

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 Belarussian 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 Belarussian 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 3 200 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 ($0.8 \text{ m}^3/\text{s}$), estimated to be caused by the INPP with average production⁵ of 1 800 MW, from the natural average outflow ($\text{MQ}=3.3 \text{ m}^3/\text{s}$). The estimated present mean discharge to the River Prorva is thus $2.5 \text{ m}^3/\text{s}$.

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 $0.7 \text{ m}^3/\text{s}$ 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

⁵ 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 minimum allowable discharge in River Prorva will remain at the present level ($0.64 \text{ m}^3/\text{s}$) in all of the scenarios.

The decrease in the mean discharge in River Dysna is so small (7 % of the mean discharge $10 \text{ m}^3/\text{s}$) 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 $2\,230 \text{ MW}_{\text{released}}$ 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 $3\,160 \text{ MW}_{\text{released}}$. Thermal loads of $4\,460\text{--}6\,310 \text{ MW}_{\text{released}}$ 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 ($3\,400 \text{ MW}_e$) 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 radiation doses due to 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 3 200 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

An evaluation of aquatic routine releases from the new NPP has been performed in terms of public individual doses as is recommended in international practice (*IAEA Safety Reports Series No. 19*). This approach is following from an analysis of INPP routine releases, which is presented in detail by Mažeika and Motiejūnas (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 Dysna 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 infants, children and 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 (^3H , ^{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 m³/s (observation in 1980-1983, below locality Drisviaty in Belarus), R. Dysna 10 m³/s (observation in 1945-1960, below confluence with Druksa rivulet), R. Dysna 30 m³/s (observation in 1945-1981, below locality Sharkovshchina in Belarus), R. Daugava 288 m³/s (observation in 1944-1988, below Dysna town in Belarus), R. Daugava 451 m³/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 m³/s and water volume of $1.1 \cdot 10^{12}$ m³ 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 Mažeika and Motiejūnas (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, ^3H) 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 (^3H , ^{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), radiological impact of the new NPP 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 type	ESBWR	ABWR	AP-1000	APWR	EPR	EC-6
	Number of Units	2	2	3	2	2	4
Downstream location (Compartment No)	Outflow from Lake Druksiai – Prorva rivulet (1)	2.20E-04	1.20E-03	1.04E-02	1.64E-02	1.96E-02	5.20E-02
	Dysna r. at confluence with Drisviata rivulet (2)	2.40E-05	1.40E-04	1.18E-03	1.96E-03	2.40E-03	6.20E-03
	Dysna r. locality Sharkovshchina in Belarus (3)	1.32E-05	8.20E-05	6.20E-04	1.04E-03	1.22E-03	3.20E-03
	Daugava R., below Dysna town in Belarus (4)	4.00E-06	1.90E-05	2.60E-04	4.20E-04	5.20E-04	1.38E-03
	Daugava r., in Daugavpils (5)	1.72E-06	8.80E-06	1.08E-04	1.74E-04	2.20E-04	5.80E-04
	Daugava R., Riga (6)	4.80E-07	2.40E-06	3.20E-05	5.00E-05	6.20E-05	1.64E-04
	Gulf of Riga, Baltic Sea (7)	1.40E-07	7.20E-07	8.80E-06	1.42E-05	1.78E-05	4.60E-05

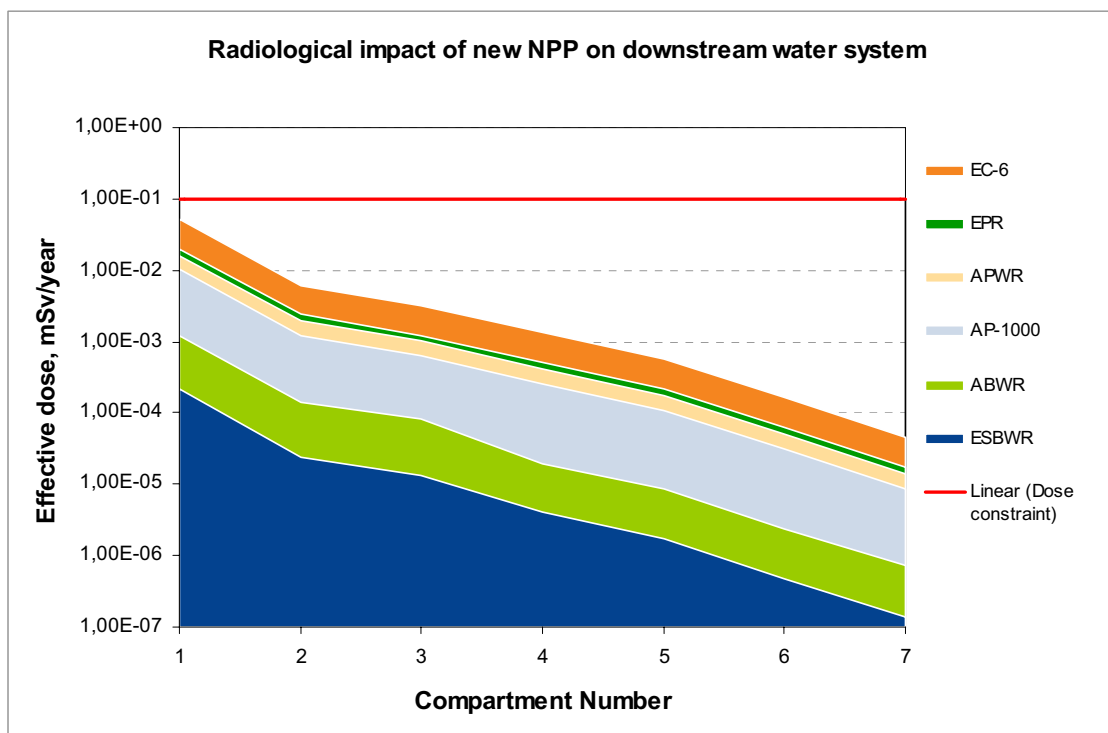


Figure 8.11-1. Radiological impact of new NPP on downstream water course. Location of compartment is given in Table 8.11-1.

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 ³H release rate compared to other types of reactors.

The cross border transfer of new NPP effluents via hydrological pathway to Belarus and especially to Latvia is insignificant. In downstream Lake Obole compartment (Belarus) the committed dose is less than the exemption level (0.010 mSv/year).

In order to investigate the change in dose due to radioactive releases into atmosphere with distance, the dose for the population at different locations from the release point was evaluated. The radiation exposure at distances up to 20 km 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”.

According to the results of the calculations, the change in dose with distance is presented in Figure 8.11-2. 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. 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 calculations the dose due to releases from all types of reactors, except CANDU, is less than the exemption level (0.010 mSv/year) at a distance of 3 km from the NNPP; for CANDU this distance is about 8 km. The transboundary impact due to releases is therefore insignificant.

Transboundary radiological impacts in case of accidents are evaluated in Chapter 10.

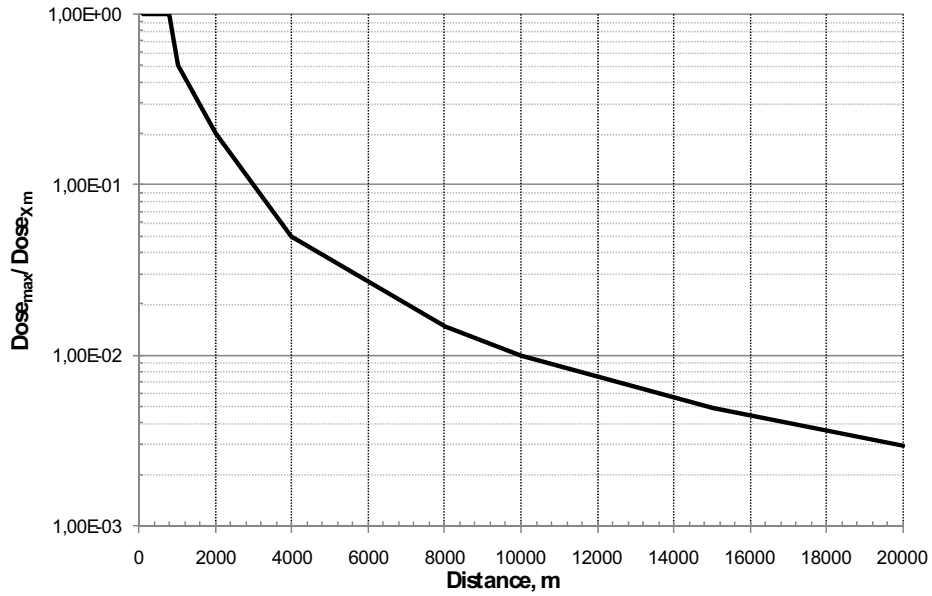


Figure 8.11-2. Dose decrease rate with a distance.

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.