on experience from other countries and estimations about the impact of the NNPP on the public, the sanitary protection zone for the NNPP is suggested to be of 1 kilometre radius for all reactor types analysed in the EIAR. The proposed sites for the NNPP are within the existing INPP industrial site and sanitary protection zone. The shortest distance from the proposed sites to the boundary of the existing sanitary protection zone is about 1.5 km.

Site No. 1 is slightly more preferable than Site No. 2 for the construction of the NNPP from an environmental point of view. Site No. 1 will impact the designation values of the Lake Druksiai Natura 2000 –area and endangered species less, although constructing the NNPP would potentially impact biodiversity values negatively at both sites. Mitigation measures are required to achieve an acceptable level of impacts on biodiversity values.

The environmental impact assessment did not find any environmental or social impacts of such significance caused by construction or operation of the NNPP that they could not be accepted or mitigated to an acceptable level. Thus the impacts from the construction, operation and decommissioning of all the Generation III/III+ NPP technologies considered for the NNPP would be acceptable at both sites considered.

Risk assessment performed in EIA differs from risk assessment which is performed later in the Safety Analysis Report of a NPP. The EIA also does not take a position on the acceptability of a severe accident risk. The assessment in EIA has aimed at presenting, as clearly as possible, the probability of a severe accident and comparison information regarding the related consequences with defined criteria so that the readers can use them as needed in the formation of their own opinion. The fundamentals of nuclear safety and the probability of a severe accidents have been examined in Section 5.3 and Chapter 10.

When handled properly, the spent fuel and other radioactive waste of the new nuclear power plant do not cause harmful impacts on the environment or people. The solutions for handling of these radioactive wastes will undergo their own environmental impact assessment procedures where the environmental feasibility of these solutions will be assessed.

8 TRANSBOUNDARY IMPACTS

Potential transboundary impacts during construction and normal operation of the new nuclear power plant (NNPP) have been summarized in this chapter. The impacts are discussed more thoroughly in Chapter 7 of this Environmental Impact Assessment Report.

8.1 WASTE

8.1.1 Radiological impacts

According to Lithuanian legislation, management of radioactive waste must ensure among others the following:

- At all stages of the radioactive waste management, by applying appropriate methods, individuals, society and the environment in Lithuania and beyond its borders are adequately protected against radiological, biological, chemical and other hazards that may be associated with radioactive waste;
- Safety of radioactive waste management facilities is guaranteed during their operating lifetime and after it.

Radioactive waste is stored, abiding by the above mentioned factors, in the NNPP region on Lithuanian territory. The solution for long-term storage and disposal of spent nuclear fuel (SNF) has not been chosen yet. The handling, storage and disposal of radioactive waste from the NNPP will be the subject of separate environmental impact assessment procedures in the future.

The European Atomic Energy Community (Euratom) Treaty requires that each Member State provides the Commission with plans relating to the disposal of radioactive waste (Article 37) and that the licensee declares to the Commission the technical characteristics of the installation for its control (Article 78) and submits an investment notification (Article 41).

Handling of radioactive waste is not expected to cause any significant transboundary radiological impacts.

The transboundary impacts of NNPP liquid effluents containing radionuclides are discussed in Section 8.2.1.

8.1.2 Non-radiological impacts

Non-radioactive waste will be handled regionally in Lithuania complying with the Lithuanian Law on Waste Management (*State Journal, 1998, No. 61-1726; 2002, No. 72-3016*) and the requirements of the Regulations for Waste Management (*State Journal, 2004, No. 68-2381*).

Handling of non-radioactive waste is thus not expected to cause any transboundary non-radiological impacts.

The transboundary impacts of treated waste water discharge from the NNPP to Lake Druksiai are discussed in Section 8.2.2.

8.2 THE STATE OF WATERS

This Section concentrates on the impacts on Lake Druksiai as a whole, as this lake is partially located in Belarusian territory as well as on the River Prorva in Belarus, the river, via which the waters flow out from Lake Druksiai.

8.2.1 Radiological impacts

The radioactivity of the monitored nuclides in the aquatic environment around Ignalina NPP has been continuously decreasing during the last ten years. The new NPP will be constructed and operated using the best available techniques and practises, which means an essential improvement to the environmental performance. Thus, the total releases to aquatic ecosystem are assumed to decrease. The realised releases from the new NPP will be so small that they will not cause any significant harmful impacts on the environment.

8.2.2 Non-radiological impacts

8.2.2.1 Waste water impact

The nutrient load from the NNPP will be small compared to the total load to Lake Druksiai coming from other sources (e.g. Visaginas municipality and natural runoff). Thus the impacts of the new NPP on water quality and eutrophication are considered insignificant. The impacts of the treated waste waters on the lake are estimated to be minor and acceptable. However, these impacts will be monitored and if unacceptable consequences occur, the treatment of waste waters will be improved.

8.2.2.2 Cooling water impact

The amount of waste heat discharged to Lake Druksiai depends not only on the electricity produced but also on the cooling system chosen. In direct cooling system all the heat is discharged to the lake when in case of cooling towers only a minor part of the heat enters the lake and the major part is transmitted to air.

Model computations of the effect of release of warm cooling water to Lake Druksiai in direct cooling were carried out using a three dimensional hydrodynamic water flow model, specifically designed for modelling lakes and coastal areas. The effects of different NNPP electric production capacities and different NNPP cooling water inlet and outlet locations on the water temperature of Lake Druksiai as a whole, including the Belarusian territory, were investigated.

Based on modelling results and expert assessments it can be concluded that the ecologically acceptable thermal load to the lake will be approximately 3 160 $MW_{released.}$, With this thermal load no significant impacts on the lake ecosystem are expected compared to the present state of the lake. With higher thermal load the impacts on lake ecosystem start to be clear and significant.

If only cooling towers are utilized the lake temperatures will return to the natural level and this can somewhat improve the living conditions of the species preferring cool water. However, recovery of the conditions or species composition before commissioning of INPP is not expected. If the general intensive eutrophication process continues, this alternative may also lead to low-oxygen conditions during periods of ice-cover. From this point of view, moderate warming of the lake can even be environmentally advantageous. Thus this option has somewhat diverse impacts on the lake ecosystem: it is the best option when the warming of lake is considered, but may result in partly adverse effects due to oxygen depletion if the eutrophication of the lake will continue.

The current outlet is the best alternative when the area warmed up is used as criteria. However, the different outlet options do not significantly differ from each other. The present NPP outlet position allows the cooling water to spread efficiently to the main part of the lake, allowing both cooling by heat exchange to atmosphere and mixing to cooler lake water. The southern outlet position is more confined and shallow, which restricts the warm outlet water mixing with cooler lake water thus reducing the surface area where the cooling to atmosphere takes place. Thus the southern outlet would lead to more distinct warming and eutrophication impacts in the southern Belarusian part of the lake than other outlet options.

Dividing the outlet to two locations is not a significantly better solution than the present outlet option when comparing the average size of warmed up areas.

The deep inlet option would produce higher surface temperatures in the whole lake during the warmest periods compared to the present inlet option due to destruction of the thermocline of the lake.

The main hydrological impacts of the operation of the new NPP are the evaporative losses created when the heated cooling water will transfer the heat load to air by evaporation. The total losses depend on the plant effect and the cooling method selection.

During normal hydrological years the average lake level is not expected to fall below the normal and thus the hydrological effects on the lake and their ecological consequences are considered minor. During dry years (with a 1-in-20 year return period) the lake level would fall below normal, however staying above the minimum allowed regulation level (for approximately three successive dry years). Thus also the consequences of this kind of event can be estimated to be small.

Impacts on River Prorva

Evaporation of water by cooling the NNPP would reduce the overall volume of water in Lake Druksiai, thereby impacting the quantity of water discharged to River Prorva. The operation of the new NPP would result in a net decrease of water available to the River Prorva equal to the evaporation caused by the cooling systems. The discharges out through River Prorva have not been measured during the operation period of INPP. Thus the outflow has been estimated by subtracting the additional evaporation (0.8 m^3/s), estimated to be caused by the INPP with average production[6] of 1 800 MW, from the natural average outflow (MQ=3.3 m^3/s). The estimated present mean discharge to the River Prorva is thus 2.5 m^3/s.

The new mean discharge is calculated similarly (by subtracting the additional evaporation due to the NNPP from the natural MQ).

The evaporation from the new plant (assuming effect of 3 400 MW) would be approximately 0.7 m^3/s higher than at present (corresponding to the increase of 1 600 MW). Consequently, the present mean annual discharge to River Prorva would decrease approximately by 28 %.

The decrease of mean flow would impact the approximately 50 km long stretch of River Prorva before the confluence of River Dysna. Reduced flows could alter the riparian

[6] The average production has been calculated as a yearly average from period 1993–2004 when both units were in operation.

vegetation and habitat for riparian and wetland species along the River Prorva. They could also have adverse impacts on the river water use for e.g. irrigation or cattle watering. However, the decrease in the flow is estimated to be so small that no significant negative impacts either on people or nature are expected. The minimum discharge in River Prorva will remain at the present level (0.64 m^3/s) in all of the scenarios.

The decrease in the mean discharge in River Dysna is so small (7 % of the mean discharge 10 m^3/s) that after the confluence with River Dysna the impact of NNPP can be considered negligible.

Ice conditions

The impact of the cooling water releases on wintertime ice conditions was also simulated using three different NNPP thermal load levels. At thermal load of 2 230 $MW_{released}$ the ice free area would be located close to the NNPP outlet. At times, depending on winter temperature in general, the impact on the ice cover would be significant, especially with thermal loads of over 3 160 $MW_{released}$. Thermal loads of 4 460–6 310 $MW_{released}$ would keep the main part of the lake open longer from the start of the winter. In general the impact on the ice cover would be smaller in the southern and western part of the lake compared to the rest of the lake. Impacts on the ice cover of the Belarusian part of Lake Druksiai are possible at higher power levels utilizing direct cooling.

Monitoring of the impacts of the NNPP cooling waters on Lake Druksiai and the discharging rivers will be performed, thus allowing changes in operation of the NNPP if necessary.

8.3 CLIMATE AND AIR QUALITY

8.3.1 Radiological impacts

All nuclear power plants during operation cause certain radioactive releases to the atmosphere. According to Lithuanian legislation radioactive materials may be released into the environment only after the permission for discharges of radioactive substances to the environment is obtained. This permission is issued by the Ministry of Environment to the operator of the nuclear installation according to the conditions and procedures established in regulations and following the requirements of the normative document LAND 42-2007 “On the Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring” (*State Journal, 2007, No. 138-5693*).

Radioactive emissions from the NNPP to the atmosphere will be well under permissible levels defined to protect people and the environment against adverse effects from radiation. The radioactive emissions will be continuously monitored.

Transboundary annual exposure of the population due to gaseous releases into the environment is discussed in Section 8.11.1.

8.3.2 Non-radiological impacts

The NNPP would not cause carbon dioxide (CO_2) emissions into the atmosphere during the operational phase. The total amount of CO_2 emissions from thermal power plants producing the same amount of electricity as the NNPP with maximum capacity (3 400 MW_e) if the NNPP is not built would be about 5.8 million tonnes per year of which about 3.8 million would be produced in Lithuania. This corresponds to 45 % of Lithuania's total CO_2 emissions from fuel combustion in the energy sector in 2006. CO_2 is a so called greenhouse gas which contributes to global warming. The NNPP will thus have a positive transboundary impact as it counteracts global warming.

The construction and operation of the NNPP will only have very local adverse impacts on air quality, mainly during the construction phase. Transboundary impacts on air quality are not expected.

8.4 GROUNDWATER

8.4.1 Radiological impacts

Based on experiences from INPP operation there will not be harmful impacts on any confined aquifers or shallow unconfined groundwater even locally.

Transboundary radiological impacts on groundwater are therefore not expected.

8.4.2 Non-radiological impacts

Transboundary non-radiological impacts on groundwater are not expected.

8.5 SOIL

8.5.1 Radiological impacts

It is expected that during normal operation of the new NPP the concentration of radionuclides in the soil will be negligible.

Transboundary radiological impacts on soil are therefore not expected.

8.5.2 Non-radiological impacts

The main impacts on soil will occur during the construction stage and will be confined to the construction areas.

Transboundary non-radiological impacts on soil are therefore not expected.

8.6 GEOLOGY

8.6.1 Radiological impacts

The construction and operation is not expected to affect the deeper geological layers.

The new NPP has to be built on a stable foundation which is not located on a tectonic fault. Both NNPP site alternatives are located on the same tectonic block which is quite stable. The absolute values of shifts at the sites are infinitely small in practice and negative impact due to the tectonic movements on the construction or operation of the new NPP is not expected.

Transboundary radiological impacts on or because of geological conditions are therefore not expected.

8.6.2 Non-radiological impacts

Transboundary non-radiological impacts on or because of geological conditions are not expected.

8.7 BIODIVERSITY

8.7.1 Radiological impacts

Based on available analysis data, it may be stated that the radioecological state of soil, flora and fauna in the Ignalina NPP region and its surroundings is quite good. The radioecological state of flora and fauna in the neighbouring countries can therefore also be considered good. The impact of the new NPP on the radioecological state of the region is estimated to be lower than the impact of the existing Ignalina NPP.

Transboundary radiological impacts on flora, fauna and biodiversity are therefore not expected.

8.7.2 Non-radiological impacts

Cooling water thermal discharge to Lake Druksiai, direct damage of the NNPP construction site as a habitat, disturbance to the surroundings of the construction site and traffic will potentially impact biodiversity.

The impacts of the thermal discharge of the NNPP on Lake Druksiai have been assessed. The animal species depending on fish, insects and other aquatic animals and plants as a food resource would have enough food also in the future since the amount of fish, insects etc. is not predicted to decrease – only the species composition can be expected to change if a very significant amount of cooling water is discharged to Lake Druksiai. However, taking the precautionary principle into consideration, it can not be ruled out that thermal load significantly exceeding 3 160 $MW_{released}$ discharged to Lake Druksiai could cause significant negative impacts on the ecology of the lake and thus on biodiversity values of the lake through complex interaction chains. This could have transboundary implications on biodiversity of the lake as well.

The NNPP can have a positive transboundary impact on especially bird fauna biodiversity as it would keep parts of the continuously lake ice-free in wintertime. This is especially true keeping in mind that the Ignalina NPP will be shut down in 2009, after which there will be no significant thermal load to the lake, which will lead to the lake being ice-covered at least periodically in wintertime which will have a negative impact on the diversity of the bird fauna.

No significant transboundary impacts on terrestrial and semi-aquatic fauna, flora and biodiversity are expected. Potential adverse impacts on animal populations will be small or can be mitigated to an acceptable level where the future of the species at Lake Druksiai is not threatened because of the NNPP.

8.8 LANDSCAPE AND LAND USE

8.8.1 Radiological impacts

Not relevant.

8.8.2 Non-radiological impacts

The landscape in the Lake Druksiai watershed has changed because of the building and operation of INPP, Visaginas town and related infrastructure.

Construction of the new NPP near the INPP will not significantly change the landscape as perceived from the shores of Lake Druksiai, also from the shores in Belarus. Only at a few places by the lake shore will the NNPP be visible to larger amounts of people.

The NNPP will not be visible to Latvian territory.

Significant transboundary impacts on landscape are therefore not expected.

8.9 CULTURAL HERITAGE

8.9.1 Radiological impacts

Not relevant.

8.9.2 Non-radiological impacts

No transboundary impacts on cultural heritage objects will occur.

8.10 SOCIO-ECONOMIC ENVIRONMENT

8.10.1 Radiological impacts

Not relevant.

8.10.2 Non-radiological impacts

A significant positive impact on the socio-economic environment in the foreign parts of the NNPP region is expected. A need for Latvian workforce will occur. A significant part of the total workforce, which is in the order of 3 000 – 3 500 workers, during the construction phase will come from other countries than Lithuania and Latvia, and will need accommodation for several years. A part of this workforce will bring their families with them. As the border between Lithuania and Latvia is open it can be predicted that the workforce will be spread out living not only in Visaginas or its vicinity, but potentially also on the Latvian side at least as far as Daugavpils. During the operational phase a significant amount of foreigners, about 800 – 1000 workers also needing accommodation, will periodically work at the NNPP when yearly overhauls are being conducted.

The workforce will to a significant extent utilize the services of the regional main town Daugavpils on the Latvian side, which will bring significant positive socio-economic impacts to this region of Latvia.

There is no need for impact on international air transportation while this is already a no flight zone because of the Ignalina nuclear power plant.

The NNPP project has met some resistance among the public abroad, for instance in Latvia, which indicates that the project causes concern among at least a part of the public abroad. This is at least partially an indication of a negative attitude against nuclear power as such.

Significant positive transboundary socio-economic impacts are expected. No significant negative socio-economic impacts are expected as the NNPP will be constructed next to an existing NPP, to which the surrounding areas have adjusted.

8.11 PUBLIC HEALTH

8.11.1 Radiological impacts

8.11.1.1 Impacts due to waterborne releases

The possible exposure of population due to radionuclide releases from the new NPP into Lake Druksiai was evaluated using dose factors provided in annex of LAND 42-2007 (*State Journal, 2007, No. 138-5693*). More detailed information on this evaluation and obtained results is provided in Section 7.10.2.2. In this section radionuclide transfer through river continuum: Druksiai → Prorva → Druksa → Dysna → Daugava → Gulf of Riga is presented and possible transboundary impacts are assessed.

This approach of radionuclide transfer and possible impacts is following from an analysis of INPP routine releases, which is presented in detail by Mazeika and Motiejunas (*2003*).

Calculations of radionuclide transfer through lakes and rivers as well as the maximum annual effective doses for the critical group members was performed using PC CREAM (Consequences of Releases to the Environment Assessment Methodology) model (*Simmonds et al., 1995*). However, the PC CREAM 97 code does not include a lake module. Therefore, a simple box model for lakes was combined with the river PC CREAM model. The simulation included a Lake Druksiai model (two-compartment – water and bottom sediments), a river dynamic model Prorva-Dysna (as far as Disna town in Belarus), a river dynamic model Daugava (as far as Daugavpils in Latvia), and simple dilution models for the rest of Daugava and the Gulf of Riga.

Radionuclide activity concentrations, associated with suspended sediments and with bed sediments as well as with filtered water were calculated for three operational durations (1, 5, 50 years) for each simulated compartment and were then used to derive external irradiation (gamma and beta radiation in shoreline material and in fishing gear in lake assessment, gamma and beta radiation in shoreline material in river assessment), intakes by fish ingestion and intakes by spray inhalation in lake assessment, intakes by fish and drinking water ingestion in river assessment) and subsequent individual committed doses to adults. The site-specific and generic radionuclide transfer parameter values applied during the calculation using PC CREAM 97 code were: freshwater sediment distribution coefficients K_d, sedimentation coefficients k' and concentration factors for freshwater fish (*Simmonds et al., 1995*); gamma energies and decay constants λ for each radionuclide (*ICRP, 1983*); beta doses for each radionuclide (*US DoE, 1988*); and dose coefficient for intakes by ingestion (*IAEA, 1996*). For photon exposure the reduction factors recommended by NRC (*1977*) (0.3 for lake shoreline, 0.2 for river shoreline) were applied.

Ten typical radionuclides (^{3}H, ^{14}C, ^{54}Mn, ^{59}Fe, ^{60}Co, ^{90}Sr, ^{95}Nb, ^{131}I, ^{134}Cs, ^{137}Cs) with more significant abundance in the releases and in environmental objects were selected for calculations. For comparison of doses received in the environment of different hydrological pathway chains, only members of one critical group (fisherman) were investigated.

Main hydrological parameter values were obtained from the state hydrological networks of Lithuania, Belarus and Latvia. Mean river flow rates were evaluated as follows: R. Prorva 3 m^3/s (observation in 1980-1983, below locality Drisviaty in Belarus), R. Dysna 10 m^3/s (observation in 1945-1960, below confluence with Druksa rivulet), R. Dysna 30 m^3/s (observation in 1945-1981, below locality Sharkovshchina in Belarus), R. Daugava 288 m^3/s (observation in 1944-1988, below Dysna town in Belarus), R. Daugava 451 m^3/s (observation in 1921-1980, in Daugavpils town).

For calculations of radionuclide activity in water in the lower reaches of River Daugava and in Gulf of Riga the flow rate of 700 m^3/s and water volume of $1.1 \cdot 10^{12}$ m^3 respectively were adopted (the length of the hydrological path from INPP site to Gulf of Riga is 550 km).

Exposure pathways for Lake Druksiai include ingestion of fish, inhalation of spray, external gamma and beta radiation from bank sediments and from fishing gear.

Exposure pathways for river compartments include ingestion of fish, ingestion of drinking water (which assumed to be filtered river water without water treatment processes) and external gamma and beta radiation from bank sediments.

As was shown by Mazeika and Motiejunas (*2003*) for the Lake Druksiai compartment the fishermen dose is mainly caused by ^{137}Cs, ^{90}Sr and ^{134}Cs. Contribution of ^{90}Sr is growing downstream and gets to prevail due to water transport, while total dose decreases. Contribution of immobile radionuclides (for example, ^{60}Co) among considered exposure pathways (fish consumption, water ingestion, spray inhalation, external gamma and beta radiation from shoreline sediments) to the irradiation reduces significantly along the hydrological stream. The main exposure pathway for Lake Druksiai is ingestion of fish, however for downstream compartments contribution of fish ingestion decreases while importance of external gamma exposure increases significantly. Partial contribution of the mobile radionuclides (for example, ^{3}H) to the dose along the hydrological pathway changes only little. For critical groups related to downstream river compartments the main exposure pathway is water ingestion, while fish ingestion makes up to 10 % of the dose. This assumption is very conservative because water supply from rivers is hardly possible.

Radionuclide environmental transfer factors (Sv/year : Bq/year) evaluated for INPP aquatic routine releases dispersed downstream the hydrological pathway (Lake Druksiai – Gulf of Riga) can be applied to the new NPP located close to Lake Druksiai assuming the same environmental features and radionuclide-dependent parameters. Based on radionuclide environmental transfer factors and predicted annual releases (^{3}H, ^{14}C, ^{54}Mn, ^{59}Fe, ^{60}Co, ^{90}Sr, ^{95}Nb, ^{131}I, ^{134}Cs, ^{137}Cs) from reactors of different types (see Chapter 7.1.2), radiological impact of the new NPP consisting of corresponding number of reactors on the downstream water course has been evaluated in Table 8.11–1 and Figure 8.11-1.

Table 8.11–1. Radiological impact of new NPP on downstream water system in terms of effective dose, mSv/year.

	Reactor model	ABWR	ESBWR	AP-600	AP-1000	EPR	EC-6	APWR	WWER
	Number of Units	2	2	5	3	2	4	2	3
Downstream location (Compartment No)	Outflow from Lake Druksiai – Prorva rivulet (1)	1.37×10^{-3}	2.52×10^{-4}	1.85×10^{-2}	1.60×10^{-2}	1.97×10^{-2}	7.11×10^{-2}	1.69×10^{-2}	7.88×10^{-3}
	Dysna r. at confluence with Drisviata rivulet (2)	1.42×10^{-4}	2.42×10^{-5}	2.05×10^{-3}	1.79×10^{-3}	2.36×10^{-3}	8.60×10^{-3}	1.97×10^{-3}	9.47×10^{-4}
	Dysna r. locality Sharkovshchina in Belarus (3)	8.20×10^{-5}	1.33×10^{-5}	1.06×10^{-3}	9.30×10^{-4}	1.23×10^{-3}	4.49×10^{-3}	1.04×10^{-3}	4.93×10^{-4}
	Daugava R., below Dysna town in Belarus (4)	1.90×10^{-5}	3.94×10^{-6}	4.49×10^{-4}	3.94×10^{-4}	5.27×10^{-4}	1.91×10^{-3}	4.20×10^{-4}	2.11×10^{-4}
	Daugava r., in Daugavpils (5)	8.74×10^{-6}	1.71×10^{-6}	1.85×10^{-4}	1.63×10^{-4}	2.18×10^{-4}	7.89×10^{-4}	1.75×10^{-4}	8.72×10^{-5}
	Daugava R., Riga (6)	2.50×10^{-6}	4.90×10^{-7}	5.30×10^{-5}	4.65×10^{-5}	6.22×10^{-5}	2.25×10^{-4}	5.00×10^{-5}	2.49×10^{-5}
	Gulf of Riga, Baltic Sea (7)	7.13×10^{-7}	1.40×10^{-7}	1.51E-05	1.33×10^{-5}	1.78×10^{-5}	6.44×10^{-5}	1.43×10^{-5}	7.12×10^{-6}

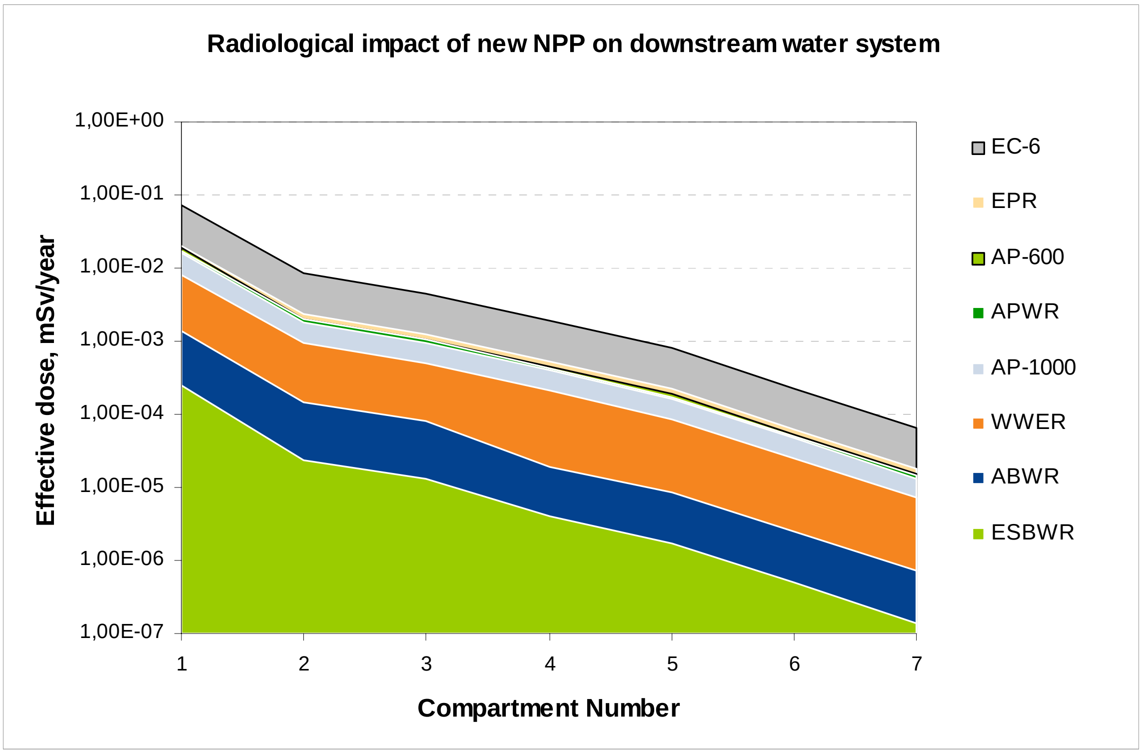


Figure 8.11-1. Radiological impact of new NPP on downstream water course. Description and location of compartment are given in Table 8.11–1 and Figure 8.11-2.

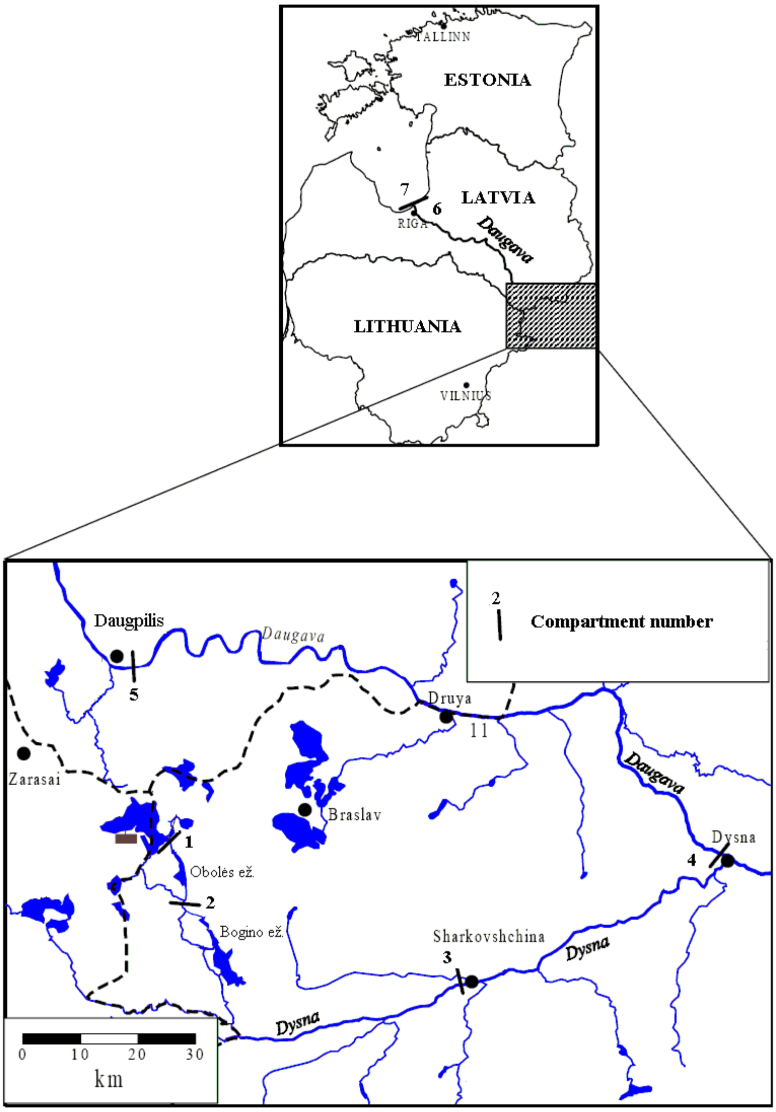


Figure 8.11-2. Locations of downstream compartments

The calculated individual committed dose due to new NPP effluents is less than the dose constraint for all reactor types and reduces significantly with distance from the release point. Highest doses were calculated for the EC-6 reactor which is characterized by the highest ^{3}H release rate compared to other types of reactors.

The cross border transfer of radionuclides releases from new NPP in water via hydrological pathway to Belarus and especially to Latvia is insignificant. In downstream Lake Obole compartment (maximal dose from four EC-6 reactors in the compartment No. 2 is 0.008 mSv/year) the committed dose to population of Belarus due to waterborne releases is less then the exemption level (0.010 mSv/year).

8.11.1.2 Impacts due to airborne releases

In order to investigate the possible impacts to population of neighbouring countries the critical group of farmers, which is analogical to 1st critical group (see Section 7.10.2.2), was selected. Change in dose due to radioactive releases into atmosphere with distance (up to 20 km from the release point) was calculated using appropriate models as recommended by the IAEA Safety Report Series No. 19 “Generic Models for use in Assessing the Impact of Discharges of Radioactive Substances to the Environment”.

Parameters used for evaluation is provided in Table 7.10–28. These parameters are conservative and do not depend on country of resident.

According to the results of the calculations, the change in dose due to airborne releases with distance is presented in Figure 8.11-3. The highest exposure dose is expected at the release point and up to a distance of 800 m. A gradual decrease in radiation dose is then observed (see Figure 7.10-12). At a distance of 1 km the radiation dose to the population is lower than the maximal radiation dose by a factor of 2, at a distance of 3 km by a factor of 10, and at a distance of 10 km by a factor of 100. According to dose calculations for the EC-6 and ESBWR reactors which give the highest impacts (see Figure 7.10-12) and dose decrease with distance (see Figure 8.11-3), it can be stated that the dose due to airborne releases from all types of reactors is less than the exemption level (0.010mSv/year) at a distance approx. 4 km from the NNPP. The shortest distance from the planned NNPP Site No. 1 to Belarusian border, which crosses lake Druksiai, is about 3.5 km (annual dose to infant from two ESBWR reactors is about 0.015 mSv), while the shortest distance to Latvian site is about 8 km (annual dose to infant from two ESBWR reactors is about 0.003 mSv). The transboundary impact due to releases is therefore insignificant and is less than the exemption level (0.010mSv/year) at a distance approx. 4 km from the new NPP.

Transboundary radiological impacts in case of accidents are evaluated in Chapter 10.

Figure 8.11-3. Dose decrease rate with a distance.

8.11.1.3 Impacts from Direct Radiation

As it is mentioned in Section 7.11.1, the results of the monitoring of radiation fields performed at the INPP industrial site and its surroundings shows that increase in direct radiation dose rates is observed locally and only close to some of radioactive material handling facilities. This means that the influence due to direct exposure from the existing Ignalina NPP nuclear facilities do not create exceptional impacts at distances greater than approximately 1 km. The impact stipulated by the direct radiation of the new NPP will be similar. For instance, the EPR safety analysis report (U.S. EPR Final Safety Analysis Report) shows that the annual dose to the population at the boundary of the restricted zone (at the distance of ~800 m from a NPP) is lower than 0.01 mSv. The manufactures of other reactors do not even estimate the impact of direct radiation, stating that this impact is insignificant. Therefore the radiological transboundary impact due to direct ionising radiation is insignificant.

8.11.1.4 Total Transboundary Impact from all Nuclear Facilities

Total radiological impact due to the new NPP, as well as due to the existing and planned nuclear facilities of Ignalina NPP is summarised in Section 7.11.1. It is planned that the new NPP will start operation not earlier than in 2015. Therefore, total radiological impact was estimated considering this year. The total estimated annual effective dose to the critical group members of the Lithuanian population due to radionuclide releases into the environment from the new NPP, as well as from the existing and new nuclear facilities of Ignalina NPP located within the existing SPZ (with 3 km radius), will be below 0.0514 mSv, i.e., will be about 4 times less than the dose constraint (0.2 mSv/year). When the distance increases, this dose rapidly decreases, and the transboundary impact becomes insignificant – the annual dose is lower than the clearance level (0.010 mSv/year).

8.11.2 Non-radiological impacts

The new nuclear power plant will be located within the Ignalina NPP industrial site and within the existing 3 km radius sanitary protection zone of INPP. The NNPP will be located at a considerable distance from permanently living population in Latvia and Belarus.

No significant transboundary non-radiological impacts on public health are therefore expected.

9 MONITORING

9.1 LITHUANIAN LEGISLATION AND REGULATIONS ON ENVIRONMENTAL MONITORING

Environmental monitoring means the systematic observation of the state of the environment and its components and changes thereof, and evaluation and prognosis of anthropogenic impact. The Law on Environmental Monitoring of the Republic of Lithuania (*State Journal, 2006, No. 57-2025*) establishes the organizational structure and procedure of implementation of monitoring, and liability with regard to this.

In carrying out environmental monitoring, one observes, evaluates and makes forecasts on the following:

- The state of the air, water, underground, soil and biota;
- The state of the natural and anthropogenically affected natural components (natural habitats, ecosystems) and the landscape;
- Physical, radiation, chemical, biological and other sources of anthropogenic impact and influence thereof upon the environment;
- The change and tendencies of the global processes taking place within the environment (acid rain, change in the ozone layer, greenhouse effect etc.).

According to Clause 4 of The Law on Environmental Monitoring (*State Journal, 2006, No. 57-2025*), the environmental monitoring system shall consist of state, municipal and economic entity environmental monitoring, in the course of the implementation whereof, information shall be accumulated and analysed regarding the state of all natural environment elements and their changes on a state, regional and local scale.

State environmental monitoring shall be implemented in order to obtain information that allows estimation in an integrated manner of natural processes and anthropogenic impact on the environment, as well as the quality of the environment throughout the territory of the Republic of Lithuania, to forecast and control the state of the environment, as well as the impact of economic activities both at national and international scale. The Ministry of Environment shall organise state environmental monitoring, and the Ministry of Environment or its authorized bodies, the Ministry of Agriculture or its authorized bodies, the State Food and Veterinary Service or other state authorities shall implement it.

State environmental monitoring shall be implemented following the State Environmental Monitoring Programme. The content of the State Environmental Monitoring Programme and the procedure for preparation, coordination, and implementation of the Programme, as well as for ensuring control of the state environmental monitoring and submitting information is defined by the Regulations on State Environmental Monitoring (State Journal, 2007, No. 4-179). At present the state environmental monitoring is carried out in accordance with the State Environmental Monitoring Programme for 2005–2010 (State Journal, 2005, No. 19-608; 2008, No. 104-3973).

Municipal environmental monitoring shall be implemented seeking to obtain more detailed information concerning the state of the environment of the municipality area, to plan and implement local environmental protection measures, as well as to assure adequate quality of the environment. Municipal environmental monitoring shall be organised according to a municipal environmental monitoring programme, developed by a municipal executive body. The content of the Municipal Environmental Monitoring

Programme and the procedure for preparation, coordination, and implementation of the Programme, as well as for ensuring control of the state environmental monitoring and submitting information is defined by the Regulations on Municipal Environmental Monitoring (*State Journal, 2007, No. 76-3035*).

Economic entity environmental monitoring shall be implemented in order to identify the amount of pollutants, emitted from the sources of economic entities, and the economic activity impact upon the environment, as well as to assure mitigation of pollution or other negative impact, caused by economic entities. According to Clause 8 of the legal document ”Regulation on Exercise of Environment Monitoring of Economy Entities” (*State Journal, 2003, No. 50-2240; 2004, No. 181-6712*), economic entities, which keep records of emissions into the environment and which have permissible pollution standards established, shall carry out monitoring of pollution sources. Monitoring of pollution sources is economic entity monitoring of emissions (pollutant releases or discharges) into the environment from stationary sources. According to Clause 9 of this regulation, monitoring of stationary air pollution sources is implemented pursuant to the control schedule of stationary air pollution sources. In accordance with Clause 15 of this legal document an economic entity shall carry out monitoring of water pollution sources (discharges) pursuant to the discharge and water control plan, developed following legal documents ”Order on Use of Water Resources and on Primary Records and Control of Pollutants Released with Sewage“ (*State Journal, 2001, No. 29-941*), ”Regulations on Mitigation of Water Pollution with Priority Hazardous Substances“ (*State Journal, 2002, No. 14-222*) and ”Regulations on Mitigation of Water Pollution with Hazardous Substances“ (*State Journal, 2002, No. 14-523*). Economic entity environmental (environmental impact) monitoring is monitoring of impact on the environment and its components due to pollutants, emitted (released or discharged) by economic entities. According to Clause 16 of the normative act ”Regulation on Exercise of Environment Monitoring of Economy Entities” (*State Journal, 2003, No. 50-2240; 2004, No. 181-6712*), economic entity environmental (environmental impact) monitoring shall be carried out following the Economic Entity Environmental Monitoring Programme that covers observation and evaluation of impact on components of the environment (except for underwater) caused by pollutants produced in the course of an economic activity. Procedure for development and coordination of the Economic Entity Underwater Monitoring Programme, as well as for exercise of monitoring and submitting of information is governed by the legal act ”Regulation on Exercise of Underwater Monitoring of Economy Entities” (*State Journal, 1999, No. 54-1763*). The Economic Entity Environmental (Environmental Impact) Monitoring Programme is developed by an economic entity taking into account the EIA Report of a proposed economic activity of the economic entity. The Programme is drawn up for 3–5 years.

9.1.1 Requirements for state radiological monitoring

State radiological monitoring is the systematic and continuous state observation of the levels of radiation dose and radionuclide contamination of the environment and its components, as well as of drinking water and food stuff, and assessment and prognosis of anthropogenic impact. State radiological monitoring is governed by the legal act ”Order on Organization, Implementation of State Radiological Monitoring and Notification of the State and Local Authorities, The Commission of the European Communities and the Public” (*State Journal, 2002, No. 100-4460; 2004, No. 103-3804*).

According to Clause 6 of the given legal act, state radiological monitoring (Monitoring further on) is carried out throughout the whole area of the state and consists of dense and sparse monitoring networks. Dense monitoring network is a monitoring network comprising the whole state territory intended for determination of averages of radioactivity levels. Sparse monitoring network is a network, where high sensitivity measurements are performed thus giving a transparent representation of actual levels and trends of radioactivity levels.

Permanent monitoring is achieved as appropriate through:

- Continuous sampling and measurements;
- Continuous sampling and periodic measurements;
- Periodic sampling and periodic measurements;
- Direct continuous measurements.

The territory of the Republic of Lithuania is defined as a single monitoring area. According to Clause 8 of the legal act, Monitoring is organised and carried out by the following bodies:

- Environmental Protection Agency – ambient gamma dose rate, airborne particles and surface water monitoring (this part of monitoring is a part of State Environmental Monitoring);
- Radiation Protection Centre of Ministry of Health Care (further on in the text – Radiation Protection Centre) – drinking water, milk and “mixed diet” monitoring.

The Radiation Protection Centre supplies additional data on measurements of amounts of radionuclides in atmospheric precipitation and on ambient dose equivalent to the population in Kupiskis and Ignalina regions. The State Food and Veterinary Service supplies the radiological control data of raw materials.

9.1.2 Requirements for radiological monitoring of nuclear installations

Radiological monitoring of nuclear installations shall be performed in accordance with the requirements set in the regulation LAND 42-2007 “The Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring” *(State Journal, 2007, No. 138-5693*).

According to Clause 4 of Article 3 and Article 29 of the Law on Civil Protection (*State Journal, 1998, No. 115-3230, 2006, No. 72-2691*) and pursuant to Clauses 11.5, 11.7, 11.10-11.13 and other relevant clauses of the Plan of Protection of the Population in Case of Radiation Accident at Ignalina Nuclear Power Plant (*State Journal, 2000, No. 32-908*) by the decision of the Fire Protection and Rescue Department under the Ministry of the Interior, in case of local or general accident and emergency (extreme radiation case) an enhanced or special operating mode of the radiation monitoring system is introduced.

9.1.2.1 General principles

The new NPP can start operation only after receiving permission for release of radionuclides to the environment. The permission is issued by the Ministry of Environment. According to the clause 17 of LAND 42-2007, the operating organization of the new NPP shall submit to the Ministry of Environment an application for permission, a plan on releases of radionuclides and a radiological monitoring programme confirmed by the Environment Protection Agency, Lithuanian Hydro-meteorological Service under the Ministry of Environment and Radiation Protection Centre. According to clause 21 of LAND 42-2007, the permission is issued indefinitely.

According to clause 27 of LAND 42-2007, the operator during operation or decommissioning of a nuclear facility shall:

- Limit release of radionuclides into the environment as much as possible;
- Perform monitoring of the environment pollution as to prove that its activity is performed in accordance with licensed conditions and to be able to assess exposure dose for the critical group members of population;
- Collect and store records on monitoring results and exposure doses as prescribed by the regulations in force.

According to clauses 35 and 41 of LAND 42-2007, the radiological monitoring of the nuclear facility is performed in accordance with the radiological monitoring programme and shall consist of monitoring of releases and monitoring of environmental components. The operator shall perform meteorological and hydrological observations which data is necessary for assessment of radionuclide dispersion in the environment of the nuclear facility and for calculation of exposure dose for the critical group members of population.

9.1.2.2 Requirements for the Radiological Monitoring Programme

According to clause 40 of LAND 42-2007, the following shall be specified in the monitoring programme: monitoring objectives, organization principles, executives, short description of the nuclear facility and its expected impact on the environment, principles for selection of monitoring locations and justification, scheme of the site with indicated locations of pollution sources and observation / sampling points, plan for meteorological and hydrological observations, environmental components to be monitored, frequency of sampling and analyses, list of methodologies and procedures used for measurements, detection limits, procedures for calibration of measurement methods and for quality assurance, data collection, methodologies for dose assessment, criteria for evaluation of monitoring results, terms and conditions for submission of reports on monitoring data and results.

According to clause 39 of LAND 42-2007, the monitoring programme shall include the monitoring of all radionuclide migration and population exposure pathways, allowing the assessment of annual emissions of activity into atmosphere and water bodies, short operational fluctuations of emissions and effective doses of the critical group members.

9.1.2.3 Requirements for the Monitoring of Releases

Airborne releases

According to clause 43 of LAND 42-2007, in order to estimate the activity of radionuclides released to the environmental air systems gas sampling from the general ventilation flow or direct measurement systems shall be installed. The flow of exhaust gas shall be measured in a credible manner under any conditions.

According to clause 44 of LAND 42-2007, the content of radionuclides released into the ambient air shall be estimated and their activities shall be measured (with the exception of ^{3}H, ^{14}C) not less than once per month.

According to clause 45 of LAND 42-2007, activity of ^{3}H released into the ambient air in the basic physical-chemical forms shall be measured not less than once per quarter.

According to clause 46 of LAND 42-2007, to estimate short-term change of contamination of a nuclear facility the total activity of radionuclides released into the ambient air shall be measured not less than once per day (for the flows of the key radionuclides – hourly). It is recommended that the radionuclides are classified into the following groups: noble radioactive gases, radioactive iodine and radioactive aerosols. The measurement shall be performed directly or by continuous integrated sampling.

Waterborne releases

According to clause 47 of LAND 42-2007, the radioisotope content of waterborne discharges and the activity of radionuclides (including ^{3}H but except ^{14}C) shall be assessed at least once per month. Stationary systems for the direct measurement or sampling of integral samples shall be installed at the main pathways of permanent discharges (it is recommended to install automatic systems) and the total activity of the waterborne releases at these pathways shall be assessed at least once per day. At less important pathways sampling shall be performed with regularity corresponding to frequency of releases. The flows of waterborne discharges shall be credibly measured in all pathways at any condition.

According to clause 48 of LAND 42-2007, if the waterborne releases before discharging into environment are cumulated for a long time, the samples shall be taken and the radioisotope content together with activities of radionuclides of the waterborne discharges shall be evaluated.

Additional requirements

According to clause 49 of LAND 42-2007, the activity of ^{14}C released into the environmental air and water shall be measured or estimated by means of calculations, verifying them by measurements when a nuclear facility works under different operating conditions.

According to clause 50 of LAND 42-2007, activity of radionuclides released into the environmental air and water shall be estimated under conditions of short-term increase of contamination. In case more intensive than normal radionuclide contamination of the environment is foreseen (e.g., during start-up or closedown of a nuclear facility or its part during the repair) additional supervision of contamination shall be carried out. To this effect stationary supervision systems are used and laboratory methods are applied.

9.1.2.4 Requirements for the Environmental Monitoring

According to clause 51 of LAND 42-2007, monitoring shall envelope measurements of the ionizing radiation dose rate and external absorbed dose, as well as the radionuclide activity in different components of the environment. When selecting the environmental objects the impact of radionuclides accumulated in the objects on the exposure of the members of the critical groups shall be considered.

According to clause 52 of LAND 42-2007, continuous measurements of the ionizing radiation shall be performed considering the locality peculiarities in the representative locations of a nuclear facility territory and sanitary protection zone, as well as when receding from the nuclear facility towards important neighbouring populated localities. For measurement of the dose rate automatic telemetric devices shall be employed, and for measurement of the external absorbed dose accumulating (e.g., thermo luminescent) devises shall be employed.

According to clause 53 of LAND 42-2007, in points of radionuclide releases (discharges) or in their vicinity, as well as in points of the maximum expected contamination (according to the assessment of radionuclide spreading and the locality peculiarities) in the area of potential environmental impact of a nuclear facility, established in the monitoring programme, sampling of the environmental components shall be performed.

According to clause 54 of LAND 42-2007, in case of terrestrial ecosystems the following samples shall be taken: samples of air (gases and aerosols), precipitation, soil, berries and mushrooms and plants from forests, grasses from pastures, food (meat, milk and grain-crops), potable water, underground water (including groundwater), indicatory organisms and materials (characterized with a feature to accumulate the radionuclides).

According to clause 55 of LAND 42-2007, in case of aquatic ecosystems the following samples shall be taken: samples of filtered water, suspended matter, sediments, aquatic plants, bottom dwellers, fishes and indicatory organisms and materials.

According to clause 56 of LAND 42-2007, sampling shall be carried out with the periodicity corresponding to seasonal changes of the environmental components, and the obtained data shall be sufficient to estimate the exposure of the members of the critical group (groups). Sampling periodicity of the environmental components, which monitoring is also carried out as part of the state environmental monitoring, shall not be less than provided by the State Environmental Monitoring Programme for the surveillance of these components.

According to clause 57 of LAND 42-2007, for the assessment of the pollution of environmental objects the radioisotope content of samples shall be estimated, and the concentrations of the gamma emitters (^{137}Cs, ^{134}Cs, ^{60}Co, ^{54}Mn, ^{95}Zr, ^{9}5Nb, ^{131}I etc.) shall be measured. The pollution with beta emitters (^{89}Sr, ^{90}Sr, ^{3}H and ^{14}C) and alpha emitters (^{239,240}Pu) shall be assessed using analysis of chosen archetypal samples. Performing measurements of the concentration of beta and alpha emitters the methods of chemical seduction of elements shall be applied, if necessary.

According to clause 58 of LAND 42-2007, if it is known or supposed that the activities or content of airborne and waterborne releases can change, the samples can be taken more frequently, and additional measurements can be performed.

9.1.2.5 Main requirements for the applied methods and facilities

According to clause 60 of LAND 42-2007, monitoring shall be performed applying measuring methods and using devices that allow measuring with sufficient accuracy the activities of radionuclides of single isotopes due to which doses higher than 0.01 mSv per year can be received.

According to clause 63 of LAND 42-2007, monitoring systems shall be redundant and permanently operating to allow the estimation of activity of radionuclides released into the environment of any period and the comparison with the activity limit.

According to clause 64 of LAND 42-2007, for the data quality assurance the monitoring systems shall be installed, tested, calibrated, operated and renovated in accordance with the nuclear industry standards and the QA programme.

9.1.2.6 Requirements for the Groundwater Monitoring

According to clause 4 of the regulation "Regulation on Ground Water Monitoring of Economy Entities" (*State Journal, 2003, No. 101-4578*), the groundwater monitoring programme, developed and approved in accordance with the requirements of this regulation, is an obligatory annex to the application for the issue of a Permission on Integrated Prevention and Control of Pollution.

According to clause 12.5 of the “Regulation on Ground Water Monitoring of Economy Entities” (*State Journal, 2003, No. 101-4578*), the monitoring network and its substantiation (documentation of the monitoring network, passports of the monitoring points and observation wells prepared in accordance with the requirements of the “Regulation on Register of Earth Entrails” (*State Journal, 2006, No. 54-1961*)) shall be given in the groundwater monitoring programme.

9.1.2.7 Requirements for wastewater and surface water monitoring

The wastewater of the new NPP shall be managed according to the requirements of the “Regulation on Wastewater Management” (*State Journal, 2007, No. 110-4522*). According to clause 6 of this regulation, the discharge of wastewater into the environment may be performed only through a perfect discharger (e.g. accredited as perfect for use by order established in regulations, having the permission for wastewater discharge etc.) and only when the conditions for the wastewater discharge are approved by competent authorities.

The surface water of the new NPP shall be managed according to the requirements of the “Regulation on Surface Water Management” (*State Journal, 2007, No. 42-1594*). According to clause 5 of this regulation, storm drain (surface) water shall be managed separately from wastewater.

According to Clause 7 of this regulation in the design of surface water management system the following technical solutions shall be examined and applied, if possible:

- Minimization of generation and (or) collection of surface water (the number of impervious surfaces installed (with the exception of potentially contaminated areas) shall be as little as possible, equipment for clean surface water infiltration in the ground shall be outfitted, the number of potentially contaminated areas planned shall be as little as possible);
- Reduction of the quantity of surface water discharged into the environment in the centralized manner (e.g., the use of waste water for the needs of production, watering of green zones, etc.);
- Reducing contamination of produced surface water e.g., provision of dry cleaning of potentially contaminated areas, erection of sheds at locations being most dangerous in respect of contamination, etc.).

According to clause 8 of the “Regulation on Surface Water Management” (*State Journal, 2007, No. 42-1594*), the design of the wastewater and surface water management systems shall be performed in accordance with the requirements of STR 2.07.01:2003 (*State Journal, 2003, No. 83-3804*).

9.2 STATE RADIOLOGICAL MONITORING

9.2.1 System of automatic ionizing radiation gamma dose rate measurement stations

The regulation ”Order on Notification of Administrative Departments of the Ministry of Environment, Subsidiary and other Bodies about Emergency Radiological Situations“ (*State Journal, 2005, No. 4-79*) regulates interchange of information and data among administrative departments of the Ministry of Environment of the Republic of Lithuania, subsidiary and other bodies (further on – Competent Authorities) in case of Emergency Radiological Situations in Lithuania or other countries. Emergency radiological situation refers to an extreme case, such as an increase of ionising radiation gamma dose rate, a radiation accident, an incident at a nuclear facility or during nuclear activity, due to which radioactive substances have been released or might be released into the environment with potential for negative radiological impact on the population and the environment.

Following Clause 3 of the given regulation (*State Journal, 2005, No. 4-79*), the Environmental Protection Agency (further on – EPA) carries out automatic ionizing radiation gamma dose rate monitoring (further on – Monitoring), bears responsibility for the permanent radiological emergency warning and monitoring system (RADIS), accumulates and analyses Monitoring data, as well as develops radionuclide transport forecasts (if emergency radiological situation occurred in the territory of the Republic of Lithuania or within 200 km from the state border in all directions). Radionuclide transport forecast is performed applying decision support tool ARGOS (Accident Reporting and Guiding Operational System), based on the meteorological data and the information on radionuclide releases into ambient air, received from State Nuclear Power Safety Inspectorate (further on – VATESI). The EPA is responsible for the on-line ARGOS database and links to the workstations, and it allows VATESI, the Fire Protection and Rescue Department under Ministry of the Interior and the Radiation Protection Centre of Ministry of Health Care to perform a forecast of radionuclide transfer in ambient air independently (using the ARGOS workstations, installed at their offices, and the link to the main ARGOS database, located at the EPA), Figure 9.2-1. In case of emergency radiological situations the EPA provides the Competent Authorities with information on the level of ionizing radiation gamma dose rate and forecasted radionuclide transfer in ambient air.

According to Clause 4 of Article 3 and Article 29 of the Law on Civil Protection (*State Journal, 1998, No. 115-3230, 2006, No. 72-2691*) and pursuant to Clauses 11.5, 11.7, 11.10-11.13 and other relevant clauses of the Plan of Protection of the Population in Case of Radiation Accident at Ignalina Nuclear Power Plant (*State Journal, 2000, No. 32-908*) by the decision of the Fire Protection and Rescue Department under the Ministry of the Interior, in case of local or general accident and emergency (extreme radiation case) an enhanced or special operating mode of the radiation monitoring system is introduced.

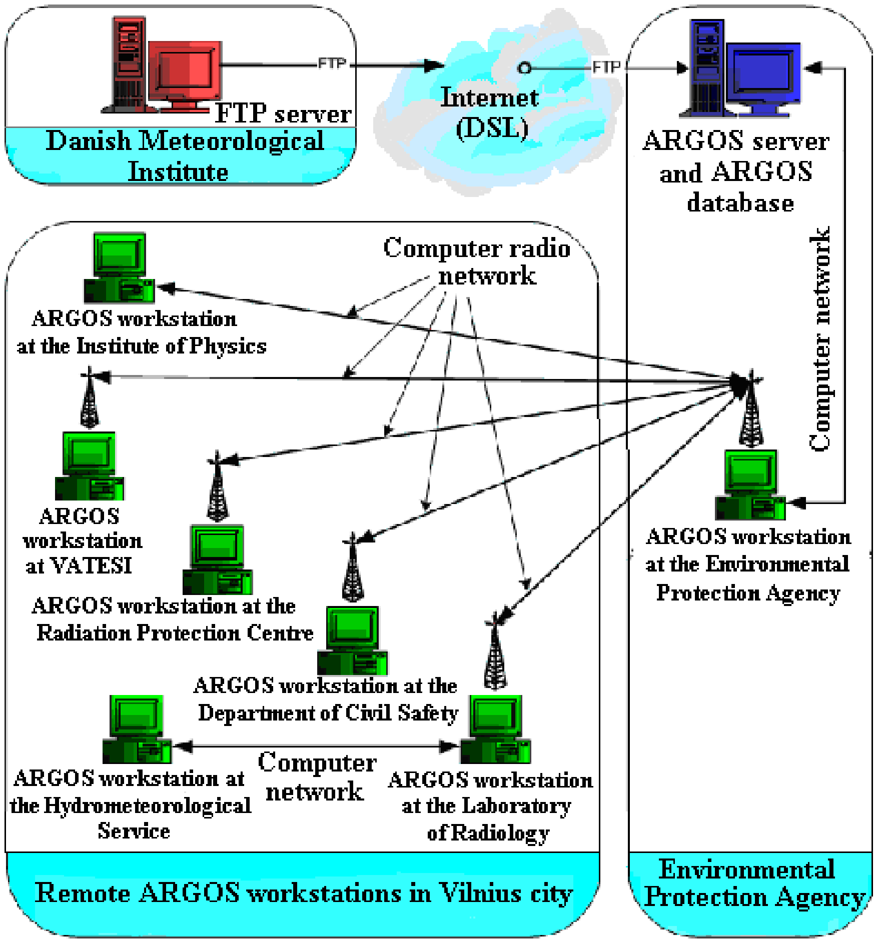


Figure 9.2-1. Workstations of the ARGOS system (*website of AAA http://193.219.133.11/v1/*)

Radiological Emergency Warning and Monitoring System RADIS

At present RADIS operates 18 gamma radiation monitoring stations, located throughout the whole territory of Lithuania. The RADIS network consists of 3 networks of radiation monitoring stations; PMS, ALNOR and AGIR (*Website of the EPA http://193.219.133.11/v1/*).

Permanent Measuring Stations (PMS) are Danish automatic radiation monitoring stations. There are 9 such stations at the moment. 5 PMS's are installed in the largest cities of Lithuania: Vilnius, Kaunas, Klaipeda, Siauliai and Alytus. Four more stations are mounted in the environment of Ignalina NPP: Visaginas, Turmantas, Rimse and Macionys.

ALNOR stations are Finnish automatic radiation monitoring stations (another designation for ALNOR stations is AAM-95). There are 2 operational stations of this type at the moment. One ALNOR station is installed in Utena, the second one in Tilżė.

AGIR stations (automatic registers of gamma intensity in air) are Lithuanian automatic radiation monitoring stations. There are 7 operational stations of this type at the moment. All the AGIR stations are installed at the stations of Lithuanian Hydrometeorological Service.

The main functions of the radiological emergency warning and monitoring system RADIS are given in Figure 9.2-2.

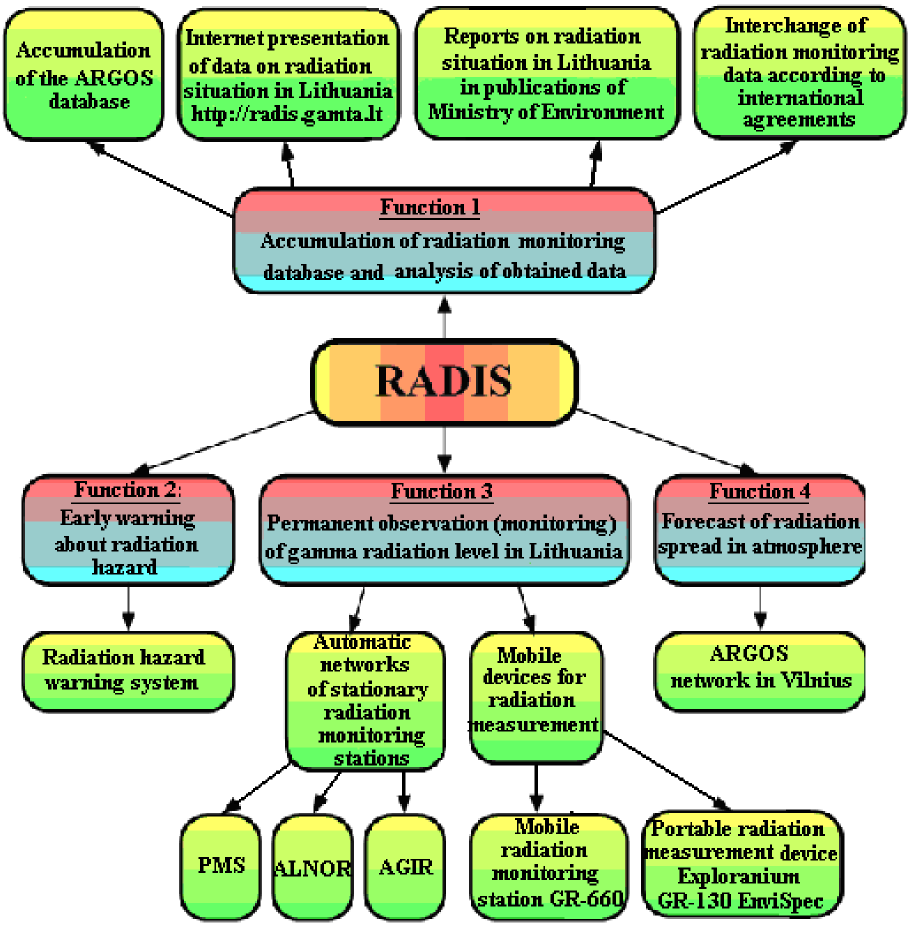


Figure 9.2-2. The main functions, performed by RADIS (*website of AAA http://193.219.133.11/v1/*)

PMS stations

In Lithuania the radiation monitoring network of PMS stations is comprised of 9 stations, linked to the main PMS server and database. All the stations and the related infrastructure (the server, computer networks, etc.) were installed in accordance with Denmark and Lithuania bilateral agreement “On Support in Field of Nuclear Safety, Radiation Protection and Emergency Preparedness”.

PMS radiation monitoring stations operate in uninterrupted mode; measured data are accumulated in the memory of the station computer. All the data, accumulated by the PMS stations, at the set out frequencies are received by the PMS server, located at the EPA. Later on the data goes into the main RADIS database. In a normal radiological situation data from each PMS station is received once per day.

The PMS stations also perform the function of early warning about radiation hazard. In case the PMS monitoring station or other EPA stations measure an ionising radiation gamma dose rate exceeding 300 nSv/h (nanosiverts per hour), the RADIS system automatically sends a warning signal, a text message to the RADIS experts’ cell phones-communicators with short description of the reason. The EPA experts check the state of the RADIS system and, if they are convinced of the validity of the warning signal, they turn on more frequent inquiry mode of the monitoring station – at least on an hour basis. The EPA immediately notifies the Competent Authorities by phone. The EPA sends monitoring data to the Competent Authorities every hour pursuant to the set out form, following the requirements of the regulation “Order on Notification of Administrative

Departments of the Ministry of Environment, Subsidiary and other Bodies about Emergency Radiological Situations“ (*State Journal, 2005, No. 4-79*).

If in case of an emergency radiation situation the criteria, verified by the Government resolution No. 241 of March 9, 2006 "On Enactment of Criteria of Extreme Cases" (*State Journal, 2006, No. 29-1004; 2008, No. 143-5702*), are reached or exceeded, the State Environmental Protection Inspectorate (further on – SEPI) immediately notifies the direction of Ministry of Environment and the manager of the Control Centre of Extreme Cases.

In case of reception of unofficial or anonymous information about possible radiation risk, by the decision of the EPA the monitoring stations can be inquired at more frequent mode – every hour. The Competent Authorities are immediately notified about this by phone. Under their request the Competent Authorities are provided with Monitoring data every hour under the set out form.

The PMS stations are fully automatic and require only minimal maintenance. Accumulators, completed with each station, allow the stations to function in case of loss of power, as well (up to 5 days). Measurements of gamma radiation intensity are carried out employing a sodium iodide (NaI) detector. By using a detector of this type not only the level of ionising radiation gamma dose rate, but also energy spectrum can be found. Analysis of energy spectrum is automatically performed both at the station and at the PMS server. The PMS stations additionally measure temperature and rain intensity, as well. The rain intensity sensor allows avoiding "false" alarms, related to natural increase of gamma dose rate when raining. Each station is additionally equipped with one more gamma dose rate detector of Geiger-Müller type (*Website of the EPA http://193.219.133.11/v1/*).

ALNOR stations

In Lithuania the network of the ALNOR radiation monitoring stations is comprised of two stations, linked to the main ALNOR server and database. The arrangement of the ALNOR stations in Lithuania was supported by Sweden.

The ALNOR radiation monitoring stations were developed in Finland. They operate in uninterrupted mode; measured data is accumulated in the data storage unit of the station. Later on the data, accumulated by the ALNOR stations installed in Lithuania, is received at the set out frequencies by the ALNOR server, located at the EPA, Vilnius. In a normal radiological situation data from each ALNOR station is received once per day. The ALNOR stations also perform the function of early warning about radiation hazard, as described above in the section about the PMS stations.

The ALNOR stations are fully automatic and require only minimal maintenance. Accumulators, completed with each station, allow the stations to function in case of loss of power (up to 3 days). In the ALNOR stations the level of ionising radiation gamma dose rate is measured using a detector of Geiger-Müller type RADOS RD-02L (*Website of the EPA http://193.219.133.11/v1/*).

AGIR stations

In Lithuania the network of the AGIR (automatic registers of gamma intensity in air) radiation monitoring stations is comprised of 7 at present operational stations, installed at the stations of Lithuanian Hydrometeorological Service. The AGIR stations were developed and manufactured by the Institute of Physics, Lithuania. The software was developed by the Environmental Protection Agency, RADIS.

Ionising radiation sensors and electronics, installed at the stations, record gamma radiation intensity and allow observing daily and seasonal fluctuation of equivalent dose rate in the near-ground air. The AGIR stations operate in uninterrupted mode and measured data is accumulated in the data storage unit of the station. Later on the data is automatically transferred to the local computer of the hydrometeorological station, were a data file is formed. This data file is transferred along with meteorological information, formed and sent every three hours by the operator of the hydrometeorological station. Thus the data file on ionising radiation gamma dose rate is stored in the server of the database of the Hydrometeorological Service. Later on this data is transferred via the Internet to the AGIR server and RADIS database. The AGIR stations are fully automatic and require only minimal maintenance (*Website of the EPA http://193.219.133.11/v1/*). The AGIR stations also perform the function of early warning about radiation hazard, as described above in the section about the PMS stations.

Mobile radiological monitoring station

RADIS possesses one mobile radiation monitoring station Exploranium GR-660. The monitoring station is installed at the base of a cross-country vehicle; therefore it can be used for search of radioactive sources and examination of radionuclide contamination of the environment. The activated system GR-660 continuously measures ambient gamma radiation intensity in an automatic mode and records the obtained data on the hard disk of the computer at set out intervals (e.g. every second). Not only complete energy spectrum of each measurement, but also exact geographical coordinates of the measurement point, identified by the DGPS (Differential Global Positioning System), are recorded. Moreover, there is a possibility to observe measurement results “on-line”, displayed on the monitor. One can observe varying energy spectrum, activities of particular radionuclides, movement pattern of the system, etc. The set of the mobile monitoring station also includes a portable spectrometer (*Website of the EPA http://193.219.133.11/v1/)*.

Location of Lithuanian radiological monitoring stations, structure of RADIS system and main data base of ARGOS

The location of the radiation monitoring stations in Lithuania is given in Figure 9.2-3.

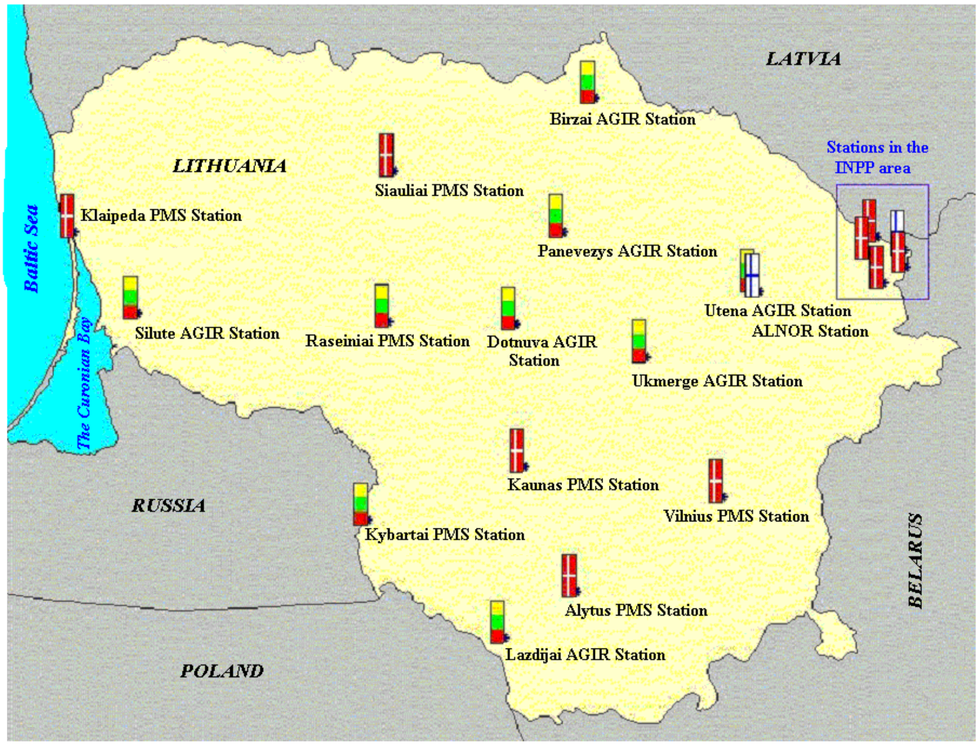


Figure 9.2-3. Location of the radiation monitoring stations in Lithuania (*website of AAA http://193.219.133.11/v1/*)

The main seat of RADIS in Vilnius accommodates the RADIS server and the RADIS database, which both operate twenty-four hours a day. This database accumulates and analyses data, received from various sources in different ways (via computer network, modem, Internet, from compact discs, etc.). The RADIS not only receives, but also provides information. Figure 9.2-4 shows the RADIS structure according to information sources and its recipients.

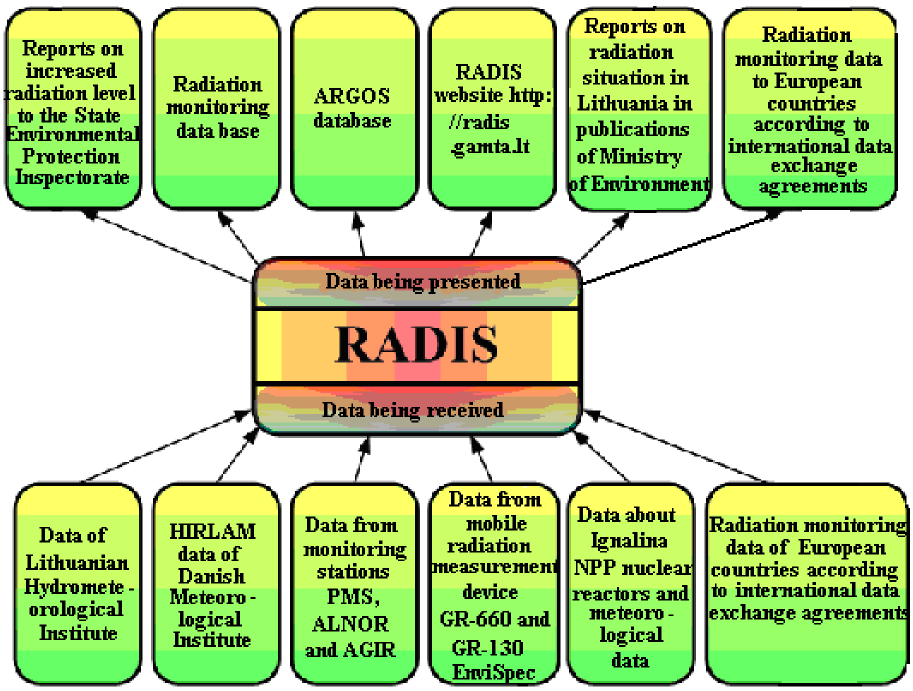


Figure 9.2-4. RADIS structure according to information sources and its recipients (website of AAA http://193.219.133.11/v1/)

HIRLAM (**HI**gh-Resolution **L**imited-**A**rea **M**odel) is a meteorological data burst. The RADIS receives this data from the Danish Meteorological Institute. Meteorological data HIRLAM is used to make ARGOS forecasts of radiation contamination spreading in the atmosphere.

The hardware, forming the RADIS system (radiation monitoring stations, computers and servers), is installed at different locations in Lithuania. Moreover, the RADIS has permanent connections of information exchange with related organizations both in Lithuania and abroad. Figure 9.2-5 shows the RADIS structure according to physical installation points of the hardware.

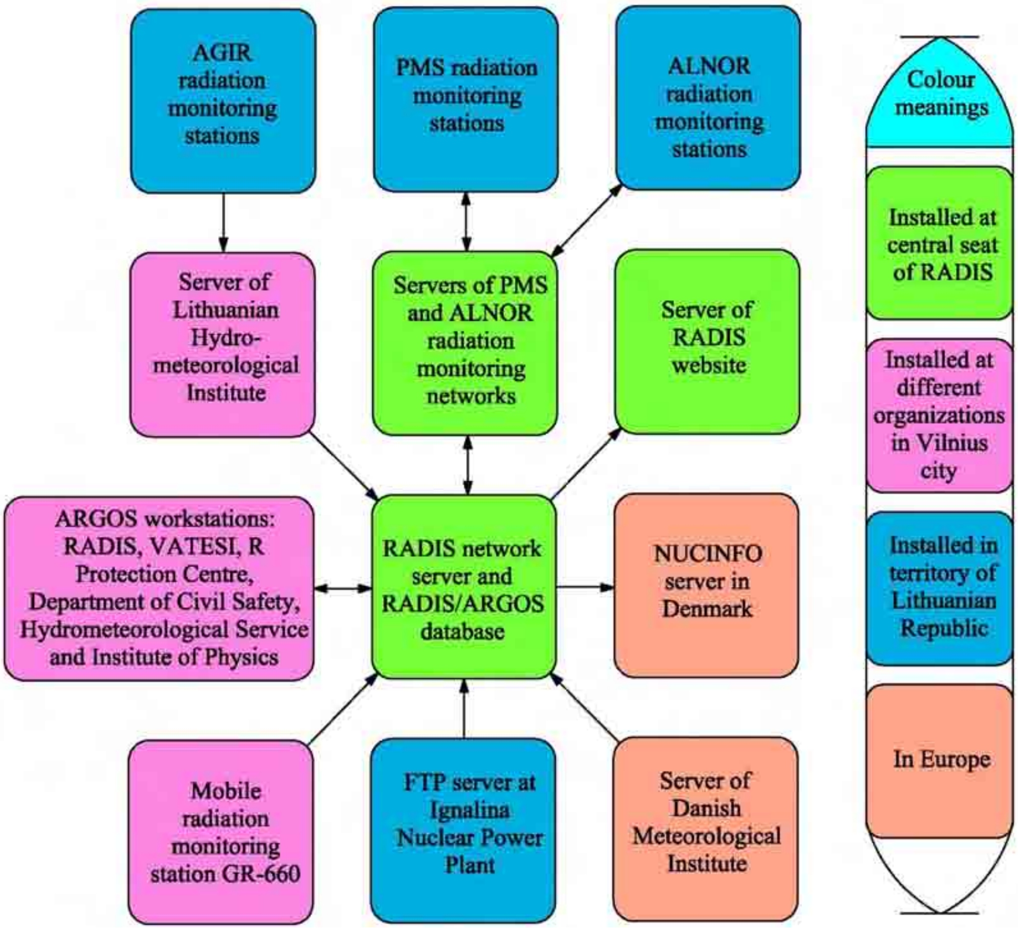


Figure 9.2-5. RADIS structure according to physical installation points of the hardware (*website of AAA http://193.219.133.11/v1/*)

The ARGOS database can be appended with data from various sources. It can be records, manually entered by the ARGOS clients, or data, automatically imported from radiation monitoring stations of various types. A diagram of data, passing into the main ARGOS database, is given in Figure 9.2-6.

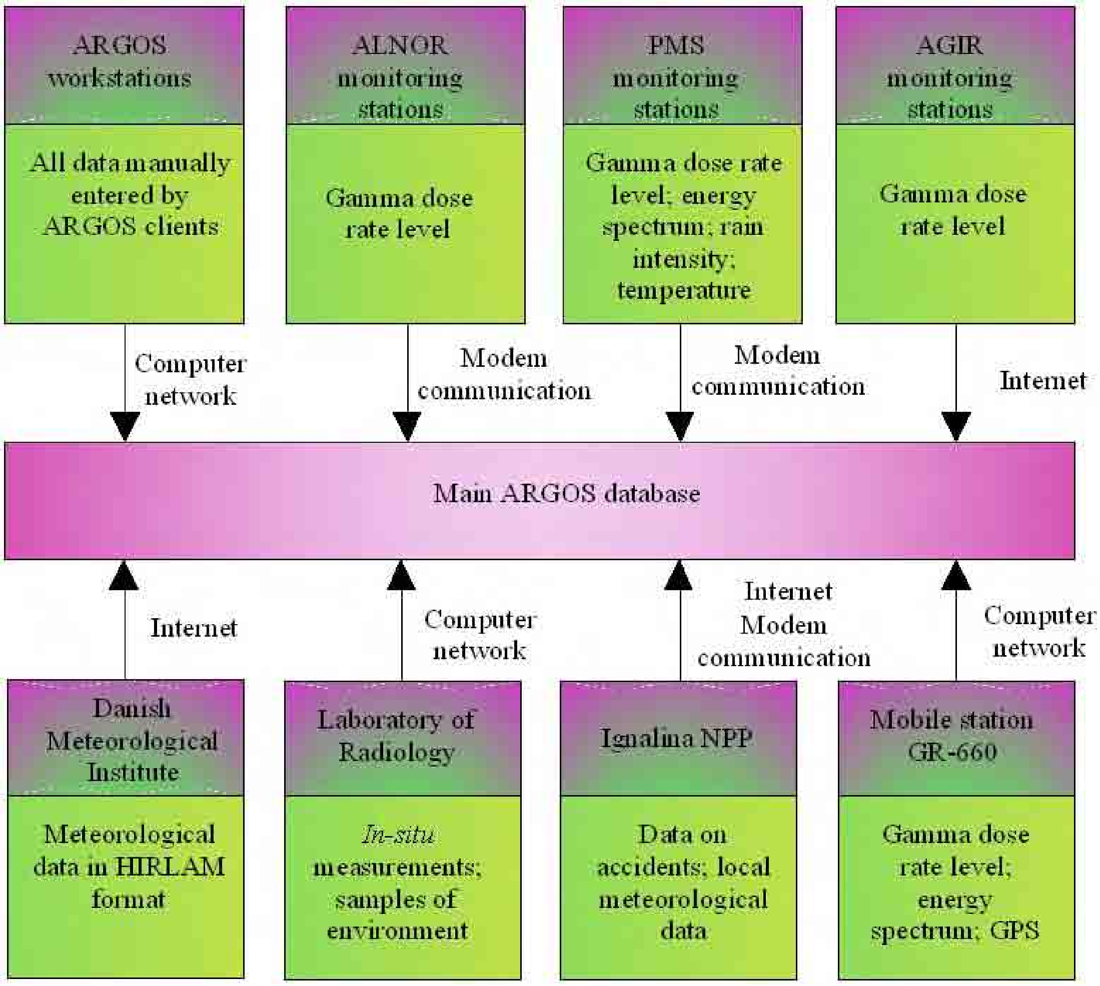


Figure 9.2-6. Data, passing into the main ARGOS database (*website of AAA* http://193.219.133.11/v1/)

9.2.2 Radiological monitoring carried out in accordance with the State Environmental Monitoring Programme

The State Environmental Monitoring Programme for 2005-2010 (*State Journal*, *2005*, *No. 19-608*, *2008*, *No. 104-3973*) has corrected the network of the ambient air radiological monitoring, that shall ensure the determination of the composition of radioactive aerosol additions during Ignalina NPP operation and decommissioning, shall track the radionuclide flows entering and leaving Lithuania, shall assess the radiological environment of the territory with the potential for the highest collective dose to the public, i.e. the city of Vilnius (Clause 6.1.6). One of the aims of this Programme in the field of surveillance of the state of the ambient air is to obtain data to analyse, estimate and forecast the ambient air quality throughout the territory of Lithuania taking into account long-range and short-range radionuclide transport (from nuclear facilities, as well). The tasks to reach the goal are as follows (Clause 8.1.2):

- Identification of airborne radionuclide sources, estimation of environmental spread of radionuclides released by Ignalina NPP, as well as their impact on the public during both operation and decommissioning of the plant;
- Recording of the radiological state in Lithuania in immediate mode, estimation of changes of equivalent dose rate.

The State environmental radiological monitoring has been carried out in Lithuania for more than 40 years. It is exercised by the Environmental Protection Agency (EPA). According to the State Environmental Monitoring Programme, which has been prepared in the light of the European Commission (EC), the International Atomic Energy Agency (IAEA) and the Helsinki Commission (HELKOM) recommendations, radiological monitoring of gamma dose rate, air aerosols, fallout, as well as of surface waters and bottom sediments in the rivers, the lakes, the Baltic Sea and the Curonian Lagoon is carried out.

The atmospheric fallout is continuously collected at 5 stations (Vilnius, Kaunas, Klaipeda, Utena and Dukstas). The total beta activity is measured.

Aerosol samples are continuously collected in Utena. The alternation of the activity concentration of cosmogenic and technogenic gamma emitters is observed.

Samples of surface water are taken once a quarter, in Kaunas Lagoon and Lake Druksiai - more often. Activity concentrations of ^{137}Cs and other gamma emitters, as well as of ^{90}Sr are determined. Samples of bottom sediments are taken 1-4 times per year; specific activities of ^{137}Cs and other gamma emitters, as well as of ^{90}Sr are measured.

9.2.3 Radiological monitoring performed by the Radiation Protection Centre

Radiological monitoring of food and drinking water is performed by the Radiation Protection Centre (RPC). Samples of milk, meat, fish, vegetables (potatoes, cabbage) have been taken for analysis since 1976 in the Ignalina region, and since 1979 in the Zarasai region. Samples of the food products from Utena and grain samples from the Ignalina and Zarasai regions have been monitored since 1992. In 1998–2000 samples have also been taken in the Svencioniu region.

Since 2002, RPC has executed state radiological monitoring of food products and drinking water based on Recommendations of the European Commission (*2000/473/Euratom*) in accordance with the Order of Ministers of the Environment and Health Protection of the Republic of Lithuania from October 7, 2002 No. 528/490 *(State Journal, 2002, No. 100-4460*). Measurements of specific activities (and volumetric – in milk) of total alpha and beta, ^{90}Sr and ^{137}Cs in samples of food products are performed. Analysis of total alpha and beta (except $^{3}H_{1}$, ^{14}C, ^{40}K) and tritium volumetric activities are performed in samples of drinking water.

Specific activity of ^{137}Cs is regulated in food. In addition analyzing of ^{90}Sr in food products during radiological monitoring is recommended because it easily penetrates into bone tissue and accumulates in it. Analysis of total alpha and beta activities is also performed in food. According to the Lithuanian Hygiene Standard HN 24:2003 “Requirements on safety and quality of drinking water” (*State Journal, 2003, No. 79-3606; 2007, No. 127-5194*) volumetric activity of tritium and total alpha and beta activity are regulated in drinking water (for evaluation of annual effective dose).

9.3 IGNALINA NPP CURRENT ENVIRONMENTAL MONITORING SYSTEM

Since startup of operation the INPP performs monitoring of the environment within a 30 km radius monitoring zone around the power units. The monitoring is performed in accordance with regulatory approved environmental monitoring programme. The INPP environmental monitoring programme (*Environmental Monitoring Programme. INPP, Code PTOed-0410-3*) specifies requirements for:

- Monitoring of water quality in the lake and of groundwater (physical – chemical parameters);

- Monitoring of radionuclide concentration in the atmospheric air and fallouts;
- Monitoring of the radioactivity of sewage and drainage water from the INPP site;
- Monitoring of radionuclide releases into the air;
- Meteorological observations (e.g. temperature, wind directions and speed, humidity);
- Monitoring of water temperature (see Chapter 7.1.1.9);
- Monitoring of radionuclide concentration in the lake and groundwater;
- Dose and dose rate monitoring in the sanitary protection zone (3 km) and observation area (30 km);
- Monitoring of radionuclide concentration in fish, algae, soil, grass, sediments, mushrooms, leaves;
- Monitoring of radionuclide concentration in food products (milk, potatoes, cabbage, meat, grain-crops).

The chemical content of sewage (domestic wastewater) from the industrial site of INPP is controlled by "Visagino energija".

The radiological measurements performed according to the INPP current environmental monitoring programme (*Environmental Monitoring Programme. INPP, Code PTOed-0410-3*) are summarized in Table 9.3–1.

Table 9.3–1. Summary of radiological measurements performed according to the INPP environmental monitoring programme (*Environmental Monitoring Programme. INPP, Code PTOed-0410-3*).

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
1.	Liquid discharges into the environment	7	Total β activity	Radiometric	1 per week – service water taken by Reactor Units 1,2; water, discharged by reactor and turbine compartments; water, discharged from Bld. 150; 1 per month – service water after the heat exchangers; At every discharge – water from special laundry.	0.1 to 1.85×10^8 Bq/l depending on measuring object
			Activity concentration of radionuclides	Spectrometric	1 per month – water, discharged by reactor and turbine compartments; service water after the heat exchangers; water, discharged from Bld. 150, pit of corridor 003 (D1, D2); At every discharge – spent water from Bld. 150.	$0.74 \div 1.85 \times 10^8$ Bq/l
			Sr-89, Sr-90	Radiometric	1 per month – water, discharged by reactor and turbine compartments.	$0.1 \div 3 \times 10^3$ Bq/l
			Total α activity	Radiometric	1 per month – water, discharged from Bld. 150.	$0.01 \div 10^3$ Bq/l
2.	Emission of gases and aerosols into atmosphere	7	Total β activity	Radiometric	From 1 time per day to 1 time per quarter depending on filter exposition duration.	from 2.4×10^{-8} to 1.85×10^7 Bq/l depending on measuring object
			Total α activity	Radiometric	1 per month – releases of gases/aerosols from reactors 1,2 through vent stack.	$0.01 \div 10^3$ Bq/l
			Activity of radioactive noble gases	Spectrometric	1 per week – releases of gases/aerosols from Bld. 150 through installation 153.	$1.85 \div 3.7 \times 10^5$ Bq/l
			Activity of radioactive aerosols	Spectrometric	1 per day and week – releases of gases/aerosols from reactors 1,2 through vent stack; 1 per month – from Bld. 130, from Bld. 156; 1 per quarter – from Bld. 157.	from 2.5×10^{-6} to 3.7×10^5 Bq/l depending on measuring object

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
			Activity of radioactive noble gases	Spectrometric	1 per day – releases of gases/aerosols from reactors 1,2 through vent stack; 1 per week – releases due to residual heat during repair of reactors 1,2.	$1.85 \div 3.7 \times 10^{5}$ Bq/l
			Activity of radioactive aerosols	Spectrometric	1 per day and per month – 1 releases of gases/aerosols from reactors 1,2 through vent stack; 1 per week – releases of gases/aerosols from reactors 1,2 through vent stack, releases from Bld. 150 through installation 153, releases due to residual heat during repair of reactors 1, 2.	from 2.5×10^{-6} to 6.7×10^{3} Bq/l depending on measuring object
			Sr-89, Sr-90	Radiometric	1 per month – releases of gases/aerosols from reactors 1,2 through vent stack, from Bld. 130, from Bld. 156, from Bld. 159.	$0.1 \div 3 \times 10^{3}$ Bq/l
			I-131	Spectrometric	1 per day, per week, per month – releases of gases/aerosols from reactors 1,2 through vent stack; 1 per week – releases from Bld. 150 through installation 153, releases due to residual heat during repair of reactors 1,2.	from 2.4×10^{-7} to 26 Bq/l depending on measuring object
			H-3, C-14	Radiometric	Releases of gases/aerosols from reactors 1,2 through vent stack. Depending on carrying out of IAEA project LIT/9/005	
3.	Water from heat power station in Bld. 119	2	Total β activity	Radiometric	1 per day – water of heating networks.	$0.1 \div 3 \times 10^{3}$ Bq/l
			Volume activity of radionuclides	Spectrometric	1 per two weeks– water from installation 141; 1 per quarter – water of heating networks.	$0.74 \div 1.85 \times 10^{8}$ Bq/l
4.	The air and atmospheric precipitation	9	Activity of γ nuclide	Spectrometric	3 times per month – atmospheric air at points of permanent surveillance; and 1 per month – atmospheric precipitation at points of permanent surveillance and industrial site.	$1.5 \times 10^{-6} \div 15$ Bq/m^{3}
			Sr-90	Radiometric	2 times per year (in winter and summer) - atmospheric air at points of permanent surveillance.	$3 \times 10^{-5} \div 3 \times 10^{2}$ Bq/m^{3}

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
5.	Aquatic environment of INPP	104	Activity of γ nuclide	Spectrometric after evaporation	20 times per month (on working days) – discharge of technical water and water of intake channel; 1 time per 10 days – sewage water, water of industrial site PLK-1,2, PLK-3, PLK-SFSF; 1 per month – water from channel surrounding landfill of industrial waste, drainage water of INPP industrial site; 1 per quarter (in January, April, July, October) – water of heating networks; 2 times per year (in spring, autumn) – water of surveillance boreholes in the industrial site and area of SFSF; 4 times per year (in February, May, August, November) – potable water from water supply (watering-place), potable water from wells in Tilze and Gaide; 1 per year (in summer) – water of Lake Druksiai; 1 per year (in winter) – snow at points of permanent surveillance, sampling points of precipitation of industrial site and SFSF site.	$1\times10^{-3}\div0.3$ Bq/l
			Sr-90	Radiochemical segregation	2 times per year (in spring, autumn) – discharge of technical water and water of intake channel, sewage water, water of surveillance boreholes in the industrial site and area of SFSF; 1 per year (in summer) – water of Lake Druksiai; 1 per year (in winter) – water of heating networks, water from channel surrounding landfill of industrial waste, snow at points of permanent surveillance, sampling points of precipitation of industrial site and SFSF site, water of industrial site PLK-1,2, PLK-3, PLK-SFSF, drainage water of INPP industrial site.	0.3 Bq/l
			Activity of Pu isotopes	Radiochemical segregation	2 times per year (in spring, autumn) – discharge of technical water and water of intake channel.	1×10^{-2} Bq/l

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
			H-3	Without concentration, by filtering	1 per month – discharge of technical water and water of intake channel, sewage water, sampling points of precipitation of industrial site and SFSF site, water of industrial site PLK-1,2, PLK-3, PLK-SFSF; 1 per quarter – water from channel surrounding landfill of industrial waste; 2 times per year (in spring, autumn) – water of surveillance boreholes in the industrial site and area of SFSF; 4 times per year (in February, May, August, November) – potable water from wells in Tilze and Gaide.	3 Bq/l
			Total α activity	Concentrated sample	4 times per year (in February, May, August, November) – potable water from water supply (watering-place), potable water from wells in Tilze and Gaide.	0.1 Bq/l
			Total β activity	Concentrated sample	4 times per year (in February, May, August, November) – potable water from water supply (watering-place), potable water from wells in Tilze and Gaide.	0.01 Bq/l
6.	Monitoring of radiation dose and dose rate	86 Location of TLD is presented in Figure 9.3-1.	γ radiation dose rate	Radiometric	4 times per year (in February, May, August, November) – in the dump of construction materials and on the roads. 1 times per quarter – dose rate from SPD-1, SPD-2 equipment, clothes, shoes and machinery;	from 2×10^{-8} to 10 Sv/h depending on measuring object
					Constantly – SkyLink system.	$2\times10^{-8}\div10$ Sv/h
			γ radiation dose	Radiometric, TLD	2 times per year (in spring, autumn) – dose at locations of TLD in SPZ and SA.	$2.5\times10^{-4}\div5$ Sv
7.	Sludge from storage area	1	Activity of γ nuclide	Without concentration	1 per month	15 Bq/kg
			Activity of Pu isotopes	Radiochemical segregation	2 times per year (in spring, autumn)	300 Bq/kg

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
8.	Bottom sediments of Lake Druksiai	10 Sampling points in Lake Druksiai are indicated in Figure 9.3-2.	Activity of γ nuclide	Dried, concentrated sample. Spectroscopic	1 per quarter – in discharge channel of industrial site PLK-1, PLK-3, SFSF site, PLK-SFSF, downstream purification plant.	3 Bq/kg
			Gamma nuclide content of upper layer (2 cm)	Dried, concentrated sample. Spectroscopic	1 per year (in summer) – at sampling points of Lake Druksiai.	15 Bq/kg
			Sr-90 in upper layer (2 cm)	Burning and radiochemical segregation	1 per year (in summer) – at sampling points of Lake Druksiai.	30 Bq/kg
			Distribution profile of gamma nuclides (3-10 cm)	Radiochemical segregation	1 time in 5 years – at sampling points of Lake Druksiai.	15 Bq/kg
			Distribution profile of Pu isotopes (3-10 cm)	Radiochemical segregation	1 time in 5 years – at sampling points of Lake Druksiai.	300 Bq/kg
9.	Aquatic vegetation of Lake Druksiai	11 Sampling points in Lake Druksiai are indicated in Figure 9.3-2.	Activity of γ nuclide	During drying Spectroscopic	1 times per quarter – in discharge channel of industrial site PLK-1, PLK-3, SFSF site, PLK-SFSF, downstream purification plant; 1 per year (in summer) – at sampling points of Lake Druksiai.	3 Bq/kg
			Sr-90	Burning and radiochemical segregation	1 per year (in autumn) – in discharge channel, downstream purification plant; 1 time in summer– at sampling points of Lake Druksiai.	3 Bq/kg

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
10.	Foodstuff, plants, soil	34	Activity of γ nuclide	Concentrated /not concentrated sample depending on measuring object	1 per month – milk in Tilze; 1 per month (from May to October) – pasture grass at points of permanent surveillance and in Grikiniskiu peninsula; 2 times per year (in spring, autumn) – fish of Lake Druksiai; 1 per year (in summer) – organisms of aquatic environment (molluscs); 1 per year (in August) – cabbage in Tilze; 1 per year (in September) – potatoes in Tilze; 1 per year (in autumn) – soil at points of permanent surveillance an in Grikiniskiu peninsula, mushrooms and moss at locations of Vilaragis, Grikiniskes, Tilze, Gaide, Visaginas, roe deer meat in the radius of 10 km around INPP, grain crops (rye and oats) in Tilze, meat (pork, beef) in Tilze and at location of Turmantas.	3 Bq/kg
			Sr-90	Radiochemical segregation	1 per month (from May to October) – pasture grass at points of permanent surveillance and in Grikiniskiu peninsula; 1 per year (in spring) – fish of Lake Druksiai; 1 per year (in summer) – organisms of aquatic environment (molluscs); 1 per year (in August) – cabbage in Tilze; 1 per year (in autumn) - milk in Tilze.	3 Bq/kg
					1 per year (in autumn) – soil at points of permanent surveillance and in Grikiniskiu peninsula.	30 Bq/kg
			Activity of α nuclides	Radiochemical segregation	1 per year (in summer) – organisms of aquatic environment (molluscs).	3 Bq/kg

*) The detection limit is indicated in the table and it is the lowest measuring activity of the sample with 95 % trustiness. The lower activities may measure with lower trustiness. Also, samples of the same type may be of different composition (samples of e.g. soil may be of different granulometric consistence) – therefore detection limits of samples will be different. Conservative (maximum) values of the detection limits are shown in the table.

In the table:

Bld. 150 – is liquid radioactive waste treatment and bitumising building in INPP;

D1, D2 – INPP 1 and 2 reactors control, electrical and deaerator rooms;

Installation 153 - venting stack of the radioactive waste reprocessing building 150;

Bld. 130 – repair building in INPP;

Bld. 156 – special laundry in INPP;

Bld. 157 – intermediate- and high-level waste storage in INPP;

Bld. 159 – cars wash building in INPP;

PLK-1, 2, PLK-3 – industrial drainage outputs from INPP to Lake Druksiai;

PLK-SFSF – industrial drainage output from SFSF site to Lake Druksiai;

SPD-1, 2 – militarized fire stations of INPP.

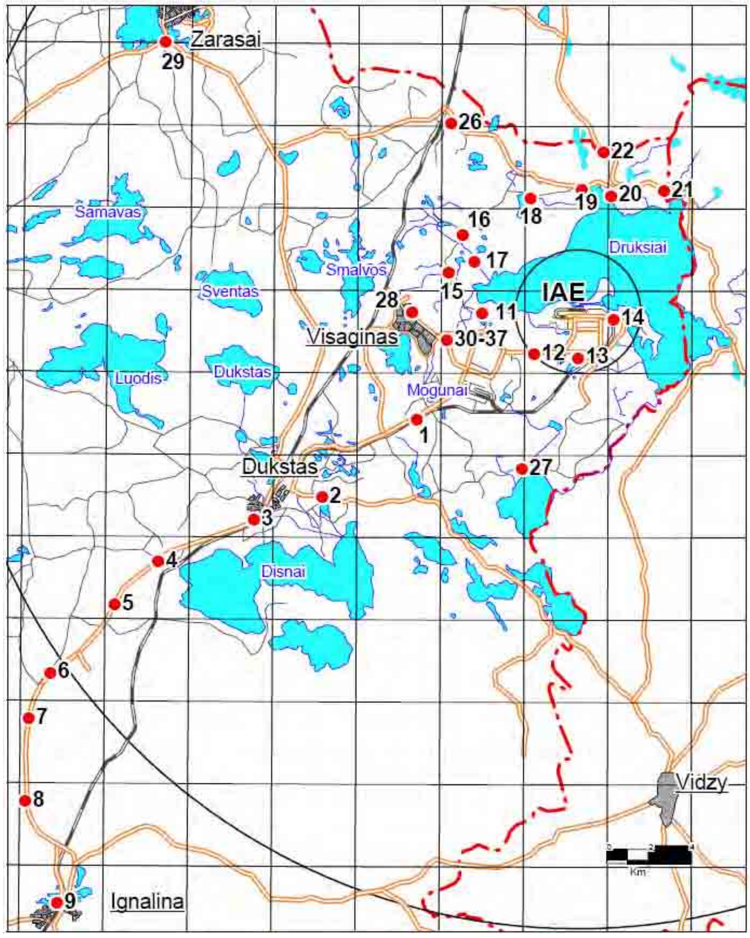


Figure 9.3-1. Location of thermoluminescent dosimeters around the INPP (Environmental Monitoring Programme. INPP, Code PTOed-0410-3).

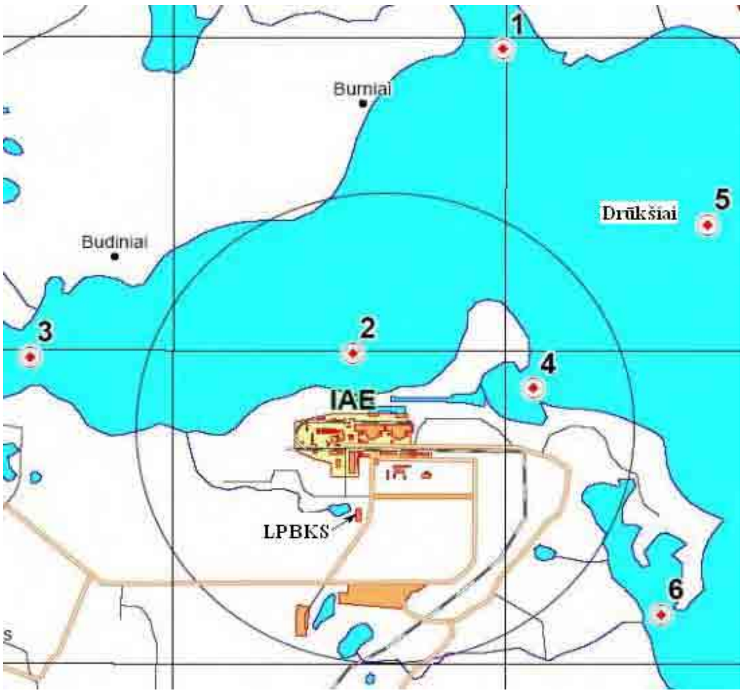


Figure 9.3-2. Sampling locations in Lake Druksiai (Environmental Monitoring Programme. INPP, Code PTOed-0410-3).

9.4 PROPOSALS FOR THE MONITORING SYSTEM FOR THE NEW NPP

The monitoring system for the new NPP will be designed to fulfil all the requirements of the Lithuanian legislation and regulations, and the IAEA recommendations and obligations under the United Nations Conventions.

After the final shutdown of the INPP Unit 2, the operation of the existing or future nuclear facilities of this entity will continue for several decades, therefore radiological monitoring (both pollution and environmental) will have to be exercised. According to the provisions of Clause 42 of LAND 42-2007, the monitoring program shall be reviewed, so the sampling locations, frequency, etc. can be changed. The new nuclear power plant will be a separate entity, therefore a separate environmental monitoring program shall be prepared and its implementation shall be ensured.

The monitoring programme of the new NPP will be confirmed by the Ministry of Environment, Environment Protection Agency, Lithuanian Hydrometeorological Service under the Ministry of Environment and Radiation Protection Centre. According to clause 38 of LAND 42-2007, monitoring will be performed at least one year before the start of operation of the new NPP. The first revision of the radiological monitoring programme will be performed after one year of operation of the new NPP and then after every five years.

9.4.1 Airborne releases

Accurate release measurements of radioactive substances are used to ensure that the airborne releases from the NNPP do not exceed the release limits set in the permission for release of radionuclides to the environment issued by the Ministry of Environment. Releases of radioactive materials from the nuclear power plant take place through monitored release routes. Releases into the air are emitted in a centralized manner through the vent stack of the plant and possibly, to a minor extent, through the air conditioning of the turbine building. For the assessment of the radionuclide activities of airborne releases from the new NPP the releases will be monitored by sampling and continuous measurements.

For the assessment of short-term alternation of the releases from nuclear reactors the total activity of the releases will be measured at least daily (hourly for the flows of the key radionuclides). The radionuclides will be divided into three groups: radioactive noble gases, radioactive iodine and radioactive aerosols. Activity will be measured directly or from integral samples given continuously. The flow of discharged gases will be credibly measured at any condition, the monitoring system will be redundant. The radioisotopic content of airborne releases will be assessed and the activity of radionuclides will be measured. The activity of releases in the main physical-chemical forms of ^{3}H will be measured. Proposals for monitoring of the common gaseous and particle releases of the NPP and examples of the radionuclides in releases and their detectable limits are presented in Table 9.4–1.

Table 9.4–1. Proposals for monitoring of the common gaseous and particle releases of the NNPP and examples of the radionuclides in releases and their detectable limits (Edilex 2008).

Release	Monitoring method	Reduplication	Radionuclide	Minimal detectable activity in release flow
Noble gases	continuous monitoring	yes	^{133}Xe	10 kBq/m³ during monitoring < 10 min
	laboratory determination at minimum weekly	yes	^{85}Kr	10 kBq/m³
			^{87}Kr	1 kBq/m³
			^{133}Xe	1 kBq/m³
Iodines	continuous monitoring		^{131}I	2 Bq/m³ during monitoring < 1 h
	laboratory determination at minimum weekly	yes	^{131}I	4 mBq/m³
Aerosols	continuous monitoring		all	4 Bq/m³ during monitoring < 1 h
	laboratory determination at minimum weekly	yes	^{60}Co	1 mBq/m³
			^{137}Cs	1 mBq/m³
Alpha activity	laboratory determination at minimum monthly	yes	all	total activity 1 mBq/m³
			^{241}Am	0.1 mBq/m³
Significant single nuclides	laboratory determination at minimum monthly	yes	^{89}Sr and ^{90}Sr	combined activity 0.1 mBq/m³
	laboratory determination at minimum monthly		^{3}H	0.1 kBq/m³
	laboratory determination at minimum monthly		^{14}C	10 Bq/m³

Content of radionuclides in releases is determined on the basis of gamma spectre measurement of spectrometric aerosol particles and inert gases in samples from the ventilation air stacks, and this allows evaluation of penetration of every radionuclide to the surface air. Since radionuclides may be released from the power plant to the ambient air via ventilation stacks of reactor units and via ventilation tubing of the rooms with the radioactive waste treatment equipment, calculations will be performed for three different height cases. All points of radionuclide release to the ambient air will be monitored. The equipment will be based on the most effective and advanced techniques that can be practically adopted. The solid particles contained in the sample flow are caught in the sampling filter that is changed and analysed regularly. The level of radioactivity of gaseous substances is measured using a continuously operating radioactivity meter. Samples will also be taken of the gas at regular intervals for isotope-specific analysis.

During the construction of the new NPP, it is imperative to assess the state of the RADIS system and to complement the early warning system with ten automated dosimeters recording gamma radiation dose rate, located within the 3–5 km ring around the new NPP, as high as possible above the ground. The program of calculation of airborne radionuclide transfer from the point of the new NPP dislocation (regardless the working of the NNPP systems during an accident) will estimate the amounts of airborne radionuclide releases on the basis of the actual or predictive meteorological data (easily available online) and the dose rate value recorded by at least one leeward automated dosimeter. The distribution of radionuclides released during an accident and the radiation dose rate in the area will be calculated every 15 minutes.

9.4.2 Waterborne releases

A similar sampling procedure as for airborne releases will also be used to monitor the radioactivity of waste waters discharged from the plant to Lake Druksiai. The radioisotopic content of waterborne discharges and the activity of radionuclides will be assessed. Stationary systems for the direct measurement or sampling of integral samples will be installed at the main pathways of permanent discharges. Automatic systems will be installed when reasonable. The total activities of the waterborne releases at the main pathways will be assessed at least daily. At less important pathways sampling will be performed regularly. The flows of waterborne discharges will be credibly measured in all pathways at any condition. Proposals for monitoring of the common liquid releases and examples of the detectable limits of the monitors are presented in Table 9.4–2.

All waste waters from the NNPP site will be treated in the liquid waste water treatment plant. From the treatment plant the waste water will be collected to specific discharge containers where the monitoring of the radioactivity releases of aqueous waste will be performed. The plant laboratory will measure the level of radioactivity in the water and clear it for pumping out if the level is acceptably low. If the radioactivity level of the water is not low enough it will be returned for further treatment. In conjunction with discharging the water into the lake, a collective sample will be taken for release measurements. There will be an automatically operating unit of measurement based on best available techniques in the discharge tube. There will also be valves which are closed automatically in cases when discharged water activity level is too high. In addition the auxiliary plants such as the solid waste treatment and storage facility and the existing spent fuel storage facility in the vicinity of the NNPP site will be included into the power plant’s release control.

The systems designed to monitor the release of radioactive materials will have means for calibration and operability testing.

Table 9.4–2. Proposals for monitoring of the common liquid releases and examples of the detectable limits of the monitors (Edilex 2008).

Release	Monitoring method	Reduplication	Radionuclide	Minimal detectable activity in release flow
Gamma activity	continuous monitoring	yes or verification by sampling	all	400 kBq/m³
	release-specific laboratory determination		all	1 kBq/m³
Alpha activity	laboratory determination monthly		all	total activity 1 kBq/m³
			^{241}Am	10 Bq/m³
Significant single nuclides	laboratory determination monthly		^{89}Sr and ^{90}Sr	combined activity 0.2 kBq/m³
	laboratory determination monthly		^{3}H	50 kBq/m³

The activity of ^{14}C in airborne and waterborne releases will be systematically measured or assessed by calculations, which will be validated using the measurements performed under various modes of nuclear object operation. The activity of the radionuclides in airborne and waterborne releases will be credibly assessed during short-term increase of releases. If an increase of releases is foreseen (e.g. during start-up or shutdown of the NNPP), an additional observation shall be performed. Accordingly stationary observation systems or the application of laboratory methods will be used.

9.4.3 Monitoring of the radioactive loads to the environment and people

The purpose of environmental radiation monitoring is to determine the radiation load caused to the environment and people by the radioactive releases from the nuclear power plant. The radiation measurements of the power plant area and surroundings allow ensuring that the radiation dose limits set by the authorities are not exceeded. Radiation monitoring also allows confirming the measurement results of the power plant's radioactive releases and detects any short-term and long-term changes in the normal radiation situation of the surroundings. The radiation monitoring program contains e.g. external radiation measurement and analyses of activity in inhaled air and in samples representing different phases of the food chains leading to humans.

A radiological monitoring programme for the new NPP will cover monitoring of all environment radiation ways, capable of impacting people and environment.

The environmental monitoring will include the measurements of the dose rate, external absorbed dose and activities of radionuclides in various components of the environment. Continuous measurements of radiation will be performed in the sanitary protection zone of the NNPP and at some distances from it towards the nearest main settlements, taking into account the location peculiarities of the NNPP territory. All the devices for dose rate measurements and for the measurements of the external absorbed dose will represent best available techniques. Samples of environmental indicators will be taken in the sanitary protection zone and locations where pollutants are released or discharged and where the maximal pollution (according to assessments of radionuclides dispersion and territory peculiarities) is expected. The samples will be taken with a frequency corresponding to the alternation of components of the environment and the quantity of gathered data will be such that it allows assessment of the exposure of the members of the critical group (groups). For the assessment of the pollution of environmental indicators the radio isotopic content of samples will be estimated, and the concentrations of the gamma emitters (^{137}Cs, ^{134}Cs, ^{60}Co, ^{54}Mn, ^{95}Zr, ^{95}Nb, ^{131}I etc.) will be measured. The pollution with beta emitters (^{89}Sr, ^{90}Sr, ^{3}H and ^{14}C) and alpha emitters ($^{239,\ 240}Pu$) will be assessed using the analysis of chosen archetypal samples. If it is known or supposed that the activities or content of airborne and waterborne releases can change, the samples will be taken more frequently, and additional measurements will be performed. The monitoring will be performed applying measurement methods and using devices which allow measuring the activities of individual isotopes that can lead to doses higher than 0.01 mSv per year with sufficient accuracy. The monitoring systems will be doubled and operated continuously, which allows assessing the concentrations of any period and comparing with the maximum permissible concentrations.

For the data quality assurance the monitoring systems will be installed, tested, calibrated, operated and renovated in accordance with the nuclear industry standards and the quality assurance program.

A proposal for a programme for monitoring radionuclides of the new NPP is presented in Table 9.4–3.

9.4.3.1 External radiation

External radiation will be measured continuously. All the monitoring equipment and stations will be used and located by utilizing existing sites and some devices wherever reasonable (e.g. sensors of the SkyLink System). All decisions should however be based on the best available techniques. Continuously operating environmental dose rate meters and thermoluminescent dosimeter stations located at 0–10 km from the NNPP will be used for continuous measuring and recording. In addition there will be supplementary gamma-spectrometric measurements once every two years.

9.4.3.2 Airborne radioactive particles and iodine

Sampling of the environmental components will be performed in points of radionuclide releases or in their vicinity, as well as in points of the maximum expected contamination (according to the assessment of radionuclide spread and the locality peculiarities) in the area of potential environmental impact of the NNPP, established in the monitoring programme. Monitoring of airborne radioactive particles and iodine in the new NPP area will be performed by high-volume air sample collectors. Existing observation stations will be used when reasonable. Air samples will be collected continuously and simultaneously. All the devices including the filters used in collectors will represent best available techniques. The filters will be changed 2 times per month, but during maintenance and refuelling outages of the power plants, filters from the sampler closest to the power plant will be changed weekly. A portable air sample collector will be used when needed for complementary monitoring, e.g. once a week during refuelling.

9.4.3.3 Deposition

Deposition will be measured continuously in rain and snow water. Deposition collectors (rain and snow sample collectors) for dry and wet deposition will be located at distances of 1–10 km from the new NPP. Electric warming will be used to prevent freezing and for melting the snow deposited in the collector in winter. The sample vessels will be changed regularly (*STUK-A227, 2008, p. 27*).

9.4.3.4 Soil samples

Before the start of operation of the new NPP the pollution of soil in the region will be evaluated. During operation of the new NPP samples will be taken from the area of assumed maximum deposition to determine the accumulation of long-lived radionuclides. Samples will be drawn from 6 standard points twice a year.

9.4.3.5 Grazing grass

Samples of grazing grass will be taken twice per growing season at distances of 0–10 km from the new NPP. Grazing grass will be taken as a collective sample representing farms producing milk.

9.4.3.6 Plants from forests, natural products and game

Samples of plants from forests (moss) and natural products (mushrooms and berries) will be taken at minimum in three ecological sites. Samples of game (roe deer meat) will be taken from one sampling site. An attempt will be to gather the samples from an area which is as small and uniform as possible. Samples of wild berries and mushrooms growing in the vicinities of the new NPP will be taken twice a year during the growth season simultaneously with the soil sampling. Samples of game will be taken once a year. Samples of moss will be taken once a year after the refuelling of the NNPP.

9.4.3.7 Other food

Samples will be taken of meat (pork, beef), milk, fish, vegetables (cabbage, potatoes, lettuce) and grain crops (rye or oats). The samples will be taken at distances ranging from 0 to 30 km from the new NPP, similar as they are taken in existing INPP. Milk samples will be taken once a week from local dairies operating in the new NPP region. The samples representing the whole production of the local dairy will be taken once a month from collection tanks according to standard methods used in sampling of food supplies. Samples of cabbage, potatoes and lettuce will be taken twice a year during the growth season from a chosen garden grown as for normal household use. Grain samples of rye or oats will be taken once a year in local grain stores. Meat samples (pork and beef) will be taken once a year from livestock raised at the new NPP region.

9.4.3.8 Drinking water

Samples of drinking water will be taken 2–4 times a year directly from the network of water pipes or from raw water reservoirs.

9.4.3.9 Surrounding residents

The internal radioactivity measurements of the nearby residents allow ensuring that there are no significant, unrecognised exposure pathways for the residents of the surroundings. Measurements will be taken of 8–15 residents once a year.

9.4.3.10 The lake ecosystem

Samples of the lake ecosystem will be taken in six stations in the surrounding area of the new NPP: filtrated water (4 times a year), aquatic indicator organisms (twice a year) bottom sediments (twice a year), aquatic vegetation (once a year), sinking matter (once a year) and bottom dwellers (once a year). The fish samples will consist of 2–4 economically important species from the discharge area and from a comparison area.

9.4.4 Groundwater monitoring

Observation wells for monitoring of groundwater shall be foreseen around the new NPP site as part of the required environmental monitoring. The groundwater monitoring programme shall be developed in accordance with the requirements of the regulation “Regulation on Ground Water Monitoring of Economy Entities“ (*State Journal, 2003, No. 101-4578*) and presented to the Geological Survey of Lithuania for approval.

Detailed information on the groundwater monitoring system of the new NPP, with the justification of its separate components, the groundwater quality indicators foreseen to be monitored, and the periodicity of their observation will be presented in Basic Design of the NNPP.

Table 9.4–3. Proposal for a programme for monitoring radionuclides of the new NPP (adapting STUK-A227, 2008, p. 14–17)

Monitoring object	Type of measurements or samples	Measuring or sampling frequency	Analyses and frequencies
External radiation	Environmental dose rate meters at 0-10 km from the power plant	Continuous measurement and data accumulation	Dose rate, min., max., mean, analogue plotter charts and/or digital hourly average values
	TLD dosimeter stations at 0–10 km from the power plant	Continuous measurement	Gamma dose, 4 times a year
	Supplementary gamma-spectrometric measurements	Once every two years	Gamma spectrum, once every two years
Airborne radioactive particles and iodine	Air sample collectors at 0–10 km from the power plant	Continuous collection	Gamma emitters, twice a month (the sampler closest to the NNPP once a week)
	Supplementary monitoring performed with a portable air sample collector	Once a week during refuelling	Gamma emitters, once a week during refuelling
Deposition	Deposition collectors at 0–10 km from the power plant	Continuous collection	Gamma emitters, and ^{3}H, 4–12 times a year, ^{89}Sr and ^{90}Sr, 4 times a year
Soil	Soil samples are drawn from the area of assumed maximum deposition to determine the accumulation of long-lived radionuclides	Twice a year	Gamma emitters and ^{90}Sr, vertical distribution
Plants from forests, natural products and game	Wild berries and mushrooms from three sampling sites	Twice a year simultaneously with the soil sampling	Gamma emitters
	Roe deer meat from one sampling site close to the power plant	Once a year	Gamma emitters
	Moss from three sampling sites close to the power plant	Once a year after the refuelling	Gamma emitters
Grazing grass	Collective sample representing farms producing milk	Twice a growing season	Gamma emitters
Milk	Sample representing farms producing milk	Once a week	^{131}I and gamma emitters
	Sample representing the whole production of the local dairy	Once a month / six times a year	Gamma emitters and ^{131}I (if needed) once a month; ^{89}Sr, ^{90}Sr six times a year
Garden produce	Potatoes	Twice a growing season	Gamma emitters
	Cabbage	Twice a growing season	Gamma emitters
	Lettuce	Twice a growing season	Gamma emitters
Grain crops	Rye or oats	Once a year	Gamma emitters
Meat	Beef and pork samples from livestock	Once a year	Gamma emitters, twice a year
Drinking water	Samples of drinking water or raw water from the power plant and from the nearby town	2–4 times a year	Gamma emitters, and ^{3}H, 2–4 times a year, ^{89}Sr and ^{90}Sr, twice a year
Lake water	Samples from 6 stations in the surrounding lake areas of the power plant	4 times a year	Gamma emitters, ^{3}H, ^{89}Sr and ^{90}Sr

Monitoring object	Type of measurements or samples	Measuring or sampling frequency	Analyses and frequencies
Bottom sediments	Sinking matter collected by sediment traps at stations in the surrounding lake areas	Once a year	Gamma emitters, ^{238}Pu and $^{239,240}Pu$
	Sediment samples are taken from several stations in the surrounding lake areas	Twice a year	Gamma emitters, ^{90}Sr, ^{238}Pu and $^{239,240}Pu$, vertical distribution
Aquatic indicator organisms	Samples according to the sampling standards in force	Continuous collection during the growing season	Gamma emitters, 4 times a growing season
Bottom dwellers	Samples according to the sampling standards in force	Once a year	Gamma emitters, ^{89}Sr and ^{90}Sr
Aquatic plants	Samples according to the sampling standards in force	Once a year	Gamma emitters, ^{89}Sr and ^{90}Sr
Wild fish	The fish samples shall consist of 2–4 economically important species from the discharge area and from a comparison area	Twice a year	Gamma emitters, ^{89}Sr and ^{90}Sr

9.5 OTHER MONITORING

9.5.1 Current monitoring system

9.5.1.1 Seismic alarm monitoring system

The Lithuanian territory is traditionally considered as non-seismic or low seismic zone. However historical and recent data shows that seismic events of low or medium intensity have happened in territories of the Baltic States. Four seismological observation stations have been installed in the INPP region. The data gathered in the stations is processed and analysed according to the State Nuclear Power Safety Inspectorate (VATESI) regulation P-2006-01 “Requirements for Analysis of Seismic Impact on Nuclear Installations” (*State Journal, 2006, No. 87-3447*) and the IAEA Safety Standards.

The seismic alarm monitoring system comprises sensors located at distances of up to 30 km from the plant permitting alerting prior to arrival of earthquake shock waves at the site. It identifies seismic events larger than design earthquakes, does not interfere with other systems and its integration does not involve any risk for the plant supplier.

9.5.1.2 Monitoring of cooling and waste waters

Cooling water

Monitoring of thermal effects of the INNP cooling water is carried out according to the regulations “Standard Limits of Permissible Warming of Lake Druksiai Water and Methodology for Temperature Control” (LAND 7-95/M-02) and the Ignalina NPP Environmental Monitoring Program. A description of the content of the regulations can be found from the Section 7.1.1.9 “Water temperature monitoring of Lake Druksiai”.

Waste water

The quality of waste waters is monitored according to the “Regulation on Sewage Management” (*State Journal, 2007, No. 110-4522*) and the Ignalina NPP Integrated Pollution Prevention and Control Permission (*No. TV(2)-3, issued by Utena Regional Environment Protection Department*).

Household wastewater treatment is outsourced to the State Enterprise “Visagino Energija”, which operates the Visaginas waste water treatment plant; hence the monitoring of household waste waters is carried out by “Visagino Energija”. In addition the waste water monitoring comprises the follow up of regeneration effluents (from process water production) and discharges from the rain water disposal system. Rain water is managed according to the requirements of “Regulation on Surface Water Management” (*State Journal, 2007, No. 42-1594*). The monitoring is carried out in the cooling water discharge channel, in the inlet channel and in the rain-industrial water release channels 1,2 (PLK-1,2), 3 (PLK-3) and in the release channel of the Spent Fuel Storage Facility (PLK-SFSF).

9.5.1.3 Monitoring of the environmental impacts

Historically the monitoring of the environmental impacts was part of the various State financed scientific programs (1978–2007) which comprised both radioecological and non-radioecological monitoring. A summary of monitoring results of the aquatic ecosystem (physical-chemical parameters, plankton, aquatic vegetation, fish stocks and fishing activity) is presented in Section 7.1.1.5. Summaries of monitoring results of the radionuclides in the water of Lake Druksiai and groundwater are presented in Section 7.1.1.6, the radioecological state of flora and fauna of Lake Druksiai in Section 7.1.1.7, the ecotoxicological state of Lake Druksiai in Section 7.1.1.8 and the radioecological state of terrestrial flora, fauna and onshore land of the region in Section 7.6 of this EIA Report.

More detailed scientific monitoring data can be found in the State Scientific Program "Atomic Energy and the Environment" (*Collection of Research Reports, 1993–1997, Vol. 1–5*) and in the report of the project recently performed by Radiation Protection Centre together with various research institutions (*Radiation Protection Centre Project Report, 2007*).

9.5.1.4 Monitoring of flue gas emissions

Total emission values are calculated based on fuel consumption. The impact of flue gases on air quality can be assessed based on data from the monitoring station in Aukstaitija (see Section 7.2 Background contamination of the ambient air and greenhouse gases).

9.5.1.5 Noise monitoring

Noise levels caused by the INPP are not monitored at regular intervals.

9.5.1.6 Monitoring of social impacts

A program for the socio-economic monitoring of the INPP region was compiled and prepared by the Division of Regional Geography of Institute of Geology and Geography in 2002 (*Baubinas et al., 2002*). Preparation of the program was funded by the United Nations Development Program and coordinated by the Ministry for Social Security and Labour. The monitoring has been organized in the context of preparations for the closure of the INPP. The objective has been to diminish the possible negative impacts of the closure of the INPP and to increase the effectiveness of social policy measures.

More information on the social processes taking place in the region, their interdependence and dependence on the processes outside the region is presented in Section 7.9 of this EIA Report.

9.5.2 Proposals for the monitoring system for the new NPP

9.5.2.1 Seismic alarm monitoring system

The existing seismic alarm system has been installed in 1999 in the vicinity of the INNP. The system will be utilized also for the new NPP. The new NPP, however, will be designed and constructed to prevent the risks of possible seismic activities.

All the devices used in the alarm system will be modernized if necessary to meet the current national and international requirements.

9.5.2.2 Monitoring of cooling and waste waters

Cooling water

Monitoring of the cooling water comprises the amount, temperature and quality of the discharged water.

The amount of the cooling water will be followed based on the operation data of the new NPP and the output of cooling water pumps.

Temperature monitoring will be carried out by a continuous temperature measurement system which will be installed at the new NPP. Monitoring will be performed with automatic temperature monitoring devices. The temperature of inflow and outflow water (sample stations within the inlet and outlet channels) will be monitored continuously with real-time monitoring devices. The results will be saved to a computer system. Also information of the new NPP operation will be continuously saved in the computer system. The measurements are used in calculations of the temperature rise in condensers and in computing the flow rate of cooling water. Also the amount of thermal energy directed to Lake Druksiai will be calculated based on the measurements.

The thermal effects of the cooling water discharges are monitored in Lake Druksiai. Temperature monitoring system will be introduced for the lake. The number, location of the sample stations and depths of the sensors will be defined so that it is possible to create an algorithm describing the temperature regime of the lake in a comparable way with the criteria set in the legislation.

Based on the information produced by the monitoring system, the criteria set in the legislation for the allowed temperature regime in Lake Druksiai will be supervised online. Thus information of exceeding of the criteria will be available in good time to the operators of the NPP, enabling timely reduction of thermal load into the lake. Correspondingly, lake temperature and weather information will allow returning back to the bigger thermal load while staying within the limits of the regulatory thermal regime criteria.

The monitoring information will be presented to the environmental authority in order to facilitate supervision.

Waste water

The quality of the sanitary waste waters will be monitored by the Visaginas waste water treatment plant (WWTP). The WWTP performs monitoring of waste water discharge quality and amount as it is responsible for the water quality discharged to the environment. A reconstruction project of the plant was started May 2008 and the new plant will be able to meet the current Lithuanian (Regulation on Sewage Management; *State Journal, 2007, No. 110-4522),* Regulation on Surface Water Management; *State Journal, 2007, No. 42-1594*) and EU effluent standards (*Council Directive 91/271/EEC concerning urban waste-water treatment*).

The monitoring will follow the Lithuanian legislation and regulations and protocols required by the urban waste water treatment directive. Flow-proportional or time-based 24-hour samples will be collected at the same well-defined point in the outlet and if necessary in the inlet. The minimum annual number of samples will be 12, which will be collected at regular intervals during the year. Monitoring will comprise at least the following parameters: $BOD_{5/7}$, COD, total suspended solids, total phosphorus and total nitrogen. The monitoring program may comprise also other parameters, such as pH, nitrites, nitrates or phosphates, if considered reasonable. The quality requirements (concentrations/ percentage of reduction) are presented in Section 7.1 “The state of waters”. The pH in the neutralization basin will be measured with an automatic device before discharging to the cooling water channel. The quality of cooling water discharged will be monitored every 10 days. The monitored parameters will include at least the following: pH, N_{tot}, NH_4-N, NO_2-N/NO_3-N, P_{tot}, $BOD_{5/7}$, TDS, COD, sulphates and chlorides. In case pesticides are used, they will be included in the monitoring program. Other parameters should be considered when reasonable.

All the waters from the rain water disposal system will be collected and continuously followed in inspection wells and settling basins. Oil detector devices, which automatically alarm when oil is detected, will be installed. Detected oil will be removed in oil separators before discharging to the lake. The quality of discharged water will be monitored every 10 days. The monitored parameters will include at least the following: pH, N_{tot}, NH_4-N, NO_2-N/NO_3-N, P_{tot}, $BOD_{5/7}$, TDS and COD.

Good sampling and laboratory practices (based on international standards) will be applied.

9.5.2.3 Monitoring of the environmental impacts

Monitoring of the environmental impacts will be included in the monitoring program. A detailed monitoring plan will be established together with the authorities but it can comprise e.g. the following indicators; physical-chemical water quality, primary production (chlorophyll-a), aquatic vegetation and fish stock. A proposal for parameters and frequencies of monitoring is presented below.

The physical-chemical water quality in Lake Druksiai will be monitored 3–12 times of year at 2–5 sampling stations. It will comprise at least monitoring of pH, O_2/l, O_2%, N_{tot}, NH_4-N, NO_2-N/NO_3-N, P_{tot}, $BOD_{5/7}$ and TDS. Also other parameters should be considered when reasonable.

Monitoring of the primary production can be based either solely on the chlorophyll-a measurements or combination of it and phytoplankton samples. It should be carried out regularly (2–6 times/ month) at several sample stations (2–5) during the growing season.

The composition and abundance of aquatic vegetation will be monitored every 3–6 year during the growing season at several sample stations (2–5).

Monitoring of the fish stock will be carried out with an interval of 1 to 4 years. The composition and abundance of fish will be monitored by gillnetting (standard gillnets) both in the pelagic and littoral zone (at 2–5 sample stations). Also other methods (such as hydroacoustics or trawling) can be applied.

The existing sample stations will be kept unaltered when possible. All the methods applied in sampling and analyzing the samples will be based on national/international standards to ensure the comparability of the results.

9.5.2.4 Monitoring of flue gas emissions

Flue gas emissions will be calculated based on fuel consumption as it has been done for the INPP. Air quality will be monitored at the integrated monitoring stations as recently.

9.5.2.5 Noise monitoring

During construction of the NNPP noise measurements will be carried out if necessary.

During operation of the new NPP noise will be measured at regular intervals in order to ensure that noise levels from the power plant complies with the levels set in the regulations.

If necessary, the noise level in open air will be measured at locations in which such noise is perceived most clearly.

9.5.2.6 Keeping records of the waste

Keeping records of different types of waste arising at the NNPP will be carried out.

9.5.2.7 Monitoring of social impacts

The methods and results of existing socio-economic monitoring of the INPP will be utilized where applicable for the new NPP.

Cooperation with stakeholder groups is an important part of the normal operations of any modern, social responsible company. The opinions of people living in the area could be studied by queries and be used to support the assessment of the social impacts of the project. The assessment of health impacts is also part of the assessment of the project's social impacts.

Useful information on the negative impacts of the project and on the means available for mitigating or preventing them can be obtained through open exchange of information with interest groups. The connections established during the environmental impact assessment procedure can serve as channels for interaction in the future.

The operator will organise regular meetings with representatives of neighbouring areas and the existing information centre of the INPP can offer information on the new NPP (tours, the information bulletin, the news sheet, booklets, calendars, magazines etc.).

Indirect and direct impacts of the project on employment and businesses could also be studied.

9.6 MONITORING DATA REPORTING

The data concerning monthly monitoring of air and water effluents will be submitted to the Environmental Protection Agency, the Radiation Protection Centre and VATESI at the first week of the following month (except data on ^{3}H, which will be submitted every three months). An annual report on the results of environmental monitoring will be submitted to the Ministry of Environment, the Environmental Protection Agency, VATESI, the Radiation Protection Centre and the Local Municipalities before first of April of the following year. In accordance with clause 68 of LAND 42-2007, the report will include information as follows:

- results of all measurements foreseen in the Monitoring Programme and their analysis;
- activities of radionuclides released into ambient air and water (by months) and total annual activities of radionuclides (according to the list given in the LAND 42-2007 Appendix No.4 document „COMMISSION RECOMMENDATION of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation (2004/2/Euratom)");
- general information concerning realized activities (amount of produced electricity, generated, conditioned, stored or disposed of radioactive waste);
- comparison of radionuclide activities with limits;
- releases and contamination changing trends and their analysis;
- evaluative doses of members of critical groups, caused by radionuclides, their comparison with dose constraint;
- reasons of extraordinary releases of radionuclides into environment and their analysis;
- any other important information.

10 RISK ANALYSIS AND ASSESSMENT

10.1 INTRODUCTION TO RISK ASSESSMENT

Potential emergency situations (risks) resulting from the proposed economic activity, which could lead to environmental impact are addressed in this chapter.

Risk assessment for environmental impact assessment (EIA) differs from risk assessment which is performed later in the Safety Analysis Report (SAR) of a NPP. Usually during the environmental impact assessment process a Technical Design of the NPP is not available yet, therefore for EIA it is important to identify potential emergency situations which are general for different types of power plants and to define emergency situations which have bounding impact on the environment. The risk assessment as presented in an EIA Report shall be considered as preliminary and does not substitute necessity for more sophisticated and detailed risk analysis which has to be based on actual design solutions. At later stages, when reactor type will be selected and Technical Design of this selected type of NPP will be available, a detailed risk analysis, resulting consequences and preventive/mitigation measures will be described in a Safety Analysis Report.

Emergency situations, which could lead to releases and cause radiological exposure of personnel and/or general public, are of primary concern for environmental impact assessment. For this proposed economical activity most of the potential emergency situations can cause radiological and non-radiological or only non-radiological consequences (i.e. emergency shutdown of reactor). Accidents with non-radiological consequences as a rule lead to considerably lower impacts. Most of the non-radiological chemical materials at the power plant are used in auxiliary processes. Design of storage tanks for chemicals and implemented procedures assure the safety usage and storage of chemicals both for the environment and for the personnel. The risk of harmful amounts of chemicals or oils being discharged into the water, atmosphere or soil is minor, therefore in the further analysis consequences of radiological accidents are considered.

The Lithuanian legal document "Regulations on Preparation of Environment Impact Assessment Program and Report" (*State Journal 2006, No. 6-225*) defines that the emergency situations of a proposed economic activity and their potential risks should be assessed according to normative document "Recommendations for Assessment of Potential Accident Risk of Proposed Economic Activity" (*Information Publications, 2002, No. 61-297*).

"Regulations on Prevention of Industrial Accidents, their Elimination and Investigation" (*State Journal, 2004, No. 130-4649*) provide requirements for how industrial accidents shall be assessed. Clause 3.1 of this document states that these regulations are not applicable to facilities which can cause radiological impact. Since radiological impact is of primary concern for EIA the industrial accidents and their investigation will be considered in the Technical Design phase.

Risk assessment performed in this EIA Report contains the following steps:

- Identification of the initiating events, design basis accidents (DBA), severe accidents;
- Screening and selection of accidents which have bounding impact to environment;
- Definition of source terms and releases into environment in case of accidents;
- Dispersion modelling of accidental releases and public exposure assessment;

- Description of protective actions of public in case of radiological or nuclear accident.

Selection of initiating events, DBA and severe accidents is based on the IAEA safety guides and reports:

- External Human Induced Events in Site Evaluation for Nuclear Power Plants *(IAEA Safety Guide No. NS-G-3.1)*;
- Meteorological Events in Site Evaluation for Nuclear Power Plants *(IAEA Safety Guide No. NS-G-3.4)*;
- Accident Analysis for Nuclear Power Plants *(IAEA Safety Reports Series No. 23)*.

Analysis of accidents, classification of consequences and selection of bounding cases is provided in Section 10.2 and is based on "Recommendations for Assessment of Potential Accident Risk of Proposed Economic Activity" (*Information Publications, 2002, No. 61-297*).

Definition of source terms and releases into environment in case of accidents is based on Design Control Documentation (DCD) of different type of reactors. DCD are freely available on the website of the US Nuclear Regulatory Commission (www.nrc.gov). DCD contains information which radionuclides are released during normal operation and in case of accidents into environment from different type of reactors.

For dispersion modelling of accidental releases from the NNPP an Air Quality and Emergency Modelling System SILAM (http://silam.fmi.fi) has been used. Accidental releases, dispersion modelling and possible consequences are provided in Section 10.3.

Assessment of consequences in case of accident, protective actions of public in case of radiological or nuclear accident is based on Lithuanian Hygiene Standard HN 87:2002. "Radiation Protection in Nuclear Objects" (*State Journal, 2003, No. 15-624; 2008, No. 35-1251*) and Lithuanian Hygiene Standard HN 99:2000 "Protective Actions of Pubic in Case of Radiological or Nuclear Accident" (*State Journal, 2000, No. 57-1691*).

10.2 NNPP RISK ASSESSMENT

10.2.1 Operational states and accidental conditions at NPP

The entire set of limits and conditions for which an NPP is designed and for which damage to the fuel and release of radioactive material are kept within authorized limits, form the design basis of an NPP. NPPs are designed, operated and maintained to prevent initial events leading to accidental conditions and furthermore, "defence in depth" concept, safety culture, permanent training, independent supervision, accident management capabilities, etc, ensure that the probability of accidents leading to extreme consequences is extremely low. Despite the measures taken in design to avoid accidents and sources of radiation exposure, within the NPP design basis, a number of unintended events are considered, including human errors and equipment failures, whose consequences or potential consequences may not be negligible in terms of safety. According to the frequency of its occurrence and potential consequences, an event may be classified as an anticipated operational occurrence (also called a transient), design basis accident, beyond design basis accident or severe accident.

Normal operation is NPP operation within specified operational limits and conditions. This includes start-up, power operation, shutting down, shutdown, maintenance, testing and refuelling. Assessment of possible radiological impacts on the environment during normal operation of the NNPP is presented in Chapter 7.

Anticipated operational occurrence (AOO) is an operational process deviating from normal operation which is expected to occur at least once during the operating lifetime of an NPP but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety or lead to accident conditions. AOO is not classified as accident; it is a part of NPP operational state which consists of Normal operation and AOO. Examples of anticipated operational occurrences are loss of normal electrical power and faults such as a turbine trip, malfunction of individual items of a normally running plant, failure to function of individual items of control equipment, and loss of power to the main coolant pump. NPPs are design to withstand such AOO, radioactive releases into the environment rarely exceed the limits that are assigned to normal operation. The dose constraint of annual population exposure during normal operation of NPP and taking into account AOO shall not exceed 0.2 mSv/year.

Design basis accident (DBA) is an accident condition against which a nuclear facility is designed according to established design criteria, and for which the damage to the fuel and the release of radioactive material are kept within authorized limits. Occurrence frequency of DBA typically varies from 10^{-4} to 10^{-2} per reactor operating year (*IAEA Safety Reports Series No. 23*). In case of DBA the safety systems and containment of NPP limit the amount of radioactive materials released into the environment to such a level that according to HN 87:2002 (*State Journal, 2003, No. 15-624; 2008, No. 35-1251*) maximal radiation dose for the population in the case of DBA shall not exceed 10 mSv. Examples of typical DBAs are loss of reactivity control, fuel handling accidents, loss of coolant accident (LOCA), etc.

An accident occurring outside the NPP design basis is called a Beyond Design Basis Accident (BDBA). Occurrence frequency of BDBA in modern reactor designs is expected to be of order range 10^{-6} to 10^{-4} per reactor year (*IAEA Safety Reports Series No. 23*). Such an accident may or may not involve degradation of the reactor core (leading to significant core damage). Examples of BDBAs are total loss of power, total loss of feedwater, LOCA combined with complete loss of an emergency core cooling system, etc. Usually specific procedures are developed and implemented in nuclear power plants to return the plant to design basis conditions and these administrative and technical measures reduce the risk of BDBA.

An accident condition involving significant core degradation is called a Severe Accident (SA). In case of SA a large proportion of the fuel in the reactor is damaged, and a large amount of this radioactive material is released from the fuel matrix (the first barrier). However, there are further barriers, such as reactor vessel and primary circuit, inner and outer containment, which prevent a release to the environment. The limit of release after a core damage accident and an effective final barrier (the containment) should not cause acute health effects to the population in the vicinity of the NPP, nor should it cause long term restrictions on the use of extensive areas of land or water. There are no regulations for releases in case of SA in Lithuanian legislation. Therefore the limit for the release of radioactive materials arising from a severe accident (100 TBq release of Cs-137) defined in Finnish legislation (*Council State decision 395/91*) is used for environmental impact estimation. According to the Council State decision (*395/91*) accidents leading to large releases of radioactive materials shall be very unlikely. The numerical design objective for this very unlikely release is specified in Finnish Radiation and Nuclear Safety Authority (STUK) Guide YVL 2.8, where it is stated that the mean value of the probability of a release exceeding the target value 100 TBq of Cs-137 must be smaller than $5 \cdot 10^{-7}$ per year.

In terms of frequency of such events, the frequency of core damage SA should be less than 10^{-6} per year of reactor operation (*IAEA Safety Reports Series No. 23*), and events involving significant early containment failure should be an order of magnitude or more lower. This is demonstrated in the Probabilistic Risk Assessment (PRA) which considers and integrates the full range of potentially damaging initiating events (see below), the probability of failure of protective systems and actions (the 'safeguards'), and by use logical analysis, estimates the frequency of different release types. Typically, the end point of the PRA considers different scenarios: intact containment, containment bypass, containment late or early failure etc. Large release frequency for different scenarios varies from 10^{-10} to 10^{-6} per year. Chapter 5.1.3 describes the end points of the European Utilities Requirements against which a number of the candidate reactor designs have already, or are in the process of, demonstrated compliance.

Many of the engineered provisions for radiation protection of the public in normal operation also contribute to the radiation protection in accident conditions. The special measures provided for public protection during accident situations refer to:

– ensuring containment isolation to terminate releases;
– reducing activity releases.

The first requirement for public protection is to ensure that releases are terminated. Containment isolation is provided by diverse means including isolation based on measurements of Reactor Building airborne activity.

The second requirement is to ensure that where releases take place, these are reduced by appropriate filtration and by ensuring that the volatility of radionuclides (in particular iodine) is reduced.

Table 10.2–1 presents possible subdivision of event occurrences.

Table 10.2–1. Subdivision of event occurrences, derived from (*IAEA Safety Reports Series No. 23*).

Occurrence (1/reactor year)	Characteristics		Terminology	Acceptance criteria
10^{-2} – 1 (Expected in the life of the plant)	Expected	AOO	Anticipated transients, transients, frequent faults, incidents of moderate frequency, upset conditions, abnormal conditions	No damage to fuel
10^{-4} – 10^{-2} (Chance greater than 1% over the life of the plant)	Possible	DBA	Infrequent incidents, infrequent faults, limiting faults, emergency conditions	No radiological impact at all or no radiological impact outside the exclusion area
10^{-6} – 10^{-4} (Chance less than 1% over the life of the plant)	Unlikely	BDBA	Faulted conditions	Radiological consequences outside exclusion area within limits
< 10^{-6} (Very unlikely to occur)	Remote	SA	Faulted conditions	Emergency response needed

10.2.2 External and internal events

Safety analysis of nuclear power plants focuses on the assessment of how external and internal events can affect the safety of a NPP. This assessment and results obtained are presented in a safety analysis report of a nuclear power plant. The environmental impact assessment report is not aimed at assessing what external or internal events have caused the accident. For the EIA it is essential to identify and examine the accidents, which environmental impact is the maximum compared to other accidents. More about the impact of accidents being estimated in the EIA Report see in Subsection 10.3.1.

External and internal events that are considered in NPP technical design and its safety evaluation usually are divided in such four groups of events:

- External natural events;
- External human induced;
- Internal human induced events;
- Equipment or elements failures.

External natural events that are typically considered in NPP design and its safety evaluation are as follows:

- Earthquake;
- External flooding;
- Extremes of temperature;
- Extreme winds and whirlwinds;
- Rain, snow, ice formation;
- Drought;
- Lightning;
- Natural fires.

External human induced events that may be considered are:

- Aircraft crash;
- Hazards from adjacent installations, transport activities (missiles, gas cloud, explosion wave, etc.);
- Electromagnetic interference;
- Sabotage, terrorist attack;
- Subsidence;
- External fire;
- Blockage or damage to cooling water intake structures.

Internal human induced events are:

- Internal fire;
- Internal explosion (including generation of flying objects);
- Hazardous (asphyxiant, toxic), flammable and explosive gases generation and/or release into environment;
- Chemically aggressive gases and liquids generation and/or release into environment;
- Personnel sabotage and intentional harm;
- Personnel errors.

As it was mentioned earlier, these and others external and internal events are considered in NPP design and during its safety analysis report preparation, where consequences of such events are evaluated and technical and administrative protective measures are foreseen in order to prevent or to mitigate these consequences.

10.2.3 International Nuclear Event Scale (INES)

Description of accidental conditions at a NPP is provided in Section 10.2.1. However, this subdivision does not give understanding about the significance of the accident. For instance both fuel handling accidents and LOCA are design basis accidents, but consequences of these accidents are very different. Therefore, the International Nuclear Events Scale (*IAEA and OECD/NEA, 2001*) was implemented to facilitate rapid communication to the media and the public regarding the safety significance of events at all nuclear installations associated with the civil nuclear industry, including events involving the use of radiation sources and the transport of radioactive materials. By putting events into proper perspective, the INES eases common understanding about incidents and accidents at NPPs (see Table 10.2–2). Events which should be communicated are those which are rated at level 2 or above, and events attracting international public interest.

Events which have nuclear or radiological significance are classified using the INES scale, which is divided into eighth levels. Industrial events which do not involve nuclear or radiological operations are termed ‘out of scale’. An example of an ‘out of scale’ event is a fire, if it did not involve any possible radiological hazard and did not affect the safety levels. Anticipated operational occurrences belong to the INES level 0.

Five levels have been selected regarding off-site impacts, the most serious of which is INES level 7. Such an incident would involve a large fraction of the core inventory of a NPP being released. The least serious, INES level 3, involves a dose to a member of the public equivalent to about one tenth of the annual dose limit. Below INES level 3, only the on-site impact and the impact on defence in depth have to be considered.

Incidents, in which civil defence actions are not required, range from INES level 1 (anomaly) to INES level 3 (serious incident). An accident without significant off-site risk is classed as INES level 4. These levels are defined by the committed dose to the critical group. Consequences of the accidents rated at INES level 5 are limited releases which would be likely to result in partial implementation of countermeasures covered by emergency plans to lessen the likelihood of health effects. INES levels 6-7 are classified as those accidents where civil defence actions are necessary, in order of increasing seriousness. These latter levels are defined in terms of the quantity of activity released, radiologically equivalent to a given number of terabecquerels of the radioisotope Iodine-131.

The vast majority of reported events from operating worldwide NPPs are rated below INES level 3.

Table 10.2–2. International Nuclear Events Scale (*IAEA and OECD/NEA, 2001*).

Level / Descriptor	Nature of the events
INES 0 Deviating events	Deviations from normal operating conditions can be classed as INES 0, where operational limits and conditions are not exceeded and are properly managed in accordance with adequate procedures. Examples include: a single random failure in a redundant system discovered during periodic inspections or tests, a planned reactor trip and minor spread of containment within controlled area without wider implications for safety culture.
INES 1 Anomaly	Anomaly beyond the authorised regime, but with significant defence in depth remaining. This may be due to equipment failure, human error or procedural inadequacies and may occur in areas covered by the scale, such as plant operation, transport of radioactive materials, fuel handling and waste storage. Examples include: breached of technical specifications or transport regulations and minor defects in the pipe work beyond the expectations of the surveillance programme.

Level / Descriptor	Nature of the events
INES 2 Incident	Includes incidents with significant failure in safety provisions but with sufficient defence in depth remaining to cope with additional failures. Events resulting in a dose to a worker exceeding a statutory annual dose limit and/or an event which leads to the presence of the significant quantities of radioactive in the installations in areas not expected any design and which require corrective action.
INES 3 Serious incident	The external release of radioactivity resulting in a dose to the critical group of the order of tenths of mSv. With such a release, off-site protection measures may be needed. On-site events resulting in sufficient dose to workers to cause acute health effects and/or resulting in sever spread of contamination. Or the further failure of safety systems could lead to accident conditions. On such incident was at the Paks NPP in Hungary in 2003. During an outage, fuel assemblies were purified on the bottom of a deep water basin in separate purification equipment. Due to a design failure of the equipment, its cooling circulation system was disturbed and the fuel assemblies overheated. This cause the release of radioactive noble gases and a small amount of Iodine in to the reactor hall. Off-site release was small; levels of external radiation at the site or near its vicinity did not exceed normal background levels. No person was injured; the radiation dose to personnel was at most 10% of the annual dose limit.
INES 4 Accident without significant off-site risk	External release of radiation resulting in a dose to the critical group of the order of a few mSv. Off-site protective actions unlikely. On-site, significant damage to installations. Accident results in the irradiation of one or more workers resulting in an overexposure where a high probability of death occurs. On such event was a criticality accident that occurred in Japan at the Tokkaimure nuclear fuel factory in 1999. Three workers were over-exposed to radiation, two of which died later due to their exposure. The factory was located in an urban area, which was subsequently evacuated, and residents further away advised to protect themselves. The thin walls of the building and the Uranium container did not protect the environment from radiation. The largest dose to a person outside the staff was 16 mSv.
INES 5 Accident with off-site risk	External release of radioactive materials (in quantities radiologically equivalent to hundred to thousands of terabecquerels of Iodine-131). Such a release would be likely to result in partial implementation of countermeasures covered by emergency plans to lessen the likelihood of health effects. On-site events result in severe damage to installations. The Three Mile Island incident in the US in 1979 was an INES level 5 event. The accident initiated from a leak in the reactor system. The reactor emergency cooling was automatically started, and was then incorrectly interrupted by the operators. This caused the overheating and partial melting of the core. Despite the severe damage to the reactor core, the pressure vessel and containment remained intact, preventing external release. The environmental impacts were small.
INES 6 Serious accident	External release of radioactive materials (in quantities radiologically equivalent to tens of thousands of terabecquerels of Iodine-131). Such a release would be likely to result in full implementation of countermeasures covered by local emergency plans to limit serious health effects. Only one such INES level 6 accident has ever occurred. This was in Soviet Union (presently Russia) in 1957, at the reprocessing plant near the town of Kyshtym. A tank containing high-level liquid waste was exploded, causing the release of radioactive material. Health effects were limited by countermeasures, such as evacuation of the population in the environment.

Level / Descriptor	Nature of the events
INES 7 Major accident	External release of large fractions of the radioactive material in a large facility (e.g. the core of a power reactor). This would typically involve mixture of short and long lived radioactive fission products (in quantities radiologically equivalent to more than tens of thousands of terabecquerels of Iodine-131). Such a release would result in the possibility of acute health effects; delayed health effects over a wide area, possibly involving more than one country; long term environmental consequences. Only one INES level 7 event has occurred; the 1986 accident at Chernobyl nuclear power plant in the Soviet Union (in the area of the present Ukraine). A reactor was destroyed in an explosion, followed by a fire in the graphite used as a moderator in the reactor. This caused a large release of radioactive material to the environment. Several workers of the power plant and people taking part in the cleaning died of the injuries from the accident or of the immediate health effects caused by radiation. An exclusion zone area of 30 km was ordered around the reactor and about 135 000 people were evacuated.

A very high number of individual accident scenarios at a NPP can be derived from combinations of event categories, plant operational states, applicable acceptance criteria, etc. Even for Safety Analysis Report the complete analysis of all the resultant scenarios is not practicable. Therefore, only typical accidents (criticality accident, loss of coolant accident, fuel handling accidents, etc.) of NPPs are considered in the environmental impact assessment. Since anticipated operational occurrences have no significant impacts on personnel and no impact on the environment they are not considered in the EIA.

10.2.4 Risk identification and analysis

The results of risk analysis are presented in Table 10.2–3. Typical hazards, risks and consequences which are general for all nuclear power plants and also typical preventive measures are summarized in this table. The table structure and content was elaborated according to recommendations of normative document “Recommendations for Assessment of Potential Accident Risk of Proposed Economic Activity” (*Information Publications, 2002, No. 61-297*). Requirements for classification of consequences of potential accident (for life, environment and property), accident development speed and probability of accident occurring are explained below. More detailed explanations can be found in “Recommendations for Assessment of Potential Accident Risk of Proposed Economic Activity” (*Information Publications, 2002, No. 61-297*). It should be noted that above mentioned recommendations for risk assessment are general for all types of proposed economic activities and should not be equated to risk assessment which is performed during the safety analysis of nuclear facilities.

Classification of consequences for life and health (L)

ID	Class	Characteristic
1	Unimportant	Temporary slight discomfort
2	Limited	A few injuries, long lasting discomfort
3	Serious	A few serious injuries, serious discomfort
4	Very serious	A few (more than 5) deaths, several or several tens of serious injuries, up to 500 evacuated
5	Catastrophic	Several deaths, hundreds of serious injuries, more than 500 evacuated

Classification of consequences for the environment (E)

ID	Class	Characteristic
1	Unimportant	No contamination, localized effects
2	Limited	Minor contamination, localized effects
3	Serious	Minor contamination, widespread effects
4	Very serious	Heavy contamination, localized effects
5	Catastrophic	Very heavy contamination, widespread effects

Classification of consequences for property (P)

ID	Class	Total cost damage, thousands Lt
1	Unimportant	Less than 100
2	Limited	100–200
3	Serious	200–1000
4	Very serious	1000–5000
5	Catastrophic	More than 5000

Classification of accident development speed (S)

ID	Class	Characteristic
1	Early and clear warning	Localized effects, no damage
2	Medium	Some spreading, small damage
3	No warning	Hidden until the effects are fully developed, immediate effects (explosion)

Classification of accident probability* (Pb)

ID	Class	Frequency (rough estimation)
1	Improbable	Less than once every 1000 years
2	Hardly probable	Once every 100–1000 years
3	Quite probable	Once every 10–100 years
4	Probable	Once every 1–10 years
5	Very probable	More than once per year

* - the classification of accident probabilities is general for all types of proposed economical activity. For nuclear facilities much higher reliability requirements are applied, therefore this classification has some inconsistencies with lower hazard developments.

Prioritization of consequences (Pr)

ID	Characteristic of consequences
A	Unimportant
B	Limited
C	Serious
D	Very serious
E	Catastrophic

L – Life S – Speed
E – Environment Pb –Probability
P – Property Pr – Priority

Table 10.2–3. Risk analysis of potential accidents resulting from proposed economic activity.

Object	Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
						L	E	P	S	Pb	Pr		
NPP	Electricity production; SNF and radwaste storage	Impact on constructions	External natural events (Design basis external events)	Property	Loads and impacts on NPP operation due to earthquake, flooding; extremes of temperature; winds and whirlwinds; rain; snow; lightning; etc.	-	-	1	1	**5**	**A**	Load combinations for external natural events are considered in the NPP design and construction, safety systems are design against these external natural loads and impacts	
NPP	Electricity production; SNF and radwaste storage	Impact on constructions	External human induced events (Design basis external events)	Property	Loads and impacts on NPP operation explosion wave and missiles; external fire; electromagnetic interference; etc.	-	-	1	1	**2**	**A**	External human induced events are considered in the design of NPP. Appropriate design standards and materials are used.	The level of water in Lake Druksiai is regulated by a hydrotechnical construction (see Section 7.1.1). If this regulating construction is destroyed by external events, water level decreases to 139.1 m. The water level decrease process will be rather long. The bottom of the present cooling water inlet channel is at 135 m level. Therefore, cooling of NPP will not be lost completely and immediately.
			Aircraft crash; terrorist attack (Design basis external events)	Operating personnel, population, property	These extreme events can cause damages of NPP construction and releases of radioactivity are possible.	3	2	3	3	**1**	**B**	It is expected that all NNPP will demonstrate a full capability to withstand the effect of aircraft crash and other	

Object	Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
						L	E	P	S	Pb	Pr		
												terrorist threats to the integrity of the structures. Appropriate physical protective measures.	
NPP	Electricity production	Radiation exposure	Loss of reactivity control (DBA)	Operating personnel, population, property	Loss of reactivity control could lead to excessive heat production in the nuclear fuel and to potential damage to the barriers against radioactive releases. High radiation fields from direct neutron and gamma radiation leading to potentially high radiation exposure to personnel; exposure of population due to releases; pause in operation	2	2	1	1	**2**	**B**	The reactivity control systems are designed with appropriate limits on the potential amount and rate of reactivity increase to assure that the effects of reactivity accidents can neither result in damage to the reactor coolant pressure boundary nor sufficiently disturb the core, its support structures, or other reactor pressure vessel internals to impair significantly the capability to cool the core.	The radiological consequences of the LOCA accident being considered in the EIA report (rated to Level 5 according to the INES scale) are higher than that of this Design Basis Accident.
NNP	Fuel Transfer	Radiation exposure	Criticality accident (DBA)	Operating personnel, population, property	High radiation fields from direct neutron and gamma radiation leading to potentially high radiation exposure to personnel; exposure of population due to releases; pause in operation	1	2	1	2	**1**	**B**	Occurrence of accident and consequences are limited by design and operational procedures.	The main hazard is to personnel. A second consequence might be off-site release of short lived radioactive fission products and potentially contamination within the facility. In most cases off-site and on-site impact is limited to INES level 4.
NNP	Fuel Transfer	Radiation exposure	Fuel Handling Accident (DBA)	Operating personnel	Accident can occur as a result of a failure of the fuel assembly lifting mechanism, resulting in dropping a raised	1	1	-	1	**3**	**A**	According to operating procedures in case of such accident ventilation system shall	Events during the handling of fresh fuel typically are rated at INES level 0 if there has been no risk of damaging spent fuel

Object	Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
						L	E	P	S	Pb	Pr		
					fuel assembly onto the reactor core or into the SNF storage pool. Radiation exposure to personnel; pause in operation							be shut down and the fuel-handling area of the Reactor Building or Fuel Building isolated. Depending on the NPP configuration, containment will also provide a safety layer in most cases.	elements The radioactive inventory of single irradiated FA is much lower than the inventory of the spent fuel pool or the reactor core. As long as the cooling of the spent FA is assured, this provides an important safety layer since the integrity of the fuel matrix is not affected by overheating. In general there will be very long time-scales associated with fuel overheating. Events which do not affect the cooling of the spent FA element and only result in a minor release or no release typically ate be classified at INES level 0. Level 2 may be appropriate for events in which there is damage to the fuel cladding integrity as a result of substantial heat up of the fuel element.
NPP	SNF storage	Radiation exposure	Failure in SNF storage pool cooling (DBA)	Operating personnel	Decay heat removal from spent FAs can be disturbed and damages to fuel cladding are possible. Releases into storage pool water and in space of SNF storage pools hall	1	1	-	2	**3**	**A**	Because of the large water volume and the relatively low decay heat, there is usually plenty of time available for corrective actions to be taken for events involving degradation of spent fuel pool cooling. Also the leakage from the pool is limited by design.	Minor leakages from SNF pool are typically rated at INES level 0. Operation outside operating limits and conditions or a substantial increase in temperature or decrease of the spent fuel pool coolant level is rated at INES level 1. An indication of INES level 2 is the start of fuel element uncovering.
NPP	Electricity production;	Fire	Internal fire	Property	Ignition of combustible materials. Pause in operation	-	-	1	3	**4**	**A**	The new NPP will be provided with the	According to the INES scale this accident can be not rated, if the

Object	Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
						L	E	P	S	Pb	Pr		
	SNF and radwaste storage		(DBA)									appropriate fire prevention and fire suppression measures, there will also be established the fire rescue forces, the size and scope of which will be determined during the preparation of emergency preparedness plan, in accordance with the LR Government Resolution No. 794 (*State Journal*, *2003*, *No. 60-2726*).	fire does not cause the release of radionuclides into the environment. However, if such releases would occur, the radiological consequences of the LOCA accident being considered in the EIA report (rated to Level 5 according to the INES scale) are higher than that in case of the fire.
NPP	Mainte-nance/ Deconta-mination	Chemical hazard	Chemical accident	Operating personnel	Spread of harmful or potentially harmful chemicals.	1	-	-	2	**3**	**A**	Design, construction and operation of discharge equipment, storage and transport pipelines. Automatic alarms and supervision instructions to ensure that no uncontrolled or undetected leaks may arise.	Most of the chemicals stored at NPP are used in auxiliary processes such as the processing of water. Chemicals are also used for purposes such as the decontamination of primary circuit equipment and pipelines.
NPP	Electricity production	Radiation exposure	Loss-of-Coolant Accident Inside Containment (containment intact, nominal leakage) (DBA)	Operating personnel, population, property	Piping break inside containment resulting the loss of coolant from reactor coolant system; the cooling capability for the reactor core is reduced. Significant number of fuel claddings can be damaged. Releases into containment.	2	2	2	1	**3**	**B**	The piping is of high quality, designed to nuclear construction industry codes and standards, and for seismic and environmental conditions. Also design of the containment assures integrity and design limits of	DBA LOCA is not expected to occur during the life of the plant, but postulated as a maximal design basis accident. The DBA LOCA accident being considered in Section 10.3 for the APWR reactor corresponds to Level 5 according to the INES scale

Object	Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
						L	E	P	S	Pb	Pr		
												releases in case of this accidents	
NPP	Electricity production	Radiation exposure	Main Steam line or Feedwater line Break Accident Outside Containment (DBA)	Operating personnel, population.	A large steam or feedwater line pipe breaks outside containment. Activity released from the broken line is released directly to the environment. There is no fuel damage as a result of this accident.	1	2	-	2	**2**	**A**	The piping is of high quality, designed to nuclear construction industry codes and standards, and for seismic and environmental conditions.	The radiological consequences of the DBA LOCA accident being considered in the EIA report (rated to Level 5 according to the INES scale) are higher than that of this Design Basis Accident.
NPP	Electricity production	Radiation exposure	Core damage (SA)	Operating personnel, population, property	Large release into containment. Containment isolation prevents or mitigates releases.	3	4	4	1	**1**	**D**	Multiple safety systems to prevent the core damage. Containment assures that there is no large release into environment.	Core damage will require the simultaneous failure of multiple safety systems and several incorrect actions from the operating personnel. Core damage frequency is less than 10^{-5} per year and the large release frequency is less than the 10^{-6} per year. The radiological consequences of the Severe Accident being considered in the EIA report (rated to Level 6 according to the INES scale) are higher than that of this Beyond Design Basis Accident.
NPP	Electricity production	Radiation exposure	Core damage and containment failure (Severe Accident)	Operating personnel, population, property	Large release of fission products into environment.	5	5	5	1	**1**	**E**	Multiple safety systems to prevent the containment failure. A fundamental objective is to prevent, as far as possible, all Severe Accidents which might challenge and lead to early failure of the Primary Containment.	The more likely severe accident sequences do not result in containment failure for 72 hours or more. The low frequency severe accident sequences do not result in containment failure in less than 24 hours. Large release frequency is in the range of 10^{-10} – 10^{-8} per year

10.3 ACCIDENT CONSEQUENCES ESTIMATION

The aim of consequences estimation of possible accidents in NNPP is to determine protective actions for the public that should be undertaken in case of design basis (with maximal impact) and severe accidents. Criteria e.g. cloud-shine dose rate, soil contamination with I-131, Cs-137, and etc. exceeding which appropriate protective actions for the public should be undertaken, are presented in HN 99:2000 (*State Journal, 2000, No. 57-1691*). For this reason results of accidents consequences modelling contains only those results according which it is possible to determine what protective actions should be undertaken.

Assumptions characterising accidental release, their dispersion modelling methodology and results, according which protective actions for the public that should be undertaken in case of design basis and severe accidents are determined in section 10.4, are given in subsections below.

10.3.1 Source Term Definition for Accident Releases

Accident releases from the new nuclear power plant (NNPP) have been considered for two cases:

- Design basis accident (DBA), which according to the estimations below corresponds to Level 5 of the INES scale.
- Severe accident, which according to the estimations below corresponds to Level 6 of the INES scale.

Lithuanian legislation does not provide specific guidance or requirements on how impact on the environment shall be evaluated in case of DBAs or Severe Accidents. Therefore, experience of foreign countries has been used and the following documents have been considered:

- Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.183, 2000;
- Accident Source Terms for Light-Water Nuclear Power Plants, NUREG-1465, 1995;
- Decision 395/91 of the Council of State on the general regulations for the safety of nuclear power plants, Finland 1991;
- Accident analysis for nuclear power plants. IAEA Safety Reports Series No. 23, 2002.
- The International Nuclear Event Scale (INES). Jointly prepared by IAEA and OECD/NEA. 2001.

There are different DBAs (criticality accident, fuel handling accident, fire, etc.) at NPPs, however for EIA it is important to identify the typical accident which envelopes consequences of all DBAs. According to RG 1.183, such enveloping design basis accident is loss-of-coolant accident LOCA with intact containment (i.e. containment leakage limited to design basis leakage), which is a conservative surrogate accident that is intended to challenge selective aspects of the facility design.

Regulations of Finnish Decision 395/91 have been used for estimation of the source term to represent severe accident releases.

Different technological alternatives (reactor types) are considered as options for the new NPP in Lithuania. The activity of released radionuclides depends on reactor type, therefore based on freely available information comparison of activity released from different reactor types in case of accidents was done. The technological alternatives (reactor types) which are considered as options for new NPP in Lithuania are described in Chapter 5.

Two freely available information sources were used for estimation of accident releases:

- Website of U.S. Nuclear Regulation Commission (ABWR; AP1000; ESBWR; U.S. EPR; US-APWR)
- Website of Health and Safety Executive (HSE) (ACR-1000; UK EPR; ESBWR; AP1000).

Detailed information about some reactors (V-392, V-448, SWR-1000, etc.) is not freely available. However, analysis of freely available information on accident releases from different modern power reactors has shown that activity of released radionuclides depends principally on reactor power. Therefore, the impact to environment from the most powerful reactors such as ESBWR, EPR and APWR should be considered as the basis of a bounding estimate of source term and potential consequences.

Also it should be noted, that freely available information for some reactors is very comprehensive (all assumptions, initial data, intermediate results and final results are provided) and for some only initial data and resulting radiological consequences are presented.

The set of isotopes, which have been taken into account for estimation of releases in case of DBA and Severe accident, is based on their specific health detriment as identified in the International Nuclear Event Scale manual (*IAEA and OECD/NEA, 2001*).

DBA Loss of Coolant Accident (LOCA)

ABWR (*DCD US-ABWR, 2008*), APWR (*DCD US-APWR, 2007*) and ESBWR (*DCD US-ESBWR, 2007*) data was examined as basis for source term definition, since characteristics (power densities, fuel discharge irradiation, enrichment) for these reactors are provided in detail and this will tend to maximise the build up of short and long lived fission products important in the determination of consequences. Analysis of the activities of released isotopes presented in (*DCD US-ABWR, 2008*), (*DCD US-APWR, 2007*), (*DCD US-ESBWR, 2007*) for different DBAs, has led to the conclusion that the releases to the environment in case of DBA LOCA is a bounding case for assessment of DBA consequences. Conservatively, APWR DBA LOCA releases have been used, since activity releases from this reactor model is highest. Detailed information about the potential release paths of radioactivity to the environment in case of DBA LOCA in APWR reactor is provided in (*DCD US-APWR, 2007*).

Time dependent releases into environment in case of DBA LOCA at APWR (*DCD US-APWR, 2007*) are summarized in Table 10.3–1. It can be seen, that the major part of activity is released during the first 24 hours. Release data presented in Table 10.3–1 is based on APWR design control documentation. Release of certain radionuclides during some periods is indicated as equal “0.00E+00”. There is no clear explanation in (*DCD US-APWR, 2007*) what this “zero” activity means, however it can be understood, that in time dependent release estimation some threshold limit value was accepted and activity values below this threshold have not been considered further. DBA LOCA radioactivity release duration 30 days (720 hours) is assumed according to accident dose criteria specified in RG 1.183.

Accidents in the INES scale are rated according to releases of the I-131 radiological equivalent to the environment. In order to assess the level according to the INES scale of a severe accident, activities of different released radionuclides regarding the I-131 equivalent must be estimated. The INES User's Guide (*the IAEA and EBPO/BEA, 2001*) provides the factors of radiological equivalent of these nuclides. This release in case of DBA LOCA can be rated as INES Level 5 event.

Table 10.3–1. Time Dependent Released Activity into Environment during DBA LOCA (Bq) (*DCD US-APWR, 2007*).

Nuclide	Half-life	0-8hr	8-24hr	24-96hr	96-720hr	TOTAL
Kr-85 (eq for NG)	10.72 y	3.44E+16	1.71E+16	1.13E+16	2.04E+16	8.32E+16
I-131	8.04 d	5.25E+13	2.08E+13	6.85E+13	2.07E+14	3.49E+14
Cs-134	2.06 y	5.33E+12	5.99E+10	0.00E+00	0.00E+00	5.40E+12
Cs-137	30.0 y	3.03E+12	3.41E+10	3.70E+07	0.00E+00	3.06E+12
Te-132	78.2 hr	5.22E+12	6.33E+10	3.70E+06	0.00E+00	5.29E+12
Sr-90	29,12 y	1.45E+11	1.89E+09	0.00E+00	0.00E+00	1.47E+11
Co-60	5.27 y	5.88E+08	7.40E+06	3.74E+04	0.00E+00	5.96E+08
Ru-106	368.2d	9.88E+10	1.28E+09	0.00E+00	0.00E+00	9.99E+10
Am-241	432.2 y	2.78E+06	3.61E+04	0.00E+00	0.00E+00	2.81E+06
Pu-239	24065 y	1.48E+07	1.92E+05	0.00E+00	0.00E+00	1.50E+07

Severe Accident

As it was mentioned in Section 10.2.1 there are no regulations for releases in case of severe accident in Lithuanian legislation. Therefore the limit for the release of radioactive materials arising from a severe accident (100 TBq release of Cs-137) defined in Finnish legislation (*Council State decision 395/91*) is used to represent a typical large release scenario to indicate the potential scale of consequences for such events, and thus inform the extent of emergency planning provisions that might be implemented should construction and operation of a new NPP proceed.

Since the APWR reactor is used for DBA LOCA accident, this type of reactor is also selected for severe accident impact estimation.

Only a limitation for Cs-137 is defined in (*Council State decision 395/91*); however the release of other isotopes must be taken into account also. The source term for release into the environment is estimated based on a 100 TBq release of Cs-137. The releases of other isotopes are scaled according to APWR core inventory at time of the release. Such assumption leads to underestimation of impacts due to releases of short-lived noble gases. However, as it is shown below, impact from noble gases is not very significant. Core inventory of APWR is provided in (*DCD US-APWR, 2007*).

According to probabilistic risk assessment and severe accident evaluation of APWR (such assessment has been done by the reactor supplier and is presented in DCD for US-APWR) containment integrity is maintained more than 24 hours after onset of core damage for a high proportion of core damage sequences. The time period of 24 hours is a goal for containment performance defined in US NRC regulations and also in European Utility Requirements (*EUR 2001*), which includes a deterministic goal that containment integrity shall be maintained for approximately 24 hours following the onset of core damage and a probabilistic goal that the conditional containment failure probability shall be less than approximately 0.1 for the composite of core damage sequences assessed in the probabilistic risk assessment. Therefore, 24 hours delay before the release into the environment is assumed for source term calculations.

Releases into the environment in case of severe accident are summarized in Table 10.3–2. The source term for the release is normalized for Cs-137 100 TBq release. The activities of other released isotopes are scaled according to core inventory after 24 h and “Accident Source Terms for Light-Water Nuclear Power Plants” (*NUREG-1465, 1995*).

The core inventory is used for definition of ratios between the different nuclides. Release fractions into containment for various radionuclides are defined basically in accordance with (*NUREG-1465, 1995*). An exception is the release fraction for Cs, which is assumed to be 0.50 (0.75 is provided in (*NUREG-1465, 1995*)). Since the release is normalized to 100 TBq Cs-137, a higher release fraction of Cs-137 into containment will underestimate activities of other isotopes. Also different countries assume different release fractions into containment. "A Comparison of World-Wide Uses of Severe Reactor Accident Source Terms" (*SAND94, 1994*) gives an overview on how source term for severe accident is defined in various counties.

A release height of 100 m is assumed. Such height is conservative for the nearby range, as there is no population living in the sanitary protection zone (1-3 km). For the assessment of consequences the maximum should fall within a populated area. Conservatively, release duration is assumed to be 6 hours. Consequences from a longer release duration will be lower.

As mentioned before, accidents in the INES scale are rated according to releases of the I-131 radiological equivalent to the environment. 100 TBq Cs-137 source term release is assessed in the table below in terms of I-131 equivalent as used for the INES scale. Radiological equivalences for different radionuclides are provided in INES User's Manual (*TATENA and EBPO/BEA, 2001*). The last column of Table 10.3–2 contains information on total release radiologically equivalent of I-131 which is equal 8.18E+15 Bq. Therefore this severe accident release can be rated as INES Level 6 event.

Table 10.3–2. Releases into the environment in case of Severe Accident (Bq).

Nuclide	Half-life	Core Inventory		Release fraction into containment	Releases into Environment after	Eq. I-131
		0 h	24 h		24 h	
Kr-85m	4.48 h	1.79E+18	4.41E+16	1.00	1.24E+13	0.00E+00
Kr-85	10.72 y	6.40E+16	6.40E+16	1.00	1.79E+13	0.00E+00
Kr-87	1.27 h	3.55E+18	7.49E+12	1.00	2.10E+09	0.00E+00
Kr-88	2.84 h	5.00E+18	1.43E+16	1.00	4.00E+12	0.00E+00
Xe-133	5.245 d	1.11E+19	1.07E+19	1.00	2.99E+15	0.00E+00
Xe-135	9.09 h	3.38E+18	4.23E+18	1.00	1.19E+15	0.00E+00
I-131	8.04 d	5.33E+18	4.97E+18	0.75	1.04E+15	1.04E+15
Te-132	2.06 y	7.59E+18	6.13E+18	0.50	8.59E+14	2.58E+14
Sr-90	30.0 y	5.14E+17	5.14E+17	0.05	7.20E+12	7.20E+13
Cs-134	78.2 h	1.25E+18	1.25E+18	0.50	1.76E+14	3.51E+15
Cs-137	29.12 y	7.14E+17	7.14E+17	0.50	1.00E+14	3.00E+15
Pu-239	5.27 y	2.09E+15	2.09E+15	0.001	5.84E+08	5.84E+12
Co-60	368.2 d	1.61E+16	1.61E+16	0.05	2.25E+11	1.35E+13
Ru-106	432.2 y	2.79E+18	2.78E+18	0.05	3.89E+13	2.73E+14
Am-241	24065 y	9.77E+14	9.81E+14	0.003	8.24E+08	7.42E+12
Total						8.18E+15

The basis of the Severe Accident source term definition is the release of Cs-137 and the releases of other isotopes are scaled according to the core inventory at the time of the release. The scaling has been done similarly to all of the nuclides, which leads to a comparatively small release of noble gases.

The release from fuel into containment and to atmosphere is a mix of noble gases and aerosol species. Noble gases have little interaction with their surroundings and will tend to be released without significant attenuation or removal mechanisms other than securing containment.

Comparison in terms of core inventory release fractions of SA releases used in the assessment with SA releases from AP-1000, EPR, APWR and ESBWR reactors is summarized in Table 10.3-3. It can be seen that SA releases normalized for Cs-137 100 TBq overestimates the release of Iodine and Caesium and underestimates the release Noble gases (Xe, Kr).

Table 10.3-3. Release fraction of core inventory

Reactor	Release frequency	Release Fraction (% core inventory)		
		Xe, Kr	Iodine	Ceasium
AP-1000	2.20E-07	2.6E-03	2.3E-05	1.2E-05
EPR	5.00E-07	1.9E-03	1.0E-05	2.6E-05
APWR	1.10E-06	2.1E-03	1.7E-06	1.7E-06
ESBWR	1.12E-08	2.7E-03	1.6E-04	2.2E-04
SA releases in EIAR	**5.00E-07**	**3.0E-04**	**2.0E-04**	**1.4E-04**

Noble gases represent an external radiation hazard as the plume passes by. Aerosols on the other hand are associated with physical species that can have significant internal health effects from either inhalation, skin deposition dose, or ingestion via the food chain. Deposited aerosols also contribute to external radiation exposure.

The environmental effects of noble gases are substantially smaller than the effects of the other nuclides in the release. This is because noble gases have short half-lifes and they only contribute to the external dose.

However, to assess the effects of a bounding case, computations were made with larger releases of noble gases than the ones in Table 10.3–2. The computations were carried out for Severe Accident with a noble gas release that is 10 times higher than above. This release is based on an assessment of four of the candidate reactor designs (AP-1000, EPR, APWR and ESBWR) for which the information on frequency of core damage and intact containment and associated noble gas, Iodine and Caesium release fractions were publicly available. The effect of a larger noble gas release on the consequences of Severe Accident is considered in Section 10.4.

10.3.2 Dispersion and uptake of radionuclides

10.3.2.1 Methodology

The dispersion simulations for the two accident scenarios were made with Air Quality and Emergency Modelling System SILAM of the Finnish Meteorological Institute (FMI) (http://silam.fmi.fi). The SILAM system is a dual-core Lagrangian-Eulerian modelling framework, which was developed by FMI in co-operation with several other institutes from different countries for solving a wide range of emergency, air quality and regulatory problems. Following the standards of the emergency modelling, SILAM evaluates concentrations and depositions of each released nuclide and its derivatives along the decay chain.

The dispersion model was run with meteorological data obtained from the European Centre for Medium Range Weather Forecasts (ECMWF) Operational Data Archives. The data covers two consecutive years 2001 and 2002, which were chosen because meteorologically these years represent typical years in Europe.

The assessment of doses from an accidental radioactive release from the NNPP is based on the results of dispersion simulations and it utilizes empirical coefficients and methodologies for converting the modelled concentrations in air and depositions to doses. The methodologies and coefficients are chosen so that the estimations would be conservative.

There are several water bodies around the NPP including the lake (about 45 km^2) used for the system cooling, but they are all small in comparison with regional-model resolution of 20 km (the area of the grid cell is then 400 km^2). Therefore they do not need any special treatment in the model where a fraction of water surface in a grid cell is a standard parameter applied anyway. For high-resolution simulations some grid cells can appear to be mostly covered with water but then the crudeness of the dataset leads to conservative estimates of deposition: dry deposition velocity on the water surface is smaller than on other types of surface. And, with dry deposition accounting less than 30 % of the total deposition, this additional correction does not play any significant role. Small size of the lakes, availability of other sources of fresh water and absence of intensive regular fishery in the near-plant lake allowed skipping the aquatic path of the food chain altogether – without significant discrepancies introduced into the assessment numbers.

The specific formulations and all numerical constants used for the dose assessment computations are defined in a separate report (*Sofiev et al. 2008*).

Comparison with other methodologies

An approach widely used in past similar assessments of dispersion is based on simulations with simple Gaussian plume model using artificial conditions seen as the “worst-case dispersion scenario”. The outcome of the Gaussian simulations is equilibrium concentrations and deposition fluxes considered as the upper-limit estimates of the accident impact. Providing reasonable results in the nearest vicinity of the plant, Gaussian models ignore the real pattern of dispersion – with wind meandering, actual developments of vertical and horizontal mixing along the day etc. They do not indicate the probability of observation of the simulated pattern in reality. The results are obtained without information on how realistic they are and how often such dispersion conditions take place in the specific geographical region.

The approach applied in this current work is based on brute-force multi-scale computations of dispersion using actual meteorological data, including rain, from weather archives. The 3-D modelling system used in this assessment is built to solve the turbulent dispersion equation taking into account the variability of the meteorological conditions and the inhomogeneity of the turbulent diffusion coefficient in space or time. This approach is tied to real conditions and allows replacing the artificial “worst case” with physically and statistically grounded characteristics. Having the simulations made over a sufficiently long period, the percentiles of concentrations and depositions can be calculated in a straightforward way. This methodology is very expensive computationally but it is also the most universal: it is applicable at any scale and for any type of source.

10.3.2.2 Results of the dispersion modelling and dose estimates

The exposure of the environment and people depends on the specific meteorological conditions during the accident and the geographical location of the receiving point. To cover all realistic meteorological conditions several cases in different meteorological conditions during the years 2001 and 2002 have been simulated. The simulated cases have different characteristics and hence different dispersion with distance. As a result 2-dimensional maps have been created of the exposure levels, which are not exceeded with a certain probability for any realistic meteorological conditions. The transportation of nuclides is not equal to the different directions from the NNPP and thus there is no linear dependency between the exposure level and the distance from the plant.

The dispersion has been simulated for an area of about 1200 km wide (computation domain), which is extensive enough for the purpose of the assessment. For the DBA loss of coolant accident (LOCA) and severe accident (SA) release scenarios, the simulation of a particular case lasts until the pollutants released during the accident leave the computation domain. An estimate of the time needed is: $t = X_s / 30$, where X_s is the domain size in km, and 30 km/h is a typical wind speed at the top of the boundary layer. Hence, for a domain of about 1200 km in horizontal size the transport time of nuclides outside the area is about 40 hours.

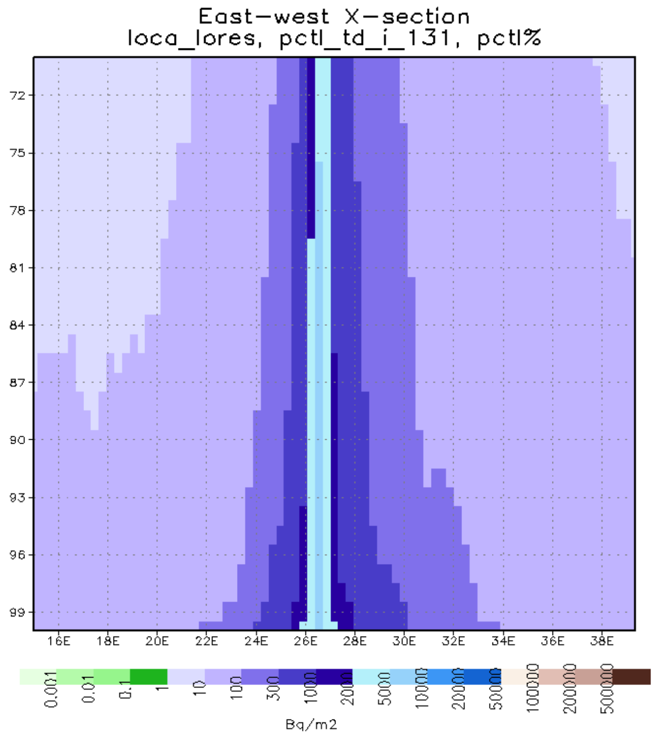
Using the above screening formula, simulation duration for a single case was taken as 32 days for DBA LOCA scenario and 2 days for SA. The model starts computations of a case at the beginning of each day during the whole period selected for the assessment (2 years 2001 and 2002). Due to the short duration of the release for SA, two sets of cases had to be analysed: day-time release and night-time release. Daytime and night-time releases appear under strongly different atmospheric conditions and this is why it is reasonable to assess these two sets of cases independently. The release duration for DBA LOCA is approx 24 hours, with additional releases lasting ~48 hours and thus only one set of cases is assessed for DBA LOCA. The assessed SA term is chosen to be representative of a particular class of major release and is normalized to 100 TBq of Cs-137 and accompanying nuclides. Its release duration has been chosen conservatively. The assessed DBA LOCA case on the other hand is based on a defined case which has a release duration based on physical basis. The formal Safety Analysis report for licensing of the chosen reactor design will contain a definitive analysis of the consequences of different radionuclide release events.

Each of the 3 cases (DBA LOCA, SA-day, SA-night) have been analysed with two spatial resolutions to account for both regional and local effects. A resolution of 20 km is used for long-range transport and a resolution of 2 km for near-range transport.

The assessment was performed on the basis of 98 % of depositions and doses. This means that, in case of an accident, the presented values can be exceeded in some places only with the probability of 2 %. Thus, if 98-th percentile of deposition at some place for the DBA LOCA scenario is equal to 100 Bq/m^2, it means that if a DBA LOCA happens, the probability for this place to be affected by concentrations higher than 100 Bq/m^2 is 2 %. Importantly, the information is place-specific, i.e. the assessment results in geographical maps of the percentiles.

The following figures (Figure 10.3-1) illustrate the dependence of the deposition values on distance from the NNPP and on percentile. The X-axis represents the longitude for East-West cross-section and latitude for North-South cross-section. The Y-axis represents the percentile – the range shown is from 70 % to 100 % (max value), with 100 % at the bottom. Because of the anisotropy of wind directions both latitudinal and longitudinal cross-sections are provided. For example, directly to the east from the NNPP on the meridian of 20^{0}E, the deposition in case of a DBA LOCA is maximum 10 Bq/m^2 with the probability of about 83 %. The results of this study for the deposition of I-131 in case of DBA LOCA are the geographical regions corresponding to the 98-th percentiles in these cross-sections. Similarly, the dose values also depend on the distance from the NNPP and the percentile.

As expected, the area with higher concentrations is larger for the higher percentile. This increase is observed (but not necessarily uniformly) over the whole grid: at every point the concentration for 99 % is higher than for 98 %. The cross-section figures show significant and irregular jumps from 99 % to 100 %. The maximum values are the most sensitive among all parameters to model limitations and inaccuracies in the meteorological data – and thus the most uncertain. This is why it is reasonable not to use the maximum percentiles as the basis for the assessment.



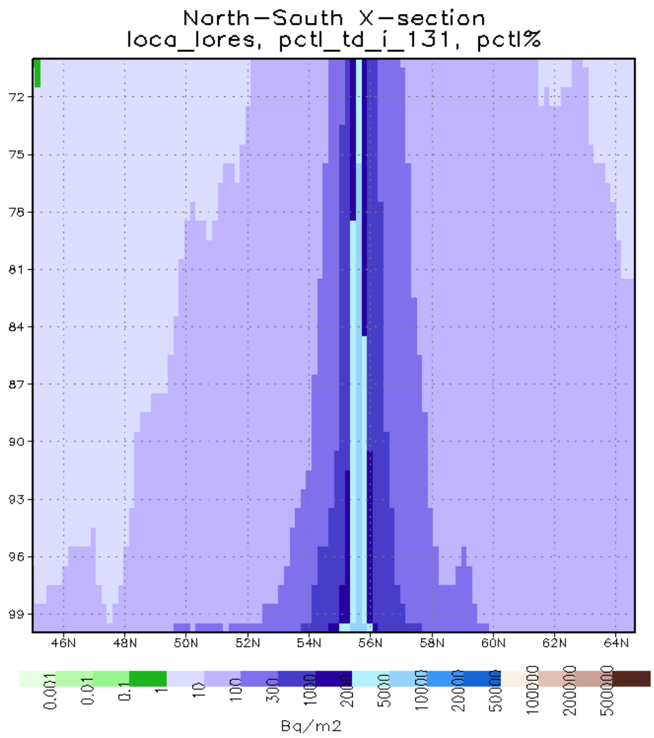


Figure 10.3-1. DBA Loss of coolant accident (LOCA), deposition of Iodine-131 in Bq/m^2 in the large domain with 20 km resolution; upper map: east-west cross-section, lower map: north-south cross section.

The maps presented to describe the results have the scale in latitudinal and longitudinal degrees. The geographical location of the NNPP itself is 26.56^{0}E, 55.6044^{0}N. At this latitude one degree of distance along parallel (west-east cross-section) is equivalent to 62.8 km while one degree distance along meridian (south-north cross-section) is equivalent to 111 km.

Deposition

Caesium-137 (Cs-137) and Iodine-131 (I-131) are essential nuclides when assessing the radioactive deposition and dose after a postulated NPP accident, since they are biologically the most significant of the radionuclides released in an NPP accident. Cs-137 has a radiological half-life of 30 years. Thus once it is released into the environment, it remains present for many years. This is why it is especially important in the assessment of the long-term impacts. Compared to Cs-137, I-131 has a short radiological half-life of 8 days. I-131 can accumulate in the thyroid and harm it as it decays. The risk relates especially to children, but it can be mitigated by taking iodine supplements. In this report the deposition maps are presented for Cs-137 and I-131. The unit of radioactivity used in these maps is Becquerel [Bq].

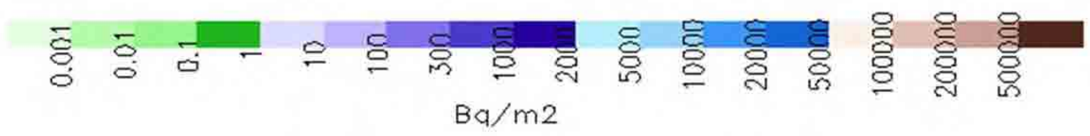


Figure 10.3-2. The scale of deposition used in the maps.

Doses

Radioactive releases to the atmosphere may contribute to radiation exposure through several pathways either externally or internally. External exposure is due to the direct radiation from a radioactive plume or from radionuclides deposited on the ground. External dose thus includes the dose from cloud shine and the dose from ground shine. Internal exposure is due to inhalation or ingestion of radioactive material. The ingestion dose includes the intake of radioactive substances taking into account the migration of the radioactive nuclides along the food chains finally reaching the human body.

The total effective dose includes both external and internal dose. The short-term effective dose is determined by the dose from cloud and ground shine as well as inhalation dose. Long-term effective dose is mainly due to ground shine and, in case when no protective actions are applied, ingestion. In case of a severe accident several protective actions should be applied in order to reduce the effective dose (section 10.4). Significant part of the ingestion dose would be avoided due to the restrictions of foodstuffs, drinking water and feeding stuffs and the long-term effective dose would mainly consist of external dose.

In this chapter dose maps are presented for cloud-shine dose, total external dose over 50 years. Also the rates for ground-shine dose and external dose are presented to be compared with the criteria for protective actions (section 10.4). The unit of dose is Sievert [Sv]. The chapter also includes maps for thyroid dose for both infant and adult, for which the unit used is Gray (Gy).

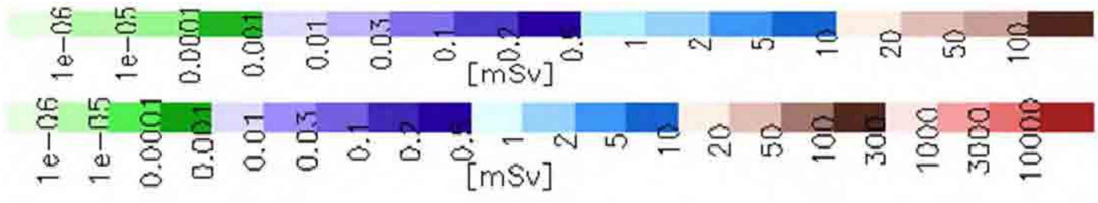


Figure 10.3-3. The scale of cloud-shine and external dose used in the maps.

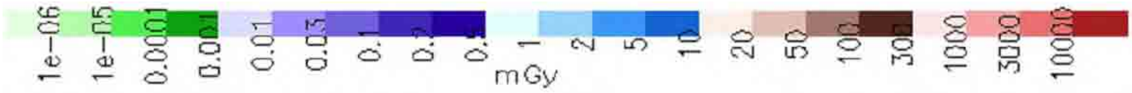


Figure 10.3-4. The scale of thyroid dose used in the maps.

LOSS OF COOLANT ACCIDENT

This section contains the 98-percentile maps for the depositions of I-131, Cs-137 and Sr-90 as well as cloud-shine, external and thyroid doses resulting from the DBA LOCA release scenario. Also the rates for ground-shine dose and external dose are presented. In the maps one degree of distance along parallel (west-east cross-section) is equivalent to 62.8 km while one degree distance along meridian (south-north cross-section) is equivalent to 111 km.

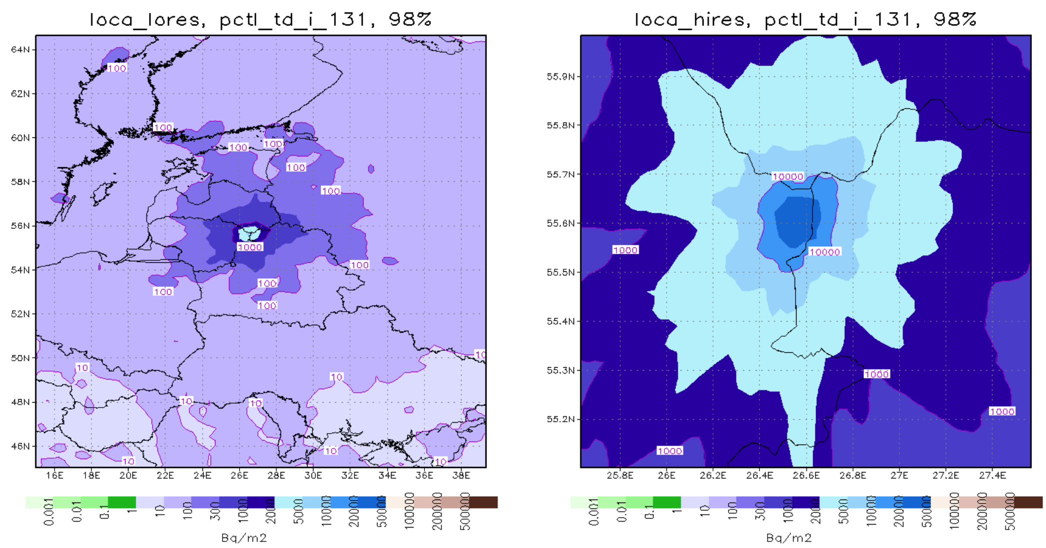


Figure 10.3-5. DBA Loss of coolant accident (LOCA), total deposition of I-131 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

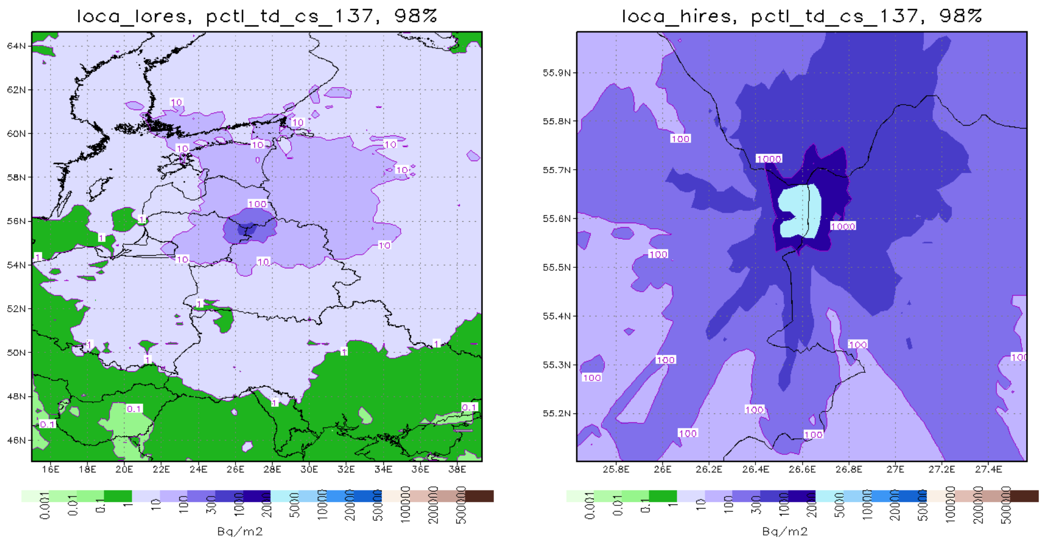


Figure 10.3-6. DBA Loss of coolant accident (LOCA), total deposition of Cs-137 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

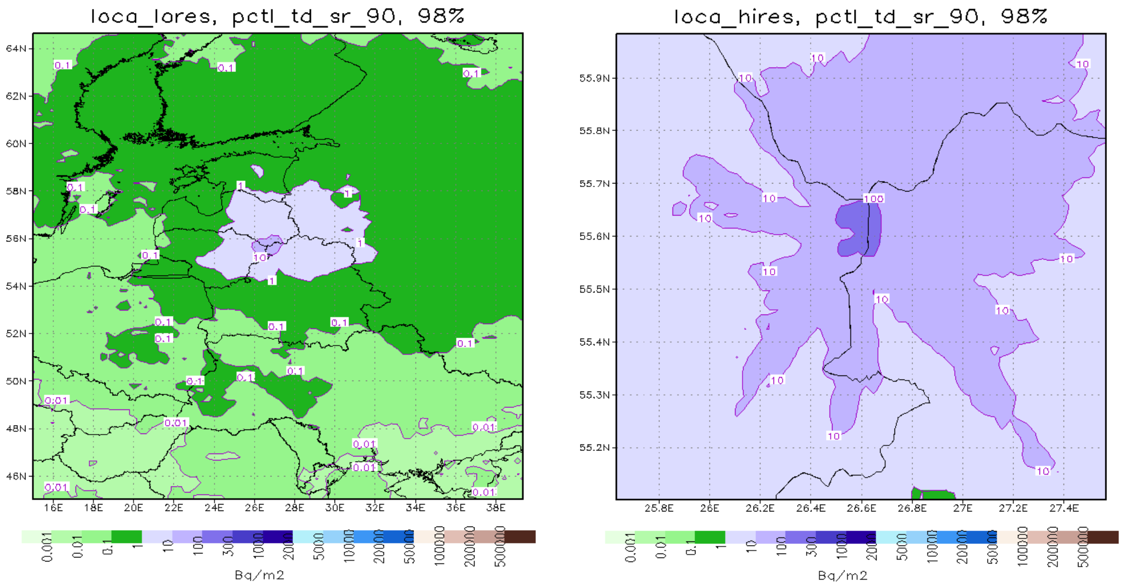


Figure 10.3-7. DBA Loss of coolant accident (LOCA), total deposition of Sr-90 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

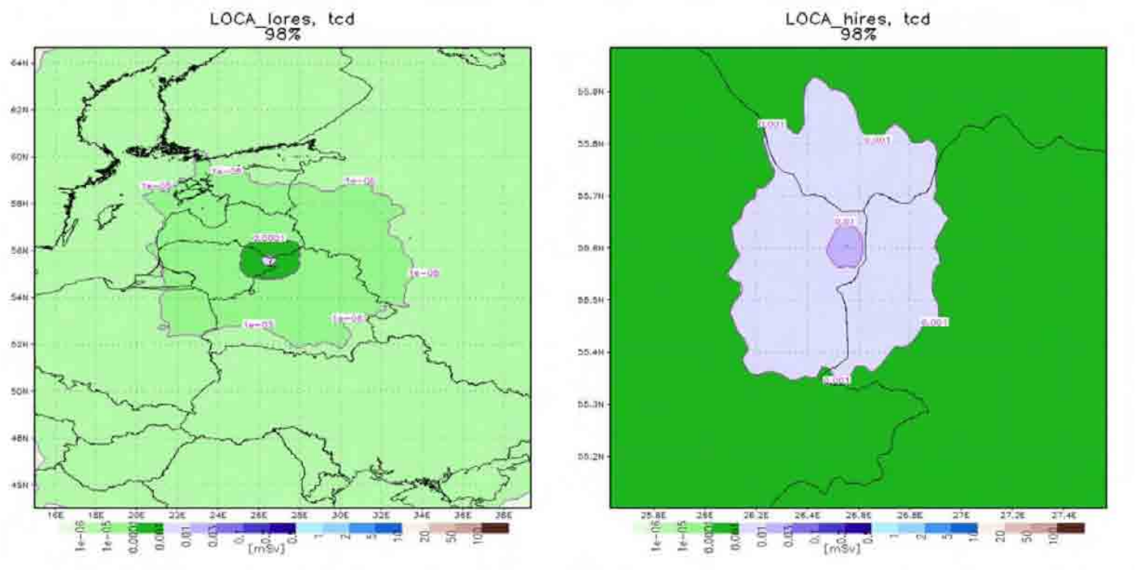


Figure 10.3-8. DBA Loss of coolant accident (LOCA), cloud-shine dose [mSv] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

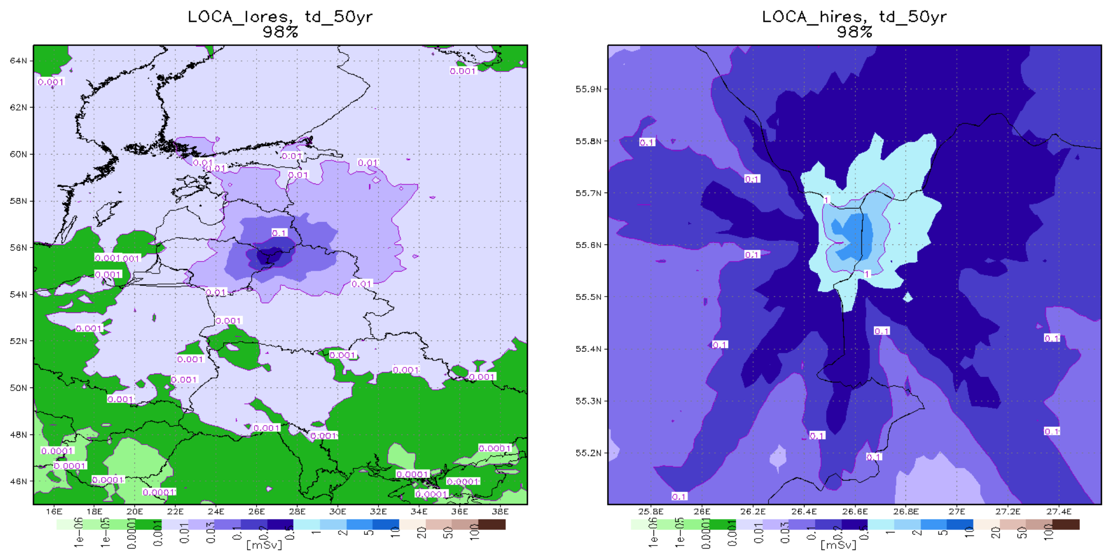


Figure 10.3-9. DBA Loss of coolant accident (LOCA), total external dose over 50 years [mSv] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

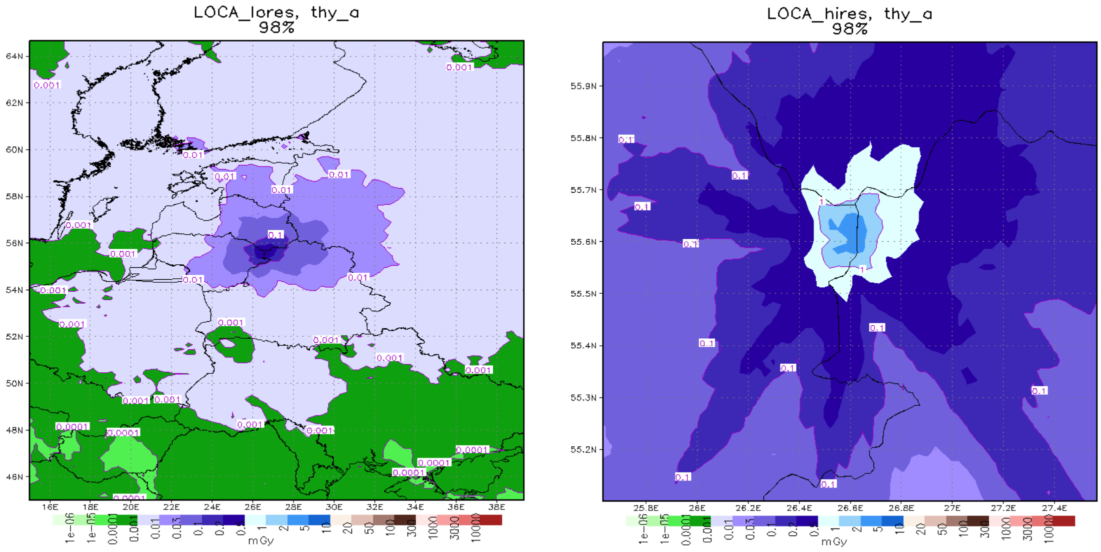


Figure 10.3-10. DBA Loss of coolant accident (LOCA), thyroid dose for adult [mGy] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

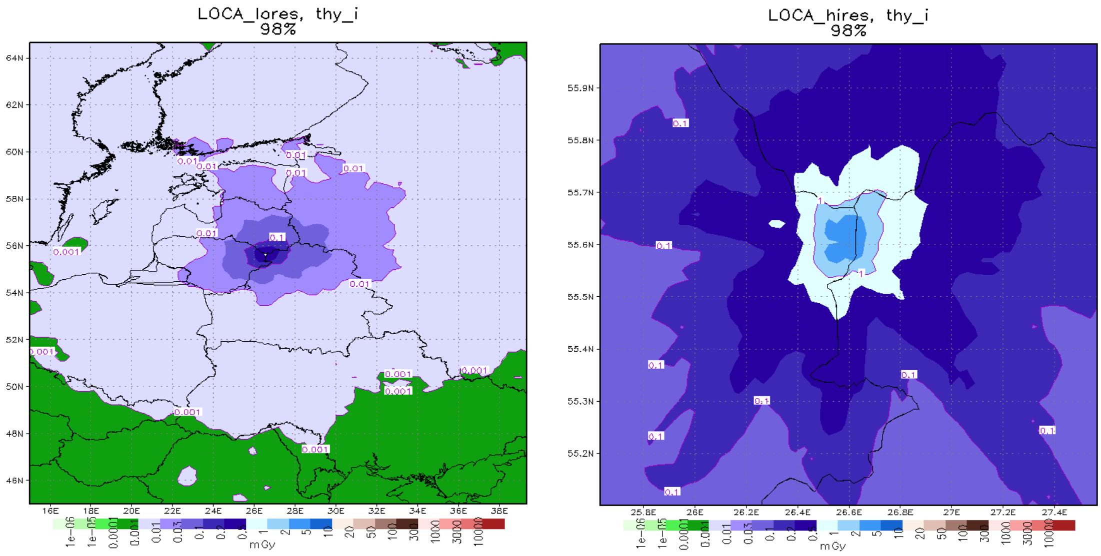


Figure 10.3-11. DBA Loss of coolant accident (LOCA), thyroid dose for infant [mGy] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

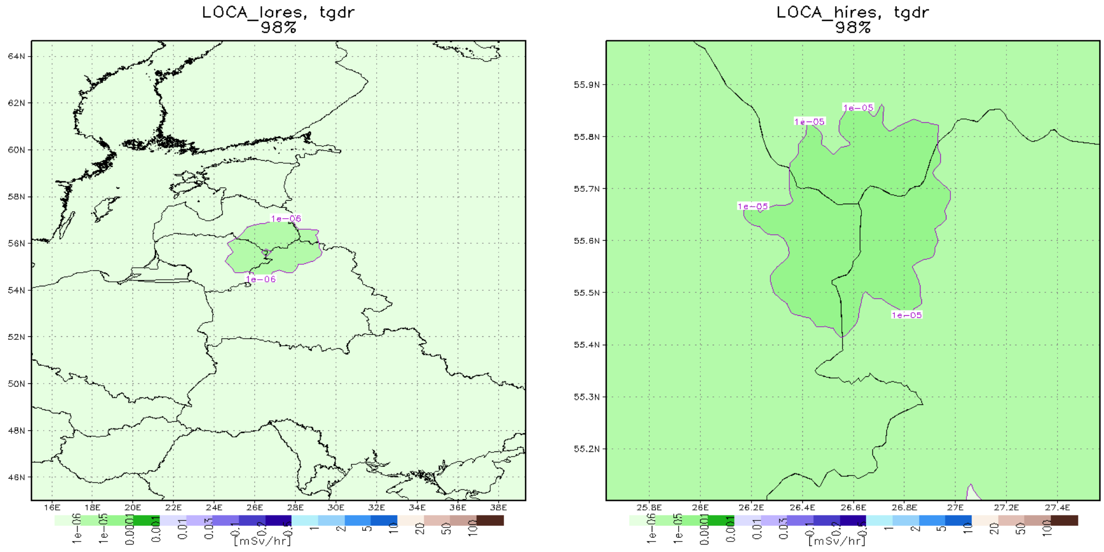


Figure 10.3-12. DBA Loss of coolant accident (LOCA), ground-shine dose rate [mSv/hr] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

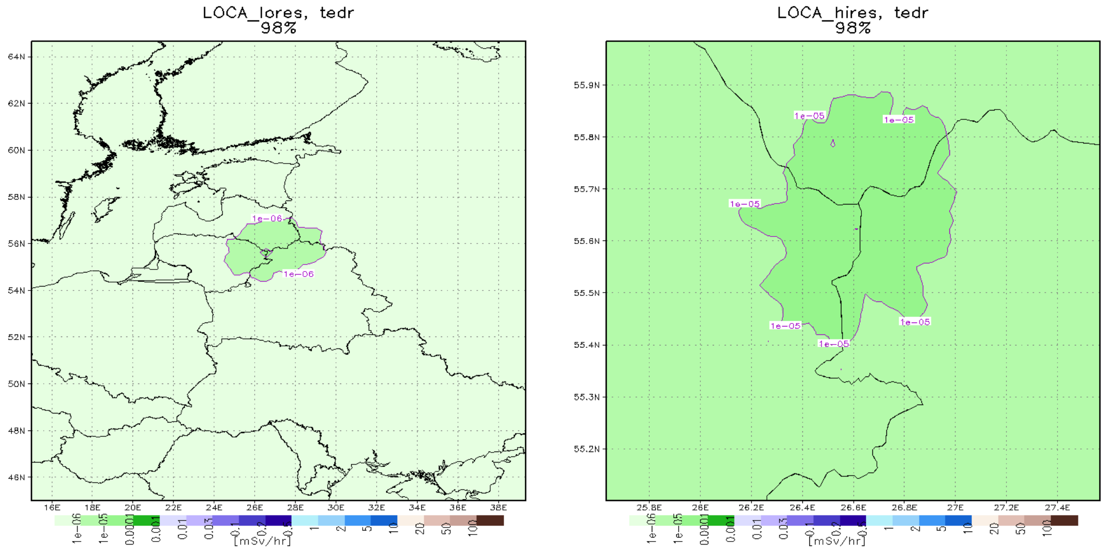


Figure 10.3-13. DBA Loss of coolant accident (LOCA), external dose rate [mSv/hr] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

SEVERE ACCIDENT

Severe accident, daytime release

This section contains the 98-percentile maps for the depositions of I-131, Cs-137 and Sr-90 as well as cloud-shine, external and thyroid doses resulting from the SA, daytime release scenario. Also the rates for ground-shine dose and external dose are presented. As before, in the maps one degree of distance along parallel (west-east cross-section) is equivalent to 62.8 km while one degree distance along meridian (south-north cross-section) is equivalent to 111 km.

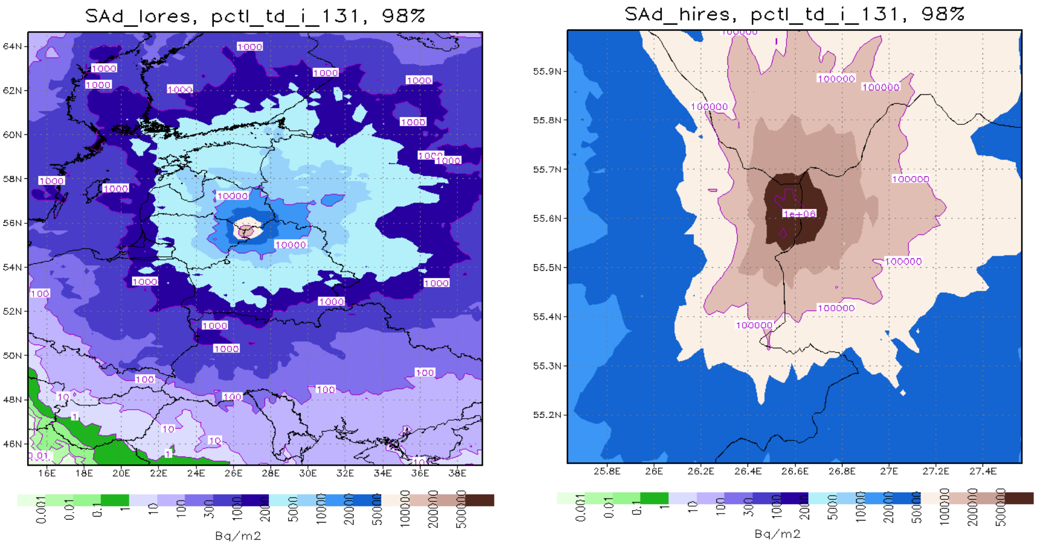


Figure 10.3-14. Severe accident, daytime release (SAd); total deposition of I-131 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

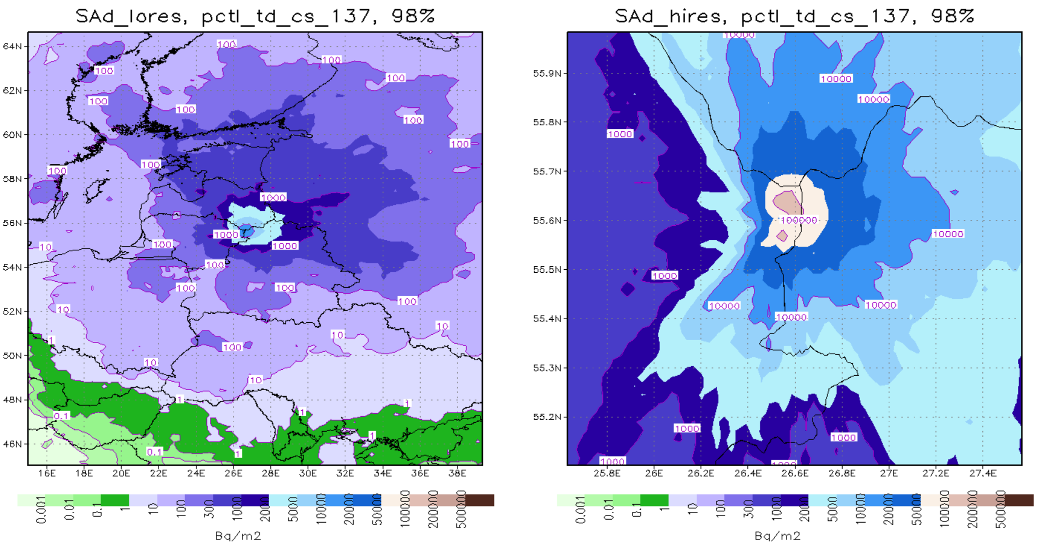


Figure 10.3-15. Severe accident, daytime release (SAd); total deposition of Cs-137 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

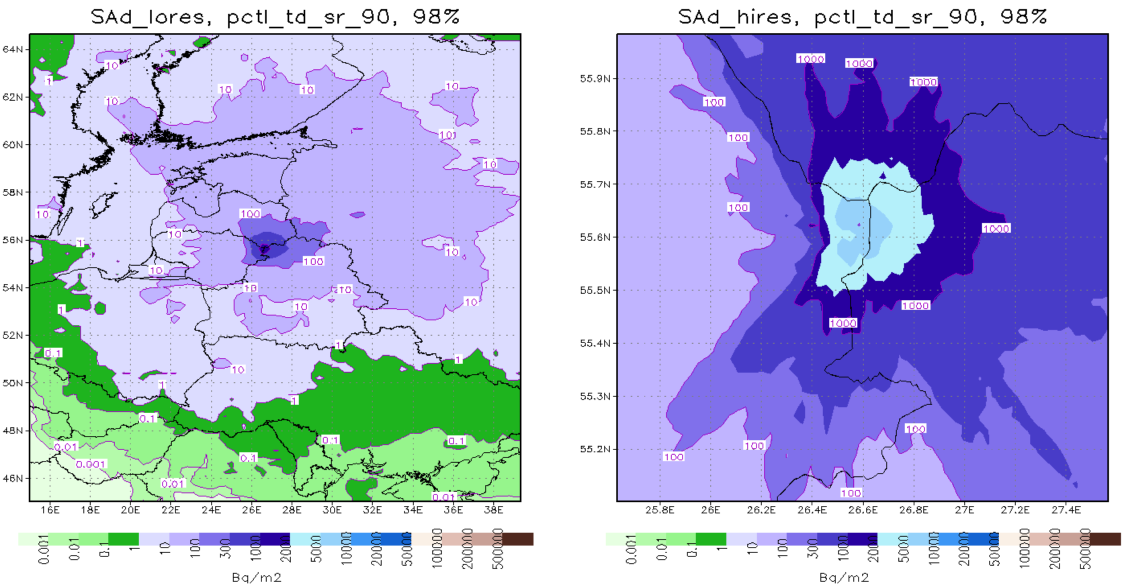


Figure 10.3-16. Severe accident, daytime release (SAd); total deposition of Sr-90 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

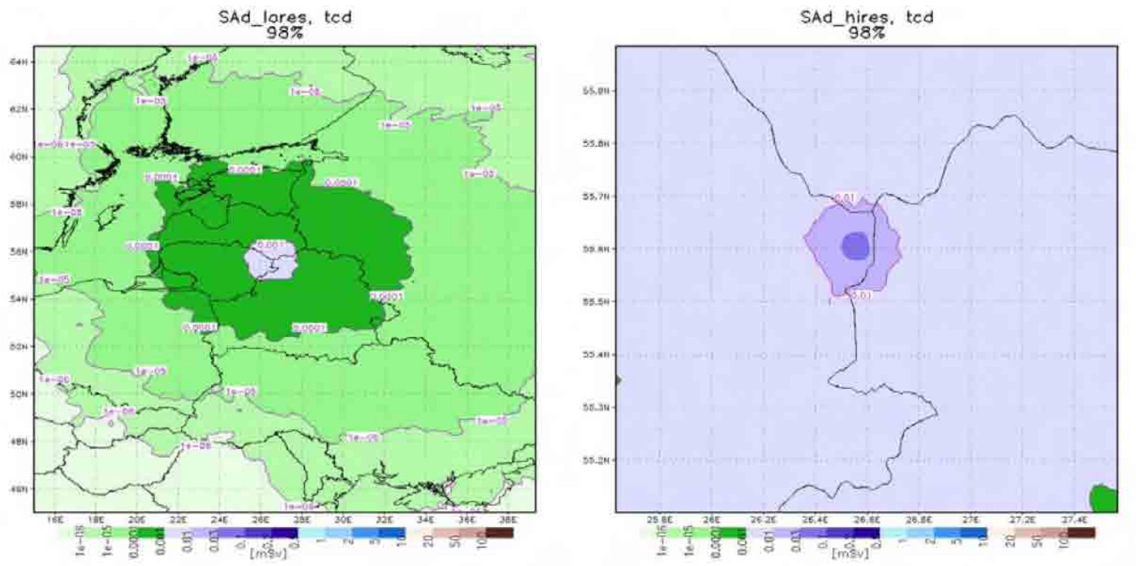


Figure 10.3-17. Severe accident, daytime release (SAd); cloud-shine dose [mSv] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

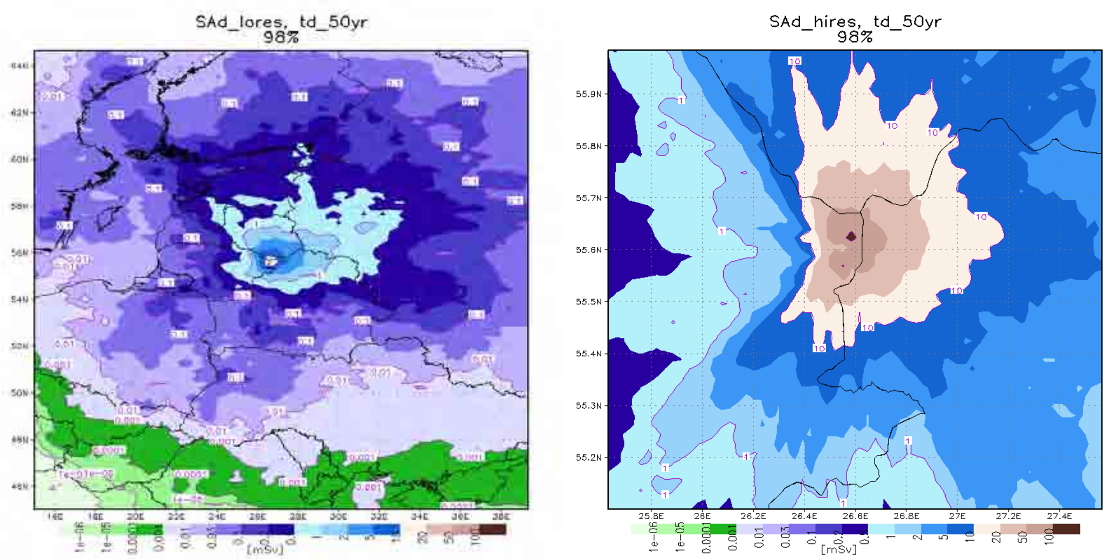


Figure 10.3-18. Severe accident, daytime release (SAd), total external dose over 50 years [mSv] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

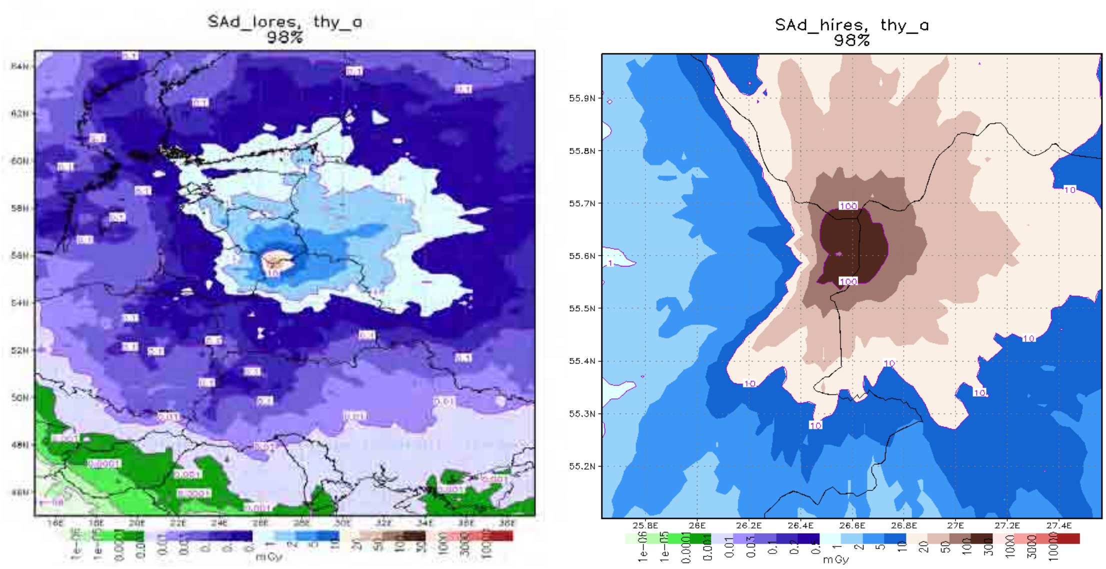


Figure 10.3-19. Severe accident, daytime release (Sad), thyroid dose for adult [mGy] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

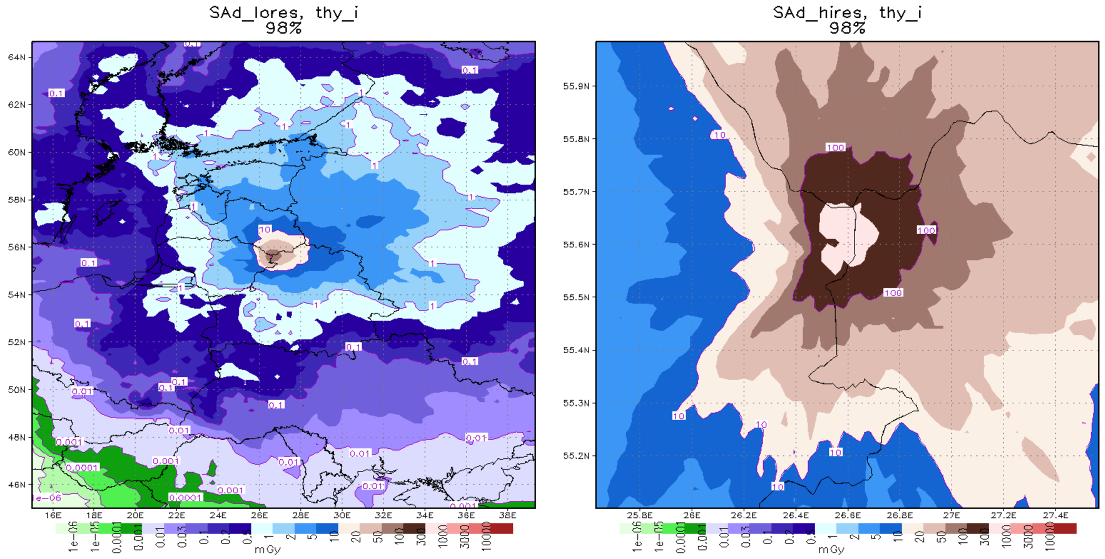


Figure 10.3-20. Severe accident, daytime release (SAd), thyroid dose for infant [mGy] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

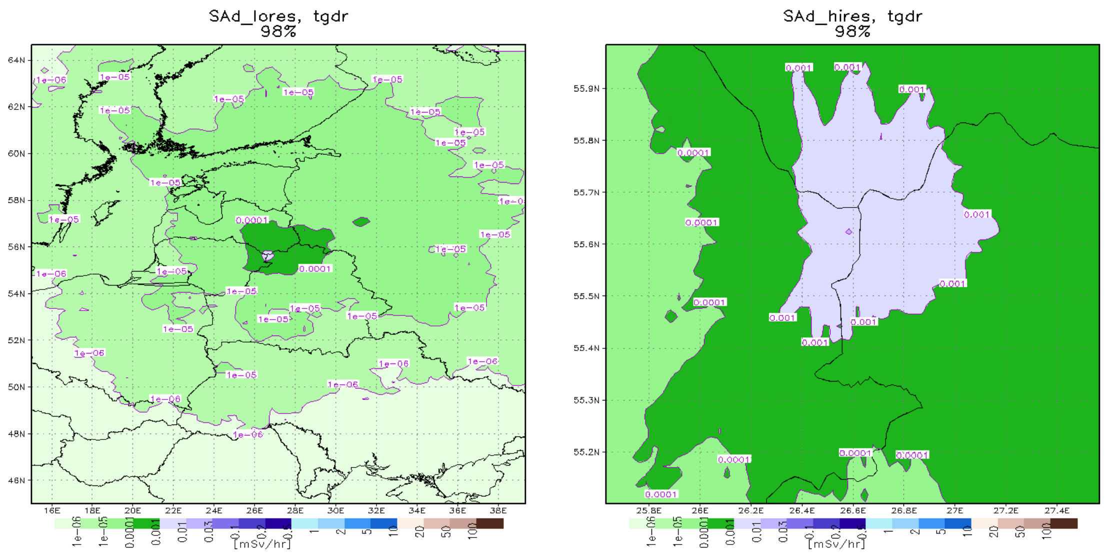


Figure 10.3-21. Severe accident, daytime release (SAd), ground-shine dose rate [mSv/hr] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

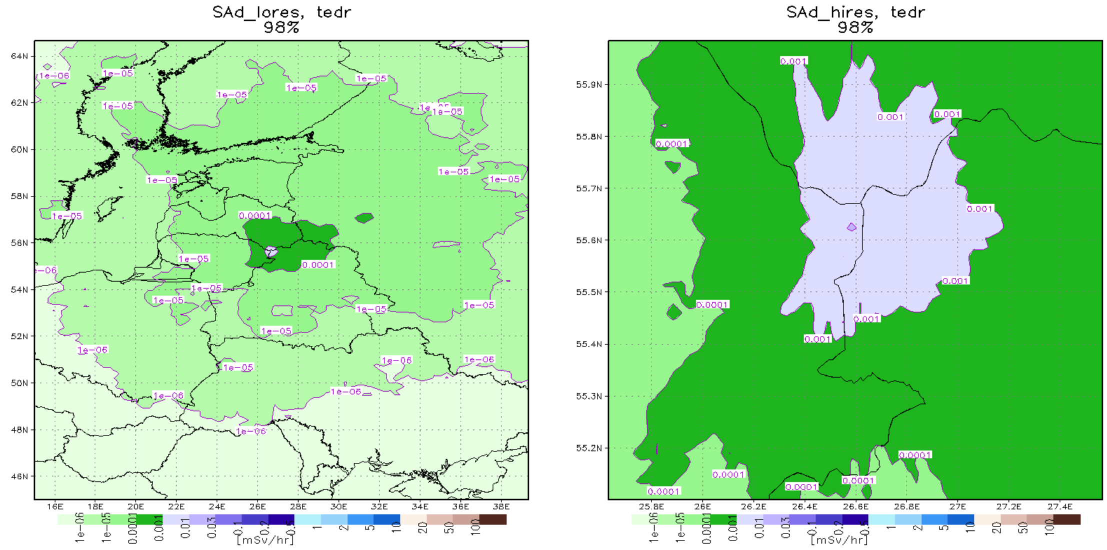


Figure 10.3-22. Severe accident, daytime release (SAd), external dose rate [mSv/hr] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

<u>Severe accident, night-time release</u>

This section contains the 98-percentile maps for the depositions of I-131, Cs-137 and Sr-90 as well as cloud-shine, external and thyroid doses resulting from the SA, night-time release scenario. Also the rates for ground-shine dose and external dose are presented. As before, in the maps one degree of distance along parallel (west-east cross-section) is equivalent to 62.8 km while one degree distance along meridian (south-north cross-section) is equivalent to 111 km.

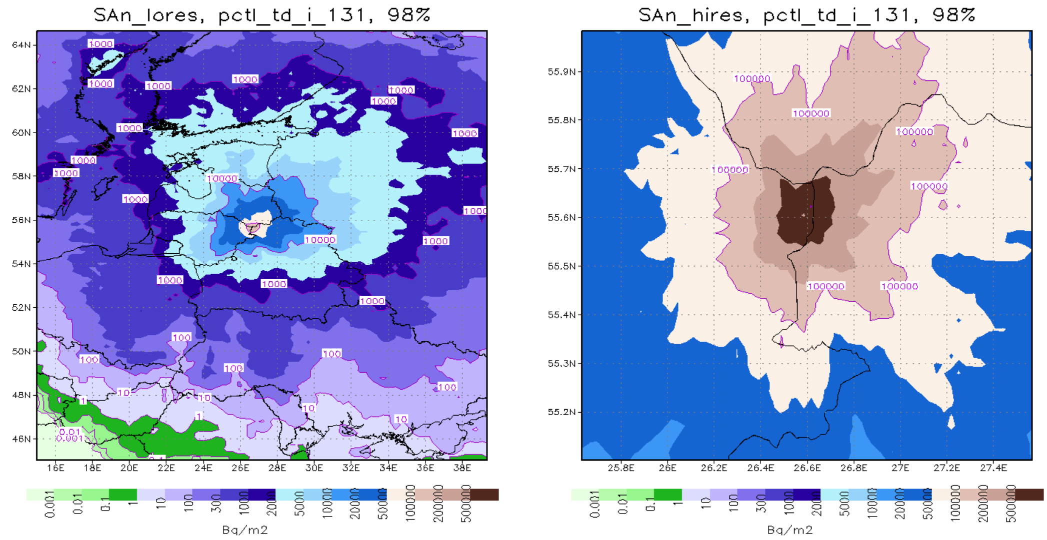


Figure 10.3-23. Severe accident, night-time release (SAn); total deposition of I-131 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

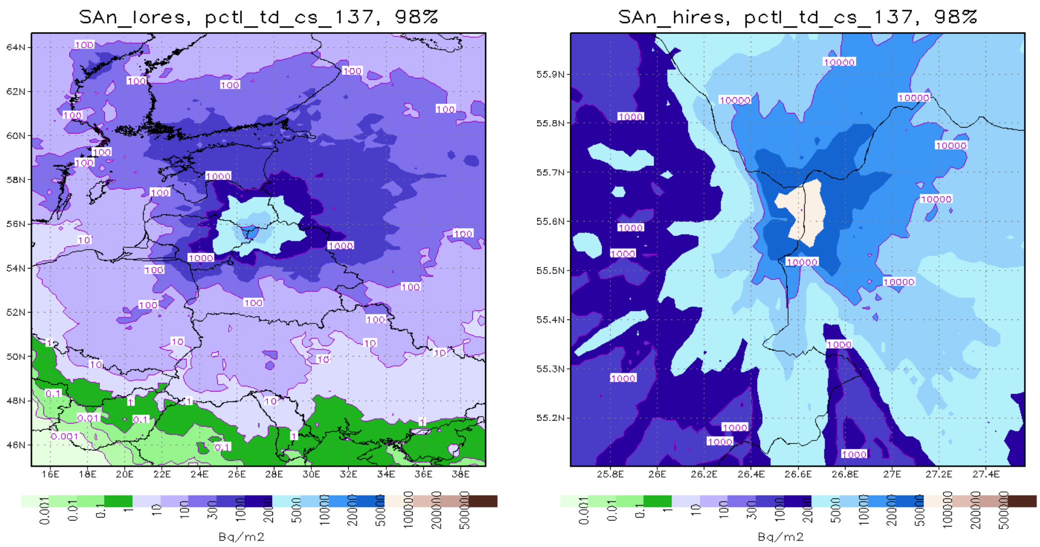


Figure 10.3-24. Severe accident, night-time release (SAn); total deposition of Cs-137 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

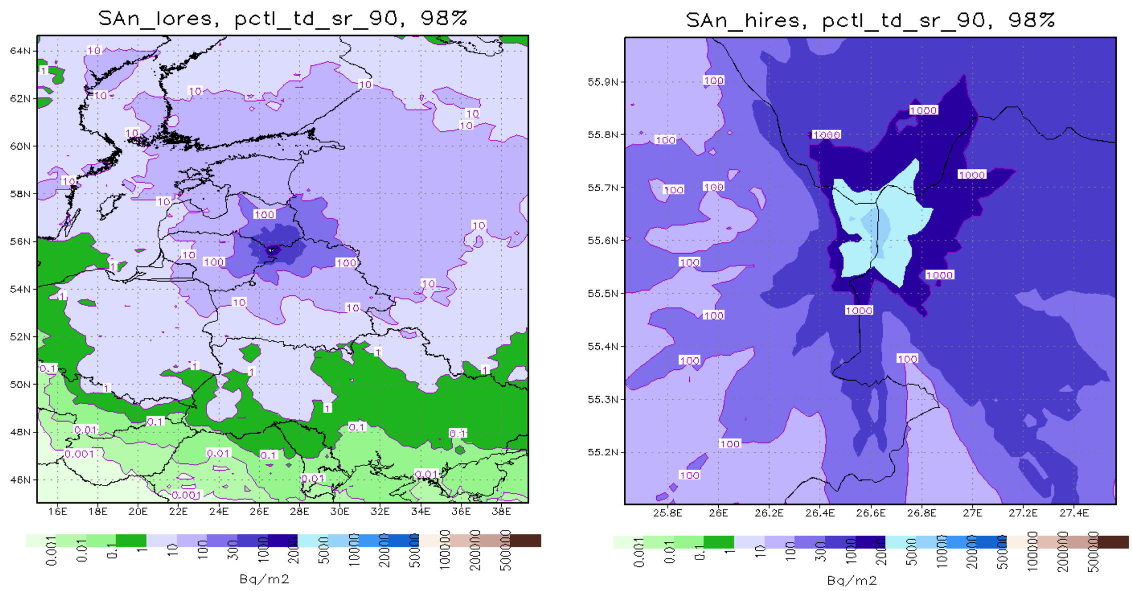


Figure 10.3-25. Severe accident, night-time release (SAn); total deposition of Sr-90 in Bq/m^2 (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

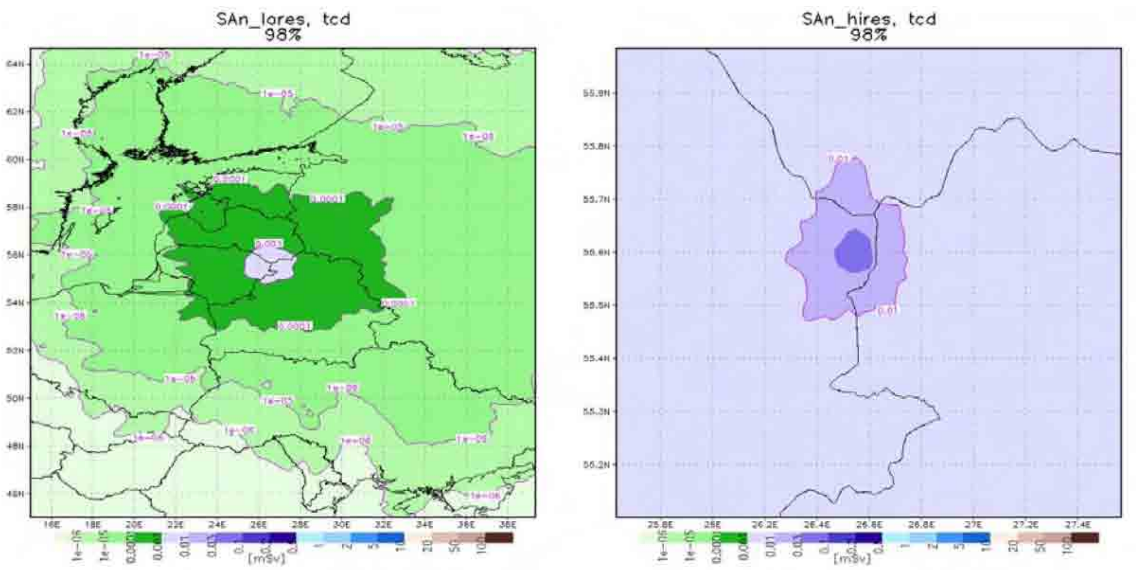


Figure 10.3-26. Severe accident, night-time release (SAn); cloud-shine dose [mSv] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

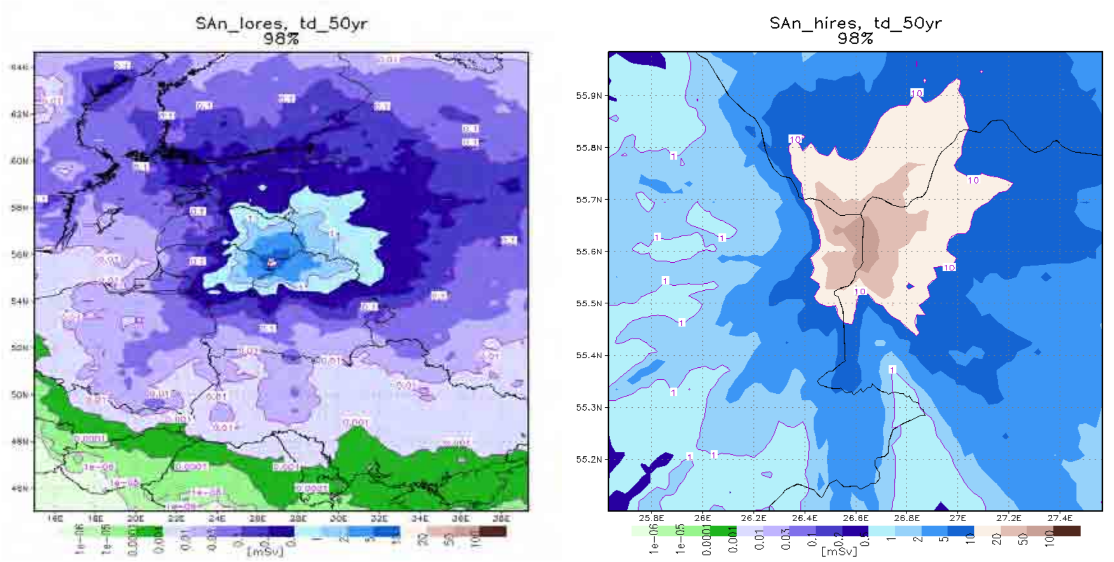


Figure 10.3-27. Severe accident, night-time release (SAn); total external dose over 50 years [mSv] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

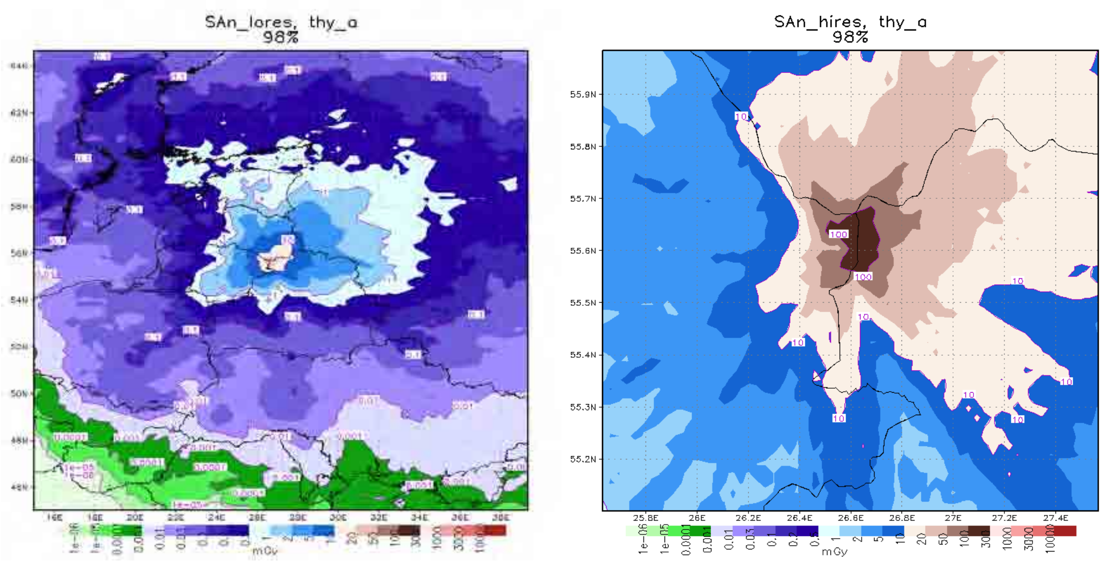


Figure 10.3-28. Severe accident, night-time release (SAn); thyroid dose for adult [mGy] (left panel: large domain with 20 km resolution; fine-grid domain with 2 km resolution).

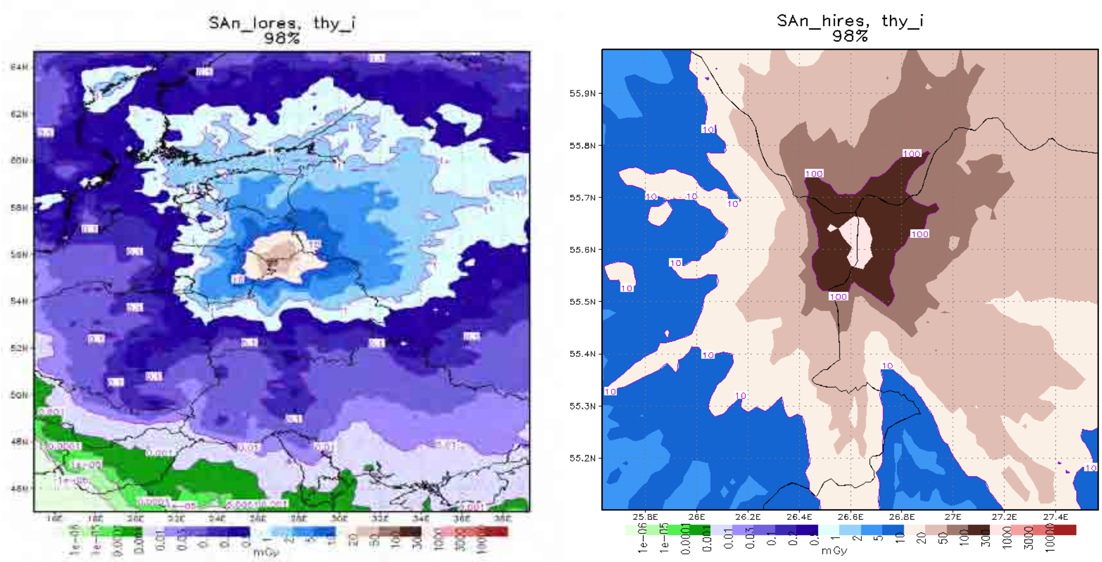


Figure 10.3-29. Severe accident, night-time release (SAn), thyroid dose for infant [mGy] (left panel: large domain with 20 km resolution; right panel; fine-grid domain with 2 km resolution).

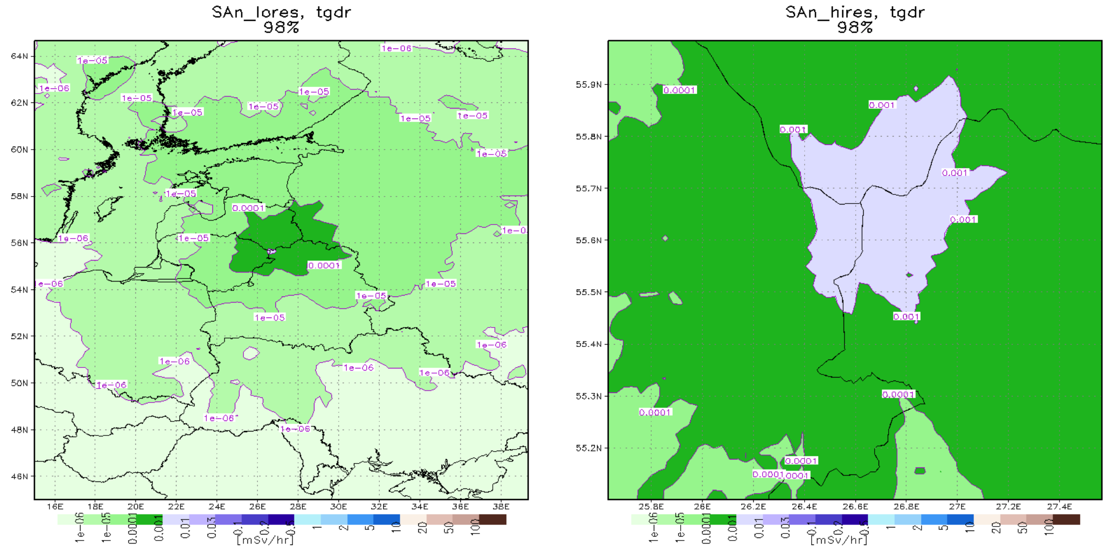


Figure 10.3-30. Severe accident, night-time release (SAn); ground-shine dose rate [mSv/hr] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

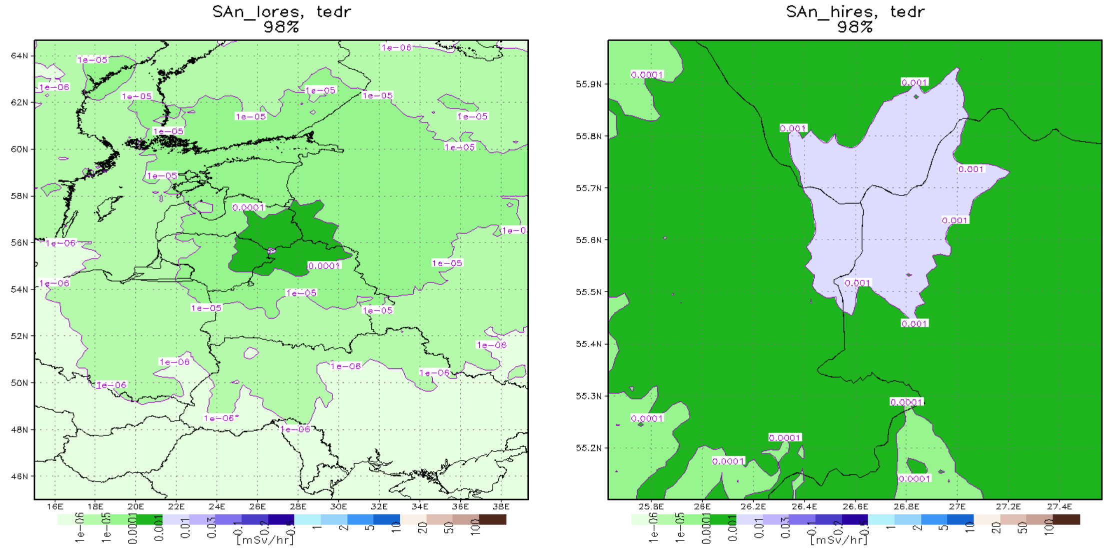


Figure 10.3-31. Severe accident, night-time release (SAn); external dose rate [mSv/hr] (left panel: large domain with 20 km resolution; right panel: fine-grid domain with 2 km resolution).

10.4 ASSESSMENT OF ACCIDENT CONSEQUENCES

The accident consequence analyses for the DBA and reference SA illustrated in Section 10.3 provide a basis for accident consequence assessment in the EIA and for the description of the considerations for, and extent of, emergency planning. Specifically, estimates of radiation doses can be made at different distances and for individual pathways of exposure. This information can be used to determine protective actions that might need to be undertaken and the spatial scales over which those actions might need to be implemented. In particular, examination of the variability in spatial patterns of doses from realisation to realisation yields information on the extent to which responses would be affected by the meteorological conditions at the time of the accident, and scaling the results to releases of different magnitude yields information on the extent to which responses would be affected by the source-term characteristics of the accident.

These issues are not addressed in detail here, as this is a matter for comprehensive safety assessment studies. Rather information is provided related to the assessment of accident consequences and the emergency actions that would be taken in response to a wide range of conditions. However, indications are given in Table 10.4–3 of the protective actions that could be needed in the case of DBA and SA.

According to HN 87:2002 (*State Journal, 2003, No. 15-624; 2008, No. 35-1251*), safety of the new designed and constructed nuclear power plant shall assure that during operation or decommissioning the dose for the members of public caused by one design basis accident shall be less than the intervention level applied for protective action – sheltering, i.e. 10 mSv. HN 99:2000 (*State Journal, 2000, No. 57-1691*) states, that the level of avertable dose when the sheltering should be taken is ≥ 10 mSv no longer than 2 days. Conservatively estimated maximal dose for infant during 2 days in case of DBA LOCA accident from all possible exposure pathways (cloud-shine, inhalation, eating food, drinking milk, and etc.) is 7.6 mSv. Requirements for protective actions of the public in case of a radiological or nuclear accident are provided in HN 99:2000 (*State Journal, 2000, No. 57-1691*). HN 99:2000 provides generic intervention levels which are based on avertable dose level, exceeding which generic intervention must be undertaken. Avertable dose is the measure of effectiveness of protective action undertaken to protect population against exposure to radiation (i.e., the difference between the dose to be expected without protective action and that to be expected with that). Protective actions are divided into urgent and longer term protective measures. Urgent protective actions shall be applied in pre-release (time between the start of accident sequence having the potential for off-site consequences and the emission of radioactive material into the atmosphere; the duration may vary from about half an hour to one day or more) and in early (time of release; the release phase may last from a fraction of an hour to several days) phase of emergency. According to HN 99:2000, urgent protective actions are summarized in Table 10.4–1.

Table 10.4–1. Urgent protective actions.

Protective action	Description
Sheltering	Sheltering protects population from external exposure from plume, from inhalation of radioactive aerosols (internal exposure) and from deposits of radionuclides on skin and clothes. The level of avertable dose when the sheltering should be taken is ≥ 10 mSv no longer than 2 days. Regulatory authority may wish to recommend sheltering at lower intervention levels for shorter periods or so as to facilitate further protective actions, e.g. evacuation. Sheltering is recommended in any case when general emergency is classified (before the release of radionuclides into environment), projections indicate that urgent protective actions should be taken and operational intervention levels are as follow: – ambient dose rate in the plume – (0.1 – 1) mSv/h; – ambient dose rate from deposition – ≥ 1 mSv/h;
Iodine prophylaxis	The purpose of iodine prophylaxis is to prevent exceeding of threshold dose for deterministic effects of thyroid gland (acute radiation thyroiditis, chronic lymphocytic thyroiditis and hypothyroidism) and to decrease thyroid doses as much as possible to reduce risk of thyroid cancer and benign thyroid nodules. The avertable committed absorbed dose level to the thyroid gland due to radioiodine is ≥ 100 mGy for people of all ages. Reference levels of avertable dose to the thyroid of neonates, infants, children, adolescents up to 18 years and pregnant and lactating women are ≥ 10 mGy, for adults under 40 years - ≥100 5 mGy.

Protective action	Description
Evacuation	Evacuation is an urgent protective action that should be pre-planned in advance and implemented before the radioactive release into the environment has occurred. Evacuation of population from contaminated area can also be implemented in early phase of emergency after the release occurs. The purpose of evacuation is to prevent or decrease the danger of short term exposures after the accident: – to protect population from inhalation of radionuclides (e.g. to decrease internal exposure); – to prevent population from external exposure due to ground contamination. If the level of avertable dose is ≥ 50 mSv, the evacuation should be lasting no longer than one week. However, the evacuation at lower or higher intervention level than 50 mSv may be undertaken. Evacuation is implemented with respect of these Operational Intervention Levels: – ambient dose rate in the plume ≥ 1 mSv/h; – ambient dose rate from ground deposition ≥ 1 mSv/h. Evacuation is recommended in any case even though one of Operational Intervention Level is exceeded.
Improvised respiratory protection	In early phase of emergency, for population being in the open area at the time of passing of radioactive cloud, improvised respiratory protection is recommended. It decreases the internal exposure from intake of inhaled radioactive aerosols and radioactive iodine. Special respirators are used for respiratory protection. If they are not available, simple materials for protection can be used

Protective action	Description
Restriction of foodstuffs, drinking water and feeding stuffs	Restriction or banning of consumption of contaminated foodstuffs and drinking water are important protective actions in early and late phase of emergency. Considering the projections and scale of general emergency, movement direction of radioactive plume, people are warned against consumption of fresh vegetables, berries, fruits from the open area, unprotected well water, from drinking milk within 100 km radius in grazing time for 2-3 weeks period. In case the value of ambient dose rate from deposition is ≥ 1 μSv/h, consumption of potentially contaminated foodstuffs should be restricted. This operational intervention level shows, that ambient dose rate from deposition during the first days after the accident exceeds natural background and the values of maximum permitted activity concentration of foodstuffs could be exceeded. Due to soil contamination by I-131 2-7 days after general emergency consumption of surface contaminated foods and milk in case the animals were grazing contaminate grass is banned. Due to contamination of soil by I-131 more than ≥ 10 kBq/m^2 consumption of potentially contaminated foods or ≥ 2 kBq/m^2 – milk and drinking water shall be banned. Restrictions are valid while the volumetric or specific concentration measurements of foodstuff, milk, drinking water will be performed. Due to soil contamination by Cs-137 2-7 days after general emergency consumption of foods which potentially could be contaminated is banned. Due to contamination of soil by Cs-137 more than ≥ 2 kBq/m^2 consumption of potentially contaminated foods or Cs-137 ≥ 10 kBq/m^2 – milk and drinking water shall be banned. Restrictions are valid while the volumetric or specific concentration measurements of foodstuff, milk, drinking water will be performed. First 1 – 2 weeks after general emergency consumption of contaminated foods shall be restricted or banned if the value of specific concentration of I-131 exceeds ≥ 1 kBq/kg and volumetric concentration of milk and drinking water exceeds ≥ 0.1 kBq/l. First 1 – 2 weeks after general emergency consumption of contaminated foods shall be restricted or banned if the value of specific concentration of Cs-137 exceeds ≥ 0.2 kBq/kg or volumetric concentration of milk and drinking water exceeds ≥ 0.3 kBq/l.
Decontami-nation of persons and clothing	Decontamination is complete or partial removal of radionuclides from a human body, clothing, other objects and the surface of the ground. Decontamination of contaminated persons affected by radioactive plume, by radioactive substances on skin and clothing, from ground deposition should be organised in decontamination points. Decontamination points can be a part of intermediate evacuation points or separate mobile decontamination points. Tasks of decontamination point: – take in and register people from contamination territory; – to measure a radioactive contamination of people, clothes and personal belongings; – decontamination of people and control of its effectiveness; – to evaluate whole body, organ, tissue exposures and incorporated radionuclides; – to collect separately contaminated clothes, other things in order to prevent the possible spread of contamination; – first medical aid or medical examination shall be performed if necessary.

The long term protective actions are applied in the late phase (late phase lasts until the time when any protection measures are not necessary; depending on emergency scale it may last several and more years) of emergency. The purpose of long term protective actions is generally to reduce the risk of stochastic health effects (cancer and genetic effects) and to prevent serious deterministic effects of protracted exposures. According to HN 99:2000, long term protective actions are summarized in Table 10.4–2. It should be emphasised, that according HN 73:2001 and also IAEA Safety Standard Series publication No. 115, doses to be compared with these intervention levels are the total doses due to all the sources, which having taken countermeasures can be averted. Usually these doses do not include doses from foodstuff and drinking water.

Table 10.4–2. Long term protective actions.

Protective action	Description
Temporary relocation	Temporary relocation is organized and concerted measure of relocation of population from affected area for longer but limited time (for several months to a year). The purpose is to protect population from external irradiation from the radioactive material deposited on the ground and surfaces, to prevent internal exposure from inhalation of re-suspended particulate radioactivity. Temporary relocation from contaminated territory shall be initiated, when generic intervention level is 30 mSv per month. Recommendations for temporary relocation are based on ambient dose rate from deposition. When ambient dose rate from deposition exceeds ≥ 0.2 mSv/h and 50% reduction in dose due to partial occupancy is taken into account, population is averted 30 mSv dose in 30 days. If the dose that can be averted by the relocation is less than 10 mSv in the subsequent month relocation is terminated. In the time of temporary relocation of population recovery operations in contaminated area are initiated: decontamination of soil, buildings, roads, etc.
Permanent resettlement	Permanent resettlement should be considered if the lifetime dose is projected to exceed 1 Sv.
Decontami-nation of environment	In late phase of emergency the following measures are recommended: – To decontaminate the soil by using different depth of ploughing; – To remove a shallow surface layer of the contaminated soil (5 – 10 cm).
Recovery measures in agriculture	The main principle of the recovery actions is application of materials (sapropell, potassium fertilizers, aluminosilicates, farmyard manure, phosphate fertilizers, etc.) that reduce radiocaesium and radiostrontium uptake into plants. Also it is recommended to apply changes in land use, select suitable varieties of a crop that accumulate lower levels of the caesium and strontium radionuclides; to alter animal species, replace sheep or goats with cattle (sheep and goats accumulate caesium in milk and meat 2-5 times more than cows); and other recovery measures.

Based on modelling results (see Section 10.3), protective actions that might be needed in case of DBA LOCA and Severe Accident at new NPP are described in Table 10.4–3. It should be noted that the modelling was performed on the basis of 98 % probability of depositions and doses given that a release of radioactive material has occurred. This means that the results presented in Section 10.3 can be exceeded only with the probability of 2 %. Thus the depositions and doses resulting from an accident can also, and are generally likely to, be less than the presented values. It should also be noted that the modelling results are site specific, as can be seen from the maps included in Section 10.3. Because of the reasons explained, the protective actions do not necessarily extend up to the distance given in Table 10.4–3. It is also likely that the areas where the protective actions are implemented are not uniform around the NNPP, since they depend on how the radioactive plume will disperse. The dispersion of the plume depends on the prevailing weather conditions.

It should be emphasized that the doses accumulated during the accident episode (cloud-shine dose, skin dose, etc) should be clearly distinguished from the dose rates, such as the ground dose rate, total external dose rate, etc. The primary difference between these parameters is that e.g. the cloud dose is collected only during the accident episode itself – i.e. during 2 days or 32 days for SA and DBA LOCA cases, respectively. After the main episode is over the accumulation stops because the contaminated cloud has gone or has been deposited. To the opposite, the doses originating from the deposited radioactivity – ground-shine dose, ingestion dose, etc – are essentially long-term and by the end of the episode only the rate of their accumulation is established. With this rate (minus radioactive decay and environmental self- and forced cleaning) the accumulation continues for a long period of time.

Table 10.4–3. Protective actions in case of DBA LOCA and Severe Accident at NNPP.

Protective action	Criteria	DBA LOCA	Severe Accident
Sheltering	Ambient dose rate in the plume: (0.1–1) mSv/h. Ambient dose rate from deposition: ≥ 1 mSv/h.	Maximum calculated total dose from the cloud (plume) during the whole LOCA episode (32 days) is 3.1E-02 mSv. Maximum calculated dose rate from deposition is 1.0E-04 mSv/h. Maximum calculated values are in the vicinity of NPP (up to 10 km). Sheltering is not necessary in case of LOCA.	Maximum calculated total dose from the cloud (plume) during the whole SA episode (2 days) is 6.2E-02 mSv. Maximum calculated dose rate from deposition is 0.011 mSv/h. Maximum calculated values are in the vicinity of NPP (up to 10 km). Sheltering is not necessary in case of Severe Accident.
Iodine prophylaxis	Absorbed dose to the thyroid gland due to radioiodine: ≥ 100 mGy for people of all ages; ≥ 10 mGy for neonates, infants, children, adolescents up to 18 years and pregnant and lactating women; ≥ 5 Gy for adults under 40 years	Maximum calculated absorbed dose to the thyroid gland does not exceed 2 mGy. Based on criteria in case of LOCA iodine prophylaxis is not necessary.	Maximum calculated absorbed dose to the thyroid gland in the vicinity of NPP exceeds 100 mGy. Based on criteria, iodine prophylaxis will be necessary for adults under 40 years within approx. 10 km distance from NPP; for neonates, infants, children, adolescents up to 18 years and pregnant and lactating women within approx. 150 km distance.
Evacuation	Avertable dose ≥ 50 mSv; Ambient dose rate in the plume: ≥ 1 mSv/h; Ambient dose rate from deposition: ≥ 1 mSv/h.	Avertable dose is less than 50 mSv. Maximum calculated total dose from the cloud (plume) during the whole LOCA episode (32 days) is 3.1E-02 mSv. Maximum calculated dose rate from deposition is 1.0E-04 mSv/h. Evacuation is not necessary in case of LOCA.	Avertable dose is less than 50 mSv. Maximum calculated total dose from the cloud (plume) during the whole SA episode (2 days) is 6.2E-02 mSv. Maximum calculated dose rate from deposition is 0.011 mSv/h. Evacuation is not necessary in case of Severe Accident.

Protective action	Criteria	DBA LOCA	Severe Accident
Restriction of foodstuffs, drinking water and feeding stuffs	Ambient dose rate from deposition: ≥ 1 μSv/h; I-131 deposition: ≥ 10 kBq/m^2 (food ban); I-131 deposition: ≥ 2 kBq/m^2 (milk and drinking water ban); Cs-137 deposition: ≥ 2 kBq/m^2 (food ban); Cs-137 deposition: ≥ 10 kBq/m^2 (milk and drinking water ban).	Maximum calculated dose rate from deposition is 1.0E-04 mSv/h. Maximum calculated deposition of I-131 and Cs-137 is 41.2 and 4.3 kBq/m^2 respectively. According to criteria of I-131 deposition food should be banned at the distance of 10-15 km; milk and drinking water should be banned at the distance of 30-35 km. According to criteria of Cs-137 deposition food should be banned at the distance of about 5 km.	Maximum calculated dose rate from deposition is 0.011 mSv/h (11 μSv/h). Maximum calculated deposition of I-131 and Cs-137 is 1272.0 and 143.8 kBq/m^2 respectively. According to criteria of I-131 deposition food should be banned at the distance of 100-250 km; milk and drinking water should be banned at the distance of 200-600 km. According to criteria of Cs-137 deposition food should be banned at the distance of 50-100 km; milk and drinking water should be banned at the distance of 20-50 km.
Temporary relocation	30 mSv per month; Ambient dose rate from deposition exceeds ≥ 0.2 mSv/h (2-30 days after emergency)	Maximum calculated dose rate from deposition is 1.0E-04 mSv/h. Dose received per month would be 0.074 mSv. Temporary relocation is not necessary in case of LOCA.	External dose rate is 0.011 mSv/h. Dose received per month will be 7.92 mSv. Temporary relocation is not necessary in case of Severe Accident.
Permanent resettle-ment	Lifetime dose: > 1 Sv.	Maximum calculated lifetime external dose is 3.44 mSv. Permanent resettlement is not needed in case of LOCA.	Maximum calculated lifetime external dose is 117 mSv. Permanent resettlement is not needed in case of Severe Accident.

The only protective action in case of DBA LOCA is restriction of foodstuffs, drinking water and feeding stuffs. The protective actions in case of Severe Accident are iodine prophylaxis and restriction on the use of foodstuffs, milk and drinking water. In case of DBA LOCA the territory where restriction of foodstuffs, drinking water and feeding stuffs might be needed is much smaller (up to 35 km from NPP) in comparison with Severe Accident (up to 600 km). It should be noted that the highest distances for protective actions is caused due to deposition of I-131. However the restrictions on the use of foodstuffs, milk and drinking water are temporary, since the radiological half-life of I-131 is 8 days and activity of I-131 deposition reduces rapidly. Activity of Cs-137 deposition is lower than I-131, however Cs-137 has radiological half-life of 30 years, therefore based on criteria defined for Cs-137 distances for restriction on the use of foodstuffs, milk and drinking water will be lower (up to 5 km in case of DBA LOCA and up to 100 km in case of SA), but this restriction will be long-lasting.

Neither of the cases, DBA LOCA or Severe Accident, would cause any direct or immediate health impacts in the vicinity of the plant even without protective actions. Delayed random impacts from radiation exposure may only be estimated statistically. The International Commission on Radiological Protection (ICRP) has estimated that exposure to a radiation dose of 1000 mSv at small doses and dose rates increases the risk of cancer by 5.5% (*ICRP 2007*). In the case of Severe Accident the maximum calculated lifetime external dose without any protective actions is significantly lower, 117 mSv.

In case of Severe Accident a larger release of noble gases would lead to higher cloud-shine doses. The computations carried out during the EIA showed that increasing the release of noble gases 10-fold would make the cloud-shine dose due to Severe Accident about 3 to 4 times higher. However, the cloud-shine dose would still be lower than the criteria for protective actions (sheltering, iodine prophylaxis, evacuation) and thus the higher release of noble gases would not lead to further actions than the ones mentioned in Table 10.4–3.

10.5 EMERGENCY PREPAREDNESS AND RESPONSE

Emergency response arrangements at nuclear power stations means adequate provision is made for responding to an emergency situation. Civil defence actions are implemented in a radiation hazard situation. Nuclear energy and civil defence legislation sets requirements for civil defence, rescue and emergency response actions. The main regulations governing emergency preparedness and response are as follows:

- Emergency Preparedness Requirements for an Organization Operating a Nuclear Facility (P-2008-01) (*State Journal, 2008, No. 130-5017*);
- Law on Civil Protection (*State Journal, 1998, No. 115-3230, 2006, No. 72-2691*);
- Law on Fire Safety (*State Journal, 2002, No. 123-5518*).

According to Emergency Preparedness Requirements for an Organization Operating a Nuclear Facility (*State Journal, 2008, No. 130-5017*) a new NPP operator shall have:

- to ensure the prevention of accidents and incidents, and in case of an accident, to conduct the following main tasks of emergency preparedness:
  - to exercise the measures ensuring that the nuclear facility is returned to the state of normal operation;
  - to protect the people at the nuclear facility;
  - to mitigate the consequences of the accident;
  - to establish an accident class;
  - to inform the VATESI and the other public administrations and regulatory bodies involved in the accident response about the accident;
  - to obtain assistance from the off-site emergency services;
  - to perform the monitoring of radioactive releases within the nuclear facility and in the sanitary protection zone;
  - to assist the public administrations and regulatory bodies in notification of the public.
- to provide mitigation measures of the accident consequences including:
  - preparation of the accident management program;
  - installation of communication lines between the control panel of the object and the subdivisions, involved in the emergency preparedness according to the set out procedure, and ensuring their operability under accident conditions;
  - provision of the procedure according to which the assistance from emergency services and support staff will be obtained, in what manner they will be informed of the current emergency situation and how they will access the object;
  - provision of locations, methods and resources for decontamination of the staff and the workers participating in accident elimination.
- When ensuring the planning of urgent protection measures, the following shall be done:

  - it shall be provided that depending on the accident class the nuclear facility will immediately present recommendations to the public administrations and regulatory bodies and municipalities on implementation of urgent protection actions of the population;
  - it shall be described how the people present within the facility and the sanitary protection zone will be warned about an accident and how they will be provided with instructions of implementation of urgent protection actions;
  - adequate places for gathering and evacuation routes for the people, present at the facility, shall be provided;
  - the monitoring system to measure doses at the places of people gathering within a nuclear facility shall be provided;
  - means of communication to ensure the implementation of urgent protection actions in case of an accident shall be provided;
  - the criteria to stop each protection action shall be described;
- When ensuring the public warning and notification, the following shall be done:
  - it shall be provided, how and what information about the accident and the response of the nuclear facility to the accident will be submitted to the public;
  - it shall be provided in what manner the public will be warned in case of notification about a particular accident;
  - within the area of the impact of a nuclear facility the entirety of organizational and technical measures of the warning and informing system is designed, also electronic whole-tone and voice sirens are installed to ensure the transfer of a warning audible signal of the civil defence, as well as of information about an impending emergency situation, its potential impacts, measures of their elimination and ways of protection against emergency to the population, state and municipal institutions and economic entities.
- When ensuring proper planning, preparation of necessary instructions and material-technical supply, as well as planning of emergency equipment, communications systems and resources, the following shall be done:
  - standard forms or rules of instructions for the preparation of these instructions shall be provided;
  - the obligations to keep all the instructions, information materials, documents, required to perform the functions, accessible in places where these functions are implemented shall be provided;
  - the procedures, the analytical tools and computer programs for the implementation of emergency response functions shall be provided;
  - tools, means, stocks, equipment, communications systems, documentation for the implementation of functions of emergency response organization shall be provided;
  - as the main emergency response point the accident control center of a nuclear facility, provided with the necessary equipment and staff, shall be foreseen;
  - technical equipment for the staff operating the nuclear facility allowing to mitigate the consequences of an accident effectively and being easily accessible shall be provided;
  - the measures and devices allowing to perform the analysis of samples at a stationary or a mobile laboratory, located outside the boundary of the area of urgent protection actions, shall be foreseen if the facilities on the site becomes unavailable or contaminated;

- measures allowing to monitor the radiation levels within the facility and within the boundaries of the sanitary protection zone shall be foreseen;
- a system capable to identify potential emergency situations shall be provided;
- equipment, which will be used to provide information during the accident shall be foreseen;
- individual protection means for the workers involved in accident elimination, including means for the workers arriving at the nuclear facility to help, shall be provided;
- the reserves of the measures needed to respond to the accident shall be foreseen and the manner of organization of their delivery shall be provided.

Emergency preparedness and emergency elimination are described in detail in the emergency preparedness plan – this is a document providing for the organizational, financial, technical, medical, evacuation and other measures taken in the event of an accident at a nuclear facility, in order to protect workers, residents and the environment from the consequences of the accident. This plan is prepared taking into account the technical design data, the conclusions of the safety analysis, technical regulation, operating procedures and other documents drawn up after the responsible authority decides that the planned economic activities are permitted on the chosen site. Emergency preparedness plan shall be prepared and coordinated with the VATESI and other public administrations and regulatory bodies and tested in practice, before the start of operation of the nuclear facility.

During the new NPP construction, accidents not causing radiological impact are possible as well (fire, traffic accidents, chemical hazards, etc.), for the prevention and elimination of which the means will be provided during the development of construction and logistics planning.

During the period of operation of Ignalina NPP of nearly 30 years, both the nuclear power station operator and the public administrations and regulatory bodies have acquired considerable amount of experience in the fields of emergency preparedness and accident elimination. There is no doubt that the experience gained, and the procedures of accident response and elimination will be adapted for the new nuclear power plant, taking into account the requirements of the above-mentioned legislation. Detailed information on the emergency preparedness, the amount of means and forces required for elimination, protection of the workers and the population will be submitted during the preparation of the new NPP Basic Design and the Safety Analysis Report. The information on the Ignalina NPP current emergency preparedness is presented below.

The current scheme of the emergency notification and submission of operative information of Ignalina NPP and communication and information means used during accident elimination at Ignalina NPP are provided in Figure 10.5-1 and Figure 10.5-2. A similar system is likely to be implemented for the new NPP.

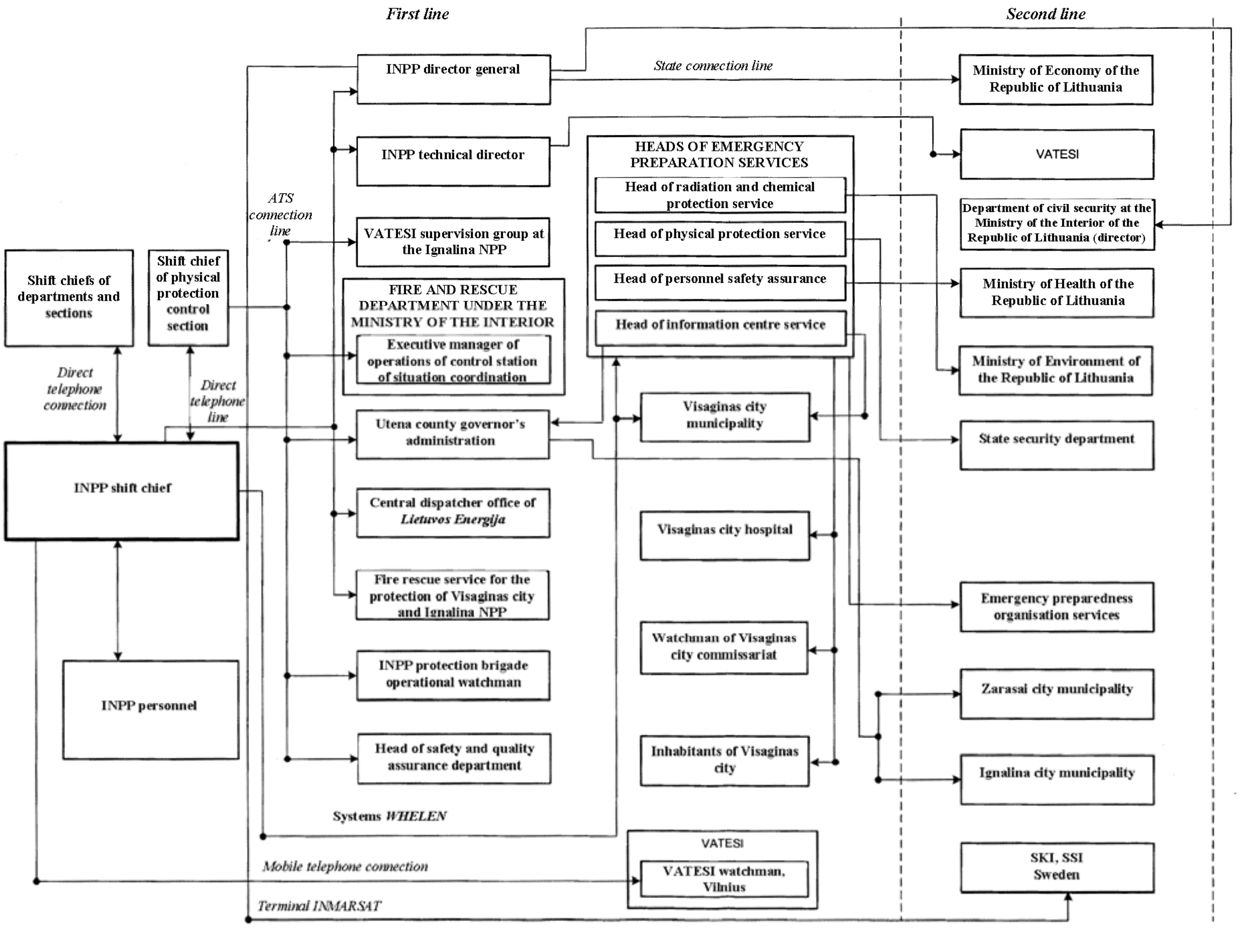


Figure 10.5-1 Current scheme of the emergency notification and submission of operative information of Ignalina NPP (*INPP code PTOed-0812-20V2*)

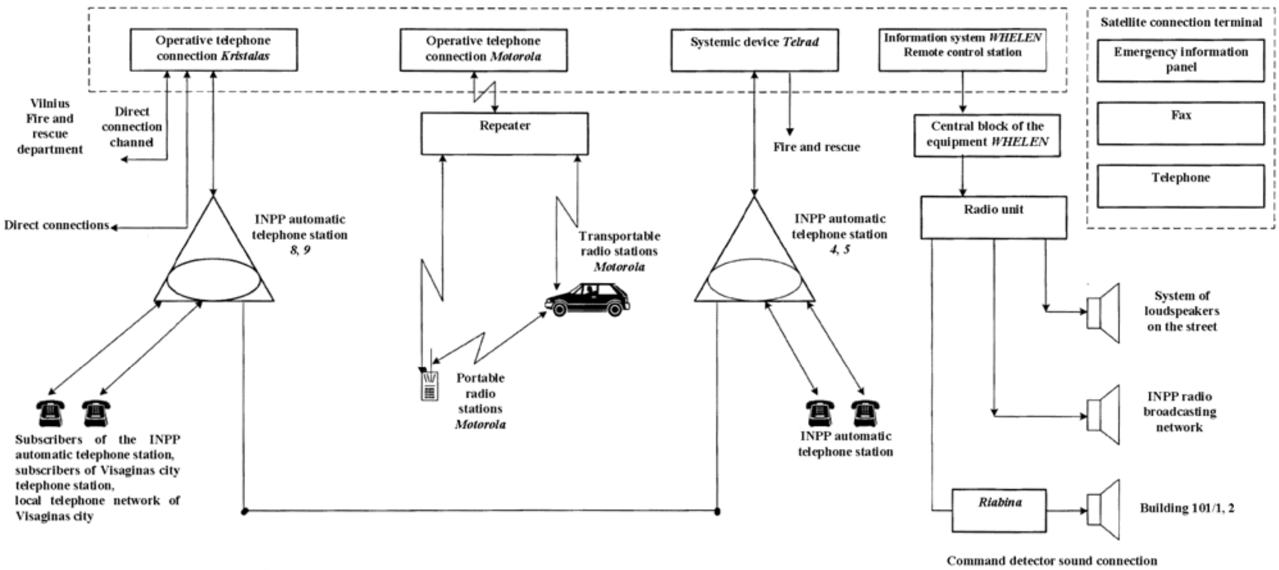


Figure 10.5-2. Current communication and information means used during accident elimination at Ignalina NPP (*INPP code PTOed-0812-20V2*)

INPP emergency response plan is implemented during an emergency or recognition that a serious problem may be evolving at the plant. The measures needed in an accident and the civil defence actions are described in the emergency preparedness plan. The plan is designed for the protection of personnel as well as confinement and mitigation in the case of a radiation accident at the nuclear power plant. This basic document provides instructions for the organisation of engineering, medical, evacuation and other actions which may be required. This plan is valid for all on-site personnel, the fire protection staff, the security guards and the attached persons.

The emergency situations are classified into three types according to severity and controllability: emergency standby, site emergency and general emergency. Each situation has their own actions, according to the nature and scope of the situation.

During emergency standby, the safety level of the power plant is intact but the operators may consider or recognise the potential for the situation to deteriorate and therefore take pre-emptive, precautionary local actions. The preparedness is raised by the manning of the emergency operator centre. The situation is also reported to VATESI and the local rescue authority.

During a site emergency, safety has deteriorated or is in imminent danger of deteriorating, such that a radiation threat is considered a possibility. The emergency organisation is alerted in full, should the event escalate to a general emergency (core damage, release of radioactive material, or excessive radiation hazard). VATESI is alerted and the local rescue authority informed.

During a general emergency, there is a realistic or actual risk of radioactive releases which require civil defence actions. The emergency organisation is alerted in full, and is ready to immediately implement protective actions. VATESI and the local rescue authority are alerted immediately.

The Ignalina nuclear power plant, and site of the new power plant, is situated 6 km from the town of Visaginas, which has a population of about 32 600. The emergency preparedness plan currently in force enables notification of an accident to the residents through remote control communication. This includes loudspeaker communication network and alarm warning sirens. The emergency preparedness plan does not provide a shelter. It does however provide for action to be taken including: communication to the population of the town advising them to stay indoors and to close all windows and doors, the administration of Iodine tablets, evacuation to an area out of the path of radioactivity being blown by the wind and the control of food and water supplies.

During the first stages of an accident, it is important to be protected against the radiation from the release plume and avoid radiation dose by inhalation. Evacuation is the most efficient form of protection, but in most accidents cases the radiation dose is reduced adequately enough by the protection of a building (i.e. sheltering).

Taking Iodine tablets can protect the thyroid against radioactive Iodine. This ensures the thyroid is filled with stable Iodine, and as a result little radioactive Iodine is absorbed into the body.

The radiation dose caused directly by the fallout and dust can be decreased significantly by temporarily transferring the population away from the contaminated area, followed, if required or possible, by local cleaning (decontamination) of the ground and buildings. A restriction on movement may be implemented to control access to contaminated area, except during necessary emergency actions. If required, and if possible, evacuation is implemented before the radioactive plume reaches the area. Taking into account wind direction a number of evacuation routes are prepared. Inhabitants are evacuated by public or personnel transport, to intermediate evacuation points controlled by the municipal emergency situation commissions. These points are set up to control departure from and arrival to contaminated territory, fulfil radiologic control of people, animals and transporting means, ensure necessary medical aid, perform sanitary treatment of people and decontamination of engineering.

The use of Iodine pills, evacuation of the population and restrictions on movement can efficiently decrease the largest radiation dose caused by the accident. Such restrictions are only required in the immediate vicinity of the nuclear power plant, and only cover a small area. Further away from the contaminated area, the dose will be so small that no long-term restrictions on movement will be expected.

Protecting domestic and production animals can reduce the radiation dose to foodstuffs, by moving animals indoors and protecting their feed. In fallout situations, instructions will be given for producing as clean feed as possible and reserving clean water. The control of food and water supplies is essential, after a large accidental release of radioactivity into the environment. Some foodstuffs may be restricted. The maximum permitted levels of radioactive contamination in foodstuffs are given in Lithuanian Hygiene Standard HN 99:2000.

Large-scale civil defences are only required during a severe accident, during an INES level six accident or greater. Civil defence structures of neighbouring countries, such as Latvia, Belarus and the Kaliningrad region of Russia, IAEA, Europe Commission would be informed about an accident by the VATESI using inter-state means of communication, and civil defence structures of Latvia and Belarus also via the local warning zone of the nuclear power plant (serving a 30 km radius for Ignalina, to be confirmed for a new nuclear plant, but may be reduced with agreement of the appropriate Regulatory authorities).

Should an off-site release of radioactivity occur, the Ministry of Environment shall first of all present information regarding the nuclear accident to VATESI. VATESI then provides information regarding the accident to the IAEA, European Commission and neighbouring countries, including; time, exact place and nature of accident, possible or determined causes of the accident, general characteristics of environmental release and the quality, composition and height of the radioactive release. In case of a nuclear accident the Fire Protection and Rescue Department under the Ministry of the Interior Authority will provide information to the municipal civil defence subdivisions about the accident via an automatic management and notification system.

The Visaginas population including plant personnel would be evacuated by the decision of the Government in accordance with the plan of the Fire Protection and Rescue Department under the Ministry of the Interior Authority. The new power plant unit will not bring any changes to the existing civil defence actions of the area.

The Fire Protection and Rescue Department organises radiation monitoring. A permanent radiation level monitoring system is currently employed at the Ignalina site and its vicinity. Variations of radiation levels in Lithuania, caused by the transfer of radioactive substances from other countries or released into the atmosphere by an accident at the Ignalina site can be monitored and tracked. In case of very high and also accidental contamination, special ecological and others extreme situations and accidents, Environmental Protection Agency performs investigations, evaluates and forecasts surface-water and environment air conditions according to the special ecological and others extreme situations and accidents cases environmental impact assessment data.

11 DIFFICULTIES AND UNCERTAINTIES OF THE ENVIRONMENTAL IMPACT ASSESSMENT

The potential uncertainty factors or practical difficulties encountered during the EIA work have been identified as comprehensively as possible during the assessment work, and their implications on the reliability of the impact assessment results have been taken into consideration. Identified uncertainties and difficulties and their implications are mainly described in the relevant sections of Chapters 7 and 10.

The available environmental data and the assessment of impacts always involve generalisations and assumptions. At this stage of the NNPP project for instance the technical data is still preliminary and incomplete, thus causing the need for above mentioned generalisations and assumptions.

The limited amount of data regarding the Belarus region has caused difficulties in parts of the assessment work. Only information on performed radiological monitoring was received from Belarus despite official requests through the Lithuanian Ministry of Environment for other information as well.

Some difficulties were encountered when trying to compile sufficiently reliable up to date data on Lake Druksiai hydrology and the hydrology of River Prorva and other rivers in Belarus. For instance actual data of the present outflow from the lake does not exist. Extrapolations from available measurement data had to be made in order to acquire sufficient hydrological data. Lack of sufficient data may cause uncertainties and inaccuracy in the assessment work. Therefore the represented assessment of water balance should be considered preliminary.

There are no regulations for releases in case of a severe nuclear accident in Lithuanian legislation. Therefore the limit for the release of radioactive materials arising from a severe accident (100 TBq release of Cs-137) defined in Finnish legislation had to be used for environmental impact estimation.

12 REFERENCES

Chapter 1

European Commission 2007. ”European Energy Policy”. Commission’s bulletin to the European Council and European Parliament. Commission of the European Communities, January 10, 2007 [http://eurlex.europa.eu/LexUriServ/site/fi/com/2007/com2007_0001fi01.pdf] (March 3, 2008).

European Commission, 2008. Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources. Brussels, 23.1.2008, COM(2008) 19 final, 2008/0016 (COD) [http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0019:FIN:EN:PDF].

Ignalina NPP Decommissioning Service, 2007. INPP Unit 1 Decommissioning Project for Defueling Phase. Environmental Impact Assessment Report (U1DP0 EIAR). Ignalina NPP Decommissioning Service, A1.4/ED/B4/0006, Issue 7, 2007.

Ignalina Nuclear Power Plant, 2003. Ignalina NPP, Turbine Hall. Operation; Technical Description of Hydraulic Structures.

Lietuvos Respublikos Vyriausybes 2008 m. geguzės 7 d. nutarimas Nr. 442 „Del Lietuvos Respublikos Vyriausybes 2003 m. gruodzio 9 d. nutarimo Nr. 1568 „Del Lietuvos Respublikos teritorijos bendrojo plano igyvendinimo priemoniu plano patvirtinimo“ papildymo. Valstybės zinios, 2008, Nr. 55-2080 (in Lithuanian).

NUKEM Technologies GmbH and LEI, 2008. EIA Report for New Solid Waste Management and Storage Facility at Ignalina NPP. NUKEM Technologies GmbH and LEI, S/14-780.6.7/EIAR/R:5, 2008.

Chapter 2

Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991). Ratified on 1999-10-07. State News 1999, No. 92-2688.

Description of Order on Strategic Evaluation of Consequences to the Environment for Plans and Programmes. Approved by the Decision of the Government of the Republic of Lithuania No. 967, dated August 18, 2004 (in Lithuanian).

The Law of Republic of Lithuania on Assessment of the Impact on the Environment of the Planned Economic Activities No. X-258, State News 2005 No. 84-3105 (in Lithuanian).

The Order of Informing the Public and the Public Participation in the Process of Environment Impact Assessment. Approved by the Order of Minister of Environment No. D1-370 dated July 15, 2005. State News 2005, No. 93-3472 (in Lithuanian).

Chapter 3

The Law of Republic of Lithuania on Assessment of the Impact on the Environment of the Planned Economic Activities No. X-258, State News 2005 No. 84-3105 (in Lithuanian).

The Order of Informing the Public and the Public Participation in the Process of Environment Impact Assessment. Approved by the Order of Minister of Environment No. D1-370 dated July 15, 2005. State News 2005, No. 93-3472 (in Lithuanian).

Chapter 4

IAEA TECDOC Series No. 1408, 2004. Energy Supply Options for Lithuania. A detailed Multi-sector Integrated Energy Demand, Supply and Environmental Analysis. IAEA, Vienna.

IAEA TECDOC Series No. 1541, 2007. Analyses of Energy Supply Options and Security of Energy Supply in the Baltic States. IAEA, Vienna.

Messner & Strubegger (1995); Riahi & Roehrl (2000). MESSAGE – Model for Energy Supply Strategy Alternatives and their General Environmental Impact. International Institute for Applied Systems Analysis (IIASA), Austria.

National Energy Strategy. Approved by the Decision No. X-1046 of the Parliament of the Republic of Lithuania of 18 January 2007. State Journal, 2007, No. 11-430.

Chapter 5

AP1000 Fact Sheet [www.energetics.com/pdfs/nuclear/ap1000.pdf].

ESBWR Fact Sheet [www.energetics.com/pdfs/nuclear/esbwr.pdf].

Fennovoima Oy 2008. Environmental Impact Assessment Report for a Nuclear Power Plant. October 2008.

General Electric Fact Sheet [www.energetics.com/pdfs/nuclear/esbwr.pdf].

Kwasny R., Aul F., Lohrey K., 2007. Recent Activities and Trends in the Uranium Market. Alzenau. Heft 11/2007.

OECD and IAEA, 2006. Uranium 2005 – Resources, production and demand.

International Nuclear Safety Advisory Group, 1996. Defence in Depth in Nuclear Safety. INSAG-10.

IAEA, 2005. Management systems fir the safety of the treatment, handling and storage of radioactive waste [http://www-ns.iaea.org/downloads/standards/drafts/ds336.pdf].

IAEA, 2006. Fundamental Safety Principles: Safety Fundamentals. IAEA Safety Standards Series, No. SF-1, Vienna.

IAEA, 2008. INFCIS (Integrated Nuclear Fuel Cycle Information Cycle). June 2008 [http://www-nfcis.iaea.org].

US-APWR Fact Sheet [www.mnes-us.com/htm/usapwrdesign.htm].

WNA, 2007. World Nuclear Association. Information Papers. World Uranium Mining. July 2007 [http://www.worldnuclear. org/info/inf23.html].

WNA, 2008a. World Nuclear Association. Information Papers. Uranium Enrichment. March 2008 [http://www.world-nuclear.org/info/inf28.html].

WNA, 2008b. World Nuclear Association. Information papers, In Situ Leach (ISL) Mining of Uranium. March 2008 [http://www.world-nuclear.org/info/inf27.html?terms=ISR].

WNA, 2008c. World Nuclear Association. Information Papers. Processing of Used Nuclear Fuel for Recycle. April 2008 [http://world-nuclear.org/info/inf69.html].

WNA 2008d. World Nuclear Association. Information Papers. Transport of radioactive materials. February 2008 [http://www.world-nuclear.org/info/inf20.html].

WNA 2008e. World Nuclear Association. Information Papers. World Uranium Mining. July 2008 [http://www.world-nuclear.org/info/inf23.html].

WNA 2008f. Information Papers. Environmental Aspects of Uranium Mining. August 2008. [http://www.world-nuclear.org/info/inf25.html]

Chapter 6

DCD APWR, 2007. Design Control Document for the US-APWR. Chapter 11 – Radioactive Waste Management. MUAP- DC011, December 2007 [http://www.nrc.gov/reactors/new-reactors/design-cert/apwr.html].

DCD AP-1000, 2005. AP1000 Design Control Document, Chapter 11 – Radioactive Waste Management, Revision 10. 2005 [http://www.nrc.gov/reactors/new-reactors/design-cert/ap1000.html].

DCD AP-600, 1999. AP600 Design Control Document, Chapter 11 – Radioactive Waste Management, 1999 (NRC Accession Number ML003691382).

DCD ABWR, 2007. US ABWR Design Control Document/Tier 2; Chapter 11 – Radioactive Waste Management. August 2007 [http://www.nrc.gov/reactors/new-reactors/design-cert/abwr.html].

DCD ESBWR, 2007. US ESBWR Design Control Document /Tier 2; Chapter 11 – Radioactive Waste Management, Rev. 4, September 2007 [http://www.nrc.gov/reactors/new-reactors/design-cert/esbwr.html].

Devgun J. S., 2008. A Review of Decommissioning Considerations for New Reactors. WM2008, Phoenix, Arizona, USA, February 24–28.

EIA ACR-1000, 2006. Description for the ACR-1000 Environmental Assessment. 10820-03700-ENA-001-NP, November 2006.

EPR FSAR, 2007. U.S. EPR Final Safety Analysis Report. AREVA.

IAEA TECDOC Series No. 1394. Planning, Managing and Organizing the Decommissioning of Nuclear Facilities: Lessons Learned. IAEA, Vienna, 2004.

IAEA TECDOC Series No. 1478. Selection of Decommissioning Strategies: Issues and Factors. IAEA, Vienna, 2005.

IAEA-TECDOC-1492. Improvements of radioactive waste management at WWER nuclear power plants. IAEA, Vienna 2006.

Kanopiene R., Sliaupa S., Lazauskiene J., Giedraitis R., Mazeika J., Maseliene V., Baliukevicius A. 2005. Investigations of Possibilities to Dispose of Spent Nuclear Fuel in Lithuania: a Model Case. Volume 1: Suitability of Geological Environment in Lithuania for Disposal of Spent Nuclear Fuel / Edited by: Satkunas J.; Radioactive Waste Management Agency, Lithuanian Energy Institute, Geological Survey of Lithuania, Institute of Geology and Geography, Swedish Nuclear Fuel and Waste Management Co. – Vilnius: LGT, 2005. – 66 p.: iliustr. – Bibliogr.: p. 65–66.

Poskas, P., Brazauskaite, A., Narkunas, E., Smaizys, A. & Sirvydas, A. 2006. Generic repository concept for RBMK-1500 spent nuclear fuel disposal in crystalline rocks in Lithuania. Paper at TopSeal 2006 conference on 17–20 September 2006, Olkiluoto, Finland [http://www.euronuclear.org/events/topseal].

Regulation on Sewage Management. Approved by the Minister of Environment Ordinance No. D1-515 of 8 October 2007. State Journal, 2007, No. 110-4522.

Regulation on Surface Water Management. Approved by the Minister of Environment Ordinance No. D1-193 of 2 April 2007. State Journal, 2007, No. 42-1594.

Reisenweaver, D. W., 2003. The International Atomic Energy Decommissioning Concept, Proc. of an Int. Conf. on Safe Decommissioning for Nuclear Activities, Berlin, 14–18 Oct. 2002, IAEA, Vienna (2003) 123–130.

Safety Standards Series No. WS-R-5. Decommissioning of Facilities Using Radioactive Material. Safety Requirements. IAEA, Vienna, 2006.

TQ AECL, 2008. Response to Technical Questions from Atomic Energy of Canada Limited (AECL), dated 4th April 2008.

WNA, 2008. Information Papers. Waste Management in the Nuclear Fuel Cycle. August 2008 [http://www.world-nuclear.org/info/inf04.html].

Section 7.1

Belene NPP Environmental Impact Assessment Report BNPP-EIA-PEC-NEK-0001-E3 March, 2004. http://www.bluelink.net/ (visited on 10 Oct. 2008)

Council Directive 78/659/EEC of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support fish life 1978-07-20 Official Journal L: 1978-08-14 No. 222-1.

Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, Brussels, 21 May 1992.

Adliene D., Adlyte R., 2005. Contamination of aquatic plants with long-lived radionuclides in the vicinity of Ignalina Nuclear Power Plant. Environmental research, engineering and management, 3(33), 32-39.

Almenas K., Kaliatka A., and Uspuras E. 1998. Ignalina RBMK-1500. A Source Book. Extended and updated version. Prepared by Lithuanian Energy Institute. Publisher Lithuanian Energy Institute, Kaunas

Final Safety anglysis report of solid radwaste storame facilities at Ignalina NPP. Final Supplementary Report to SAR T12/13. SKB International Consultants AB, Contract 405-10-1559, April 2003.

Status of lake ecosystem at the begining of Ignalina NPP operation. Series „Thermal power and environment“, T. 10, 1 d., 248 p., 1992. (in Russian).

EPA Annual Reports, 2002-2006. Environmental Protection Agency (EPA). Reports on State monitoring of the lakes 2002–2006 [http://aaa.am.lt/VI/index.php#r/1696].

Report No. 33978DSP, 1986. Technical Report on Engineering-geological Investigations in INPP Site (ORU–750) (in Russian).

Radiation Protection Centre Project Report, 2007. Project „For the assessment of radioecological and ecotoxicological state of Lake Druksiai to collect information about the radionuclides activity in bottom sediments, flora and fauna of Lake Druksiai and in flora of the vicinity of Ignalina NPP and to measure their activity during the operation of both units as well as after closure of the first unit of Ignalina NPP” Report. Vilnius, Radiation Protection Centre, Institute of Geology and Geography, Institute of Physics, Institute of Botany, p. 1–251 (in Lithuanian).

Blindow I., 1992. Decline of Charophytes during eutrophication: comparison with angiosperms. Freshwat. Biol. vol. 28, p. 9-14.

Bruzinskiene A., Virbickas J. 1988. Versline ir megejiska zvejyba Lietuvos TSR vandenyse 1974 – 1985 metais. [Commercial fishing and angling in the waters of the Lithuanian SSR in 1974-1985] Vilnius. P. 1-169.

Bukantis A., Rimkus E., 2005. Climate variability and change in Lithuania, Acta Zoologica Lituanica, Volumen 15, Numerus 2, ISSN 1392-1657, p. 100-104.

Bulgakov, N. G. & A. P. Levich, 1999. The nitrogen : phosphorus ratio as a factor regulating phytoplankton community structure. Archiv für Hydrobiologie 146. p. 3–22.

Dryzius R. et al., 1984. Report on scientific work. The development of active and preventive measures to combat pollution of water and technical studies of cooling capacity of the lake Druksiai – cooling reservoir of INPP. Institute of Physical and Technical Problems of Energy, Kaunas, 55 p. (in Russian).

EPA, 1996a. Ecological effects test guidelines. OPPTS 850.4150. Terrestrial plant toxicity, Tier I (vegetative vigor). EPA 712-C-96-163.

EPA, 1996b. Ecological effects test guidelines. OPPTS 850.4250. Vegetative vigor, Tier II. EPA 712-C-96-164.

Depthdata, 2008. Depth contour data provided by the INPP office, 1m interval contours for the whole lake Druksiai in DXF format.

Grigelis A., 1993: State of zoobenthos // Energy and environment: Ecosystem of the water–cooling reservoir of INPP at the initial stage of its operation. Vilnius Vol. 10 (2). P. 105–110 (in Russian).

Gudelis A., Remeikis V., Plukis A., Lukauskas D., 2000. Efficiency Calibration of HPGe Detectors for Measuring Environmental Samples. Environmental and Chemical Physics 22(3-4): 117-125.

Helsingin energia, 2008. Annual report 2007. [http://www.helsinginenergia.fi/vuosi2007/tal_lampo.html].

Magone I. 1989. Bioindication of phytotoxicity of transport emission. In: Kachalova OL, editor. Bioindication of toxicity of transport emissions in the impact of highway emissions on natural environment. Riga, Latvia: Zinatne, P 108–116.

INPP letter No. 109-4859 (12-14, dated 2007-08-27).

INPP Report PTOot-0545-15, 2008. Results of Radiation Monitoring at INPP Region in 2007, INPP.

Ichikawa S., 1992. Tradescantia stamen – hair system as an excellent botanical tester of mutagenicity: its response to ionizing radiations and chemical mutagens, and some synergistic effects found. Mutation Research, 270, 3-22.

IEA 2005. Energy balances for OECD and non-OECD countries.

Jakimaviciute V., Mazeika J., Petrosius R., Zuzevicius, 1999. A. Evaluation of Long-term Influence of Ignalina NPP Radioactive Waste Storage on Natural Waters. Geologija, No. 28, 78–92 p. (in Lithuanian).

US Nuclear Regulation Commission, design control documentation (DCD) of different types of reactors. Available at www.nrc.gov. Visited 26.6.2008.

United Nations Environment programme, International Labour Organisation, World Health Organization, 1998. International programme on chemical safety. Environmental health criteria: 204 Boron.

Koponen J, Kummu M., Lauri H., Virtanen M., Inkala A.,Sarkkula J., Suojanen I., Veijalainen N., 2008. EIA 3D model manual [http://www.eia.fi/wup-fin/training/manuals.html].

Langford, T., 1990. Ecological effects of thermal discharges. Elsevier Applied Science Publisher Ltd. London 1990.

LST EN ISO 7346-1:2000. Vandens kokybė. Medžiagų ūminio letalaus toksiško poveikio gėlavandenei žuviai [Brachydanio rerio Hamilton-Buchanan (Teleostei, Cyprinidae)] nustatymas. 1 dalis. Statiškasis metodas (ISO 7346-1:1996) (in Lithuanian).

LST ISO 9698:2006. Vandens kokybė. Tričio tūrinio aktyvumo nustatymas. Skysčio scintiliacijos skaičiavimo metodas (tpt ISO 9698:1989) (in Lithuanian).

LST ISO 10229:2000. Vandens kokybė. Medžiagų ilgalaikio toksiško poveikio gėlavandenei žuviai nustatymas. Metodas įvertinti medžiagos poveikį vaivorykštinio upėtakio [Oncorhynchus mykiss Walbaum (Teleostei, Salmonidae)] augimo greičiui (tpt ISO 10229:1994) (in Lithuanian).

Luksiene B., Druteikiene R., Gvozdaite R., Gudelis A., 2006. Comparative Analysis of ^{239,240}Pu, ^{137}Cs, ^{210}Pb and ^{40}K Spatial Distribution in the Top Soil Layer at the Baltic Coast. J. Environ. Radioactivity, 87: 305-314.

Luksiene D., 1995. Changes of reproductive system of pike Esox lucius L. In Lake Druksiai – the cooler of Ignalina NPP. In: The impact of the Ignalina Nuclear Power Plant on nature and society. Selected papers (Eds.: L. Kairiukstis, Z. Rudzikas, Suveizdis P., Grybauskas P.). Institute of Botany, Vilnius, Lithuania. pp. 191-195 (in Lithuanian).

Marcinkevicius V., Buceviciute S. et al., 1995. Hydrogeological and Engineering-Geological Mapping of Ignalina NPP Area at a Scale 1:50 000 in Topographical Sheets N-35-5-G-v,g; N-35-17-B; N-35-17-G-a,v; N-35-18-V-a,b (Druksiai object). Report: Archive of Geological Survey of Lithuania, Vilnius, 4436 p. (in Russian).

Marciulioniene D., Kazlauskienė N., Svobiene R., Budrienė S., 1996. Ecotoxicological Investigation in Cooling Water Reservoir of Ignalina NPP and Dnepr Cascade Water Reservoir by Using Biotests. Ekologija, 1, P. 74–80.

Marciulioniene D., Montvydienė D., Kiponas D., Luksiene B., Butkus D. 2004: Toxicity to Tradescantia of Technogenic Radionuclides and their Mixture with Heavy Metals. Environmental Toxicology, 19(4), P. 346–350.

Marciulioniene D., Petkeviciute D., 1997. Peculiarities of technogenic radionuclides accumulation in fresh water fish. Ecology (Vilnius). 3, 44-48 (in Lithuanian).

Mazeika J., 2002. Radionuclides in Geoenvironment of Lithuania. Monograph. Vilnius, Institute of Geology, 216 p., ISBN 9986-615-32-1.

Minouflet, M., S. Ayrault, P.-M. Badot, S. Cotelle, J.-F. Ferard, 2005. Assessment of the Genotoxicity of 137Cs Radiation Using Vicia-micronucleus, Tradescantia-micronucleus and Tradescantia-stamen-hair Mutation Bioassays. J. Environmental Radioactivity, 81, 143-153.

Research Study/Institute of Botany, 2008. Description of the Aquatic Ecosystem of Lake Druksiai. Institute of Botany, Vilnius Report No. 14-193.8.8, 55 p.

Montvydienė D., Marciulioniene D. 2004: Assessment of Toxic Interactions of Heavy Metals in a Multicomponent Mixture using Lepidium sativum and Spirodela polyrrhiza. Environmental Toxicology, 19(4), P. 351–358.

OECD 208. (draft version), 2003, Terrestrial Plant Test: Seedling Emergence and Seedling Growth test, OECD – Organization for Economic Cooperation and Development, Paris.

Assessment of incoming pollution and a balance of nutrients in order to develop environmental regulation for discharges in cooling water reservoir of INPP. 1991. Final report No. 11/91-KS: INPP – Institute of ecology and genetics of microorganisms. Perm, 187 p. (in Russian).

Lithuanian State Scientific Research Programme "Ignalina Nuclear Power Plant and the environment" (1993-1997), 1998. The state and development of the ecosystems in the region of Ignalina Nuclear Power Plant, Final collection of scientific reports. Vilnius, 6 vol. (in Lithuanian).

Pimpl M. 1996. Analytical Procedure to Determine Radionuclides in Soil. IAEA International Training Course on Determination of Radionuclides in Environmental Samples. Karlsruhe, 1-7.

Salickaite-Bunikiene L., Kirkutytė I., 2003: The investigation of nutrients of Ignalina Nuclear Pover Plant Cooler (Lake Druksiai) in the period 1998–2002. Aplinkos tyrimai, inzinerija ir vadyba, Nr. 3 (25).

Sandström, O. & Svensson B 1990. (in Swedish) Kylvattnets ekologiska effekter. Froskningen i Bitestsjön, Forsmark, 1984-1988. Statens vattenfallsverk. Grafik & Prab. 55 s.

Sokolova I. 1971. Calcium, Strontium-90 and Strontium in Sea Organisms. Kijev, 1-239.

Sparrow A., Underbrink A., Rossi H., 1972. Mutations induced in *Tradescantia* by small doses of x-rays and neutrons. Science, 176, 916-918.

State of INPP cooling water reservoir ecosystem during initial operational period, 1992. Series „Thermal Energy and Environment", T. 10, Part 1, P. 248 (in Russian).

State Journal, 2006, No. 5-159. Description of Requirements for Protection of Surface Water Bodies where Freshwater Fish Can Inhabit and Reproduce.

STUK, 2004. Ydinturvallisuus. Toim. Jorma Sandberg. Säteilyturvakeskus, Helsinki.

STUK, 2005. Ydinturvallisuus. Suomi ja lähialueet. Neljännesvuosiraportti 1/2005. Kirsti Tossavainen (eds.). ISBN 952-478-008-9 (pdf).

STUK, 2006. Säteily ja ydinturvallisuus. Neljännesvuosiraportti 1/2006. Elina Kainulainen (eds.) [http://www.stuk.fi/ydinvoimalaitokset/nvr/nvr1-2006.html]. ISBN 952-478-008-9 (pdf).

STUK, 2007. Säteily ja ydinturvallisuus. Neljännesvuosiraportti 1/2007. Risto Isaksson (eds.) [http://www.stuk.fi/julkaisut/stuk-b/stuk-b78.pdf].

Suomela J. 1993. Methods for Determination of Strontium-90 in Food and Environmental Samples by Cerenkov Counting. SSI-report No. 93-11. Swedish Radiation Protection Institute, Stockholm.

Шевченко В.А., Померанцева М.Д., 1985. Генетические исследования действия ионизирующих излучений. Москва, Наука, 278 с. (in Russian).

Regulatory document on the environment LAND 64-2005 "Detection of the radioactive strontium–90 in the samples of the environment elements. Radiochemical method", State Journal, 2005, No. 24-786.

Regulatory document on the environment LAND 42-2007 "On the Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring", State Journal, 2001, No. 13-415; 2007, No. 138-5693.

Virbickas J. et al., 1993. Productivity of ichtiocenosis//Energy and environment: Ecosystem of the water–cooling reservoir of INPP at the initial stage of its operation. Vilnius. Vol. 10(2) P. 123-130 (in Russian).

Virbickas J., 1988. The structure and dynamics of populations and freshwater fish populations under the influence Thermal Power Plants. Doctoral thesis, Vilnius. 440 p. (in Russian).

Vosyliene M. Z., Kazlauskiene N., Jokstas K. 2005. Toxic effects of crude oil combined with oil cleaner simple green on yolk-sac larvae and adult rainbow trout Oncorhynchus mykiss. Environ. Sci. & Pollut. Res. 12(3), 136-139.

Wang W. 1992. Use of plants for the assessment of environmental contaminants. Reviews of Environmental Contamination and Toxicology, 126, 88–127.

Section 7.2

Ignalina NPP Decommissioning Project Management Unit, 2004b. Environmental Impact Analysis for the New Steam Boiler Plant implemented at Ignalina NPP in the frame of INPP decommissioning support investment package B5, B5/TN/B2/0006, Issue: 01.

Ambient Air Pollution Standards. Approved by the Minister of Environment and Minister of Health Protection Order No. 591/640 of 11 December 2001. State Journal, 2001, No. 106-3827.

Belene NPP Environmental Impact Assessment Report BNPP-EIA-PEC-NEK-0001-E3 March, 2004. http://www.bluelink.net/ (visited on 10 Oct. 2008)

INPP Report PTOot-0545-15, 2008. Results of Radiation Monitoring at INPP Region in 2007, INPP.

Ignalina NPP Decommissioning Project Management Unit, 2004a. Environmental Impact Analysis for the New Heat Only Boiler Plant implemented at Ignalina NPP in the frame of INPP decommissioning support investment package B5, B5/TN/B2/0005, Issue: 01.

LAND 42-2007. Regulatory document on the environment “On the Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring”. State Journal, 2007, No. 138-5693.

National Energy Strategy 2007. Resolution on the approval of the national energy strategy (official translation). 18 January 2007 No X-1046, Vilnius, Parliament of the Republic of Lithuania.

National Greenhouse Gas Emission Inventory Report, 2008. National Greenhouse Gas Emission Inventory Report of the Republic of Lithuania (Reported Inventory 1990-2006), Annual report under the UN Framework Convention on Climate Change.

Section 7.3

Hidroprojektas Report, 2006a. Report on Applied Scientific Geological Investigations of the Construction Site of a New Nuclear Power Plant at the Territory of the State Enterprise Ignalina Nuclear Power Plant. (Site Survey–Selection Stage), Kaunas.

Hidroprojektas Report, 2006b. Applied Scientific Geological Engineering Investigations of the Construction Site of a New Nuclear Power Plant at the Territory of the State Enterprise Ignalina Nuclear Power Plant. Stage II (Verification Stage), Volumes I and II, Kaunas.

Hidroprojektas Report, 2006c. Preliminary Engineering Geological Investigations on the Construction Site of Future Shunt Reactor Facility in the Shunting Station of 330 kV in Ignalina Nuclear Power Plant, Volume I, part 2, Kaunas.

Report No 33978DSP, 1986. Technical Report on Engineering-Geological Investigations in INPP Site (ORU–750). 33978DSP (in Russian).

Jakimaviciute V., Mazeika J., .Petrosius R., Zuzevicius A., 1999. Evaluation of Long-Term Influence of Ignalina NPP Radioactive Waste Storage Facilities on Natural Waters. Geologija, 1999, No. 28, P. 78–92 (in Lithuanian).

Marcinkevicius V., Buceviciute S. et al., 1995. Hydrogeological and Engineering-Geological Mapping of Ignalina NPP Area at a Scale 1:50 000 in Topographical Sheets N-35-5-G-v,g; N-35-17-B; N-35-17-G-a,v; N-35-18-V-a,b (Druksiai object). Report: Archive of Geological Survey of Lithuania, Vilnius, P 4436 (in Russian).

Mazeika J., 2002. Radionuclides in Geoenvironment of Lithuania. Monograph. Vilnius, Institute of Geology, P. 216, ISBN 9986-615-32-1.

Procedure on Inventory for Release of Dangerous Materials into Groundwater and on Data Collection. Approved by the Ordinance No. 1-06 of the Head of the Geological Survey of Lithuania under the Ministry of Environment of 3 February 2003. State Journal, 2003, No. 17-770.

The Implementation Order of Groundwater Monitoring of Economical Entities. Approved by the Ordinance No. 1-59 of the Head of the Geological Survey of Lithuania under the Ministry of Environment of 24 October 2003. State Journal, 2003, No. 101-4578.

“Vilniaus hidrogeologija” Report, 2003. Report on Assessment of Sanitary Protection Zone for Visaginas Town Waterworks and Recalculation of its Limits (SPZ Design). INPP DPMU and Joint-Stock Company “Vilniaus hidrologija” Report, Vol. I (Text and Annexes), Vilnius, 2003, P. 103.

Section 7.4

INPP Report PTOot-0545-15, 2008. Results of Radiation Monitoring at INPP Region in 2007, INPP.

Kadunas V. et al, 1999. Geochemical Atlas of Lithuania / Editor J. Satkunas: Geological Survey of Lithuania, Institute of Geology. Vilnius: LGT (in Lithuanian).

Kerasevicius T. & Kropas A., 2006. Applied Scientific Geological Investigations of the Construction Site of the New Nuclear Power Plant at the Territory of the State Enterprise Ignalina Nuclear Power Plant. Site Survey-Selection Stage. UAB “Hidroprojektas”, Kaunas.

Klimas A., 1988. Spatial and Temporal Irregularity of Groundwater Infiltrational Recharge // Vodnye resursy, 1988, No. 3, P. 66-72 (in Russian).

Mazeika J., 1993. Izotopical Investigations of Groundwater Migration. Geologija. 15. Vilnius. P. 67–73 (in Lithuanian).

Marcinkevicius V. et al., 1995. Hydrogeological and Engineering-Geological Mapping of Ignalina NPP Area at a Scale 1:50 000 in Topographical Sheets N-35-5-G-v, g; N-35-17-B; N-35-18-A; N-35-17-G-a, v; N-35-18-V-a, b (Druksiai object). Report. Archive of Geological Survey of Lithuania, Vilnius, 4436 p. (in Russian).

Radiation Protection Centre Project Report, 2007. Project „For the assessment of radioecological and ecotoxicological state of Lake Druksiai to collect information about the radionuclides activity in bottom sediments, flora and fauna of Lake Druksiai and in flora of the vicinity of Ignalina NPP and to measure their activity during the operation of both units as well as after closure of the first unit of Ignalina NPP” Report. Vilnius, Radiation Protection Centre, Institute of Geology and Geography, Institute of Physics, Institute of Botany, p. 1–251 (in Lithuanian).

Section 7.5

Conclusion of working group on evaluation of seismic conditions at Ignalina NPP industrial site, 1988. Moscow. Archives of INPP (in Russian).

Preliminary evaluation of seismic hazard of at the Ignalina NPP site of the second succession according to archive and literature data, 1981. Report “Hidroprojekt”, Moscow. Archives of INPP (in Russian).

Jonusas A., Kropas A., Kerasevicius T., 2006. Applied scientific geological investigations of the construction site of a new nuclear power plant at the territory of the state company Ignalina Nuclear Power Plant. Verification stage. UAB ”Hidroprojektas”. Kaunas.

Juknelis I., Marcinkevicius V., Sestokas I., 1990. Faults in Ignalina NPP Region. Problems of Environmental Geology in Baltic States and Belarus. Abstracts. Vilnius. Institute of Geology (in Russian).

Juozapavicius G., Juodkazis V., 1987. Conclusions on the possible changes of geological, hydrogeological and engineering geological conditions in the area of Ignalina NPP. Geology Directorate, Institute of Geology. Vilnius. Archives of Lithuanian Geological Survey.

Kerasevicius T., Kropas A., 2006. Applied scientific geological investigations of the construction site of the new Nuclear Power Plant at the territory of the State Ignalina Nuclear Power Plant. Site survey-selection stage. UAB “Hidroprojektas”, Kaunas.

Krainiukov S., Krivulin N., Horundzyj V., 1996. Technical report on geotechnical investigations at the Ignalina NPP site of the second succession OPY-750. VNIPET. Leningrad. Archives of INPP (in Russian).

Order on Inventory of Dangerous Materials‘ Releases into the Groundwater and Gathering of Information. Approved by the Minister of Environment of the Republic of Lithuania Ordinance No. 135 of 26 March 2002. State Journal, 2002, No. 38-1406.

Marcinkevicius V., Buceviciute S., Vaitonis V., Guobyte R., Danseviciene D., Kanopiene R., Lashkov E., Marfin S., Rackauskas V., Juozapavicius G., Hydrogeological and Engineering-Geological Mapping of Ignalina NPP Area at a Scale 1:50 000 in Topographical Sheets N-35-5-G-v, g; N-35-17-B; N-35-18-A; N-35-17-G-a, v; N-35-18-V-a, b (Druksiai object). Report. Archive of Geological Survey of Lithuania, Vilnius, 1995, 4436 p. (in Russian).

Mikhailitchenko O., Moshzakhenko D., Nikolski M, 1989. Analysis of seismological information of Ignalina NPP microzonning (according to the investigation PNIIS on the topic No 568). Report on investigations. Institute of ENERGY and Technology (VNIPET). Moscow. Archives of INPP (in Russian).

Order on Inventory of Dangerous Materials‘ Releases into the Groundwater and Gathering of Information. Approved by the Director of the Geological Survey of Lithuania under the Ministry of Environment Ordinance No. 1-06 of 3 February 2003. State Journal, 2003, No. 17-770.

Regulations on Design of Anti-seismic Nuclear Installations. PN AE G-5-006-87. Moscow (in Russian).

Requirements for Analysis of Seismic Impact on Nuclear Installations, P-2006-01. Approved by Ordinance No. 22.3-33 of the Head of VATESI dated June 30, 2006. State Journal, 2006, No. 87-3447.

Stanionis A., 2005. Investigation of Earth Crust movements at Ignalina NPP area using geodetic methods. Doctor thesis. Vilnius Gediminas University. Vilnius (in Lithuanian).

SNiP C-7-81, 1995. Construction in Seismic Territories. Regulations of Design, part II, Section 7. Ministry of Construction. Moscow, GP CPP (in Russian).

Technical Regulation of Construction STR 1.04.02: 2004 „Engineering Geological (Geotechnical) Investigations. State Journal, 2004, No. 25-779.

IAEA Safety Requirements No NS-R-3. Site Evaluation for Nuclear Installations. IAEA, Vienna, 2003.

IAEA Safety Fundamentals. Safety Series No 110. „The safety of nuclear installations". Vienna, 1993.

IAEA Safety Guide No NS-G-1.6. Seismic Design and Qualification for Nuclear Power Plants. IAEA, Vienna, 2003.

IAEA Safety Guide No NS-G-3.3. Evaluation of Seismic Hazards for Nuclear Power Plants. IAEA, Vienna, 2002.

Order on Performance of Groundwater Monitoring by Economy Entities. Approved by the Director of the Geological Survey of Lithuania under the Ministry of Environment Ordinance No. 1-59 of 24 October 2003. State Journal, 2003, No. 101-4578.

Voskresenskaia L., Mindel I., Trifonov B., Smidt G., 1988. Report on instrumental investigations and seismic microzoning of Ignalina NPP industrial site. Volume 2 Text and text appendices. Industrial and Scientific Institute of Geotechnical Investigations (PNIIS). Moscow. Archives of INPP (in Russian).

Zakarevicius A., 1999. Recent movements of Earth Crust at Ignalina NPP area. Science of Lithuania. Geosciences. Monograph, Book 23. Vilnius, issued by "Lithuanian science". p. 490-501 (in Lithuanian).

Section 7.6

Baleviciene J., Sinkeviciene Z., Balevicius A., 1997. Druksiu ezero litorales augmenijos bukle ir daugiametes jos kaitos. – Lietuvos valstybine mokslo programa Atomine energetika ir aplinka. Moksliniu ataskaitu rinkinys. 1993–1997. 3. 3-73 (in Lithuanian).

Baleviciene J., Lazdauskaite Z., Sinkeviciene Z., Stankeviciute J. 1997. AE regiono augmenijos charakteristika, dinamika, kaitos, apsauga. – Lietuvos valstybine mokslo programa Atomine energetika ir aplinka. Moksliniu ataskaitu rinkinys. 1993 – 1997. 4. 103-184 (in Lithuanian).

Barauskas R., Baskyte R., Kirstukas M., Mikalauskas G., Snitkiene L., Valantiejiene V., 2004. Lietuvos gamta. Saugomos teritorijos. Lutute (in Lithuanian).

European Commission 2007: Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC. Clarification of the concepts of: Alternative solutions, Imperate reasons of overriding public interest, Compensatory measures, Overall Coherence, Opinion of the Commission. January 2007.

Kozulin A. V., Vergeichik L. A., Nikiforov M. E., Ivanovski V. V., Birjukov V. P., Dombrovski V. Ch., Grichik V. V., Mximenkov M. V, Byshniov I. I., Sidorovich V. E., Cherkas N. D., Mongin E. A. 2002. Treasures of Belorusian Nature. Minsk.

Kurlavicius P. & Raudonikis L., 2001. Lietuvos paukstiu vietiniu perinciu populiaciju gausa. Ciconia. 9:92-97 (in Lithuanian).

Radiation Protection Centre Project Report, 2007. Project „For the assessment of radioecological and ecotoxicological state of Lake Druksiai to collect information about the radionuclides activity in bottom sediments, flora and fauna of Lake Druksiai and in flora of the vicinity of Ignalina NPP and to measure their activity during the operation of both units as well as after closure of the first unit of Ignalina NPP" Report. Vilnius, Radiation Protection Centre, Institute of Geology and Geography, Institute of Physics, Institute of Botany, p. 1–251 (in Lithuanian).

Rasomavicius V. (edit.). 2007. Lithuanian Red Book. Lietuvos raudonoji knyga. Lutute (in Lithuanian).

Raudonikis L., 2004. Europos Sajungos reiksmes paukstiams svarbios teritorijos Lietuvoje. Important bird areas of the European Union importance in Lithuania. Lietuvos ornitologu draugija ir Ekologijos institutas. Kaunas, Lutute (in Lithuanian).

Raudonikis L. & Kurlavicius P., 2000. Paukstiams svarbios teritorijos Lietuvoje. Important bird areas in Lithuania. Lietuvos ornitologu draugija. Kaunas, Lutute (in Lithuanian).

Results of Radiation Monitoring at INPP Region in 2007. INPP Report PTOot-0545-15, 2008.

Svazas S., Drobelis E., Balciauskas L., Raudonikis L., 1999. Important wetlands in Lithuania. OMPO and Institute of Ecology. Vilnius.

Svazas S., Balciauskas L., Stankeviciute J., Ivinskis P., Rimsaite, J., Sorokaite J., Raudonikis L., Matuseviciute A., 2008. Description and evaluation of terrestrial biodiversity of region of the Ignalina Nuclear Power Plant. Institute of Ecology. Report No. 14-000.8.8. 206 p. (in Lithuanian).

Section 7.7

Pauliukevicius G., Masiliunas L., Eitmanaviciene N., 1997. Cartography of Landscapes and its Components and Evaluation of Stability of Geosystems in the Ignalina NPP Region. State Scientific Research Programme "Atomic Energy and Environment", Collection of Research Reports, 1993–1997, Vilnius, Vol. 4, P. 2–102 (in Lithuanian).

Environmental Impact Assessment Report U1DP0, 2007. INPP Unit 1 Decommissioning Project for Defueling Phase. Ignalina NPP Decommissioning Service, A1.4/ED/ B4/0006, Issue 7.

Section 7.8

Working Report of the Society of Lithuanian Archaeology, 2006. On the Archaeological Research of Stabatiskes Manor Place (Village Place) and the Designed Near Surface Radioactive Waste Repository Impact Assessment on the Real Values of Cultural Heritage. The Society of Lithuanian Archaeology. Working report.

Pauliukevicius G., Masiliunas L., Eitmanaviciene N., 1997. Cartography of Landscapes and its Components and Evaluation of Stability of Geosystems in the Ignalina NPP Region. State Scientific Research Programme "Atomic Energy and Environment", Collection of Research Reports 1993–1997, Vilnius, Vol. 4, P. 2–102 (in Lithuanian).

EIA Report of the Near Surface Repository, 2007. State Enterprise Radioactive Waste Management Agency. EIA Report on the Arrangement of the Near Surface Radioactive Waste Repository. Vilnius.

Section 7.9

Resident Survey Report, 2008. The Report of the Survey of the Residents of Visaginas Town and its Surrounding Areas on their opinion on the Construction of the New Nuclear Power Plant. RAIT Ltd., 31 March, 2008, P. 64.

Section 7.10

10 CFR. U.S. NRC Regulations Title 10, Code of Federal Regulations. U.S.

Belene NPP Environmental Impact Assessment Report BNPP-EIA-PEC-NEK-0001-E3 March, 2004. http://www.bluelink.net/ (visited on 10 Oct. 2008).

YVL 1.10. Safety criteria for siting a nuclear power plant, Finland, 2000.

State Journal 1996, No. 119-2771. Law on Nuclear Energy.

INPP DPMU, 2004. Final Decommissioning Plan for Ignalina NPP Units 1 and 2. A1.1/ED/B4/0004, Issue 06. INPP Decommissioning Project Management Unit, 2004.

Ignalina NPP Decommissioning project management unit, 2004a. Environmental Impact Analysis for the New Heat Only Boiler Plant implemented at Ignalina NPP in the frame of INPP decommissioning support investment package B5, B5/TN/B2/0005, Issue: 01.

Ignalina NPP Decommissioning project management unit, 2004b. Environmental Impact Analysis for the New Steam Boiler Plant implemented at Ignalina NPP in the frame of INPP decommissioning support investment package B5, B5/TN/B2/0006, Issue: 01.

Ignalina NPP Decommissioning Environmental Impact Assessment Programme. A1.1/ED/B4/0001, Issue 05. INPP Decommissioning Project Management Unit, 2004.

State Journal, 2007, No. 138-5693. Regulatory Document on the Environment LAND 42-2007 “Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring”.

State Journal, 2002, No. 11-388; 2003, No. 90-4080. Lithuanian Hygiene Norm HN 73:2001 “Basic Standards of Radiation Protection”.

State Journal, 2003; No. 15-624, 2008, No. 35-1251. Lithuanian Hygiene Norm HN 87:2002 “Radiation Protection in Nuclear Objects”.

State Journal, 2004, No. 109-4091. Rules of assessment of the cases of public impact not included in the law of environment impact assessment of the planned economic activity.

Nedveckaite T., Motiejunas S., Kucinskas V., Mazeika J., Filistovic V., Jusciene D., Maceika E., Morkeliunas L. and Hamby D. M. Environmental releases of radioactivity and the incidence of thyroid disease at the Ignalina nuclear power plant, Health Physics, vol. 79, No. 6, 2000.

OECD, 2008. Occupational Exposures at Nuclear Power Plants, Sixteenth Annual Report of the ISOE Programme 2006, NEA Report No. 6318, 2008.

State Journal, 2004, No. 106-3947. Methodical guidelines for the public impact assessment.

RSC 2008. Lithuanian Radiation Protection Centre. [www.rsc.lt], (July 2008).

State Journal 2004, No. 134-4878. "On the approval of regulations for establishing of boundaries and requirements for sanitary protected zones", Order of the Minister of Health No. V-586 dated August 19, 2004.

State Journal, 2002, No. 56-2225. Law of public health care of the Republic of Lithuania.

Section 7.11

INPP DPMU, 2004. Final Decommissioning Plan for Ignalina NPP Units 1 and 2. A1.1/ED/B4/0004, Issue 06. INPP Decommissioning Project Management Unit, 2004.

INPP, PTOot-0545-15. Report on Radiation Monitoring Results at the INPP Region for year 2007.

Ignalina NPP Decommissioning Environmental Impact Assessment Programme. A1.1/ED/B4/0001, Issue 05. INPP Decommissioning Project Management Unit, 2004.

J. Dahlberg, U. Bergström, 2004. INPP Landfill. Studsvik Report. ISBN 91-7010-371-2. Studsvik, RadWaste AB, Sweden.

LEI, 2006. Derivation of Preliminary Waste Acceptance Criteria for Landfill Facility. Final report.

State News, 2007, No. 138-5693. Regulatory Document on the Environment LAND 42-2007 “Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring”.

State Journal, 2003; No. 15-624, 2008, No. 35-1251. Lithuanian Hygiene Norm HN 87:2002 “Radiation Protection in Nuclear Objects”.

New Solid Waste Management and Storage Facilities at Ignalina NPP. Environmental Impact Assessment Report. S/14-780.6.7/EIAR/R:5, Revision 5, Issue date July 8, 2008. Consortium GNS – NUKEM, Lithuanian Energy Institute, 2008.

Interim Storage of RBMK Spent Nuclear Fuel from Ignalina NPP Units 1 and 2, Environmental Impact Assessment Report, Revision 4, Issue date October 24, 2007. Consortium GNS – NUKEM, Lithuanian Energy Institute, 2007.

RATA, 2007. Supplemented environmental impact assessment report for construction of a near-surface repository for radioactive wastes. Version 3-2. RATA, Vilnius 2007 (in Lithuanian)

Section 7.12

Safety Standards Series No. NS-R-3. Site Evaluation for Nuclear Installations. Safety Requirements. IAEA, Vienna, 2003.

Chapter 8

ICRP (1983). Radionuclide transformation, energy and intensity of emissions. ICRP Publication 38. Pergamon Press.

Mazeika J., Motiejunas S. Evaluation of aquatic routine radioactive releases from the Ignalina Nuclear Power Plant. Ekologija, Vilnius, 2003, Nr. 4, 36-42.

Simmonds, J. R, Lawson, G & Mayall, A. (1995). Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment. CEC Luxembourg, EUR 15760 EN.

US DoE (1988). External dose rate conversion factor for calculation of dose to the public. DoE/EH – 0070.

NRC (1977). Nuclear Regulatory Commission, Regulatory Guide 1.109. Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50 (NRC, Washington).

IAEA (1996). International basic safety standards for protection against ionizing radiation and for the safety of radiation sources. Safety series 115. Vienna, IAEA.

IAEA Safety Reports Series No. 19 „Generic Models for use in Assessing the Impact of Discharges of Radioactive Substances to the Environment“.

Chapter 9

Commission Recommendation of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole (notified under document number C(2000) 1299). 2000/473/Euratom.

Council Directive (91/271/EEC) of 21 May 1991 concerning urban waste water treatment. The Council of the European Communities. Official Journal L 135, 30/05/1991 P. 0040 – 0052.

Environmental Monitoring Program. Ignalina NPP, Code PTOed-0410-3V2.

Baubinas R. et al., 2002. The Socio-economic monitoring of the Ignalina Nuclear Power Plant region: methodology, program, implementation. Institute of Geology and Geography, Vilnius.

Edilex 2008. Monitoring of discharges of radioactive substances from a nuclear power plant (in Finnish) [http://www.edilex.fi/stuklex/fi/lainsaadanto/saannosto/YVL7-6].

Radiological-Ecological Investigation of INPP Region before Start of Operation, 1985. Final Report 1-05-03-01-033 160-126, Moscow–Vilnius–Kaunas (in Russian).

Regulatory Document on the Environment LAND 36-2000 “Measurement of Environmental Elements Contamination with the Radionuclides”. State Journal, 2000, No. 101-3208; 2005, No. 59-2083.

Regulatory document on the environment LAND 42-2007 “On the Restrictions on the Release of Radionuclides from Nuclear Installations and Procedure for the Authorisation of Release of Radionuclides and Radiological Monitoring”, State Journal, 2001, No. 13-415; 2007, No. 138-5693.

Lithuanian Hygiene Standard HN 24:2003 “Requirements on Safety and Quality of Drinking Water”, State Journal, 2003, No. 79-3606; 2007, No. 127-5194.

Lithuanian Hygiene Standard HN 73:2001. “Basic Standards of Radiation Protection”, State Journal, 2003, No. 90-4080.

Lithuanian Hygiene Standard HN 87:2002 “Radiation Protection in Nuclear Installations”, State Journal, 2003, No. 15-624; 2008, No. 35-1251.

State Scientific Program “Atomic Energy and the Environment”, Collection of Research Reports, 1993–1997, Vilnius, Vol. 1–5 (in Lithuanian).

Law on Environment Protection of the Republic of Lithuania, No. I-2223. State Journal, 1992, No. 5-75; 2005, No. 47-1558.

Law on Environment Monitoring of the Republic of Lithuania, No. X-595. State Journal, 2006, No. 57-2025.

Regulation on Sewage Management. Approved by the Minister of Environment Ordinance No. D1-515 of 8 October 2007. State Journal, 2007, No. 110-4522.

Regulation on Surface Water Management. Approved by the Minister of Environment Ordinance No. D1-193 of 2 April 2007. State Journal, 2007, No. 42-1594.

Radiation Protection Centre Project Report, 2007. Project „For the assessment of radioecological and ecotoxicological state of Lake Druksiai to collect information about the radionuclides activity in bottom sediments, flora and fauna of Lake Druksiai and in flora of the vicinity of Ignalina NPP and to measure their activity during the operation of both units as well as after closure of the first unit of Ignalina NPP" Report. Vilnius, Radiation Protection Centre, Institute of Geology and Geography, Institute of Physics, Institute of Botany, p. 1–251 (in Lithuanian).

Requirements for Analysis of Seismic Impact on Nuclear Installations, P-2006-01. Approved by the Head of VATESI Ordinance No. 22.3-33 of June 30, 2006. State Journal, 2006, No. 87-3447.

STUK-A227, 2008. Ilus Erkki, Klemola Seppo, Vartti Vesa-Pekka, Mattila Jukka, Ikäheimonen Tarja K. Monitoring of Radionuclides in the Vicinities of Finnish Nuclear Power Plants in 2002–2004. Helsinki.

Thermal Power Generation and Environment, 1992. Ecosystem of the Water-Cooling Reservoir of Ignalina NPP at the Initial Stage of its Operation, Academia Publishers, Vilnius, Vol. 10 (in Russian).

Regulation on Performance of Environment Monitoring of Economy Entities. Approved by the Minister of Environment Ordinance No. 230 of May 15, 2003. State Journal, 2003, No. 50-2240; 2004, No. 181-6712.

Regulation on Ground Water Monitoring of Economy Entities. Approved by the Director of the Geological Survey of Lithuania under the Ministry of Environment Ordinance No. 1-59 of October 24, 2003. State Journal, 2003, No. 101-4578.

Chapter 10

DCD US-ABWR. Design Control Document. Tier 2. Chapter 15. Accident and Analysis. 2008 [http://www.nrc.gov/reactors/new-reactors/design-cert/abwr.html].

DCD US-APWR. Design Control Document. Chapter 15. Transient and Accident Analyses. 2007 [http://www.nrc.gov/reactors/new-reactors/design-cert/apwr.html].

DCD US-ESBWR. Design Control Document. Tier 2. Chapter 15. Safety Analyses. 2007 [http://www.nrc.gov/reactors/new-reactors/design-cert/esbwr.html].

EUR 2001. European Utility Requirements for LWR Nuclear Power Plants. Generic Nuclear Island Requirements.

ICRP, 2007. The 2007 Recommendations of the International Commission on Radiological Protection. Annals of the ICRP, Vol 37, Nos 2-4 2007. ICRP Publication 103. Elsevier. Ed. J. Valentin.

Ignalina NPP code PTOed-0812-20B2, Emergency preparedness. Code on INPP emergency notification.

YVL 2.8. Probabilistic safety analysis in safety management of nuclear power plants. Finland, 2003.

State Journal, 2003, No. 15-624; 2008, No. 35-1251. Lithuanian Hygiene Standard HN 87:2002 Radiation Protection in Nuclear Objects.

State Journal, 2000, No. 57-1691. Lithuanian Hygiene Standard HN 99:2000 Protective Actions of Public in Case of Radiological or Nuclear Accident.

NUREG-1465, 1995. Accident Source Terms for Light-Water Nuclear Power Plants.

Recommendations for Assessment of Potential Accident Risk of Proposed Economic Activity, R 41-02. Approved by the Minister of Environment, Order No. 367 from 16 July 2002. Information Publications, 2002, No. 61-297.

Regulations on Preparation of Environment Impact Assessment Program and Report. Approved by the Order of Ministry of Environment No. D1-636 dated December 23, 2005. State Journal 2006, No. 6-225; 2008 No. 79-3138.

Regulations on Prevention of Industrial Accidents, their Elimination and Investigation. State Journal, 2004, No. 130-4649.

SAND94, 1994. A Comparison of World-Wide Uses of Severe Reactor Accident Source Terms.

Sofiev, M., Prank, M., Jalkanen, J.-P., Valkama, I., Karppinen, A. & Pietarila, H. 2008. Dispersion simulations and dose estimates for Accidental Radioactive Releases from the Planned New Nuclear Power Plant in Lithuania. – Finnish Meteorological Institute, Helsinki, 9.9.2008.

Council State decision 395/91. Decision of the Council of State on the general regulations for the safety of nuclear power plants. Finland, 1991.

Requirements for emergency preparedness for operator of a nuclear facility (P-2008-01), State Journal, 2008, No. 130-5017.

Criteria for Installations Posing the Risk of Fire the Owner (Manager) of which has to Establish Fire Rescue Divisions (Departmental Fire Rescue Forces). LR Government Resolution No. 794. State Journal, 2008, No. 60-2726.