JSC “Specialus montažas–NTP” Lithuanian energy institute

Landfill Facility for Short-Lived Very Low Level Waste(B19)

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ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FACILITY FOR SHORT-LIVED VERY LOW LEVEL WASTE

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TABLE OF REVISIONS

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LIST OF ABBREVIATIONS

ALARA	An acronym for radiation protection principle **A**s **L**ow **A**s **R**easonably **A**chievable (the radiation dose should be minimized to the greatest possible extent, except where the additional cost or impracticality of further dose-reduction measures would be unreasonable)
Bld.	Building
Buffer storage	Storage facility for measurements, accumulation and safe interim storage of the very low level waste between disposal campaigns in the disposal facility for very low level waste
CJSC	Closed Joint-Stock Company
CRWP	Combustible Radioactive Waste Package (multilayered plastic containers with spent ion-exchange resins or plastic bales with pressed combustible waste)
DB	Data Base
DDBandDMS	Decommissioning Data Base and Decommissioning Management System
EIA	Environment Impact Assessment
FIHC	Fuel Inspection Hot Cell
IAEA	International Atomic Energy Agency
INPP	Ignalina Nuclear Power Plant
ISAM	An acronym for the methodology, recommended by IAEA (**I**mprovement of **S**afety **A**ssessment **M**ethodologies for Near Surface Disposal Facilities)
ISFSF	Interim Spent Fuel Storage Facility
Landfill	Disposal facility for short-lived very low level waste. Specific disposal for short-lived very low level waste, operated according to the VATESI license
LEI	Lithuanian Energy Institute
LRW	Liquid Radioactive Waste
NCRW	Non-Combustible Radioactive Waste
NCRWP	Non-Combustible Radioactive Waste Package (half height ISO container with NCRW)
NEO	Nuclear Energy Object
NPP	Nuclear Power Plant
RAW	Radioactive Waste
R/c	Reinforced concrete
RWP	Radioactive waste package, i. e. RAW, placed into a waste container or treated by some other means in order to perform subsequent management operations (transportation, measurement of activity, storage and disposal) in a proper way
SAC	Special Areas for Conservation
SCI	Site of Community Importance
SNF	Spent Nuclear Fuel
SNFS	Spent Nuclear Fuel Storage
SPA	Special Protection Area
SPZ	Sanitary Protection Zone

SRW	Solid Radioactive Waste
SWMSF	Solid radioactive Waste Management and Storage Facility
SWTSF	Solid radioactive Waste Treatment and Storage Facility
TLD	Thermoluminescent dosimeter
VATESI	State Nuclear Power Safety Inspectorate (Lithuanian acronym)
VLLW	Very Low Level Radioactive Waste
WAandSMS	Waste Account and Storage Management System
WAC	Waste Acceptance Criteria

INTRODUCTION

A *Landfill* facility for short-lived very low-level waste should be constructed at the INPP in the scope of the preparation for decommissioning. The entire *Landfill* facility shall consist of disposal units of the RAW and a buffer storage facility for the waste awaiting their disposal.

Proposed economic activity considered in this document is an installation of the buffer storage facility as well as Landfill disposal units for short-lived very low-level waste generated during operation and decommissioning of Ignalina Nuclear Power Plant.

The objective of the buffer storage facility is activity measurement, accumulation and safe interim storage of the waste between disposal campaigns in the *Landfill* disposal units, which will take place not rare than once in two years.

The purpose of disposal units is to dispose very low activity waste according to the safety requirements [1], providing the necessary protection level of the environment, both from radiological and non-radiological impact..

The proposed economic activity belongs to the type of activity, for which the environment impact assessment (EIA) is obligatory (see. Appendix 1, par. 9.5 in document [2]).

Structure and content of the EIA report are prepared in compliance with rules established in document 3] and its appendix and according to the requirements, defined in Chapter VIII “Environment Impact Assessment” of the Requirements on the disposal of very low activity radioactive waste [1].

The proposed economic activity as well as the developed EIA report concerns design, erection, installation, setting-to-work, commissioning, operation and decommissioning of the buffer storage, and design, erection, installation, setting-to-work, commissioning and operation of the disposal units as well as the institutional control period of the disposal facility after its closure.

SUMMARY

In scope of the proposed economic activity a new complex of the Landfill facility will be constructed. Short-lived very low-level waste generated during operation and decommissioning of Ignalina Nuclear Power Plant will be disposed of in the Landfill facility. The entire *Landfill* facility shall consist of disposal units of the RAW and a buffer storage facility for the waste awaiting their disposal. The disposal units and buffer storage facility will be installed in two different sites.

It is planned to locate buffer storage facility at the site of the former INPP Reactor Unit 3 in the vicinity of the site for planned Free Release Measurement Facility. The buffer storage facility as well as disposal units will be constructed in the area assigned for industrial needs of the Ignalina NPP Buffer storage facility is intended for measurements, accumulation and safe interim storage of the waste between disposal campaigns planned to perform not rare than once in two years. Commissioning of the buffer storage facility is planned for 2010. It is planned to operate the buffer storage facility within period of approx. 30 years, i.e. until 2040. After termination of the project for decontamination and dismantling of the buildings and equipment located at the INPP industrial site according to *Final Decommissioning Plan for Ignalina NPP* no more very low-level radioactive waste will be generated. Afterwards the *Landfill* buffer storage facility will be decommissioned and dismantled.

Landfill disposal units are planned to be construct in the site close to INPP, to south from the sites of the designed new Spent Nuclear Fuel Storage Facility (SNFSF) and new Solid Waste Treatment and Storage Facilities (SWTSF). The objective of disposal units is the disposal of short-lived very low-level radioactive waste following the safety requirements, ensuring the protection of environment against both radiological and non-radiological impact. Commissioning of the first disposal unit of the *Landfill* disposal facility is foreseen no sooner than in 2011, that is when the disposal facility will be constructed, and the buffer storage will have accumulated amount of waste packages necessary for performing the first disposal campaign. Disposal of very low level RAW will be carried out till the end of INPP decommissioning activities. The last disposal campaign may be estimated in 2040, after which the disposal facility will be closed, and the institutional control period will begin. In compliance to the requirements for disposal the period of active institutional surveillance of *Landfill* disposal facility has to continue not less than 30 years, and after it a passive surveillance of the disposal facility should follow.

The impact should be different during separate periods of the activity: construction, operation, decommissioning of the buffer storage facility and disposal units as well as after closure of the Landfill repository. The waste, produced during the operation of the buffer storage and disposal units is under consideration as an important aspect as well. Hazardous waste will not be generated during proposed economic activity. The amount of other waste generated will not be large. It will be managed according to the requirements of legislation and normative documents of Republic of Lithuania.

A noise and air pollution during construction period of the facilities as well as during transportation of containers with RAW during operation period should be a potential source of non-radiological impact on the health of population.

The construction of the buffer storage facility is intended within industrial area of INPP which is relatively distant (approx. 10 km) from the densely populated regions (Visaginas town). Therefore the non-radiological impact resulted from the proposed economic activity should be negligible and no negative impact on the health of population is expected.

A local increase of noise is expected during construction of the storage facility. The impact of noise should be expected in the close vicinity where are no permanent residents. Releases of non-radioactive contaminants (exhaust gases from mobile sources) during operation of the buffer storage

are negligible and will not cause any significant impact to the environment as well to the public health. The intensity of the RAW delivery to the buffer storage is estimated no more than 2 containers day. Fork-lift trucks intended to use for loading of RAW packages are equipped with the exhaust gas cleaning system and are designed to work in closed premises.

Since in the vicinity of the site planned for the construction of the *Landfill* facility there are no permanent residents (proposed economic activity will be carried out in the Ignalina NPP industrial site, i.e. in the existing sanitary-protection zone with radius 3 km) it is estimated that the impact on the public health should be negligible during its construction phase. Moreover, the duration of disposal campaigns will not be lengthy and they will be carried out quite rarely (it is foreseen one campaign 1-2 month long per 1-2 years). It will not be the source of noise that should impact the public health.

The RAW transportation route will be inside the sanitary protection zone of the INPP and will not pass through populated territories. The impact zone will encompass the construction zone, the road, and their close environment (a zone within a diameter of approx. 100 m). Considering that RAW transportation intensity will be rather low therefore the impact during the construction of the *Landfill* disposal facility as well as during its operation will be negligible.

Non-radiological impact of other type on the components of environment or public health is not expected during proposed economic activity is not expected.

Potential impact resulted from the proposed economic activity under normal operation conditions should be due to direct irradiation from the facility and equipment containing radioactive materials as well as due to releases of airborne radionuclides from the contaminated surface of containers through the ventilation system of the buffer storage facility. All liquid radioactive waste generated during operation of the buffer storage facility will be safely collected and transported to INPP LRW treatment facility for proper treatment. Therefore the sources of potential radiological impact on environment under normal operation conditions are considered in the report as follows:

- Direct irradiation from the buffer storage facility;
- Airborne radionuclide releases through the ventilation system of the buffer storage facility;
- Waterborne radionuclide releases from the disposal units after the closure of the Landfill disposal facility;
- Release of gaseous radioactive substances from the disposal facility during operation period;
- Direct irradiation from the disposal facility;
- Unintended intrusion into the disposal facility after the period of institutional control

The annual effective dose to a member of the critical group of population due to direct irradiation from the buffer storage structure should be about 0.036 mSv, and it would be insignificant in comparison to the value of the dose constraint 0.2 mSv per year [4]. The estimated dose value is the conservative (overestimated) one assuming exposure duration of 730 h per year at the distance of 100 m as well as the buffer storage facility maximally loaded with RAW.

The activity of airborne radionuclide releases through the ventilation system of the buffer storage facility should be negligible as the estimated activity value is five orders of magnitude lower in comparison to established permissible activity limit of radionuclide releases and planned radionuclide releases into atmosphere from the NEO located within the INPP site.

The buffer storage will be constructed at the INPP industrial site. The area of the INPP site has been changed in the past because of construction and industrial activity, thus natural soil in this area is almost totally absent. The INPP site is almost entirely covered by artificially changed ground. No soil pollution is foreseen under normal operation conditions of the proposed economic activity. The site area will be permanently monitored. In case of local soil contamination by conventional pollutants or radioactive material appropriate procedures will be implemented to eliminate the hazard and consequences of this impact.

The proposed economic activity will not affect the underground component of the environment. The buffer storage will be constructed at the INPP industrial site, on the territory of the former third unit, and additional impact to the geological structure will be insignificant.

The functional and structural changes in Lake Druksiai biota are caused by thermal releases from INPP and chemical pollution, which main sources are waste waters of INPP and Visaginas municipal sewerage that are returned to Lake Druksiai, after being processed at the general household sewage water cleaning system. Buffer storage facility will not affect the thermal releases, and discharges of waste water during the operation of the buffer storage will comprise only an insignificant part of the waste water from INPP.

A site of the *Landfill* disposal units is distant approximately 2 000 m from southern shore of Lake Druksiai. Lake Druksiai is the largest lake in Lithuania and has its eastern margin in Belarus. The region is dominated by clay, loamy and sandy loam soils, which are responsible for varying water filtration conditions in different parts of the region. Due to design solutions as well as favourable hydraulic properties and runoff conditions in the site the flooding of the Landfill disposal units is not expected during operation period as well as after repository closure.

There will be no uncontrolled waterborne releases into the environment under normal operation conditions of the disposal units. The bottom slab, technological systems and its components used for collection and storage of potentially radioactive effluents will be designed to isolate them fully against any potential interaction with environmental water.

Liquids generated during operation phase, rainwater occurred during disposal campaign as well as sanitary waste water from the showers and sinks will be collected in on-site collecting tank.

However, potential impact on the water component is possible after the active institutional control period of *Landfill* disposal units since in case of barriers damage no repair activities shall be performed.

Activity of the released radionuclides into the water component after closure of the disposal units is insignificant. The potential dose to the members of the critical group of the population in case of water consumption for daily needs is estimated approximately to 0.002 mSv per year, i.e. by two orders of magnitude below the value of the dose constraint – 0.2 mSv per year [4].

Potential radiological impact on the members of the critical group of the population caused by gaseous release of airborne radioactive substances from the disposal units under normal operational conditions should be below 5.6E-07 mSv per year and therefore is negligible in comparison to the dose constraint (0.2 mSv per year). Potential radiological impact at the distance of 25 m (a nearest distance of the member of critical group of the population to the disposal facility) due to direct irradiation should be approximately 3.1E-08 mSv per year, i.e. negligible.

Potential radiological impact on the health of the population resulted from the disposal units after the institutional control period in case of unintended intrusion into the disposal facility is estimated to 0.022 mSv per year, i.e. much below the value of 10 mSv per year, specified by Lithuanian Hygiene Standard [4], used for such cases and, based on clause 91 of document [4], accepted according to the recommendations of document [20].

The surface of the site has been artificially changed in the past (during the construction of INPP) and later re-cultivated. Filled-up ground is laying under the vegetative layer in some places. The site should be deforested as well as a lot of the excavation works should be carried out for the construction of the *Landfill* disposal units. The layer of the fertile soil will be removed. As the layer of the fertile soil will be removed during construction phase of the *Landfill* disposal units it will be kept and used after closure of the disposal facility for forming of a vegetative layer at the top of the facility. No soil pollution is foreseen under normal operation conditions of the proposed economic activity.

Existing and planned nuclear facilities located at the Ignalina NPP site and considered in this assessment are: as follows:

- Ignalina NPP;
- New NPP;
- Existing SNF storage;
- New ISFSF (project B1);
- New SWMSF (projects B2/3/4);
- Building 158 (bituminised waste storage facility transformed into the repository) and new interim storage facility for solidified radioactive waste (bld.158/2);
- *Landfill* buffer storage facility;
- Near-surface repository for low and intermediate level RAW.

An estimation of the common impact resulted from the proposed economic activity as well as from the existing and planned nuclear facilities during operation period of the *Landfill* facility demonstrates that the maximum annual effective dose to the member of critical group of population should be approx. 8.74E-02 mSv, i.e. below the dose constraint (0.2 mSv per year). The most contribution to the total dose is caused by impact from buffer storage facility, new NPP as well as due to radionuclide releases from the NEO in the INPP industrial site during decommissioning of INPP.

The estimated total annual effective dose to a member of the critical group from the existing and planned nuclear facilities during period after closure of the Landfill disposal units equals to 0.062 mSv, i.e. about factor of three below the dose constraint (0.2 mSv per year).

The analysis of the direct irradiation from the existing and planned nuclear facilities revealed that the increase dose rate is observed just in the close vicinity of the NEO and should be negligible at the boundary of the SPZ of INPP.

Analysis of alternatives demonstrates that the conditions in the selected sites for the proposed economical activity (buffer storage facility as well as the disposal units) are most favourable.

Emergency situations (emergencies) potentially resulting from the proposed economic activity and which could potentially cause an impact on the environment are analysed in the EIA report. The main goal of the analysis is to demonstrate the possibility of the proposed economic activity in the selected site considering the character of the planned activity as well as the potential impact on environment.

The analysis of the potential emergency situations and the estimation of their consequences demonstrates that in case of the identified emergency , i.e. the fire of 24 packages with combustible RAW in the buffer storage, the annual effective dose to the member of critical group of population should be below 0.01 mSv, i.e. negligible assuming both external and internal exposure pathways.

The accident of a plane crash on the Buffer Storage / the disposal units has been chosen for the analysis of the potential environmental impact of Beyond Design Basis Accident. Other scenarios of Beyond Design Basis Accidents, such as intentional sabotage by a worker (with use of explosives) or a terrorist act, were not estimated, considering that:

a) The activity of the stored/disposed waste is very low, therefore it is unlikely, that they could be the target of terrorists, since consequences of the terrorist act would be insignificant and easily eliminated,
b) The waste do not contain materials which could be used for preparation of large-scale terrorist acts (a "dirty" radioactive bomb);
c) The storage facility will be arranged on the well protected industrial site of INPP, the disposal units will also be constructed within the protected zone and provided with necessary measures of physical protection;
d) For prevention of terrorist acts and diversions, and also for liquidation of possible

consequences "Comprehensive Plan of Protection Against Terrorist Acts" has been developed and has been in force at INPP;

e) Consequences and potential impact of similar cases (waste spilling, waste fire) are completely covered by an accident of a plane crash, which is further analyzed as having the most serious consequences.

The probability of aircraft crash event is extremely low ($\sim 10^{-7}$). The analysis of the consequences resulted from aircraft crash demonstrates that the annual effective dose to the member of critical group of population assuming both external and internal exposure pathways would be approximately 0.31 mSv/year in case of the Buffer Storage and approximately 8 mSv/year in case of the disposal units, i.e. below the limiting value (10 mSv) [4] determined for the design basis accident.

The analysis of the consequences in case of fire during disposal campaign in the Landfill disposal facility revealed that the annual effective dose to the public should be approx. 0.58 mSv, i.e. below 10 mSv established for the design basis accident [4].

Landscape around the INPP 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 recreation areas along Lake Druksiai with their specific natural and visual qualities have a great value for the quality of life. The valuable landscape areas (like Grazute Regional Park and Smalva hydrographical reserve) are located at about 10 kilometers from the buffer storage building. The planned storage will be constructed and operated at the INPP industrial site. Impact to the existing landscape is not expected. A slightly more intensive traffic on the roads of the INPP industrial site, due to radioactive waste transportation, will not change the general view.

The proposed economic activity will be held within the INPP industrial site and within the existing 3 km radius sanitary protection zone of INPP. There is no permanently living population within the existing sanitary protection zone, and the economic activity is limited as well.

No impacts or evident changes of social and economical environment are foreseen. Necessary labor resources to perform the proposed economic activity are available at INPP. Moreover, this project will decrease the social and economic impacts of the INPP final shutdown by using the work force with a high skill level associated with work in the nuclear industry.

No negative impact on the environmental components both social-economic and natural of the neighbouring countries (Latvia and Belarus) is expected due to proposed economic activity. No impact on the health of the population of the neighbouring countries is expected as well. The potential impact on the public health of Latvia and Belarus in case of emergencies should be below the limits of the radiation protection.

Summarizing the results obtained after the assessment of the environmental impact from the proposed economic activity, both for the construction of the Buffer Storage and of the Disposal Units for very low level waste, it can be concluded that no components of the environment will be impacted significantly.

To mitigate the impact on such components as the soil and the biodiversity, corresponding mitigation measures will be taken during the construction and operation of the disposal units.

Impact on the population health is much below the limits established by the normative documents of the Republic of Lithuania both in case of normal operation of the planned nuclear facilities and in the period after closure of the disposal units, therefore for the planned economic activity the impact is estimated as negligible.

In case of implementation of the planned economic activity the total impact from the nuclear facilities located in the INPP sanitary protection zone also remains within the permissible limits.

During normal operation of both the Buffer Storage and the Disposal Units negative impact on the environment and the population health of the neighboring states is not expected.

The estimation results of the dose to the members of the critical group of the population in case of design basis and beyond design basis accidents have revealed that the exposure will be below the maximum permissible effective dose established by the normative documents of the Republic of Lithuania.

Both the construction of the Buffer Storage and the Disposal Units for very low level waste will not have a significant negative impact either on the environment or on the population health.

The proposed economic activity will be performed in accordance with the modern environmental requirements using state-of-the-art technologies. The proposed economic activity represents the EU direct investment for the INPP decommissioning. It will be performed in compliance with the radioactive waste management principles of the IAEA and in compliance with good practices in other European Union Member States.

1 GENERAL INFORMATION CONCERNING BUFFER STORAGE FACILITY AND DISPOSAL UNITS

1.1 Organizer of the proposed economic activity

The organizer of the proposed economic activity is **State Enterprise Ignalina Nuclear Power Plant**:

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1.2 Developer of the EIA Report

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1.3 Title and Description of the Proposed Economic Activity

The title of the proposed economic activity is **Disposal Facility and Buffer Storage facility for Short-Lived Very Low Level Waste**. The entire *Landfill* facility shall consist of two main objects, i.e. the disposal units and a buffer storage facility for the waste awaiting their disposal. Each object will be located in separate sites (Figure 1.1).

The objective of the buffer storage facility is activity measurement, accumulation and safe interim storage of the waste between disposal campaigns in the *Landfill* disposal facility, which will take place not rare than once in two years. Buffer storage facility will be able to contain up to 4 000 m^3 of the radioactive waste packages [5, Appendix 1].

The purpose of disposal units of *Landfill* disposal facility is to dispose very low level radioactive waste according to the requirements in [1], ensuring the necessary protection level of the environment. It is estimated that *Landfill* disposal facility will comprise three disposal units with the capacity of each 20 000 m^3 of packed radioactive waste [5, Appendix 1].

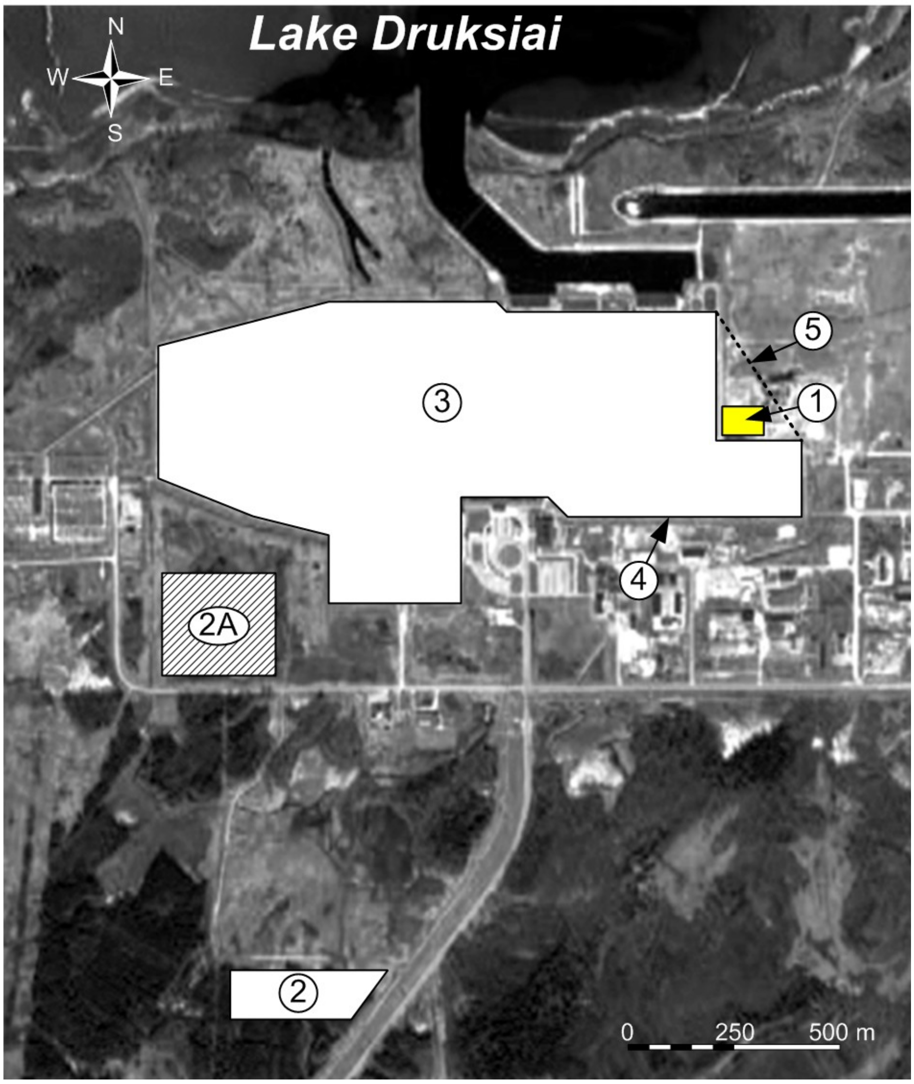

Figure 1.1. Location scheme for the *Landfill* buffer storage facility and disposal units:

① – Site of the *Landfill* buffer storage facility (B19);
② – Site of the of the *Landfill* disposal units (B19) with the alternative location for buffer storage facility;
(2A) – Alternative site of the *Landfill* disposal units;
③ – INPP industrial site;
④ – Existing perimeter of INPP;
⑤ – Relocated perimeter of INPP.

1.4 Stages of Activity and Implementation Period of the Proposed Economic Activity

Commissioning of the buffer storage facility is planned for 2010. It is planned to operate the buffer storage facility within period of approx. 30 years [5], i.e. until 2040. After termination of the project for decontamination and dismantling of the buildings and equipment located at the INPP industrial site according to *Final Decommissioning Plan for Ignalina NPP* [6] no more very low-level radioactive waste will be generated. Afterwards the *Landfill* buffer storage facility will be decommissioned and dismantled.

Commissioning of the first disposal unit of the *Landfill* disposal facility is foreseen no sooner than in 2011, that is when the disposal facility will be constructed, and the buffer storage will have accumulated amount of RWP necessary for performing the first disposal campaign. Disposal of very low level RAW, that is operation of disposal units will be carried out till the end of INPP decommissioning activities. The last disposal campaign may be estimated in 2040, after which the disposal facility will be closed, and the institutional control period will begin. According to clause 16 of the *Requirements for disposal of very low level radioactive waste* [1] the period of active institutional surveillance of *Landfill* disposal facility has to continue not less than 30 years, and after it a passive surveillance of the disposal facility should follow. Durations of active and passive institutional surveillance based on the project and results of the safety analysis shall be specified in the disposal facility license [1].

1.5 Site Status and Area Planning Documentation

The construction of the *Landfill* buffer storage facility as well as disposal units is planned within the industrial area allocated for the State Enterprise Ignalina NPP (land identification No. 453500020005) [7]. According to the State Land Exploitation Agreement No. PN 45/03-0071 [8] dated from July 2, 2003, the State Enterprise Ignalina NPP uses the site under term-less conditions.

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 energetic installations and other)”. The proposed economic activity will use the land in accordance with the defined land usage purpose.

1.6 Characteristics of Radioactive Wastes

1.6.1 General Information

With regard to the “Regulation on the Pre-Disposal Management of Radioactive Waste at the Nuclear Power Plant” VD-RA-01-2001 [9] Class A solid radioactive waste can be disposed of in the *Landfill* disposal facility if they comply with requirements as follow:

- The dose rate on the surface of waste shall be less than 0.5 mSv/h;
- Containing beta or gamma emitting radionuclides with half-lives less than 30 years, including ^{137}Cs, and/or long-lived alpha emitting radionuclides, with measured and/or calculated, by using approved methods specific activity is less than 4000 Bq/g in individual waste packages, on condition that an overall average specific activity of long-lived alpha emitting radionuclides is less than 400 Bq/g per waste package;
- Final waste processing (conditioning) is not required;
- Waste acceptance criteria (WAC) [1] are satisfied.

The limits of specific activity and dose rate established in Regulations [9] are applicable just to classify the RAW and assign the proper way to dispose it. Actually the real limits will be determined by WAC. Preliminary estimations have demonstrated considerably lower values than indicated in the Regulations.

1.6.2 Types and Classes of Wastes

There are two main groups of wastes intended for the storage in the *Landfill* buffer storage facility as well as for disposal in the disposal units [5, Appendix 4]:

1. *Operational waste* and
2. *Decommissioning waste.*

Operational waste are generated and stored on INPP since middle 80'ies and will be produced until the year 2010, when INPP Unit 2 will be shut down [5, Appendix 4].

Generation of the *decommissioning waste* starts, when dismantling of the systems of the INPP Unit 1 finally shut down at the end of the year 2004 begins, and will continue until all systems and structures of Ignalina NPP both units will be finally dismantled [5, Appendix 4].

The operational and decommissioning waste are divided into combustible and non-combustible waste [5, Appendix 4] taking into account radioactive waste processing techniques used at INPP.

A part of industrial waste, operational Group 1 waste and spent ion-exchange resins of condensate cleaning system are intended for *Landfill* disposal. Industrial waste is waste, generated inside INPP controlled area, which does not fall under definition of radioactive waste according to the old classification, currently used at INPP (see Figure 1.2) According to the old classification system, the dose rate on the surface of industrial waste must not exceed 0.6 μSv/h and surface contamination should be less than 8 Bq/cm^2 [5, Appendix 4].

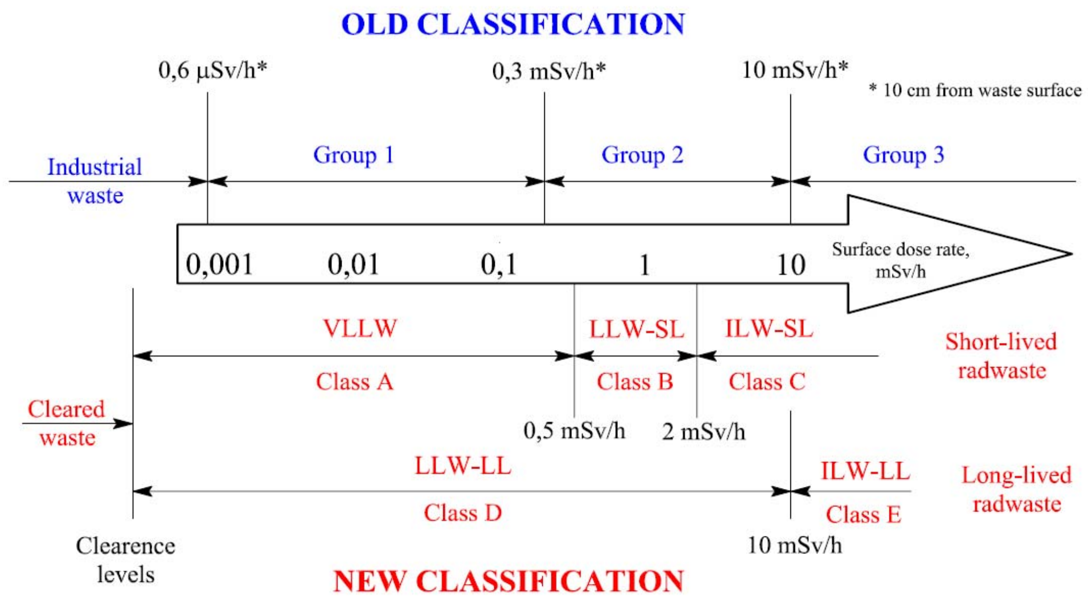

Figure 1.2. Comparison of the new and old waste classification systems. Spent sealed sources (class F according to the new classification) are not indicated

According to the new classification system a part of these wastes is attributed to Class A – very low-level waste. Criteria for division of industrial waste into "clean" and very low-level waste is conformity of nuclide activity in the waste with the free release levels given in document [10].

It is planned to install a new sorting and activity measurement system for industrial waste (project B2 – Solid Waste Retrieval Facility) at INPP. By means of this system industrial waste will be sorted into cleared waste and Class A waste according to the new waste classification system. According to the new classification, the Group 1 waste is attributed to Class A waste and is also intended for *Landfill* disposal. The content of Group 1 waste is the same as industrial waste and the difference makes only surface dose rate [5, Appendix 4].

1.6.3 Waste Amounts and Volume

The preliminary total volumes of untreated waste intended for *Landfill* disposal, based on the data given in document [6] are presented in Table 1.1 [5, Appendix 4].

Table 1.1. Preliminary volume of waste intended for *Landfill* disposal

Waste type		**Mass, tons**	**Volume, m^3**
Operational	*Combustible*	2 524	10 000
	Non-combustible	4 660	8 025
Decommissioning	*Combustible*	4 433	28 672
	Non-combustible	23 992	15 638

Combustible wastes shall be compacted up to specific weight of 0.6 tons/m^3 and packed into plastic bales of 1 m^3 volume, as it was indicated in Final Decommissioning Plan for INPP [6]. Main parameters of the combustible waste packages are presented in Table 1.2 [5, Appendix 4].

Table 1.2. Main parameters of the combustible waste package

Package type	
Type	Bale
Dimensions	~ 1.2×1.1×0.7 m *
Material	Plastic film
Net volume	~ 1m^3
Package characteristics	
Weight	600 – 1000 kg
Activity (α+β+γ)	~1 – 2×10^3 MBq
Dose Rate	< 0.5 mSv/h (on the surface)
Surface β/γ contamination	< 4 Bq/cm^2
Gross volume	~ 1 m^3

* According to the data from [11]

Non-combustible waste will be cut and placed into standard 20 feet half-height ISO containers with filling coefficient about 0.8. Since external volume of the container is equal to 19 m^3 and internal to – 15.5 m^3, it was estimated, that total volume of the packed non-combustible waste should increase by a factor of 1.53. Main characteristics of the non-combustible waste package are presented in Table 1.3 [5, Appendix 4].

Table 1.3. Main parameters of the non-combustible waste package

Package type	
Type	20 feet half-height ISO container
Dimensions	~ 6.1×2.4×1.3 m
Material	Carbon steel
Net volume	~ 15.5 m^3
Package characteristics	
Weight	Is defined by container type (up to 24 ton)
Activity ($\alpha+\beta+\gamma$)	~ 1 – 3.5×10^4 MBq
Dose rate	< 0.5mSv/h (on surface)
Surface β/γ contamination	< 4 Bq/sm^2
Gross volume	~ 19 m^3

Spent ion-exchange resins after decontamination and drying up to air-dry condition will be placed into the reinforced plastic containers. The main parameters of the ion-exchange package are presented in Table 1.4 [5, Appendix 4].

Table 1.4. Main parameters of the ion-exchanging resins package

Package type	
Type	Container
Dimensions	~ 1×1×1 m
Material	Reinforced plastic container (FIBC)
Net volume	~ 1 m^3
Package characteristics	
Weight	800 – 1000 kg
Activity ($\alpha+\beta+\gamma$)	~ 1 – 2×10^3 MBq
Dose Rate	< 0.5 mSv/h (on surface)
Surface β/γ contamination	< 4 Bq/cm^2
Gross volume	~ $1.1m^3$

The preliminary total volumes of the packed waste intended for *Landfill* disposal, based on the data in document [6], are given in Table 1.5 [5, Appendix 4].

Table 1.5. Volume and quantity of the packed waste intended for *Landfill* disposal

Radioactive waste		**Packed waste volume, m^3**	**Quantity of packages**
Group	**Type**		
Operational	*Combustible*	4 206	4 206*
	Non-combustible	~12 300	~648**
Decommissioning	*Combustible*	7 408	7 408***
	Non-combustible	~24 000	~1 262**

* Number of 1 m^3 bales
** Number of 20 feet half-height ISO containers
*** Including 720 fiberglass reinforced containers for spent ion-exchange resins and 6688 1 m^3 bales.

In total about 11 614 m^3 packed combustible radioactive waste and about 36 300 m^3 packed non-combustible radioactive waste will be sent to the *Landfill* disposal facility. From estimations of the waste volume, presented in Table 1.5, it can be seen that relation between volumes of combustible and non-combustible waste will be approximately 1:3, i.e. about 25 % of the total volume of RAW, intended for disposal in the *Landfill* disposal facility, will be combustible waste. As a result from the mentioned above and taking into account the maximal volume of waste, which could be placed in the buffer storage facility, i.e. 4 000 m^3, it is assumed that 3 000 m^3 of non-combustible RAW and 1 000 m^3 of combustible waste will be stored in maximally loaded storage facility.

1.6.4 Waste Composition

The composition and the relative quantities of the operational and industrial wastes based on data presented in document [12] are given in Table 1.6 [5, Appendix 4].

Table 1.6. Composition of operational combustible waste

Material	**Quantity (by volume), %**
Wood	15 – 20
Filters	15 – 20
Paper, textile (working clothes, cleaning material)	40 – 50
Plastics and rubber	15 – 20

The content and the approximate quantities of the non-combustible operational and decommissioning waste are given in Table 1.7 [5, Appendix 4].

Table 1.7. Content of non-combustible operational and decommissioning waste

Waste material	Quantity	
	tons	**m^3**
Operational waste		
Metal*	1 050	1 875
Construction Materials	1 800	1 875
Thermal insulation	113	1 125
Cables and casings	675	2 175
Dry sediments	1 000	900
Other	23	75
Operational waste in total	**4 661**	**8 025**
Decommissioning waste		
Tools	473	473
PVC	315	2 100
Concrete fragments	2 925	2 925
Metal (dismantled equipment)**	18 456	9 228
Untreated wastes	1 823	912
Decommissioning waste in total	**23 992**	**15 638**
Non-combustible waste in total	**28 653**	**23 663**

* Data concerning waste volume and mass, are obtained from the INPP records.
** It is assumed that during decommissioning more advanced methods of waste size reduction will be used. It has been taken into account when assessing waste volume.

1.6.5 Radiological Characteristics of the Waste

For preliminary assessment of RAW activity intended for storage in the buffer storage facility as well as for *Landfill* disposal nuclide vector for industrial waste (see Table 1.8), and also nuclide vectors for the waste from decommissioning of the building G1 (see Table 1.9), building 117/1 (see Table 1.10) and building V1 (see Table 1.11) are used.

Table 1.8. Nuclide vector for determining of activity in industrial waste from INPP in relation to the activity of ^{60}Co [13]

Radionuclide	Scaling factor	Radionuclide	Scaling factor
^{54}Mn	0.3	^{134}Cs	0.05
^{55}Fe	2.9	^{137}Cs	0.16

Radionuclide	Scaling factor	Radionuclide	Scaling factor
^{65}Zn	0.012	^{238}Pu	6.6×10^{-5}
^{90}Sr	7.6×10^{-3}	^{239}Pu	4.9×10^{-5}
^{93}Zr	1.0×10^{-4}	^{240}Pu	6.2×10^{-5}
^{93m}Nb	0.13	^{241}Pu	0.013
^{94}Nb	0.01	^{241}Am	1.4×10^{-4}
^{110m}Ag	3.3×10^{-2}	^{244}Cm	1.99×10^{-4}

Table 1.9. Nuclide vector for determining of activity in solid waste from decommissioning of the building G1 in relation to the activity of ^{60}Co and ^{137}Cs [14]

Radionuclide	Scaling factor by activity of radionuclide ^{60}Co	Scaling factor by activity of radionuclide ^{137}Cs
^{14}C	8.77×10^{-4}	
^{54}Mn	0.17	
^{55}Fe	4.2	
^{59}Ni	2.25×10^{-3}	
^{63}Ni	0.27	
^{65}Zn	1.56×10^{-4}	
^{90}Sr	1.70×10^{-3}	
^{93m}Nb	2.95×10^{-1}	
^{94}Nb	2.3×10^{-2}	
^{93}Zr	3.6×10^{-5}	
^{99}Tc	1.97×10^{-5}	
^{110m}Ag	1.0×10^{-3}	
^{129}I		4.73×10^{-7}
^{134}Cs		0.09
^{234}U	4.38×10^{-7}	
^{235}U	8.73×10^{-9}	
^{238}U	1.37×10^{-7}	
^{237}Np	2.78×10^{-8}	
^{238}Pu	1.45×10^{-4}	
^{239}Pu	6.96×10^{-5}	
^{240}Pu	1.18×10^{-4}	

Radionuclide	Scaling factor by activity of radionuclide ^{60}Co	Scaling factor by activity of radionuclide ^{137}Cs
^{241}Pu	8.56×10^{-3}	
^{241}Am	1.97×10^{-4}	
^{244}Cm	9.82×10^{-5}	

Table 1.10. Nuclide vector for radionuclides detected in the building 117/1 installations in relation to the activity of ^{60}Co [15]

Radionuclide	Scaling factor	Radionuclide	Scaling factor
^{14}C	2.4×10^{-3}	^{134}Cs	3.2×10^{-2}
^{54}Mn	0.12	^{137}Cs	0.69
^{55}Fe	9.5	^{234}U	1.8×10^{-7}
^{59}Ni	1.7×10^{-4}	^{235}U	3.5×10^{-9}
^{63}Ni	0.13	^{238}U	5.6×10^{-8}
^{65}Zn	1.6×10^{-4}	^{237}Np	1.1×10^{-8}
^{90}Sr	1.3×10^{-3}	^{238}Pu	6.6×10^{-5}
^{93m}Nb	1.8×10^{-1}	^{239}Pu	2.8×10^{-5}
^{94}Nb	1.4×10^{-3}	^{240}Pu	4.8×10^{-5}
^{93}Zr	1.4×10^{-5}	^{241}Pu	1.8×10^{-3}
^{99}Tc	2.0×10^{-5}	^{241}Am	1.5×10^{-4}
^{110m}Ag	1.1×10^{-3}	^{244}Cm	1.3×10^{-4}
^{129}I	3.2×10^{-7}		

Table 1.11. Nuclide vector for determining of activity in solid waste from decommissioning of the building V1 in relation to the activity of ^{60}Co and ^{137}Cs [16]

Radionuclide	Scaling factor in relation to ^{60}Co activity for RAW generated after dismantling of ventilation system and tanks of the repair cooling (1WZ и 1TQ)	Scaling factor for RAW generated after the dismantling of the bld. V1 excluding ventilation system, tanks of the repair cooling and filter medium		Scaling factor for filter medium	
		In relation to ^{60}Co activity	In relation to ^{137}Cs activity	In relation to ^{60}Co activity	In relation to ^{137}Cs activity
^{14}C	0.12	26		0.12	
^{54}Mn	0.07	0.07		0.08	

Radionuclide	**Scaling factor in relation to ^{60}Co activity for RAW generated after dismantling of ventilation system and tanks of the repair cooling (1WZ и 1TQ)**	**Scaling factor for RAW generated after the dismantling of the bld. V1 excluding ventilation system, tanks of the repair cooling and filter medium**		**Scaling factor for filter medium**	
		In relation to ^{60}Co activity	**In relation to ^{137}Cs activity**	**In relation to ^{60}Co activity**	**In relation to ^{137}Cs activity**
^{55}Fe	2.0	2.0		0.7	
^{59}Ni	7.9×10^{-4}	7.9×10^{-4}		7.9×10^{-4}	
^{63}Ni	0.1	0.1		0.1	
^{65}Zn	1.6×10^{-4}	1.6×10^{-4}		1.6×10^{-4}	
^{90}Sr	1.4×10^{-4}	0.22		5.7×10^{-1}	
^{93m}Nb	0.21	0.21		0.01	
^{94}Nb	1.7×10^{-2}	1.7×10^{-2}		5.1×10^{-4}	
^{93}Zr	1.6×10^{-4}	1.6×10^{-4}		5.0×10^{-6}	
^{99}Tc	2.0×10^{-5}	2.0×10^{-5}		2.0×10^{-5}	
^{110m}Ag	1.1×10^{-3}	1.1×10^{-3}		1.1×10^{-3}	
^{129}I	5.5×10^{-8}		4.73×10^{-7}		4.73×10^{-7}
^{134}Cs	3.6×10^{-3}		0,03		0.03
^{137}Cs	0.12				
^{234}U	1.3×10^{-6}	1.3×10^{-6}		3.2×10^{-8}	
^{235}U	2.7×10^{-8}	2.7×10^{-8}		6.4×10^{-10}	
^{238}U	4.2×10^{-7}	4.2×10^{-7}		1.0×10^{-8}	
^{237}Np	8.5×10^{-8}	8.5×10^{-8}		2.0×10^{-9}	
^{238}Pu	2.7×10^{-4}	2.7×10^{-4}		6.3×10^{-6}	
^{239}Pu	2.1×10^{-4}	2.1×10^{-4}		5.1×10^{-6}	
^{240}Pu	3.6×10^{-4}	3.6×10^{-4}		8.7×10^{-6}	
^{241}Pu	0.15	0.15		1.0×10^{-3}	
^{241}Am	8.4×10^{-4}	8.4×10^{-4}		8.5×10^{-6}	
^{244}Cm	1.8×10^{-4}	1.8×10^{-4}		2.7×10^{-6}	

Investigations carried out by Institute of Physics [15] have shown, that the waste produced during dismantling, contain very small amounts of radionuclides ^{3}H, ^{36}Cl, ^{135}Cs and ^{242}Pu, which do not represent any radiological hazard. Therefore the mentioned radionuclides have not been included into the lists of declared nuclide vectors, given in Table 1.8 –

Table 1.11.

Values of the specific activity limits that are taken into consideration in the further calculations are presented in Table 1.12. Preliminary waste acceptance criteria for *Landfill* facility, presented in the document [17] are used for determination of RAW activities intended for *Landfill* disposal. The specific activity limits resulted from the scenarios of the operational period of the *Landfill* disposal facility ($B_{i,l}$) has been determined after the analysis of the scenario of direct irradiation (during loading and stacking of the containers and packages with RAW), scenario of gaseous releases (due to volatile radionuclides presenting in the RAW) as well as scenario of fire (as the combustible waste will be disposed of in the disposal facility). The analysis of the mentioned scenarios has been carried out in the document [17] according to the recommendations of IAEA [18]. The specific activity limits resulted from the scenarios of the RAW leaching from the disposal facility ($C_{i,l}$) has been determined in case of institutional control period of 100 years (30 years of active control and 70 years of passive control) under the assumption that the surface engineering barriers will be absolutely degraded after the period. It should be noted that in the mentioned document the dose constraint value of **0.2 mSv per year** [4] have been used to determine limiting activity values according to inadvertent intrusion scenario. However, as it is indicated in the IAEA report [19], the use of the dose constrain value of 0.2 mSv per year in case of inadvertent intrusion scenarios occurring after the end of the institutional control period (both active and passive) is treated as a too cautious and conservative approach. Therefore, Table 1.12 provides updated values ($C_{i,l}$) for inadvertent intrusion scenarios that were obtained considering the recommendations of the International Commission for Radiological Protection (ICRP) for scenarios of inadvertent intrusion (the value of annual effective dose is 10 mSv [20]).

Table 1.12. Preliminary specific activity limits, used for the estimations of the *Landfill* facility

Radionuclide	**Half-life, years**	**Specific activity limits, Bq/kg**		
		$B_{i,l}$* [17]	$A_{i,l}$** [17]	$C_{i,l}$***
^{14}C	5.73×10^{3}	3.0×10^{7}	$\mathbf{4.0\times10^{5}}$****	1.4×10^{7}
^{54}Mn	8.56×10^{-1}	$\mathbf{1.3\times10^{6}}$	1.0×10^{20}	1.0×10^{20}
^{55}Fe	2.7	$\mathbf{8.7\times10^{6}}$	1.0×10^{20}	1.5×10^{19}
^{59}Ni	7.54×10^{4}	1.5×10^{11}	$\mathbf{6.0\times10^{5}}$	3.4×10^{8}
^{60}Co	5.27	$\mathbf{4.3\times10^{5}}$	1.0×10^{20}	4.6×10^{10}
^{63}Ni	9.60×10^{1}	5.1×10^{10}	1.0×10^{20}	$\mathbf{2.89\times10^{8}}$
^{65}Zn	6.68×10^{-1}	$\mathbf{1.8\times10^{6}}$	1.0×10^{20}	1.0×10^{20}
^{90}Sr	2.91×10^{1}	4.2×10^{8}	5.8×10^{15}	$\mathbf{4.2\times10^{5}}$
^{93m}Nb	1.36×10^{1}	$\mathbf{3.7\times10^{10}}$	1.0×10^{20}	9.9×10^{10}
^{94}Nb	2.03×10^{4}	6.7×10^{5}	$\mathbf{6.5\times10^{4}}$	1.4×10^{5}
^{93}Zr	1.53×10^{6}	2.7×10^{9}	$\mathbf{2.9\times10^{4}}$	1.4×10^{8}
^{99}Tc	2.13×10^{5}	5.1×10^{9}	$\mathbf{4.0\times10^{5}}$****	4.0×10^{5}****
^{110m}Ag	6.84×10^{-1}	$\mathbf{4.0\times10^{5}}$	1.0×10^{20}	1.0×10^{20}
^{129}I	1.57×10^{7}	2.0×10^{5}	$\mathbf{4.0\times10^{4}}$****	7.3×10^{4}
^{134}Cs	2.06	$\mathbf{6.8\times10^{5}}$	1.0×10^{20}	5.0×10^{19}
^{137}Cs	3.00×10^{1}	$\mathbf{1.8\times10^{6}}$	1.0×10^{20}	3.3×10^{6}

Radionuclide	Half-life, years	Specific activity limits, Bq/kg		
		$B_{i,l}$* [17]	$A_{i,l}$** [17]	$C_{i,l}$***
^{234}U	2.45×10^{5}	7.1×10^{6}	**5.3×10^{3}**	6.0×10^{6}
^{235}U	7.04×10^{8}	7.8×10^{6}	**4.9×10^{3}**	1.8×10^{6}
^{238}U	4.47×10^{9}	8.3×10^{6}	**5.1×10^{3}**	3.5×10^{6}
^{237}Np	2.14×10^{6}	1.3×10^{6}	**2.2×10^{3}**	1.2×10^{6}
^{238}Pu	8.77×10^{1}	**6.1×10^{5}**	1.0×10^{20}	1.4×10^{6}
^{239}Pu	2.41×10^{4}	5.6×10^{5}	**7.2×10^{4}**	5.9×10^{5}
^{240}Pu	6.54×10^{3}	**5.6×10^{5}**	5.6×10^{7}	5.9×10^{5}
^{241}Pu	1.44×10^{1}	**2.9×10^{7}**	1.0×10^{20}	3.8×10^{9}
^{241}Am	4.32×10^{2}	**6.9×10^{5}**	1.0×10^{20}	8.5×10^{5}
^{244}Cm	1.81×10^{1}	**1.2×10^{6}**	1.0×10^{20}	5.7×10^{7}

Notes:
* The specific activity limit for radionuclide *i* from the scenario for operational period;
** The specific activity limit for radionuclide *i* from the leaching scenario;
*** The specific activity limit for radionuclide *i* from the inadvertent intrusion scenario (for the value of the annual effective dose of **10 mSv** [20]);
**** Corresponds to the clearance level specified in the normative document [10];
Value 1.0×10^{20} is conditional figure indicating that the scenario is not limiting;
Most restrictive values of the specific activity limits are indicated in bold.

Specific activity values of ^{94}Nb, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am and ^{244}Cm, for which inadvertent human intrusion scenario was the limiting scenario (see document [17]), after update (Table 1.12), are limited by the operational period scenarios (namely, a fire scenario), except for ^{94}Nb, ^{239}Pu, for which leaching scenario is the limiting one. In comparison to the values of specific activity limits for *Landfill* disposal facility in Sweden, which were suggested for the *Landfill* disposal facility in INPP [21], for main radionuclides – ^{60}Co 3×10^{5} Bq/kg and ^{137}Cs 4×10^{4} Bq/kg – activity limits presented in Table 1.12 for ^{60}Co are of the same order of magnitude (4.3×10^{5} Bq/kg), and for ^{137}Cs are by two orders of magnitude higher (1.8×10^{6} Bq/kg). However, it should be noted that activity limits presented in Table 1.12 are a conservative approach as the assessment of the more significant environmental impact will be carried out. The activity limits will be defined more exactly on basis of the results obtained from the safety analysis report.

Maximal values of specific and total activities of RAW, intended to store in the buffer storage facility as well as to dispose in the *Landfill*, are presented in Table 1.13. Estimated values are obtained by using nuclide vectors, presented in Table 1.8 –

Table 1.11, and taking into account the following summation criteria: $X = \sum_i \frac{Q_i}{C_{i,l}} < 1$; $Y = \sum_i \frac{Q_i}{A_{i,l}} < 1$; $Z = \sum_i \frac{Q_i}{B_{i,l}} < 1$ (Q_i – specific activity of radionuclide *i* in the package, $C_{i,l}$, $A_{i,l}$, $B_{i,l}$

estimated on the basis of activity limits presented in Table 1.12).

Table 1.13. Maximal values of specific and total activities of RAW, intended to store in the buffer storage facility and to dispose in the *Landfill*

Radionuclide	Maximum values of specific activities (Q_i), Bq/kg						Maximum values of total activity, Bq	
	Industrial waste	RAW from bld. 117/1	RAW from bld. V1			RAW from bld. G1	Intended for storage in the buffer storage facility	Intended to dispose of in the *Landfill* disposal facility
			Type 1 [a)]	Type 2 [b)]	Type 3 [c)]			
^{14}C		8.86E+02	4.82E+04	3.98E+05	4.52E+04	3.14E+02	9.42E+08	1.41E+10
^{54}Mn	1.06E+05	4.43E+04	2.81E+04	1.07E+03	3.01E+04	6.09E+04	1.83E+11	2.74E+12
^{55}Fe	1.03E+06	3.51E+06	8.03E+05	3.06E+04	2.64E+05	1.50E+06	4.51E+12	6.77E+13
^{59}Ni		6.27E+01	3.17E+02	1.21E+01	2.97E+02	8.06E+02	2.42E+09	3.62E+10
^{60}Co	3.54E+05	3.69E+05	4.01E+05	1.53E+04	3.77E+05	3.58E+05	1.07E+12	1.61E+13
^{63}Ni		4.80E+04	1.53E+04	1.53E+03	3.77E+04	9.67E+04	2.90E+11	4.35E+12
^{65}Zn	4.25E+03	5.90E+01	6.42E+01	2.45E+00	6.02E+01	5.58E+01	1.68E+08	2.51E+09
^{90}Sr	2.69E+03	4.80E+02	5.62E+01	3.37E+03	2.15E+05	6.09E+02	1.83E+09	2.74E+10
^{93m}Nb	4.60E+04	6.64E+04	8.43E+04	3.22E+03	3.77E+03	1.06E+05	3.17E+11	4.75E+12
^{94}Nb	3.54E+03	5.17E+02	6.82E+03	2.60E+02	1.92E+02	8.23E+03	2.47E+10	3.71E+11
^{93}Zr	3.54E+01	5.17E+00	6.42E+01	2.45E+00	1.88E+00	1.29E+01	3.87E+07	5.80E+08
^{99}Tc		7.38E+00	3.06E+00	3.06E-01	7.53E+00	7.05E+00	2.12E+07	3.17E+08
^{110m}Ag	1.17E+04	4.06E+02	4.41E+02	1.68E+01	4.14E+02	3.58E+02	1.07E+09	1.61E+10
^{129}I		1.18E-01	2.21E-02	3.11E-03	7.64E-02	7.27E-02	2.18E+05	3.27E+06
^{134}Cs	1.77E+04	1.18E+04	1.44E+03	1.97E+02	4.85E+03	1.38E+04	4.15E+10	6.22E+11
^{137}Cs	5.66E+04	1.58E+05	4.82E+04	6.57E+03	1.62E+05	1.54E+05	4.61E+11	6.91E+12
^{234}U		6.64E-02	5.22E-01	1.99E-02	1.20E-02	1.57E-01	4.70E+05	7.06E+06
^{235}U		1.29E-03	1.08E-02	4.13E-04	2.41E-04	3.13E-03	9.38E+03	1.41E+05
^{238}U		2.07E-02	1.69E-01	6.43E-03	3.77E-03	4.90E-02	1.47E+05	2.21E+06
^{237}Np		4.06E-03	3.41E-02	1.30E-03	7.53E-04	9.95E-03	2.99E+04	4.48E+05
^{238}Pu	2.34E+01	2.44E+01	1.08E+02	4.13E+00	2.37E+00	5.19E+01	1.56E+08	2.34E+09
^{239}Pu	1.73E+01	1.03E+01	8.43E+01	3.22E+00	1.92E+00	2.49E+01	7.48E+07	1.12E+09

Radionuclide	Maximum values of specific activities (Q_i), Bq/kg						Maximum values of total activity, Bq	
	Industrial waste	RAW from bld. 117/1	RAW from bld. V1			RAW from bld. G1	Intended for storage in the buffer storage facility	Intended to dispose of in the *Landfill* disposal facility
			Type 1 [a)]	Type 2 [b)]	Type 3 [c)]			
^{240}Pu	2.19E+01	1.77E+01	1.44E+02	5.51E+00	3.28E+00	4.22E+01	1.27E+08	1.90E+09
^{241}Pu	4.60E+03	6.64E+02	6.02E+04	2.30E+03	3.77E+02	3.06E+03	9.19E+09	1.38E+11
^{241}Am	4.96E+01	5.54E+01	3.37E+02	1.29E+01	3.20E+00	7.05E+01	2.12E+08	3.17E+09
^{244}Cm	7.04E+01	4.80E+01	7.22E+01	2.76E+00	1.02E+00	3.52E+01	1.05E+08	1.58E+09
						Total:	**6.92E+12**	**1.04E+14**

a) for RAW generated after dismantling of ventilation system and tanks of the repair cooling.
b) for RAW generated after the dismantling of the bld. V1 excluding ventilation system, tanks of the repair cooling and filter medium.
c) filter medium.

As can be seen from Table 1.13 maximal activity values of ^{54}Mn, ^{55}Fe, ^{60}Co, ^{134}Cs, ^{137}Cs obtained for considered nuclide vectors are values of the same order. Contamination of equipment in the building 117/1 is negligible. It is assumed that after decontamination of equipment in the building 117/1 a greater part of the equipment will comply with the free release criteria, and the amount of radioactive waste from the building 117/1 will be insignificant. It is seen from Table 1.13 that there are no ^{14}C , ^{59}Ni, ^{63}Ni, ^{99}Tc, ^{129}I radionuclide s and no isotopes of uranium in industrial waste. Therefore the indicated radionuclides are detected in RAW from the building G1. So, it is assumed that the greatest stream of the waste intended for disposal in the *Landfill* disposal facility is expected from the building G1. Therefore the maximal activity values obtained from nuclide vector for waste from the building G1 will be considered for further analysis in the EIA report, and possible deviations, depending on supposed nuclide vectors, will be discussed in the uncertainty analysis. These values are obtained on condition that the maximal volume of the waste packages intended for storage in the buffer storage facility will equal to 4 000 m^3, and intended for the *Landfill* disposal – 60 000 m^3 as indicated in section 1.1. The results of modelling of the container loaded with waste from bld. G1 carried out under conservative assumptions (a container maximally loaded with metal waste is assumed) have demonstrated that the dose rate at the surface of the container at the distance 0.1 m is about 0.22 mSv/h [22], that is twice lower than the limit 0.5 mSv/h, specified in the requirements [9] for RAW class *A*.

1.6.6 Physical and Chemical Properties of Combustible Waste

Wood

There is a rather big amount of wood contained in combustible waste. For example wooden scaffolding and wooden things that are in common use in the controlled area. Long wooden things usually are cut at the place of origin into pieces no longer than 1 m, but possibly pieces of 3 m length can be found.

Physical properties

Humidity

Humidity is used for quantitative estimation of water content in the wood. Wooden humidity is a ratio (in percentage) of mass of water to mass of dry wood:

$$W = \frac{(m - m_0)}{m_0} \times 100,$$

where

m is original mass of wooden sample (model), g,

m_0 is mass of absolutely dry wooden sample (model), g.

There are two types of water contained in wood: free water and combined water. Combined water is found in cell walls and free water is found in cell cavities and in intercellular space. Physicochemical links keep combined water. Changing of combined water content leads to considerable changing of wood properties. Free water is kept only by mechanical links therefore it has minor influence on wood properties and can be removed easier.

In practice there are the following types of wood depending on humidity:

1. wet, W >100%, long time is kept in water;
2. freshly cut down, W = 50-100 %, humidity of growing tree;
3. air dry, W = 15-20 %, kept at open air;
4. room dry, W = 8-12 %, kept for a long time in heated room;
5. absolutely dry, W = 0 %, dried at temperature t = 103 ±20 C.

The main part of wooden waste intended for disposal in Landfill should have air-dry humidity.

Dehumidification and swelling

Dehumidification in fact does not depend on kind of wood. Ability for dehumidification is a negative feature of wood. Dry wood placed in wet conditions becomes wet. It leads to swelling, lowering of biological stability as well as deterioration of physical and mechanical properties. Full scale swelling in percentage is calculated by formula:

$$a_{max} = \frac{(a_{max} - a_{min})}{a_{min}} \times 100,$$

where

a_{max}, a_{min} is size (volume) of wooden sample with humidity equal or higher than saturation limit of cell's walls and size (volume) of wooden sample with absolutely dry condition mm (mm^3).

Density and porosity

Density of wood is lower than density of wooden substance since the wood concludes interstices (cell's cavity and intercellular spaces), which contains air. Relative volume of cavities filled with air characterizes porosity of wood:

$$P = \frac{(v_0 - v_{w.s.})}{v_0} \times 100,$$

where

v_0, $v_{w.s.}$ is volume of sample and volume of wooden substance in the sample when W = 0 %.

Porosity of wood is in the range of 40-80 %.

The density of wood is in a very wide range. Densities of some widespread kinds of wood at humidity of 12 % are given in Table 1.14.

Table 1.14. Density of some kinds of wood

Kind of wood	**Density, kg/m^3**
Pine	500
Larch	600
White wood	450
Birch	490

Chemical properties

Wood mostly consists of organic substances (99 % of total mass). Chemical composition is the same for different kind of wood. Absolutely dry wood contains 49 % of carbon, 44 % of oxygen, 6 % of hydrogen, 0.1-0.3 % of nitrogen. Ash is arisen as result of burning. Ash consists of the following elements: calcium, potassium, natrium, magnesium and others. All a.m. chemical elements form the main organic substances: cellulose, lignin and hemicellulose.

Besides the main organic substances wood contains relatively low content of **extractive substances** (tannides, resins, gums, pectins, fats and etc), which are soluble in water, alcohol or ether.

Used Filters

Various filters are used inside the radiological controlled area for different purposes. Ventilation filters contain the major part of radioactivity of combustible waste in Group 1 and Group 2.

Filters typically constructed of a wooden or steel frame and filter media filling. The filter media is usually 20 mm thick fibrous perchlorovinyl sheet (density 6 kg/m^3). Most common filter types, their characteristics and quantity will be accumulated by the year 2010 are presented in Table 1.15.

Table 1.15. Most common ventilation filter types in use at INPP [12]

Filter type	**Frame material**	**Weight, kg**	**Dimensions, mm**	**Quantity by the year 2010**			**Quantity of filter material**
				Number	**Weight, t**	**Volume, m^3**	**Weight, t**
D-23	Wood	32	636×572×610	8 285	265	1 293	23.0
D-33	Wood	31	636×590×750	693	21.5	111	2.7
A-17	Steel	45	625×572×610	2 310	104	367	4.7
			Total:	11 288	391	1 771	30.4

Filters will be treated at the new unit for solid waste treatment (Project B2/3/4) before disposal to Landfill. Filter media will be removed from the frame than compacted by 70 tons compactor and packed in bales. It is intended that filter frames will be subject to incineration or super compaction.

Paper and Carton

The most part of paper waste comprises drafts of documents, dud documents (industrial designs, equipment operating instructions, blanks of control sheets, drawings, journals of on-line data, etc.) and other types of papers (packaging paper, paper wipes, used for decontamination, wipes). This waste is produced on the personnel workplaces located within the INPP controlled access zone, during maintenance and repair activities of the equipment contaminated with radioactive substances. Physical, chemical and mechanical properties of different kinds of paper mostly depend on types of wood used for paper manufacturing, methods of making and bleach wash and type and quantity of added non-fibrous components.

Physical characteristics

The main substratum of paper is cellulose. Cellulose is a fibrous substance. It is not melting and not transforming to a vaporous state. Cellulose is decomposing (become charred) when heated up to 350°C. Cellulose is insoluble in water as well as in most other organic and inorganic solvents.

Chemical characteristics

Under the action of concentrated alkali water solvent a so-called mercerization takes place. Mercerization is a partial creation of cellulose alcoholates, which leads to fibre swelling. Some number of carbonyl and carboxyl groups appears in cellulose macromolecule as a result of oxidation. The disintegration of cellulose macromolecule occurs under influence of strong solvents. Cellulose hydroxyl groups are able to alkylate and acidulate making simple and complex ethers.

One of the most typical features of cellulose is ability to be subjected to hydrolysis in presence of acids with creation of glucose.

Etherification reaction is typical for cellulose since cellulose molecule has hydroxyl groups. Cellulose reactions with nitric acid and acetic acid anhydride have practical importance.

Cellulose is a combustible substance. Carbon oxide (IV) and water are generated during cellulose combustion. Decomposition of cellulose and other substances occurs under heating of wood without air access. Charcoal, methane, methyl alcohol, acetic acid, acetone and some other substances are produced as result of decomposition of wood.

Plastics

Plastics make a large group of organic, polymeric, easily formed materials, which are used for manufacturing light, strong, rigid and corrosion-proof goods. These substances mainly consist of carbon (*C*), hydrogen (*H*), oxygen (*O*) and nitrogen (*N*). All polymers have a high molecule mass from 10 000 to 500 000 and more. The main types of plastics (polymeric materials) in use at INPP and intended for Landfill are as follows:

1. various things from polyethylene (mainly packages);
2. PVC (polyvinylchloride) used for floor cover of technological and operating rooms;
3. Isolation of electric cables.

There are some other types of plastics but their quantity is very low and their influence on plastic waste properties is negligible. The real density of plastic waste is about 116 kg/m^3.

Physical characteristics

General physical characteristics of some kind of plastics are given in Table 1.16.

Table 1.16. Physical characteristics of some kind of plastics

Chemical name	**Density, g/cm^3**	**Softening temperature, °C**	**Flow temperature, °C**	**Sample for combustion: behaviour in a flame/ flame colour / note**	**Properties of decay products: colour / acid or alkaline reaction / aroma**
Rigid polyvinylchloride	1.38	75-77	160-180	Hardly burned / greenish / burns with dispersion	White vapour / acid / *HCl*
Soft polyvinylchloride (treated by softening agent)	1.30	-	140-160	The same/ the same/ burns with dispersion even after flame removal	The same/ acid / *HCl* and softening agent
Polystyrene	1.05-1.09	80-100	More than 160	Self-inflammable / yellow, luminous; smoky/ melted	White vapour, heavier than air / neutral / sweetish, floral, with nuance of benzol
Polyethylene	0.92-0.96	105-130	120-160	Burns/ at the beginning bluish, then yellow/ melted, flows drop by drop, drops burn	White / neutral / paraffin
Polymethacrylate	1.18	130-150	175-190	Burns/ yellow, weakly smoky/ burns gently, with cracking noise	Colourless / alkaline at the beginning then acid / fruit, sweetish
Polyvinylacetate	1.16-1.18	40-180	-	Burns/ bluish with yellow top; smoky / melted, drops do not burn	White / acid / acetum
Polyether	-	-	-	Burns/ luminous; smoky / become charred	Whitish-brownish / neutral / sweetish
Polyurethane	-	Treatment within 40-100°C	-	Burns/ luminous/ flows drop by drop	The same / alkaline / strong, obnoxious

Chemical characteristics

Chemically polymer is similar to monomer (or monomers), composing the polymer. Hydrocarbons ethylene $H_2C = CH_2$, propylene $H_2C = CH - CH_3$ and styrene $H_2C = CH - C_6H_5$ are subjected to polymerization by forming polyethylene, polypropylene and polystyrene.

The polymers behave as hydrocarbons. They are soluble in hydrocarbons, non-wetting by water, do not react with acids, alkalis, burns like hydrocarbons, can be chlorinated, bromated and in case of polystyrene can be nitrated and sulphurized.

All basic chemical properties of polymers can be predicted on the basis of their formula considering from the point of classic organic chemistry.

Ion-exchange resins (cation and anion) belong to ionite class – ion-exchange sorbents, which constitute solid, practically insoluble substances and materials able to ion exchange. Ion-exchange resins are synthetic macromolecule (polymeric) organic substances. The following types of ion-exchange resins are used at INPP: KU 2-8, AB 17-8, Lewatit MonoPlus S100, Lewatit MonoPlus M500.

All above listed resins belong to group of gelatinous cation/anion on a base of styrene divinyl benzene copolymers. These ion-exchange resins have a high mechanical, chemical and osmotic stability (properties of polymer styrene see in chapter “Plastics”). The main properties of ion-exchange resins intended for disposal in Landfill are given in Table 1.17.

Table 1.17. Physical and chemical properties of ion-exchange resins intended for disposal in Landfill

Parameter	**Lewatit MonoPlus S100**	**Lewatit MonoPlus M500**	**AB 17-8**	**KU 2-8**
Granule diameter(not less than 90% of content), mm	0.58-0.60	0.61	0.315-1.25	0.315-1.25
Full swelling, %	8	8	-	-
Mass portion of divinyl benzene, %	-	-	8	8
Particle density, g/ml	1.22-1.28	1.08	-	-
Content of combined water, %	42-53	50-60	35-50	50-60
Bulk weight, g/l	780-820	670	700-740	750-800
Stability at temperature, °C	(-10)-(+120)	(-20)-(+100)	-	-
Stability in the range of pH	0-14	0-14	1-14	1-14

There are no hazardous and toxic substances in the combustible VLLW of INPP in accordance to documents [23, 24]. There are no free liquids as well as no ease flammable wastes among combustible waste.

1.6.7 Physical and Chemical Properties of Non-combustible Waste

Metal waste

Metal waste consists of wide range of different metal items generally of a small size. These are elements of metal structures, valves as well as parts of equipment and cables. Number of massive metal things is a very few. Metal waste with big internal cavities (e.g. pipes, tanks etc.) should be compacted.

The most common materials are carbon steel and stainless steel and some quantity of non-ferrous metals (copper, aluminium) and their alloys.

Contamination of most of dismantled equipment resulted from contact with circulated inside technological medias and therefore concentrated in a thin oxide layer that mainly consists of a

Fe_2O_3 (hematite) and Fe_3O_4. As all oxide they are relatively stable and well preserved in a nature conditions. Density of steel is ~ 7.8 g/cm^3.

Chemical content of some types of steels used at INPP are given in Table 1.18.

Table 1.18. Chemical content of some types of steels

Chemical element	St 22K, %	St 20, %	08Kh18N10T, %
Carbon (*C*), no more than	0.19-0.26	0.17-0.24	0.08
Silicon (*Si*), no more than	0.2-0.4	0.17-0.37	0.8
Copper (*Cu*), no more than	0.3	0.25	0.30
Arsenic (*As*), no more than		0.08	
Manganese (*Mn*), no more than	0.75-1	0.35-0.65	2.0
Nickel (*Ni*)	0.3	0.25	9.0-11.0
Titanium (*Ti*)			0.4-0.7
Phosphorus (*P*), no more than	0.025	0.035	0.035
Chromium (*Cr*)	0.04	0.25	17.0-19.0
Sulfur (*S*), no more than	0.025	0.04	0.020

Aluminium is mainly used at INPP as cables and sheets for thermo-insulation liners. Density of aluminium is 2.7 g/cm^3. Technical aluminium is marked A85, A8, A7...A0 (99.0 % *Al*). *Fe, Si, Cu, Mn, Zn* can be found in aluminium as admixture. Aluminium has a high corrosion resistance in consequence of creation of strong, thin film of Al_2O_3. The cleaner aluminium is the higher corrosion resistance it has.

Copper in consequence of its high electrical conductivity is mainly used at INPP as cables. Admixtures presenting in copper make a dig influence on its properties. Admixtures can be divided into three groups by the character of interactions with copper:

1. Admixtures constituting solid solutions with copper: *Ni, Zn, Sb, Sn, Al, As, Fe, P* and other; these admixtures (especially *Sb* and *As*) abruptly reduce electrical and thermo conductivity of copper. Therefore copper M0 and M1 containing ≤ 0,002 *Sb* and ≤ 0,002 *As* are used for conductors.
2. *Pb, Bi* and other admixtures are practically insoluble in copper, constitute easily melted eutectics that concentrated at granules border makes difficult of treatment by pressure. In presence of 0.005 % *Bi* copper is destroyed during hot pressure treatment. In case of higher content of *Bi* copper becomes cold-brittle. These admixtures have small impact on electrical conductivity of copper.
3. Admixtures of oxygen and sulphur constitute with copper brittle chemical substances Cu_2O and Cu_2S, which included in eutectic content. Oxygen being in solution reduces electrical conductivity but sulphur does not impact on it. Sulphur makes better cutting of copper. Oxygen in copper constitutes copper protoxid and leads to a “hydrogen” illness.

Copper is corrosion resistant on usual atmospheric conditions, under sweet water, seawater and other aggressive media but it has a bad stability in sulphuric gases and ammonia.

Construction Waste (Concrete, Brick)

Concrete and bricks in the waste to be disposed of in Landfill appears as a construction waste resulting from maintenance and reconstruction of structural part in controlled area.

Concrete is an artificial stony material derivable as a result of hardening thoroughly mixed and thickened mixture of mineral or organic binding substance with water and fine and coarse aggregate taken in a certain ratio. Concrete made from cement or other inorganic binding substances is widely used in construction.

Concrete consists of cement, sand, gravel or crushed stone and water. Cement and water are the active components of concrete. Cement stone fixing particles of aggregate in a monolith is formed as a reaction between cement and water. After hardening concrete is a monolith material relatively strong and long-lived, insoluble in water.

The main component of bricks is clay that consists of one or several minerals of kaolin type. After thermal treatment (baking) it becomes hard and like concrete has relatively good mechanical properties. Bricks are insoluble in water.

Main technical characteristics of bricks and some types of concrete are given in Table 1.19.

Table 1.19. Main technical characteristics of bricks and some types of concrete

Type	Density, g/cm^3	Thermal conductivity, W/m°C	Frost resistance, cycles	Compression strength, MPa
Bricks	1.85-2.10	0.69-0.98	25-100	15-40
Light concrete	0.5-1.8	0.07-0.7	25-100	5-7.5
Heavy concrete	1.8-2.5		50-700	10-40

The main type of heat-insulated materials used at INPP is mineral wool items.

Mineral wool is fibrous materials produced from silicate melt of rocks, metallurgical dross and their mixtures. The main property of mineral wool, which is different to other thermal-insulated materials, is incombustibility in a combination with high thermal and sound insulating ability, thermal strain resistance. Mineral wool is no hygroscopic and has high chemical and biological resistance and inactivity, ecological compatibility and is easily mounted.

Mineral wool is no hygroscopic and water content in normal condition is about 0.5 % by volume. But very often storage at building yard and mounting of thermal insulation is occurred in wet condition (e.g. during rain). In order to minimize water absorbing mineral wool is subjected to treatment by special water-repellent composition (organic-silicon substances). All things made from mineral wool are ecologically safe.

Physic-chemical properties and operational characteristics of fibrous thermal-insulated materials are given in Table 1.20.

Table 1.20. Physical-mechanical properties and operational characteristics of fibrous materials

Properties	Basalt extra thin fibre	Glass fibre	Mineral fibre
Density, kg/m^3	25-50	15-50	75-150
Working temperature, °C	(-269)-(+750)	(-60)-(+460)	(-60)-(+400)
Coefficient of thermal conductivity,	0.027-0.035	0.044-0.047	0.040-0.045

Properties	Basalt extra thin fibre	Glass fibre	Mineral fibre
kcal/(m×h×K)			
Normative coefficient of sound-absorbing, dB	0.90-0.99	0.90-0.99	0.70-0.80
Hygroscopicity, %	0.5-1.0	5-20	20
Presence of formaldehyde, %	Do not have	-	-
Presence of phenol, %	Do not have	up to 2	-
Presence of glass fibre dust, %	Do not have	up to 4	-

Dry sediments

There are different kinds of dry materials collected at different places of controlled area. These materials include the following:

1. Sand;
2. Sediments from tanks bottom and pumps;
3. Activated carbon (carbon treated by special agents that increase sorption ability).

These materials originally could have relatively high content of water but it is implied that they have dried during storage.

There are no hazardous and toxic substances in the combustible VLLW of INPP in accordance to documents [23, 24]. There are no free liquids among non-combustible waste.

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2 BUFFER STORAGE FACILITY

2.1 Demand for Resources and Materials

2.1.1 Demand for Resources and Materials during Construction Phase of the Buffer Storage Facility

Demand for resources and materials during construction phase of the buffer storage facility is presented in Table 2.1. Amounts presented in the table are preliminary and will be better estimated during the design phase.

Table 2.1. Demand for resources and materials during construction phase of the buffer storage facility

Resources/Materials	Measurement unit	Volume, mass or amount
Concrete (for site preparation layer and foundation slab)	m^3	~ 1 800
Concrete (for outer side walls)	m^3	~ 120
Concrete (for inner walls)	m^3	~ 70
Reinforcing steel (for foundation slab)	t	~ 215
Drilled pile	-	~ 400
R/c column	-	~ 40
R/c beam	-	~ 30
R/c roof slab	-	~ 40
R/c blocks for side walls	-	~ 120
Maximal electrical power	kW	~ 100
Water demand (total for technological, household and fire protection needs)	l/s	~ 11

2.1.2 Electrical Power

It is estimated that the electrical power supply system of the buffer storage will be connected to the electrical power supply system of the INPP. Existing installations are sufficient to provide necessary electrical power for the proposed economic activity.

Electrical power will be used for buffer storage equipment, lighting, ventilation, air conditioning, etc. The estimated electrical power demand is to be about 80 MWh per year.

2.1.3 Thermal Energy

Existing installations are sufficient to provide necessary thermal energy for the proposed economic activity.

The required amount of the thermal energy (thermal water) will be supplied from the central hot water supply pipe (i.e. from Ignalina NPP or from water boiler heating station). The total heat supply is estimated to be about 668 MWh per year (273 MWh per year – for heating needs and 395 MWh per year – for ventilation system).

Diesel fuel is necessary for transportation needs. The estimated diesel fuel demand during operation of the buffer storage facility is to be about 1.739 t per year.

The total demand for energy and fuel resources is summarized in Table 2.2.

Table 2.2. Demand for energy and fuel resources during operation of the buffer storage facility

Energy and fuel resources	Measurement unit	Capacity or amount	Supply source
Electrical energy	MWh per year	80	From the power grid
Thermal energy	MWh per year	668	From the steam boiler plant
Diesel fuel	t per year	1.739	External supply

2.1.4 Demand for Water

The capacities of existing INPP installations are sufficient to provide necessary water supply for the proposed economic activity. The potable water is necessary for personnel sanitary purposes (hand washing, showers and toilets), and also for fire fighting system (fire hydrants). Potable water is processed at local water purification plants. Its quality is constantly monitored. Total demand of potable water during the operation of the buffer storage should comprise about 326 m^3 per year (for technological processes – 50 m^3 per year, for household needs – 276 m^3 per year).

2.2 Conception of the Buffer Storage Facility

Buffer storage facility is intended for measurements, accumulation and safe interim storage of the waste between disposal in the *Landfill* repository campaigns, which will be performed not rare than once in two years. It is planned to locate buffer storage facility at the site of the former INPP Reactor Unit 3 in the vicinity of the site for planned Free Release Measurement Facility, see Figure 1.1.

The building is projected as one-storey construction with an entresol at +6.0 m mark. Preliminary outer dimensions of the building are 60×30 m and the height – above 8 m.

Buffer storage facility should be able to stow about 4 000 m^3 of treated and packed waste, intended for disposal of in the *Landfill* repository.

As a result, buffer storage building, taking into account the functional features, is conventionally divided to the following areas, see Figure 2.1:

Area A – RAW entrance control area.
Area B – Area of RAW reception and interim storage during measurement.
Area C – RAW measurement area.
Area D – RAW buffer storage area.
Area E – Area of sanitary and hygienic rooms.
Area F – Area of service, administrative and other work rooms.

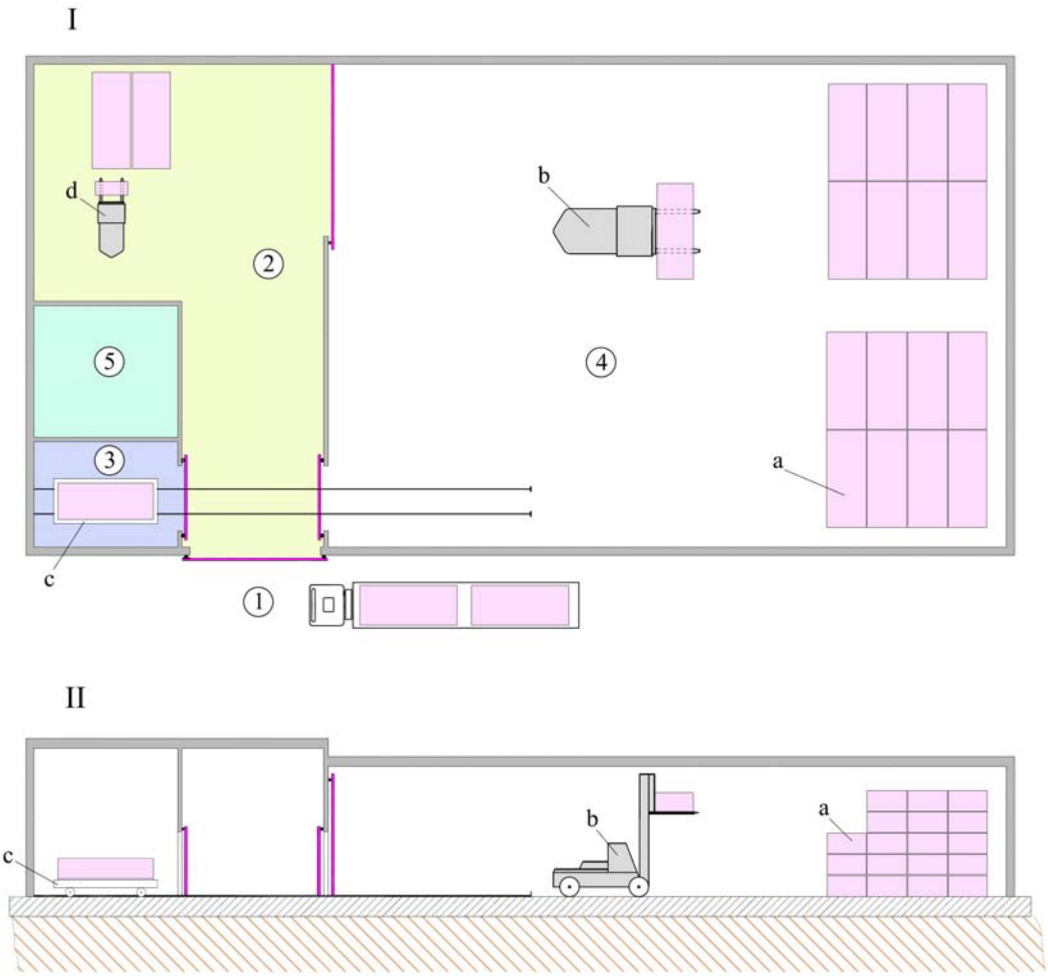

Figure 2.1. Conceptual layout of the buffer storage facility: top view (I) and side view (II):

① – RAW entrance control area (A) and loading site;
② – Area (B) of RAW reception and interim storage during measurement;
③ – RAW measurement area (C);
④ – RAW buffer storage area (after measurement) (D);
⑤ – Area (E) of sanitary and hygienic rooms and service, administrative and other work rooms (F).
a – Radioactive waste packages;
b – High lift capacity fork-lift truck for transportation of non-combustible waste packages;
c – Rail transfer trolley;
d – Low lift capacity fork-lift truck for transportation of combustible waste packages (bales).

The fork-lift trucks are preferred to remote controlled transport means considering the following:

- Estimated maximum dose rate value is approx. 0.2 mSv/h (the value is obtained under conservative assumptions) [9], i.e. twice lower in comparison to the maximum permissible value of 0.5 mSv/h [8];
- Quantity of the waste packages with dose rate close to the estimated maximum value is relatively low;
- Arrival of RWP to the facility is low, i.e. up to 2 containers per day;

- Low doses to personnel considering duration of technological operations using fork-lift;
- Economic and simplicity issues.

During operation of the buffer storage facility, the following functions will be performed:

1. RAW transportation;
2. RAW reception (entrance control);
3. Unloading of RAW;
4. RAW transfer to the measurement room;
5. Characterization, marking and saving of waste descriptions;
6. RAW handling after measurement;
7. Retrieval of an empty or partially filled 20-foot ISO half-height container from the buffer storage building;
8. Empty 20-foot ISO container handling;
9. Interim waste storage in the buffer storage of the *Landfill* facility;
10. Unloading of RAW from the buffer storage facility and transfer to the disposal unit.

2.2.1 Waste Transportation

Waste that is to be stored at the buffer storage and disposed off at the *Landfill* facility, will be presorted by the waste suppliers according to its physical, chemical and radiological characteristics, and respectively loaded into ISO half-height containers, packed into bags or in armed plastic containers. Description of features and characteristics of the packages is presented in Chapter 1.6.

Transportation of waste from places of origin to the buffer storage building and from the buffer storage building to the disposal units will be carried out on semitrailers with bolster-type tractor. For transportation of non-combustible waste standard 20-foot half-height ISO containers will be used, see Figure 2.2. Main parameters of non-combustible waste packages are presented in Table 2.3. During transportation and storage containers are equipped with reusable detachable steel lids. Lids are fastened to containers by locks excluding self-opening.

Containers have paint-and-lacquer coating with high degree of resistance against weather conditions and deterioration, resistance to impacts of chemical substances (under working conditions), with increased bending strength.

Figure 2.2. 20 foot half-height ISO container with removable cover

Transportation and storage of packages of combustible waste and ion-exchange resins will be made both in standard 20-foot ISO containers and in half-height containers. One more option of transportation - without use of ISO containers, by transportation of packages of combustible waste and ion-exchange resins in the body of the vehicle or directly on the platform of the container truck. In this case package fixing on the platform will be provided.

Containers for transportation and storage of bales and plastic containers with ion-exchange resins will have doors in one of two ends for loading/retrieval of packages or completely opened side face. Lock-out of doors is made by means of two locking mechanisms excluding self-opening. Options of 20-foot ISO container with completely opened side face and with a door in the end face are presented in Figure 2.3. Main parameters of 20-foot ISO containers are provided in Table 2.3. Main parameters of combustible waste are presented in Table 1.2, and of ion exchange resins – in Table 1.4.

Figure 2.3. Options of 20-foot ISO container with completely opened side face and with a door in the end face

Table 2.3. Main parameters of 20-foot ISO containers

Type	20-foot ISO container. Door in the end face / opened side face
External dimensions	Approx. 6.06×2.44×2.59 m
Internal dimensions	5.84×2.35×2.39 / 5.95×2.29×2.26 m
Internal volume	32.8 / 30.8 m^3

Doorway - end face (W×H)	2.34×2.27 / 5.61×2.14 m
Material	Carbon steel 2 – 3 mm
Container weight	2 472 / 2 960 kg
Useful loading	21 528 / 21 040 kg
Maximum weight (gross)	24 000 kg

For performance of transport-technological operations of RWP transferring inside the buffer storage and for transfer of RWP to/out of the measurement zone (MZ), two front fork-lift trucks (with load-carrying capacity of 25 t and 1.5 t) and also an electrically driven transfer trolley will be used.

2.2.2 Acceptance of RWP (Incoming Control)

Technical Specification of the *Landfill* facility [1] indicates that the waste, which gets into the buffer storage, will be already sorted according to its chemical and physical properties, as well as by the results of the engineering radiological inventory of the INPP equipment, and it will meet the WAC, determined according to the normative document [2]. The final radiological waste characterization will be carried out in the buffer storage, i.e. waste compliance to the waste acceptance criteria established in the Safety Analysis Report will be checked.

Waste sorting, what excludes the possibility for spent sealed sources and other inappropriate waste to get into the *Landfill* facility, and its packaging will be performed at Solid Waste Retrieval Facility (B2 Project), as well as when forming packages during the dismantling of the equipment. Waste packaging, re-packaging or other waste handling operations, as well as possibility to carry out detailed waste analysis (e.g., chemical or radiochemical) is out of scope of this project. Absence of operations, during which waste packages would be opened at the buffer storage, reduces the risk of radiological impact on the personnel and the environment and assures less complicated and cheaper operation.

If required, visual control and selective sampling can be performed at B2 facility (or at another point of a package generation) during formation of waste packages. There is a possibility to perform a detailed waste analysis at the INPP or external laboratories.

During the performance of the incoming control for packages of all considered types:

1. CRWP (multilayered plastic containers with spent ion-exchange resins or plastic bales with pressed combustible waste, delivered without use of any transport container, in the body of the vehicle or directly on the platform of the container truck);
2. half-height container with CRWP or non-combustible radioactive waste (NCRW) and
3. 20-foot container;

the following operations are carried out:

- Identification of CRWP/half-height container/container;
- Measurement of surface contamination of CRWP/half-height container/container with radioactive substances;
- Measurement of equivalent dose rate of gamma radiation from CRWP/half-height container/container;
- Entering of the measurements' results into the database of the waste account and storage management system (DB of the WAandSMS), comparison of the measurements' results with the limiting values;
- Marking of CRWP/half-height container/container, that has passed the incoming control, by a barcode of the waste account and storage management system

(WAandSMS), in case of admission of CRWP/half-height container/container to measurement equipment;
- Marking CRWP/half-height container/container, that has not passed the incoming control, with special plates;
- Admission of CRWP/half-height container/container to the zone of performance of transport-technological operations (reload) in case if measurement results do not exceed the limiting values, and return of CRWP/half-height container/container to the supplier in case if measurement results exceed the limiting values;
- Transfer of the results of the incoming control into Decommissioning Data Base and Decommissioning Management System (DDBandDMS) (including the reasons of the return of CRWP/half-height container/container in case if it has not passed the incoming control).

Identification of CRWP/half-height container/container means check of completeness of the data presented in the accompanying documentation on CRWP/half-height container/container, and its comparison with the data of actually delivered CRWP/half-height container/container. Identification of CRWP/half-height container/container is performed at the load site in zone A.

For carrying out of identification of CRWP/half-height container/container, the vehicle stops at “STOP” line between the inspection sites. Works on identification are carried out by an operating engineer.

In case if within the accompanying documentation on CRWP/half-height container/container all necessary data are presented and they correspond to the data of actually delivered CRWP/half-height container/container, measurements of surface contamination of CRWP/half-height container/container with radioactive substances and measurements of equivalent dose rate of gamma radiation from CRWP/half-height container/container are performed.

Measurements of surface contamination of CRWP/half-height container/container with radioactive substances and measurements of equivalent dose rate of gamma radiation from CRWP/half-height container/container are performed by a radiation supervisor.

The radiation supervisor enters the results of measurements into the database of the waste account and storage management system (DB of the WAandSMS), where the results of measurements are compared to the limiting values defined in the criteria of acceptance for disposal.

If results of measurements of CRWP/half-height container/container exceed the established limits, the system will not enter the data of CRWP/half-height container/container into the database of the waste account and storage management system (DB of the WAandSMS) and will print out a special label for a single CRWP/half-height container/container that has not passed the inspection. The radiation supervisor pastes the given label on the surface of CRWP/half-height container/container, and then CRWP/half-height container/container that has not passed the inspection will be returned to the supplier of RWP.

The system enters CRWP/half-height container/container, which results of measurements do not exceed the established limits, into the DB of the WAandSMS and prints out a special label with a barcode for a single CRWP/half-height container/container, as well as a check-list allowing vehicle unloading. The radiation supervisor sticks the given label on the surface of CRWP/half-height container/container and indicates in the check-list about the admission of CRWP/half-height container/container into the buffer storage building. Then the vehicle moves to the gates of the building for unloading of CRWP/half-height container with CRWP or NCRW/container with CRWP.

2.2.3 Unloading of RWP

2.2.3.1 Unloading of a Single CRWP from the Vehicle

After the permission for admission of CRWP into the buffer storage building has been received, the operator of the transport-processing equipment opens the doors of the building, using the fork-lift truck unloads CRWP from the vehicle and places it on the transfer trolley.

Before transfer of CRWP to the measuring chamber, the radiometry technician reads out the barcode from the surface of CRWP, thereby, on demand of WAandSMS, giving access to the information from DDBandDMS, necessary for waste characterization. Upon acceptance of CRWP in the buffer storage the results of dosimetric control are registered in DDBandDMS by means of WAandSMS.

In some cases, when it is impossible to perform characterization of CRWP immediately after its delivery, the given CRWP is transferred and loaded into a container or in a half-height container, placed for interim storage in the zone B.

2.2.3.2 Unloading of Half-height Container with CRWP from the Vehicle

After the permission for admission of a half-height container with CRWP into the buffer storage building has been received, the operator of the transport-processing equipment opens the doors of the building, using the fork-lift truck, unloads half-height container from the vehicle and transfers it to the site of interim storage in the zone B.

The half-height container with CRWP is placed in a strictly defined place, for intermediate storage, then the operator of the transport-technological process, with the help of the fork-lift truck, removes a lid from the half-height container and moves it to the lid storage area (zone D).

Then the operating engineer carries out the identification of CRWP, located in the half-height container.

Identification of CRWP means check of completeness of the data presented in the accompanying documentation on CRWP, and its comparison with the data of actually delivered CRWP.

In case if within the accompanying documentation on CRWP all necessary data are presented and they correspond to the data of the actually delivered CRWP, measurements of surface contamination of the CRWP with radioactive substances and measurements of equivalent dose rate of gamma radiation from the CRWP are performed.

Measurements of surface contamination of the CRWP with radioactive substances and measurements of equivalent dose rate of gamma radiation from the CRWP are performed by a radiation supervisor at the surface accessible for measurement.

Unloading of CRWP from the half-height container, measurement results of which exceed the established limits, is forbidden. The given CRWP are marked by a special label which is pasted by the radiation supervisor on the surface of CRWP. The reasons of the return of the half-height container are entered in DDBandDMS and it is returned to its supplier.

2.2.3.3 Unloading of a Container with CRWP from the Vehicle

After the permission for admission of a container with CRWP into the buffer storage building has been received, the operator of the transport-processing equipment opens the doors of the building, using the fork-lift truck unloads the container from the vehicle and transfers it to the site of interim storage in the zone B.

The container with CRWP is placed in a strictly defined place, for intermediate storage.

Identification of CRWP located in the container is performed by the operating engineer straight before retrieval of a single CRWP from the container.

Identification of CRWP means check of completeness of the data presented in the accompanying documentation on the CRWP, and its comparison with the data of the actually delivered CRWP.

In case if within the accompanying documentation on the CRWP all necessary data are presented and they correspond to the data of the actually delivered CRWP, the CRWP is unloaded from the container for subsequent transportation to the measurement equipment.

2.2.3.4 Unloading of a Half-height Container with NCRW from the Vehicle

After the permission for admission of a half-height container with NCRW into the buffer storage building has been received, the operator of the transport-processing equipment opens the doors of the building, using the fork-lift truck unloads the half-height container from the vehicle and places it on the transfer trolley for subsequent characterization.

In cases, when it is impossible to perform characterization of a half-height container with NCRW immediately after its delivery, the given half-height container is transferred for interim storage to the zone D.

Before moving of the half-height container with NCRW to the measuring chamber, the radiometry technician reads out the barcode from its surface, thereby, on demand of WAandSMS, giving access to the information from DDBandDMS, necessary for waste characterization. Upon acceptance of the half-height container with NCRW in the buffer storage the results of dosimetric control are registered in DDBandDMS by means of WAandSMS.

2.2.3.5 Unloading of a Single CRWP from a Half-height container / Container and Acceptance (Incoming Control) of a Single CRWP

The unloading of a single CRWP from a half-height container/container is performed by the operator of the transport technological process.

With the help of the fork-lift truck, the operator retrieves the CRWP from the half-height container/container and places it on the transfer trolley for carrying out of the incoming control.

After placing the CRWP on the transfer trolley, the radiation supervisor performs measurements of surface contamination of the CRWP with radioactive substances (earlier not measured) and measurements of equivalent dose rate of gamma radiation from the CRWP.

The radiation supervisor enters the results of the measurements into the database of the waste account and storage management system (DB of the WAandSMS), where the results of measurements are compared to the limiting values.

If the results of the measurements of the CRWP exceed the established limits, the system will not enter the given CRWP into the DB of the WAandSMS and will print out a special label for a single CRWP that has not passed the control. The radiation supervisor pastes the given label on the surface of the CRWP, then the CRWP that has not passed the control will be returned for interim storage. The reasons of the return of the CRWP are entered in DDBandDMS. All not accepted CRWP are returned to their supplier.

The system enters the CRWP, which results of measurements do not exceed the established limits, into the DB of the WAandSMS and prints out a special label with a barcode for that single CRWP. The radiation supervisor pastes the given label on the surface of the CRWP.

Before moving CRWP to the measuring chamber, the radiometry technician reads out the barcode from the surface of the CRWP, thereby, on demand of WAandSMS, giving access to the information from DDBandDMS, necessary for waste characterization. Upon acceptance of CRWP in the buffer storage the results of dosimetric control are registered in DDBandDMS by means of WAandSMS.

2.2.4 Transfer of CRWP / Half-height Container with NCRW to the Measuring Chamber

Transfer of a CRWP/half-height container with NCRW to the measurement area is carried out by means of the transfer trolley controlled by the radiometry technician.

2.2.5 Characterization, Marking and Saving of Descriptions of CRWP / Half-height Container with NCRW

Buffer storage facility is provided with the characterization unit and other equipment necessary for the waste characterization as well as for the record keeping of RWP.

The nuclide content as well as the activity value within limits of free release and class B is determined using the characterization unit.

Measurement of CRWP/half-height container with NCRW is performed directly on the transfer trolley. In the process of characterization of CRWP/half-height container with NCRW the following activities are performed:

- Weighing of the CRWP/half-height container with NCRW;
- Measurement of the key radionuclide content;
- Calculation of remaining radionuclide content on a basis of the key nuclide vector;
- Determination of the approximate activity distribution ("hot spots") in the RWP;
- Comparison of the measurements and calculations results with the limiting values;
- Issue of conclusion about the correspondence to the acceptance criteria.

Upon finishing of the measurements of CRWP/half-height container with NCRW, results are entered in the database of WAandSMS. Then WAandSMS defines a storage place of CRWP in the container or a place for a half-height container with NCRW.

In case of inconsistency to the acceptance criteria waste is returned to its supplier, and the corresponding information is entered to DDBandDMS.

2.2.6 Waste Handling after Measurement

2.2.6.1 Handling of a Single CRWP after Measurement

After finishing the measurement, the radiometry technician transfers CRWP from the measuring chamber by means of the transfer trolley on the basis of the check-list formed by WAandSMS.

Unloading of the CRWP from the transport trolley, transfer of the CRWP to the zone B and its placing inside the transport container at the place of its storage, defined by WAandSMS, is carried out by the operator of the transport-processing equipment by means of the fork-lift truck. As a transport container for CRWP 20-foot ISO containers will be used. Capacity of the container is limited to 24 units of CRWP.

2.2.6.2 Transferring of 20-foot ISO Container with CRWP to Container Storage Area of the Buffer Storage Building

After full loading of the transport container, the operating engineer examines the container filled with CRWP, checking the compliance to the requirements of fire safety.

After the inspection and performance of all procedures related with fire safety, the operator of the transport-processing equipment closes the container and transfers it to the interim storage area (zone D). Then he places the container filled with CRWP to the location which is defined on the basis of the check-list formed by WAandSMS.

2.2.6.3 Handling of Half-height Container with NCRW after Measurement

After finishing the measurement, the radiometry technician moves the half-height container with NCRW from the measuring chamber by means of the transfer trolley on the basis of the check-list formed by WAandSMS.

Unloading of the half-height container with NCRW from the transport trolley and its transfer to the interim storage area (zone D) is carried out by the operator of the transport-processing equipment.

The half-height container with NCRW is placed at the location, defined on the basis of the check-list formed by WAandSMS.

2.2.7 Retrieval of an Empty or Partially Filled 20-foot ISO Half-height Container from the Buffer Storage Building

Retrieval of an empty (or partially filled with CRWP, that have not passed the incoming inspection) 20-foot ISO half-height container from the buffer storage building is performed after unloading of all CRWP submitted to characterization.

Before retrieval, the operating engineer performs the identification of the half-height container being returned to the supplier of RWP.

Identification of the half-height container, being returned to the supplier, means check of completeness of the data presented in the accompanying documentation. Identification of a half-height container, being returned to the supplier, is performed in the zone B of the buffer storage building.

After carrying out of the identification the operator closes the half-height container with a lid, and the radiation supervisor carries out measurements of the half-height container and the lid surface contamination with radioactive substances, and also measurements of equivalent dose rate of gamma radiation.

If results of the measurements of the half-height container, being returned to the RWP supplier, and the lid do not exceed the established limits, the system unregisters the given half-height container from the DB of the WAandSMS and issues the permission for its retrieval. Then the operator of technological process moves it to the building gate and loads the half-height container on the container truck, for sending to the RWP supplier.

In case the results of the measurements of the half-height container, being returned to the RWP supplier, and the lid exceed the established limits, retrieval of the half-height container from the buffer storage building is forbidden. The permission for retrieval can be received only after decontamination and repeated outgoing control.

2.2.8 Empty 20-foot ISO Container Handling

After unloading from the container of all CRWP, submitted to characterization, the operator of the transport-technological process moves the empty container into location for intermediate storage of CRWP in the zone B. The given container will be used for intermediate storage of CRWP after characterization.

In some cases the return of an empty 20-foot ISO container to the RWP supplier is possible, and then the process of container retrieval is similar to the process of retrieval of a 20-foot ISO half-height container for return to the RWP supplier, which description is presented in chapter 2.2.7.

2.2.9 Interim Waste Storing in the Buffer Storage of the *Landfill* Facility

Interim storing of CRWP in the buffer storage building is carried out in transport 20-foot ISO containers during the whole period of storage.

Containers with packages of combustible waste and half-height containers with non-combustible radioactive waste during the storage in the zone D will be closed by removable metal lids.

Storing of standard 20-foot half-height ISO containers with radioactive non-combustible solid waste in the zone D will be carried out in stacks of five tiers. Storing of standard 20-foot ISO containers with radioactive combustible solid waste in the zone D will be carried out in stacks of two tiers plus one half-height container.

2.2.10 Unloading of Containers from the Buffer Storage Building and their Transportation to the Disposal Units

The description of the technological process including unloading of containers with CRWP and half-height containers with NCRW from the buffer storage building and their loading onto the vehicle for further transportation to the disposal units is presented in Chapter 3.

2.3 Operational Waste

2.3.1 Construction

It is planned to install the buffer storage facility at the site for the former INPP unit 3. Non-radioactive waste, generated during construction, will be common construction waste, generated during construction of reinforced concrete structures, mounting equipment and performing other preparation works for operation (i.e. constructional waste, packing waste, household waste, and etc.). No detrimental or chemically hazardous waste will be generated. Waste, generated during construction, will be collected into the existing on the site tanks (liquid waste) or containers (solid waste) and will be transported for the appropriate treatment and disposal.

2.3.2 Operation

Due to handling of RWP within the technological process, and also as a result of technological maintenance and repairs of the equipment in the buffer storage of the *Landfill* facility, generation of an insignificant amount of very low level waste and non-contaminated solid waste is estimated.

2.3.2.1 Non-radioactive waste

Solid non-radioactive waste, generated during operation of the buffer storage, will be of the utility type: household waste and similar small construction waste, and waste of technical maintenance and repair works. It is assumed that their amount will be insignificant. Management of non-radioactive waste will be performed according to the requirements of the existing laws and regulations on waste management [3–5], INPP regulation [6] and Permission on Integrated Prevention and Control of Pollution [7].

2.3.2.2 Radioactive waste

2.3.2.2.1 Solid radioactive waste (SRW)

Radioactive waste, generated during the operation of the buffer storage facility, will be performed according to the new waste classification system [8].

Taking into consideration methods of radioactive waste treatment implemented at INPP, solid radioactive waste will be additionally classified into combustible, non-combustible, compactable, non-compactable and non-treatable waste.

Solid radioactive waste will include:

- Used individual protection means and overalls (cloth, plastic, paper);
- Packaging material (plastic);
- Wiping material (cloth, paper);
- Filtering material;
- Parts of mechanical and electrotechnical equipment, replaced during technical maintenance and repair works.

Estimated generation of solid waste during operation of the buffer storage facility is presented in Table 2.4.

Table 2.4. Estimated amounts of generated solid waste

No.	Type of waste	Units	Value	Comments
1.	Used individual protection means and overalls	m^3/year	4.0	
2.	Wiping material	m^3/year	0.5	
3.	Filtering material of ventilation system.	m^3/year	0.7	
4.	Packaging material	m^3/year	0.3	
5.	Parts of mechanical and electromechanical equipment, replaced during technical maintenance and repair works	m^3/year	0.4	

Used overalls, footwear and towels will be collected and sorted into plastic bags, installed on special racks. Filled plastic bags will be transferred to a special laundry by means of the appropriate transport, used for this purpose at INPP.

Wiping material will be sorted and collected into plastic bags at their generation place, and afterward delivered to the location of temporary storage.

Filtering material, retrieved from ventilation systems during the process of planned technical maintenance, will be packed into plastic bags at the place of their generation and immediately transferred outside the buffer storage facility by means of the appropriate transport, used for this purpose at INPP.

Packaging waste, when possible, will not be allowed in the buffer storage facility; removal of packaging material and its packaging in plastic bags will be performed at the load site in front of transportation gate under the control of health physicist.

Parts of mechanical and electrotechnical equipment, replaced during technical maintenance and repair works will be sorted and collected into plastic bags at their generation place, and afterward transferred to the location of their temporary storage.

For temporary storage of SRW two standard 200-litre metal drums with closing lids for separate storage of combustible and non-combustible waste will be installed in the RWP reloading room (room 103) of the buffer storage facility.

Metal drums for SRW storage, upon their filling, will be transferred to the treatment facility (SWTF) by transport, used for this purpose at INPP.

Before transportation outside the buffer storage facility of the *Landfill* facility, all packages with SRW, generated during operation, will undergo dosimetric control. Before transportation of containers with SRW outside the storage of the *Landfill* facility, monitoring of surface contamination and gamma radiation dose rate from containers with SRW will be performed.

Decontamination of container surface will be performed, if necessary.

2.3.2.2.2 Liquid radioactive waste (LRW)

During operation of the Buffer Storage of the Landfill facility liquids of the following types can be produced:

- Liquids, produced during cleaning and decontamination of the equipment and premises. For cleaning of the Buffer Storage building a vacuum cleaner for wet cleaning will be used, which will result in small volumes of liquids. Decontamination is carried out only in exceptional cases, when deviations from normal operation mode of the Buffer Storage occur, e.g., when solid radioactive waste is spilled. In this case, decontamination is performed by using wet absorbing materials (cloth, paper towels). Such decontamination requires only a small amount of liquids, which are absorbed by materials used for decontamination. As a result, during decontamination instead of liquid waste, wet solid combustible waste is generated;
- Building condensation water is the condensation water from the heating, ventilation and air conditioning system elements, located within the "contaminated" area of the storage, collected in the drip trays of the air conditioning and heating systems, as well as moisture, condensed on the surfaces of the storage equipment, containers and half-height containers with RWP;
- Effluent from showers and washbasins, located within the storage controlled access area;
- Water of the fire control system produced in case of a fire extinguishing;
- Spent oils, remaining after maintenance and repair activities of the equipment.

Preliminary evaluation of generation of liquid waste is presented in Table 2.5.

Table 2.5. Generation of liquid radioactive waste

Waste description	**Volume of liquid waste per year (m^3/year)**
Sanitary waste water (effluents from showers and washbasins, located within the controlled access area)	275.63
Technological waste water (liquids from decontamination and cleaning , water condensate (from the „contaminated" zone), fire extinguishing water, spent oils)	50.0
Total	**325.63**

2.3.3 Decommissioning

Operation of the buffer storage will last until termination of the project for decontamination and dismantling of the buildings and equipment located at the INPP industrial site. Afterwards no more very low-level radioactive waste will be generated. Thus, disposal in the *Landfill* disposal units will be finished, the buffer storage will be decommissioned and dismantled. The decommissioning of the buffer storage could start in ~ 2040.

When waste storage has been ceased, all equipment will be disconnected and removed. Non-contaminated materials and equipment that may be recycled will be removed from the buffer storage. When contamination of the building walls, equipments or its components is detected, conventional decontamination procedures will be applied.

Only short lived very low-level radioactive waste intended for *Landfill* disposal will be stored in the buffer storage. It is supposed that the greater part of the equipment and structures will meet disposal or reuse criteria. It is expected that the buffer storage decommissioning waste could be classified as very low-level radioactive waste and they could be disposed in the *Landfill* disposal.

After all internal equipment has been dismounted and removed, and also preliminary analysis of concrete structures has been performed to identify the concrete contamination level, the facility building structure may be dismantled. The results of this contamination analysis will show which blocs of concrete should be disposed. Then the radioactive surfaces will be separated, loaded into half-height ISO containers and disposed in *Landfill* facility.

2.4 Potential Impact of the Buffer Storage Facility on the Components of the Environment and Impact Mitigation Measures

2.4.1 Water

2.4.1.1 Hydrological Conditions

Installation of the buffer storage is planned at the INPP industrial site, which is located on the southern shoreline of Lake Druksiai. Lake Druksiai is the largest lake in Lithuania, which borders at the East with Belarus. The total volume of water is about 369×10^6 m^3 for normal affluent levels (water level altitude of 141.6 m). The total area of the lake, including nine islands, is nowadays about 49 km^2 (6.7 km^2 in Belarus, 42.3 km^2 in Lithuania). The greatest depth of the lake is 33.3 m, and the average is 7.6 m. The length of the lake is 14.3 km, the maximum width is 5.3 km, and the perimeter is 60.5 km. Some characteristics of the lake are presented in Table 2.6 [10-12].

Table 2.6. Main characteristics of Lake Druksiai

Characteristics of Lake Druksiai	Value
The catchment area of Lake Druksiai, km^2	564
Water area of the lake, km^2	49
Multiyear flow rate of water from the lake, m^3/s	3.19
Multiyear discharge from the lake, m^3/year	100.5×10^6
Multiyear quantity of atmospheric precipitation, mm/year	638
Multiyear value of evaporation from water surface, mm/year	600
Normal affluent level of the lake, m	141.6
Minimum permissible lake level, m	140.7
Maximal lake level, m	142.3
Regulating volume of the lake, m^3	43×10^6
Permissible drop of the lake level, m	0.90

The INPP region is drained into watersheds of the rivers Nemunas (Sventoji) and Daugava. The small territory in the north-eastern part of the region belongs to the upper course of the

Stelmuze stream (Stelmuze–Luksta–Ilukste–Dviete–Daugava). The greater northern part of the region belongs to the Laukesa watershed (Nikajus–Laukesa–Lauce–Daugava). The greatest part of the region belongs to the Dysna watershed, which may be divided into two parts: the upper course of the Dysna and the Druksa watershed with Lake Druksiai (Druksiai lake – the present effluent Prorva – from the Drisveta or Druksa watershed – Dysna) (Table 2.7) [13, 14].

Table 2.7 lent. The main river watersheds of the INPP region

River	Main watershed	The length of river till the INPP region, km	The distance from the mouth, km	Watershed area, km^2	Average height of spring flood, mm
Sventoji	Nemunas	23.0	241.6	218	90
Dysna	Daugava	19.1	154.3	445.2	90
Druksa	Daugava	0.5	44.5	620.9	90
Laukesa	Daugava	2.3	29.1	274.9	95
Stelmuze	Daugava	3.8	7.8	48.3	100

There are a lot of lakes in the INPP region. Their total area of water surface is 48.4 km^2 (without Lake Druksiai). The net density of rivers is 0.3 km/km^2. There are 11 tributaries to Lake Druksiai and one river that flows from it (the Prorva). The main rivers, which are connected to Lake Druksiai are the Ricianka (area of catchment: 156.6 km^2), the Smalva (area of catchment: 88.3 km^2) and the Gulbine (area of catchment: 156.6 km^2) [10-13].

The catchment basin of Lake Druksiai (Figure 2.4) is small (only 564 km^2). The greatest length of the catchment basin (from south-west to north-east) is 40 km; maximum width is 30 km and average 15 km. The lake is characterized by relatively slow water exchange rate. The main outflow is the River Prorva (99 % of all surface outflows) in the south part of the lake. Then, following the hydrographical net lake Druksiai → Prorva → Druksa → Dysna → Daugava → Gulf of Riga (at the Baltic Sea) which makes about 550 km, before the outflows of Lake Druksiai enters the Baltic Sea [13, 14].

The Ignalina NPP region is predominated by clay, loamy and sandy loam soils, which determine variation of water filtration conditions in different parts of the region. The percentage of forestland in the region is also widely varying and is the highest in the basin of Lake Druksiai. The average annual precipitation ranges from 590 to 700 mm. Two thirds of this value belongs to warm season. The snow cover accumulates 70–80 mm of precipitation. The total evaporation from the surface is about 500 mm [13].

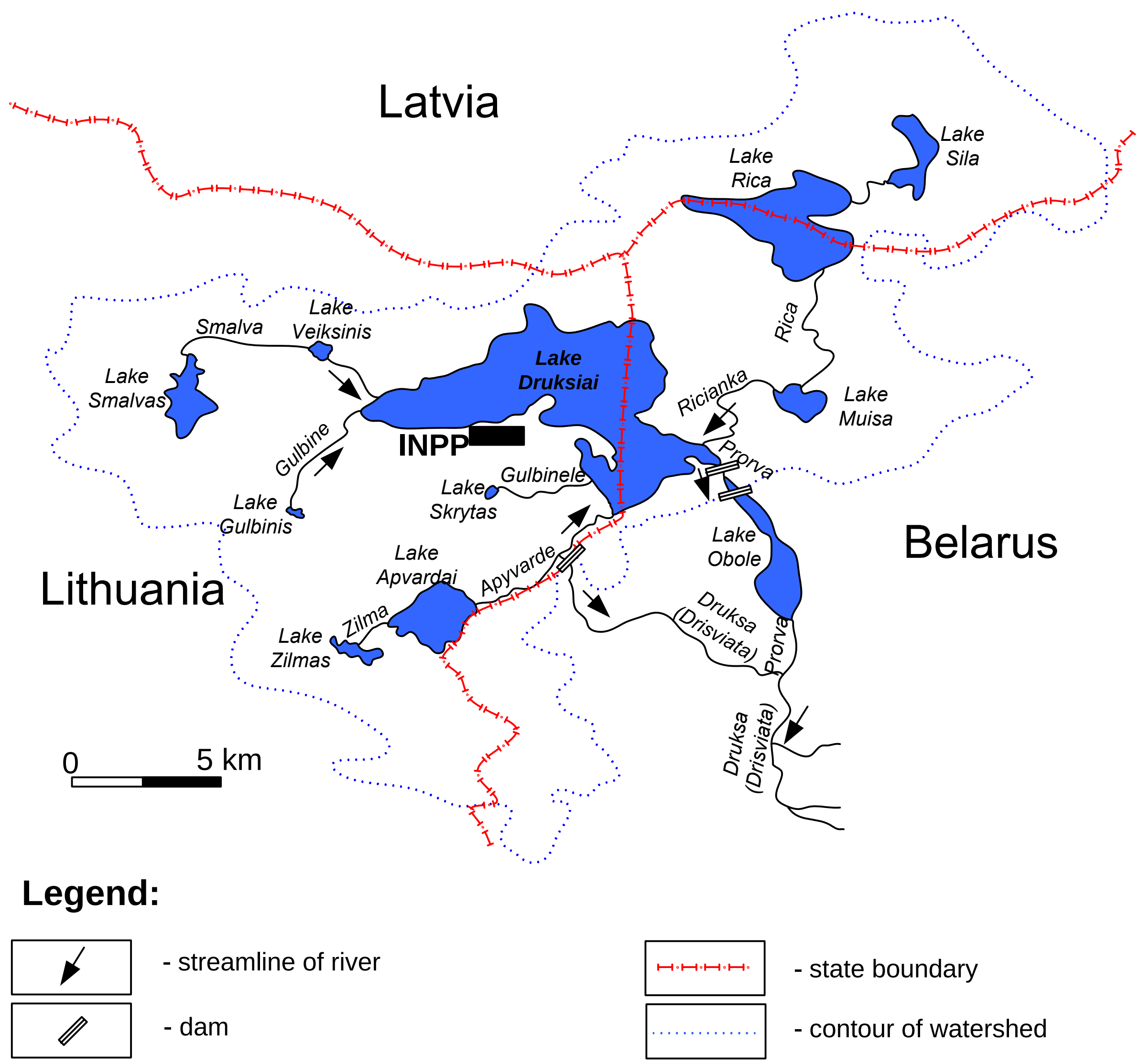

Figure 2.4. Scheme of Lake Druksiai catchment basin

2.4.1.2 Hydrogeological Conditions

The area of the INPP is located in the recharge area of the eastern part of the Baltic artesian basin. The hydrogeological cross-section data indicates presence of hydrodynamical zones of the active, slower and slow water exchange. Active water exchange zone is separated from the slower water exchange zone by 86–98 m thick regional Narva aquitard, located at the depth of 165–230 m. It is composed of loam, clay, domerite and clayey dolomite. The lower part of the aquitard contains an 8–10 m thick layer of gypsum-containing breccia. The slower water exchange zone is separated from slow water exchange zone by 170–200 m thick regional Silurian–Ordovican aquitard, located at the depth of 220–297 m [15].

Thickness of the Quaternary aquifer system is 60–260 m (mostly – 85–105 m). This aquifer system includes seven aquifers: the upper shallow unconfined groundwater aquifer and six confined groundwater aquifers located in Baltijos–Grudos, Grudos–Medininku, Medininku–Zemaitijos, Zemaitijos–Dainavos, Dainavos–Dzukijos and Dzukijos intertill fluvioglacial deposits [15].

The shallow aquifer is located in moor deposits (peat), aquaglacial deposits (sand, gravel, cobbles and pebbles), and the fissured upper part of the eroded silt of the glacial till, and the lenses of sand and gravel within the glacial till, here the aquifer is sometimes confined [15].

The aquifers in the intertill deposits are composed of sand, gravel, and in some paleovalleys – cobble and pebble deposits. The thicknesses of different aquifers vary from 0.3–2 m to 20–40 m, and in paleovalleys – 100 m and higher [15].

The confined aquifers in the intertill deposits are separated from each other by the low permeability till aquitards of sandy silt and silt, with lenses of sand and gravel. The thickness of different aquitards varies from 0.5 to 50–70 m, mostly – from 10–15 to 25–30 m [15].

The Sventoji–Upninkai aquifer system is located under the Quaternary aquifer complex in the interlayering deposits of fine and very fine grained sand, weak cemented sandstone, silt and clay. The aquifer system is 80–110 m thick. The Sventoji–Upninkai aquifer system is used for the water supply for Visaginas town and INPP. The Visaginas town waterworks are located in about 4 km to the southwest from the buffer storage site. Geological-tectonical and hydrogeological conditions form relative natural safety for the Sventoji–Upninkai aquifer complex. The system is covered by an isolating layer of more than 25 m and 50–75 % of its section is composed of clay or loam [14, 16].

According to the field investigations [17, 18] the shallow unconfined groundwater aquifer at the industrial INPP site was found mainly at the depths 1.0–4.0 m below the soil surface. Locally the aquifer was found at depths of 0–19 m below the soil surface. The typical feature is that the aquifer can consist of several hydraulically connected layers. The main flow is directed to the north and northeast towards Lake Druksiai.

Ground water at the buffer storage site is collected above clay low plasticity, in sandy mounds. Thickness of aqueous layer is – 0.2–0.5 m. Water lies at the depth of 4.2–6.3 m beneath the earth surface. Level of ground water settles at the range of altitudes of 143.31-144.30 m. Besides ground water, intramoraine water spread sporadically was found in the territory. It was found at the range of depth of 11.0-20.5 m. Thickness of aqueous pebbles and layers comprise 1.7-7.0 m [19].

2.4.1.3 Water demand

Estimated water demand during proposed economic activity, covering buffer storage installation, is presented in Chapter 2.1.4. It is estimated that the demand will be 325.63 m^3 of water per year. Water supply to the buffer storage will be performed via connection to the existing INPP water supply system. The potable water is supplied by “Visagino energija”. Existing installations are sufficient to provide necessary potable water supply. No new boreholes are foreseen. The potable water is processed at local purification plant. Its quality is constantly monitored.

2.4.1.4 Waste Water Management

After performing wet cleaning of the storage premises, liquids from the vacuum cleaner tank are discharged directly into the drain of the trap water system. Waste water from showers and lavatories, located in controlled area of the building, is discharged via flow pipes into the trap water system. Water condensate from the heating, ventilation and air conditioning system, collected in trays under conditioners and heating systems, is discharged into collection tank. Condensate from inner units of the heating, ventilation and air conditioning system of the “clean area” outflows outside the building via pipes and is discharged on the ground, and from the “contaminated area” – via trap water system into collection tank. Moisture, condensed on the surface of the equipment, containers, and half-height containers with RWP in the buffer storage facility, flows on the floor of the rooms, where they are; and afterwards it is collected by the trap water system. Water from the fire-fighting system, in case of fire-fighting, falls also on the floor of the rooms, in which this system is foreseen, and afterwards, it is collected by the trap water system.

Trap water is collected in a collection tank, with working capacity of 1.35 m^3. In order to exclude a possible leakage of radioactive substances, the tank is made of stainless steel with double walls, and is equipped with an alarm in case of leakage.

Two submersible pumps are installed in the collection tank, which allow liquids from the tank to be pumped into storage tanks. For temporary storage of all liquid waste two storage tanks with the capacity of 2.5 m^3 each are installed in the buffer storage facility. The capacity of the storage tanks is sufficient to collect all liquid discharges, generated during 20 work shifts under normal operation conditions of the storage, and also for a single collection of all fire-fighting system discharges, in case of fire.

The generated effluents will be handled in the same way as potential radioactive waste. Measurement of chemical and radiological parameters of the collected effluents will be carried out. After the assessment of the measurement results, the collected liquids will be either pumped into LRW tank for transportation to INPP LRW treatment facility or discharged into the waste water drainage system. The effluents will be discharged into the waste water drainage system following the order established by legal acts of Republic of Lithuania [47] after the permission for discharges of radionuclides to the environment is obtained and under the condition that the limiting values indicated in the permission will not be exceeded. The specific procedures (including the assessment of the measurement results of the effluents) as well as limiting values of the activities will be prepared according to the provisions of normative documents in force before commissioning of the object.

Only the non-radioactive liquid waste can be released to the sanitary-technological waste water system. The sanitary waste water is transferred to State Enterprise “Visagino energija” under an agreement.

The INPP surface water drainage system meets the requirements of the regulation [21].

2.4.1.5 Potential Impact

There will be no uncontrolled waterborne releases into the environment during planned economic activity under normal operation conditions. The structures, technological systems and its components used for collection and storage of potentially radioactive effluents will be designed to isolate them fully against any potential interaction with environmental water.

Flooding by water rise in Lake Druksiai is not expected. Flooding of facility by surface water will be prevented by maintenance of the present system of the storm water drainage.

In accordance with hygiene standard HN 44:2006 [22], the site of the buffer storage is outside the boundaries of the sectors 3a and 3b of the third sanitary protection zone of waterworks [16]. The water is extracted from Sventoji – Upninkai aquifer complex of upper and middle Devonian formations. The site of the buffer storage is located at the distance of approx. 3 km to the north-east from the SPZ of waterworks. Therefore the operation of the buffer storage facility will not affect waterworks for Visaginas town.

Accidental situations are analysed in Chapter 2.8 „Risk Analysis and Assessment “.

2.4.1.6 Impact Mitigation Measures

The buffer storage will be constructed at the INPP industrial site, which is surrounded by the existing system of boreholes for underground water monitoring. Radionuclides concentration in the storm drain water and in the groundwater of each observation borehole, which are installed at INPP site, as well as the chemical content of storm drain water and groundwater are monitored (see Chapter 2.7 „Monitoring“).

Accidental spills of combustive-lubricating materials from vehicles during transportation of RAW packages could potentially contaminate soil and groundwater at INPP site. Personnel will be trained to store and handle hazardous and toxic materials. An emergency response plan will be prepared and retained on the site, and the workers will be trained to follow specific procedures in the event of an accidental spill.

2.4.2 Environmental Air (Atmosphere)

2.4.2.1 Climatic and Meteorological Conditions

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 INPP 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 INPP area is characterized by bigger 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 [11].

<u>Precipitation and snow cover</u>

Monthly average precipitation in the region of the buffer storage is presented in Table 2.8.

Table 2.8. Monthly average precipitation (mm) in the region of the buffer storage [23-25]

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	652	216	436

There are not significant differences in data of precipitation amount for the periods 2000–2007 and 1988–1999 at the INPP region.

Average annual amount of precipitation at the buffer storage area is 648 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).

<u>Wind</u>

Western and southern winds dominate. The strongest winds blow from West and South-East. 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 average of 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 [11].

Prevailing wind directions at the buffer storage area based on local wind measurements [24, 25] are presented in Figure 2.5.

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 the reliability coefficient 1.4, calculated value of uniform wind load is 0.42 kPa and extreme wind load (with frequency 1 per 10 000 years) is 1.05 kPa with the reliability overloading coefficient 2.5 [1].

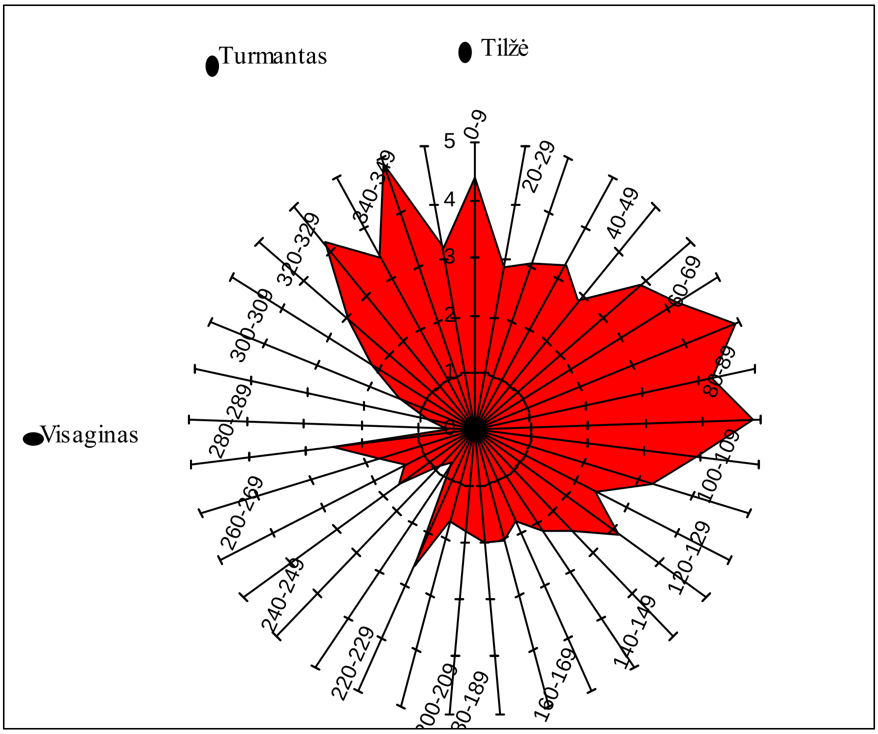

Figure 2.5. Prevailing wind directions at the INPP region (wind direction – off INPP)

Temperature

Monthly average temperatures in the region of the buffer storage are given in Table 2.9.

Table 2.9. Monthly average temperatures (°C) for the buffer storage region [25, 26]

Meteorological station and observation period	Month												Average **01 - 12**
	01	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	
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

The last decade of the 20th century (1988–1999) monthly averaged air temperature variation in the warm season (April–October) and the beginning of the cold season (November–December) does not differ from long-term (1961–1990) observations. However the second half of the cold season (January–March) during the last decade was warmer and the average air temperature for this period is higher by 4.3–2.3 °C. The average monthly temperatures on the period 2000–2007 seem to indicate a slight increase from March to December. The seven successive warm winters (1988/1989 to 1994/1995) are identified as a unique climatic phenomenon for Lithuania.

Average calculated air temperatures of the coldest five-day period are –27 ºC. Absolute maximum of recorded temperature is 37.5 ºC and absolute minimum is –42.9 ºC. Absolute maximum of calculated temperature with a frequency of 1 in 10000 years is 40.5 ºC and absolute minimum of calculated temperature with a frequency of 1 in 10000 years is –44.4 ºC [1].

2.4.2.2 Potential Non-Radiological Impact

2.4.2.2.1 Potential Sources of the Emission of Non-Radioactive Contaminants into Atmosphere

During construction of the buffer storage facility the main air pollutant sources will be a mobile sources (like trucks etc.) used for transportation of construction materials and for civil engineering construction works.

During operation of the storage facility the trucks as well as the loaders performing radioactive waste transfer will be the main pollutant sources.

Airborne releases from stationary sources during operation of the buffer storage are mainly caused by RWP transfer operations within the buffer storage and existing facility ventilation system.

2.4.2.2.2 Potential Environmental Air Pollution

During the buffer storage construction phase, environmental air pollution from mobile sources will be temporary (during relatively short period of construction) and within a limited area (construction will take place at the INPP industrial site); therefore, will not cause releases, that may have significant impact to the environmental air.

During the buffer storage operation the environmental air quality will be directly affected by the emissions of NO_X, SO_2, dusts, CO, CO_2 and unburnt carbohydrates C_XH_X generated by the road transfer of containers with radioactive waste, as well as by the fork-lift trucks working in the buffer storage premises. According to [27], assessment of emissions is necessary for the contaminants analysed. Assessment of potential contamination of atmosphere due to transportation of RAW from its generation points to the buffer storage facility and performing of transportation-technological operations on transfer of RAW within the storage, is presented in the document [28]. The assessment methodology is presented in the document [29]. It is assumed that a truck with a semi trailer will access the storage area twice a day for incoming and outgoing waste. Consumption of diesel fuel by the truck (according to the catalogue data) is 48 l/100 km. During assessment of fork-lift trucks off-gas releases it was taken into account that they will be operated by one driver and simultaneously only one fork-lift truck will be operated. The assessment results are presented in Table 2.10. For comparison, permitted (licensed) emissions for the years 2006–2009 from INPP [7] and amounts of total emission from mobile sources of environmental air pollution at INPP [30] are presented in Table 2.11.

Table 2.10. Estimation of releases of non-radioactive contaminants during operation of the buffer storage facility

No.	Source	Non-radioactive contaminants, t/year				
		CO	CH	NO_x	SO_2	SP
1	From INPP industrial site	0.003	0.00097	0.00074	0.000024	0,0001
2	From the buffer storage facility	0.03	0.025	0.01	0.0014	0,00082

No.	Source	Non-radioactive contaminants, t/year				
		CO	CH	NO_x	SO_2	SP
	Total	**0,033**	**0.02597**	**0.01074**	**0.001424**	**0.00092**

Table 2.11. Permitted (licensed) emissions from INPP and values of total emission from mobile sources of environmental air pollution

No.	Non-radioactive contaminants, t/year	CO	CH	NO_x	SO_2	SP
1	Licensed emissions in 2006-2009	104.823	0.596	37.773	0.017	1.31
2	From mobile sources	107.7	23.5	9.03	0.295	0.928

As it could be seen from Table 2.10, non-radioactive emissions during operation of the buffer storage are insignificant.

2.4.2.2.3 Impact Mitigation Measures

Estimated traffic intensity of the transport vehicles will be low, and potential impact will cover only INPP industrial site. Most of the works will be carried out in open air so that the natural air circulation will prevent the accumulation of significant concentrations of such substances.

Since fork-lift trucks are equipped with the exhaust gas cleaning system and are designed to work in closed premises, their emissions into environment will be negligible. No specific additional means for impact mitigation are foreseen.

2.4.2.3 Potential Radiological Impact

2.4.2.3.1 Potential Sources of Radioactive Airborne Releases

Radionuclide releases into environmental air from the stationary sources during operation of the buffer storage will be generated as a result of the building ventilation system operation.

Gas evolution during microbial decay in organic components of radioactive waste is unavoidable. Taking into account the nuclide composition of the waste intended to store at the Buffer Storage Facility and to disposed at the Landfill repository the most important element in the evaluation of radiological effects of gas evolution on humans and the environment is the radionuclide ^{14}C. Microbial decay of organic materials such as paper, rags, cotton, wood, plastics and rubber, is discussed below.

These organic materials can be divided into two groups: the cellulose-containing materials (paper, rags, cotton, and wood) and other materials (plastics, rubber). Decay rate is strongly influenced by the organic material form as well as the surface area available to the microbiological impact [31]. The ratio between the surface and the volume of cellulose-containing materials is high in comparison to the ratio between the surface and the volume of plastics and rubber.

There is very few data on microbial decay of plastics and rubber under aerobic conditions in literature [32]. In general case the process of microbial decay can be described as follows:

$$C_{org} + \text{Oxidant} \rightarrow C_{org}^{*} + CO_2 + H_2 + H_2O + \text{Reducing agent.}$$

Thus, in the course of decay carbon dioxide gas is produced. Several experiments confirmed that this is an extremely slow process. The calculations showed that the decay rate of the aforementioned materials is 0.002 mol/(kg of organic matter) per year, which is equivalent to the total decay of organic matter in about 15 000 years, and the gas evolution rate reaches 0.02 l/(kg of organic matter) per year, assuming that 50% of the gas will be inert [33].

The chemical environment is essential for microbial decay of cellulose. The most favourable conditions for reproduction of microorganisms are a neutral pH, temperature of 25–30 ºC and absence of biotoxic materials. The oxygen will be used for microbial decay of cellulose under aerobic conditions:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

The equation shows that carbon dioxide gas as well as water is produced during microbial decay of cellulose under aerobic conditions. However, the process is very slow under ambient air conditions. It is known that approximately 75% of cellulose decomposes in 5 years under the impact of atmosphere (sun, cold, humidity) [34]. Thus, it can be expected that cellulose will completely decompose in about 7–10 years, which results in the degradation rate of 0.5 mol/(kg of organic matter) per year and in the gas evolution rate of 10 l/(kg of organic matter) per year, assuming that 50% of the gas will be inert [32].

Considering the major part of the waste will consist of antimicrobial-treated waste (rags, paper, cotton), it can be expected that microbial decay will last for a long time under the existing conditions. Consequently, no releases of volatile radionuclides during RAW storage at the buffer storage facility are envisaged, therefore radiological impact on the ambient air due to microbiological influence during normal operation of the planned economic activity is not foreseen.

As there will be neither sorting nor treatment of waste in the buffer storage facility, only storage and measurement of packages will be performed, the only possible source of radionuclide releases is contaminated surface of the transport and storage containers.

2.4.2.3.2 Potential Releases into Environmental Air

The airborne activity source term is typically estimated by following linear equation:

Airborne activity source term = MAR × DR × ARF × RF × LPF.

Where:

MAR – activity of the radioactive material (material at risk), (Bq);

DR = 1, damage ratio;

ARF = 0,001, airborne release fraction;

RF = 1, respirable fraction;

LPF = 1 leak path factor, i.e. activity, lost by deposition on filters mechanisms (no credit on filters is given in this report).

The data on *ARF* and *RF* are selected basing on recommendations of U.S. Department of Energy handbook [31]. The data in this handbook are used in a variety of applications, such as safety and environmental analyses, and to provide information relevant to system and experiment design. As a conservative approach the bounding values of *ARF* and *RF* are used in this assessment.

Activity of the radioactive material (*MAR*) in this analysis is obtained taking into account the data on:

- The maximal number of the containers in the buffer storage (see Chapter 1);
- Dimensions of the containers;
- Permissible activity limit for the surfaces of the premises and surfaces of equipment located in the area of the permanent stay of personnel (4 Bq/cm^2 [1]).

When evaluating radionuclide releases into atmosphere it is conservatively assumed that there are no filters and radionuclides are released directly into environment. Annual radionuclide releases into environmental air from the buffer storage under normal operation conditions are presented in Table 2.12. With the purpose of comparison Table 2.12 contains information about permissible limit of radioactive emissions and planned radioactive emissions into atmosphere from the NEO within the INPP site [36].

Table 2.12. Evaluated activity of the released radionuclides from the buffer storage into atmosphere under normal operation conditions and permissible activity of the radionuclide releases from the NEO within the INPP site established in the Permission for Releases of Radioactive Material into Environment

Radionuclide	**Evaluated activity of the released radionuclides, Bq/y**	**Permissible activity of the released radionuclides, Bq/y**	
		Limit	**Planned**
C-14	5.54E+01	2.27E+11	1.27E+11
Mn-54	1.07E+04	9.05E+10	7.14E+08
Fe-55	2.66E+05	-	-
Ni-59	1.42E+02	-	-
Co-60	6.32E+04	2.88E+11	4.14E+09
Ni-63	1.71E+04	-	-
Zn-65	9.86E+00	8.32E+08	3.57E+07
Sr-90	1.07E+02	5.38E+09	4.44E+07
Nb-93m	1.86E+04	-	-
Nb-94	1.45E+03	-	-
Zr-93	2.28E+00	-	-
Tc-99	1.25E+00	-	-
Ag-110m	6.32E+01	-	-
I-129	1.28E-02	-	-
Cs-134	2.44E+03	1.33E+09	7.18E+07
Cs-137	2.71E+04	1.39E+11	9.84E+08
U-234	2.77E-02	-	-
U-235	5.52E-04	-	-
U-238	8.66E-03	-	-
Np-237	1.76E-03	-	-
Pu-238	9.17E+00	-	-
Pu-239	4.40E+00	-	-
Pu-240	7.46E+00	-	-
Pu-241	5.41E+02	-	-
Am-241	1.25E+01	-	-
Cm-244	6.21E+00	-	-
Total:	**4.07E+05**		

As it could be seen from Table 2.12, activity of the released radionuclides from the buffer storage into environmental air is insignificant.

Accidental situations, which could potentially lead to contamination of the environmental air and relative mitigation measures are assessed in Section 2.8.

2.4.2.3.3 Impact Mitigation Measures

Possible radionuclide releases, and therefore, impact on environment are evaluated as very low. No special mitigation measures of radiological impact are foreseen.

2.4.3 Soil

2.4.3.1 Information about the Site

The buffer storage will be constructed at the INPP industrial site. The area of the INPP site has been changed in the past because of construction and industrial activity, thus natural soil in this area is almost totally absent. The INPP site is almost entirely covered by artificial ground which consists of clay loam with pebble and gravel, sand at places with organic remains. Layer thickness is about 2 m [17, 18].

According to the INPP monitoring programme, samples of the soil in the INPP region are continuously monitored. The information on detected radionuclides and their radioactivity is presented in Table 2.13 [25].

Table 2.13. Specific activity of the radionuclides in the soil of INPP 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

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

2.4.3.2 Potential Impact

It is planned to construct the buffer storage facility at the site of the former INPP Reactor Unit 3 and no additional negative impact on the upper soil layer and significant soil contamination from the proposed economic activity is expected.

No soil pollution is foreseen under normal operation conditions of the proposed economic activity. The site area will be permanently monitored (see Chapter 2.7 „Monitoring“). In case of local soil contamination by conventional pollutants or radioactive material appropriate procedures will be implemented to eliminate the hazard and consequences of this impact.

2.4.3.3 Impact Mitigation Measures

Since no negative impacts of the proposed economic activity to soil are identified, no measures for impact mitigation are foreseen.

2.4.4 Underground (Geology)

2.4.4.1 Characterisation of the Underground Conditions

The INPP 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 [15].

The crystalline basement is buried to a depth of about 720 m from the current ground level. 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 INPP varies in the range of 703–757 m. Pre-Quaternary succession is represented by the Upper Proterozoic Vendian complex, overlain by sediments of the Paleozoic systems. The Vendian deposits are represented by a succession of gravelstone, feldspar-quartz sandstone of different grain size, siltstone and shale. The Paleozoic section comprises the successions of the Lower and Middle Cambrian, the Ordovician, the Lower Silurian and the Middle and Upper Devonian sediments (Figure 2.6 and Figure 2.7).

The Lower Cambrian is represented by quartz sandstone with inconsiderable admixture of the 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 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 the 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 the 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 – 28–75 m and the total thickness of the Devonian sediments reaches 250 m [15].

Sub-Quaternary relief of the area is highly dissected by paleoincisions. The thickness of the Quaternary cover varies from 62 up 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). The 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 up to 25–30 m (Figure 2.8). The intersticial deposits are composed of very fine-grained and fine-grained sand, silt and peat (Figure 2.10 and Figure 2.11). The Holocene deposits are represented by alluvial, lacustrine and bogs 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 [15].

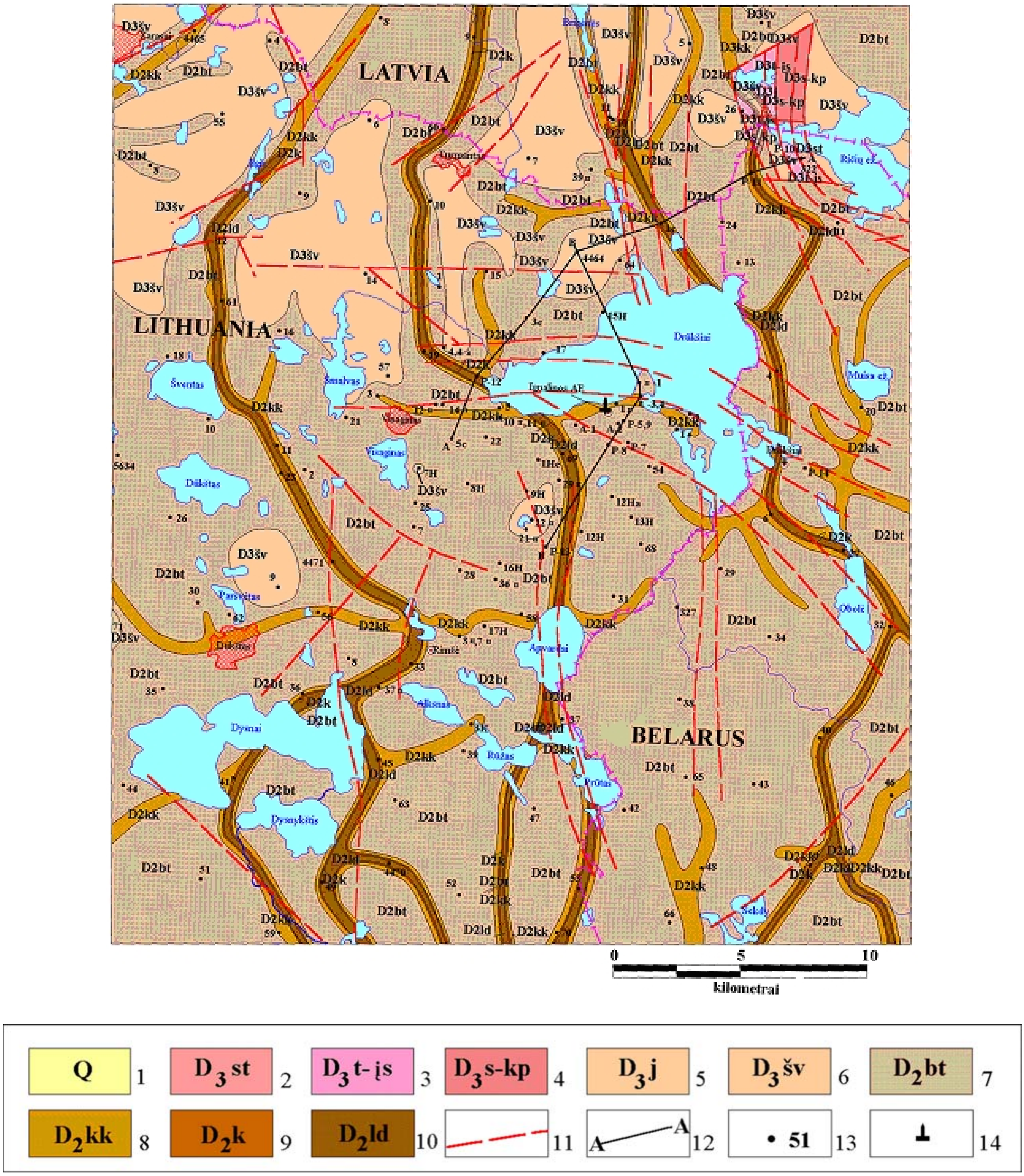

Figure 2.6. Pre-Quaternary geological map of the INPP region [15]:

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 – Ignalina NPP

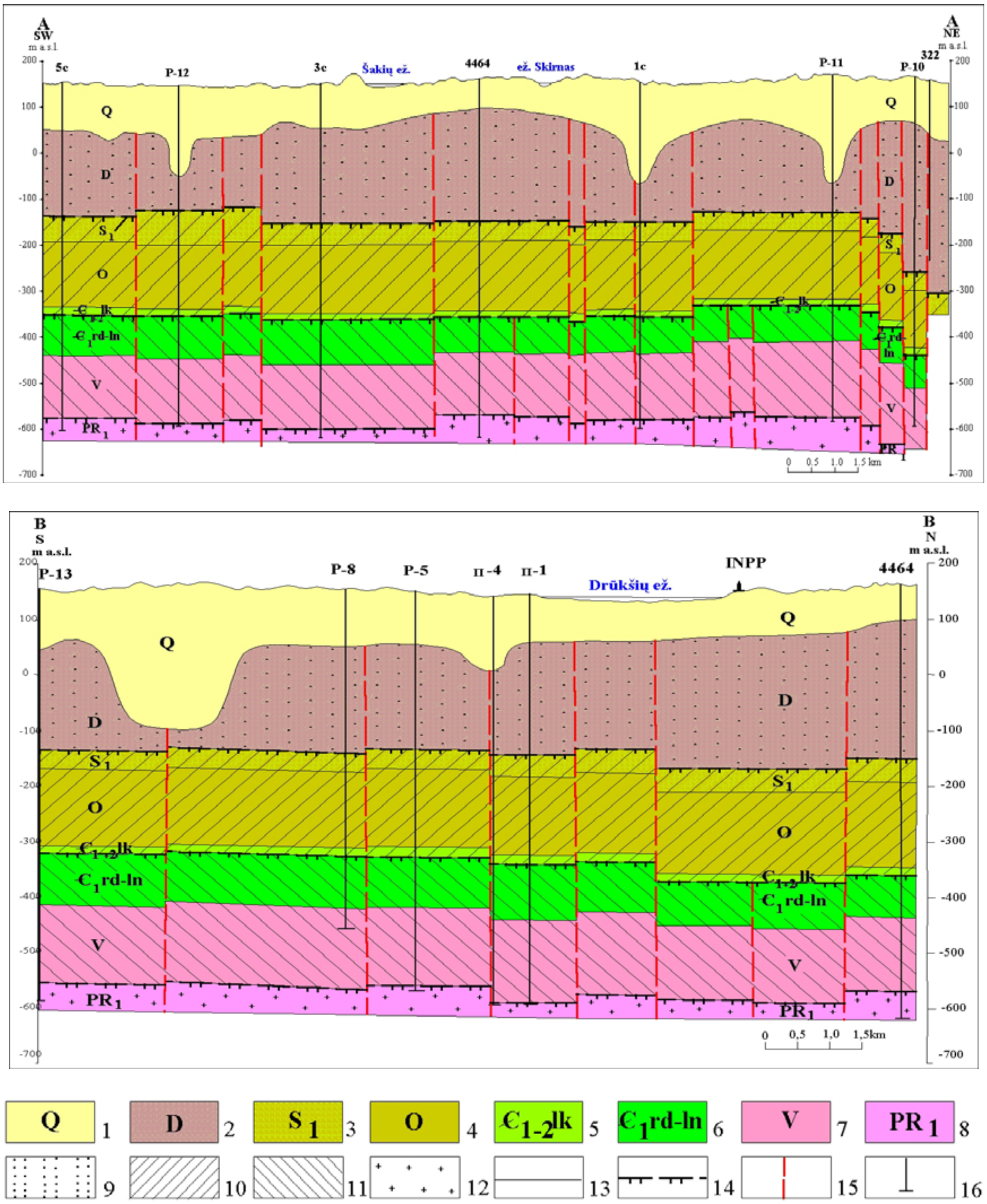

Figure 2.7. Geological-tectonic cross-sections of the INPP region [15] (cross-section location see in Figure 2.8):

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; 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

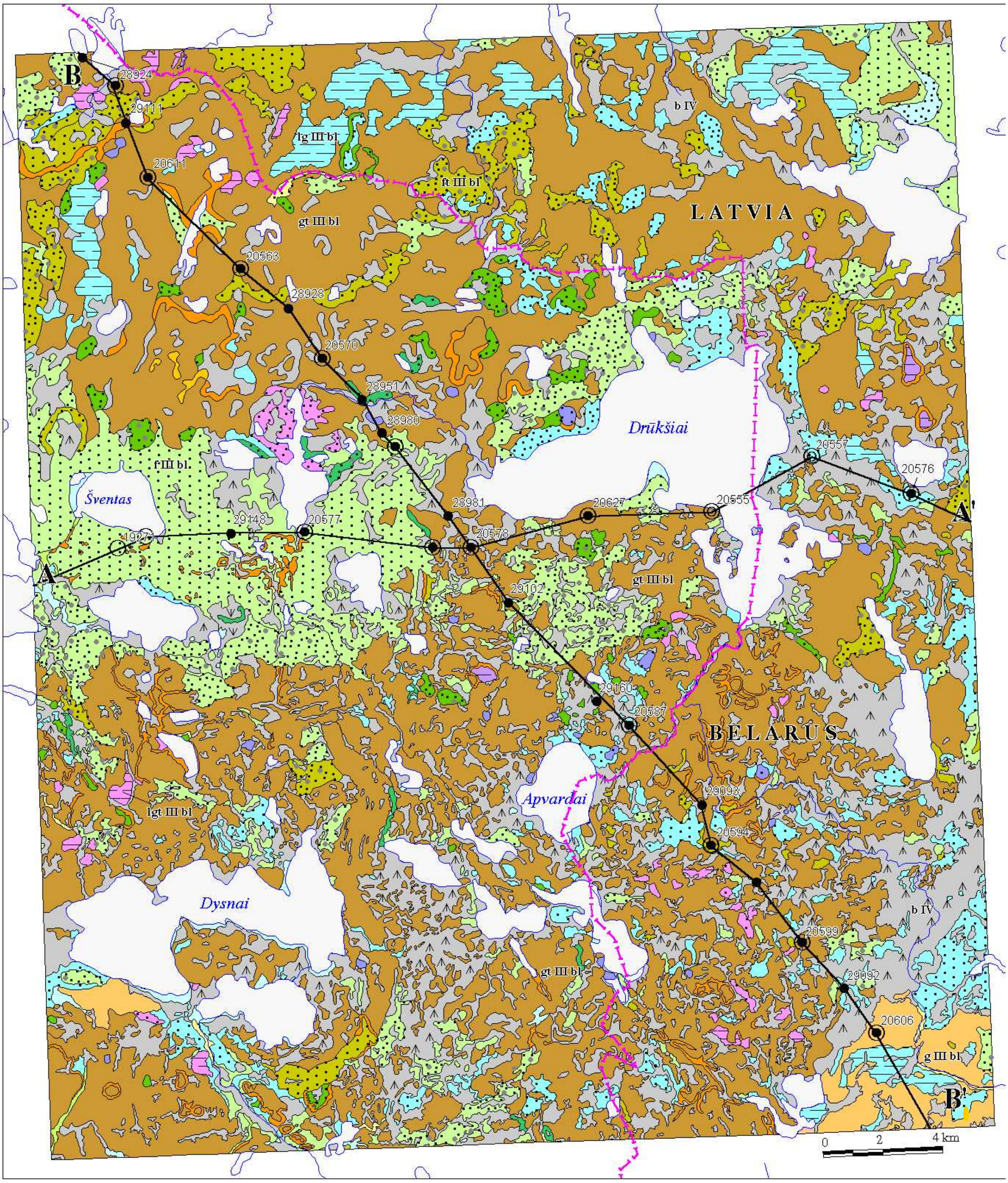

Figure 2.8. Quaternary geological map of the INPP area (original scale 1:50 000, author: R. Guobyte [15]); legend see in Figure 2.9

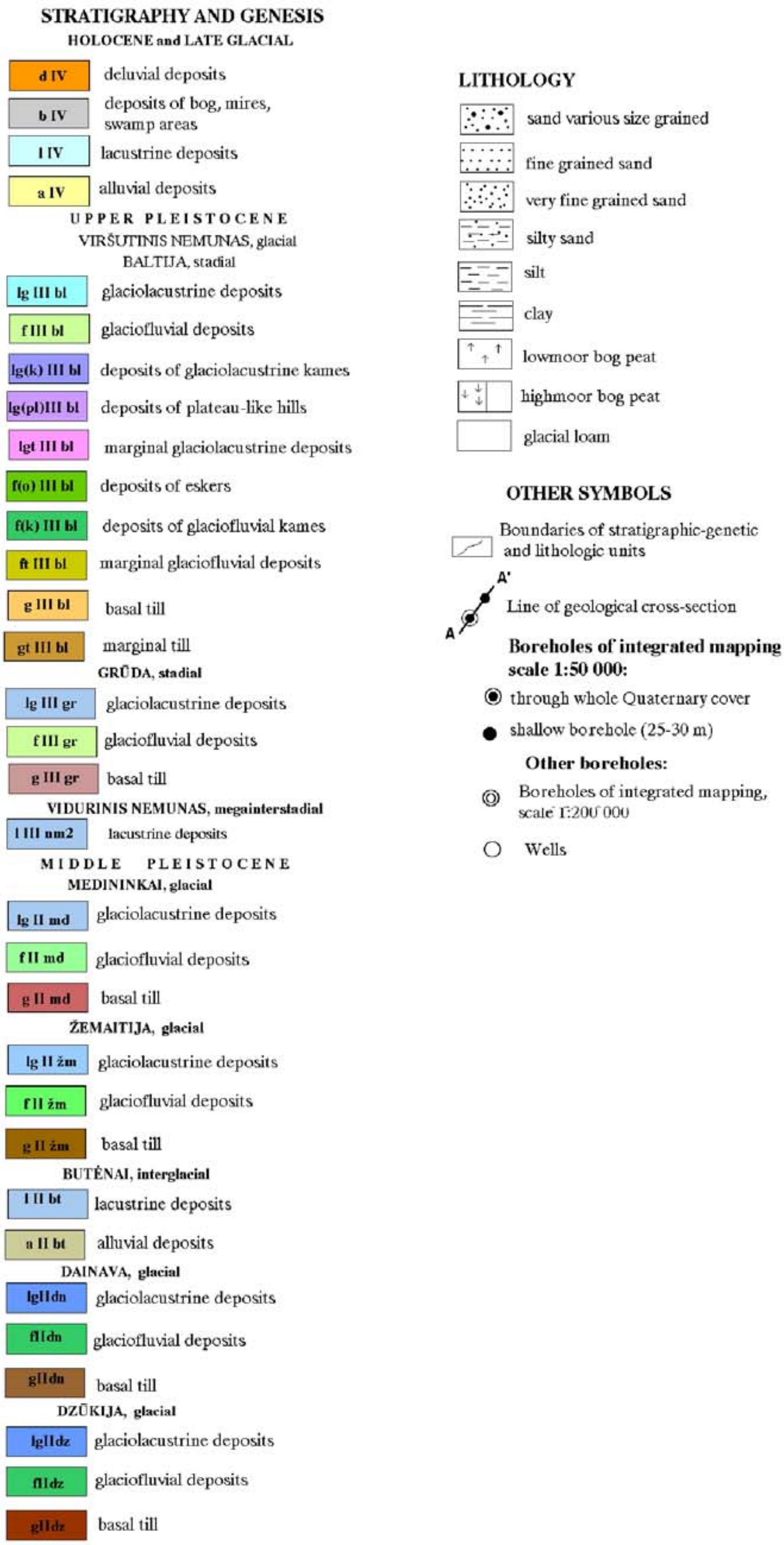

Figure 2.9. Legend for Quaternary geological map and geological cross-sections of the INPP region

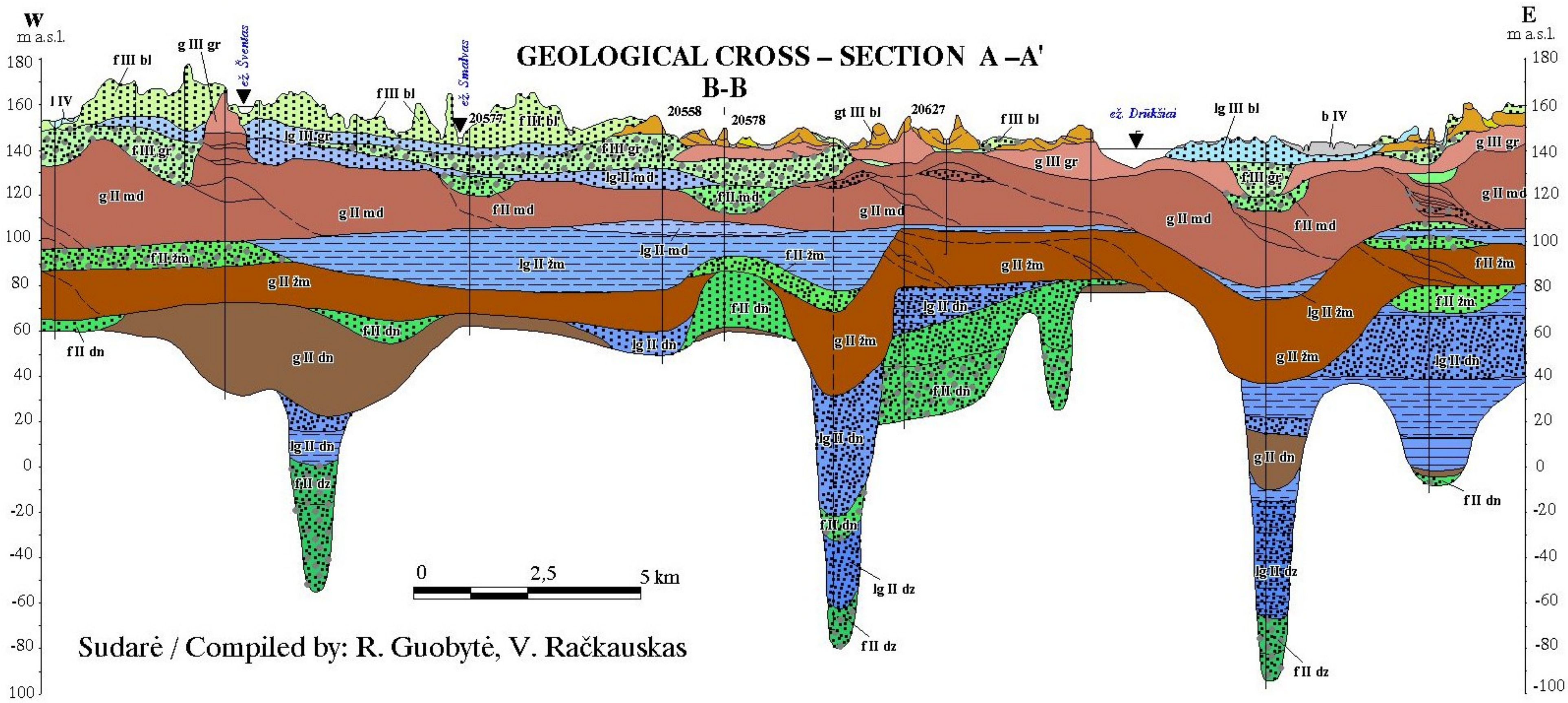

Figure 2.10. Quaternary geological cross-section A-A of the INPP area (original scale 1:50 000, authors: R. Guobyte, V. Rackauskas [15]); legend see in Figure 2.9

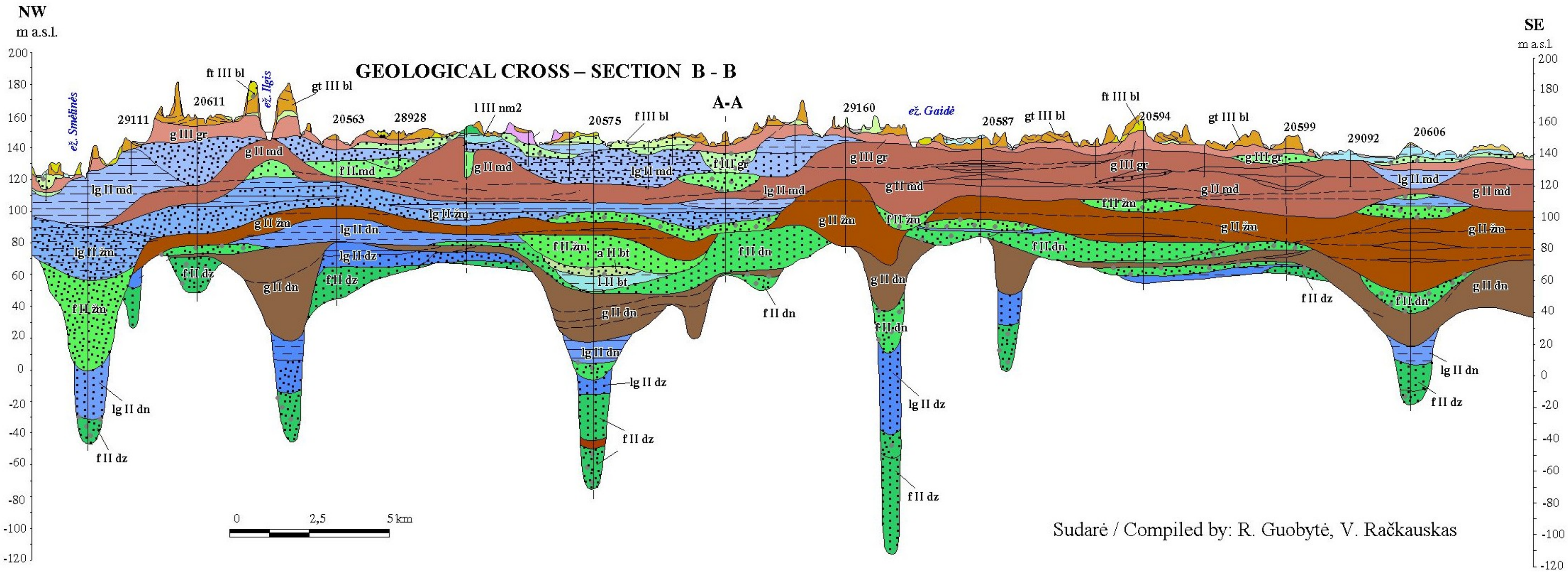

Figure 2.11. Quaternary geological cross-section B-B of the INPP area (original scale 1:50 000, authors: R. Guobyte, V. Rackauskas [15]); legend see in Figure 2.9

2.4.4.2 Potential Impact

The proposed economic activity will not affect the underground component of the environment. The buffer storage will be constructed at the INPP industrial site, on the territory of the former third unit, and additional impact to the geological structure will be insignificant.

No valuable natural resources have been found at the buffer storage site. The planned economic activity under normal operation conditions will have no effect on possible off-site activities in the vicinity.

2.4.4.3 Impact Mitigation Measures

Since no negative consequences of the proposed economic activity on the region underground are identified, no impact mitigation measures are required.

2.4.5 Biodiversity

2.4.5.1 NATURA 2000 Network and Other Protected Areas

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 [37] and 92/43/EEC [38]. The main objective of the NATURA 2000 network is to ensure the survival of species and habitats that are threatened or rare throughout Europe.

Basing on the Council Directive 79/409/EEC of 2 April 1979 on the Conservation of Wild Birds (further – Birds Directive) the Special Protection Areas (SPAs) are to be designated. 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) the Special Areas for Conservation (SACs) are to be established.

Prior to the establishment of SACs, based on scientific research, sites, meeting the criteria of Special Areas for Conservation are selected. The list of sites meeting the criteria of Special Areas for Conservation is presented to the European Commission (EC). After the list of sites meeting the criteria of Special Areas for Conservation is approved by EC, they are supposed to be called Sites of Community Importance (SCIs). Based on Sites of Community Importance the member states shall establish Special Areas for Conservation.

Sites, corresponding to the criteria of Special Areas for Conservation, meet the criteria of SACs designation, approved by the Minister of the Environment [39]. According to the EU Habitat 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 LR Law on Protected Areas [40], first a national protected area is to be established. Later on it can be granted with the status of SPA or a site meeting the criteria of Special Area for Conservation, or a Site of Community Importance or SAC can be established. The European Commission has already approved the list of sites meeting the criteria of Special Area for Conservation or SCIs.

The order of the LR Minister of Environment [39] is the legal base of designation of the aforementioned SCIs.

The nearest to INPP Sites of Community Importance (SCIs) of the “NATURA 2000” network are listed in Table 2.14 and shown on Figure 2.12.

Table 2.14. The nearest to INPP Sites of Community Importance (SCIs) of the "NATURA 2000" network

The name of location	Area, ha	SCI code in "NATURA 2000" network data base and comments on SCI boundaries	Valuable species in the area	Preliminary area habitats, ha
Lake Druksiai	3611	LTZAR0029 The border is defined according to the special map.	Spinned loach (*Cobitis taenia*)	
			European otter (*Lutra lutra*)	
River Smalvele and adjacent limy fens	547	LTZAR0026 The border is the same as for Smalvos hydrographical reserve.	Fire-bellied toad (*Bombina bombina*)	
			European otter (*Lutra lutra*)	
Lakes and wetlands Smalva and Smalvykstis	2225	LTZAR0025 The border is the same as for Smalvos landscape reserve.	3140, Hard oligo-mesothrophic waters with benthic vegetation of Chara formations	354.6
			3160 Dystrophic lakes	45.0
			7140 Transition mires and quaking bogs	265.9
			7210 Calcareous fens with Cladium mariscus and Carex davaliana	88.7
			7230 Alkaline fens	88.7
			9010 Western taiga	265.9
			9080 Fennoscandian deciduous swamp woods	88.7
			91D0 Bog woodlands	88.7
			Fen orchid (*Liparis loeselii*),	
			Slender green feather-moss (*Hamatocaulis vernicosus*)	
Grazute regional park	26125	LTZAR0024 The border is the same as for Grazute regional park, with the exception of recreational, agriculture and residential priority zones.	3130 Oligothrophic waters with amphibious vegetation	105
			3140 Hard oligo-mesothrophic waters with benthic vegetation of Chara formations	18.4
			3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	2.0
			6120 Xeric sand calcareous grasslands	5.0
			6210 Semi-natural dry grasslands	1568.0
			7120 Degraded upland bogs	26.0
			7140 Transition mires and quaking bogs	69.6
			7160 Non calcareous springs and springy bogs	2.0

The name of location	Area, ha	SCI code in "NATURA 2000" network data base and comments on SCI boundaries	Valuable species in the area	Preliminary area habitats, ha
			9010 Western taiga	810.0
			9020 Broad leaved and mixed woodlands	99.0
			9060 Coniferous woodlands on fluvioglacial eskers	45.0
			9080 Fennoscandian deciduous swamp woods	201.0
			91D0 Bog woodlands	2012.0
			Large copper (*Lycaena dispar*)	
			(*Thesium ebracteatum*)	
			Fire-bellied toad (*Bombina bombina*)	
			Great crested newt (Triturus cristatus)	
			European otter (*Lutra lutra*)	
			Eastern pasque flower (*Pulsatilla patens*)	
Pusnis wetland	779	LTIGN0001 The border is the same as for Pusnis telmological reserve	6230 Species-rich Nardus grasslands	8.0
			6430 Hydrophilous tall herb fringe communities of plains	39.0
			7140 Transition mires and quaking bogs	234.0

Protected territories or their parts in the Republic of Lithuania comprising Special Protection Areas (SPA) are approved by the Government [41]. The nearest to INPP Special Protection Areas of the "NATURA 2000" network are listed in Table 2.15 and shown on Figure 2.12. Information on what protected bird species of European importance are found in each SPA is also indicated in Table 2.15. Forbidden activities in the Special Protection Areas are summarized in Table 2.16.

Table 2.15. The nearest to INPP Special Protection Areas (SPAs) of the "NATURA 2000" network

LR protected area (or its part)	Code in "NATURA 2000" network data base and location of the SPA	Protected bird species of European importance	Comments on SPA boundaries
Part of the protected zone for Lake Druksiai	LTZARB003 Lake Druksiai	Great Bittern (*Botaurus stellaris*)	SPA takes a part of the protected territory. The border is defined according to the plan.
Parts of protected zone for Lakes Dysnai and Dysnyksciai	LTIGNB004 The limy fens complex of Dysnai and Dysnykstis lake area	Corn crake (*Crex crex*)	SPA takes a part of the protected zone. The border is defined according to the plan.
Part of Grazute regional park	LTZARB004 North eastern part of Grazute regional park	Black-throated Diver (*Gavia arctica*), Pygmy owl (*Glaucidium passerinum*)	SPA takes a part of the protected territory. The border is defined according to the plan.

LR protected area (or its part)	Code in "NATURA 2000" network data base and location of the SPA	Protected bird species of European importance	Comments on SPA boundaries
Smalva hydrographic reserve	LTZARB002 The complex of Smalva limy fens	Black Tern (*Chlidonias niger*)	The border of the SPA is the same as for Smalva hydrographic reserve

Table 2.16. Forbidden activities in the Special Protection Areas (SPAs) nearest to the INPP site

"NATURA 2000" code and location of the SPA	Bird species of European importance	Forbidden activities [42]
LTZARB003 Lake Druksiai	Great Bittern (*Botaurus stellaris*)	Reap reeds (in certain areas); Visiting places of above water vegetation overgrowth from ice melting till July 1 (in certain areas); Boating and yachting (in certain areas); Camping, excepting in specially predefined recreational areas, from ice melting till July 1 (in certain areas); Hunting of water and wetland birds excepting cases of regulation of cormorant population in pisciculture waters; Change the land usage main purpose excepting cases of changing to more conservative purpose; Change the hydrological regime if it leads to decrease of habitability area or quality; Plant forest.
LTIGNB004 The limy fens complex of Dysnai and Dysnykstis lake area	Corn Crake (*Crex crex*)	Change the land usage main purpose excepting cases of changing to more conservative purpose; Convert meadows and pastures into plough-land; Change the hydrological regime if it leads to decrease of habitability area or quality; Plant forest.
LTZARB002 The complex of Smalva limy fens	Black tern (*Chlidonias niger*)	Boating and yachting from May to July; Change the hydrological regime if it leads to decrease of habitability area or quality; Perform water body bed renovation works if it leads to decrease of habitability area or quality.
LTZARB004 North eastern part of Grazute regional park	Black-throated Diver (*Gavia arctica*)	Visiting from ice melting till July 1 (in certain areas); Erect constructions which are not related to purpose of protected territory and expand infrastructure (in certain areas).
	Pygmy owl (*Glaucidium passerinum*)	Perform general deforesting (in certain areas); Perform deforesting and timbering works from February till May (in certain areas); In case of general deforesting not less than 20 (per hectare) seminal of main group and trees (arranged in biogroups) necessary to maintain biodiversity shall be left (in certain areas).

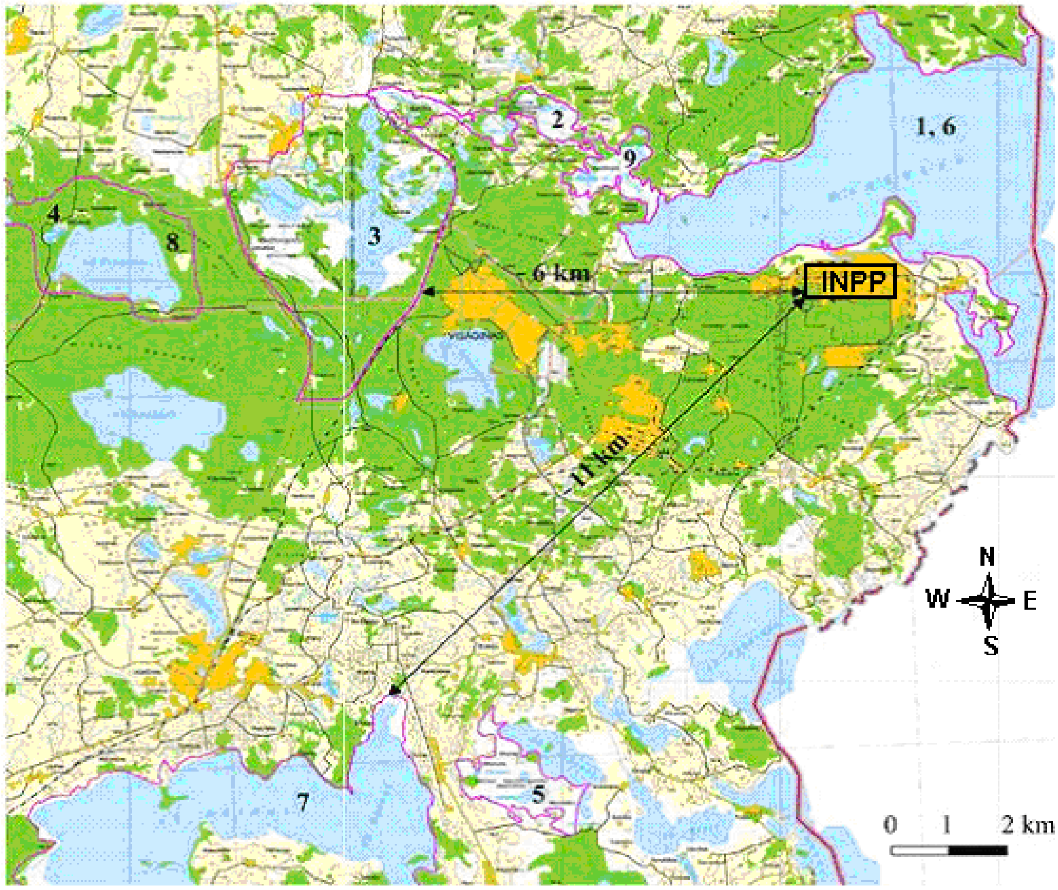

Figure 2.12. The nearest to the INPP site "NATURA 2000" network areas (perimeters are indicated in red)

Sites of Community Importance (SCIs): 1 – Lake Druksiai; 2 – River Smalvele and adjacent limy fens; 3 – Lakes and wetlands Smalva and Smalvykstis; 4 – Grazute Regional Park; 5 – Pusnis wetland. Special Protection Areas (SPAs): 6 – Lake Druksiai; 7 – the limy fens complex of Dysnai and Dysnykstis lake area; 8 – North eastern part of Grazute Regional Park; 9 – the complex of Smalva limy fens

2.4.5.2 Potential Impact

The functional and structural changes in Lake Druksiai biota are caused by thermal releases from INPP and chemical pollution, which main sources are waste waters of INPP and Visaginas municipal sewerage that are returned to Lake Druksiai, after being processed at the general household sewage water cleaning system. Buffer storage facility will not affect the thermal releases, and discharges of waste water during the operation of the buffer storage will comprise only an insignificant part of the waste water from INPP.

The proposed economic activity will be held within the INPP industrial site. Protected species, as designated by Lithuanian or European Law, are not encountered within the boundaries of the INPP industrial site.

The proposed economic activity will have no relevant interaction with biodiversity outside the INPP industrial site. Buffer storage project, either individually or in combination with other plans or projects, will not have an effect on the deterioration of natural habitats, the habitats of species and birds as well as disturbance of the species for which the SCIs and SPAs have been designated. There will be no project implications for the SCIs and SPAs in the vicinity of INPP in view of their conservation objectives.

2.4.5.3 Impact Mitigation Measures

No impacts on biodiversity due to implementation of proposed economic activity are foreseen. Therefore no impact mitigation measures are proposed.

2.4.6 Landscape

2.4.6.1 Information about the Site

The buffer storage building will be constructed within the INPP site. The landscape of the site is industrial and is characterized by power production units and buildings connected to power production operation. The most visible part of the power plant is stack.

Landscape around the INPP 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 recreation areas along Lake Druksiai with their specific natural and visual qualities have a great value for the quality of life. The valuable landscape areas (like Grazute Regional Park and Smalva hydrographical reserve) are located at about 10 kilometres from the buffer storage building.

2.4.6.2 Potential Impact

The planned storage will be constructed and operated at the INPP industrial site. Impact to the existing landscape is not expected. A slightly more intensive traffic on the roads of the INPP industrial site, due to radioactive waste transportation, will not change the general view.

For the exterior finishing of the facade of the buffer storage modern materials will be used, and the new building will only improve the general view of the INPP industrial site.

2.4.6.3 Impact Mitigation Measures

Since no potential impacts on landscape are identified, there are no impact mitigation measures foreseen.

2.4.7 Social and economic environment

2.4.7.1 Population and Demography

According to data for 2005 the total population of the INPP 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 71700 (in Visaginas 28 700 people and in Ignalina and Zarasai districts 21 400 and 21 600 people, respectively). Even INPP region comprises 4.3 % of Lithuania territory, however the population number is about 2 % of the total Lithuania population. During the recent years, a decrease of population in the INPP region is 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 2.17, Table 2.18 and Figure 2.13.

Table 2.17. Demographic indicators of INPP 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

Factor	Ignalina district	Zarasai district	Visaginas	INPP region
% 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 2.18. 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 2.13. Population distribution within 5, 10, 15, 20, 25 and 30 km radius around the INPP

Inhabitants, living in the territories of Latvia and Belarus, which fall into 30 km radius zone around INPP are taken into account (see Table 2.18). Within the 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 INPP region is one of the lowest in Lithuania.

A 3 km radius sanitary protected zone is established around the INPP there are neither farms nor settlements and economic activities are limited. The closest town is Visaginas, which is situated about 6 km from the INPP.

2.4.7.2 Economic Activities

A 3 km radius sanitary protected zone is established around the INPP where economic activities are limited. Land use in the surrounding area is made of: lakes – 15 %, swamps – 15 %, farming land – 40 % and forests – about 30 %.

From the economic point of view the INPP region, except 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). 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. No important minerals (with the exception of quartz sand) are found in the region.

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.

Neither chemical nor oil process industries exist in the vicinity of the INPP.

2.4.7.3 Road and Railway Connections, Forbidden for Flights Areas

The existing road and railway systems are shown on Figure 2.14. The nearest highway passes 12 km to the west of INPP. This highway joins Vilnius with Zarasai the border town to Latvia and has an exit to the highway connecting Kaunas–St Petersburg. The entrance of the main road from INPP to the highway is near the town of Dukstas. The road from INPP to Dukstas is about 20 km.

Figure 2.14. Road and railway network

The main railroad line Vilnius–St Petersburg passes 9 km to the west of INPP. The INPP is connected to the railroad by an extension from Dukstas. The railway station Dukstas is used for cargo traffic as well as for passenger transportation.

There are 3 zones where flights are prohibited in Lithuania, the one of which is territory within 10 km around the INPP (Figure 2.15).

There are about 30 000 flights per year (in 2005) from Vilnius airport, which is located 130 km from the INPP site. About 125 000 aeroplanes per year cross the Lithuanian air space. Altogether 30 airports of civil, military and mixed purpose are located in the country.

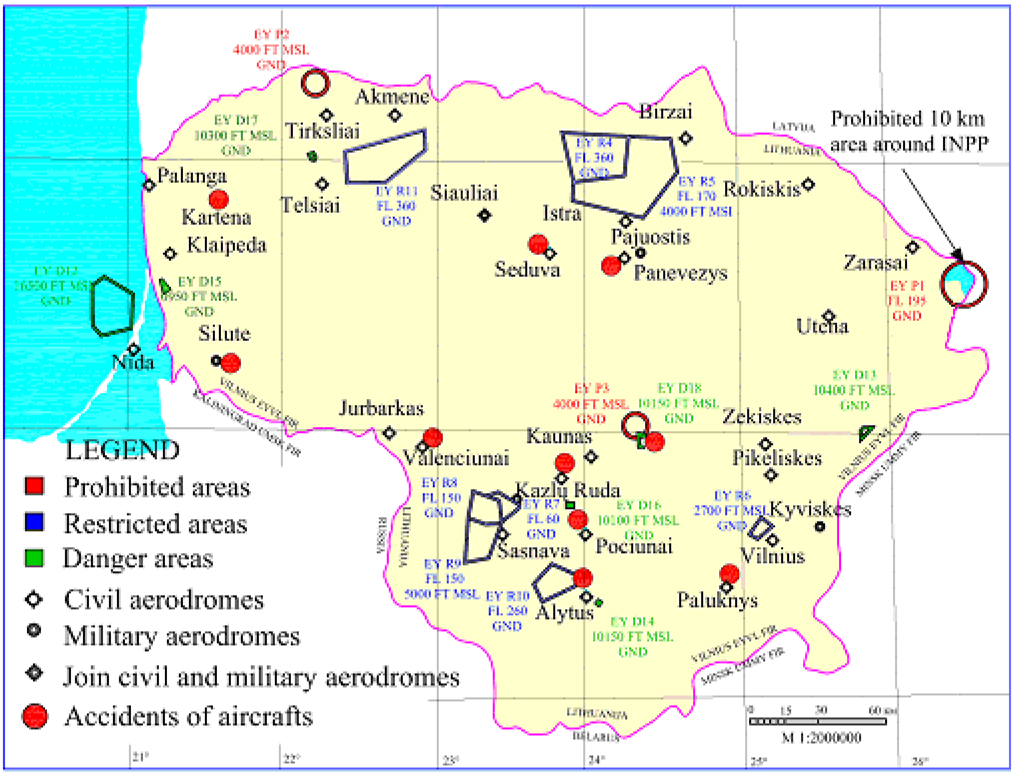

Figure 2.15. Airports, forbidden, restricted and dangerous areas in Lithuania

2.4.7.4 Potential Impact

The proposed economic activity will be held within the INPP industrial site and within the existing 3 km radius sanitary protection zone of INPP. There is no permanently living population within the existing sanitary protection zone, and the economic activity is limited as well.

No impacts or evident changes of social and economical environment are foreseen. Necessary labour resources to perform the proposed economic activity are available at INPP. Moreover, this project will decrease the social and economic impacts of the INPP final shutdown by using the work force with a high skill level associated with work in the nuclear industry. The project will employ about 6 people.

The proposed economic activity will be performed in accordance with the modern environmental requirements using state-of-the-art technologies. The proposed economic activity represents the EU direct investment for the INPP decommissioning. It will be performed in compliance with the radioactive waste management principles of the IAEA and in compliance with good practices in other European Union Member States.

2.4.7.5 Impact Mitigation Measures

No impacts or evident changes of social and economical environment are foreseen. Moreover, this project will decrease the social and economic impacts of the INPP final shutdown by using the work force with a high skill level associated with work in the nuclear industry.

2.4.8 Ethnic and cultural conditions, cultural heritage

2.4.8.1 Information about the Site

There are several cultural heritage sites in the area around Ignalina nuclear power plant (village Druksiniai, Visaginas municipality):

1. Grikiniskes settlement antiquities (territory area – 3.08 ha).
2. Grikiniskes settlement antiquities II (territory area – 4.95 ha).
3. Grikiniskes settlement antiquities III (territory area – 1.82 ha).
4. Petriskes settlement antiquities (territory area – 0.8 ha).
5. Petriskes mound (territory area – 0.48 ha).
6. Petriskes settlement antiquities II (territory area – 0.31 ha).
7. Stabatiskes manor place (territory area – 1.47 ha).

In the vicinity of INPP there are: Grazutes regional park (area 24230 ha), Ceberaku (Pasamanes) mound, called Baznyciakalnis (cultural heritage code A1537) and other objects of cultural heritage (Figure 2.16).

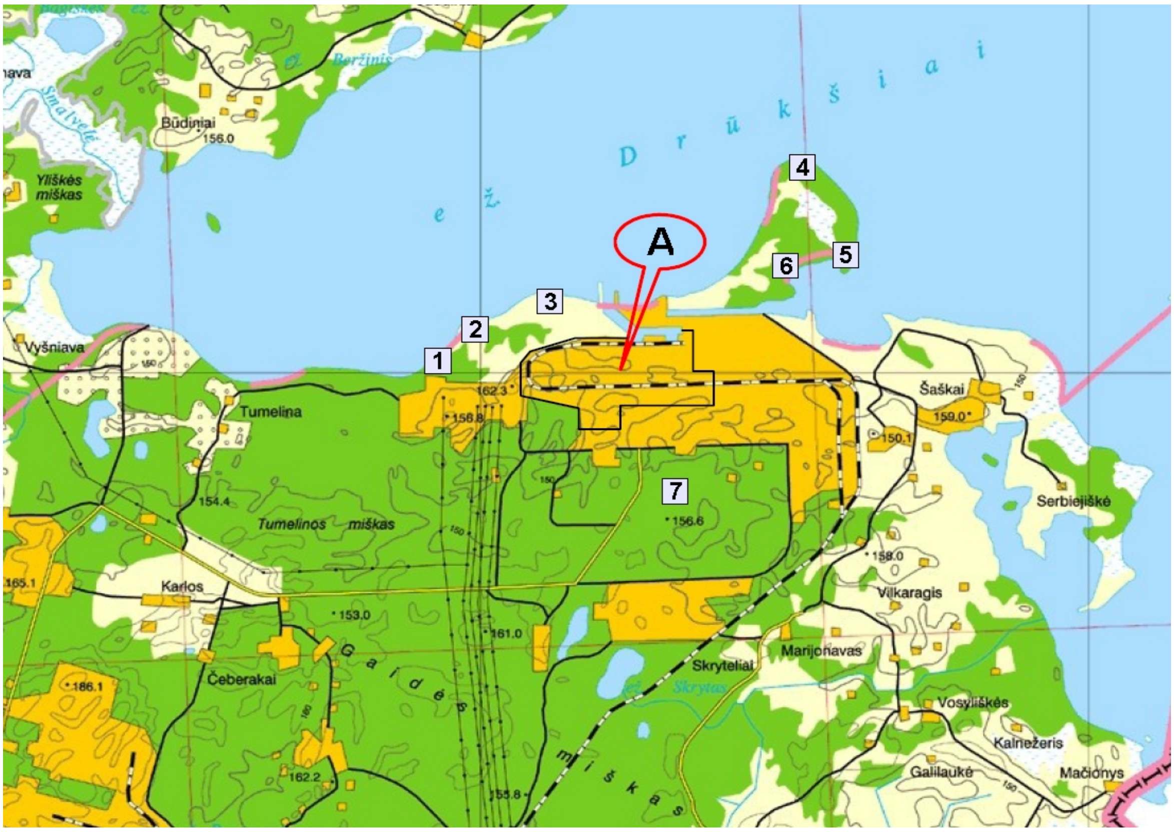

Figure 2.16. Cultural heritage objects in the vicinity of the INPP site:

A – INPP site; 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 place

2.4.8.2 Potential Impact

The identified immovable cultural heritage objects and areas will not be affected by the construction and operation of the buffer storage facility as they are located far away from the building. There are no other sites of cultural heritage, ethnic or cultural conditions that could be negatively impacted by the proposed economic activity.

2.4.8.3 Impact Mitigation Measures

There are no required mitigation measures relating to the protection of cultural heritage as no impact from the proposed economic activity is expected.

2.4.9 Public health

2.4.9.1 General Information

General information about population health indicators for the Ignalina NPP region (Visaginas Municipality, Ignalina and Zarasai districts) is summarized in Table 2.19 and Figure 2.17.

Table 2.19. Population health indicators for the INPP region in 2005/2006

Factor	Ignalina district	Zarasai district	Visaginas	INPP region
Registered morbidity per 100 thousands of adults	1245	1710	2162	1706
Registered morbidity per 100 thousands of children	2236	2826	3504	2856
Incidence of malignant neoplasms per 100 thousands of pop.	581	589	300	490
Prevalence of malignant neoplasms per 100 thousands of pop.	2080	2097	1195	1791
Incidence of mental disorders per 100 thousands of pop.	129 *	496 *	451 *	359 *
Prevalence of mental disorders per 100 thousands of pop.	1910 *	6182 *	2481 *	3524 *
Admissions per 100 thousands of pop.	169 *	138 *	194 *	167 *

* Data for 2006

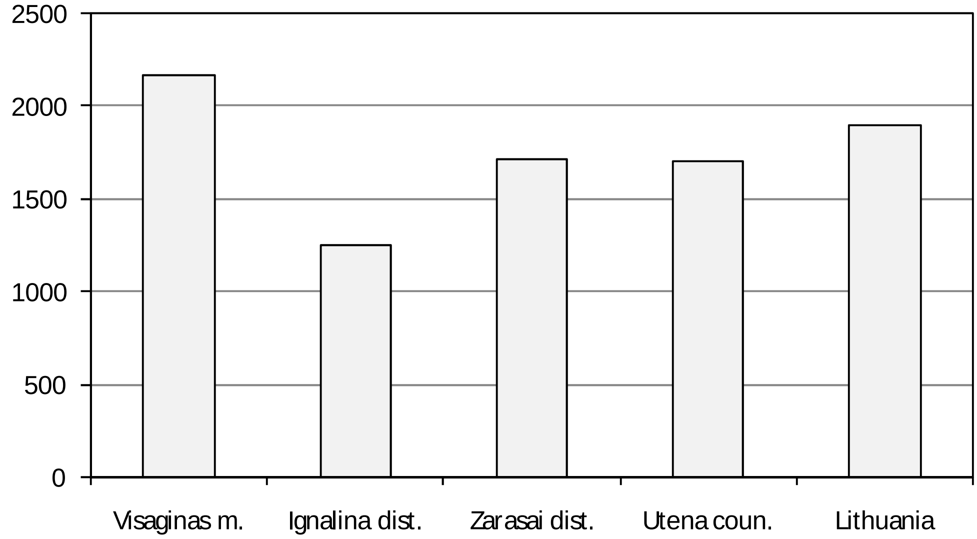

Figure 2.17. Registered morbidity per 100 thousands of adults for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2005 [43]

Death rate per 100 thousands of population and percent of working age population for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2005 are presented in Figure 2.18 and Figure 2.19.

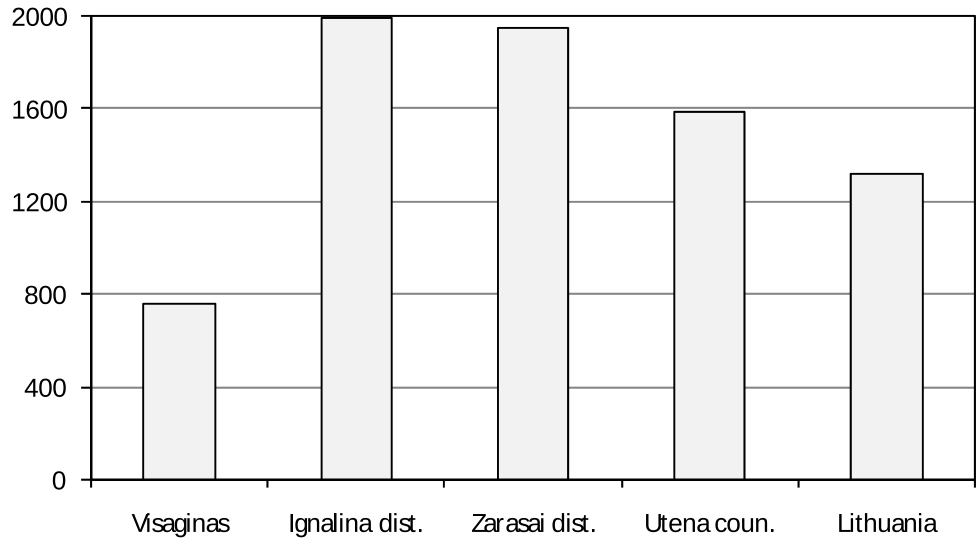

Figure 2.18. Death rate per 100 thousands of population for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2006 [43]

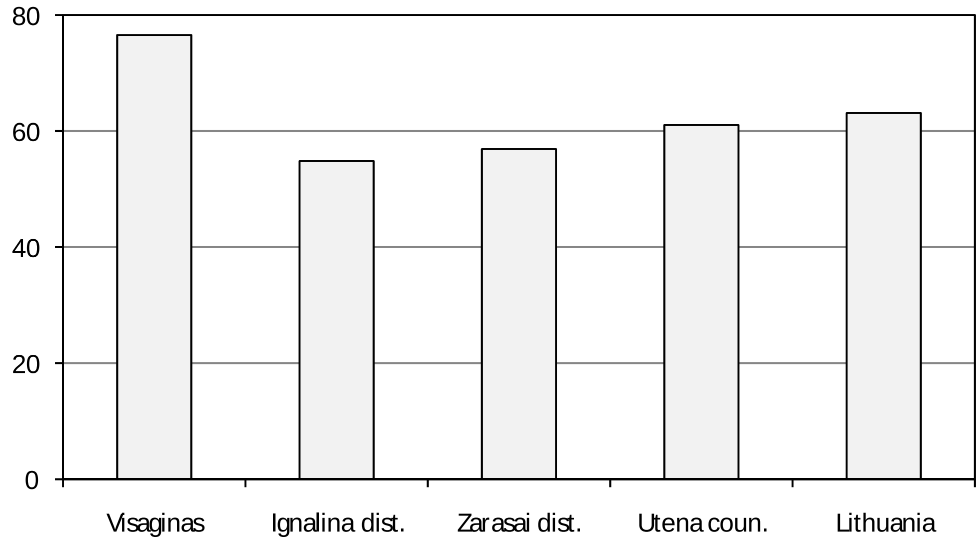

Figure 2.19. Percent of working age population for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2006 [43]

As it can be seen from Figure 2.18, the death rate per 100 thousands of population for town of Visaginas is lowermost in the whole country and the death rate per 100 thousands of population for Ignalina and Zarasai districts is the uppermost. This is not connected anyhow with operation of INPP; the reason is the age of population. As it can be seen from Figure 2.19, the percent of working age population for town of Visaginas is uppermost in the whole country and the percent of working age population for Ignalina and Zarasai districts is one of the lowermost in Lithuania.

2.4.9.2 Non-Radiological Impact on Public Health and Impact Mitigation Measures

2.4.9.2.1 Noise

During construction of the storage facility local increase of noise is expected as a result of operation of motor vehicles, and also mechanisms of construction technique. Noise level during operation will be controlled and maintained within the limits, defined by normative documents of the Republic of Lithuania. The greatest noise impact may be caused to the buffer storage construction workers. If necessary, in case of exceeding the permissible noise level, technical measures will be implemented (e.g. timely technical maintenance of transport and construction machines, noise shielding), organizational measures will be taken (e.g. planning of work in areas with increased noise) and also personal protection means (e.g. headphones) will be used.

Since in the vicinity of the planned buffer storage there are no permanent residents (proposed economic activity will be carried out in the Ignalina NPP industrial site, i.e. in the existing sanitary-protection zone with radius 3 km), during its construction impact to the public health is estimated as negligible.

During operation, the storage will not be a source of noise that could be heard in the neighbouring residential areas, since intensity of the RAW delivery to the buffer storage is estimated no more than 2 containers a day, other technological operations with packages will be carried out within the buffer storage, i.e. in the confined space.

2.4.9.2.2 Waste Water

Only the non-radioactive liquid waste can be released to the sanitary-technological waste water system. The sanitary waste water from INPP is transferred to State Enterprise “Visagino energija" under an agreement. The INPP surface water drainage system meets the requirements of the regulation [21].

Accidental spills of combustive-lubricating materials from vehicles during transportation of RAW packages could potentially contaminate soil and groundwater at INPP site. An emergency response plan will be prepared, and the workers will be trained to follow specific procedures in the event of an accidental spill.

2.4.9.2.3 Non-Radioactive Emissions into Atmosphere

Assessment of non-radioactive contaminants release into the atmosphere is presented in Chapter 2.4.2.2. It is shown that releases of the non-radioactive contaminants during operation of the buffer storage are negligible and will not cause any significant impact to the INPP environment, and hence, public health.

2.4.9.3 Radiological Impact on Public Health and Impact Mitigation Measures

Potential impact (dose to member of critical group of public) may be resulted from the release of airborne and waterborne radionuclides as well as from the direct irradiation from the facility and equipment containing radioactive materials. There will be no uncontrolled waterborne releases into the environment during planned economic activity under normal operation conditions (see Chapter 2.4.1.5). Estimated radionuclide releases into atmosphere are presented in Chapter 2.4.2.3. Radiation doses to population due to airborne releases, resulted from the proposed economic activity are evaluated in the Chapter below.

2.4.9.3.1 Radiation Protection Requirements

Lithuanian Hygiene Standard HN 73:2001 [44] prescribes 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 cm^2 area of skin subjected to maximal exposure.

In optimization of radiation protection the source related individual dose is bounded by a dose constraint. The dose constraint for each source is intended to ensure that the sum of doses to critical group members from all controlled sources remains within dose limit. The dose constraint for the members of public due to operation and decommissioning of nuclear facilities is 0.2 mSv per year [45].

If radionuclides are dispersed into 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.

The design, operation and decommissioning of nuclear object shall be such as to assure that the annual dose to the critical group members due to operation and decommissioning of nuclear facility including short time anticipated operational transients shall not exceed the dose constraint [47].

For comparison purpose it can be indicated that annual effective doses to the Lithuanian inhabitants due to natural sources of ionizing radiation varies in range from 1.2 to 10 mSv with average value of 2.2 mSv.

2.4.9.3.2 Radiological Impact Assessment Methodology for Radionuclide Releases into Atmosphere

The radiation exposure of the critical group members of the population in the environment of INPP resulting from the determined release of radioactive material with air is calculated using appropriate models as recommended by the IAEA publication Safety Report Series No. 19 [48]. This Safety Report is intended to be a complete and self-contained manual describing a simple but robust assessment methodology that may be implemented without the need for special computing facilities. The report also describes a procedure for the application of the methodology to the assessment of impact from radioactive discharges into the environment. The report is primarily addressed to the national regulatory bodies and the technical and administrative personnel responsible for performing environmental impact analyses.

The application of the methodology [48] is in line with the requirements of the Lithuanian normative document LAND 42-2007 [47] where the use of this methodology is recommended also.

The models selected in [48] for this impact assessment include and consider all main airborne radionuclides migration pathways as relevant for the environment of the buffer storage site:

- The calculation of atmospheric dispersion and the resulting near-ground concentration of the released airborne radionuclides 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 activity of the deposited radionuclides on the ground and the calculation of the external exposure annual effective dose to the human from the soil contaminated by the deposited radionuclides;
- The calculation of the deposition of the radionuclides on the pasture field. The calculation of the radionuclide accumulation in the pasture grass, transfer of radionuclides 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 the radionuclides on the pasture field. The calculation of the radionuclides accumulation in the crop field, transfer of radionuclides into crop products and calculation of the internal annual effective dose to the human due to the consumption of crop products;
- Effective doses are calculated for two age groups of critical group members – adults (age > 17 years) and infants (1-2 year).

Two different critical groups of population is under consideration when analysing the impact of the certain radionuclide releases in to the atmosphere:

- *Group 1:* A member of the group is represented by local inhabitant, which passes the SPZ of Ignalina NPP twice per day (forward to the point of destination and backward). In correspondence to the diameter of the present SPZ (6 km) it is estimated that the duration of the staying of the Group 1 member within SPZ INPP should last 2 hours per day or 730 hours per year. It is conservatively assumed that the member of Group 1 will stay in the point where the maximum activity concentration of the airborne releases will occur. The total annual effective dose E resulting from external as well as internal exposure pathways to the member of Group 1 is calculated according to the following formula:

$$Dose = (\sum_j H_j + \sum_j e(g)_{j,inh} I_{j,inh})k ,$$

where:

H_j is annual dose equivalent due to the external exposure from radionuclide j to the critical group member;

$e(g)_{j,inh}$ is expected effective doses per unit intake by inhalation for radionuclide j by the age group g [44];

$I_{j,inh}$ is annual intake via inhalation of radionuclide j;

k – part of year spentat SPZ of INPP.

- *Group 2:* A member of the group is represented by local individual residing at the boundary of the SPZ (2500 m as a minimum distance from the buffer storage facility). A member of Group 2 is a farmer (cattle breeding, gardening). The total annual effective dose E resulting from external as well as internal exposure pathways to the member of Group 2 is calculated according to the formula as follows:

$$Dose = \sum_j H_j + \sum_j e(g)_{j,ing} I_{j,ing} + \sum_j e(g)_{j,inh} I_{j,inh} \text{ ,}$$

where:

H_j is annual dose equivalent due to the external exposure from radionuclide j to the critical group member;

$e(g)_{j,ing}$ and $e(g)_{j,inh}$ are the expected effective doses per unit intake by ingestion and inhalation for radionuclide j by the age group g [44];

$I_{j,ing}$ and $I_{j,inh}$ are the annual intakes via ingestion and inhalation of radionuclide j respectively.

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 [48]. The model is considered appropriate for representing the dispersion of either continuous or long-term intermittent releases within a distance of a few kilometres of the source.

The buffer storage will be constructed in the INPP existing sanitary protection zone where is no permanently living population. Therefore the impact to population is assessed considering hypothetical critical group (see recommendations of the article 7 of LAND 42:2007 [47]), for which the impact in the surroundings of the buffer storage site would potentially be highest. The exposure doses are calculated for the locations of the highest impact (i.e. where maximal near ground concentrations or maximal dose rates are expected). The approach in selection of critical group and estimation of potential impact shall be considered as conservative because exposure of members of any realistic critical group will be lower.

The main parameters used for airborne dispersion, radionuclide migration and human exposure calculation are summarized in Table 2.20. Details on the mathematical models can be found in [48].

Table 2.20. Main parameters used for assessment of critical group member exposure due to release of airborne radionuclides [48]

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	2.66E-04	Generic value
Infant (1-2 a) breathing rate, m^3/s	4.44E-05	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

2.4.9.3.3 Radiological Impact due to Radionuclide Release into Atmosphere

The annual average doses to a member of the critical group are calculated assuming atmospheric discharges occur through the ventilation opening on the top of the buffer storage building (at a height of 11 m). Influence of the storage structure to radionuclide dispersion is also considered.

Under the assumed dispersion conditions the maximum airborne radionuclides near-ground activity concentration for the releases is expected at a distance of about 100 m (the same distance from the point of releases to the security fence of the INPP) and decreases with a distance. The data on activity of the released radionuclides from the buffer storage (see Table 2.12) is used for calculation of the maximal expected exposure.

The annual average doses to a member of critical group 2 of population due to ingestion pathways are calculated assuming a continuous discharge / radionuclide deposition over a 30-year period (time of the operation of the buffer storage).

The assessment results of the total doses are presented in Table 2.21.

Table 2.21. Evaluated expected annual effective dose to a member of the critical group 1 and 2 of population due to released into air radionuclides from the buffer storage facility under normal operation conditions

Radionuclide	**Annual effective dose, mSv/year**			
	Member of critical group 1 (100 m from buffer storage facility)		**Member of critical group 2 (2500 m from buffer storage facility)**	
	Infant	**Adult**	**Infant**	**Adult**
C-14	0.00E+00	0.00E+00	3.42E-13	3.42E-13
Mn-54	2.08E-08	2.08E-08	3.16E-09	2.88E-09
Fe-55	1.96E-10	2.83E-10	2.53E-08	8.87E-09
Ni-59	2.66E-14	3.55E-14	1.26E-10	2.14E-11
Co-60	2.13E-06	2.13E-06	5.29E-07	3.13E-07
Ni-63	7.89E-12	1.04E-11	3.50E-08	5.70E-09
Zn-65	1.03E-11	1.03E-11	2.53E-11	1.33E-11
Sr-90	2.81E-10	2.95E-10	1.42E-09	8.43E-10
Nb-93m	5.46E-10	5.65E-10	3.63E-10	1.75E-10
Nb-94	1.27E-08	1.28E-08	1.78E-09	1.65E-09
Zr-93	3.37E-15	1.04E-14	3.00E-14	1.18E-13
Tc-99	1.09E-15	8.68E-16	6.49E-13	1.66E-13
Ag-110m	3.20E-10	3.21E-10	5.46E-11	4.71E-11
I-129	1.51E-15	1.90E-15	2.38E-13	1.98E-13
Cs-134	1.86E-08	1.86E-08	5.77E-09	9.10E-09
Cs-137	3.54E-07	3.54E-07	8.59E-08	1.17E-07
U-234	3.05E-12	3.23E-12	4.51E-13	4.65E-13
U-235	9.63E-15	1.28E-14	2.85E-15	3.02E-15
U-238	9.93E-13	1.04E-12	1.44E-13	1.47E-13
Np-237	3.92E-14	7.90E-14	1.61E-14	2.52E-14

Radionuclide	Annual effective dose, mSv/year			
	Member of critical group 1 (100 m from buffer storage facility)		Member of critical group 2 (2500 m from buffer storage facility)	
	Infant	Adult	Infant	Adult
Pu-238	1.57E-10	5.85E-10	8.18E-11	1.69E-10
Pu-239	7.84E-11	3.05E-10	4.12E-11	8.82E-11
Pu-240	1.33E-10	5.17E-10	6.98E-11	1.50E-10
Pu-241	1.37E-10	6.91E-10	6.90E-11	2.04E-10
Am-241	2.18E-10	7.45E-10	1.06E-10	2.07E-10
Cm-244	8.20E-11	2.33E-10	4.04E-11	6.25E-11
Total:	**2.54E-06**	**2.54E-06**	**6.88E-07**	**4.60E-07**

As it could be seen from the results in Table 2.21, the annual effective dose to the member of critical group 1 of the population equals to 2.54E-06 mSv to both adult as well as infant. The annual effective dose to the member of critical group 2 of the population should be lower 7.0E-07 mSv. Table 2.21 shows that the total dose is mainly caused by ^{60}Co and ^{137}Cs radionuclides. Therefore, when analyzing the uncertainties due to the change of the nuclide vector, only the above mentioned radionuclides were considered. It can be seen from Table 1.13 that in the worst case with regard to ^{60}Co radionuclide, when it is present in the type 1 waste of Building V1, its activity would be 12% higher (according to the ratio between the specific activity values for the type 1 waste of Building V1 and the corresponding values, determined for Building G1). In the worst case with regard to ^{137}Cs radionuclide, when it is present in the type 3 waste of Building V1, its activity would be 5% higher (according to the ratio between the specific activity values for the type 3 waste of Building V1 and the corresponding values, determined for Building G1). Hence, in the case under consideration we find that due to the uncertainties of the nuclide vector the value of the total annual dose would increase about 12% and would be equal to approximately 3E-06 mSv, i.e. would be insignificant in comparison to the value of the dose constraint, 0.2 mSv per year [45].

The performed analysis has shown that irrespective of the nuclide vector the values of the exposure doses do not exceed the value limits, since when determining the maximal values of activities, provided for storing at the buffer storage and for disposal at the *Landfill* facility (Table 1.13), there were estimated all the acceptance criteria: X, Y and Z (see Chapter 1.6.5).

Uncertainties of methodology used for the assessment of the impact of airborne releases are discussed in [48]. The document [48] summarizes the two types of uncertainties: 1) uncertainties of the assessment of atmospheric dispersion of radionuclides and 2) uncertainties of radionuclide transfer through the food chain.

It is emphasized in the document [48] that the application of the recommended methodology of the assessment of the atmospheric dispersion of radionuclides can result in the underestimation of real doses in about order of magnitude. Uncertainties of the model of the atmospheric dispersion of radionuclides are quantified as follows [48]:

- expected average values of volumetric activity calculated by using the Gaussian dispersion model, can vary within factor of 4 (the difference between the minimum and maximum values) under conditions of flat terrain and up to factor of 10 when dispersion is evaluated under conditions of complex terrain;

- estimations of the influence of buildings located next to the release source are conservative and may vary up to 2 times (the difference between the minimum and maximum values);
- environmental conditions (part of the year when the wind blows in the receptor‘s direction, average wind speed, deposition of radionuclides and atmospheric stability class) are estimated conservatively.

As it is pointed out in the paper [48] the application of the recommended methodology of the assessment of the radionuclide transfer through the food chain can result in the overestimation of doses in about order of magnitude. Uncertainties of the model of radionuclide transfer through the food chain are summarised as follows [48]:

- models of radionuclide transfer through the food chain are conservative, given the fact that no decrease of radionuclide activity during the preparation and processing of food products is evaluated, which may have a significant impact;
- When assessing radionuclide transfer in meat and milk, usually cattle meat and milk is estimated. In case when meat and milk of other livestock is used an essential dose reduction will likely not occur, i.e. radionuclide volumetric activity in milk evaluated in the model should not differ from the real values more than 3 times.
- When assessing radionuclide transfer to aquatic animals a simple method of multiplication of radionuclide concentrations by bioaccumulation factors is used. Conservative values are chosen for the bioaccumulation factors.

Summarizing it should be stated that values of the annual total doses could be about two orders of magnitude higher in most conservative case, however they would still remain significantly (~ 1 000 times) below the value of the dose constraint 0.2 mSv per year.

Figure 2.20 presents changes in estimated effective dose, received by a member of the critical group of population due to radionuclide releases, depending on the distance from the buffer storage. As it could be seen from Figure 2.20 at the boarder of the SPZ (~ 2.5 km), dose for a member of the critical group of population will not exceed 7E-07 mSv/year for an infant and 5E-07 mSv/year for an adult, what complies with the requirements of the normative document [45] (the limit of 0.2 mSv per year is not exceeded).

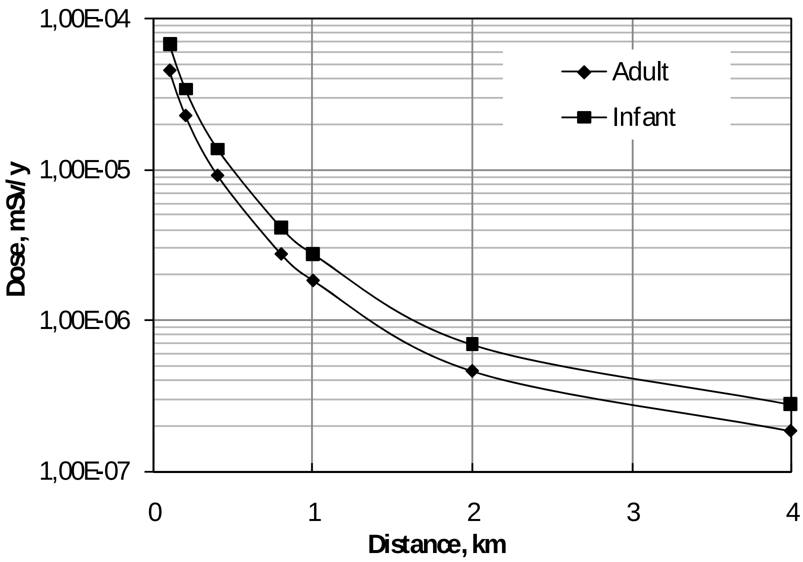

Figure 2.20. Estimated annual effective exposure dose, received by a member of the critical group 2 of population due to releases into the atmosphere from buffer storage under normal operational conditions, against the distance from the buffer storage

It can be concluded that conservative assessment of the dose to a members of the considered critical groups of population due to radionuclide releases into atmosphere under normal operation conditions is insignificant.

2.4.9.3.4 Radiological Impact due to Direct Irradiation from the Buffer Storage Structure

The external irradiation dose rate values from the buffer storage structure are evaluated assuming the source of radiation is 220 half-height ISO containers with non-combustible RAW, stacked in the zone D [50] (see Figure 2.1).

Modelling assumptions and conditions as well as initial data on the considered constructions and RAW characteristics are presented in the document [50] Changes in dose rate from the buffer storage building depending on the distance from the storage are presented in Figure 2.21.

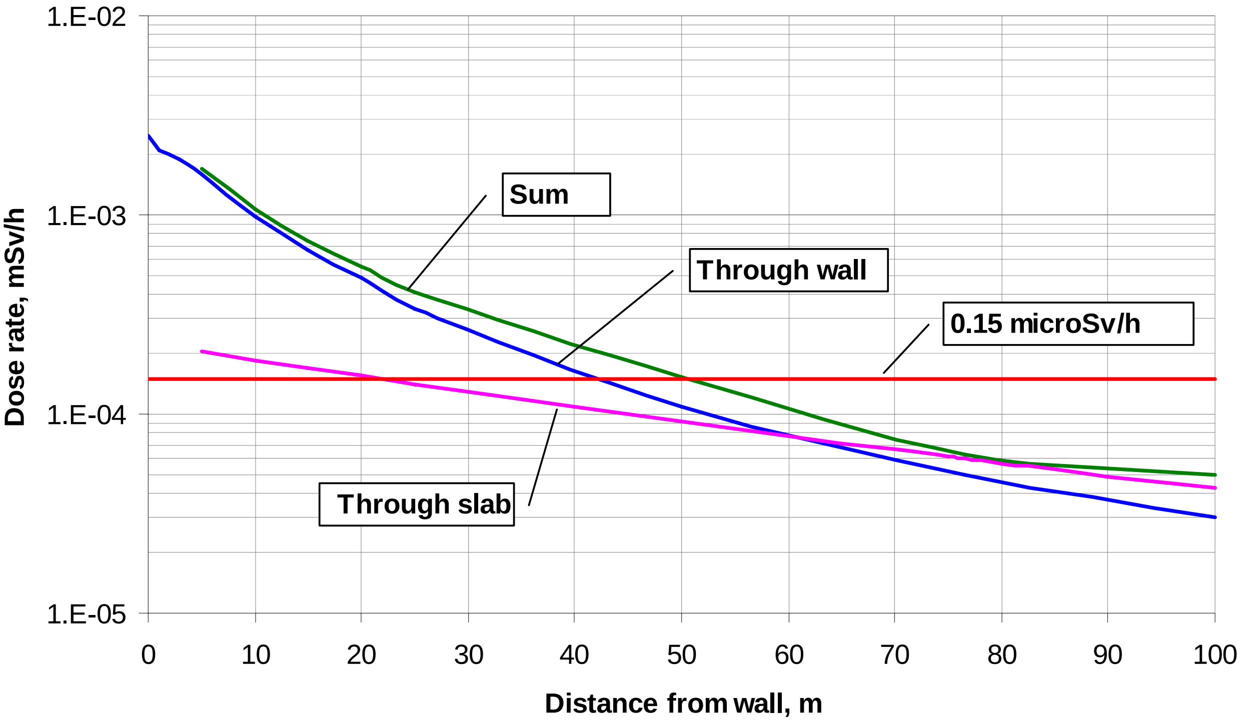

Figure 2.21. Changes in dose rate due to radiation through walls and roof slab of the buffer storage with 220 half-height ISO containers

The assessment has shown that the annual effective dose to a member of the critical group 1 of population (see description in section 2.4.9.3.2) due to direct irradiation from the buffer storage structure on a border of the INPP industrial site in the shortest distance (i.e. 100 m) is about 3.6E-2 mSv, assuming exposure duration of 730 h per year and maximally loaded with RAW buffer storage. Actually the buffer storage loading will last about 1-2 years (delivery rate is about 10-20 containers per month), thus the maximally loaded storage can be expected only for a small fraction of the year. It also should be considered that containers with higher surface gamma dose rate will be located in the middle of the stack. In summary, the presented dose estimation on the border of the INPP industrial site due to direct irradiation from the buffer storage building is conservative (overestimated).

Evaluations of the maximal dose value due to direct irradiation to the member of critical group 2 of population, i.e. local individual residing at the boundary of the SPZ of INPP (about

2 500 m from the buffer storage facility), assuming that duration of the exposure is 8 760 hours per year (all the year round), equals to 4.6E-04 mSv per year, therefore is considered as negligible value.

2.4.9.3.5 Radiological Impact from other Existing and Planned Nuclear Facilities

The buffer storage will be constructed in the INPP industrial site with the existing 3 km radius sanitary protection zone (SPZ). For the purposes of dose assessment with regard to the dose constraint, the contribution of doses from the other existing and planned nuclear facilities located in the INPP sanitary protection zone must also be considered.

Existing and planned nuclear facilities, located at the Ignalina NPP site and considered in this assessment are:

- Ignalina NPP;
- New NPP;
- Existing SNF storage;
- New ISFSF (project B1);
- New SWMSF (projects B2/3/4);
- Building 158 (bituminised waste storage facility transformed into the repository) and new interim storage facility for solidified radioactive waste (bld.158/2);
- Disposal units for very low level RAW (*Landfill* facility);
- Near-surface repository for low and intermediate level RAW.

The layout of the objects indicated above and the buffer storage site are shown in Figure 2.22. Activity phases (operation, decommissioning, institutional control, etc.) of the nuclear facilities are summarized in Figure 2.23.

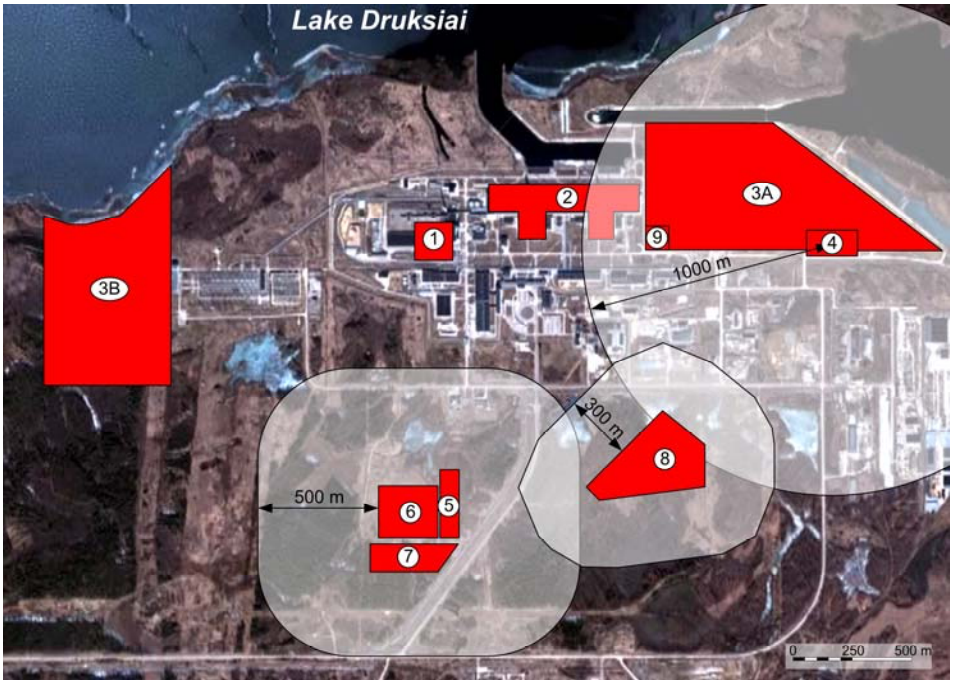

Figure 2.22. Existing and planned nuclear facilities at the Ignalina NPP site:

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 (B1); 6 – new SWTSF (B3/4); 7 – disposal units of the *Landfill* facility; 8 – near-surface repository for low and intermediate level RAW; 9 – buffer storage of the *Landfill* facility

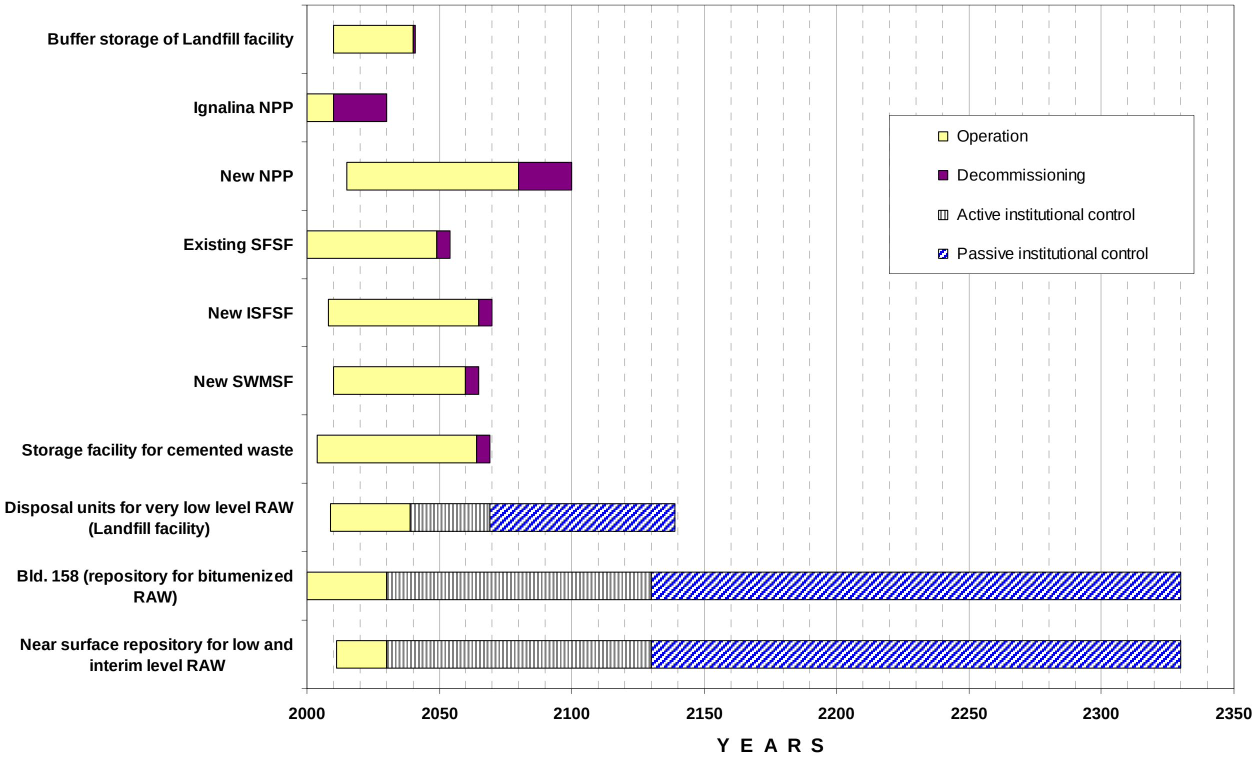

Figure 2.23. Main activity phases of the existing and planned nuclear facilities, located in the existing Ignalina NPP sanitary protection zone of 3 km radius

Impact of Radionuclide Releases

Radionuclide Releases from the Existing Facilities in the SPZ of INPP

According to the data in the report [25], doses due to the waterborne release to Lake Druksiai and airborne release from the NEO in the INPP site are presented in Figure 2.24. 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 [45]). 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).

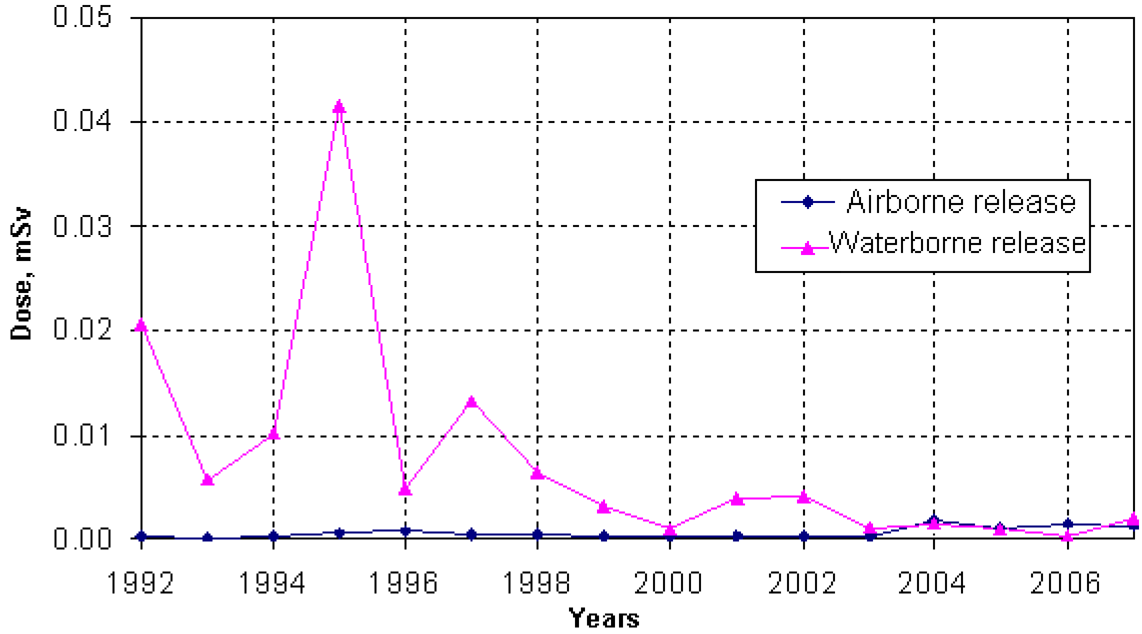

Figure 2.24. Annual effective dose to the critical group member of population due to radionuclide releases (airborne emissions and waterborne discharges) from the nuclear facilities located in the SPZ of INPP for time period 1992 – 2007 [25]

It is 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 emission is 1.9E-03 mSv (year 2004 dose), and due to waterborne releases is 4.19E-03 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) [51]. The U1DP0 activities are planned to be implemented in years from 2005 to 2012;
- Operation of the new Cement Solidification Facility for liquid radioactive waste solidification and of the Interim Storage Building for the storage of solidified waste [52]. 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 discharges from the existing nuclear facilities in the SPZ of INPP is summarized in Figure 2.25. It can be seen that the doses due to airborne emissions and liquid discharges from the existing nuclear facilities in the SPZ of INPP are low. The observed dose maximum (9.69E-03 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 (3.69E-03 mSv) and the assumption that the doses resulting from the operation of INPP (6.09E-03 mSv) are still relevant.

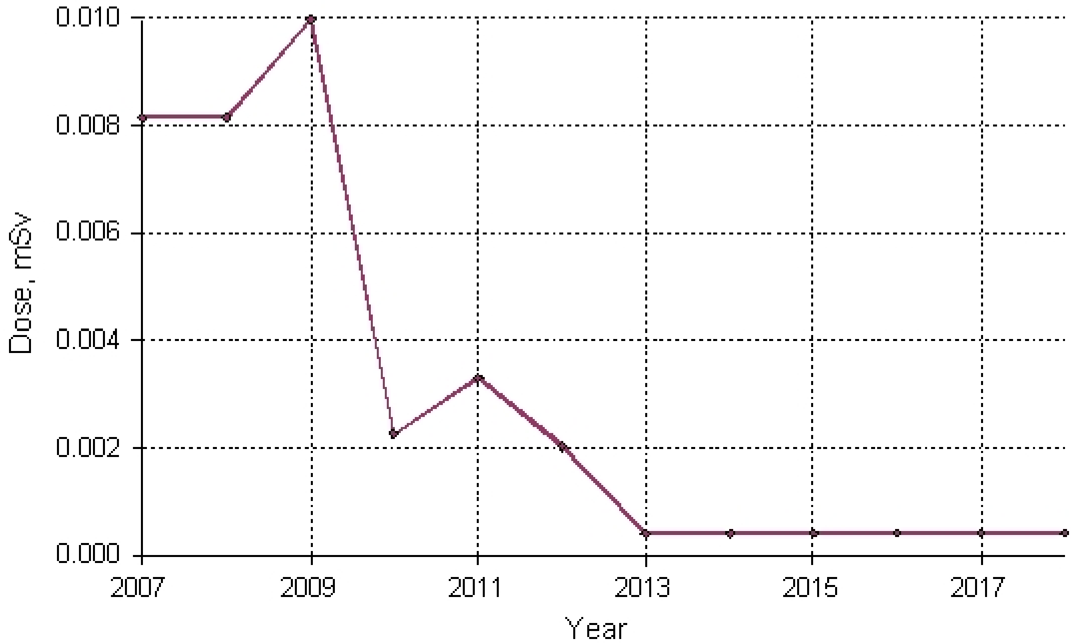

Figure 2.25. Forecast for the dose to the critical group member of population due to radionuclide releases (airborne emissions and waterborne discharges) from the nuclear facilities located in the SPZ of INPP

The dose forecast as presented in Figure 2.25 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 radionuclide 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 the Reactor Unit 2 in several years after the final reactor shutdown. In comparison to activities at the Reactor Unit 1, the equipment in-line decontamination at the Reactor Unit 2 could start in shorter time after the final reactor shutdown. Therefore the activity of the released radionuclides (short-lived Mn-54, Fe-55, Co-58, Co-60, Cs-134, etc.) will be higher and could result in higher doses as compare to the doses from the similar U1DP0 activities. It is anticipated that equipment in-line decontamination at the Reactor Unit 2 can stipulate approximately two times higher annual dose to the critical group member of population (i.e. up to 8.00E-03 mSv). Therefore it is forecasted that during years 2008–2018 the annual effective dose due to airborne emissions and liquid discharges from the existing nuclear facilities in the SPZ of INPP will be below 1E-02 mSv.

No dose estimations due to radionuclide releases during further decommissioning projects for existing INPP facilities are available at the moment. EIA Program of INPP decommissioning [53], provides that every subsequent environmental impact assessment shall take into account the results of previous reports.

Impact due to Radionuclide Releases from the Newly Planned Facilities in the INPP SPZ

This chapter presents estimation of radionuclide releases from the newly planned facilities in the INPP SPZ during operation of the buffer storage facility and considers radionuclide releases from this proposed economic activity (buffer storage), *Landfill* disposal facility (disposal units), the new Solid Waste Management and Storage Facility (SWMSF), the new Interim Spent Nuclear Fuel

Storage Facility (ISFSF) and the newly planned nuclear power plant.

The estimation of doses resulting from airborne emissions from the **buffer storage** is presented in Chapter 2.4.9.3.3. The conservatively estimated annual effective dose to the critical group member of population due to radioactive releases from the buffer storage is below 2.54E-06 mSv.

Impact assessment due to discharges from the ***Landfill*** **disposal units** is presented in Chapter 3.4.9.3.3. Annual effective dose to a member of the critical group of population, caused by radionuclide releases from the disposal units, will be below 6E-07 mSv.

The impact from **SWMSF** is assessed in the EIA Report for SWMSF [54]. The conservatively estimated annual effective dose to the critical group member of population due to radioactive airborne emissions is about 7.79E-03 mSv.

The impact from **ISFSF** is assessed in the EIA Report for ISFSF [55]. The conservatively estimated annual effective dose to the critical group member of population due to radioactive airborne emissions stipulated by the SNF handling at the Reactor Units and ISFSF will not exceed 4.15E-04 mSv. It is planned that by the year 2016 the 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 in the FIHC of ISFSF additional exposure of up to 1.46E-04 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 probable. The cask will be designed as double-barrier welded system for the 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.

Lietuvos Energija JSC in year 2007 has initiated an environmental impact assessment procedure aiming to assess the environmental impact of the proposed economic activity “New nuclear power plant (new NPP) in Lithuania”. The total electricity production of new nuclear power plant would be at most 3400 MW. Possible technological alternatives for the new nuclear power plant are as follows: boiling water reactors, pressurized water reactors or pressurized heavy water reactors. It is planned that at least the first unit of the new nuclear power plant is in operation not later than 2015. The operation of the new reactors would last about 60 or more years.

The new NPP impact has been estimated in the EIA report [56]. The impact on a member of the critical group of the population has been estimated using the dose conversion factors, presented in the appendix of the normative document LAND 42-2007. Depending on the type of the reactor, capacity and quantity of the units of the new nuclear power plant the annual dose of a member of the critical group of the population due to the activity of environmental (airborne and waterborne) radionuclide releases varies from 0.0042 to 0.033 mSv.

Summary of the Expected Impact of the Radionuclide Releases

Forecast of the maximal annual effective dose to the critical group member of population due to radionuclide releases (airborne emissions and liquid discharges) from the existing and planned nuclear facilities located in the SPZ of INPP is summarized in Table 2.22.

Table 2.22. Forecast of the radionuclide releases impact

NEO	Dose due to radionuclide releases, mSv/y
Buffer storage	2.54E-06
Landfill disposal units	5.6E-07

NEO	Dose due to radionuclide releases, mSv/y
SWMSF	7.79E-03
ISFSF	4.15E-04
SNF reloading at ISFSF	1.46E-04
New NPP	3.30E-02
INPP	1.00E-02
Total:	**5.14E-02**

It can be seen from Table 2.22 that the greatest contribution to the dose due to radionuclide releases is made by radionuclide releases from the nuclear facilities, located within the INPP industrial site, resulting from the INPP decommissioning, as well as due to radionuclides releases from the new NPP.

Impact due to Direct Irradiation

The monitoring of radiation fields performed in the INPP industrial site and its surroundings shows that increase in ionizing radiation dose rates is observed locally and only close to some of radioactive material handling facilities. Only in exceptional cases the increase of ionizing radiation dose rate is measured outside the border of INPP industrial site. Locally increased radiation fields are also registered around the existing SNF storage facility.

Potential changes in ionizing radiation fields resulting from modifications of the presently existing nuclear facilities and from construction of new nuclear facilities are discussed below.

It can be noted that during decommissioning of INPP the radioactive materials (spent nuclear fuel, radioactive waste, etc.) will be removed from the buildings and storage facilities located at the INPP site. Therefore with the reactors final shutdown and progress in decommissioning the radiation fields in the INPP industrial site should only to decrease.

Buffer Storage

The external irradiation dose rate values from the radioactive waste in the buffer storage are presented in Chapter 2.4.9.3.4. It was demonstrated that the annual effective dose to a member of the critical group of population due to direct irradiation from the buffer storage structure on a border of the INPP industrial site in the shortest distance (i.e. 100 m) is about 0.036 mSv. This estimation is highly conservative (overestimated) because of the made assumptions. It was assumed that the buffer storage is fully loaded with radioactive waste (220 half-height ISO containers for the whole year) and a member of the critical group of population will stay in a certain place of the INPP SPZ 730 hours per year (2 hours per day).

Bituminised Waste Disposal Facility

The radiation fields monitoring data show that increase in ionizing radiation dose rate is observed only in some spots close to the Bituminized Waste Storage Facility building structure. No impact from ionizing radiation is present outside the INPP industrial site.

At present the storage facility is filled up to about of 60% of the design volume. Operational experience shows that filling of the storage facility with the waste results in insignificant changes of radiation fields.

New Interim Storage Facility for Solidified Radioactive Waste

New Cement Solidification Facility for liquid radioactive waste solidification (spent ion-exchange resins and filter aid (Perlite) deposits) was started to operate in year 2006. A new Interim Storage Facility for solidified waste is located behind the bituminised waste disposal facility which is functioning as a shielding from ionising radiation in this case. Taking into account the distance from the new interim storage facility for solidified radioactive waste to the buffer storage (what makes about 1 km), it is not expected that the further operation of the new interim storage facility for solidified radioactive waste could influence the radiological situation at the buffer storage site.

New Interim Spent Nuclear Fuel Storage Facility (ISFSF)

The planned new Interim Spent Nuclear Fuel Storage Facility will be constructed at a distance of more than 1.5 km from the buffer storage site. The 500 m radius sanitary protection zone is foreseen around the facility outside borders of which the impact of direct ionizing radiation may not further be taken into consideration. Considering trends in changes of radiation fields around the ISFSF and taking into account significant distance in between the ISFSF and the buffer storage facility, it is not foreseen that the operation of the ISFSF could influence the radiological situation at the buffer storage site.

New Solid Waste Management and Storage Facility (SWMSF)

The planned SWMSF will be constructed at a distance of more than 1.5 km from the buffer storage site. The 500 m radius sanitary protection zone is foreseen around the facility outside borders of which the impact of direct ionizing radiation may not further be taken into consideration. Considering trends in changes of radiation fields around the ISFSF and taking into account significant distance in between the ISFSF and the buffer storage facility, it is not foreseen that the operation of the ISFSF could influence the radiological situation at the buffer storage site.

Existing Spent Nuclear Fuel Storage Facility

20 CASTOR RBMK-1500 and 74 CONSTOR RBMK-1500 casks with spent nuclear fuel have been accommodated in the existing spent nuclear fuel storage facility by the end of April, 2008. The number of the CONSTOR-type containers may increase up to 98 in the future.

Measurements of radiation fields performed during years 2000–2007 [57] show that the maximum ionizing irradiation dose rates around the fence of the storage facility site were measured when SNF was transferred and stored using CASTOR RBMK-1500 type casks. The casks of this type were utilized by INPP in the years of 1999–2001. With use of CONSTOR RBMK-1500 casks for SNF storage the radiation fields around the site have been stabilized and later on are changing marginally.

Ionizing gamma and neutron radiation dose rate on the border of the SNF storage site facing the buffer storage site was about 2.4E-04 mSv/h in 2007. Radiation dose rate from the buffer storage at a distance of 100 m (on the border of the INPP industrial site) makes about 4.93E-05 mSv/h (see Chapter 2.4.9.3.4). Considering trends in changes of radiation fields around the buffer storage as well as significant distance in between the SNF storage and the buffer storage (which is not less than 500 m) and taking into account that the increase of ionizing radiation dose rate is measured in the close vicinity to the existing SNF storage facility, it is not foreseen that the operation of the buffer storage could influence the radiological situation at the SNF storage site.

Near-surface Disposal Facility for Low and Intermediate Level Short-lived Radioactive Waste in Stabatiskes Site

The proposed location for the near-surface disposal facility for low and intermediate level short-lived radioactive waste – Stabatiskes site – is to the south from the buffer storage site, see

Figure 2.22. The public exposure due to direct irradiation from operating disposal facility (i.e., during the disposal of radioactive waste packages) is estimated in the document [58]. A sanitary protection zone of up to 300 m distance around the disposal facility is foreseen outside borders of which the impact of direct ionizing radiation may not further be taken into consideration. Taking into account significant distance in between the near-surface disposal facility and the buffer storage, it is not foreseen that the operation of the near-surface disposal facility could influence the radiological situation at the buffer storage site.

Near-surface *Landfill* Disposal Facility for Very Low Level Radioactive Waste

One of the proposed sites for the *Landfill* disposal facility for very low level radioactive waste is located in the close vicinity to the ISFSF and SWTSF sites, see Figure 2.22. The disposal facility site is in the proposed sanitary protection zone of SWTSF. Taking into account the distance from the *Landfill* disposal facility to the buffer storage (what makes about 1600 m), it is not expected that the operation of the *Landfill* disposal facility could influence the radiological situation at the buffer storage site (see Section 3.4.9.3 of this Report for impact assessments due to emission of radioactive substances to the atmosphere air and due to direct exposure from disposal facilities).

New Nuclear Power Plant

The buffer storage will be constructed near to the site proposed for the new nuclear power plant. The impact of direct irradiation from the new nuclear power plant on a member of the critical group of the population has been estimated in the Environmental Impact Assessment Report of the new nuclear power plant [56], on the basis of the measurement data of the sensors of "Skylink" system presented in the INPP monitoring reports. On the basis of the measurements of this system, it can be seen that the doses registered within the INPP SPZ do not differ from the exposure due to the natural radiation. This is also confirmed by the measurements in the environments of power plants of other countries, where the registered doses do not differ from the natural background of ionising radiation. Therefore, as the document [56] affirms, the impact of direct irradiation is not significant and is not further considered.

2.4.9.3.6 Summary of Radiological Impact and Conclusions

The summarized radiological impact considers the maximal total effect of impacts potentially arising from different impact sources of this proposed economical activity under normal operation conditions:

- Release of airborne radionuclides from the buffer storage site;
- Direct irradiation resulting from the buffer storage building.

The summarized radiological impact also considers up-till-now available evaluations of radiological impacts from other existing and planned nuclear facilities in the SPZ of the INPP.

The potential radiological impact (potential annual effective dose to the critical group member of population) is summarized in Table 2.23.

Table 2.23. Summary of the total potential maximal radiological impacts from existing and planned nuclear facilities in the SPZ of the INPP

Radiological impact from nuclear facilities in the SPZ of the INPP	**Annual effective dose, mSv**
External and internal irradiation due to release of airborne radionuclides from the buffer storage site	2.54E-6

Radiological impact from nuclear facilities in the SPZ of the INPP	**Annual effective dose, mSv**
External irradiation from the buffer storage structures	3.60E-2
Total dose from proposed economic activity (buffer storage)	3.60E-2
Exposure due to release of airborne radionuclides from disposal units site[1]	5.60E-7
External and internal exposure due to release of airborne radionuclides from SNF handling at INPP (related to operation of ISFSF)[2]	4.15E-4
External and internal exposure due to release of airborne radionuclides from SNF reloading at ISFSF[3]	1.46E-4
External and internal exposure due to radionuclide releases from existing nuclear facilities of INPP[4]	1.00E-2
External and internal exposure due to radionuclide releases from the SWRF and SWTSF sites[5]	7.79E-3
External and internal exposure due to radionuclide release from the new NPP[6]	3.30E-02
Total dose from proposed economic activity together with other existing and planned activities	**8.74E-2**

[1] Data taken from subchapter 3.4.9.3.3 of this document.

[2] Data are taken from the document [55], subchapter 5.1.5.2 and represents the maximal exposure values for the most conservative scenario – "One year maximal effective dose due to handling of all leaking fuel".

[3] Data are taken from the document [55] subchapter 5.2.2.2.

[4] Assessment is presented in chapter 2.4.9.3.5.

[5] Data are taken from the document [54] subchapter 4.9.2.2.1.

[6] Data are taken from the document [56] section 7.10.2.2.

The calculated total exposure dose to the member of the critical group of population due to radioactive releases into atmosphere from the buffer storage of the *Landfill* facility and the existing and other planned activities are below 0.1 mSv [46]. The estimated total dose from the planned economical activity at the Ignalina NPP site is approx. one order of magnitude below the dose constraint of 0.2 mSv [45]. The radiation protection requirements are met.

2.4.9.4 Impact Mitigation Measures

Since radiological impact to the public health due to proposed economic activity under normal operational conditions is estimated to be very low, no specific means for impact mitigation in addition to the design based ones in the project concept are foreseen.

Radiological situation of the environment will be controlled by a constant monitoring of actual radionuclide releases into working premises and atmosphere from the buffer storage, and also monitoring of radiological situation in the INPP region will be performed.

2.4.9.5 Sanitary Protection Zone

The proposed economical activity will be held within boundaries of INPP industrial site. The site is surrounded by the security fence. Minimal distance from the buffer storage to the security fence is about 100 m. A 3 km radius sanitary protection zone (SPZ) is established around the INPP power units.

Potential radiological impact on environment components due to the proposed economical activity under normal operation conditions is evaluated to be very low. The proposed economical activity will not adversely change the existing radiological situation outside the INPP sanitary protection zone. Reconsideration of existing INPP sanitary protection zone boundaries or its status is not necessary.

2.4.9.6 Summary of Impact on Public Health

Following the Regulations for Impact on Public Health Assessment [59], the main factors and impacts of the proposed economic activity are identified and evaluated in this report. The direct and indirect impacts of the proposed economic activity on factors influencing the public health are summarized in Table 2.24.

Potential impact on public groups is summarized in Table 2.25, and assessment of impact features is presented in Table 2.26.

Table 2.24. Direct and indirect impacts of the proposed economic activity on factors influencing the health

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
1. Factors of behaviour and lifestyle (nutrition habits, alcohol consumption, smoking, consumption of narcotic and psychotropic drugs, safe sex and other)	Construction and operation of the buffer storage	Not foreseen				The proposed economic activity will be implemented within existing INPP sanitary protection zone, where there is no permanently living population. Potential impact of physical nature can be expected in the vicinity of the buffer storage. The INPP personnel will be used for operation of the buffer storage. The working conditions will be assured in accordance with requirements of regulations in force.
2. Factors of physical environment						
2.1. Air quality	Traffic of vehicles, airborne releases	The ambient air quality will be directly affected by NO_x, SO_2, dust, CO, CO_2 and unburnt carbohydrates	(–)	Impact to the air quality during construction of the buffer storage will be temporary; the impact area covers construction area and	Estimated traffic level will be low; its impact will be limited by the existing fence of the INPP industrial site. Most of the construction works will be	

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
		C_xH_x, generated by the road transfer of construction materials and by the operation of construction equipment (during buffer storage construction phase), and also during transportation and handling of RWP. Estimated releases to the atmosphere are presented in Chapter 2.4.2.2.2.		its environment within the radius of 100 m and is limited by the INPP industrial site. There will be no impact to health factors. During operation, releases to the atmosphere will be insignificant and will not affect health factors.	carried out in open air so that the natural air circulation will prevent the accumulation of significant concentrations of such substances. Since lift trucks are equipped with the exhaust gas cleaning system and are designed to work in closed premises, their releases into the environment will be negligible. No specific additional means for impact mitigation are foreseen.	
2.2. Water quality	INPP sanitary waste water system and surface drain water system	Possible controlled slight pollution due to utilities type sewage release to environment.	(–)	The potable water will be supplied by "Visagino Energija". No new boreholes are foreseen. The Sventoji-Upninkai aquifer system rich with underground water is exploited by the Visaginas town waterworks. The quality of underground water of exploited aquifer complex is good not only in the waterworks but also in all region and its changes	The INPP sanitary waste water system follows the requirements of normative document [20]. The INPP surface drain water collection system follows the requirements of normative document [21]. In case of accidental spilling of oil products during transport operations, the procedures established in regulation LAND 9-2002 [60] will be performed.	Survey boreholes (wells) for monitoring underground run-off water are installed at the INPP site as part of required environmental monitoring (see Chapter 2.7 "Monitoring").

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
				happened in the waterworks are minimal. Changes are not expected.		
2.3. Food quality	Construction and operation of the buffer storage	Not foreseen				
2.4. Soil	Construction and operation of the buffer storage	Slight physical (mechanical) impact on topsoil	(–)	The buffer storage will be constructed at the INPP industrial site, within the territory of the former INPP Reactor Unit 3. Soil of the territory was technogenicaly impacted in the past. During proposed economic activity no additional impacts, increasing existing impact level on the upper soil layers, are expected. Changes of health factors are not expected.	No soil contamination is expected under normal operational conditions.	In case of accidental spilling of oil products during transport operations, the procedures established in regulation LAND 9-2002 [60] will be performed.
2.5.1 Non-ionizing radiation	Construction and operation of the buffer storage	Not foreseen				
2.5.2. Ionizing radiation	Construction and operation of the buffer storage	1. Radionuclide releases from the buffer storage facility during handling of containers with RAW. Estimated releases to	(–)	Radionuclide releases from the buffer storage facility are evaluated as very low, and they will not result in health factor changes. Possible increase of	No specific radiological impact mitigation measures in addition to those that planned by design concept are proposed. Around the INPP site, the sanitary protection	Monitoring of the ionizing radiation impact and possible changes in the environment will be performed (see Chapter 2.7 “Monitoring“).

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
		atmosphere are presented in Chapter 2.4.2.3.2. 2. Direct irradiation from the buffer storage building during storage of the containers with RAW. Estimated exposure is presented in Chapter 2.4.9.3.4. 3. Transportation of waste from places of its generation to the buffer storage.		exposure due to ionizing irradiation from the buffer storage facility will be local. With the distance direct exposure reduces and on the boarder of the INPP SPZ there will be no impact. Changes of health factors are not expected.	zone is established, in which there is no permanent inhabitants and economic activities are limited.	
2.6. Noise	Construction and operation of the buffer storage	Traffic of vehicles, operation of construction equipment (during buffer storage construction phase), transportation of RWP.	(–)	There are no inhabitants within the sanitary protection zone (in the distance of 3 km around INPP), so there are no particular recipients of noise and vibration. Local traffic will be very low and temporal. There will be no impact to health factors.	The noisy activities will be carried out during daytime only.	
2.7. Home conditions	Construction and operation of the buffer storage	Not foreseen				
2.8. Safety	Construction of the	New nuclear facility is	(–)	It is planned to store only	All radioactive materials will	The buffer storage will be

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
	buffer storage	related to the possibility of accidental situations. Analysis and risk assessment is presented in Chapter 2.8.		very-low activity waste in the buffer storage. Environment impact assessment during accidental operation conditions has shown that impact to public health does not exceed permissible limits. Impact to health factors is not expected.	be managed according to the Lithuanian legislation and regulations, management principles of IAEA and in compliance with good practices in other European Union Member States.	designed taking into consideration external risks to the safety.
2.9. Transport	Construction of the buffer storage	Controlled slight impact on the environment	(–)	Possible temporary traffic increase. Impact to health factors is not expected.	The transportation will be carried out during daytime only.	There is no inhabitants within the sanitary protection zone.
2.10. Territory planning	Construction of the buffer storage	Not foreseen		There will be no land use or INPP sanitary protection zone changes. Impact to health factors is not expected.		
2.11. Waste management	Handling of waste, generated during construction and operation of the buffer storage	Controlled slight impact on the environment	(–)	Waste amounts generated in the buffer storage will be negligible (see Chapter 2.3), impact to health factors is not expected.	Waste will be managed in accordance with the requirements of waste management legislation and regulations in force and Permission on integrated prevention and control of pollution.	
2.12. Power	Construction and	Not foreseen				

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
appliance	operation of the buffer storage					
2.13. Risk of misadventures	Construction and operation of the buffer storage	Not foreseen				
2. 14. Passive smoking	Construction and operation of the buffer storage	Not foreseen				
2.15. Other	Construction and operation of the buffer storage	Not foreseen				
3. Social and economic factors						
3.1. Culture	Construction and operation of the buffer storage	Not foreseen				
3.2. Discrimination	Construction and operation of the buffer storage	Not foreseen				
3.3. Property	Construction and operation of the buffer storage	Not foreseen				
3.4. Income	Investments into the economy of the region	Increase of population income	(+)	Several new workplaces will be created. Impact to health factors is not expected.		The proposed economic activity represents the EU direct investment for the INPP decommissioning.
3.5. Education	Construction and	Not foreseen				

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
possibilities	operation of the buffer storage					
3.6. Employment, labour market, business opportunities	Construction and operation of the buffer storage	Workplace creation	(+)	Local companies will be involved in the project. Impact to health factors is not expected.		
3.7. Criminality	Construction and operation of the buffer storage	Not foreseen				
3.8. Leisure, recreation	Construction and operation of the buffer storage	Not foreseen				
3.9. Movement	Construction and operation of the buffer storage	Not foreseen				
3.10. Social security (social contact and welfare)	Construction and operation of the buffer storage	Not foreseen				
3.11. Sociality, sociability, cultural contact	Construction and operation of the buffer storage	Not foreseen				
3.12. Migration	Construction and operation of the buffer storage	Employment reduces emigration	(+)	Impact to health factors is not expected.		
3.13. Family constitution	Construction and operation of the buffer storage	Not foreseen				
3.14. Other	Construction and	Not foreseen				

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
	operation of the buffer storage					
4. Professional risk factors						
4.1 Chemical	Construction and operation of the buffer storage	Not foreseen				
4.2. Physical	Construction and operation of the buffer storage, emergency situations	Ionizing radiation. Risk analysis and assessment are presented in Chapter 2.8.	(–)	It is planned to store only very-low activity waste in the buffer storage. Environment impact assessment during extreme working conditions (in case of beyond design basis accidents) has shown that impact to public health does not exceed permissible limits. Impact to health factors is not expected.	Risk of most of the accident situation may be eliminated or mitigated by appropriate design solutions. All radioactive materials will be managed according to the Lithuanian legislation and regulations, management principles of IAEA and in compliance with good practices in other European Union Member States.	The buffer storage will be designed taking into consideration external risks to the safety.
4.3. Biological	Construction and operation of the buffer storage	Not foreseen				
4.4. Ergonomic	Construction and operation of the buffer storage	Not foreseen				
4.5. Psychosocial	Construction and	Not foreseen				

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
	operation of the buffer storage					
4.6. manual work	Construction and operation of the buffer storage	Not foreseen				
5. Psychological factors						
5.1. Aesthetical appearance	Construction of the buffer storage	Impact on landscape		The planned storage will be constructed and operated at the industrial site of INPP. Impact on landscape is not expected.		For the exterior finishing of the facade of the buffer storage modern materials will be used, and the new building will only improve the general view of the INPP industrial site.
5.2. Comprehensibility	Construction and operation of the buffer storage	Not foreseen				
5.3. Capability to hold the situation	Construction and operation of the buffer storage	Not foreseen				
5.4. Significance	Construction and operation of the buffer storage	Not foreseen				
5.5. Possible conflicts	Construction and operation of the buffer storage	Possible population discontent and distrust in Latvia and Belorussia.	(–)	Such a psychological impact is stipulated by changes in existing nuclear practice (shutdown and decommissioning of INPP),	Psychological impact can be mitigated explaining necessity, goals and benefits from the proposed economic	

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: positive (+) negative (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
				which results in construction of new nuclear objects.	activity.	
6. Social and health services (acceptability, suitability, succession, efficiency, protection, availability, quality, self-help technique)	Construction and operation of the buffer storage	Not foreseen				

Table 2.25. Possible impact of proposed economic activity on public groups

Public groups	Kind of activity or means, contamination sources	Group size	Impact: positive (+) negative (-)	Comments and remarks
1. Public groups (local population) in the zone of activity impact	Ionizing radiation, release of non-radioactive contaminants from transport vehicles	There are no permanently living population in the sanitary protection zone and economical activity is limited as well		Potential releases of the non-radioactive contaminants and radionuclides to the industrial environment and/or atmosphere will be insignificant. Proposed economic activity will not unfavourably change the existing radiological situation outside the INPP sanitary protection zone.
2. Personnel	Ionizing radiation,	Personnel of INPP	(–)	Potential releases of the non-radioactive contaminants and radionuclides to the industrial environment and/or

Public groups	Kind of activity or means, contamination sources	Group size	Impact: positive (+) negative (-)	Comments and remarks
	release of non-radioactive contaminants from transport vehicles			atmosphere will be insignificant. The personnel direct exposure shall be controlled and limited by workplace and individual monitoring, work planning with consideration of ALARA principle.
3. Users of activity products	Not relevant			
4. Persons with slender income	Not relevant			
5. The jobless	Not relevant			
6. Ethnical groups	Not relevant			
7. Persons sick with same diseases (dependence on drugs, alcohol etc.)	Not relevant			
8. Disables	Not relevant			
9. Single persons	Not relevant			
10. Refugees, emigrants and persons seeking political asylum	Not relevant			
11. The homeless	Not relevant			
12. Other population groups (arrestees, persons of special occupations, manual hard workers etc.)	Not relevant			
13. Other groups (single persons)	Not relevant			

Table 2.26. Assessment of features of impacts

Impact induced by factor	**Impact features**									**Comments and remarks**
	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. Air quality	X				X				X	
2. Water quality			X		X				X	
3. Soil	X					X	X			
4. Ionizing radiation			X		X				X	Possible local impact to INPP personnel. Exposure will not exceed limits prescribed by radiation protection requirements. The impact from the proposed economic activity outside the sanitary protection zone can be considered as insignificant.
5. Noise	X			X				X		There are no inhabitants within the sanitary protection zone (in the distance of 3 km around INPP), so there are no particular recipients of noise and vibration.
6. Safety			X			X			X	
7. Transport	X					X		X		

Impact induced by factor	Impact features									Comments and remarks
	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)	
8. Waste management			X	X					X	
9. Income	X				X				X	
10. Employment, labour market, business opportunities	X			X					X	
11. Migration	X			X					X	
12. Impact on landscape	X				X				X	
13. Possible conflicts			X			X			X	

2.5 Potential Impact on Neighbouring Countries

Two countries, i.e. the Republic of Belarus and the Republic of Latvia, are relatively close to the INPP site. The state border Lithuania–Belarus is in about 5 km to the east and southeast from the INPP Power Units. The state border Lithuania–Latvia is in about 8 km to the north from the INPP Power Units.

Other countries are at a distance of at least hundred kilometres away from the INPP site and will not be affected by the proposed economic activity.

2.5.1 General Information on Neighbouring Countries

The Daugavpils region of Latvia and the Braslav region of Belarus are in the immediate vicinity of the INPP (Figure 2.26).

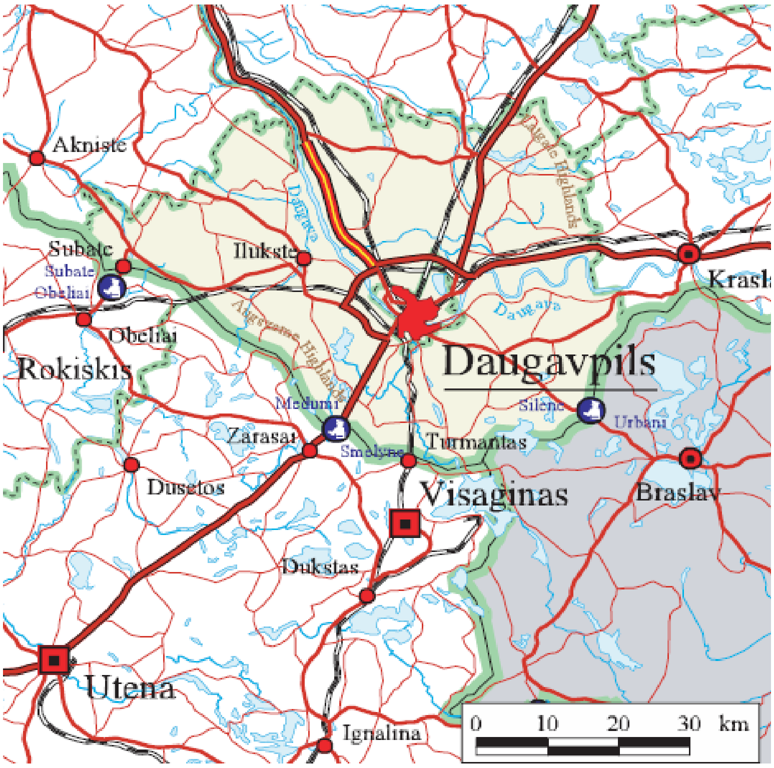

Figure 2.26. The Daugavpils region of Latvia and the Braslav region of Belarus

2.5.1.1 Daugavpils Region

Daugavpils region borders with Lithuania and Belarus. Total area of the Daugavpils region is 2598 km^2.

Land use of the region is as follows: farm lands – 48 %, wooded areas – 34 % and other uses – 18 %. However, agriculture does not significantly contribute to the economic output of the region, as Daugavpils region can be considered as an industrial one. Though there is a lot of land fit for cultivation, the conditions for farming are not very advantageous. The hilly terrain is not conducive to cultivating large fields.

Total population of the Daugavpils region is 159 000 (population census in 2000). Population density is 61 inhabitants per km^2. Daugavpils, the second big city in Latvia after Riga, is an independent structural unit with 115 300 inhabitants in 2000 and 112 000 in 2004. In the region there are 24 small rural areas and 2 towns (Ilukste – 3 177 inhabitants and Subate – 1 013 inhabitants). Approximately 75 % of the inhabitants of the Daugavpils region live in urban areas. Population density in rural areas is low and the population is rather old.

There are good road and rail connections from Daugavpils region to Riga and also with Lithuania, Belarus and Russia. Most important are the Warsaw-Vilnius-Daugavpils-St Petersburg connection and the railroad to Riga. The national major road Riga-Daugavpils, as well as the road connection to Zarasai in Lithuania and the route Daugavpils-Rezekne-Pskov in Russia have international significance.

A number of historical monuments provide good background for the development of tourism. The most popular objects in the region are Daugavpils fortress from the 17th century, Peter-Paul Cathedral, a fortress from the beginning of the 19th century and Vaclaiciena Palace. One unique object is the Duke Jacob's Channel in Asare (500 m long), built in 1667–1668 to link the two rivers, Vilkupe and Eglaine, to connect Daugava and Lielupe water routes.

Latvia's largest river, the Daugava flows through the region from Belarus towards the Gulf of Riga. The length of the Daugava river is 1040 km (367 km in the territory of the Republic of Latvia). Watershed area is 87 900 km^2; average water yield is 678 m^3/s. The Daugava river meanders throughout all the territory of the Daugavpils region, making 10 loops from Kraslava to Krauja and running calmly from Liksna and Nicgale. There are 194 lakes in Daugavpils region. Some lakes (Skujines, Medumu, Bardinska, Sventes etc.) are the nature reserves.

Daugavpils region has plenty of attractive natural landscapes. The Daugava's stretch from Kraslava to Daugavpils, where the river flows in a primeval hollow, which is almost 40 metres deep, is sometimes called the Switzerland of Latgale. Two significant highland areas – the Augszeme and Latgale highlands are located in Daugavpils region. Latvia's biggest boulder (174 m^3) is in Nicgale.

2.5.1.2 Braslav Region

Braslav region is administrative part of Vitebsk district. The only town in the region is Braslav with 10 thousand inhabitants. Other settlements are Vidzy, Pliusy and smaller villages (Figure 2.27). Braslav town is on a shore of Lake Driviaty, in a distance of 30 km from railway station Druia, 220 km from Minsk and 238 km from Vitebsk. There are factories of building materials, greengrocery production etc. in the town.

National park "Braslav Lakes" occupies 69.1 thousand hectares or about one third of Braslav region territory. The most picturesque and precious areas around the Braslav town forms a core of the national park. Extension of the park from north to south is 56 km and the width varies from 7 to 29 km. There are more than 60 lakes in the national park; they occupy 17 % of its territory. The first-rate lakes are Driviaty, Snudy, Strusto, Boginskoie (Figure 2.28). Lake Volos South is the deepest in the park and region; it is as deep as 40.4 m. There are 4 functional zones in the national park "Braslav Lakes":

- The reserved zone – 3452 hectares (4.9 %). This zone is in the most precious area of forest tract Boginskoie. The purpose of the reserved zone is preservation in untouched condition of typical and unique ecosystems and a gene pool of flora and fauna;
- The zone of controllable use – 27746 hectares (39.0 %). The purpose of this zone is studies of restoration, moving forces and trends of inviolate ecosystems;
- The recreational zone – 12103 hectares (17.0 %). This zone is assigned for allocation of units and buildings for rest and tourism, for actions on cultural work among the masses and for car parking management;

- The zone for economical activity – 25815 hectares (36.3 %). This zone is assigned for allocation of park visitors' service units, living quarters and for economical activities.

Figure 2.27. The Braslav region of Belarus

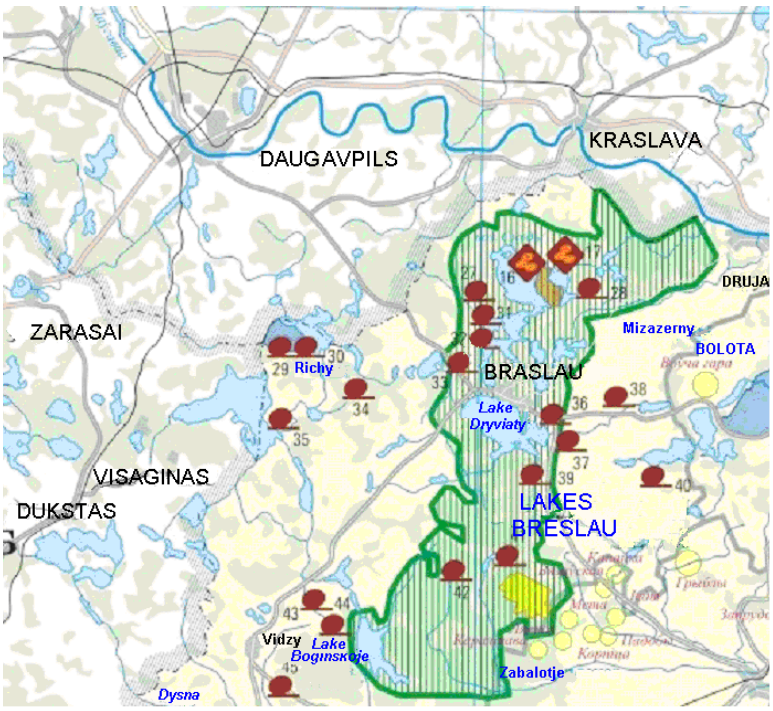

Figure 2.28. The national park "Braslav Lakes"

The territory of national park "Braslav Lakes" presents the most peculiar natural complex of the Republic of Belarus. Unique combination of hills, lakes, marshlands and river valleys make this land extraordinary picturesque.

The typical forest inhabitants are elk, wild boar, deer, squirrel, mountain hare, brown hare, fox etc. The rare species from the Red Book of Belarus are badger, lynx and brown bear. There are about 200 species of birds in the national park "Braslav Lakes". The rare species are black stork, crane, herring gull, ptarmigan, dunlin etc.

2.5.2 Potential Impact and Impact Mitigation Measures

2.5.2.1 Water

Management of liquid radioactive waste is described in Chapter 2.3 "Waste". There will be no uncontrolled discharges of radioactive waste into water component of the environment under normal operation conditions of the proposed economic activity.

Only the non-radioactive liquid waste can be released to the sanitary-technological waste water system. The sanitary waste water is transferred to State Enterprise "Visagino energija" under an agreement.

The INPP surface water drainage system meets the requirements of the document [21].

SPZ of waterworks for Visaginas town is distant about 3 km to south-west from the INPP. The water is extracted from Sventoji – Upninkai aquifer complex of upper and middle Devonian formations. The site of the disposal units is outside the boundaries of the sanitary protection zone of the waterworks [22]. A conservative estimation of the potential release of contaminants to the groundwater demonstrated that no significant impact on the waterworks for Visaginas town is expected [16]. Waterworks for Braslav region in Belorussia as well as for Daugavpils region in Latvia are much far in comparison to Visaginas waterworks.

2.5.2.2 Environmental air (atmosphere)

<u>Release of non-radioactive contaminants</u>

During construction phase of the buffer storage pollution of environmental air from mobile sources will be temporary (during relatively short construction time (about one year)) and within a limited area (construction will be performed at the INPP industrial site), therefore, will not cause significant releases and will not make any considerable impact on the environmental air of Braslav region in Belorussia as well as Daugavpils region in Latvia.

During the buffer storage operation the environmental air quality will be directly affected by the emissions of NO_X, SO_2, dusts, CO, CO_2 and unburnt carbohydrates C_XH_X generated by the road transfer of containers with radioactive waste, as well as by the fork-lift trucks working in the buffer storage premises. Assessment of non-radioactive releases (see Chapter 2.4.2.2) has shown that they will be very low. Impact zone will be limited by the INPP industrial site, and non-radioactive releases will not cause any impact to the air of the neighbouring states.

<u>Radionuclide releases</u>

A potential radiological impact on the environmental air of the neighbouring countries resulted from the proposed economical activity under normal operation conditions could be expected due to airborne releases of the radioactive substances from the buffer storage building.

The radiological impact due to airborne radionuclide releases as well as due to direct irradiation depends on the recipient distance from the source. The estimation of the releases into the environmental air from the buffer storage facility under normal operation conditions has shown that releases are insignificant (see Chapter 2.4.2.3.2). Using data on the radionuclide releases, annual effective exposure doses to a member of the critical group of population were calculated. Maximal volumetric ground level activity and, consequently, maximal exposure dose is expected at a distance of about 100 m from the release point. At such a distance annual effective exposure dose to a member of the critical group of population will be below 0.07 μSv and is insignificant (see Chapter 2.4.9.3.3). For comparison, practices and sources within the practices may be exempted if the annual effective dose expected to be incurred by any member of the population due to the exempted practice or source is 10 μSv or less [61], [62]. At a distance of 2 km, value of annual effective exposure dose to a member of the critical group of population will be by 2 orders of magnitude lower, i.e. will make only about 0.0007 μSv (see Figure 2.20), potential exposure of population in the neighbouring countries due to their greater distance from the release source, will be even lower.

It may be concluded that estimated releases of contaminants during construction and operation of the buffer storage will not cause significant impact to the environment air of Braslav region in Belarus and Daugavpils region in Latvia.

2.5.2.3 Soil

The buffer storage will be constructed within the boundaries of the existing INPP industrial site. The site does not contain valuable fertile layer of the soil. No significant impacts will occur to the soils and the vegetation outside of the borders of the INPP site.

2.5.2.4 Underground (geology)

Impact on underground (geological) component of the environment due to proposed economic activity is not expected. Buffer storage will be constructed at the INPP industrial site, on the territory of the former Reactor Unit 3, and additional impact on the geological structure of soil will be insignificant. No valuable natural resources have been found at the site. No any considerable impact on geological environment of Braslav region in Belorussia as well as Daugavpils region in Latvia is expected due to proposed economic activity.

2.5.2.5 Biodiversity

No unique bird ecosystems or mapped critical habitats occur at the INPP site. The main source of the negative impact from the proposed economic activity, such as noise, will not be perceptible at the territories of Braslav region of Belarus and Daugavpils region of Latvia since they are located at least 6 km from the INPP site. There will be no impact on biodiversity component of the environment of the Daugavpils region in Latvia and the reserved zones in the national park “Braslav Lakes” in Belorussia.

2.5.2.6 Landscape

The buffer storage will be constructed within the boundaries of the existing INPP industrial site. The landscape of the site is characterized as industrial. No impacts on residential and recreational areas in the neighbouring countries are expected.

2.5.2.7 Ethnic and cultural conditions, cultural heritage

No interactions between proposed economic activity and ethnic and cultural conditions as well as cultural heritage zones of Latvia and Belorussia are identified.

2.5.2.8 Social and economic environment

The proposed economic activity will be distant from permanently living population of Latvia and Belarus. No impacts or evident changes of social and economical environment are foreseen.

The planned economic activity will not produce any significant impacts of conventional (non radiological) and radiological nature, which could in the negative affect components of the environment and public health of Belarus and Latvia. The negative impacts might be detected only in close vicinity to the INPP and airborne releases from the buffer storage will be held within permissible limits.

The proposed economic activity will be performed in accordance with the modern environmental requirements using state-of-the-art technologies. The proposed economic activity represents the EU direct investment for the INPP decommissioning. The proposed economic activity will be performed in compliance with the radioactive waste management principles of the IAEA and in compliance with good practices in other European Union Member States.

However, population discontent and distrust is possible in Latvia and Belarus. Such a psychological impact is stipulated by changes in existing nuclear practice (shutdown and decommissioning of INPP), which results in construction of new nuclear objects. Psychological impact can be mitigated explaining necessity, goals and benefits from proposed economic activity:

- The proposed economic activity is inevitable and must be performed for imperative reasons of overriding public interest, including those of a social and economic nature. Zero alternative will stipulate irrational expenses of both material and human resources and in the worst case inadmissible negative impact on the environment as well as population health;
- The proposed economic activity is financed under the EBRD (European Bank for Reconstruction and Development) managed International Ignalina Decommissioning Support Fund;
- The calculations and assessments performed in this EIA Report have clearly shown that the proposed economic activity will not produce significant impacts, neither of radiological nature nor of non-radiological nature, which could physically affect public health and environment.

The proposed economic activity will be carried out under the strict control of national regulatory authorities. These government institutions enforce state regulations that are based on the European Union practices, as well as on guidelines and conventions established by international organisations, such as the International Atomic Energy Agency (IAEA).

2.5.2.9 Total radiological impact on the neighbouring states due to the existing and planned nuclear facilities within the territory of INPP

The total radiological impact due to the existing and planned nuclear facilities on the territory of INPP is assessed within the SPZ of INPP (of 3 km radius). The impact outside SPZ is considered as negligible. It is demonstrated in Table 2.23 that the overall impact would be about 8.74E-02 mSv per year, i.e. about 3 times below the value of the dose constraint 0.2 mSv per year. The dose would be stipulated by such components as direct exposure from the planned buffer storage, airborne and waterborne radionuclide releases from the nuclear facilities located within the SPZ of INPP, as well as airborne radioactive releases from the planned new NPP. It should be noted that the value of these components are inversely proportional to the distance. Therefore considering the distance from the INPP SPZ to the nearest foreign countries (about 2 km to Belarus and about 5 km to Latvia) the total impact on the population of foreign countries is assessed as negligible.

2.6 Analysis of Alternatives

2.6.1 Zero Alternative

It is planned that during the operation and decommissioning of the Ignalina NPP approximately 60 000 m^3 of very low level waste will be generated. If no measures on handling and disposal of such waste are taken, there should be a potential danger of the environmental contamination by radioactive materials and at the same time negative impact on the population health (ionising radiation exposure). Therefore the disposal of very low level waste is necessary, and it is defined by the requirements specified in the document [8].

”Zero” alternative analyses a situation when the buffer storage is not constructed at all, and packages of very low level waste are not accumulated in any place, but are immediately transferred directly to *Landfill* facility for final storage. In this case, the following unfavourable aspects of RAW handling process may be identified:

1. It is planned that during operation and decommissioning of Ignalina NPP on average 1-2 containers per day of very low level waste will be generated; they would need immediately to be transported into disposal place and disposed off; this process would be uninterruptible, lasting all-year around for approximately 30 years (till the end of activities related to decommissioning of INPP).
2. In case of uninterruptible process of disposal, construction of facility basement plate for the subsequent disposal unit would become undoubtedly more complicated as preparation of a new disposal unit would be performed simultaneously, and in close vicinity of the disposal unit in operation and previous disposed waste.
3. In case of uninterruptible process of disposal, *Landfill* disposal unit would be open from the beginning of its operation till its closure (approximately for 10 years) and this undoubtedly would complicate ensuring of radiation safety and physical protection. Transportation and storage of RAW packages would be carried out till the final close of the unit under any climatic conditions, what would have a negative impact on radioactive waste packages, and would accelerate their degradation.
4. In order to avoid the negative impact on RAW packages, it would be necessary to construct temporary covers or roofs and that would require additional time and also economic resources.
5. In case of uninterruptible waste delivery, positioning of containers in *Landfill* disposal unit would be performed in such order as they were delivered; in this case it would not be possible to plan container positioning in advance and to separate a segment of higher activity waste (but not exceeding permissible limit values), which could be placed inside the unit and surrounded by lower activity RAW packages, optimizing positioning of waste packages, and implementing principle ALARA.

To sum everything up it can be concluded, that waste accumulation up to a certain amount, and its disposal off in *Landfill* disposal units in campaigns would be more acceptable option from the point of view of radiological protection, economic benefits, and also planning and management of the entire process of very low level waste handling. In case of disposal off RAW in campaigns, there would be a possibility to choose the most favourable seasonal conditions; the campaign would last for a relatively short time (it is planned for 1-2 months), and after positioning of containers and packages, there would be a possibility to form surface engineering barriers at once and to provide long-term safety. Therefore, waste disposal in campaigns, which would be possible in case of buffer storage construction, is a more acceptable option in RAW handling process that allows to ensure lower impact on environment, than in case of the zero alternative.

2.6.2 Location Alternatives

For construction of the buffer storage two sites are analyzed:

- Area at the site of the former third INPP unit, in the vicinity of the free release measurement facility;

- Area in the vicinity of the proposed site for *Landfill* disposal facility, close to sites for new facilities: ISFSF (project B1) and SWTSF (project B3/4).

Taking into consideration recommendations of IAEA on assessment of sites, planned for construction of nuclear facilities [63], a comparison of characteristics of alternative sites is presented in Table 2.27.

Table 2.27. Comparison of characteristics of the alternative sites

Aspect	Site of the former INPP Reactor Unit 3	Site in the vicinity of the planned *Landfill* facility
Characteristics of the site		
Hydrological and hydrogeological conditions	The sites are located in the recharge area of the eastern part of the Baltic artesian basin.	
	Water lies at the depth of 4.2–6.3 m beneath the earth surface above clay low plasticity, in sandy mounds. Thickness of aqueous layer is – 0.2–0.5 m.	The shallow groundwater in the borings has settled at the depth of 0.3–4.5 m. Water level fluctuation is up to 0.5 m.
	The ground level at the buffer storage site is 154.4 m. The highest water level in Lake Druksiai can reach 143.5 m. Flooding of the buffer storage site is impossible.	The surface altitude varies from 151 to 162 m. The highest water level in Lake Druksiai can reach 143.5 m. Flooding of the buffer storage site is impossible.
	Ground water is that of calcium-vitriolic bicarbonate, does not penetrate into concrete and averagely penetrates into metal constructions.	Groundwater is calcium bicarbonate and can be considered as medium aggressive to concrete and metal constructions.
	According to laboratory results, the coefficient of filtration for aqueous sands varies from 0.9 to 24.8 m/day.	The coefficient of filtration for aqueous sands varies from 0.7 to 24.9 m/ day.
Meteorological conditions	Analogical for sites, since distance between sites is too small for significant changes in meteorological parameters.	
Soil	The area of the INPP site has been changed in the past because of construction and industrial activity, thus natural soil in this area is almost absent.	The surface of the site was technogenically impacted and later re-cultivated.
	Surface of the buffer storage territory is covered with mounds and technogenic formations. Mounds consist of soil, dusty sand, gravel and clay low plasticity. Thickness of mound layer is about 2 m.	A fertile soil layer is found on the periphery of the site. The thickness of the layer is up to 0.3 m.
Geological conditions	Lithuanian territory is traditionally considered as non-seismic or low seismic zone. A design basis earthquake for the analysed area is with intensity of 6 grades on the MSK-64 scale, a beyond design basis earthquake – of 7 grades.	
	Surface sediments in the area are very inhomogeneous. There are a number of engineering geologic layers with variable thickness and complex stratification.	Geologic/lithologic structure of the site is complex: frequent changes in lithologic layers and their thickness, complex interbedding.
	Soils of III seismic category are commonly found in the site.	Weak liquefied and thixotropical soils of the third seismic category, which

Aspect	Site of the former INPP Reactor Unit 3	Site in the vicinity of the planned *Landfill* facility
		are sensitive to dynamic impact, are commonly found in the site.
	The relief of the Ignalina NPP site has been changed in the process of smoothing away during the construction works. The absolute altitudes at the site of Ignalina NPP vary from 145 m to 155 m.	The site is located on a swathe of fringe formations and on the limits of two flat fluviolkamic hills with an interfoot. The slopes of hills are low-pitched. The interfoot is waterlogged. The surface of the site has an incline (151–160 m altitudes) towards southwest.
	Neither important minerals (with the exception of quartz sand) nor protected geological objects are found in the region.	
Biodiversity, protected areas	No biodiversity, which has to be protected, is identified.	The surface of the SWTSF site has been artificially changed in the past (during the construction of INPP) and later re-cultivated. No biodiversity, which has to be protected, is identified.
Landscape	The landscape of the site is industrial.	There are hills to the south-east direction. Slopes of the hills are low-pitched, inter-hill is marshy, in some places there are trees. The trees have been planted about four years ago. There are trenches up to the depth of 3 m beside the western and southern side of the site.
Human environment		
Site status	The sites are within the industrial area allocated for the State Enterprise Ignalina NPP. 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 energetic installations and other)".	
Distance from the INPP industrial site	-	The distance from the *Landfill* disposal units site to the Reactor Units makes about 1.5 km.
Social and economic environment	There is no permanently living population within the site. The building will be constructed at the INPP industrial site with a permanent security fence. Location is not accessible to the public.	The site is within the existing 3 km radius sanitary protected zone of INPP. There is no permanently living population within the existing sanitary protection zone, and the economic activity is limited as well.
Existing infrastructure	Easily accessible INPP infrastructure: electricity, potable water, heating system, technical water, household sewage, storm drain water system, road for transportation of RAW from places of its generation to storage building.	For creation of infrastructural objects some economical and natural resources will be needed.
Potential hazardous objects	There are no potentially hazardous industrial objects in the vicinity, with the exception of INPP itself. The nearest	There are no potentially hazardous industrial objects in the vicinity, with the exception of INPP itself. The

Aspect	Site of the former INPP Reactor Unit 3	Site in the vicinity of the planned *Landfill* facility
	potentially hazardous object is the fuel storage for diesel generators (at the distance of about 300 m). However, it will not cause any impact to buffer storage facility, since it is covered by other buildings.	nearest potentially hazardous object is a gas pipeline, passing at the distance of about 140 m. In the vicinity nuclear facilities are planned for the projects B1 (ISFSF) and B3/4 (SWTSF).

Summarizing data about environment of the both sites, presented in Table 2.27, it may be concluded, that characteristics of both sites are similar. However, construction of the buffer storage at the INPP industrial site is more preferable option, as it:

- the decrease of the distance of transportation of RAW packages should be achieved. This would be a benefit from the environment impact point of view as well as from the point of view of financial costs;
- simplifies the connection up to INPP existing systems as well as the use of the existing infrastructure;
- special services and organizations of INPP may be effectively used.

2.7 Monitoring

2.7.1 Supporting Documents and Investigations

Since startup of operation the INPP performs monitoring of environment within 30 km radius monitoring zone around the power units. The monitoring is performed in accordance with regulatory approved environment monitoring program. The monitoring program is originated on the base of Lithuanian radiation protection standards [44], Lithuanian legislation and regulations on environment monitoring [64], [65] and regulatory documents on the environment [46], [66]. Monitoring data is being summarized and submitted to competent institutions annually.

The INPP Environment Monitoring Programme [67] specifies requirements for:

- Monitoring of water quality in the lake and of groundwater (physical – chemical parameters);
- Monitoring of radionuclide concentration in the air and atmospheric fallouts;
- Monitoring of radioactivity of sewage and drainage water from the INPP site;
- Monitoring of radionuclide release into the air;
- Meteorological observations;
- Monitoring of radionuclide concentration in the lake and underground water;
- Dose and dose rate monitoring in the sanitary protective area (3 km) and radiation control area (30 km);
- Monitoring of radionuclide concentration in the fish, algae, soil, grass, sediments, mushrooms, leaves;
- Monitoring of radionuclide concentration in food products (milk, potatoes, cabbage, meat, grain-crops).

The chemical content of sanitary waste water discharges from the industrial site of INPP is controlled by "Visagino energija".

The radiological measurements performed according to the INPP current environment monitoring Programme [67] are summarized in Table 2.28.

Table 2.28. Summary of radiological measurements performed according to the INPP environment monitoring Programme [67]

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
			Volumetric activity 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
			Volumetric activity of radionuclides 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 per week – releases of gases/aerosols from Bld. 150 through installation 153.	$1.85 \div 3.7 \times 10^5$ Bq/l

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
			Volumetric activity of radionuclides of radioactive aerosols	Spectrometric	1 per day, per week and 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; 1 per month – from Bld. 130, from Bld. 156; 1 per quarter – from Bld. 157.	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.	$0.1\div3\times10^{3}$ 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.	$0.1\div3\times10^{3}$ Bq/l
			Volumetric activity of radionuclides	Spectrometric	1 per two weeks– water from installation 141; 1 per quarter – water of heating networks.	$0.74\div1.85\times10^{8}$ Bq/l
4.	The air and atmospheric precipitation	9	Activity of γ nuclides	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.	$1.5\times10^{-6}\div15$ Bq/m^{3}
			Sr-90	Radiometric	2 times per year (in winter and summer) - atmospheric air at points of permanent surveillance.	$3\times10^{-5}\div3\times10^{2}$ 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 nuclides	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 Druksiai lake; 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 Druksiai lake; 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 , 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 2.29	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;	1×10^{-6}–1×10^{-1} Sv/h
					Constantly – SkyLink system.	2×10^{-8}÷10 Sv/h
			γ radiation dose	Radiometric, TLD	2 times per year (in spring, autumn) – dose at locations of TLD in SPZ and SA.	2.5×10^{-4}÷5 Sv
7.	Sludge from storage area	1	Activity of γ nuclides	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 Druksiai lake	10 Sampling points in Lake Druksiai are indicated in Figure 2.30	Activity of γ nuclides	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
			Activity of γ nuclides of upper layer (2 cm)	Dried, concentrated sample. Spectroscopic	1 per year (in spring) – at sampling points of Druksiai lake.	15 Bq/kg
			Sr-90 in upper layer (2 cm)	Burning and radiochemical segregation	1 per year (in spring) – at sampling points of Druksiai lake.	30 Bq/kg
			Distribution profile of gamma nuclides (3-10 cm)	Radiochemical segregation	1 time in 5 years – at sampling points of Druksiai lake.	15 Bq/kg
			Distribution profile of Pu isotopes (3-10 cm)	Radiochemical segregation	1 time in 5 years – at sampling points of Druksiai lake.	300 Bq/kg
9.	Aquatic vegetation of Druksiai lake	11 Sampling points in Lake Druksiai are indicated in Figure 2.30	Activity of γ nuclides	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 Druksiai lake.	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 Druksiai lake.	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 nuclides	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 an in Grikiniskiu peninsula; 2 times per year (in spring, autumn) – fish of Druksiai lake; 1 per year (in summer) – organisms of aquatic environments (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 Vilkaragis, 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 an in Grikiniskiu peninsula.	3 Bq/kg
					1 per year (in spring) – fish of Druksiai lake; 1 per year (in summer) – organisms of aquatic environments (molluscs); 1 per year (in August) – cabbage in Tilze; 1 per year (in autumn) - milk in Tilze.	0.3 Bq/kg
					1 per year (in autumn) – soil at points of permanent surveillance an in Grikiniskiu peninsula.	30 Bq/kg

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
			Activity of α nuclides	Radiochemical segregation	1 per year (in summer) – organisms of aquatic environments (molluscs).	3 Bq/kg

* Detecting limit indicated in Table 2.28 corresponds to the lowest measuring activity of the sample with 95% confidence. The lower activities could be measured with lower confidence. Samples of the same type may by different in composition (for e.g. samples of soil may be different in granulometric composition) therefore detecting limits of samples will be different. Conservative (maximum) meanings of the detecting limits are presented in the table.

Abbreviations presented 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.

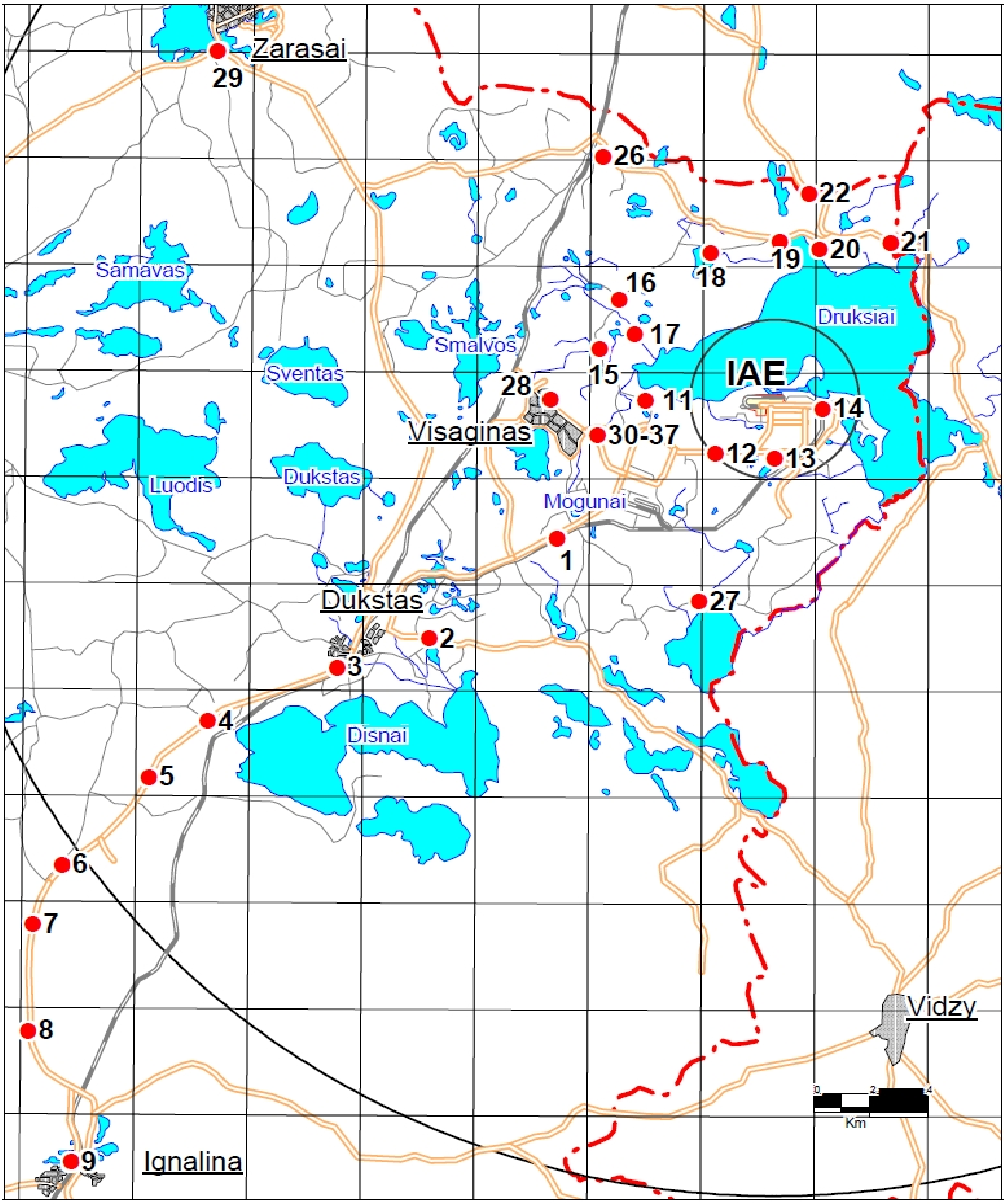

Figure 2.29. Location of thermoluminescent dosimeters around the INPP [67]

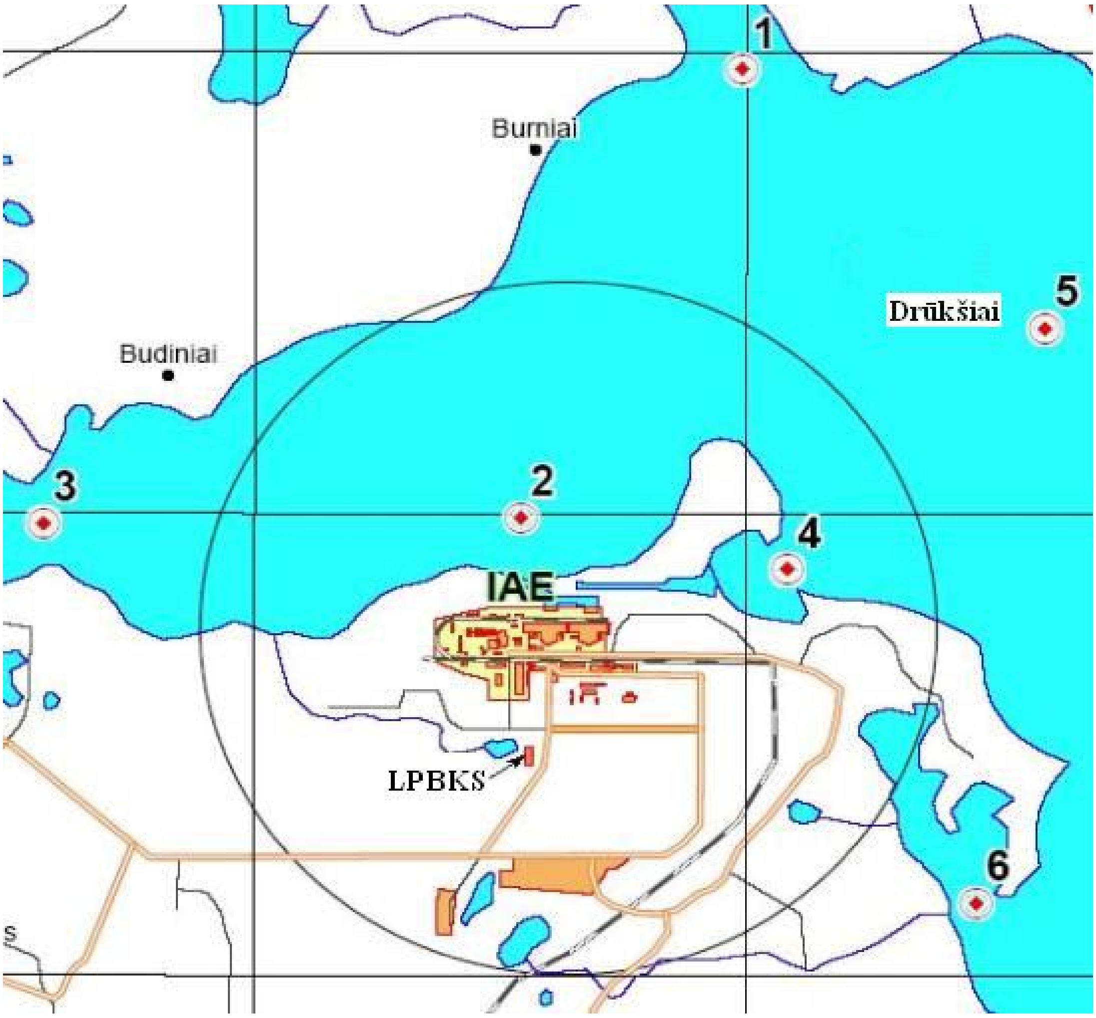

Figure 2.30. Sampling positions in Lake Druksiai [67]

2.7.2 Updating of the INPP Monitoring Program due to operation of the Buffer Storage Facility

The updating of the INPP monitoring program [67] due to operation of the buffer storage facility is summarized in Table 2.29.

Table 2.29. Updating of the INPP environment monitoring program due to operation of the buffer storage facility

No.	Monitoring object	Requirements	Need of the additional monitoring	Comments
1.	Meteorological monitoring in the INPP region	Par. 41 in the document [47]	Not required	Meteorological monitoring is already realized by INPP. The existing monitoring system allows measuring of meteorological parameters for all operating conditions and measured meteorological conditions.

No.	Monitoring object	Requirements	Need of the additional monitoring	Comments
2.	Radionuclide releases from the INPP	Pars 43-50 in the document [47]	Additional monitoring of the radionuclide releases from the buffer storage building ventilation system	Means of measuring the amount of radionuclides in effluents during normal operation and under accident conditions will be provided. The data from the radiation monitoring system will be integrated to the existing INPP monitoring system providing capability for overall assessment of radiation safety at INPP and environment.
3.	Radionuclides concentration in the air	Par. 54 in the document [47]	Not required	Monitoring is already performed periodically by sampling and sample measurement in the laboratory. The buffer storage impact is insignificant and may be conservative assessed using data from the radioactive releases monitoring.
4.	Radionuclides concentration in the precipitation	Par. 54 in the document [47]	Not required	Monitoring is already performed periodically by sampling and sample measurement in the laboratory.
5.	Radionuclides concentration in the aquatic environment	Par. 55 in the document [47]	Not required	It is taking into consideration that monitoring of chemical parameters (harmful substances) of Lake Druksiai, monitoring of the water quality of Lake Druksiai and monitoring of drainage to Lake Druksiai are already performed by INPP. The buffer storage impact is not expected.
6.	Radionuclides concentration in the water of the observation wells	Pars 4 and 12.5 in the document [68]; Par. 54 in the document [47]	Not required	Observation wells for groundwater monitoring are already installed at INPP site in accordance with the Groundwater Monitoring Program. The buffer storage impact is not expected.
7.	Chemical content of the water of the observation wells	Par. 12 in the document [68]	Not required	Observation wells for groundwater monitoring are already installed at INPP site in accordance with the Groundwater Monitoring Program. The buffer storage impact is not expected.
8.	Radionuclides concentration in the soil	Par. 54 in the document [47]	Additional monitoring of the soil samples around the buffer storage building	Actually, the spectrum of the nuclides to be analyzed in the soil samples (and in the environment) can change. This must be taken into account in the monitoring program.
9.	Radionuclides concentration in the bottom sediments	Par. 55 in the document [47]	Not required	It is taking into consideration that necessary measurements are already performed by INPP.
10.	Radionuclides concentration in the plants and food products	Par. 54 in the document [47]	Not required	It is taking into consideration that necessary measurements are already performed by INPP.

No.	Monitoring object	Requirements	Need of the additional monitoring	Comments
11.	Dose rate, dose	Par. 51 in the document [47]	Not required	The online detectors are already positioned at specific points. When evaluating the TLD it is possible to create a dose rate profile for the INPP site fence in each direction. The continuous dose rate estimation in vicinity of the buffer storage is performed according to the data from the Skylink system detector.

The kind and frequency of measurements will be in correspondence to the present monitoring program of INPP. No supplements are planned at the present stage. The detailed updating of the program is planned after the updating of *Integrated Permission of Pollution Prevention and Control for State Enterprise Ignalina NPP*.

2.8 Risk Analysis and Assessment

Emergency situations (emergencies) resulting from the proposed economic activity, which could potentially cause an impact on the environment are addressed in this chapter of the EIA Report. The risk analysis of potential emergency situations is performed in accordance with the recommendations of the document [69]. The assessment of the consequences of the possible emergency situations as well as the risk level and the impact prevention/mitigation measures are presented in the chapter.

2.8.1 Identification and Assessment of Potential Emergency Situations

The object of risk of the proposed economic activity is the storage itself, since the source of risk is within it – radioactive waste. Internal and external events, which may potentially cause accident situations, are analyzed in the report. Possibility of occurrence of equipment and system components failures, and also consequences related to that, at a greater degree depend on design solutions, which will be made during development of the technical design.

The results of the risk analysis are presented Table 2.30. The structure and content of the table is in correspondence with recommendations of document [69]. The requirements for the classification of the consequences of a potential accident (for life, environment and property), the accident development speed and the probability of accident occurrence are explained in Table 2.31. More detailed explanations can be found in the document [69].

Table 2.30. Risk analysis of the potential emergency situations during performance of the proposed economic activity

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	E	P	S	Pb	Pr		
Reception of RWP	RWP	Improper container delivery (wrong waste class)	Personnel	Direct exposure of personnel	2	1	1	5	2	B	Automatic dose control upon entering, documentation examination.	Container measurement at waste producer site before sending waste into the *Landfill* buffer storage.
		Collision of vehicles at the site with structures, systems and components of the facility	Buffer storage building	Damage of structures	1	1	1	5	2	A	Speed limiting signs and driver qualification.	Low traffic intensity (2 deliveries a day).
		Fork-lift truck fire	RWP-C, environment	Ignition of waste, potential releases into atmosphere, exposure of personnel and population	2	2	2	5	2	B	Periodical fork-lift truck examination and maintenance, fire extinguishing measures, high qualification of personnel.	
	Fork-lift truck	Exhaust gas	Environment, personnel	Impact on personnel health	1	1	1	3	2	A	Exhaust gas cleaning system, a warning sign to turn off the engine, ventilation system.	
Unload of RWP from the truck	RWP	Collision, drop	RWP, environment	Drop, spreading of waste, personnel exposure	2	2	1	5	2	B	Appropriate construction of the fork-lift truck (limited speed and lifting height) and container.	

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	E	P	S	Pb	Pr		
Transfer of the container within the buffer storage	Container with RAW	Collision, drop	RWP, environment	Drop, spreading of waste, personnel exposure	2	1	1	5	2	B	Appropriate construction of the fork-lift truck (limited speed and lifting height) and container. Marking of the traffic route. Personnel qualification.	Check lists (procedures with control) for each operation are foreseen. Maximal drop height of the container is about 0.5 m.
Transfer of the container into the measurement chamber	Container with RAW	Incorrect positioning of container on trolley	Building structure and equipment inside	Damage of building structure and equipment inside, termination of operation	1	1	1	4	2	A	Additional operational control (supervised by an employee) according to the procedure. Marking of container positioning on trolley. End switches to stop the trolley in a proper position. Automatic door and trolley blocking in certain positions.	
		Trolley fire (motor)	RWP-C, environment	Ignition of waste, potential releases into atmosphere, exposure of personnel and population	2	2	2	5	2	B	Periodical trolley examination and maintenance, fire extinguishing measures, high qualification of personnel.	
Transfer of container within the buffer storage	Fork-lift truck	Failure of exhaust gas cleaning system of the fork-lift truck	Environment, personnel	Impact on personnel health	1	1	1	3	2	A	Scheduled fork-lift truck examination and maintenance, ventilation system.	

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	E	P	S	Pb	Pr		
Placing container for temporary storage (stacking)	Container with RAW	Collisions, drop	RWP, environment	Drop, spread of waste, additional exposure of personnel	2	1	1	5	2	B	Appropriate construction of the fork-lift truck and container.	Maximal drop height of the container is 4 m. Very low level waste.
		Fork-lift truck failure	Building structure, RWP, environment	Drop, spread of waste, additional exposure of personnel	2	1	1	5	2	B	Limitation of speed and lifting height. Appropriate employee qualification.	
Interim container storage	Container with RAW	Humidity in the storage, corrosion of containers	Container with RAW	Damage of container, personnel exposure	2	1	1	1	2	B	Ventilation system and preliminary maintenance of containers (storage) are foreseen. For multiple-use containers inspection of their state is carried out (when necessary they are repaired) before reuse.	
Interim container storage	Container with RAW	Ventilation system failure (e.g. due to power supply failure, and etc.)	None	Termination of operation							(Timely) technical maintenance and repair of ventilation system.	During time, necessary for repair of ventilation system, corrosion of container is practically impossible.
Retrieval and loading of the bale	RWP-C	Fork-lift truck failure, bale drop	RWP-C	Damage of the package, personnel exposure	2	1	1	5	2	B	Scheduled fork-lift truck examination and maintenance, appropriate employee qualification.	Maximal bale lifting height is 1.2 m.
		Fork-lift truck (low lift capacity) failure	RWP-C	Ignition of waste, potential releases into atmosphere, exposure of	2	2	2	5	2	B	Fire alarm.	Maximal amount of bales is 1.

Operation	**Hazard**	**Risk**	**Threatened object**	**Consequences**	**Seriousness**				**Risk level**		**Preventive measures**	**Remarks**
					L	**E**	**P**	**S**	**Pb**	**Pr**		
				personnel and population								
Temporary storage of bales during measurement	RWP-C	Fork-lift truck (low lift capacity) failure	RWP-C	Ignition of waste, potential releases into atmosphere, exposure of personnel and population	2	2	2	5	2	B	Fire alarm and local fire extinguishing system.	Maximal amount of bales is 24. Fire extinguishing system operates by means of water pressure in the water supply system. Half-height container is open, and the full container is closed.
Interim container storage	Containers with RAW	Flooding	None	Termination of operation							Site drainage system.	Work delay, but does not influence the safety.
		Earthquake	None	Termination of operation								The probability of a design basis earthquake is 10^{-2}, and the probability of a beyond design basis earthquake is 10^{-5}. The buffer storage building is designed to sustain the load of a 7-grade earthquake. Shocks of earthquake will not have impact on containers stacked and stored in the storage up to five levels.

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	E	P	S	Pb	Pr		
		Aircraft crash (deliberate sabotage by a worker (e.g., with use of explosives), case of intentional intrusion, terrorist act, potential conflicts)	Building construction, RWP	Impact on structure, fire, release of radionuclides, population exposure	3	3	4	5	1	C	a) The activity of the stored/disposed waste is very low, therefore it is unlikely, that they could be the target of terrorists, since consequences of the terrorist act would be insignificant and easily eliminated, b) The waste do not contain materials which could be used for preparation of large-scale terrorist acts (a "dirty" radioactive bomb). c) The storage facility will be arranged on the well protected industrial site of INPP, the disposal units will also be constructed within the protected zone and provided with necessary measures of physical protection. d) For prevention of terrorist acts and diversions, and also for liquidation of possible consequences "Comprehensive Plan of Protection Against Terrorist Acts" has been developed and has been in force at INPP. e) Extremely low probability ($<10^{-7}$) of an aircraft crash.	Beyond design basis accident.

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	E	P	S	Pb	Pr		
		Loss of electrical power supply or other services	None	Termination of operation								

Table 2.31. Classification of consequences for life and health (L), environment (E), property (P), accident development speed (S), accident probability (Pb) and prioritization of consequences (Pr) according to recommendations [69]

Classification of consequences for life and health (L)

ID	Class	Characteristic
1	Unimportant	Temporary slight discomfort
2	Limited	A few injures, long lasting discomfort
3	Serious	A few serious injuries, serious discomfort
4	Very serious	A few (more than 5) deaths, several or several tenths serious injuries, up to 500 evacuated
5	Catastrophic	Several deaths, hundredths 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	Simple contamination, localized effects
3	Serious	Simple 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		
3	Medium	Some spreading, small damage
4		
5	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

Prioritization of consequences (Pr)

ID	Characteristic of consequences
A	Unimportant
B	Limited
C	Serious
D	Very serious
E	Catastrophic

2.8.2 Assessment of Potential Emergency Situations

The assessment of consequences resulted from the screened potential emergency situations is presented in this chapter assuming that the accident conditions should be caused. The accident conditions are supposed as the deviations from the normal operation more severe than anticipated operational occurrences, including design basis accidents and beyond design basis severe accidents.

Design basis accidents – are accident conditions against which a nuclear facility is designed according to established design criteria. The consequences and the release of radioactive material are kept within authorized limits in this case.

The dose constraint of 0.2 mSv per year during operation and decommissioning of the nuclear facility is prescribed in the normative document [45]). The exposure dose limit of 10 mSv to the population in case of design basis accidents is indicated in the par. 90 of the document [45].

According to the risk analysis, see Chapter 2.8.1, the potential impact is analyzed for the identified emergency – fire in the buffer storage during which 24 packages with combustible RAW burn down. The consequences of one package ignition accident are enveloped by the consequences of the above considered accident and are not analyzed.

The analysis of potential radiological consequences in case of beyond design basis accident must provide the assessment of the exposure to a member of the population due to passing through of a radioactive cloud. It is impossible to decrease the consequences of this accident due to rapid dispersion of the radionuclides in the atmosphere. Appropriate measures shall be implemented immediately after the accident (especially within the existing SPZ) to assess contamination zones and to mitigate potential consequences due to external exposure from radionuclides deposited on the ground and from ingestion of contaminated foodstuff.

This beyond design basis accident was chosen for detailed potential environmental impact assessment: aircraft crash on the buffer storage. The probability of the accident is extremely low ($< 10^{-7}$). Its consequences and potential impact completely include consequences of other incidents (scattering of RAW, fire of combustible RAW). The effective dose of a member of population in case of beyond design basis accident is calculated considering the same internal and external exposure pathways as in case of design basis accidents.

Radiological consequences evaluation methodology is presented below.

2.8.3 Methodology for Assessment of Public Exposure Determined by Airborne Radioactive Materials

In case of accidents with release of airborne radionuclides, the calculation of the atmospheric dispersion and the calculation of public exposure are based on the methodology recommended by German incident guideline [70]. This methodology is in accordance with requirements of European [61] and international normative documents [62]. This methodology has been successively applied in assessing of potential emergency consequences for the new INPP cement solidification facility and solidified waste interim storage project [52]. The dispersion modelling methodology used in [70] is described and recommended by IAEA Safety Series publication [71].

The dispersion and deposition of airborne material is calculated, using the short-term two-dimensional Gaussian distribution formula for a source which also may be elevated to a certain height above ground. Gaussian distribution central axis radionuclide activity concentration is used for assessment of maximal potential radiological consequences. Building wake effect is assumed if the release point is within the building wake influence zone. The terrain in the vicinity of the INPP up to distances of several tens of kilometres is sufficiently flat, so it can be stated that the dispersion is not influenced by the orography.

In general, accidents can happen at any time of the day and during unfavourable weather conditions. The most unfavourable factors for fallout and washout were defined to be representative for the investigated situations. The calculations were performed assuming no rain and heavy rain conditions (amount of rain of 5 mm/h). The calculations were performed for all different atmospheric stability conditions from class A (very unstable conditions) to class F (very stable conditions). The wind speed data for the height of 10 m used in the calculations are presented in Table 2.32.

Table 2.32. Wind speed parameters according to atmospheric stability class

Atmospheric stability class	A	B	C	D	E	F
Wind speed at the height of 10 m, m/s	1	2	4	5	3	2

The effective dose due to design basis accidents is calculated for a member of the population considering the following external and internal exposure pathways:

- External exposure:
  - Exposure due to gamma radiation of the passing radioactive cloud (gamma submersion);
  - Exposure due to beta radiation of the passing radioactive cloud (beta submersion);
  - Exposure due to gamma ground radiation of the radioactive fallout and washout (exposure due to radioactive material on ground surface);
- Internal exposure:
  - Exposure due to radioactive intake by respiration (inhalation);
  - Exposure due to radioactive intake by consumption of foodstuffs (ingestion), such as milk, meat, green vegetables and other plant products (grain, grain products, root vegetables, potatoes, fruit, fruit juice).

The assessment of design basis accidents considers the specificity of the existing INPP sanitary protection zone. The presence of members of population within the SPZ is assumed to be the same as in case of normal operational conditions and is limited to 730 h per year. No restrictions are imposed outside the boundary of the SPZ. Design basis accident consequences are calculated assuming no changes in daily life outside the borders of the SPZ. The annual external exposure time is assumed to be 8766 h per year, production and consumption of food products are not specially limited.

The main parameters used for assessment of human exposure under design and beyond design basis accidents are presented in 2.33.

Table 2.33. The main parameters used for assessment of exposure to a member of population during accident conditions [70]

Parameter	Value	Remark
Adult breathing rate, m^3/s	3.8E-04	Conservative value for short time exposure
Annual exposure duration within SPZ, h	730	-
Annual exposure duration outside SPZ, h	8766	Conservative value
Annual intake of crop products (grain, grain products, potatoes, root vegetables), kg/a	610	Conservative value, 95% percentile
Annual intake of fresh (sheet) vegetables, kg/a	39	Conservative value, 95% percentile
Annual intake of milk and milk products, l/a	390	Conservative value, 95% percentile
Annual intake of meat and meat products, kg/a	180	Conservative value, 95% percentile
Amount of feed consumed by milk/meat produced animal, kg/d	65	Fresh mass
Average time between slaughter and human consumption of meat and meat products, d	20	Generic value
Food crops exposure period (growing season), d	60	Generic value
Yield (fresh mass) of pasture grass, kg/m^2	0.85	Generic value
Yield (fresh mass) of sheet vegetable, kg/m^2	1.6	Generic value
Yield (fresh mass) of other products, kg/m^2	2.4	Generic value
Surface dry weight of the pasture soil (depth of 10 cm), kg/m^2	120	Generic value
Surface dry weight of the plough land (ploughshare depth of 20 cm), kg/m^2	280	Generic value

Radiation dose coefficients for inhalation and ingestion are taken from the normative document [44]. The fractions of the released radionuclide into the air presented in the IAEA document [72] are given in Table 2.34.

Table 2.34. Radionuclide airborne release fractions in case of fire

Radionuclide	Airborne fraction
C, I	1.0
Zn, Cs	0.1
Ag	0.01
Other radionuclides	0.001

2.8.4 Assessment of Radiological Consequences

2.8.4.1 Design Basis Accident – Fire in the Buffer Storage

Accident conditions consider fire in the buffer storage that may start while performing operations with combustible waste packages. It is assumed that the whole amount of waste in one ISO container (i.e. 24 packages) burns down. Waste fire is possible only in one ISO container when processing the waste packages within zone B during their measurement, in case of failure and inflammation of the loader. When performing other technological operations and during waste storage, combustible waste is stored in closed ISO containers, fire inaccessible. Release of radionuclide is through the ventilation opening in the roof of the buffer storage. It is assumed that emission occurs at the level of the buffer storage roof. The impact of the building structure on radionuclide dispersal is also considered.

Dose calculation summary for is presented in Table 2.35. The maximum calculated effective dose for a member of critical group of population due to by consumption of radioactive foodstuffs (ingestion) should be below 6.21E-03 mSv per year. Exposure dose due to deposition of radionuclides on the ground inside the INPP SPZ is below 3.6E-03 mSv per year. It equals to 7.18E-04 mSv at the SPZ boundary (at the distance of 2 500 m from the release point). The highest effective dose due to passing of the radioactive cloud at the distance of 100 m (at the INPP security fence) is below 2.2E-03 mSv. It is concluded that the maximum value of effective dose in case of the fire in the *Landfill* buffer storage facility should be insignificant, i.e much below the limit value of 10 mSv established in case of design basis accidents [45].

Table 2.35. Exposure of a member of population due to airborne release into atmosphere in case of internal fire in the buffer storage

Exposure type	**Effective dose, mSv/y in a certain distance from release point, m**		
	100 [1])	**2 500** [2])	**4 500** [3])
Dose due to passing of the radioactive cloud (gamma, beta submersion, inhalation)	2.19E-03	1.27E-05	4.98E-06
Exposure due to deposition of radionuclides on the ground	3.58E -04	7.18E-04	4.54E-04
Ingestion (consumption of radioactive foodstuffs)	-	6.21E-03	3.81E-03
Total:	**2.55E-03**	**6.95E-03**	**4.24E-03**

1) At the security fence of the INPP industrial site. Critical atmospheric stability class F (no rain).
2) At the INPP SPZ boundary. Critical atmospheric stability class E (with rain).
3) At the state boundary with Belarus. Critical atmospheric stability class E (with rain).

2.8.4.2 Beyond Design Basis Accidents – Aircraft Crash on the Buffer Storage

Conditions of beyond design basis accident consider aircraft crash (also including other emergency situations by its consequences, e.g. a intended sabotage by a worker, a terrorist act, etc.) on the buffer storage of the *Landfill* facility that is completely filled up with packages of radioactive waste. It is assumed that an aircraft penetrates the facility roof and causes fire within the storage resulting in burning of the maximum possible amount of waste (only packages with combustible RAW will burn – they make 25% of the whole volume of waste in the buffer storage).

The heat released during the fire may result in the increase of the effective emission height.

However this option was conservatively not taken into account. It also may be relevant that accident mitigations measures lead to fire suppression and to reduction of effective emission height. Therefore, it is assumed that emission happens at the level of the buffer storage roof. The impact of the building structure on radionuclides dispersion is also considered.

Dose calculation summary is presented in Table 2.36.

Table 2.36. Exposure of a member of population due to airborne release into atmosphere in case of aircraft crash on the buffer storage

Exposure type	**Effective dose, mSv/y in a certain distance from release point, m**		
	100 [1)]	**2 500** [2)]	**4 500** [3)]
Dose due to passing of the radioactive cloud (gamma, beta submersion, inhalation)	9.55E-02	5.53E-04	2.17E-04
Exposure due to deposition of radionuclides on the ground	1.56E-02	3.13E-02	1.98E-02
Ingestion (consumption of radioactive foodstuff)	-	2.71E-01	1.66E-01
Total:	**1.11E-01**	**3.03E-01**	**1.86E-01**

1) At the security fence of the INPP industrial site. Critical atmospheric stability class F (no rain).
2) At the INPP SPZ boundary. Critical atmospheric stability class E (with rain).
3) At the state boundary with Belarus. Critical atmospheric stability class E (with rain).

The maximum effective dose to a member of the critical group of population after the passing of the radioactive cloud inside the INPP SPZ is below than 0.01 mSv. Exposure due to deposition of radionuclides on the ground inside the INPP SPZ equals approximately to 0.016 mSv per year. It equals to 3.13E-02 mSv at the SPZ boundary (at the distance of 2 500 m from the release point). The maximum calculated annual effective dose to a member of the critical group of population due to consumption of radioactive foodstuffs (ingestions) would be approximately 0.27 mSv.

2.8.4.3 Compliance with Safety Limits

The established dose constraint for the members of the public during operation and decommissioning of nuclear facilities is 0.2 mSv per year (Lithuanian Hygiene Standard HN 87:2002 [45] p. 87). Item 90 states that population exposure dose in case of design basis accidents for a single design basis accident shall be less than 10 mSv.

Dose assessment results in case of a design basis accident show that possible exposure of a member of the critical group of population is insignificant. The assessment of both the internal and external exposure pathways, demonstrates that the maximum annual effective dose to a member of a critical group of population will be approximately 0.01 mSv, i.e. much below the limit value of 10 mSv established in case of design basis accidents [45].

Results of dose assessment in the case of beyond design basis accident (aircraft crash and ignition of 25% of the whole volume of RAW in the completely filled buffer storage) show that exposure dose to a member of the critical group of population will be lower than 10 mSv [45]. Appropriate accident consequence mitigation measures implemented immediately after the accident (especially within the INPP SPZ) may decrease the negative impact of external irradiation from radionuclides deposited on the ground and from ingestion of contaminated foodstuff. Moreover, plans of protection against terrorist acts and liquidation of possible consequences has been developed at INPP.

2.9 Conclusions

Summarizing the results obtained during environment impact assessment due to the buffer storage construction it can be concluded that:

1. During normal operation of the buffer storage there will be no uncontrolled releases to water component of the environment, therefore, no impact is expected.
2. Releases of both, non-radioactive contaminants and radionuclides into the atmosphere during normal operation of the buffer storage are insignificant, and will not cause considerable radiological impact to the environment.
3. The buffer storage will be constructed at the industrial site of INPP, and during the lifetime of the proposed economic activity no additional impacts, increasing existing impact level on the upper soil layers, are expected.
4. No impacts to underground (geological) components of the environment due to proposed economical activity are expected.
5. Within the INPP industrial site there are no protected habitats or flora and fauna species. The proposed economic activity will have no relevant interaction with biodiversity outside the INPP industrial site. There will be no project implications for the SCIs and SPAs in the vicinity of INPP.
6. The planned storage will be constructed and operated at the INPP industrial site. There will be no impact to the existing landscape.
7. No impacts or evident changes of social and economical environment are foreseen. Moreover, this project will decrease the social and economic impacts of the INPP final shutdown by using the work force with a high skill level associated with work in the nuclear industry.
8. Identified immovable objects and areas of cultural heritage will not be affected due to buffer storage construction, because they are quite far from the facility.
9. No perceptible non-radiological impact to the public health is expected from the buffer storage facility.
10. Potential radiological impact to members of the critical group of population due to releases of airborne radionuclides from buffer storage under normal operation conditions outside SPZ will be lower than 2,54E-6 mSv/y and is assessed as insignificant.
11. Potential radiological impact to members of the critical group of population due to direct irradiation will be about 0.036 mSv/y (under conservative conditions, on a border of the INPP industrial site in the shortest distance (~100 m) from the storage, assuming exposure duration of 730 h per year and maximally loaded with RAW buffer storage).
12. Under normal operation of the buffer storage no negative impact to the environment and public health of the neighbouring countries is expected.
13. The assessment of the zero alternative and location alternative has shown that the construction of the buffer storage is necessary, and for construction of the storage an appropriate site is selected.
14. The assessment results in case of design basis and beyond design basis accidents revealed that the exposure dose to the member of the critical group of the population will be lower that permissible dose limit.
15. Construction of the buffer storage facility will not cause significant negative impact neither to the environment, nor to the public health.

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3 DISPOSAL UNITS

3.1 Demand for Resources and Materials

3.1.1 Demand for Materials during Construction Phase of the Disposal Units

The demand for materials during construction phase of the *Landfill* disposal units is presented in Table 3.1. The quantities presented in the table are preliminary and will be specified more exact during development of the Technical design. It should be noted that the construction of the disposal units will be implemented within overall period of the facility operation (approx. 30 years) in course with the disposal campaigns (no less than one campaign per 2 years). The bottom slab would be an exception as it will be constructed the whole for each disposal unit.

Table 3.1. The demand for materials during construction phase of the disposal units

Title	Units	Volume, mass or quantity
Concrete for bottom slab, 0.5 m thick	m^3	~ 8 500
Sorbing/backfilling material & smoothing layer (sand)	m^3	~ 28 000
Bentonite cover (carpet)	m^2	~ 15 000
HDPE cover (carpet)	m^2	~ 15 000
Gravel for drainage layer, 0,5 m thick	m^3	~ 7 000
Geotextile cover (carpet)	m^2	~ 15 000
Natural material (local ground), 1 m thick	m^3	~ 18 000
Soil layer, 0.3 m thick	m^3	~ 4 500

3.1.2 Electric Power

An electrical cabinet for connection of electricity consumers (lighting of perimeter and of mobile sanitary hygienic facility) will be installed in the control point.

For lighting of the site perimeter projectors with sodium lamps of high pressure 400 W on the 15 m height supports, located at the distance of about 120 m one from another, and 1 m from the fence have to be installed. Protective lighting is connected from lighting control cabinet. The lighting may be manually turned on or off, may be automatically controlled, using central photoelectric lighting sensor. Lighting has to be 20 lux.

For earthing of projector supports ground connection circuit from 2 electrodes of 6 m length with diameter 17.2 mm, interconnected with steel belt 40 × 4 mm has to be installed. Resistance of ground connection is 10 ohm at any time of the year.

For connection of sanitary inspection building of container type a cable line from electric office of control point is required to be installed.

The demand for power supply will be defined during development of Technical design.

3.1.3 Demand for Water

The capacities of existing INPP installations are sufficient to provide necessary water supply for the proposed economic activity. The drinking water is necessary for personnel sanitary purposes (hand washing, showers and toilets), and also for fire fighting system (fire plugs). Drinking water will be supplied from waterworks system of Visaginas town. The Assessment of general demand for drinking water during construction of disposal units and in the period of its operation will be presented in Technical design.

3.1.4 Other Materials

According to the preliminary assessments the following amount of materials will be necessary for implementation of one disposal campaign:

- Sorbing material with a smoothing layer – 1900 m^3;
- Bentonite carpet – 1000 m^2;
- HDPE (high density polyethylene) carpet – 1000 m^2;
- Gravel for drainage layer of 0.5 m thickness – 450 m^3;
- Geotextile carpet – 1000 m^2.
- Material from the surroundings up to 1 m thickness – 1200 m^3.
- Soil layer of 0.3 m thickness – 300 m^3.
- Concrete blocks – ~125 pcs.

3.2 Concept of the Disposal Units

3.2.1 General Description

Landfill disposal facilities will be designed according to Lithuanian legislation and following regulations of IAEA. They will also comply with Technical specification of the project. The estimated life time will including construction, operation, closure and surveillance and control period after closure will be taken into consideration in the Technical design of the disposal units.

Technical details of the facility design such as thickness, dimensions and materials of various barriers and equipment are not final and will be specified during the development of Technical design, under in accordance to the requirements of regulations as well as Technical specification.

Landfill disposal units are intended for disposal of short-lived very low-level radioactive waste following the requirements set in the regulation [1]. Disposal units of the *Landfill* facility are planned to be build to south from the sites of the designed new Spent Nuclear Fuel Storage Facility (Project B1) and new Solid Waste Treatment and Storage Facilities (Projects B3/4), see Figure 1.1 in section 1.3.

Landfill facility will consist of three disposal units capable of containing 20 000 m^3 of waste packages each. The conceptual layout of the disposal units is presented in Figure 3.1. The disposal units will be installed above ground level. The waste will be loaded into three types of packages: in standard 20ft half height ISO containers, in 1 m^3 bales, and in 1 m^3 plastic containers. Main parameters of RWP are presented in section 1.6. Preliminary volume and amount of RWP intended for disposal are presented in section 1.6.3. About 60 000 m^3 of handled and packed waste will be disposed of in the disposal units of the *Landfill* facility. RWP will be located in several layers on the supporting concrete foundation and isolated from the environment by several layers of natural and artificial materials.

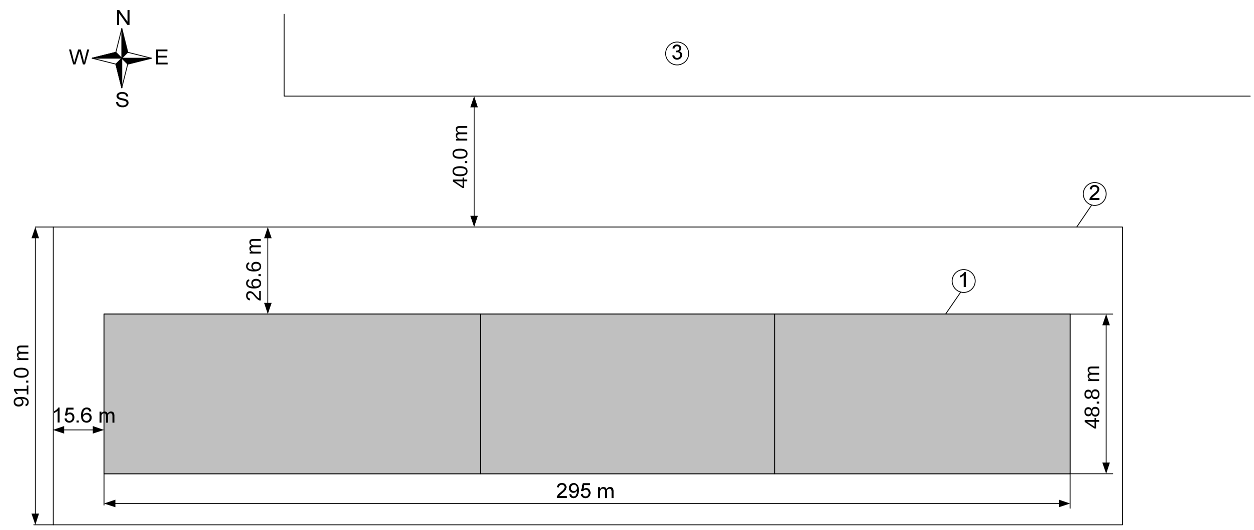


Figure 3.1. Conceptual layout of the disposal units:

① – Disposal unit of the *Landfill* facility;
② – Fence around the disposal units;
③ – Site of projects B1 (New Spent Nuclear Fuel Storage Facility (SNFSF)) and B3/4 (New Solid Waste Treatment and Storage Facilities (SWTSF)).

3.2.2 Concept of Engineering Barriers of the Disposal Unit

A concept of engineering barriers of a single disposal unit of *Landfill* repository is shown in Figure 3.2. Technical details of the unit reference design listed below, such as thickness, measures and material of different barriers and equipment, are not final and will be specified in the process of development of technical project in accordance to the requirements of regulations as well as Technical Specification.

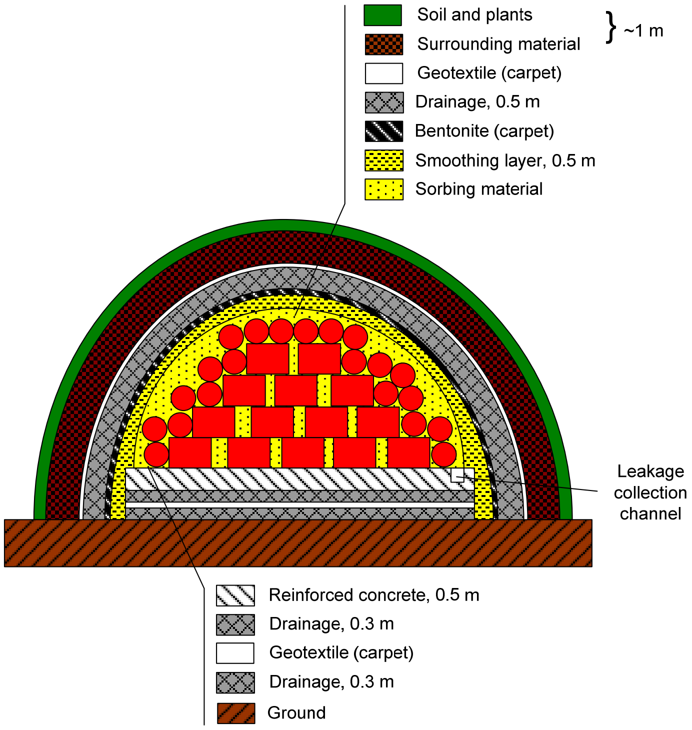


Figure 3.2. Conceptual layout of engineering barriers of disposal unit of *Landfill* repository

Main engineering barriers and also their designation are presented in detail below:

Ground: It must be hard and steady over all repository area; and it would be protected from impact of ground water as well as surface water.

Landfill foundation: As weak ground conditions (man-maid ground, peat, etc.) in the territory as well as vertical geological movements in range 2-3 mm/yr has been reported after preliminary geological investigations the construction of the bottom slab of the *Landfill* repository has been recommended. The function of the *Landfill* bottom slab is to act as stable ground for ISO container. It shall also withstand prospective land movements and thus secure the integrity of the bottom over 100 years. In addition the *Landfill* bottom shall act as "collecting surface" for leakage water, if any. In order to meet above requirements the *Landfill* bottom will be constructed as a self-supporting concrete slab, which slopes in both dimensions to a leakage sampling pit situated in one of the slab corner.

Filling and sorbing material: is assumed to be sand. Sand will give stability to the radioactive waste and also act as sorbent for prospectively released radionuclides. Not only are the containers filled with sand but also space between containers and bales.

Smoothing layer: consists of sand and gravel with total thickness of at least 0.5 m. The material of this layer will smooth the roughness of repository surface and create stable basement for the above lying layers of covering material.

Bentonite layer: protects the repository against penetration of atmospheric precipitation. There is almost no possibility for water to penetrate through the layer of bentonite. However, in case of root penetration, penetration of water will be unavoidable. Frost damage is avoided due to the flexibility of the carpet.

Top protective layer (cap): is designed for shielding the ionizing radiation of radioactive waste from the unit, and also for protection against penetration of plant roots and animals, against external emergency events, to withstand heavy meteorological precipitation, which would result in erosion of the surface layers of the repository. Erosion may be avoided by sowing of the surface with low growing plants. The top protective layer is assumed to consist of:

- *Drainage layer;*
- *Geotextile material carpet;*
- *Natural material layer ;*
- *Soil and vegetation layer.*

Drainage layer will consist of crushed aggregate with fraction 4-8 mm. Thickness of drainage layer is 0.5 m.

Geotextile material – in general, including nonwoven fabric and products manufactured of it. Geotextile is widely used in construction and reconstruction of banks, dumps and other surface installations during their operation and repair. The material structure provides good stability and filtering properties. Due to the optimal combination of its characteristics geotextile performs the major functions – separation, reinforcement, filtration, drainage and also their combination during construction of the drainages, land management and etc.

Natural material layer will consist of the local ground. The thickness of the natural material layer will be 1.0 m.

Soil and vegetation layer will consist of ground covered by perennial plants. The thickness of the soil and vegetation layer will be about 300 mm.

A summary of safety functions assigned to the engineered barriers of the *Landfill* facility is presented in Table 3.2.

Table 3.2. Safety functions assigned to the engineered barriers of the *Landfill* facility

No.	Engineered Barrier	Safety function	Validity period
1.	Top protective layer (cap)	Protection against gamma radiation	Operational and institutional control period
		Protection against root penetration and frost	Operational and institutional control period
		Protection against unintended intrusion	Post institutional control period
2.	Bentonite layer	Protection against infiltration of precipitation and protection against root penetration	Operational and institutional control period
3.	Filling and sorbing material	Protection against gamma radiation	Operational and institutional control period
		Chemical retention of the radionuclide releases (sorption)	Institutional and post institutional control period
4.	*Landfill* bottom	Containment of radionuclide release, providing the integrity of engineering barriers in normal conditions and in case of emergencies	Operational and institutional control period

No.	Engineered Barrier	Safety function	Validity period
		Chemical retention of the radionuclide releases (sorption)	Institutional and post institutional control period
		Protection against flooding	Operational, institutional and post institutional control period
5.	Ground	Protection against flooding	Operational and institutional control period

It should be noted that the optimization of the *Landfill* construction will be performed during Technical Design of the facility.

3.2.3 Drainage System

For long-term water discharge from the swamp, existing in the south side, a collector with diameter 500 mm is foreseen along the territory of the repository, connected to overflow with diameter 800 mm, laid under gas pipeline in the north-west side.

A storm water discharge from the surveillance area of the SNFSF (B1) and SWTSF (B3/4) as well as from the planned *Landfill* site to the overflow.

A circular drainage channel around the disposal units is foreseen for decrease of ground water level and its redirection to the storm-water drainage system.

3.2.4 Storm Water Collection System during Waste Loading

The implementation of the disposal campaign it is recommended within period of July-August, as this is the driest season. However, appropriate engineering measures should be taken for protection against precipitation.

Storm water collection system will be designed for the collection as well as for the monitoring of the water penetrated into the facility during loading campaign and after the facility's closure. Water via channels installed in the bottom slab will flow into collection channel and will be collected into the collection tanks.

Water from the site controlled area (the location where waste loading works will be carried out) will flow via channels installed in the slab into a tray and further via tray into a well and further into the deep tank.

During a loading campaign, in case of a rain, water from the controlled area of the site (i.e., the location where waste loading works are carried out) flows via channels installed in the slab into a tray and further via the tray into a well and further into the deepened tank. The generated effluents will be handled in the same way as potential radioactive waste. Measurement of chemical and radiological parameters of the collected effluents will be carried out. After the assessment of the measurement results, the collected liquids will be either pumped into LRW tank for transportation to the INPP LRW treatment facility or pumped out from the tank using a submersible pump into the storm water drainage system. The effluents from the tank will be discharged into the storm water drainage system following the order established by legal acts of the Republic of Lithuania [2] after the permission for discharges of radionuclides to the environment is obtained and under the condition that the limiting values indicated in the permission will not be exceeded. The particular procedures (including the assessment of the measurement results of the effluents) as well as limiting values of the activities will be prepared according to the provisions of normative documents in force before commissioning of the facility.

The tray and well should be closed by perforated stainless steel grid after the disposition of the waste packages in the certain sector before the backfilling. A fine-crushed stone prism formed above the grids will be covered by a geotextile belt. In accordance to the availability and amount of water in the tanks connected to the site with waste it will be possible to make a conclusion about the state of isolating barriers of the facility and to define approximately the leakage point after the facility closure (or completion of the disposal campaign).

Wells installed in the site, not included into controlled area, are sealed by plugs. Storm water occurred on the bottom slab (not polluted since there are no contaminants and no work is carried out at these sectors of the slab) will flow via channels installed in the slab into a tray, and further via the tray into storm water collection system.

3.2.5 Sanitary-Service and Administrative Rooms

As a sanitary inspection room and office building the modular easily-mounted structures of unit type will be used.

Easily-mounted structures will be constructed as sheet steel containers galvanized from both sides. Polyurethane foam is used as thermal and noise isolation of walls. Containers are fully equipped and ready for operation.

Sanitary inspection room will include one 20 feet sanitary container, and two 20 feet communal containers.

General view of 20 feet sanitary container is presented in Figure 3.3. The communal container is presented in Figure 3.4.

Figure 3.3. General view of 20 feet sanitary container

Toilets, showers, and washstands will be located in the sanitary container.

Water supply will be equipped via pipe through the container sidewall from the existing water supply systems.

Spent water from the showers and washstands will be collected by pipes and removed via sidewall of the container into a collection tank.

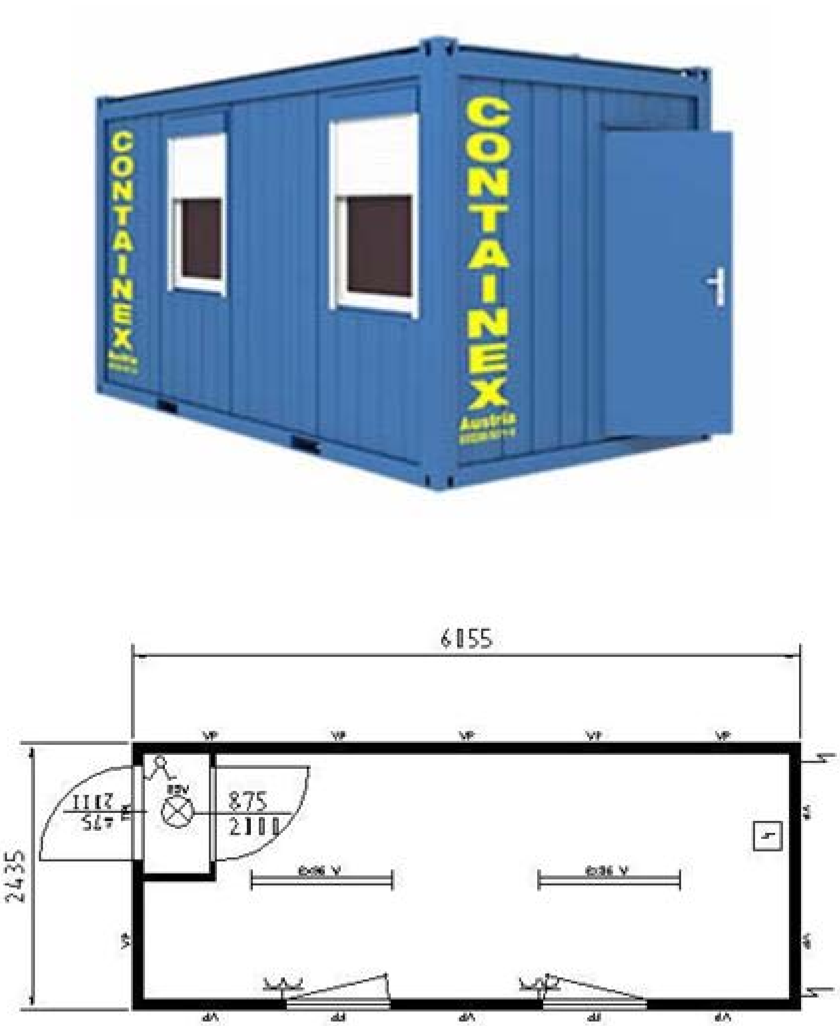


Figure 3.4. General view of 20 feet communal container

30 feet office container will be used for personnel rest, instrument storage, and also for office equipment arrangement. General view of 30 feet office contained is presented in Figure 3.5.

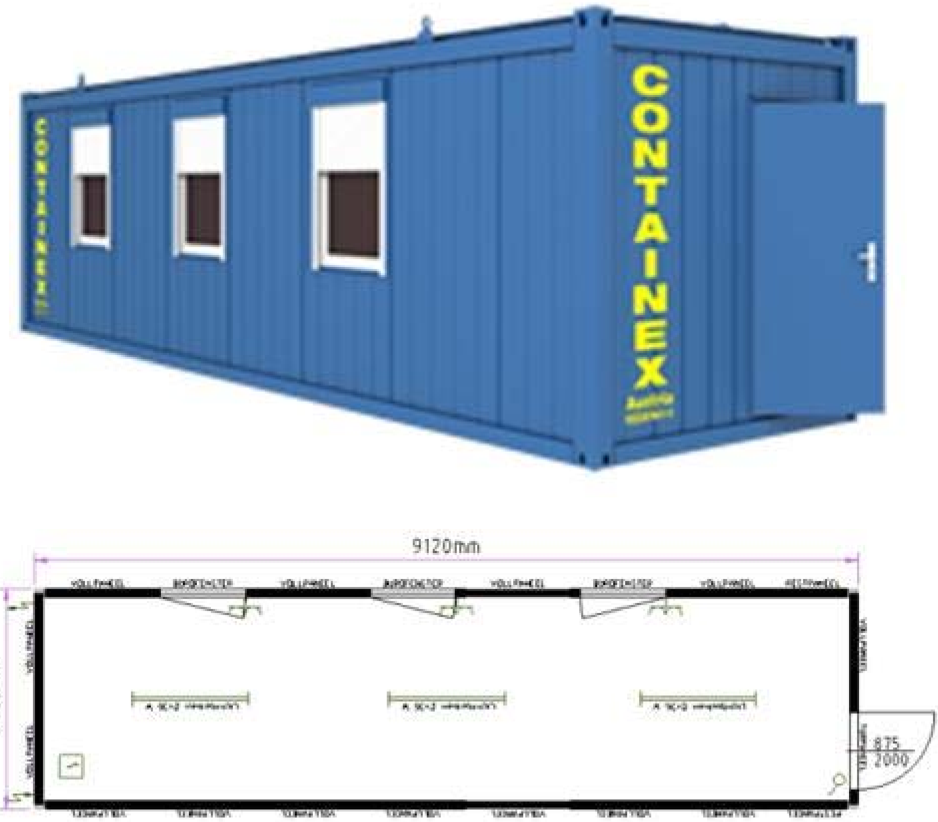


Figure 3.5. General view of 30 feet office container

The individual heating of the containers will implemented by means of electric heater with thermo-regulator and with the protection from overheating. Room ventilation will be implemented by electric fans, possibly also air-conditioners.

The containers will be connected to each other by front or end side. Containers will be placed on the foundation (wooden beams, concrete, strip footing or concrete slab) with at least six bearing points. The dimensions and kind of foundation will be presented in the project.

3.2.6 Description of Technological Processes during Operation of the disposal facility

3.2.6.1 General Description

Operation of the *Landfill* disposal unit should start after the construction of the *Landfill* bottom slab including access roads and groundwater monitoring system as well as drainage system.

Radioactive waste will be disposed in the *Landfill* disposal units during disposal campaigns that will be performed at least once within period of two years. The duration of the campaign as well as the implementation time and the conditions will be specified and optimized during the development of the Technical design.

Half height ISO containers loaded with non-combustible RAW or full height ISO containers loaded with bales with combustible RAW will be transported from the buffer storage to the disposal site. Transportation of waste from buffer storage to disposal units is assumed by public roads. For transportation of containers a trailer truck will be used, which per one run to the disposal site will be able to deliver one container with bales or two containers with non-combustible RAW. In order to assure safe transportation, packages should correspond to the requirements put for packages of class

IP1 according to the document [3]. Containers from the trailer truck will be unloaded on the bottom slab. Containers for formation of the first layer may be placed directly to their final position in the disposal facility. Stacking of containers will be performed by fork-lifter with the capacity at least 25 tons. A strict record of the position of the container in the disposal unit will be conducted.

4 000 m^3 of waste accumulated in the buffer storage are loaded into 160 half-height containers for non-combustible waste and into 720 packages for combustible waste. Half-height containers will be stacked in several (up to 5) layers. Plastic containers/bales will be positioned on the “stairs”, formed by containers. Thus, the *Landfill* geometry will be sustained in the cross section.

Loaded areas of the *Landfill* (up to 18 m length) will be closed. During stacking gaps between containers and spaces in the containers will be filled up with sorbent – sand. The stacked containers are covered with sand layer on the top and slopes are formed with inclination 1:2. Above the sand layer compacted smoothing layer of sand–gravel mixture with fraction 0 – 8 mm is formed. On the top inclination 0.05 is formed in the direction of the *Landfill* edges. A cover of bentonite is used onto the layer and above it a HDPE membrane is put on. Isolating layer is covered with gravel with fraction 4–8 mm. Geotextile, local excavated ground, and formed vegetation layer are applied on it.

After covering with isolating layers the loaded area is closed by concrete blocks at the back till the following disposal campaign.

Capacity of one disposal unit is 20 000 m^3 of packed waste.

3.2.6.2 Waste Transportation

Transportation of ISO half-height containers and ISO containers with waste from the buffer storage building to the *Landfill* disposal units will be carried out on semitrailers with bolster-type tractor. For transportation, storage and disposal of non-combustible waste standard 20-foot half-height ISO containers, which have to meet requirements for packages of class IP1 [3], will be used, see Figure 3.6. The main characteristics of the non-combustible waste package are presented in Table 1.3. During transportation and storage containers are equipped with reusable detachable steel lids. Lids are fastened to containers by locks excluding self-opening.

Containers have paint-and-lacquer coating with high degree of resistance against weather conditions and deterioration, resistance to impacts of chemical substances (under working conditions), with increased bending strength.

Figure 3.6. 20 feet half-height ISO container with removable cover

Transportation and storage of packages of combustible waste and ion-exchange resins will be made in standard 20-foot ISO containers, which have to meet requirements for packages of class IP1 [3], will be used.

Containers for transportation and storage of bales and plastic containers with ion-exchange resins will have doors in one of two ends for loading/retrieval of packages or completely opened side face. Lock-out of doors is made by means of two locking mechanisms excluding self-opening. Options of 20-foot ISO container with completely opened side face and with a door in the end face are presented in Figure 3.7. Key parameters of 20-foot ISO containers are provided in Table 3.3. Key parameters of combustible waste package are presented in Table 1.2, and these of ion-exchange resins package in Table 1.4.

Figure 3.7. Options of 20-foot ISO container with completely opened side face and with a door in the end face

Table 3.3. Key parameters of 20-foot ISO containers

Type	20-foot ISO container. Door in the end face / side opening
External dimensions	Approx. 6.06×2.44×2.59 m
Internal dimensions	5.84×2.35×2.39 / 5.95×2.29×2.26 m
Internal volume	32.8 / 30.8 m^3
Doorway - end face (W×H)	2.34×2.27 / 5.61×2.14 m
Material	Carbon steel 2 – 3 mm

Container weight	2 472 / 2 960 kg
Useful loading	21 528 / 21 040 kg
Maximum weight (gross)	24 000 kg

For performance of transport-technological operations of RWP transferring at disposal units' site two front fork-lift trucks (with load-carrying capacity of 25 t and 1.5 t) will be used.

3.2.6.3 Technological Process

Three main sets of operation will be carried out during operation of the disposal unit as follows:

1. *Initial campaign* of waste stacking into the disposal unit (start of facility operation).
2. *Regular campaign* of waste stacking into the facility (periodical additional loading of waste into the facility).
3. *Final campaign* of waste stacking into the facility (final closure of the facility).

As it was mentioned before, very low-activity waste is disposed of in half-height ISO containers, or in plastic containers/bales (see section 1.6).

Each campaign mentioned above consists of a specified set of works.

3.2.6.3.1 Initial campaign

Initial campaign of waste stacking into the facility consists of the following main works:

- **Preparation of a detailed plan of activity**, including obtaining license for transportation of waste from regulatory authority. A detailed work plan, list and format of documents for obtaining the license will be developed.
- **Preparation of a scheme for waste disposal at a repository facility.** A 3-D model of the disposal unit will be worked out. The locations for positioning of RAW packages arrived from the buffer storage facility for disposal will be specified.
- **Preparation and stacking** of the material necessary for implementation of the disposal campaign. The necessary amount of materials is delivered and stored on the site. The list, and volume of materials as well as and schemes for their storing will be developed in the Technical design.
- **Initial transportation of containers** onto the site (reserve necessary to start the works). Half-height ISO containers with non-combustible RAW or half-height ISO containers with bales containing combustible RAW will be transported from the buffer storage facility to the site of the *Landfill* disposal facility. A truck-transporter will be used for transportation of containers, which will deliver one container with bales or two containers with non-combustible RAW per trip.

Figure 3.8. Transportation of containers

- **Stacking of 20 feet half-height containers into stack** of the disposal facility. Stacking of the containers will be carried out using the fork-lift truck, with the capacity up to 25 tonnes. The precise positioning of containers in the facility is carefully recorded.

Figure 3.9. Unloading of containers

- **Transportation of the remaining containers** to the site. The remaining containers with SRW are delivered to the site. Containers are unloaded onto the bottom slab of the repository. Containers for formation of the first level may be unloaded directly to their final positioning place.
- **Filling containers with the sorbing/backfilling material.** The space between containers is filled up with sorbing material after the final positioning of the containers. The smoothing of the sorbing/backfilling material is carried out after the backfilling.

Figure 3.10. The containers filling up with sorbing/backfilling material

- **Staking of plastic containers (with ion-exchange resins) / bales.** Plastic containers/bales will be places on the “stairs” formed by containers. Thus, geometry of *Landfill* will be sustained in a cross-section. Bales will be unloaded and will be placed at the site by fork-lift truck with the capacity up to 2 tonnes. They will be stacked by mobile crane.

Figure 3.11. Unloading and stacking of bales and plastic containers

- **Backfilling of empty spaces between containers.** After placing of each level of containers the empty spaces between containers should be backfilled with dry sorbing material thus, providing stability to the structure of disposal unit.

Figure 3.12. Backfilling of empty space between containers

- **Formation of the smoothing layer.** The smoothing will be carried out using bulldozer The waste will be covered and the foundation for transport on the top of repository will be formed.

Figure 3.13. Formation of the smoothing layer

- **Arranging of hydroisolation layer (bentonite).** In order to provide isolation of the disposal facility, a bentonite carpet will be used. The entire surface of the disposal facility will be covered by bentonite carpet. Since it impossible to cover all the surface area of the facility with one piece of the carpet separate pieces of the carpet will be used. The separate pieces will be overlapped and connected using bentonite clay. In order to protect the bentonite carpet against the damage HDPE membrane will be used to cover the carpet.

Figure 3.14. Arranging of bentonite carpet and HDPE membrane

- **Mounting of temporary protective-supporting wall from concrete blocks**. The back of containers stack will be covered using the bentonite material and the temporary protective wall from the concrete blocks. The wall thickness, ensuring the protection against RAW radiological impact on the environment and people, will be evaluated and selected during the preparation of Basic Design.

Figure 3.15. Temporary closure of disposal unit

- **Shaping of soil drainage layer, application of geotextile (cover) material shaping of natural material layer (local soil).** During temporary closure access road will be deformed from the edge of the repository to its end. Trucks with materials for shaping of the estimated surface barriers will travel via this road. For smoothing of the irregularities of the layers of engineering barriers a bulldozer will be necessary. Afterwards above the bentonite level a drainage layer and the upper protective layer of geotextile cover and layer of local soil will be applied.

Figure 3.16. Formation of drainage layer, arranging of geotextile material, formation of layer using natural material

- **Formation of soil and vegetation layer.** The formation of soil and vegetation layer should be carried out during a favourable vegetation period. The work might be implemented in the beginning of summer of the next year.

3.2.6.3.2 Regular Campaign

The difference between the regular campaign of the waste stacking into the facility (periodical additional loading of waste into the facility) and the initial campaign is related to the additional works:

- **Dismantling of the temporary protective-supporting wall formed using concrete blocks;**
- **Removal of the material residues, preparation of the area** for stacking of 20 feet half-height containers.

Disclosure of the disposal unit will be necessary during implementation of the second and the following disposal campaigns. Temporary protective wall formed using concrete blocks as well as bentonite material is removed from the back of the facility.

3.2.6.3.3 Final Campaign

Disposal unit might be closed after the finishing of disposal works. The final campaign of waste stacking into the facility (the closure of the disposal unit) is different in comparison to the regular campaign because of mounting works: the formation of temporary protective-supporting formed using concrete plates should be excluded.

3.3 Waste from Construction and Operation

3.3.1 Construction

At present, there are no constructions on the disposal units' site. There are no underground and over ground communications. During the site preparation works for the *Landfill* facility the site will be cleared off trees, roots, shrubs and construction waste. After deforestation and trees sorting the timber will be used for INPP needs. Worthless shrubs, roots and branches will be burnt up on the site.

The waste generated during construction of the disposal facility will be typical civil industry waste resulting from erection of reinforced concrete structures, mounting of equipment and organizing of working activity (i.e. construction debris, packaging material waste, personnel sanitary waste etc.). No toxic or chemically hazardous waste will be produced. The appropriate measures to minimize waste generation shall be implemented.

The waste produced during construction of the *Landfill* disposal units will be collected in the collection tanks (for liquids) or containers (for solids) located in the site and will be transported off site for appropriate treatment and disposal. No direct discharge of untreated effluents will be allowed. The contractor is obliged to manage all waste material and contaminated ground generated during construction from the construction site and storage areas, and to provide any remediation work required to leave these areas in a neat and clean condition.

The overall quantity of solid waste generated during the construction phase of the disposal units will be estimated in the Technical Design.

During construction phase sanitary waste water will be collected in on-site holding tanks and transported off-site for appropriate treatment and disposal. No direct discharge of untreated liquid waste will be allowed.

No radioactive waste will be generated during the construction phase of the disposal units.

3.3.2 Operation

Solid non-radioactive waste will not be generated during operation period of the *Landfill* facility.

Liquids generated during the operation of the disposal units, the rain water penetrated inside the disposal unit during a disposal campaign as well as sanitary waste water from showers and washstands will be collected in the collecting tanks.

Management of the sanitary waste water as well as surface drainage water is presented in section 3.4.1.

3.4 Potential Impact of the Disposal Units on the Components of the Environment and Impact Mitigation measures

3.4.1 Water

This chapter contains information on hydrological and hydrogeological conditions in the site of the disposal units, characteristics of the underground water and existing surface water bodies (Lake Druksiai), water demand during the proposed economic activity and evaluation of the potential radiological impact on water component of the environment from the proposed economic activity.

3.4.1.1 Hydrological Conditions

A site of the *Landfill* disposal units is distant approximately 2 000 m from southern shore of Lake Druksiai. Lake Druksiai is the largest lake in Lithuania and has its eastern margin in Belarus. The total volume of water is about 369×10^6 m^3 (water level altitude of 141.6 m). The total area of the lake, including nine islands, is 49 km^2 (6.7 km^2 in Belarus, 42.3 km^2 in Lithuania). The greatest depth of the lake is 33.3 m and the average is 7.6 m. The length of the lake is 14.3 km, the maximum width 5.3 km and the perimeter 60.5 km. Some characteristics of the lake are given in Table 3.4 [4-6].

Table 3.4. Main characteristics of Lake Druksiai

Characteristics of Lake Druksiai	Value
The catchment area of Lake Druksiai, km^2	564
Water area of lake, km^2	49
Multiyear flow rate of water from lake, m^3/s	3.19
Multiyear discharge from lake, m^3/year	100.5×10^6
Multiyear quantity of atmospheric precipitation, mm/year	638
Multiyear value of evaporation from water surface, mm/year	600
Normal affluent level of lake, m	141.6
Minimum permissible lake level, m	140.7
Maximal lake level, m	142.3
Regulating volume of lake, m^3	43×10^6
Permissible drop of lake level, m	0.90

The INPP region is drained into watersheds of the rivers Nemunas (Sventoji) and Daugava. The small territory in the northeastern part of the region belongs to the upper course of the Stelmuze stream (Stelmuze–Luksta–Ilukste–Dviete–Daugava). The greater northern part of the region belongs to the Laukesa watershed (Nikajus–Laukesa–Lauce–Daugava). The greatest part of the region belongs to the Dysna watershed, which may be divided into two parts: the upper course of the Dysna and the Druksa watershed with Lake Druksiai (Druksiai lake – the present effluent Prorva – from the Drisveta or Druksa watershed – Dysna) (Table 3.5) [7, 8].

Table 3.5. The main river watersheds of the INPP region

River	Main watershed	The length of river till the INPP region, km	The distance from the mouth, km	Watershed area, km^2	Average height of spring flood, mm
Sventoji	Nemunas	23.0	241.6	218	90
Dysna	Daugava	19.1	154.3	445.2	90
Druksa	Daugava	0.5	44.5	620.9	90
Laukesa	Daugava	2.3	29.1	274.9	95
Stelmuze	Daugava	3.8	7.8	48.3	100

There are a lot of lakes in the INPP region. Their total area of water surface is 48.4 km^2 (without Lake Druksiai). The net density of rivers is 0.3 km/km^2. There are 11 tributaries to Lake Druksiai and one river that flow from it (the Prorva). The main rivers, which are connected to Lake Druksiai are the Ricianka (area of catchment: 156.6 km^2), the Smalva (area of catchment: 88.3 km^2) and the Gulbine (area of catchment: 156.6 km^2) [4-7].

The catchment basin of Lake Druksiai (Figure 3.17) is small (only 564 km^2). The greatest length of the catchment basin (from south-west to north-east) is 40 km; maximum width is 30 km and average 15 km. The lake is characterized by relatively slow water exchange rate. The main outflow is the River Prorva (99 % of all surface outflows) in the south part of the lake. Then, following the hydrographical net lake Druksiai → Prorva → Druksa → Dysna → Daugava → Gulf of Riga (at the Baltic Sea) which makes about 550 km, before the outflows of Lake Druksiai enters the Baltic Sea [7, 8].

The region is dominated by clay, loamy and sandy loam soils, which are responsible for varying water filtration conditions in different parts of the region. The percentage of the forestland of the region also varies widely, the highest being characteristic of Lake Druksiai basin. The average annual precipitation ranges from 590 to 700 mm. Two thirds of this value belongs to warm season. The snow cover accumulates 70–80 mm of precipitation. The summary evaporation from the land is about 500 mm [7].

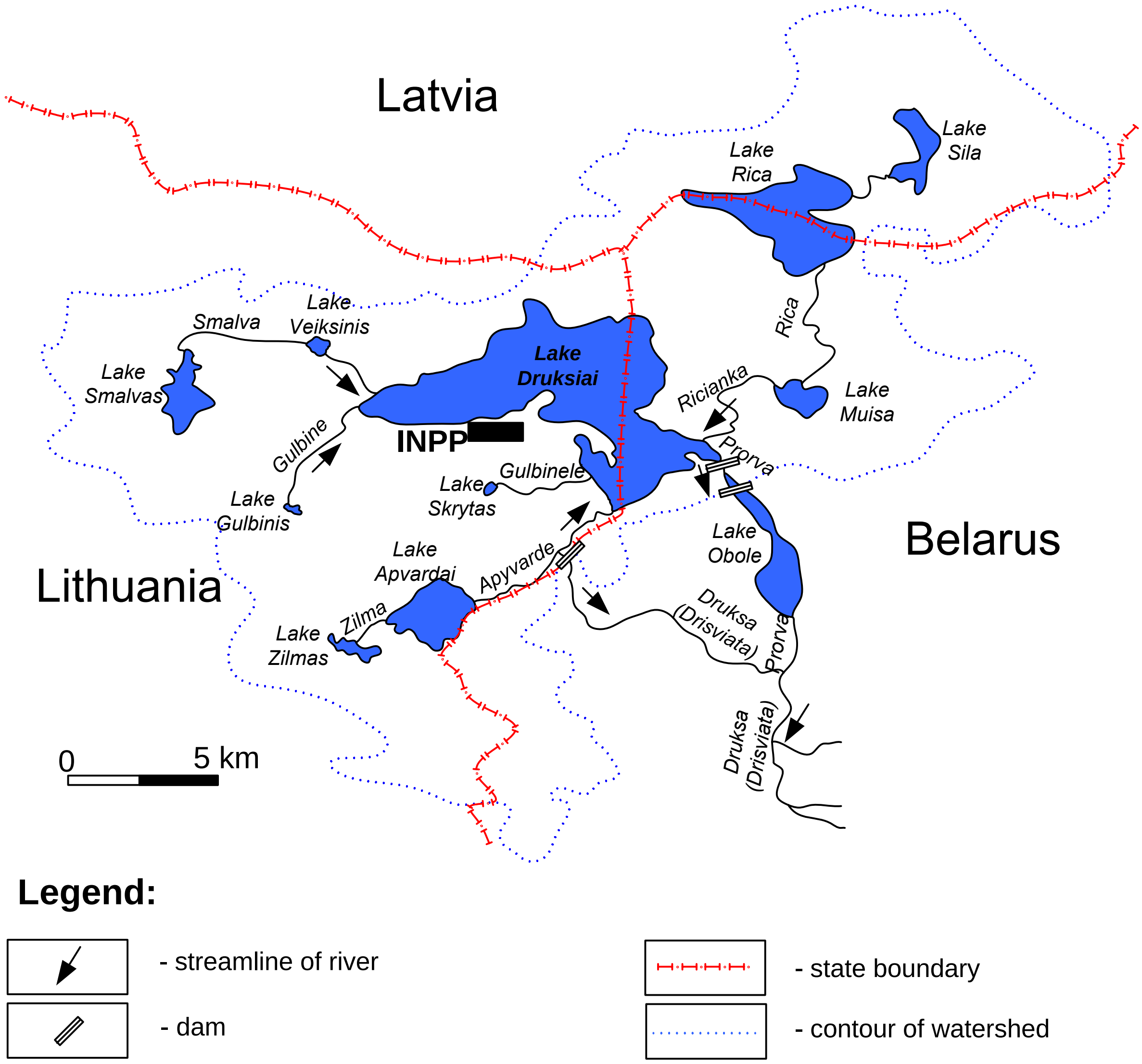


Figure 3.17. Scheme of Lake Druksiai catchment basin

3.4.1.2 Hydrogeological Conditions

The INPP area is located in the recharge area of the eastern part of the Baltic artesian basin. The hydrogeological cross-section data indicates presence of hydrodynamical zones of the active, slower and slow water exchange. The active water exchange zone is separated from the slower water exchange zone by the 86–98 m thick regional Narva aquitard, located at the depth of 165–230 m. It is composed of loam, clay, domerite and clayey dolomite. The lower part of the aquitard contains an 8–10 m thick layer of gypsum-containing breccia. The slower water exchange zone is separated from slow water exchange zone by 170–200 m thick regional Silurian–Ordovican aquitard, located at the depth of 220–297 m [9].

The thickness of the Quaternary aquifer system is 60–260 m (mostly – 85–105 m). This aquifer system includes seven aquifers: the upper shallow unconfined groundwater aquifer and six confined groundwater aquifers located in Baltijos–Grudos, Grudos–Medininku, Medininku–Zemaitijos, Zemaitijos–Dainavos, Dainavos–Dzukijos and Dzukijos intertill fluvioglacial deposits [9].

The shallow aquifer is located in moor deposits (peat), aquaglacial deposits (sand, gravel, cobbles and pebbles), and the fissured upper part of the eroded silt of the glacial till, and the lenses of sand and gravel within the glacial till, here the aquifer is sometimes confined [9].

The aquifers in the intertill deposits are composed of sand, gravel, and in some palaeo-valleys – cobble and pebble deposits. The thicknesses of different aquifers vary from 0.3–2 m to 20–40 m, and in palaeo-valleys – 100 m and higher [9].

The confined aquifers in the intertill deposits are separated from each other by the low permeability till aquitards of sandy silt and silt, with lenses of sand and gravel. The thickness of different aquitards varies from 0.5 to 50–70 m, mostly – from 10–15 to 25–30 m [9].

The Sventoji–Upninkai aquifer system is located under the Quaternary aquifer system in the interlayering deposits of fine and very fine grained sand, weak cemented sandstone, silt and clay. The aquifer system is 80–110 m thick. The water of the Sventoji–Upninkai aquifer system is used for the water supply for Visaginas town and INPP. The site of the disposal units is located outside of the waterworks at a distance of about 40-50 m from the boundary of the third region of its sanitary protection zone. The Sventoji–Upninkai aquifer system is relatively safe from the surface contamination. The system is covered by an isolating layer of more than 25 m and 50–75 % of its section is composed of clay or loam [8, 10].

According to the field investigations [11, 12], the groundwater at the INPP site was found mainly to be at 1.0–4.0 m below the soil surface. Locally the groundwater was found at depths of 0–19 m below the soil surface. The typical feature is that the aquifer can consist of several hydraulically connected layers. The main flow is directed to the north and northeast towards Lake Druksiai.

After the analysis of the data obtained from the engineering-geological researches [12, 13], hydrogeological conditions of the site of the disposal units have been defined following the conceptual hydrogeological cross section crossing both south site and the alternative north site, see Figure 3.18.

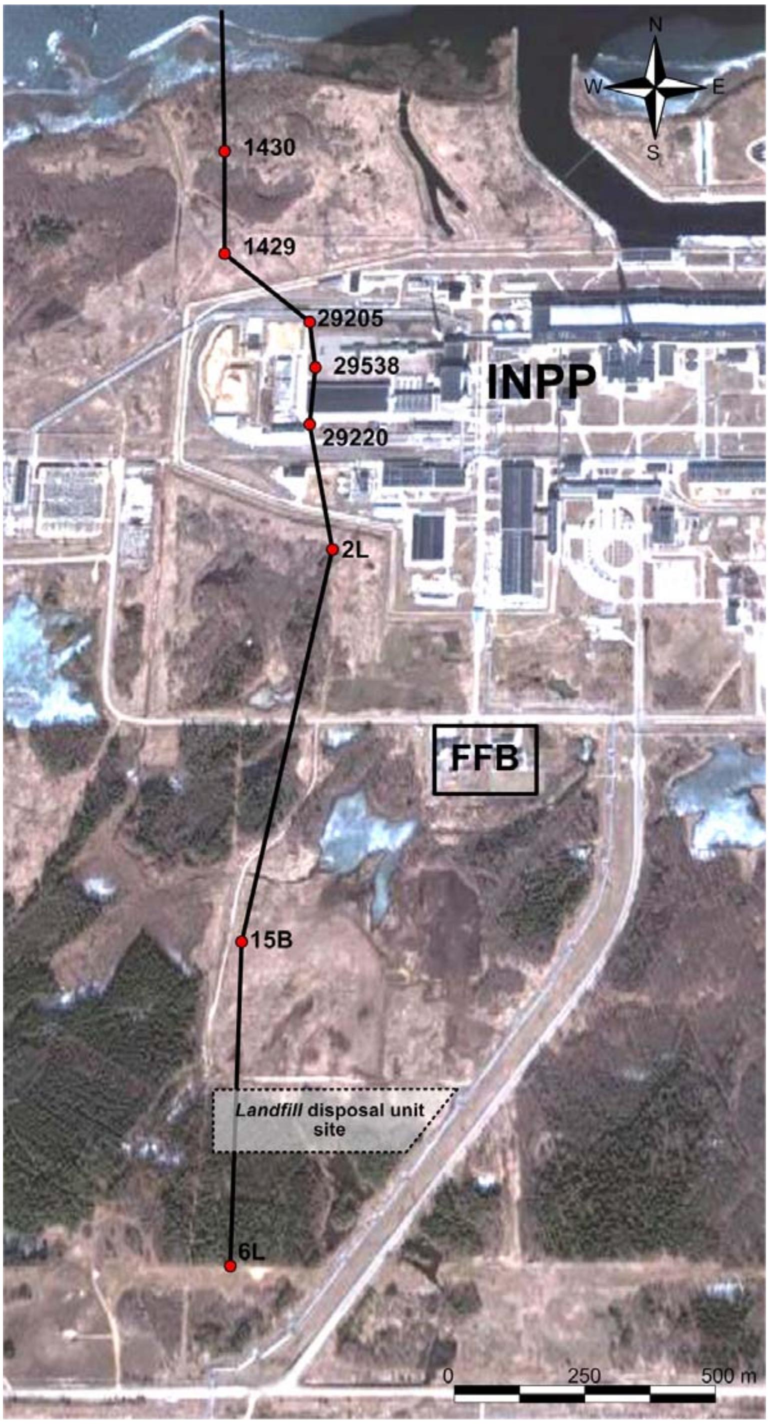


Figure 3.18. Hydrogeological cross section line from the site of the *Landfill* disposal facility to Lake Druksiai. FFB-location of the fire fighting brigade

The boreholes of the depth of 20-30 m and more shallow boreholes have been used for construction of hydrogeology cross-section. The borehole 6L characterizes the south site. The borehole 15B characterizes the planned site for interim storage of SNF. The borehole 2L characterizes the north site. The boreholes Nr. 29220, 29538 and 29205 characterize the Ignalina NPP repository of radioactive waste. The boreholes 1429 and 1430 characterize the territory between Ignalina NPP and Lake Druksiai (Figure 3.19). Data on hydraulic characteristics (averages for the zones) have-been determined by method of extrapolation of data obtained from the indicated boreholes.

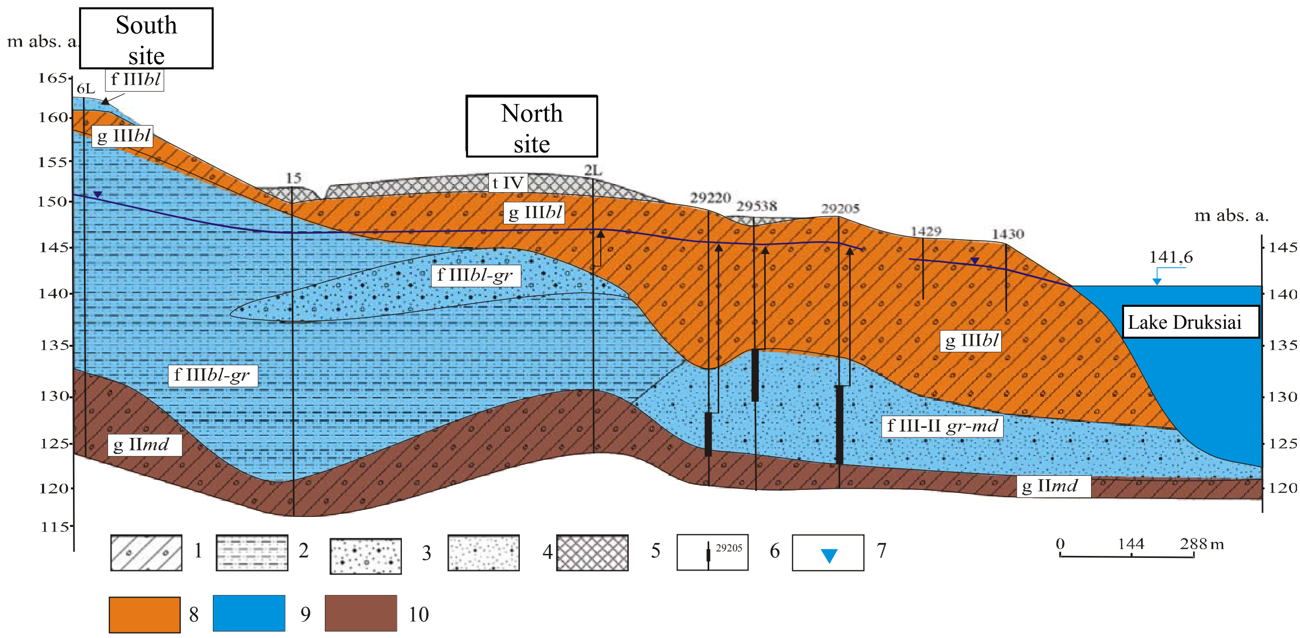


Figure 3.19. Conceptual hydro-geological cross section from the site of the *Landfill* disposal facility to Lake Druksiai

1 – till (loam and sandy loam), 2 – silty sand, 3 – sand with gravel, 4 – varied grained sand, 5 – industrial soils, 6 – borehole and its filter interval, 7 – level of water, 8 – the first little permeable layer, 9 – the unconfined-confined aquifer, 10 – confining layer

Hydrogeology of the north and south sites are rather similar. The surface of the sites composed of glaciofluvial sand with thickness 0.5-1.5 m, except lowermost poorly drained places. Shallow groundwater is accumulating seasonally in the man-maid mounds, in the fractures of till deposits, and sandy interlayer and lens, and drained by local depressions and channels to Lake Druksiai.

Unconfined-confined aquifer through the sandy unsaturated zone interacts with ground surface in many places, so it does not have pressure. In the alternative (north) site the aquifer is covered by sandy and clayey loam of 5-9 m thickness (borehole 2L). The aquifer consists of various type of sand with interlayers of dusty gravel. The thickness of aquifer is about 14-20 m. The solid layer of low permeable till is under altitude of 120-124 m. The water level is in the depth of 5-10 m (altitude – 149.99-147.04 m). The water level of Lake Druksiai is at 141.6 m within long-term period. The relations between the aquifer and local depressions are negligible. The aquifer is drained mainly to Lake Druksiai. Due to good permeability properties of the aquifer and drainage stability of Lake Druksiai the recharge and drainage conditions are rather stable, therefore the variations of water level are negligible for north site as well as for south site. The south site and its environs are in the recharge zone of aquifer. The north site is in the transit zone of aquifer. The discharge zone of the aquifer is Lake Druksiai.

Expected minimum and maximum values of water levels of intertill aquifer are within interval -0.5 to +1.0 m [13].

The altitude of the central lowermost part is approx. at 161 m for the south site and approx. at 152 m for the north site. The altitude of the surface of Lake Druksiai is about at 142 m (see Fig. 4.6). Therefore flooding is impossible in the sites, except of possibility of partial flooding in the central lowermost places (consisted of limnic and bog deposits) of the sites by melting water in spring or by hard rains. However, the water would be drained through the local hydrographical network soon.

According to the survey stage EGG investigations [13], the groundwater level depends on seasons and the level of unconfined groundwater is found at 2.5 to 3 m depth in the most part of the area. In the central depression it could reach 0.5 to 1.5 m depth, and even at the surface. However, shallow groundwater was noticed only in one borehole in the site during EGG investigations [13].

The permeability is greatly variable in the unsaturated zone. The average value of the hydraulic conductivity of the aquiclude separating the unconfined aquifer from the confined aquifer equals approximately to 4×10^{-4} m/day. The base flow from unconfined aquifer is in interval of 2 - 3 $l/(s\times km^2)$ [13].

Groundwater of intertill deposits settled in boreholes, 2.9-11.5 m deep. Hypsometrically, aquifer was partially drained in higher places of relief and water levels settled at 0.3-6.1 m deep, lower than upper boundary of aquitard. Aquifer is unconfined. Regional aquitard was reached with boreholes at 29.3-36.7 m deep (alt. 121.4-127.5 m) [13].

After the analysis of the results of the geological investigations presented in the reports [13, 13] the following basic generalised parameters of the vadose zone and the aquifer have been defined for the site of the *Landfill* disposal units:

- *Unsaturated zone:* 6 m thick, where:
  - 2 m (assumed from the range of values 1-2 m) of sandy layer with bulk density – 1.48 g/cm^3, effective porosity – 0.3 (estimated from the range of values 0.6-0.8 of total porosity), natural humidity – 0.19, hydraulic conductivity – 0.96 m/day;
  - 2 m (assumed from the range of values 0.5-3.0 m) of loamy layer with bulk density – 1.92 g/cm^3, effective porosity – 0.05 (estimated from the range of values 0.3-0.4 of total porosity), natural humidity – 0.29, hydraulic conductivity of natural clayey layer – 0.007 m/day;
  - 2 m (assumed from the range of values 0.3-7.0 m) of sandy layer with bulk density – 1.69 g/cm^3, effective porosity – 0.3 (estimated from the range of values 0.63-0.65 of total porosity), natural humidity – 0.34, hydraulic conductivity – 0.96 m/day;
  - the direction of water flow is vertically down to the aquifer.

- *Unconfined-confined aquifer:* 17 m thick (assumed from the range of values 11-26 m), bulk density – 1.64 g/cm^3, effective porosity – 0.3, the distance to the discharge point (Lake Druksiai) – 2 000 m, the longitudinal dispersion (maximal) – 200 m (10 % of distance to the lake), the hydraulic gradient – 0.006, estimated hydraulic conductivity – 5 m/day, the flow velocity (Darcy) – 0.03 m/day.

A hydrogeodynamic scheme of the site was developed (see Figure 3.20) after additional engineering geological investigations in 2008 [15] and the analysis of obtained data [16].

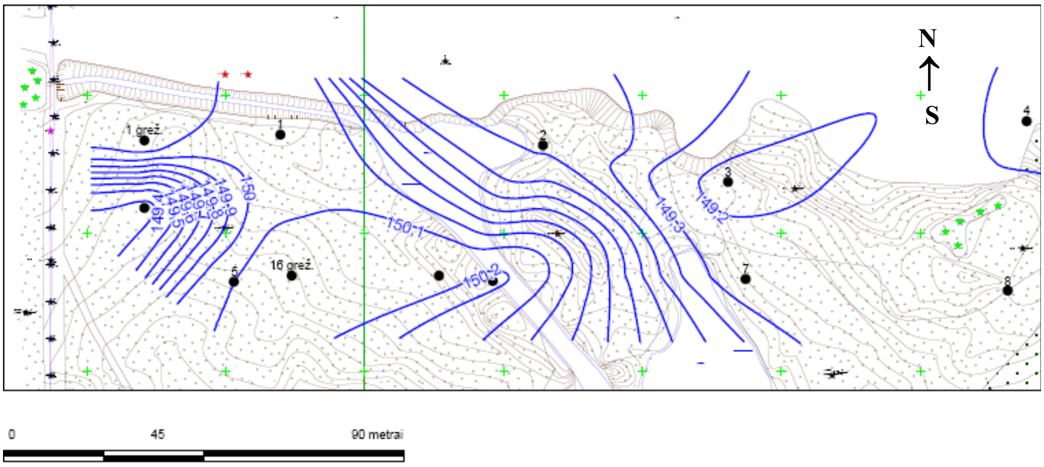


Figure 3.20. Hydrogeodynamic scheme of the ground water [16]

As it can be seen from the presented scheme, the ground water level throughout the site is distributed approximately at the same level, at 149 - 150 m altitude. It is found at a maximum height (less than 1 m from the surface) in the central part of the site, where the site is crossed by a drainage channel at altitude of 151 m.

For installation of the disposal units the surface of the site will be smoothed at 155 m altitude in average, by removing higher parts of the relief and filling falls of the site. An inclination will be formed in the direction of West and North-West towards the drainage channel located close the site.

The surface of the site will be formed of sand–gravel layer of about 1.5– 2 m thick. Its filtration coefficient value will be several times higher than that of the existing surface layer therefore the hydraulic characteristics of the site will be significantly improved.

According to the provisions of STR 2.07.01:2003, during the construction of the disposal units a rainwater collection system will be installed, a drainage network will be designed and installed around the reinforced concrete slab of the disposal units. It will facilitate to take off the groundwater from the site to the drainage channel located next to the site and draining water into Lake Druksiai. The peat layer in the central part of the site will be replaced by gravel-sand layer denser and more stable. There will be equipped a bypass drainage draining the groundwater off-site from the central part of the site.

There will be additionally installed about 0.7 m thick layer of gravel-crushed stone below the reinforced concrete slab of the disposal units excluding the possibility the capillary groundwater to reach the disposal units.

The reinforced concrete slab will be installed about 10-15 cm above the site level with inclination for water runoff into the rainwater collection system.

Due to the above-mentioned design solutions removal of the surface water and rainwater will be ensured during operation and active institutional control period of the disposal units.

After the active institutional control period of the repository the functioning of neither the rainwater collection system nor the drainage network can be guaranteed, therefore it is assumed that the systems malfunction immediately after the active institutional control period of the repository, and the runoff of the groundwater and precipitation from the site will be determined by hydraulic properties of the vadose zone as well as by runoff characteristics of the site.

According to the filtration properties of the vadose zone its permeability (4E-4 m/d or 146 mm/year, see above) is close to the annual precipitation after exclusion of evaporation (about 148 mm/year, see the water balance scheme, Figure 3.22). As seen from the hydrogeological cross section presented in Figure 3.19, the difference between altitudes of the site and Lake Druksiai is about 20 m, or 15 m after the site smoothing (also see the EIA report of the planned site for the surface repository of low and intermediate level RAW, where the altitude of the repository is very close to the altitude of the disposal units of the Landfill repository [57]). As both the surface and ground water flow directions are towards Lake Druksiai in the INPP region. It will constitute favourable conditions for surface water runoff at normal climatic conditions as well as in case of heavy rains.

For the reasons, indicated and described above, neither during the operation of the repository nor within the period after its closure the bottom of the repository will be reached by groundwater.

A conceptual hydrogeological model of the site used for the analysis of potential radionuclide release is presented in Figure 3.21.

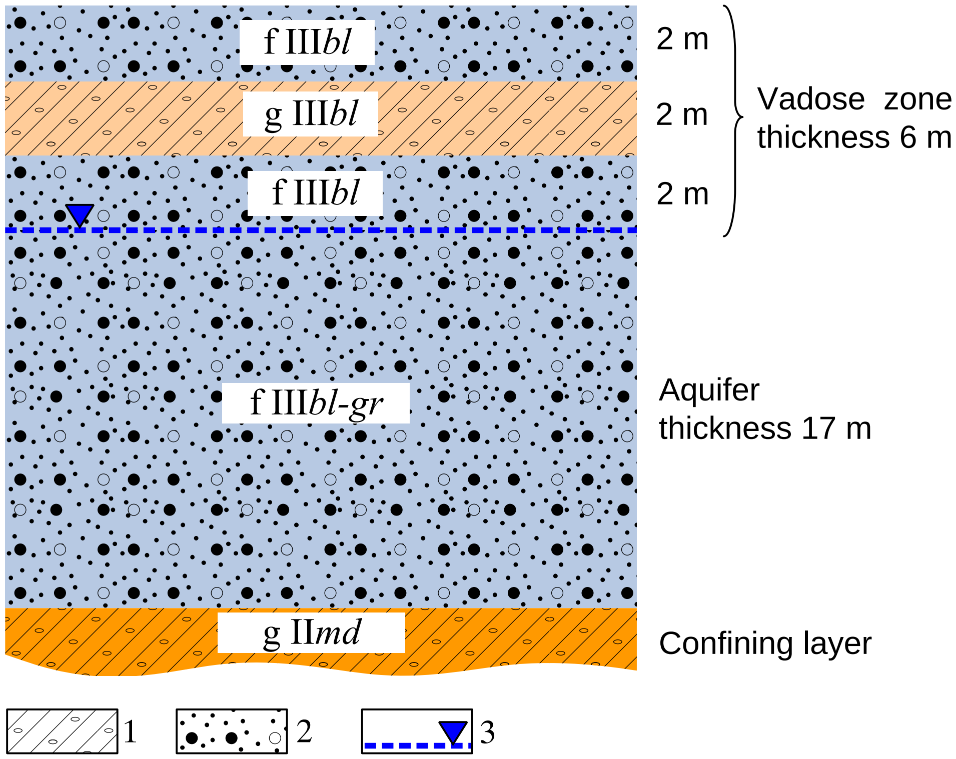


Figure 3.21. Conceptual hydrogeological model used for the analysis of radionuclide release:

1 – clay; 2 – sand; 3 – ground water level

3.4.1.3 Water Balance at INPP Region

The general balance of the water flow developed for the environment of the site of the disposal units is presented on Figure 3.22.

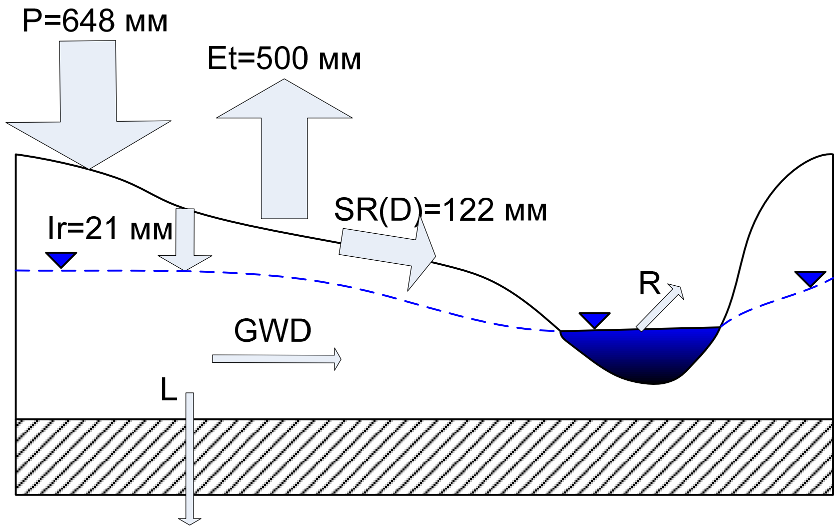


Figure 3.22. Generalized scheme of waters balance for the site region:

P – precipitation, approx. 648 mm, Et – total evaporation – 500 mm, SR(D) – surface run-off (drain) – 122 mm, Ir – infiltration – 21 mm, it consists from two components: i) GWD – flow to the local hydrographical system and, ii) L – flow to unconfined-confined aquifer

3.4.1.4 Planned Water Demand

The planned water demand will be in compliance with the existing equipment and technologies of the INPP. The drinking water is supplied by “Visagino energija”. Existing installations are sufficient to provide necessary drinking water supply. No new boreholes are foreseen. The drinking water is processed at local purification plant of “Visagino energija”. Its quality is constantly monitored. Total water consumption within construction as well as operation period of the disposal units will be estimated during development of the Technical design.

3.4.1.5 Waste Water Management

The generated effluents will be handled in the same way as potential radioactive waste. Measurement of chemical and radiological parameters of the collected effluents will be carried out. After the assessment of the measurement results, the collected liquids will be either pumped into LRW tank for transportation to INPP LRW treatment facility or discharged into the waste water drainage system. The effluents will be discharged into the waste water drainage system following the order established by legal acts of Republic of Lithuania [2] after the permission for discharges of radionuclides to the environment is obtained and under the condition that the limiting values indicated in the permission will not be exceeded. The specific procedures (including the assessment of the measurement results of the effluents) as well as limiting values of the activities will be prepared according to the provisions of normative documents in force before putting the object in commissioning.

The management of liquid radioactive waste is described in the section 3.3 “Waste”.

Only the non-radioactive liquid waste can be released to the sanitary-technological waste water system. The sanitary waste water is transferred to State Enterprise “Visagino energija” under an agreement.

The INPP surface water drainage system meets the requirements of the regulation [17].

3.4.1.6 Potential Impact

There will be no uncontrolled waterborne releases into the environment under normal operation conditions of the disposal units. The bottom slab, technological systems and its components used for collection and storage of potentially radioactive effluents will be designed to isolate them fully against any potential interaction with environmental water.

Liquids generated during operation phase, rainwater occurred during disposal campaign as well as sanitary waste water from the showers and sinks will be collected in on-site collecting tank.

Flooding by water rise in Lake Druksiai is not expected. Flooding of repository by surface water will be prevented by the drainage system that will be installed in the site of the disposal units.

The site of the disposal units is outside the boundaries of the sectors 3a and 3b of the third sanitary protection zone of waterworks [10] in accordance with hygiene standard HN 44:2006 [18]. The water is extracted from Sventoji – Upininkai aquifer complex of upper and middle Devonian formations. A direction of groundwater in the site is opposite in comparison to the SPZ boundaries of waterworks. Therefore the operation of the disposal units will not affect waterworks for Visaginas town.

During the operation of the Landfill facility waterborne radionuclide releases into the environment could potentially occur in case of radionuclides washing off the contaminated container surface during rain in the course of the disposal campaign. It should be pointed out that in the case, first, the waste activity should be about 1/15 of the total waste activity (see Table 1.13) and, second, since the surface contamination of the containers is low (not more than 4 Bq/cm^2), then the activity of radionuclides washed off the surface of waste packages being disposed during one campaign (equals to the number of packages placed in the buffer storage) would be about 10 thousand times below the overall activity of RAW being disposed during single disposal campaign. Thus, after summing up it can be stated that the radionuclide activity, potentially charged into Lake Druksiai during the repository operation period, should be about 100 thousand times below the total activity of the waste intended for disposal at the Landfill disposal units, analysed in case of radionuclide migration from the disposal units to the lake for the barrier degradation scenario. The calculations revealed that the annual dose to the member of the critical group of the population consuming water from the lake would be several thousand times lower than the value of the dose constraint 0.2 mSv per year, therefore it should be a negligible value in case of radionuclide washout off the RAW packages. Thus during the operation period of the Landfill facility no impact on Lake Druksiai is expected, and it is not further analysed.

Impacts either conventional or radiological on the water component of the environment under normal operation conditions of the disposal units will be insignificant.

However, potential impact on the water component is possible after the active institutional control period of *Landfill* disposal units since in case of barriers damage no repair activities shall be performed. Therefore further the estimation of possible radiological impact on the water component of the environment during the period after closure of the disposal units is considered.

3.4.1.6.1 Analysis methodology

The assessment of the radionuclide transport through the components of the disposal system by water pathway and the potential radiological impact on the environment has been performed following ISAM methodology [19], recommended by IAEA for the safety assessments of near surface disposal facilities. The main steps included in the ISAM are as follows:

1. The specification of the assessment context: identification of analysis purpose, safety criteria, characteristic timeframes and other parameters necessary for the specific analysis tasks.

2. Description of the disposal system: the disposal system is considered to consist of the radioactive waste, engineering barriers, pathways to geosphere and biosphere. The description of the disposal system should be undertaken with the assessment context.

3. Development of scenarios and conceptual models: scenarios and conceptual models should be developed in correspondence with the processes taking place in the components (repository, geosphere, biosphere) of the disposal system.

4. Formulation of mathematical model and calculations: conceptual models for each scenario are expressed in mathematical form, initial and boundary conditions are set for the modelling. Calculations are performed using computer tools as well as applying analytical and numerical techniques.

5. Analysis of results: interpretation of the results as well as the uncertainty analysis is carried out.

3.4.1.6.2 Assessment context

The purpose of the analysis is to assess the impact on the environment as well as on the population due to potential radionuclide migration from the disposal units regarding the long-term safety.

The physical-chemical properties of the radioactive waste as well as conceptual design of the disposal facility and geological-hydrogeological peculiarities of the candidate are taken into account in the analysis.

Maximum values of the exposure dose to a member of the critical group of the public obtained after the assessments of the repository safety are compared to the effective dose constraint, 0.2 mSv/year, defined for the members of public during operation and decommissioning period of nuclear facilities [20].

When analyzing long-term safety of the disposal facility it is necessary to take into account both the existing as well as planned nuclear facilities in the vicinity of the facility (INPP site) that could contribute to the value of the annual effective dose received by a member of the analyzed critical group.

The analyzed period covers a time period of institutional control (30 years of active control, and 70 years of passive control) and the time period following the period of institutional control while the maximum impact on a member of the critical group of the population is possible.

The potential radionuclide migration is analyzed in the characteristic points of the disposal system as follows:

- In the point of activity discharge into the drainage channel;
- In the point of activity discharge into the aquifer at the distance of 50 m from the edge of the disposal facility (into the well);
- In the point of activity discharge into the aquifer at the distance of 2 000 m from the edge of the disposal facility (into Lake Druksiai).

3.4.1.6.3 Description of the disposal system

A description of the reference design of the *Landfill* disposal facility is provided in section 3.2. The characteristics of radioactive waste intended to dispose of in the *Landfill* facility are presented in section 1.6. This section provides a summary of parameters of the disposal system components (RAW, engineered barriers, vadose zone, aquifer and biosphere) necessary for the analysis.

3.4.1.6.3.1 <u>Waste parameters</u>

A summary of physical (half-life periods) and chemical (sorption coefficients) parameters of the radionuclides present in the waste intended to dispose of in the *Landfill* disposal facility as well as considered in the safety analysis are presented in Table 3.6. It should be pointed out that values of sorption coefficients have been selected from three references, preferring more conservative (smaller) values.

Table 3.6. Physical and chemical parameters of radionuclides, considered in the analysis of the potential radionuclide migration

Radio nuclide	Half-life, years	Sorption coefficient (K_d) in the material (zone), m^3/kg[1)]				
		Sorbing/bacfilling material (Waste zone)	Concrete (bottom slab)	Sand/ gravel (foundation)	Clay (vadose zone)	Sand (Vadose zone/ aquifer)
^{14}C	5.73×10^{3}	100	200	0	1	5
^{54}Mn	8.56×10^{-1}	49	100	49	180	49
^{55}Fe	2.7	220	100	5	160	5
^{59}Ni	7.54×10^{4}	400	40	10	600	400
^{60}Co	5.27	60	40	10	500	15
^{63}Ni	9.60×10^{1}	400	40	10	600	400
^{65}Zn	6.68×10^{-1}	200	1	200	2 400	200
^{90}Sr	2.91×10^{1}	13	1	0,1	100	15
^{93m}Nb	1.36×10^{1}	160	500	500	900	160
^{94}Nb	2.03×10^{4}	160	500	500	900	160
^{93}Zr	1.53×10^{6}	600	500	500	800	5
^{99}Tc	2.13×10^{5}	0,1	500	300	1	0.1
^{110m}Ag	6.84×10^{-1}	90	1	10	180	90
^{129}I	1.57×10^{7}	1	3	0	1	1
^{134}Cs	2.06	270	1	10	1 800	270
^{137}Cs	3.00×10^{1}	270	1	10	1 800	270
^{234}U	2.45×10^{5}	33	5 000	1 000	46	33
^{235}U	7.04×10^{8}	33	5 000	1 000	46	33
^{238}U	4.47×10^{9}	33	5 000	1 000	46	33
^{237}Np	2.14×10^{6}	4.1	5 000	1 000	55	4.1
^{238}Pu	8.77×10^{1}	540	5 000	1 000	4 900	340
^{239}Pu	2.41×10^{4}	540	5 000	1 000	4 900	340
^{240}Pu	6.54×10^{3}	540	5 000	1 000	4 900	340
^{241}Pu	1.44×10^{1}	540	5 000	1 000	4 900	340
^{241}Am	4.32×10^{2}	2 000	1 000	1 000	7 600	340
^{244}Cm	1.81×10^{1}	1 000	1 000	1 000	5 400	4 000

[1)] Values from documents [22 - 24].

3.4.1.6.3.2 Parameters of the Engineering Barriers of the *Landfill* Facility

A summary of parameters of engineered barriers of the *Landfill* disposal facility is presented in Table 3.7. The parameters are used for the assessment of potential radionuclide migration.

Table 3.7. Parameters of engineered barriers of *Landfill* disposal units

Title	Material [a)]	Thickness, m	Bulk density, kg/m^3	Effective porosity	Hydraulic conductivity, m/s	Effective diffusion coefficient , m^2/s [e)]
Top layer (N/A)	*Natural surroundings*	1.0 [a)]				
Drainage layer (N/A)	*Gravels*	0.5 [a)]	2 000 [c)]			
Bentonite (N/A)	*e.g., type RAWMAT P*	0.005 [b)]			<< 1×10^{-10} [b)]	
Smoothing/bacfilling layer	*Sand/gravel*	0.5 [a)]	1 500 [c)]	0.3 [c)]	1×10^{-6} [c)]	1×10^{-10}
Sorbing material	*Sand*	5.2 [f)]	500 [c)]	0.4 [c)]	1×10^{-6} [c)]	1×10^{-10}
Bottom of facility	*Concrete*	0.5 [a)]	2 300 [d)]	0.15 [d)]	1×10^{-9} [c)]	1×10^{-11}
Foundation	*Gravel*	0.3 [a)]	2 000 [d)]	0.4 [d)]	1×10^{-6} [c)]	1×10^{-10}
	Sand	0.3 [a)]	2 000 [d)]	0.4 [d)]	5×10^{-6} [c)]	1×10^{-10}

[a)] Values from document [25];
[b)] Values from [26];
[c)] Values from document [22];
[d)] Values from document [27];
[e)] Estimated and selected as negligible component of radionuclide transport;
[f)] Estimated assuming that containers with RAW will be stacked in four levels in the disposal facility;
N/A Not taken into account for radionuclide migration assessment.

3.4.1.6.3.3 Geosphere parameters

A summary of the parameters of the vadose zone necessary for the analysis of potential radionuclide migration is presented in Table 3.8 on the basis of the data submitted in section 3.4.1.2. The value of effective diffusion coefficient for the vadose zone is set to 10^{-10} m^2/s, as the process of diffusion does not prevail in radionuclide transport through the geosphere.

Table 3.8. Generalized values of the vadose zone characteristics of the site of the disposal units

Prevailing material in the layer	Thickness, m	Bulk density, kg/m^3	Effective porosity	Hydraulic conductivity m^3/(m$^2\times$s)	Effective diffusion coefficient, m^2/s
Sand	2	1 480	0.30	1.1×10^{-5}	1×10^{-10}
Clay	2	1 920	0.05	8.1×10^{-8}	1×10^{-10}
Sand	2	1 690	0.30	1.1×10^{-5}	1×10^{-10}

The characteristics of the aquifer necessary to the radionuclide migration analysis are presented in Table 3.9 based on data provided in section 3.4.1.2.

Table 3.9. Generalized values of the aquifer characteristics (within distance from the site of the disposal units to Lake Druksiai)

Prevailing material in the layer	Thickness, m	Bulk density, kg/m^3	Effective porosity	Flow rate, m/year	Dispersivity, M
Sand	17	1 640	0.30	36	The value is equal to 10% of the distance from to release point the discharge point

3.4.1.6.4 Processes Taken Into Account in the Analysis

Release of radionuclides from the disposal units into aquatic environment is possible due to waste leaching. The processes included in the leaching scenario are as follows:

1) Water is penetrating through engineered barriers due to infiltration of precipitation;

2) It is assumed that radionuclides from the waste packages pass into water instantly, i.e. the mechanisms of radionuclide release from RAW are not considered (the conservative approach);

3) It is assumed that radionuclides dissolve in pore water of sorbing/backfilling material instantly;

4) The chemical retention of radionuclides due to sorption is considered for engineered barriers as well as for components of geosphere (the assumed values of sorption coefficients see in Table 3.6);

5) It is assumed that advection-diffusion is prevailing in the transport of radionuclides through repository;

6) The radionuclides out of the bottom of facility are transported to the geosphere components (unsaturated zone and aquifer). Geological and hydrogeological characteristics of the site (see section 3.4.1.2) show that advection-dispersion is prevailing in the transport through the geosphere. It is assumed that characteristics of geology and hydrogeology remain stable within analysed period of time.

3.4.1.6.5 Scenarios of Radionuclide Migration

Following the ISAM methodology [19], the formal procedure could be applied for scenarios development. According to the procedure the disposal system is split into components, then possible states of each component are defined and finally scenarios are developed after evaluation of potential states and relationships between components.

Considering three possible states of engineered barriers: a) intact, b) even degradation and c) completely degraded, two cases of *Landfill* evolution (i.e. alteration of indicated states as well as flow rate through the repository) are investigated:

Normal evolution scenario of the disposal facility

The engineered barriers will be intact and absolutely prevent the infiltration of water into disposal facility within period of 30 years of active institutional control. Due to hydraulic conductivity of bentonite layer the infiltration rate through the repository is 5 l/m^2 per year. Flow velocity will suddenly increase by factor of 10 (up to 50 l/m^2 per year) just after active institutional control period (30 years) and further will gradually increase to maximum value that equals to *precipitation-gross evaporation* = 648 – 500 ~ 200 mm per year (conservative value, see Figure 3.22 in section 3.4.1.3) within next 70 years of passive institutional control period as the engineered barriers should evenly degrade to complete degradation state. Therefore, after overall institutional control period (100 years) infiltration rate equals to 200 l/m^2 per year.

Engineering barrier degradation scenario

The engineered barriers will be intact and absolutely prevent the infiltration of water into disposal facility within period of 30 years of active institutional control. Due to hydraulic conductivity of bentonite layer the infiltration rate through the repository is 5 l/m^2 per year. The engineered barriers will be suddenly completely degraded just after institutional control period (30 years) and flow velocity will increase to maximum value that equals to approx. 200 l/m^2 per year.

A summary of analyzed cases of engineering barriers evolution analyzed in the assessment of potential impact of the *Landfill* facility on the aquatic environment is presented in Table 3.10.

Table 3.10. The waste leaching scenario for two cases of possible evolution of the engineering barriers of the *Landfill* facility

Duration after closure of the disposal facility	**State of engineered barriers**	**Velocity of water flow through disposal facility, l/(m^2×year)**
Normal evolution scenario		
30 years (period of the active institutional control)	Intact	5
70 years (period of the passive institutional control)	Even degradation	Gradually increasing from 50 to 200
After 100 years (after period of institutional control)	Completely degraded	200
Barrier degradation scenario		
30 years (period of the active institutional control)	Intact	5
After period of the active institutional control	Completely degraded	200

Three alternative directions of radionuclide transport by water pathway through the geosphere components are considered for estimation of the environmental impact resulted from the potential radionuclide release from the disposal units:

1. Flow is directed through vadose zone downwards to the aquifer and then released radionuclides are transported to the well, Figure 3.23. Well is located at the distance of 50 from the edge of the facility. It is estimated that 5% of total amount of the water per year flowing through the aquifer should be pumped for daily living needs (irrigation, cows watering, drinking) of local farming group;

2. Flow is directed to the local drainage network (top layer of vadose zone, 2 m thickness) just below bottom of the disposal facility and released contaminants are further transported to the discharge point, i.e. Lake Druksiai, Figure 3.24. The lake is distant approx. 2 000 m from the *Landfill* facility. Water from the lake is used for daily living needs (irrigation, cows watering) of local farming group;

3. Flow is directed to the local drainage network (top layer of vadose zone, 2 m thickness) just below bottom of the disposal facility and then it is drained up to the drainage channel, Figure 3.25. Water flow rate in the vadose zone is equated to approximate amount of water, i.e., 200 mm/year (~6.34 E-7 mm s), remaining after subtraction evaporation from the annual precipitation (Figure 3.21). As presented in Table 3.8, hydraulic conductivity of the upper sand layer of the vadose zone is about 100 times greater. The drainage channel is located at the distance of 50 m from the edge of the facility. It is estimated that amount of water per year flowing through the unsaturated zone is factor of 10 less than amount necessary for needs (irrigation, cows watering) of local farming group. Therefore a dilution factor of 10 has been assumed considering contaminant concentration in the water taken from drainage channel.

3.4.1.6.6 Conceptual Model

The conceptual models for each case of an alternative direction of radionuclide transport by water pathway through the geosphere components (see the section above) are presented in Figure 3.23-Figure 3.25. The basic components of the disposal system under consideration, through which the radionuclide release goes on, as well as the processes prevailing in each component that stipulate radionuclide transfer as well as their environmental impact (up to the recipient, i.e., the member of the critical group of population) are included in the models presented below.

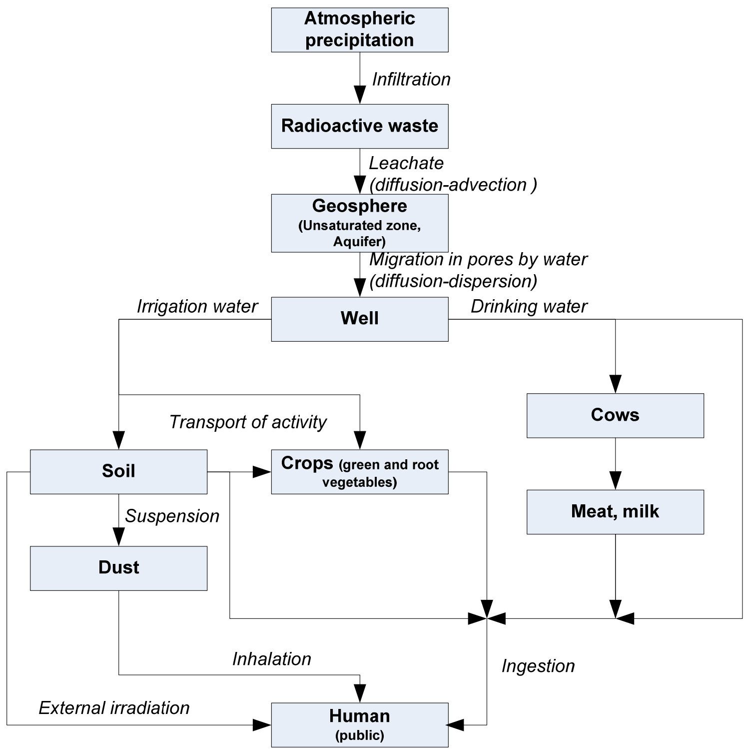


Figure 3.23. Conceptual model for leaching scenario with respect to the direction of radionuclide transport through vadose zone and aquifer to the well

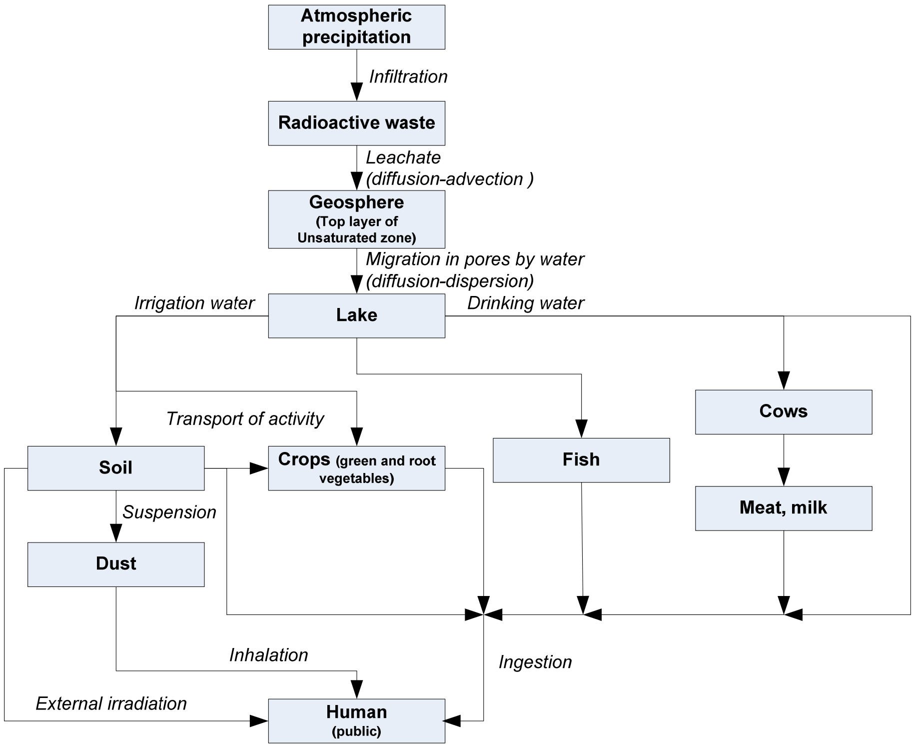


Figure 3.24. Conceptual model for leaching scenario with respect to the direction of radionuclide transport through top layer of unsaturated zone to the lake

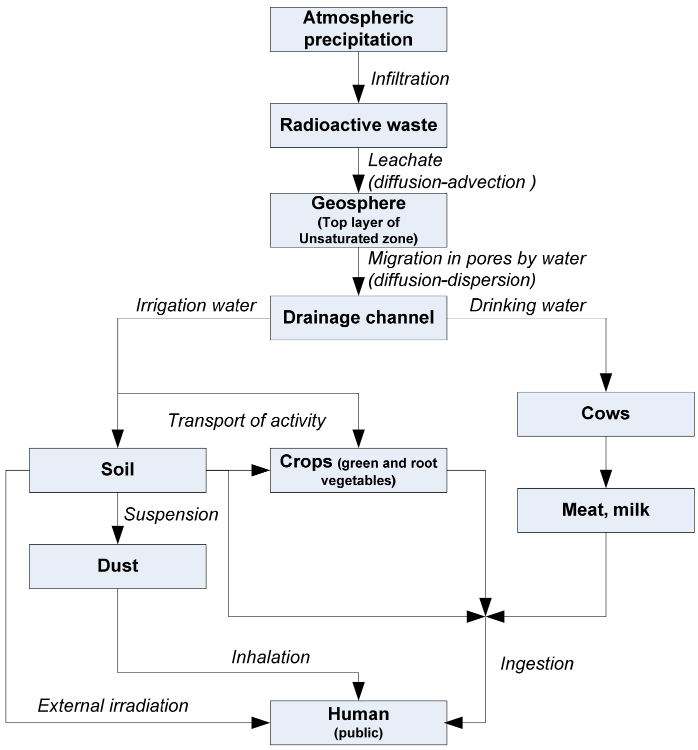


Figure 3.25. Conceptual model for leaching scenario with respect to the direction of radionuclide transport through top layer of unsaturated zone to the drainage channel

3.4.1.6.7 Mathematical models and computer programs

A one-dimensional diffusion equation is solved, considering processes of diffusive – advective transport, hydrodynamic dispersion, sorption as well as radioactive decay when modelling radionuclide transport through the components of the disposal system (disposal facility, vadose zone, aquifer) in case of the leaching scenario for the period after the facility closure. The problem is expressed by the following equation [28]:

$$\frac{\partial}{\partial t}\left(R\,\theta\,C\right)=\frac{\partial}{\partial x}\left(\theta D\frac{\partial C}{\partial x}\right)-\frac{\partial}{\partial x}\left(qC\right)-\lambda_d\theta RC\ , \qquad (3.1)$$

where

C – activity concentration of a radionuclide in pore water, Bq/m^3;
θ – effective porosity;
D – diffusion-dispersion coefficient, m^2/s;
λ_d – decay constant, $year^{-1}$;
R – retention (delay) factor;
q – rate of water flow, m/s;
t – time, s;
x – distance in the direction of water flow, m.

Coefficients of porosity, diffusion, hydrodynamic dispersion and sorption are constant, i.e. their values do not vary during the analyzed period.

The modelling of radionuclide migration through the components of the disposal system (disposal facility, vadose zone, aquifer) is carried out using the program *DUST-MS* [28].

3.4.1.6.8 Calculation results

Estimations of the maximum activity values for the considered alternatives of the direction of possible radionuclide transport from the disposal units (through the aquifer to the well or through the vadose zone to the drainage channel) to the discharge points in case of normal evolution of the disposal facility as well as in case of sudden degradation of the engineering barriers are presented in Table 3.11. A description of the disposal system including the characteristics of RAW intended for the disposal is presented in section 3.4.1.6.3.

Table 3.11. Maximum activity values in points of their discharge in case of normal evolution of the disposal facility and in case of sudden degradation of the engineering barriers

Radio nuclide	**Half-life, Years**	**Maximum activity values, Bq/year**					**Activity limits, authorised to be released into water environment by the INPP [29]**
		Normal evolution scenario		**Barrier degradation scenario**			
		Well	**Channel**	**Well**	**Channel**	**Lake** 1)	
^{14}C	5.73×10^3	2.33E+07	6.08E+06	2.38E+07	6.84E+06	8.69E+04	
^{54}Mn	8.56×10^{-1}						4.374E+09
^{55}Fe	2.7						
^{59}Ni	7.54×10^4	2.97E+03	1.49E+03	2.97E+03	1.50E+03	1.37E-02	
^{60}Co	5.27						3.704E+10

Radio nuclide	Half-life, Years	Maximum activity values, Bq/year					Activity limits, authorised to be released into water environment by the INPP [29]
		Normal evolution scenario		Barrier degradation scenario			
		Well	Channel	Well	Channel	Lake 1)	
^{63}*Ni*	9.60×10^{1}						
^{65}*Zn*	6.68×10^{-1}						
^{90}*Sr*	2.91×10^{1}	1.24E-25	2.29E-18	4.28E-25	6.81E-18		7.935E+08
^{93m}*Nb*	1.36×10^{1}						
^{94}*Nb*	2.03×10^{4}	1.18E+05	4.48E+05	1.18E+05	4.48E+05	2.28E+00	
^{93}*Zr*	1.53×10^{6}	1.16E+02	7.40E+04	1.16E+02	7.39E+04	1.20E+00	6.70E+08
^{99}*Tc*	2.13×10^{5}	1.44E+03	3.64E+05	1.52E+03	3.84E+05	6.79E+00	
^{110m}*Ag*	6.84×10^{-1}						
^{129}*I*	1.57×10^{7}	4.31E+06	4.70E+06	4.30E+06	4.73E+06	2.44E+03	
^{134}*Cs*	2.06						2.557E+08
^{137}*Cs*	3.00×10^{1}						2.08E+10
^{234}*U*	2.45×10^{5}	8.28E+00	1.12E+03	8.28E+00	1.12E+03	3.37E-02	
^{235}*U*	7.04×10^{8}	1.91E-01	2.74E+01	1.91E-01	2.74E+01	8.15E-04	
^{238}*U*	4.47×10^{9}	2.86E+00	4.09E+02	2.86E+00	5.01E+02	1.22E-02	
^{237}*Np*	2.14×10^{6}	1.22E+00	2.07E+02	1.24E+00	2.10E+02	9.97E-03	
^{238}*Pu*	8.77×10^{1}						
^{239}*Pu*	2.41×10^{4}	1.19E+00	1.58E+02	1.19E+00	1.59E+02	2.70E-06	
^{240}*Pu*	6.54×10^{3}	6.86E-08	6.47E-04	6.88E-08	6.50E-04	1.03E-16	
^{241}*Pu*	1.44×10^{1}						
^{241}*Am*	4.32×10^{2}				2.67E-37		
^{244}*Cm*	1.81×10^{1}						
	Total:	**2.78E+07**	**1.17E+07**	**2.83E+07**	**1.25E+07**	**8.94E+04**	**8.811E+12**

1) The radionuclide transport to the lake has been analysed only for case of sudden degradation of the engineering barriers of the disposal facility (i.e. more conservative case).

As it is demonstrated in Table 3.11, the analyzed discharge points are reached mainly by long-lived radionuclides. It doesn't matter when the engineering barriers degrade, in 30 years, as assumed in case of sudden degradation, or in 100 years in case of the normal evolution scenario considering the long-lived radionuclides since their half-life is by factor of tens and hundreds longer in comparison to the barrier degradation period. Such radionuclides as ^{54}*Mn*, ^{55}*Fe*, ^{60}*Co*, ^{63}*Ni*, ^{65}*Zn*, ^{90}*Sr*, ^{93m}*Nb*, ^{110m}*Ag*, ^{134}*Cs*, ^{137}*Cs*, ^{238}*Pu*, ^{241}*Pu*, ^{241}*Am*, ^{244}*Cm*, would not reach the analyzed discharge points due to the sorption processes in the vadose zone and the aquifer, as well as due to the radioactive decay. Activity values of radionuclides, not shown in the table, are insignificant ($<10E^{-10}$ Bq per year). In comparison with activity limits, authorized to be released into the water environment by the INPP [25], it can be seen that activity values that could get into the environmental water from the *Landfill* disposal units should be insignificant (below the established limits by several orders of magnitude).

3.4.1.7 Impact Mitigation Measures

It is estimated that activity of the potential radionuclide releases into the water component of the environment should be negligible; therefore no specific radiological impact mitigation measures are foreseen.

3.4.2 Environmental Air (Atmosphere)

An overview of the climate conditions in the region, potential pollution resulted from the proposed economical activity as well as the analysis of the potential impact on environmental air are presented in the section.

3.4.2.1 Climatic and Meteorological Conditions

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 INPP 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 INPP area is characterized by bigger 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 [5].

<u>Precipitation and snow blanket</u>

Monthly average precipitation in the region of the disposal units is presented Table 3.12.

Table 3.12. Monthly average precipitation (mm) in the region of the disposal units [30–32]

Meteorological station and observation period	**Month(s)**												**Total for months**		
	01	**02**		**01**	**02**		**01**	**02**		**01**	**02**		**01**	**02**	
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	652	216	436

There are not significant differences in data of precipitation amount for the periods 2000–2007 and 1988–1999 at the INPP region.

Average annual amount of precipitation at the disposal units area is 648 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).

Wind

Western and southern winds dominate. The strongest winds blow from West and South-East. 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 average of 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 [5].

Prevailing wind directions at the disposal units area based on local wind measurements [31, 33] are presented in Figure 3.26.

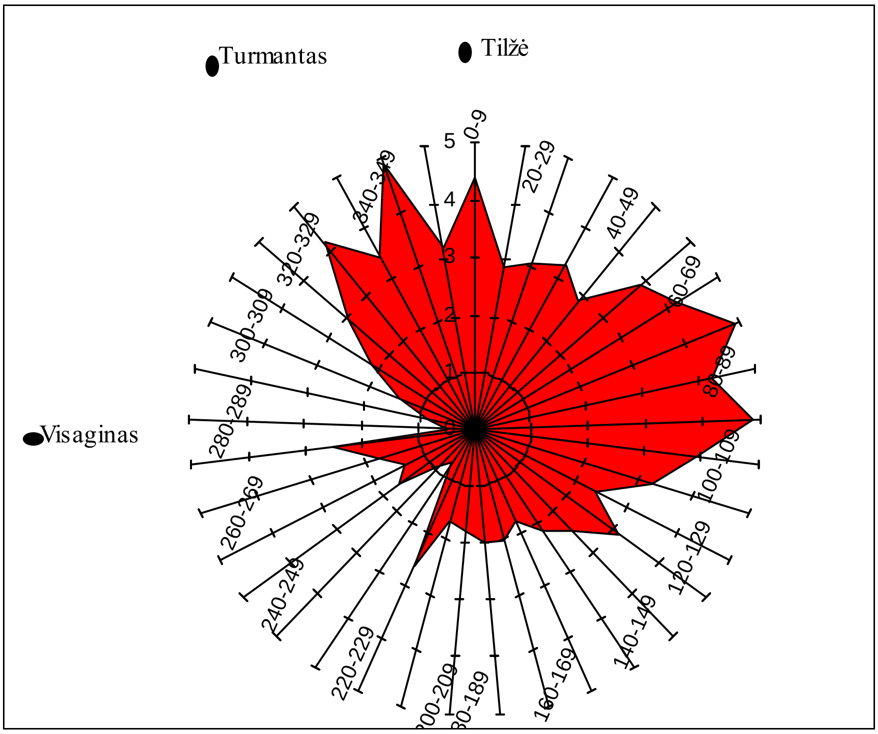


Figure 3.26. Prevailing wind directions at the INPP region (wind direction – off INPP)

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 the reliability coefficient 1.4, calculated value of uniform wind load is 0.42 kPa and extreme wind load (with frequency 1 per 10 000 years) is 1.05 kPa with the reliability overloading coefficient 2.5 [34].

Temperature

Monthly average temperatures in the region of the disposal units are given in Table 3.13.

Table 3.13. Monthly average temperatures (°C) for the disposal units region [32, 33]

Meteorological station and observation period	Month												Average 01 - 12
	01	02	03	04	05	06	07	08	09	10	11	12	
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

The last decade of the 20th century (1988–1999) monthly averaged air temperature variation in the warm season (April–October) and the beginning of the cold season (November–December) does not differ from long-term (1961–1990) observations. However the second half of the cold season (January–March) during the last decade was warmer and the average air temperature for this period is higher by 4.3–2.3 °C. The average monthly temperatures on the period 2000–2007 seem to indicate a slight increase from March to December. The seven successive warm winters (1988/1989 to 1994/1995) are identified as a unique climatic phenomenon for Lithuania.

Average calculated air temperatures of the coldest five-day period are –27 ºC. Absolute maximum of recorded temperature is 37.5 ºC and absolute minimum is –42.9 ºC. Absolute maximum of calculated temperature with a frequency of 1 in 10 000 years is 40.5 ºC and absolute minimum of calculated temperature with a frequency of 1 in 10 000 years is –44.4 ºC [34].

3.4.2.2 Potential Non-Radiological Impact

3.4.2.2.1 Potential Sources of the Emission of Non-Radioactive Contaminants into Atmosphere

The vehicles, e.g. trucks etc., used for delivery of construction materials and engineering structures will be the main source of the non-radioactive pollution of the environmental air during the construction period of the disposal facility. The vehicles transporting containers with radioactive waste will be the source of the non-radioactive pollution of the environmental air during the operation period of the disposal facility.

3.4.2.2.2 Potential Environmental Air Pollution

The environmental air pollution is possible from the mobile sources during the construction period of the *Landfill* facility and during the disposal campaigns. The environmental air quality will be directly affected by NO_X, SO_2, dust, CO, CO_2 and unburned carbohydrates C_xH_x, released by the vehicles transferring and handling the containers with the waste. The pollution will be limited in time (during relatively short construction period and when implementing a disposal campaign) and in space. The affected area will include the area of the disposal facility or the road and their close environment in a range of about 100 m and will be limited by the INPP sanitary protection zone. Therefore the planned economic activity will not cause significant releases to environmental air and will not make any considerable impact on the environmental air.

3.4.2.2.3 Impact Mitigation Measures

The predicted level of traffic will be low, and its impact will be permissible both during the construction and operation of the disposal units. Most of the works will be performed under free air conditions therefore natural circulation of the air will allow to avoid the accumulation of more significant concentration of the pollutants

Since the environmental releases are low, no specific additional measures on the non-radiological impact mitigation are foreseen.

3.4.2.3 Potential Radiological Impact

3.4.2.3.1 Potential Sources of Radioactive Airborne Releases

As there are volatile radionuclides (^{14}C) among the waste intended for disposal, depending on the number of factors, such as package containment, facility design, amount of organic materials in radioactive waste, and also activity of biota, the radionuclides (^{14}C) may be released from waste in a gaseous form. The gas formation will be resulted from the disposed waste in three disposal units of the *Landfill* facility

A conceptual model of the gaseous releases from the disposal facility is presented in Figure 3.27.

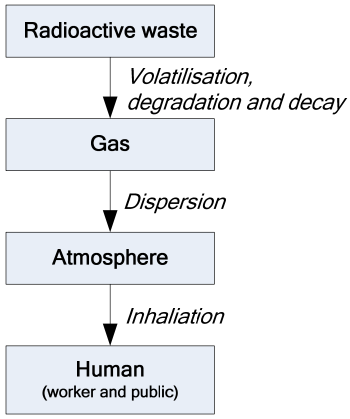


Figure 3.27. Conceptual model of the radioactive gaseous releases from the disposal facility

3.4.2.3.2 Potential Releases into Environmental Air

For the estimation of the environmental air pollution in the site area due to releases of gases (^{14}C) the following mathematical expression has been used [22]:

$$R_{gas} = A_r f_{gas} / \tau_{gas}, \qquad (3.2)$$

here:

R_{gas} – releases rate in gas (^{14}C), Bq/year;
A_r – activity of waste, were the gas generation occurs, Bq;
f_{gas} – fraction of the activity associated with the gaseous releases;
τ_{gas} – average timescale of generation of the gas, years.

Assuming the amount of the radionuclide ^{14}C equals to 1.41E+10 Bq in the *Landfill* disposal facility (see Table 1.14 in Section 1.6.5), the fraction of the activity associated with the gaseous releases is 0.2 [22] and the average timescale of generation of the gas equals to 20 years, it is approximately estimated that 1.4E+08 Bq/year of radioactive gasses (^{14}C) should be released from three *Landfill* disposal units. Annual gaseous releases from the three *Landfill* disposal units would be below by three orders of magnitude in comparison with activity limits, 2.27E+11 Bq/year, authorized to be released into the atmosphere by the INPP [29], i.e. they will be negligible.

3.4.2.3.3 Impact Mitigation Measures

Since the estimated environmental releases are negligible, no specific mitigation measures against radiological impact are foreseen.

3.4.3 Soil

3.4.3.1 Information about the Site

The site of the *Landfill* disposal units is located in the southern part of the territory of the Ignalina NPP, to the south of the sites of New Spent Nuclear Fuel Storage Facility (B1) and New Solid Waste Treatment and Storage Facilities (B3/4).

The surface of the site has been artificially changed in the past (during the construction of INPP) and later re-cultivated [35, 36]. The site of the *Landfill* facility includes submeridianal natural and partially dug depression. Its northeast part is covered with bushes, trees, dug out depressions, filled-up ground in some places [34]. The filled-up ground consisted of low-plastic moraine clay with addition of sand and vegetative layer is found on the surface of the northeast part of the site. The thickness of the layer is up to 3.0 m. The surface altitude varies from 151 to 161 m.

According to the INPP monitoring programme, samples of the soil in the INPP region are continuously monitored. The information on detected radionuclides and their radioactivity is presented Table 3.14 [33].

Table 3.14. Specific activity of the radionuclides in the soil of INPP 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/m²
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

* – Detection methodology of Sr-90 has been improved since 2003.

3.4.3.2 Potential Impact

The site should be deforested as well as a lot of the excavation works should be carried out for the construction of the *Landfill* disposal units.

The surface of the site of the *Landfill* facility in the past was technogenically impacted. Filled-up ground is laying under the vegetative layer in some places. The layer of the fertile soil will be removed.

No soil pollution is foreseen under normal operation conditions of the proposed economic activity. The site area will be permanently monitored (see section 3.7 “Monitoring“). In case of local soil contamination by conventional pollutants or radioactive material appropriate procedures will be implemented to eliminate the hazard and consequences of this impact.

3.4.3.3 Impact Mitigation Measures

As the layer of the fertile soil will be removed during construction phase of the *Landfill* disposal units it will be kept and used after closure of the disposal facility for forming of a vegetative layer at the top of the facility.

3.4.4 Underground (Geology)

3.4.4.1 Characterisation of the Underground Conditions

The INPP 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 [9].

The crystalline basement is buried to a depth of about 720 m from the current ground level. 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 INPP varies in the range of 703–757 m. Pre-Quaternary succession is represented by the Upper Proterozoic Vendian complex, overlain by sediments of the Paleozoic systems. The Vendian deposits are represented by a succession of gravelstone, feldspar-quartz sandstone of different grain size, siltstone and shale. The Paleozoic section comprises the successions of the Lower and Middle Cambrian, the Ordovician, the Lower Silurian and the Middle and Upper Devonian sediments (Figure 3.28 and Figure 3.29).

The Lower Cambrian is represented by quartz sandstone with inconsiderable admixture of the 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 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 the 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 the 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 – 28–75 m and the total thickness of the Devonian sediments reaches 250 m [9].

Sub-Quaternary relief of the area is highly dissected by paleoincisions. The thickness of the Quaternary cover varies from 62 up 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). The 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 up to 25–30 m (Figure 3.30). The intersticial deposits are composed of very fine-grained and fine-grained sand, silt and peat (Figure 3.32 and Figure 3.33). The Holocene deposits are represented by alluvial, lacustrine and bogs 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 [9].

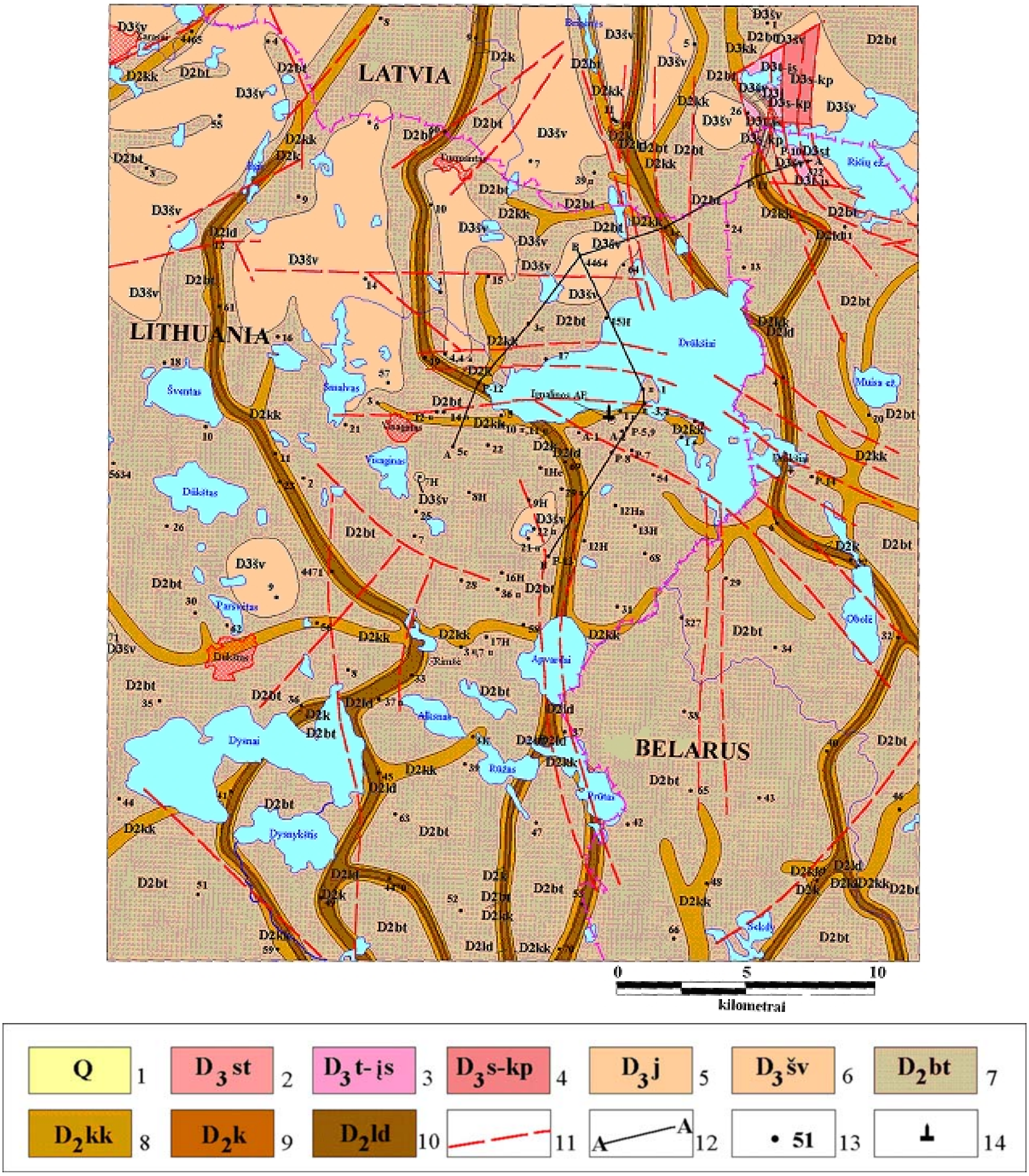


Figure 3.28. Pre-Quaternary geological map of the INPP region [9]:

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 – Ignalina NPP

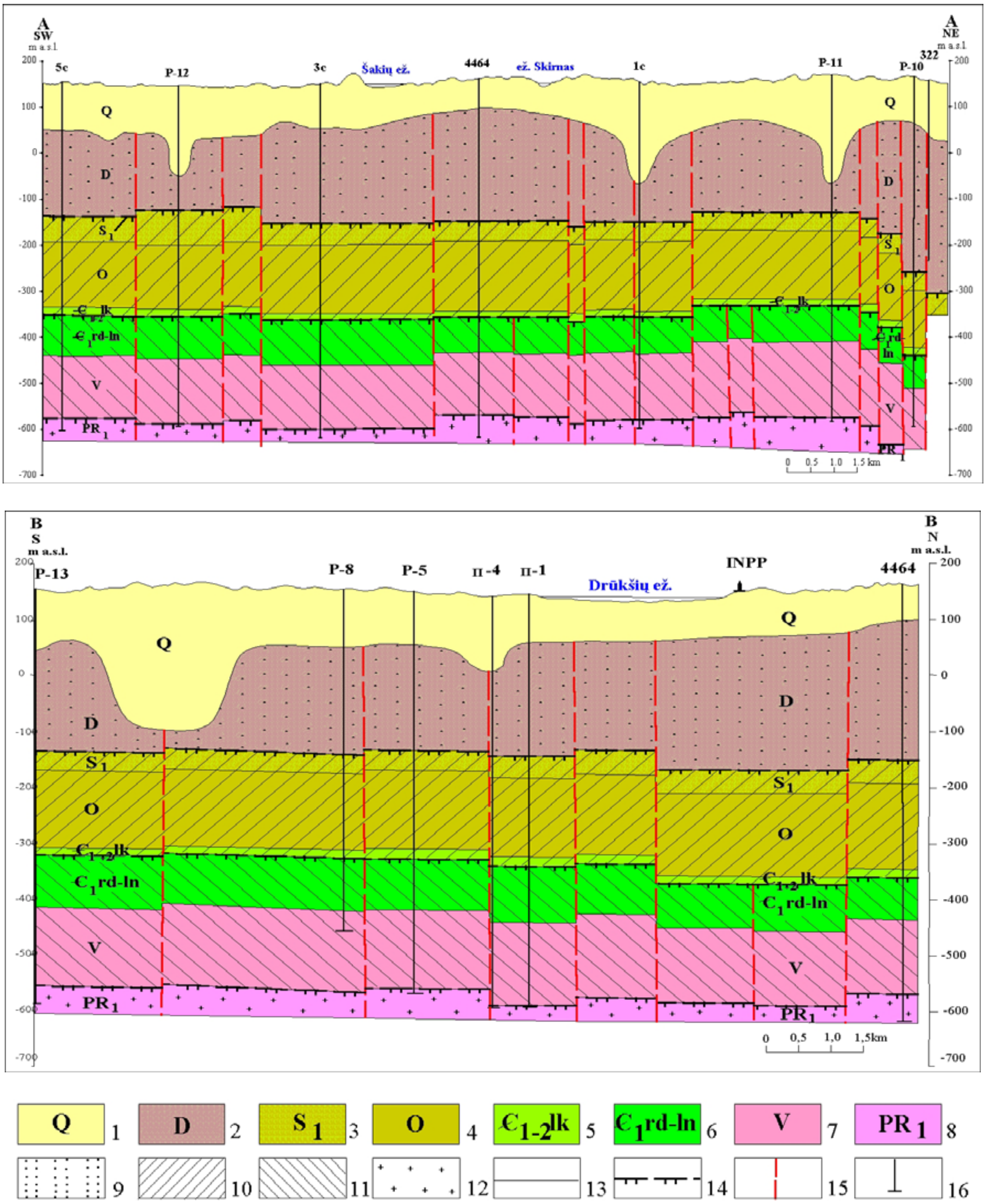


Figure 3.29. Geological-tectonic cross-sections of the INPP region [9] (cross-section location see in Figure 3.30):

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; 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

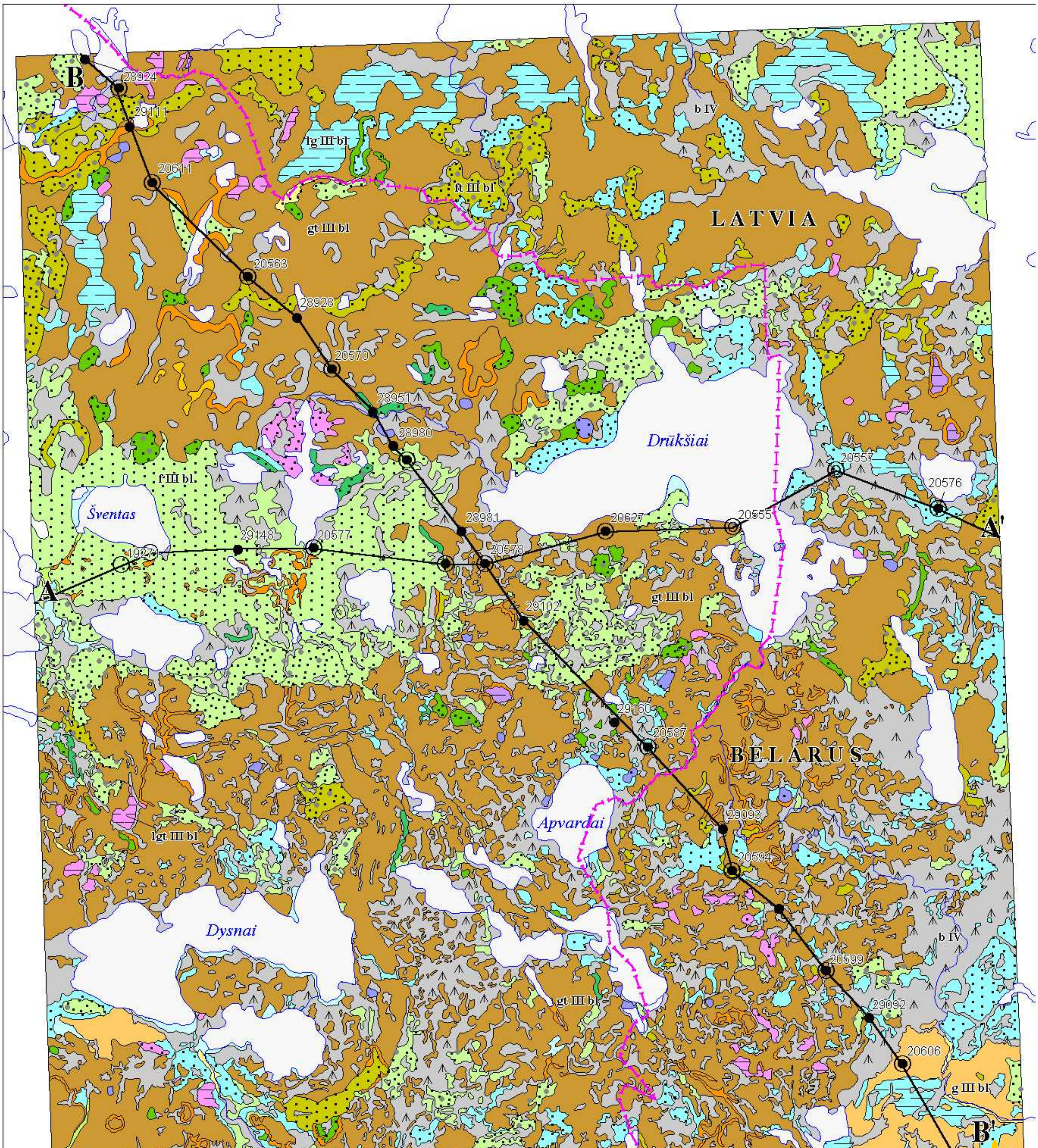


Figure 3.30. Quaternary geological map of the INPP area (original scale 1:50 000, author: R. Guobyte [9]); legend see in Figure 3.31.

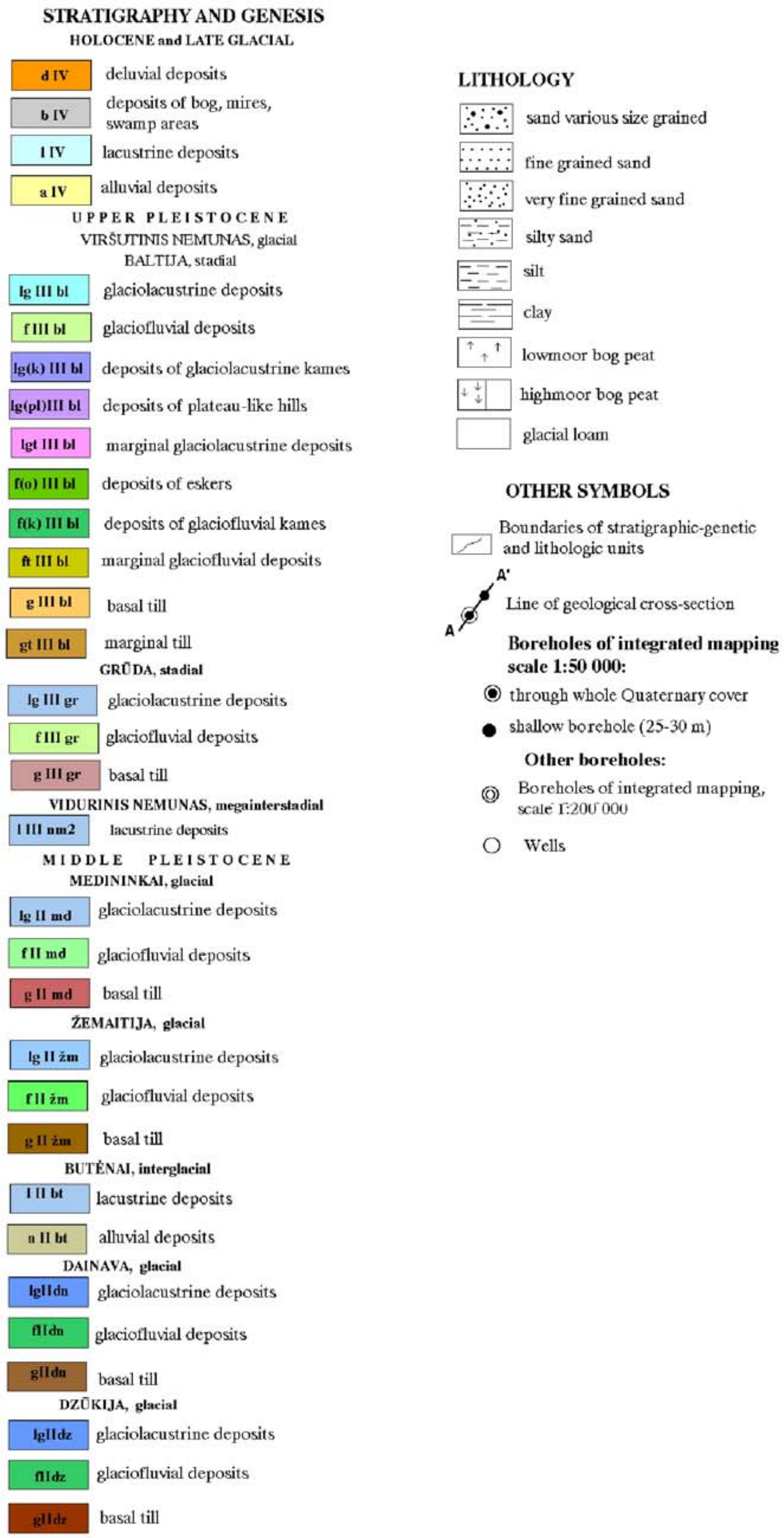


Figure 3.31. Legend for Quaternary geological map and geological cross-sections of the INPP region

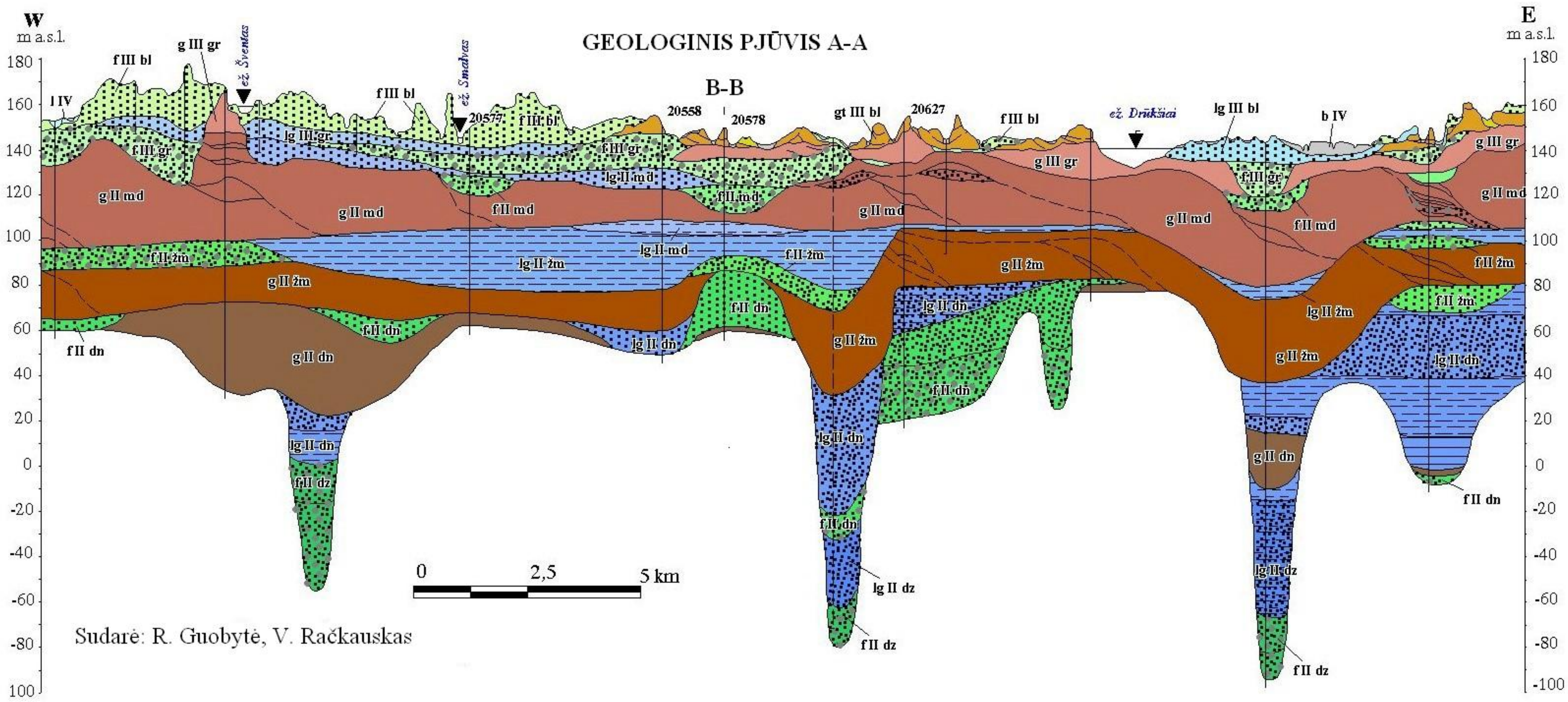


Figure 3.32. Quaternary geological cross-section A-A of the INPP area (original scale 1:50 000, authors: R. Guobyte, V. Rackauskas [9]); legend see in Figure 3.31

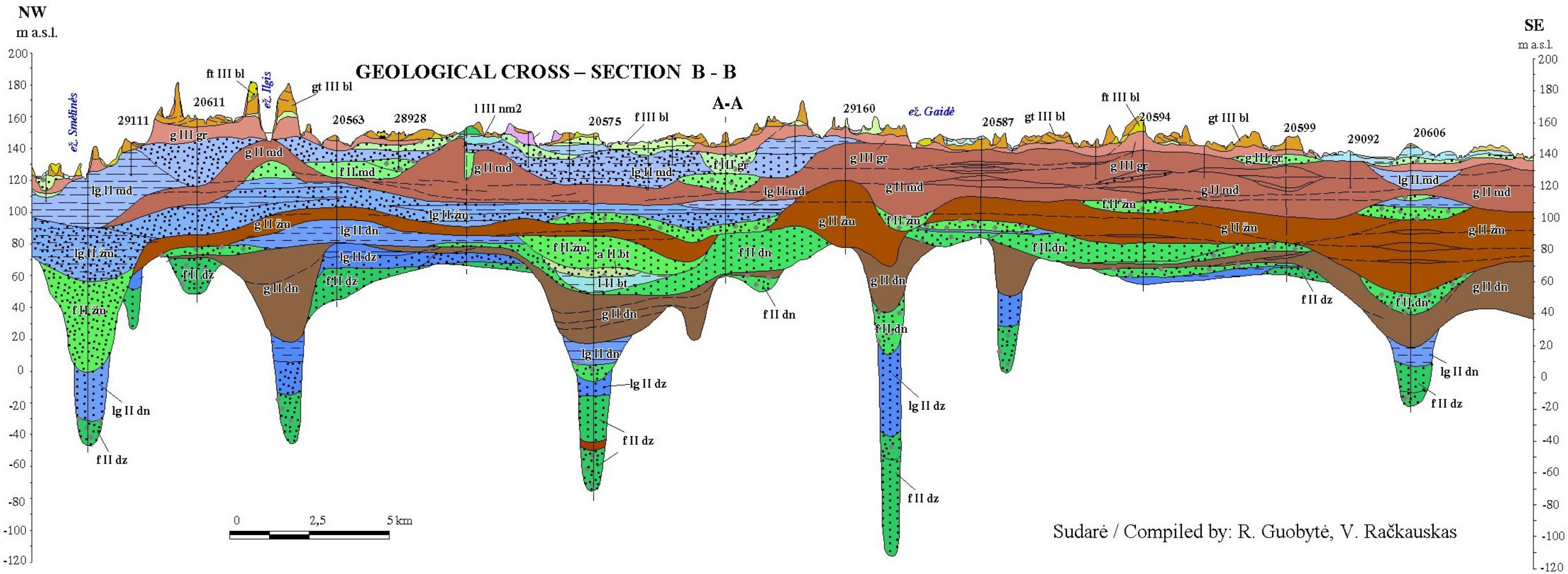


Figure 3.33. Quaternary geological cross-section B-B of the INPP area (original scale 1:50 000, authors: R. Guobyte, V. Rackauskas [9]); legend see in Figure 3.31

3.4.4.2 Potential Impact

The proposed economic activity will not affect the underground component of the environment. The disposal units will be constructed on the ground surface and the impact on the ground geological structure will be insignificant.

No valuable natural resources have been found at the disposal units site. The planned economic activity under normal operation conditions will have no effect on possible off-site activities in the vicinity.

The site for the *Landfill* facility has been chosen outside the established areas of tectonic faults. Seismic characteristics of the site will be taken into consideration during development of the Technical Design.

3.4.4.3 Impact Mitigation Measures

Since no negative impacts on the region geology due to the planned economic activity have been identified, no impact mitigation measures are needed.

3.4.5 Biodiversity

3.4.5.1 NATURA 2000 Network and Other Protected Areas

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 [37] and 92/43/EEC [38]. The main objective of the NATURA 2000 network is to ensure the survival of species and habitats that are threatened or rare throughout Europe.

Basing on the Council Directive 79/409/EEC of 2 April 1979 on the Conservation of Wild Birds (further – Birds Directive) the Special Protection Areas (SPAs) are to be designated. 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) the Special Areas for Conservation (SACs) are to be established.

Prior to the establishment of SACs, based on scientific research, sites, meeting the criteria of Special Areas for Conservation are selected. The list of sites meeting the criteria of Special Areas for Conservation is presented to the European Commission (EC). After the list of sites meeting the criteria of Special Areas for Conservation is approved by EC, they are supposed to be called Sites of Community Importance (SCIs). Based on Sites of Community Importance the member states shall establish Special Areas for Conservation.

Sites, corresponding to the criteria of Special Areas for Conservation, meet the criteria of SACs designation, approved by the Minister of the Environment [39]. According to the EU Habitat 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 LR Law on Protected Areas [40], first a national protected area is to be established. Later on it can be granted with the status of SPA or a site meeting the criteria of Special Area for Conservation, or a Site of Community Importance or SAC can be established. The European Commission has already approved the list of sites meeting the criteria of Special Area for Conservation or SCIs.

The order of the LR Minister of Environment [39] is the legal base of designation of the aforementioned SCIs.

The nearest to INPP Sites of Community Importance (SCIs) of the "NATURA 2000" network are listed in Table 3.15 and presented in Figure 3.34.

Table 3.15. The nearest to INPP Sites of Community Importance (SCIs) of the "NATURA 2000" network

The name of location	Area, ha	SCI code in "NATURA 2000" network data base and comments on SCI boundaries	Valuable species in the area	Preliminary area habitats, ha
Lake Druksiai	3611	LTZAR0029 The border is defined according to the special map.	Spinned loach (*Cobitis taenia*)	
			European otter (*Lutra lutra*)	
River Smalvele and adjacent limy fens	547	LTZAR0026 The border is the same as for Smalvos hydrographical reserve.	Fire-bellied toad (*Bombina bombina*)	
			European otter (*Lutra lutra*)	
Lakes and wetlands Smalva and Smalvykstis	2225	LTZAR0025 The border is the same as for Smalvos landscape reserve.	3140, Hard oligo-mesothrophic waters with benthic vegetation of Chara formations	354.6
			3160 Dystrophic lakes	45.0
			7140 Transition mires and quaking bogs	265.9
			7210 Calcareous fens with Cladium mariscus and Carex davaliana	88.7
			7230 Alkaline fens	88.7
			9010 Western taiga	265.9
			9080 Fennoscandian deciduous swamp woods	88.7
			91D0 Bog woodlands	88.7
			Fen orchid (*Liparis loeselii*),	
			Slender green feather-moss (*Hamatocaulis vernicosus*)	
Grazute regional park	26125	LTZAR0024 The border is the same as for Grazute regional park, with the exception of recreational, agriculture and residential priority zones.	3130 Oligothrophic waters with amphibious vegetation	105
			3140 Hard oligo-mesothrophic waters with benthic vegetation of Chara formations	18.4
			3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	2.0
			6120 Xeric sand calcareous grasslands	5.0
			6210 Semi-natural dry grasslands	1568.0
			7120 Degraded upland bogs	26.0
			7140 Transition mires and quaking bogs	69.6
			7160 Non calcareous springs and springy bogs	2.0

The name of location	Area, ha	SCI code in "NATURA 2000" network data base and comments on SCI boundaries	Valuable species in the area	Preliminary area habitats, ha
			9010 Western taiga	810.0
			9020 Broad leaved and mixed woodlands	99.0
			9060 Coniferous woodlands on fluvioglacial eskers	45.0
			9080 Fennoscandian deciduous swamp woods	201.0
			91D0 Bog woodlands	2012.0
			Large copper (*Lycaena dispar*)	
			(*Thesium ebracteatum*)	
			Fire-bellied toad (*Bombina bombina*)	
			Great crested newt (Triturus cristatus)	
			European otter (*Lutra lutra*)	
			Eastern pasque flower (*Pulsatilla patens*)	
Pusnis wetland	779	LTIGN0001 The border is the same as for Pusnis telmological reserve	6230 Species-rich Nardus grasslands	8.0
			6430 Hydrophilous tall herb fringe communities of plains	39.0
			7140 Transition mires and quaking bogs	234.0

Protected territories or their parts in the Republic of Lithuania comprising Special Protection Areas (SPA) are approved by the Government [41]. The nearest to INPP Special Protection Areas of the "NATURA 2000" network are listed in Table 3.16 and shown in Figure 3.34. Information on what protected bird species of European importance are found in each SPA is also indicated in Table 3.16. Forbidden activities in the Special Protection Areas are summarized in Table 3.17.

Table 3.16. The nearest to INPP Special Protection Areas (SPAs) of the "NATURA 2000" network

LR protected area (or its part)	Code in "NATURA 2000" network data base and location of the SPA	Protected bird species of European importance	Comments on SPA boundaries
Part of the protected zone for Lake Druksiai	LTZARB003 Lake Druksiai	Great Bittern (*Botaurus stellaris*)	SPA takes a part of the protected territory. The border is defined according to the plan.
Parts of protected zone for Lakes Dysnai and Dysnyksciai	LTIGNB004 The limy fens complex of Dysnai and Dysnykstis lake area	Corn crake (*Crex crex*)	SPA takes a part of the protected zone. The border is defined according to the plan.
Part of Grazute regional park	LTZARB004 North eastern part of Grazute regional park	Black-throated Diver (*Gavia arctica*), Pygmy owl (*Glaucidium passerinum*)	SPA takes a part of the protected territory. The border is defined according to the plan.

LR protected area (or its part)	Code in "NATURA 2000" network data base and location of the SPA	Protected bird species of European importance	Comments on SPA boundaries
Smalva hydrographic reserve	LTZARB002 The complex of Smalva limy fens	Black Tern (*Chlidonias niger*)	The border of the SPA is the same as for Smalva hydrographic reserve

Table 3.17. Forbidden activities in the Special Protection Areas (SPAs) nearest to the INPP site

"NATURA 2000" code and location of the SPA	Bird species of European importance	Forbidden activities [42]
LTZARB003 Lake Druksiai	Great Bittern (*Botaurus stellaris*)	Reap reeds (in certain areas); Visiting places of above water vegetation overgrowth from ice melting till July 1 (in certain areas); Boating and yachting (in certain areas); Camping, excepting in specially predefined recreational areas, from ice melting till July 1 (in certain areas); Hunting of water and wetland birds excepting cases of regulation of cormorant population in pisciculture waters; Change the land usage main purpose excepting cases of changing to more conservative purpose; Change the hydrological regime if it leads to decrease of habitability area or quality; Plant forest.
LTIGNB004 The limy fens complex of Dysnai and Dysnykstis lake area	Corn Crake (*Crex crex*)	Change the land usage main purpose excepting cases of changing to more conservative purpose; Convert meadows and pastures into plough-land; Change the hydrological regime if it leads to decrease of habitability area or quality; Plant forest.
LTZARB002 The complex of Smalva limy fens	Black tern (*Chlidonias niger*)	Boating and yachting from May to July; Change the hydrological regime if it leads to decrease of habitability area or quality; Perform water body bed renovation works if it leads to decrease of habitability area or quality.
LTZARB004 North eastern part of Grazute regional park	Black-throated Diver (*Gavia arctica*)	Visiting from ice melting till July 1 (in certain areas); Erect constructions which are not related to purpose of protected territory and expand infrastructure (in certain areas).
	Pygmy owl (*Glaucidium passerinum*)	Perform general deforesting (in certain areas); Perform deforesting and timbering works from February till May (in certain areas); In case of general deforesting not less than 20 (per hectare) seminal of main group and trees (arranged in biogroups) necessary to maintain biodiversity shall be left (in certain areas).

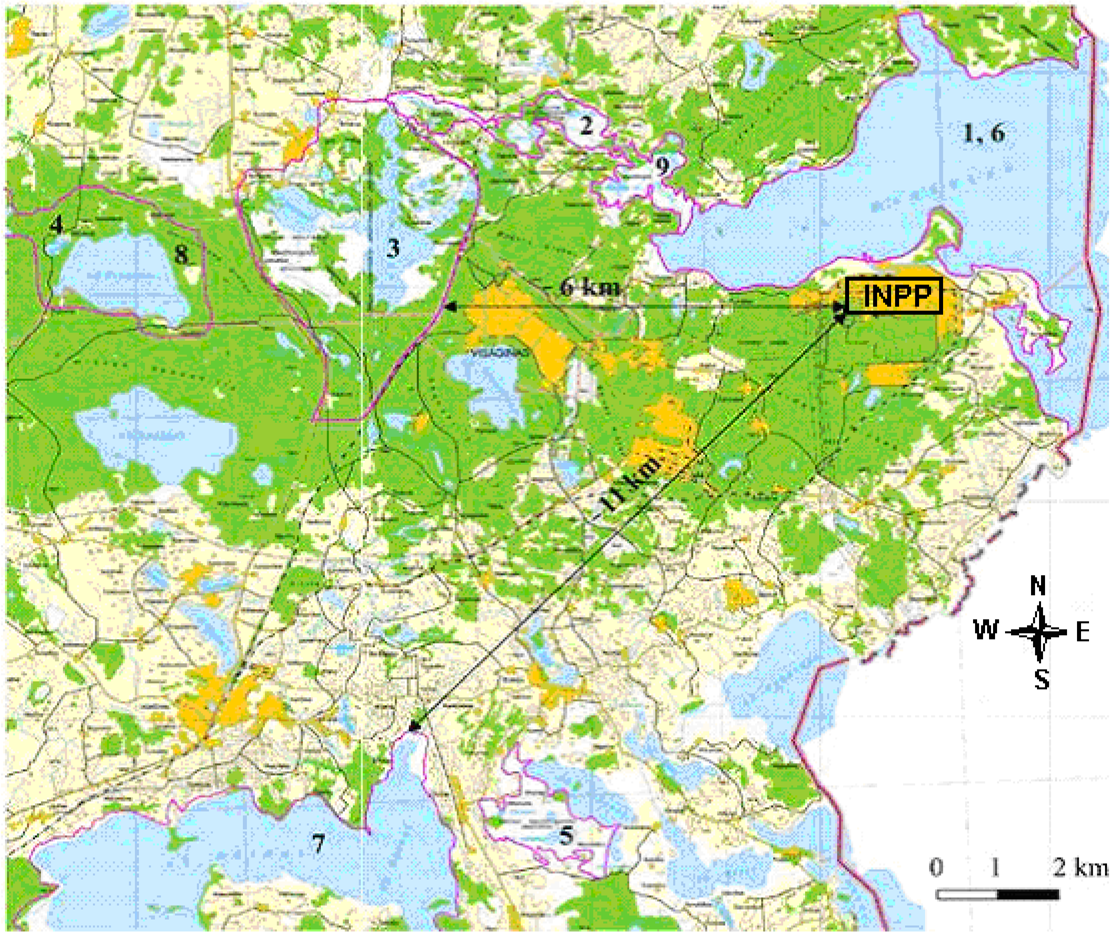


Figure 3.34. The nearest to the INPP site "NATURA 2000" network areas (perimeters are indicated in red):

Sites of Community Importance (SCIs): 1 – Lake Druksiai; 2 – River Smalvele and adjacent limy fens; 3 – Lakes and wetlands Smalva and Smalvykstis; 4 – Grazute Regional Park; 5 – Pusnis wetland. Special Protection Areas (SPAs): 6 – Lake Druksiai; 7 – the limy fens complex of Dysnai and Dysnykstis lake area; 8 – North eastern part of Grazute Regional Park; 9 – the complex of Smalva limy fens

3.4.5.2 Potential Impact

The functional and structural changes in Lake Druksiai biota are caused by thermal releases from INPP and chemical pollution, which main sources are waste waters of INPP and Visaginas municipal sewerage that are returned to Lake Druksiai, after being processed at the general household sewage water cleaning system. Construction of the disposal units will not change the thermal releases, and discharges of waste water will comprise only an insignificant part of the waste water from INPP.

The object relevant to NATURA 2000 are distant from the *Landfill* disposal facility therefore planned economic activity will not influence on them impact. No rare or endangered communities of the biodiversity, as well as plants have been found in the territory of the site of the *Landfill* disposal facility or in its vicinity.

During site preparation it will be necessary to cut down valueless bushes and trees in the territory. But these changes will not make any considerable impact on the vegetation in the surroundings of the site.

The impact on reproduction of birds due to exhaust gases of transport and construction vehicles, noise and visual irritations should be possible during the construction phase as well as during disposal campaigns. It is expected that due to the planned economic activity the territory of the *Landfill* disposal facility can be depreciated as a habitat of birds.

3.4.5.3 Impact Mitigation Measures

To avoid unnecessary deterioration of vegetation communities and habitat functions the construction site will be limited to the minimum area necessary for the *Landfill* disposal facility. The removed vegetation at the construction site and local borrow areas will be replanted after operation phase of the disposal units

Possible impact on reproduction of birds during the construction phase and disposal campaigns will be temporal. Disposal campaigns will be carried out quite rarely (once in 1-2 years), each with duration for about 1-2 months. The main impact mitigation measure is that noisy activities will be carried out during daytime only.

3.4.6 Landscape

3.4.6.1 Information about the Site

The *Landfill* disposal units will be constructed and operated in the close vicinity to the INPP industrial area.

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 recreation areas along Lake Druksiai with their specific natural and visual qualities have a great value for the quality of life. The valuable landscape areas (Grazute Regional Park and Smalva hydrographic reserve) are located at about 10 kilometres from the site of the planned *Landfill* disposal facility.

3.4.6.2 Potential Impact

The *Landfill* facility will be constructed in the INPP vicinity. During preparation of the site for the construction of the disposal units it will be necessary to cut down bushes and trees in the territory of the site, it will be necessary to do a considerable amount of the excavating works for the smoothing of the site surface. The impact on the landscape will be localised and insignificant. The disposal facility site occupies relatively small territory. The valuable landscape areas (Grazute Regional Park and Smalva hydrographic reserve) are distant from the locations of the proposed economical activity.

The disposal facility will look as a natural hill after its closure when the vegetative layer will be formed on the top.

3.4.6.3 Impact Mitigation Measures

No significant impact on the landscape resulted from the planned economic activity is expected The site will be reduced to the minimum size necessary for implementation of the construction works as well as operation of the disposal facility, thus the potential environmental impact will be reduced.

3.4.7 Social and economic environment

3.4.7.1 Population and Demography

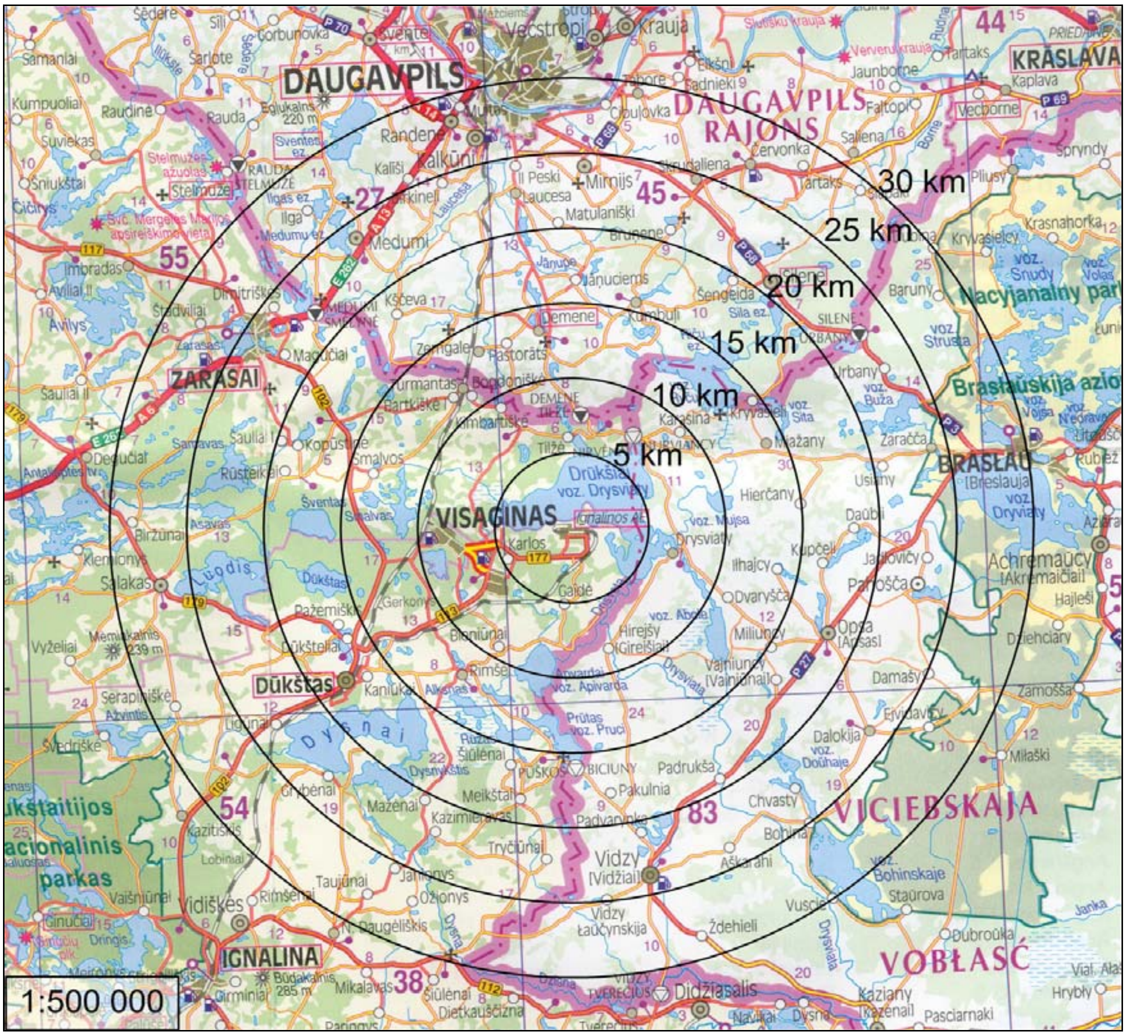
According to data for 2005 the total population of the INPP region, which includes the municipality of Visaginas (59 km^2), Ignalina district (1 496 km^2) and the Zarasai district (1 334 km^2) was 71700 (in Visaginas 28 700 people and in Ignalina and Zarasai districts 21 400 and 21 600 people, respectively). Even INPP region comprises 4.3 % of Lithuania territory, however the population number is about 2 % of the total Lithuania population. During the recent years, a decrease of population in the INPP region is 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 3.18, Table 3.19 and Figure 3.35

Table 3.18. Demographic indicators of INPP 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 3.19. 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**	



	Motorway, dual carriageway	VISAGINAS	City
	Main road		Township
	1st class road		Rural settlement
	Other road		> 5000
	Unsurfaced road		1000-5000
Turmantas	Railway, station		500-1000
	National boundary		>500

Figure 3.35. Population distribution within 5, 10, 15, 20, 25 and 30 km radius around the INPP

Inhabitants, living in the territories of Latvia and Belarus, which fall into 30 km radius zone around INPP are taken into account (see Table 3.19). Within the 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 INPP region is one of the lowest in Lithuania.

A 3 km radius sanitary protected zone is established around the INPP there are neither farms nor settlements and economic activities are limited. The closest town is Visaginas, which is situated about 6 km from the INPP.

3.4.7.2 Economic Activities

From the economic point of view the INPP region, except 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 factor of 1.5, and the volume of services is more than factor of 2.5 below than on the average in the country. No important minerals (with the exception of quartz sand) are found in the region.

The town of Visaginas has an urban type labour force, which is younger (the age of 67 % of residents is under 44, see Table 3.18) more educated people and with 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.

Neither chemical nor oil process industries exist in the vicinity of the INPP.

3.4.7.3 Road and Railway Connections, Forbidden for Flights Areas

The existing road and railway systems are shown in Figure 3.36. The nearest highway passes 12 km to the west of INPP. This highway joins Vilnius with Zarasai the border town to Latvia and has an exit to the highway connecting Kaunas–St Petersburg. The entrance of the main road from INPP to the highway is near the town of Dukstas. The road from INPP to Dukstas is about 20 km.

Figure 3.36. Road and railway network

The main railroad line Vilnius–St Petersburg passes 9 km to the west of INPP. The INPP is connected to the railroad by an extension from Dukstas. The railway station Dukstas is used for cargo traffic as well as for passenger transportation.

There are 3 zones where flights are prohibited in Lithuania, the one of which is territory within 10 km around the INPP (Figure 3.37).

There are about 30 000 flights per year (in 2005) from Vilnius airport, which is located 130 km from the INPP site. About 125 000 aeroplanes per year cross the Lithuanian air space. Altogether 30 airports of civil, military and mixed purpose are located in the country.

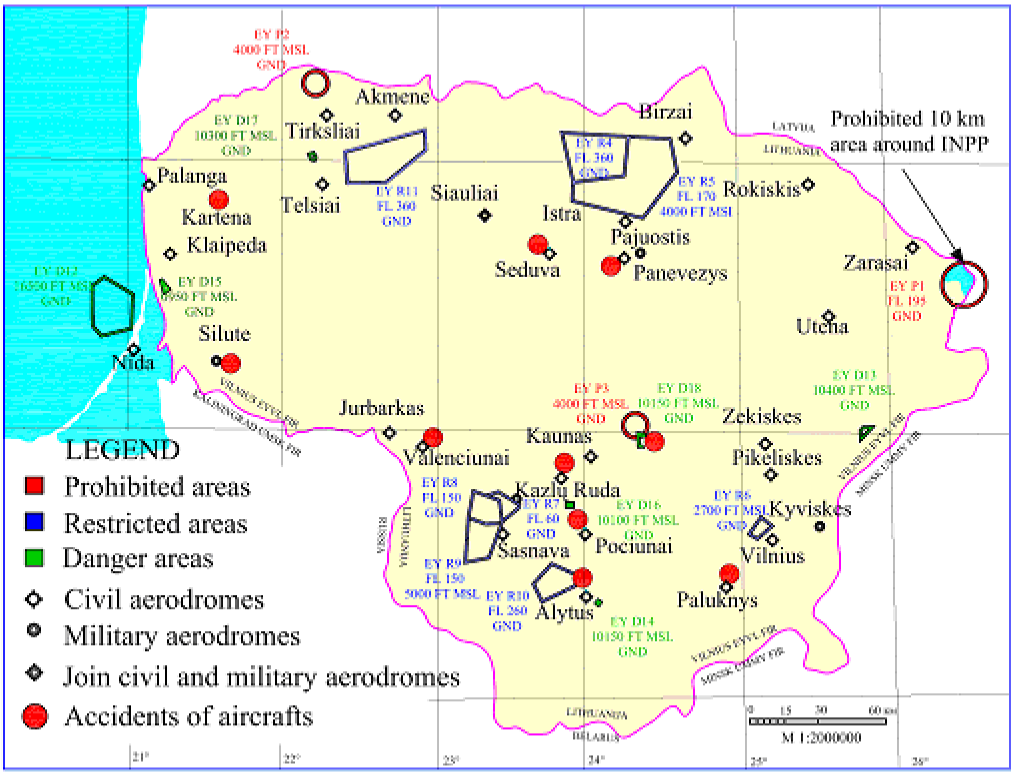


Figure 3.37. Airports, forbidden, restricted and dangerous areas in Lithuania

3.4.7.4 Potential Impact

The proposed economic activity will be implemented close to the INPP industrial site and within the existing 3 km radius sanitary protection zone of INPP. A minimal distance from the *Landfill* disposal units to the limits of existing SPZ is approximately 1.2 km. There is no permanently living population within the existing SPZ, and the economic activity is limited as well.

An individual SPZ will be established for the *Landfill* disposal facility. It will be established within existing SPZ of INPP.

No impacts or evident changes of social and economical environment are foreseen. The facility will be constructed by local contractors. Necessary labour resources to perform the proposed economic activity are available at INPP. Moreover, this project will decrease the social and economic impacts due to decommissioning of the INPP by using the work force with a high skill level associated with work in the nuclear industry. The project will employ about 6 people.

The proposed economic activity will be performed in accordance with the modern environmental requirements using state-of-the-art technologies. The proposed economic activity represents the EU direct investment for the INPP decommissioning. It will be performed in compliance with the radioactive waste management principles of the IAEA and in compliance with good practices in other European Union Member States.

3.4.7.5 Impact Mitigation Measures

No impacts or evident changes of social and economical environment are foreseen. Moreover, this project will decrease the social and economic impacts due to the INPP decommissioning by using the work force with a high skill level associated with work in the nuclear industry.

3.4.8 Ethnic and cultural conditions, cultural heritage

3.4.8.1 Information about the Site

There are several cultural heritage sites in the area around Ignalina nuclear power plant (village Druksiniai, Visaginas municipality):

1. Grikiniskes settlement antiquities (territory area – 3.08 ha).
2. Grikiniskes settlement antiquities II (territory area – 4.95 ha).
3. Grikiniskes settlement antiquities III (territory area – 1.82 ha).
4. Petriskes settlement antiquities (territory area – 0.8 ha).
5. Petriskes mound (territory area – 0.48 ha).
6. Petriskes settlement antiquities II (territory area – 0.31 ha).
7. Stabatiskes manor place (territory area – 1.47 ha).

In the vicinity of INPP there are: Grazutes regional park (area 24230 ha), Ceberaku (Pasamanes) mound, called Baznyciakalnis (cultural heritage code A1537) and other objects of cultural heritage (Figure 3.38).

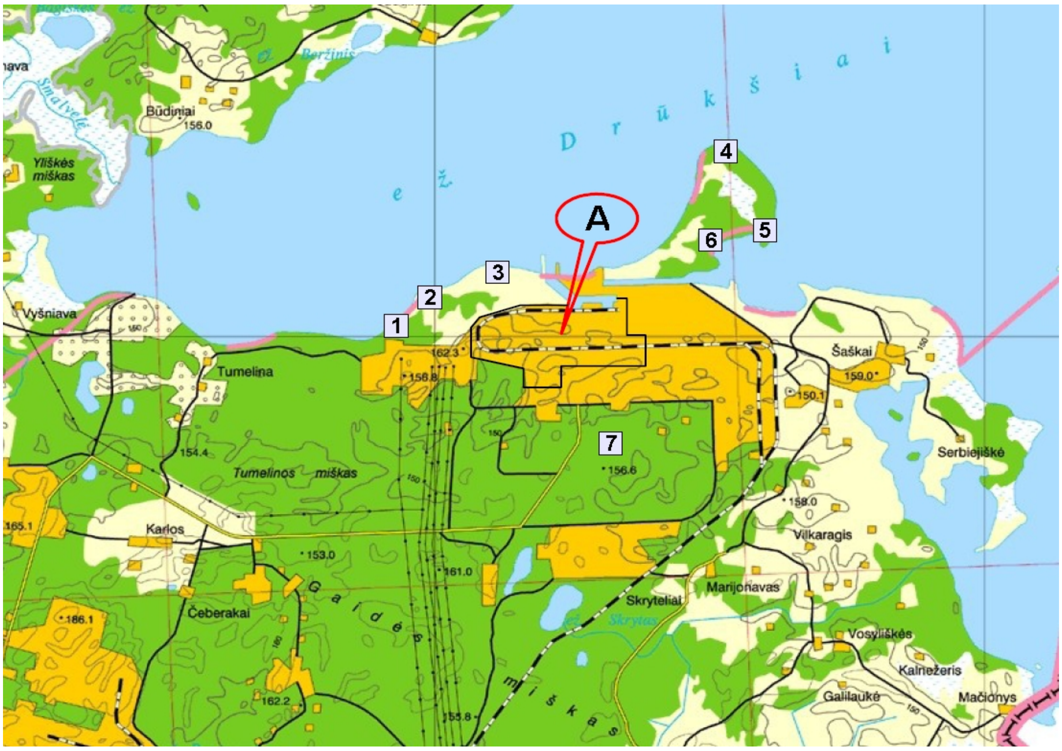


Figure 3.38. Cultural heritage objects in the vicinity of the INPP site:

A – INPP site; 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 – Stabatiske manor place

3.4.8.2 Potential Impact

The *Landfill* disposal facility will be constructed in the site Which surface has been artificially changed in the past (during the construction of INPP) and later re-cultivated.

No cultural heritage objects are identified which one should be affected by the proposed economic activity. There will be no interaction between the proposed economic activity and ethnic and cultural environment in the site as well as in the off-site area.

3.4.8.3 Impact Mitigation Measures

There are no required mitigation measures relating to the protection of cultural heritage as no impact from the proposed economic activity is expected.

3.4.9 Public health

3.4.9.1 General Information

General information about population health indicators for the Ignalina NPP region (Visaginas Municipality, Ignalina and Zarasai districts) is summarized in Table 3.20 and Figure 3.39.

Table 3.20. Population health indicators for the INPP region in 2005/2006

Factor	Ignalina district	Zarasai district	Visaginas	INPP region
Registered morbidity per 100 thousands of adults	1245	1710	2162	1706
Registered morbidity per 100 thousands of children	2236	2826	3504	2856
Incidence of malignant neoplasms per 100 thousands of pop.	581	589	300	490
Prevalence of malignant neoplasms per 100 thousands of pop.	2080	2097	1195	1791
Incidence of mental disorders per 100 thousands of pop.	129 *	496 *	451 *	359 *
Prevalence of mental disorders per 100 thousands of pop.	1910 *	6182 *	2481 *	3524 *
Admissions per 100 thousands of pop.	169 *	138 *	194 *	167 *

* Data for year 2006

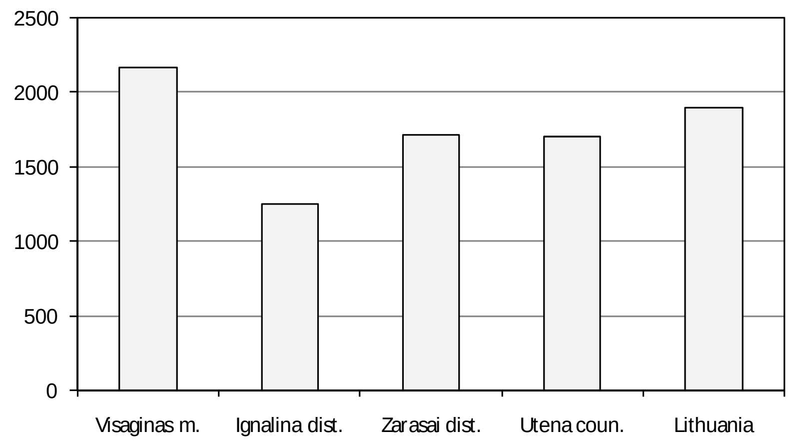


Figure 3.39. . Registered morbidity per 100 thousands of adults for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2005 [43]

Death rate per 100 thousands of population and percent of working age population for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2005 are presented in Figure 3.40 and Figure 3.41.

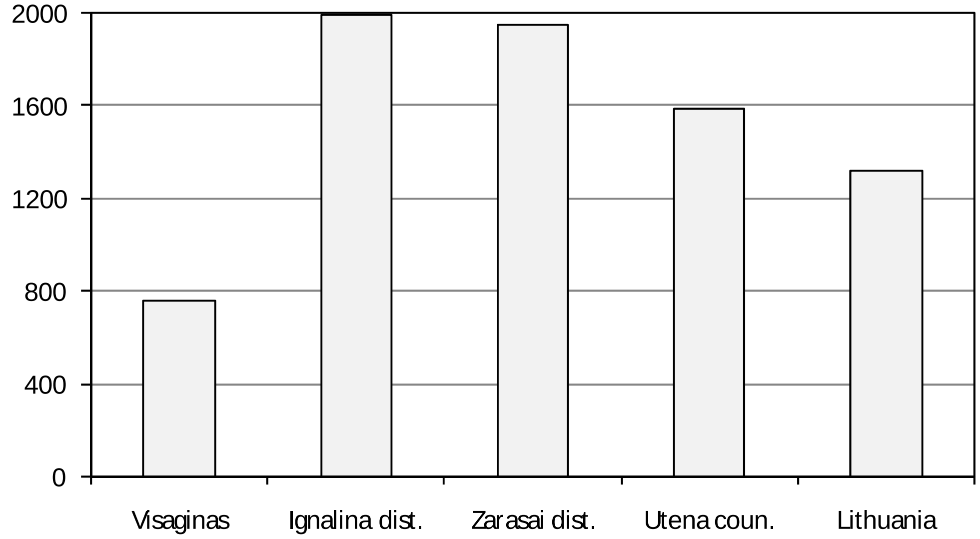


Figure 3.40. Registered morbidity per 100 thousands of adults for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2006 [43]

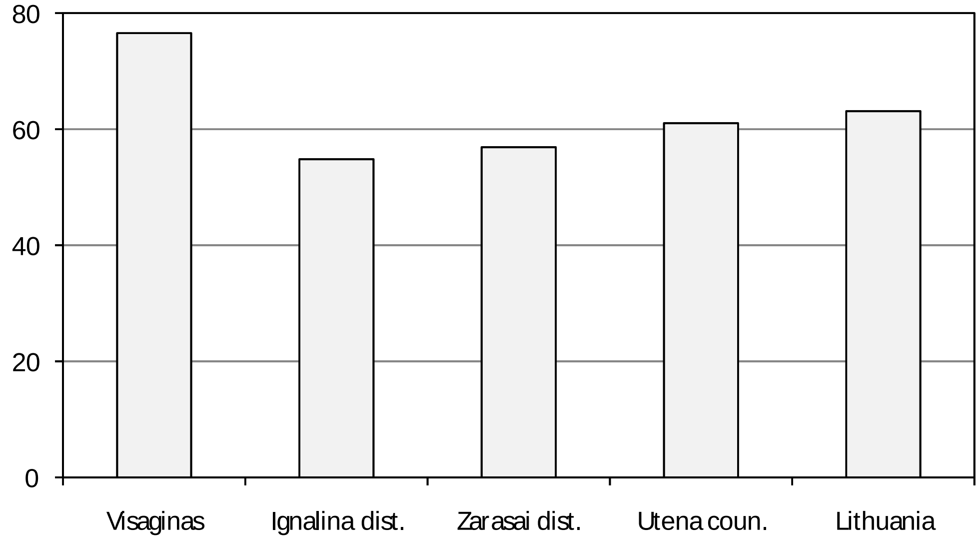


Figure 3.41. Percent of working age population for Visaginas Municipality, Ignalina and Zarasai districts, Utena County and Lithuania in 2006 [43]

As it is demonstrated in Figure 3.40, the death rate per 100 thousands of population for town of Visaginas is lowermost in the whole country and the death rate per 100 thousands of population for Ignalina and Zarasai districts is the uppermost. This is not connected anyhow with operation of INPP; the reason is the age of population. It can be seen in Figure 3.41 the percent of working age population for town of Visaginas is uppermost in the whole country and the percent of working age population for Ignalina and Zarasai districts is one of the lowermost in Lithuania.

3.4.9.2 Non-Radiological Impact on Public Health and Impact Mitigation Measures

3.4.9.2.1 Noise

The increase of local noise due to running of engines of the vehicles and operation of construction machinery is foreseen during the preparation of the *Landfill* facility site and the construction of the disposal units as well as during their operation. Noise level will be controlled and maintained within the limits, defined by normative documents of the Republic of Lithuania. The greatest noise impact may be caused to the workers constructing the disposal facility as well as to the exploiting personnel. If necessary, in case of exceeding the permissible noise level, technical measures will be implemented (e.g. timely technical maintenance of transport and construction machines, noise shielding), organizational measures will be taken (e.g. planning of work in areas with increased noise) and also personal protection means (e.g. headphones) will be used.

Since in the vicinity of the site planned for the construction of the *Landfill* facility there are no permanent residents (proposed economic activity will be carried out in the Ignalina NPP industrial site, i.e. in the existing sanitary-protection zone with radius 3 km), it is estimated that the impact on the public health should be negligible during its construction phase. Moreover, the duration of disposal campaigns will not be lengthy and they will be carried out quite rarely (it is foreseen one campaign 1-2 month long per 1-2 years).

3.4.9.2.2 Waste Water

There will be no uncontrolled waterborne releases into the environment under normal operation conditions of the disposal units. Only the non-radioactive liquid waste can be released to the sanitary-technological waste water system. The sanitary waste water from INPP is transferred to State Enterprise "Visagino energija" under an agreement. The INPP surface water drainage system meets the requirements of the regulation [17].

Accidental spills of combustive-lubricating materials from vehicles during transportation of RAW packages could potentially contaminate soil and groundwater at INPP site. An emergency response plan will be prepared, and the workers will be trained to follow specific procedures in the event of an accidental spill.

3.4.9.2.3 Emission of Non-Radioactive Contaminants into Atmosphere

The vehicles used for delivery of construction materials and engineering structures as well as the vehicles transporting containers with radioactive waste will be the main source of the non-radioactive pollution of the environmental air during the construction and operation period of the disposal facility. The environmental air quality will be directly affected by NO_X, SO_2, dust, CO, CO_2 and unburned carbohydrates C_xH_x.

The transportation route will be within the territory of the INPP sanitary protection area and will not cross the populated areas. The affected area will include the area of the disposal facility or the road and their direct environment in a range of about 100 m. The expected volume of traffic will be not high therefore its impact will be permissible both during the construction and operation of the *Landfill* facility. Most of the works will be performed under free air conditions therefore natural circulation of the air will allow to avoid the accumulation of more significant concentration of the pollutants

So, release of non-radioactive contaminants will be negligible and will not cause any significant impact to the INPP environment, and hence, public health.

3.4.9.3 Radiological Impact on Public Health and Impact Mitigation Measures

Potential impact (dose to member of critical group of public) may be resulted from the release of airborne and waterborne activity as well as from the direct irradiation from the facility and equipment containing radioactive materials. The estimation of possible impact on the population in case of unintended intrusion into the disposal units after the institutional control period also included into the section.

Estimated activity of the released radionuclides into water and atmosphere under conditions of normal operation of the *Landfill* disposal facility as well as after its closure are presented in sections 3.4.1 and 3.4.2.

3.4.9.3.1 Requirements on Radiation Protection

Lithuanian Hygiene Standard HN 73:2001 [44] prescribes 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 per year provided that the average over five consecutive years does not exceed 1 mSv per year;
- The limit on equivalent dose for the lens of the eye – 15 mSv per year;
- The limit on equivalent dose for the skin – 50 mSv per year. This limit has to be averaged over 1 cm^2 area of skin subjected to maximal exposure.

The source related individual dose is limited by a dose constraint when optimizing the radiation protection. The dose constraint for each source is intended to ensure that the sum of doses to critical group members from all controlled sources remains within dose limit. The dose constraint for the members of public due to operation and decommissioning of nuclear facilities is 0.2 mSv per year [20].

If radionuclides are dispersed into 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.

The design, operation and decommissioning of nuclear object shall be such as to assure that the annual dose to the critical group members due to operation and decommissioning of nuclear facility including short time anticipated operational transients shall not exceed the dose constraint [2].

For comparison purpose it can be indicated that annual effective doses to the Lithuanian inhabitants due to natural sources of ionizing radiation varies in range from 1.2 to 10 mSv with average value of 2.2 mSv.

3.4.9.3.2 Radiological Impact due to Radionuclide Release into Water

Water from the well or lake as well as from drainage channel should be used for daily living needs of local farming group (members of the critical group of population): garden irrigation, cows watering and drinking. Therefore the radionuclides passed to the soil due to irrigation should be the reason of the potential exposure of the local people (see Figure 3.23). The fish caught in the lake and consumed by local inhabitant should be an additional exposure pathway in case of radionuclide migration to the lake (see Figure 3.24). Exposure pathway resulted from drinking water is excluded in case of radionuclide migration to drainage channel (Figure 3.25).

Critical group of population consists of 4 persons that keep 4 dairy caws, 4 meat cattle and 200 m^2 of garden plot. The pathway of external exposure would be the contaminated soil in the garden due to irrigation with contaminated water. The internal exposure pathways are considered when estimating the dose obtained by member of critical group of population as follows:

- inhalation of air contaminated with the dust suspended from soil during works in the garden;
- ingestion of contaminated water during drinking (in the case of well or lake);
- consumption of vegetables irrigated with contaminated water;

- consumption of meat and milk from the cattle watered with contaminated water;
- consumption of fish, caught in the contaminated lake;
- inadvertent ingestion of soil (e.g., particles of soil residual on vegetables).

The biosphere parameters necessary for the assessment of the exposure doses to the members of the critical group, are presented in documents [25, 45]. The biosphere parameter values assumed taking into account the local environmental conditions [46–48] are provided in Table 3.21.

Table 3.21. Biosphere parameters

Parameter, units	**Value**
Area of Lake Druksiai, m^2	44 800 000
Depth of Lake Druksiai, m	8,2
Turnover of Lake Druksiai, years	3,4
* Yield of green vegetables, kg/m^2	1
* Yield of root vegetables, kg/m^2	0,7
** Consumption of meat and meat products, kg/year	70
** Consumption of milk and milk products, l/year	300
** Consumption of green vegetables, kg/year	36,5
** Consumption of root vegetables, kg/year	130
** Consumption of fish, kg/year	30
** Water drinking, l/year	600

* Values below averages were selected for yield parameters since it results higher concentrations of radionuclides and consequently higher exposure doses.
** Values above averages were selected for consumption parameters since it results higher exposure doses.

Well model and lake model used for the assessment of the radionuclide transport as well as the exposure doses are presented in the report [25].

An annual dose, Sv/year, due to the external exposure to contaminated soil, is calculated using following expression [25]:

$$D_{ext} = t_{\exp} c_{ts} \rho_p \left(1 - \varepsilon_{ts}\right) DC_{ext,gr}, \quad (3.3)$$

where

t_{exp} – time spent in the garden per year, h;
c_{ts} – value of specific activity of a radionuclide in the topsoil, Bq/kg;
ρ_p – soil density, kg/m^3;
ε_{ts} – porosity of soil;
$DC_{ext,gr}$ – dose conversion factor, $(Sv/h)\times(Bq/m^3)^{-1}$.

An annual dose, Sv/year, due to inhalation of dust suspended from contaminated soil is calculated by expression [25]:

$$D_{inh} = t_{exp}\, Inh\, c_{dust}\, c_{ts}\, DC_{inh}, \quad (3.4)$$

where

t_{exp} – time spent in the garden per year, h;

Inh – inhalation rate, m^3/h;
c_{dust} – dust concentration during the works in the garden, kg/m^3;
c_{ts} – value of specific activity of a radionuclide in the topsoil, Bq/kg;
DC_{inh} – dose conversion factor, Sv/Bq.

An annual dose, Sv/year, due to ingestion is calculated according to the expression [25]:

$$D_i = Cons_i \, c_i \, DC_{ing} , \quad (3.5)$$

where
$Cons_i$ – consumption of water, foodstuff (vegetables, meat and milk) or inadvertent ingestion of soil, l/year or kg/year;
c_i – specific activity or activity concentration of radionuclide in water, soil or foodstuff, Bq/kg or Bq/l;
DC_{ing} – dose conversion factor, Sv/Bq.

An annual dose, Sv/year, received by a member of the critical group of the population due to consumption of contaminated water from the well, lake or drainage channel, is calculated according to the following formula [25]:

$$D_{sum} = D_{ext} + D_{inh} + \sum_i D_i , \quad (3.6)$$

where the terms of the equation are calculated using the formulas 3.3 – 3.5.

The radionuclide migration in the biosphere and the exposure doses are estimated using the program *AMBER* [49].

Estimations of the maximal values of the annual effective dose received by the member of the critical group of the population when using water from the well, lake or the drainage channel in case of natural evolution of the disposal facility as well as in case of sudden degradation of the engineering barriers are presented in Table 3.22.

Table 3.22. Maximal values of the effective dose received by the member of the critical group of the population when using contaminated water for everyday needs

Radio nuclide	**Half-life, Years**	**Maximal values of the effective dose, mSv/year**				
		Natural evolution scenario		**Barrier degradation scenario**		
		Well	**Drainage channel**	**Well**	**Drainage channel**	**Lake 1)**
^{14}C	5.73E+03	2.71E-04	1.76E-04	2.74E-04	1.87E-04	3.70E-05
^{54}Mn	8.56E-01					
^{55}Fe	2.70E+00					
^{59}Ni	7.54E+04	5.36E-06	7.12E-06	5.36E-06	7.13E-06	4.83E-10
^{60}Co	5.27E+00					
^{63}Ni	9.60E+01					
^{65}Zn	6.68E-01					
^{90}Sr	2.91E+01	3.90E-19	2.11E-15	7.26E-19	3.64E-15	

Radio nuclide	Half-life, Years	Maximal values of the effective dose, mSv/year				
		Natural evolution scenario		Barrier degradation scenario		
		Well	Drainage channel	Well	Drainage channel	Lake 1)
^{93m}Nb	1.36E+01					
^{94}Nb	2.03E+04	5.05E-04	1.59E-03	5.06E-04	1.59E-03	1.00E-07
^{93}Zr	1.53E+06	3.09E-07	8.81E-06	3.09E-07	8.80E-06	3.22E-09
^{99}Tc	2.13E+05	8.62E-07	2.18E-05	8.85E-07	2.24E-05	3.91E-09
^{110m}Ag	6.84E-01					
^{129}I	1.57E+07	2.08E-05	2.67E-05	2.08E-05	2.68E-05	9.60E-08
^{134}Cs	2.06E+00					
^{137}Cs	3.00E+01					
^{234}U	2.45E+05	3.86E-08	5.95E-07	3.86E-08	5.94E-07	1.70E-10
^{235}U	7.04E+08	8.11E-10	1.29E-08	8.11E-10	1.29E-08	3.65E-12
^{238}U	4.47E+09	1.22E-08	1.93E-07	1.22E-08	2.13E-07	5.48E-11
^{237}Np	2.14E+06	5.43E-09	9.18E-08	5.46E-09	9.24E-08	4.37E-11
^{238}Pu	8.77E+01					
^{239}Pu	2.41E+04	4.57E-07	6.92E-06	4.57E-07	6.92E-06	1.29E-11
^{240}Pu	6.54E+03	1.29E-10	1.50E-08	1.30E-10	1.50E-08	1.01E-16
^{241}Pu	1.44E+01					
^{241}Am	4.32E+02				2.29E-25	
^{244}Cm	1.81E+01					
	Total:	**8.04E-04**	**1.83E-03**	**8.08E-04**	**1.85E-03**	**3.72E-05**

1) The radionuclide transfer into the lake has been analysed only for more conservative case of sudden degradation of the engineering barriers of the disposal facility.

As it can be seen from Table 3.22, the highest value of the annual effective dose received by the member of the critical group of the population due to possible releases of radionuclides into the water environment would be 0.0018 mSv. As it is indicated in Table 3.22, the total dose is mainly caused by ^{14}C and ^{94}Nb. Therefore, when analyzing the uncertainties due to the change of the nuclide vector, only the above mentioned radionuclides were considered. It can be seen from Table 1.13 that in most unfavourable case when disposing of the waste type 1 waste from building V1 (according to the preliminary estimation it would make only about 4–5% of total waste mass), the activity of ^{14}C would increase by factor of 1 300, but the activity of ^{94}Nb would decrease by factor of 3 in comparison to the waste from the building G1. The total annual dose would be approximately 0,09 mSv, i.e. about factor of 50 higher. However, it still would be more than twice less in comparison with the value of the dose constraint 0.2 mSv per year [20].

As mentioned in Section 2.4.9.3.2 all acceptance criteria were estimated: X, Y and Z (see Section 1.6.5) regardless of the nuclide vector, values of exposure dose do not exceed the limit values, whereas when defining the maximum values of activities, intended to be stored at the buffer storage and disposed at the Landfill facility (Table 1.13).

Modelling uncertainties for the waterborne radionuclide transport from the near surface repository of RAW were analyzed in the study [57]. It was found that relatively higher uncertainties may occur due to uncertainties of the biosphere parameters: the difference between the maximum dose values obtained from modelling the parameters of radionuclide (^{14}C) transfer in the biosphere using statistical Monte-Carlo method and the most probable dose values was estimated to be 30%. Difference up to 20% was determined when applying different mathematical models for analysis of migration of radionuclides (^{14}C), realized in DUST, GWSCREEN and AMBER software.

As mentioned above in case of the Landfill facility the annual effective exposure dose due to possible waterborne release of radionuclides is stipulated by radionuclides ^{14}C and ^{94}Nb. The statistical modelling of the transfer parameters (the probability distribution functions and the values of their parameters are given in the reports [25, 45]) in the biosphere for indicated radionuclides (for the evaluation the well model was selected, since it estimates more exposure pathways in comparison with the drainage channel model. Water consumption for drinking was assessed additionally) demonstrates that the maximum dose values obtained from the statistical modelling would be about 40% higher than the values presented in Table 3.22 for ^{14}C radionuclide and about 10 times higher for ^{94}Nb radionuclide.

It was additionally analyzed the effect of uncertainties of the geosphere parameters on the results in the present work. Since the upper layer of the vadose zone (sand layer 2 m thickness) will be changed to the utmost during the smoothing and preparing the basis for the reinforced concrete slab, the influence of uncertainties of the parameters of this layer on dose values was examined. Pessimistic values of the geosphere parameters were selected for the analysis, i.e., the values resulting in increased values of doses in case of the scenario of natural evolution of the repository, i.e., 30% lower value of effective porosity, 30% lower value of density, 30% lower values of sorption coefficient, and 30% lower value of the layer thickness. For the aquifer the flow rate of pore water was chosen 30% higher. It was found that in case of the pessimistic values of the geosphere parameters, the dose due to the radionuclide ^{14}C would increase by 33%, and the dose due to the radionuclide ^{94}Nb - 10%, i.e., in total due to the two radionuclide determining the dose - about 43%. The highest impact on the increase of the dose value would be due to uncertainties of the values of density (about 12%) and sorption coefficients (about 12%), which directly affect the value of delay coefficient. Uncertainties of the porosity value would have a minimum impact (about 1%).

Finally it can be stated that uncertainties of the geosphere, biosphere and mathematical model parameters would result higher value of the total annual dose by factor of 11, but it would still remain by an order of magnitude lower in comparison with the value of the dose constraint 0.2 mSv per year [20].

No impact mitigation measures are foreseen.

As it was mentioned in section 2.4.9.3.2, regardless of the nuclide vector the values of the exposure doses do not exceed the value limits, since when determining the maximal values of activities, provided for disposal at the *Landfill* facility (Table 1.13), there were estimated all the acceptance criteria: X, Y and Z (see Chapter 1.6.5).

3.4.9.3.3 Radiological Impact due to Radionuclide Release into Atmosphere

Potential gaseous releases of radionuclides (^{14}C) from the disposal units, which have been estimated in section 3.4.2.3, can cause the exposure to the member of the critical group of the population. The exposure pathway is through the inhalation. The estimation of volumetric activity of the contaminated air is performed according to the following mathematical expression [18]:

$$D_{inh} = C_{air,gas} t_{out}\, b_r\, DC_{inh}, \qquad (3.7)$$

here:

$C_{air,gas}$ –volumetric activity of the gas, Bq/m^3;
t_{oym} – time, spent in the contaminated air per year, h;
b_r – inhalation rate, m^3/h;
DC_{inh} – dose conversion factor, Sv/Bq.

The methodology of estimation of volumetric activity of radioactive gases in the air is presented in the document [18]. It is assumed that the member of the critical group of the population residing at the boundary of SPZ permanently will spend in the contaminated air a half of a year (i.e. 4380 hours per year will be spent outside the house) within period of 20 years. Inhalation rate is 1.0 m^3/h. It is estimated that the annual effective dose received through inhalation pathway would be approx. 5.6E-07 mSv per year, i.e. negligible in comparison with the value of the dose constraint 0.2 mSv per year, specified in the Lithuanian Hygiene Standard [17]. Therefore no impact mitigation measures are foreseen.

3.4.9.3.4 Radiological Impact due to Direct Irradiation from the disposal facility

The total volume of the disposed packed RAW covered with surface engineering barriers has been assumed as a radiation source for the estimation of radiological impact due to direct radiation from the *Landfill* disposal units. The waste in the package was homogenized and described as a rectangular parallelepiped with dimensions that equals to the internal dimensions of three disposal units when developing a model of the radiation source (see Figure 3.42). Regarding that the highest quantity of incombustible waste is metal waste, the steel with the equivalent density calculated from the waste mass in the disposal facility and its internal dimensions, has been assumed as a material-equivalent for non-combustible RAW. The estimation of activity of the waste planned to be disposed in the disposal facility, is presented in Table 1.13, section 1.6.5. Characteristics of the surface engineering barriers (the top protective layer, the drainage layer and the smoothing layer) taken into consideration during the analysis, are provided in Table 3.7 of the chapter.

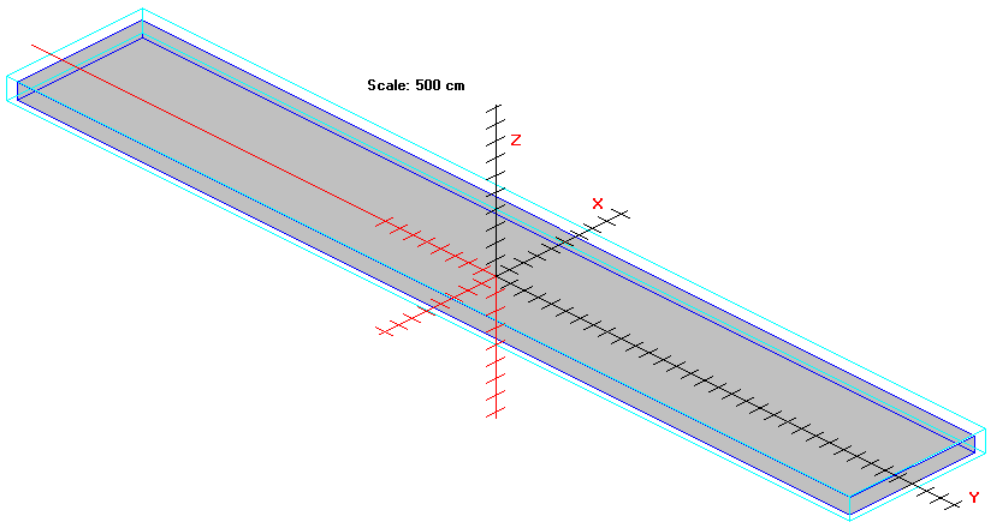


Figure 3.42. 3-D model of the *Landfill* disposal facility

In order to evaluate gamma radiation dose rate computer software VISIPLAN [50] was used. This programme is used to calculate gamma dose rate for three-dimensional, simple or complex geometry. Calculation of dose rate from ionizing radiation sources with this programme is performed with the help of division into point sources method (“point-kernel”). The main entry data of VISIPLAN is geometry of the analysed system (radioactive sources, shields, etc.), material composition and density, radiation source parameters and coordinates of points where dose rate must be estimated. Calculations of the dose rate caused by the radiation scattered in the atmosphere (skyshine) through the surface engineering barriers of the *Landfill* facility, are carried out using computer program MICROSKYSHINE [51].

The dependence of dose rate resulted from disposal units against distance is presented in Figure 3.43.

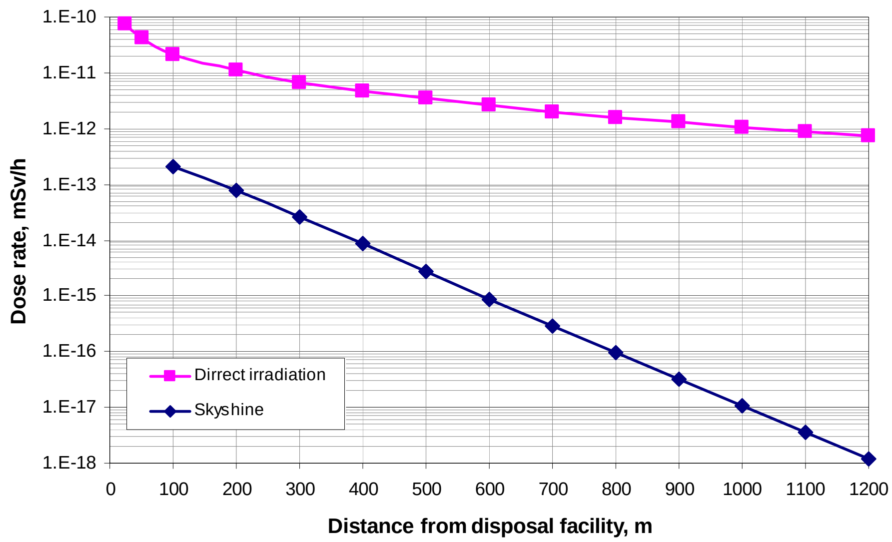


Figure 3.43. The dose rate caused by the radiation from the *Landfill* disposal facility

It is estimated that the member of the critical group 1 (see description in section 2.9.4.3.2) would receive an annual dose of approximately 3.1E-08 mSv under the conservative assumption that the he would spend 730 hours per year at the nearest distance (25 m) from the disposal facility inside the existing INPP SPZ. Assuming that the member of the critical group 2 residing at the boundary of SPZ permanently would spend 8 760 hours per year (i.e. all the year round) at the distance of about 1 200 m from the disposal facility (at the boundary of the INPP SPZ), he would receive an annual dose of about 6.6E-09 mSv. In summary, the total dose due to the direct irradiation as well as due to the radiation scattered in the atmosphere (skyshine) should be negligible values, therefore no impact mitigation measures are foreseen.

3.4.9.3.5 Radiological Impact due to Unintended Intrusion into the Disposal Facility

It is expected that an unintended intrusion into the repository can occur after the institutional control period when the restrictions on the land use as well as on activity in the repository site have already been withdrawn. Usually it is represented by two scenarios, i.e. the on-site residence scenario and the road construction scenario.

3.4.9.3.5.1 On-Site Residence Scenario

The scenario is analysed assuming that after the period of institutional control (100 years) restrictions on the land use will be withdrawn and it is quite possible that people should dwell on the site.

It is assumed that ground volume of 200 m^3 (10 m×6.6 m×3 m) should be excavated for the installation of the house foundation. The radioactive waste should be mixed with excavated ground (top layers of the disposal facility). Dilution factor depends on the proportion of excavated radioactive waste to the total amount of excavated ground. It equals to 1/3 (2 m of surface barrier layers and 1 m of RAW). Excavated ground should be distributed in the square of 10 areas of ground in layer of the 20 cm thick.

The excavated ground should be diluted once more, as the certain amount of soil should be brought from outside for the arrangements of the environment as well as for installation of the garden. Assuming that the soil brought from outside should be distributed in the layer of 10 are area of 50 cm thick the dilution factor equals to 0.25.

The conceptual model of radionuclide migration and exposure pathways in case of on-site residence scenario is presented in Figure 3.44.

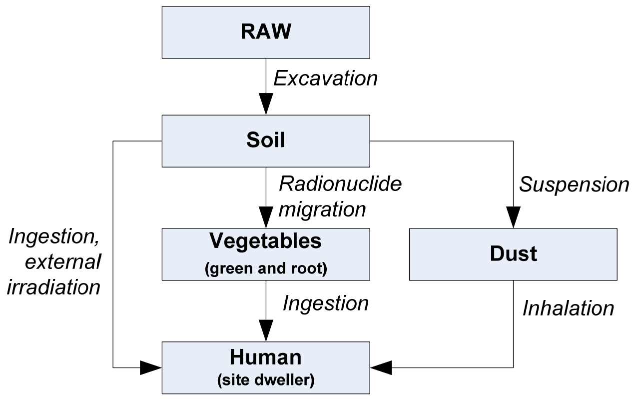


Figure 3.44. The conceptual model of radionuclide migration and exposure pathways in case of on-site residence scenario

When living in a house constructed at the site of the disposal facility, they would receive the doses caused both by external exposure from the soil mixed with the waste and by internal exposure from inhalation of dust and consumption of vegetables grown up in a garden, located at the territory of the disposal facility, next to the house.

Activity of radionuclides is calculated using the following formula [22]:

$$A_{res} = A_m e^{-\lambda t} dil_1, \tag{3.8}$$

where

A_m – initial value of specific activity of the disposed waste, Bq/kg;
λ – decay constant, year^{-1};
t – duration of institutional control period, years;
dil_1 – dilution coefficient in case of on-site residence.

A dose received in case of the on-site residence scenario is estimated as follows [22]:

$$D_{sum} = D_{ext} + D_{inh} + D_{ing}, \tag{3.9}$$

where:

D_{ext} – dose due to external exposure calculated according to the formula [22]:

$$D_{ext} = A_{res}\left(sf \cdot t_{in} + t_{out}\right)DC_{ext,gr}, \tag{3.10}$$

where

A_{res} – estimated value of specific activity of waste, Bq/kg;
sf – shielding factor;
t_{in} – time spent inside the house, h per year;
t_{out} – time spent outside the house, h per year ;

$DC_{ext,gr}$ – dose conversion factor, (Sv/h)×(Bq/kg)$^{-1}$.

D_{inh} – dose due to inhalation calculated according to the formula [22]:

$$D_{inh} = A_{res}\left(dust_{in} Inh_{in} t_{in} + dust_{out} Inh_{out} t_{out}\right) DC_{inh}, \quad (3.11)$$

where

A_{res} – estimated value of specific activity of waste, Bq/kg;
$dust_{in}$, $dust_{in}$ – dust concentration inside and outside the house respectively, kg/m^3;
Inh_{in}, Inh_{out} – inhalation rate inside and outside the house respectively, m^3/h;
t_{in} – time spent inside the house, h per year;
t_{out} – time spent outside the house, h per year;
DC_{inh} – dose conversion factor, Sv/Bq.

D_{ing} – dose due to ingestion calculated according to the formula [22]:

$$D_{ing} = A_{res}\left(TF_{veg} Cons_{veg} + Cons_{soil}\right) DC_{ing}, \quad (3.12)$$

where

A_{res} – calculated value of specific activity of waste, Bq/kg;
TF_{veg} – activity transfer coefficient from soil to plant, (Bq/kg)/(Bq/kg);
$Cons_{veg}$ – consumption of vegetables per year, kg/year;
$Cons_{soil}$ – inadvertent ingestion of soil per year, kg/year;
DC_{ing} – dose conversion factor, Sv/Bq.

The input values of specific activities are presented in Table 1.13, section 1.6.5. Parameter values assumed for the assessment of the impact in case of the residence scenario, are presented in Table 3.23.

Table 3.23. Parameters for the on-site residence model

Title	Value
* Dilution factor (dil_1):	0.3
** Second dilution	0.25
* Shielding coefficient (*sf*):	0.10
* Time spent indoors (t_{in}), h/yr:	6 575
* Time spent outdoors (t_{out}), h/yr:	2 191
* Indoor dust level ($dust_{in}$), kg/m^3:	1.0×10^{-8}
* Outdoor dust level ($dust_{out}$), kg/m^3:	2.0×10^{-8}
* Indoor breathing rate ($b_{r,in}$), m^3/h:	0.75
* Outdoor breathing rate ($b_{r,out}$), m^3/h:	1.0
** Consumption rate of green vegetables (Q_{gveg}), kg/yr:	36.5
** Consumption rate of root vegetables (Q_{rveg}), kg/yr:	130.0
* Inadvertent soil ingestion (Q_{soil}), kg/yr	0.03

* Values from document [22]
** Values relevant to local conditions.

The activities as well as exposure doses are estimated using *MS Excel* program. The assessment results, i.e. the maximal values of the annual effective doses received by the member of the critical group of the population in case of residence scenario are presented in Table 3.24.

Table 3.24. Maximal exposure doses for the member of critical group in case of residence scenario

Radionuclide	Half-life, years	Maximal value of effective dose, mSv/year
^{14}C	5.73E+03	4.5E-06
^{54}Mn	8.56E-01	-
^{55}Fe	2.70E+00	3.9E-16
^{59}Ni	7.54E+04	4.8E-07
^{60}Co	5.27E+00	1.6E-06
^{63}Ni	9.60E+01	6.7E-05
^{65}Zn	6.68E-01	-
^{90}Sr	2.91E+01	2.9E-04
^{93m}Nb	1.36E+01	2.1E-07
^{94}Nb	2.03E+04	1.2E-02
^{93}Zr	1.53E+06	1.8E-08
^{99}Tc	2.13E+05	1.4E-05
^{110m}Ag	6.84E-01	-
^{129}I	1.57E+07	2.0E-07
^{134}Cs	2.06E+00	5.5E-17
^{137}Cs	3.00E+01	9.3E-03
^{234}U	2.45E+05	5.3E-09
^{235}U	7.04E+08	3.5E-10
^{238}U	4.47E+09	2.8E-09
^{237}Np	2.14E+06	1.5E-09
^{238}Pu	8.77E+01	1.3E-06
^{239}Pu	2.41E+04	1.5E-06
^{240}Pu	6.54E+03	2.6E-06
^{241}Pu	1.44E+01	2.9E-08
^{241}Am	4.32E+02	3.7E-06
^{244}Cm	1.81E+01	4.2E-08
	Total:	**2.2E-02**

It is demonstrated in Table 3.24, that the maximal value of the exposure doses received by the member of the critical group of the population in case of the residence scenario should be approx. 0.022 mSv per year, i.e. negligible in comparison with the value of 10 mSv per year used for such cases and based on clause 91 of document [20] accepted according to the recommendations of document [21]. It is presented in Table 3.24 that the total dose is mainly caused by ^{94}Nb and ^{137}Cs. Therefore, when analyzing the uncertainties due to the change of the nuclide vector, only the above mentioned radionuclides were considered. The ratio of activities of indicated radionuclides from the other buildings to corresponding activity values of RAW from the bld. V1 presented in Table 1.13 is less than 1. Therefore the most unfavourable case is considered, i.e. the lesser dose value should be resulted in case of RAW from the other than G1 buildings.

3.4.9.3.5.2 Road Construction Scenario

Similar to case of residence scenario, it is assumed that restrictions on land use should be cancelled after the period of institutional control. Then it is rather possible that road construction through the site should occur. In that case the workers will receive doses caused both by external exposure from the uncovered radioactive waste mixed with soil and construction material, and by internal exposure through inhalation of dust and inadvertent ingestion of soil particles.

It is assumed that two disposal units should be disturbed due to road construction. Excavation depth of 6 m is considered. The excavated radioactive waste should be mixed with top layers of *Landfill* disposal facility as well as with construction materials. The construction duration for 360 m of the road is estimated to 160 h (by methodology presented in IAEA document [22])

The conceptual model of radionuclide migration and exposure pathways in case of road construction scenario is presented in Figure 3.45

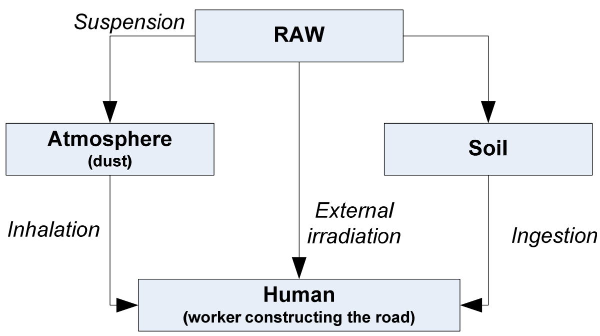


Figure 3.45. The conceptual model of radionuclide migration and exposure pathways in case of a road construction in the territory of the disposal facility

Activity of radionuclides is calculated using the following formula [22]:

$$A_{res} = A_m e^{-\lambda t} dil_2 \,, \tag{3.13}$$

where

A_m – initial value of specific activity of the disposed waste, Bq/kg;
λ – decay constant, year^{-1};
t – duration of institutional control period, years;
dil_2 – dilution coefficient in case of road construction.

An exposure dose received by a worker constructing a road is estimated by the expression [22]:

$$Dose = A_{res}\left(Cons_{soil}DC_{ing} + DC_{ext,gr} + Inh \cdot dust \cdot DC_{inh}\right)t\,, \tag{3.14}$$

where:

A_{res} – estimated value of specific activity of waste, Bq/kg;
$Cons_{soil}$ – inadvertent ingestion of soil per year, kg/year;
DC_{ing} – dose conversion factor for ingestion, Sv/Bq;
$DC_{ext,gr}$ – dose conversion factor for external exposure to ground, $(Sv/h)\times(Bq/kg)^{-1}$;
Inh – inhalation rate, m^3/h;
$dust$ – dust concentration during the road construction, kg/m^3;
DC_{inh} – dose conversion factor for inhalation, Sv/Bq;
t – duration of the road construction across the territory of the repository, h.

The input values of specific activities are presented in Table 1.13, section 1.6.5. Parameter values assumed for the assessment of the impact in case of the road construction scenario, are presented in Table 3.25

Table 3.25. Parameters for the road construction scenario

Title	Value
* Dilution factor (dil_2)	0.7
* Inadvertent soil ingestion, (Q_{soil}), kg/h	3.4×10^{-5}
* Breathing rate (b_r), m^3/h	1.2
* Dust level ($dust$), kg/m^3	1.0×10^{-6}
** Impact duration (t_2), hours	160

* Values from document [22].
** Values relevant to local conditions.

The activities as well as exposure doses are estimated using *MS Excel* program. The assessments results, i.e. the maximal values of the annual effective dose, received by the member of the critical group of the population in case of road construction scenario are presented in Table 3.26.

Table 3.26. Maximal exposure doses for the member of critical group in case of residence scenario

Radionuclide	Half-life, years	Maximal value of effective dose, mSv/year
^{14}C	5.73E+03	1.9E-08
^{54}Mn	8.56E-01	-
^{55}Fe	2.70E+00	2.8E-16
^{59}Ni	7.54E+04	4.8E-09
^{60}Co	5.27E+00	8.2E-07
^{63}Ni	9.60E+01	7.0E-07
^{65}Zn	6.68E-01	-
^{90}Sr	2.91E+01	4.1E-07

Radionuclide	Half-life, years	Maximal value of effective dose, mSv/year
^{93m}Nb	1.36E+01	1.7E-08
^{94}Nb	2.03E+04	6.3E-03
^{93}Zr	1.53E+06	1.9E-09
^{99}Tc	2.13E+05	5.9E-10
^{110m}Ag	6.84E-01	-
^{129}I	1.57E+07	6.4E-10
^{134}Cs	2.06E+00	2.6E-17
^{137}Cs	3.00E+01	4.1E-03
^{234}U	2.45E+05	4.5E-09
^{235}U	7.04E+08	2.2E-10
^{238}U	4.47E+09	1.9E-09
^{237}Np	2.14E+06	1.6E-09
^{238}Pu	8.77E+01	7.4E-06
^{239}Pu	2.41E+04	8.5E-06
^{240}Pu	6.54E+03	1.4E-05
^{241}Pu	1.44E+01	1.6E-07
^{241}Am	4.32E+02	1.7E-05
^{244}Cm	1.81E+01	1,.E-07
	Total:	**1.0E-02**

It is demonstrated in Table 3.26, that the maximal value of the exposure doses received by the member of the critical group of the population in case of the residence scenario should be approx. 0.022 mSv per year, i.e. negligible in comparison with the value of 10 mSv per year, used for such cases and, based on clause 91 of document [20], accepted according to the recommendations of document [21]. It is presented in Table 3.26 that the total dose is mainly caused by ^{94}Nb and ^{137}Cs. Therefore, when analyzing the uncertainties due to the change of the nuclide vector, only the above mentioned radionuclides were considered. The ratio of activities of indicated radionuclides from the other buildings to corresponding activity values of RAW from the bld. V1 presented in Table 1.13 is less than 1. Therefore the most unfavourable case is considered, i.e. the lesser dose value should be resulted in case of RAW from the other than G1 buildings.

3.4.9.3.6 Impact of the Existing and Planned Nuclear Facilities

The *Landfill* disposal facility will be constructed in the INPP industrial site with the existing 3 km radius sanitary protection zone (SPZ). For the purposes of dose assessment with regard to the dose constraint, the contribution of doses from the other existing and planned nuclear facilities located in the INPP sanitary protection zone must also be considered.

Existing and planned nuclear facilities located at the Ignalina NPP site and considered in this assessment are as follows:

- Ignalina NPP;

- New NPP;
- Existing SNF storage;
- New ISFSF (project B1);
- New SWMSF (projects B2/3/4);
- Building 158 (bituminised waste storage facility transformed into the repository) and new interim storage facility for solidified radioactive waste (bld.158/2);
- *Landfill* buffer storage facility;
- Near-surface repository for low and intermediate level RAW.

The layout of the objects indicated above and the site of *Landfill* disposal facility are shown in Figure 3.46.

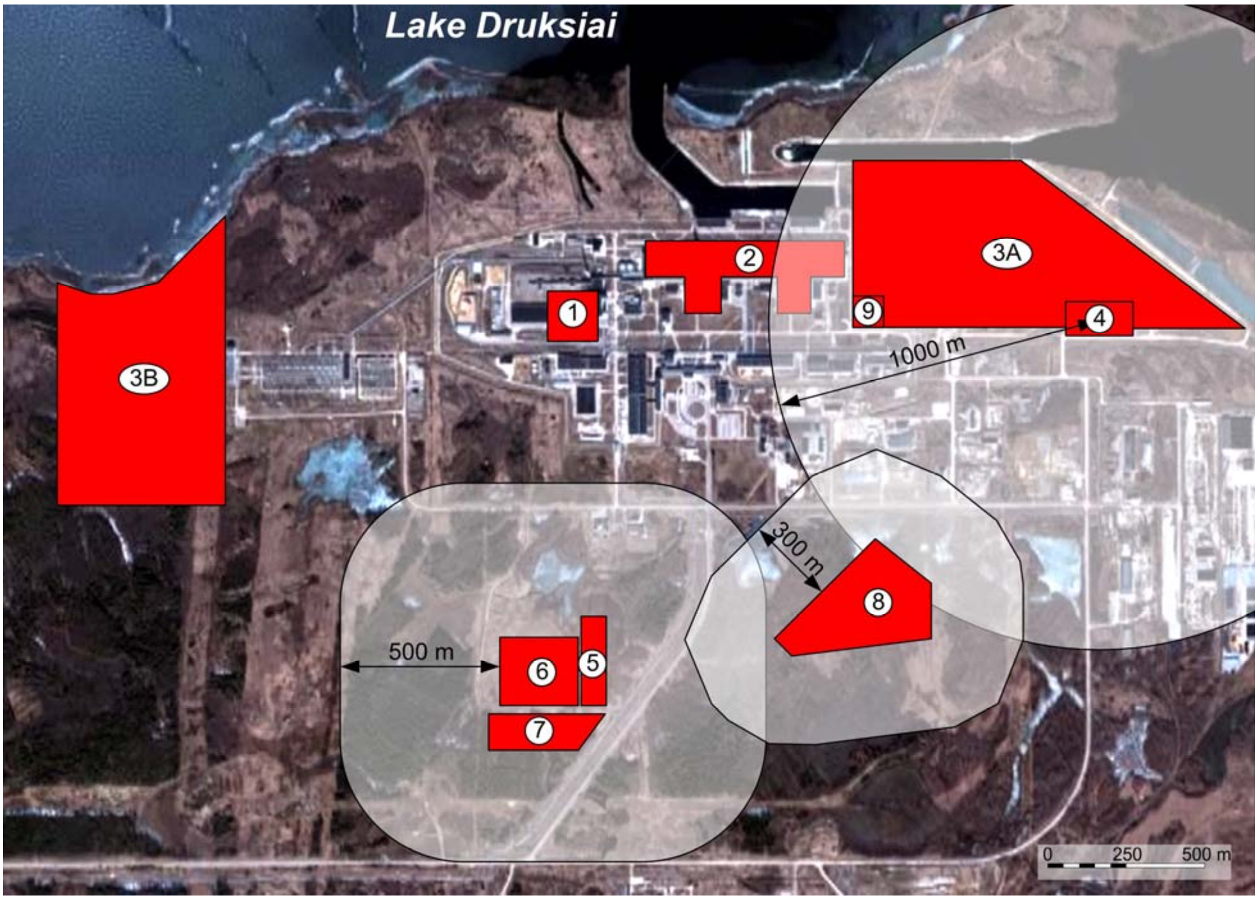


Figure 3.46. Existing and planned nuclear facilities at the Ignalina NPP site:

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 (B1); 6 – new SWTSF (B3/4); 7 – disposal units of the *Landfill* facility; 8 – near-surface repository for low and intermediate level RAW; 9 – *Landfill* buffer storage facility

Activity phases (operation, decommissioning, institutional control, etc.) of the nuclear facilities are summarized in Figure 3.47.

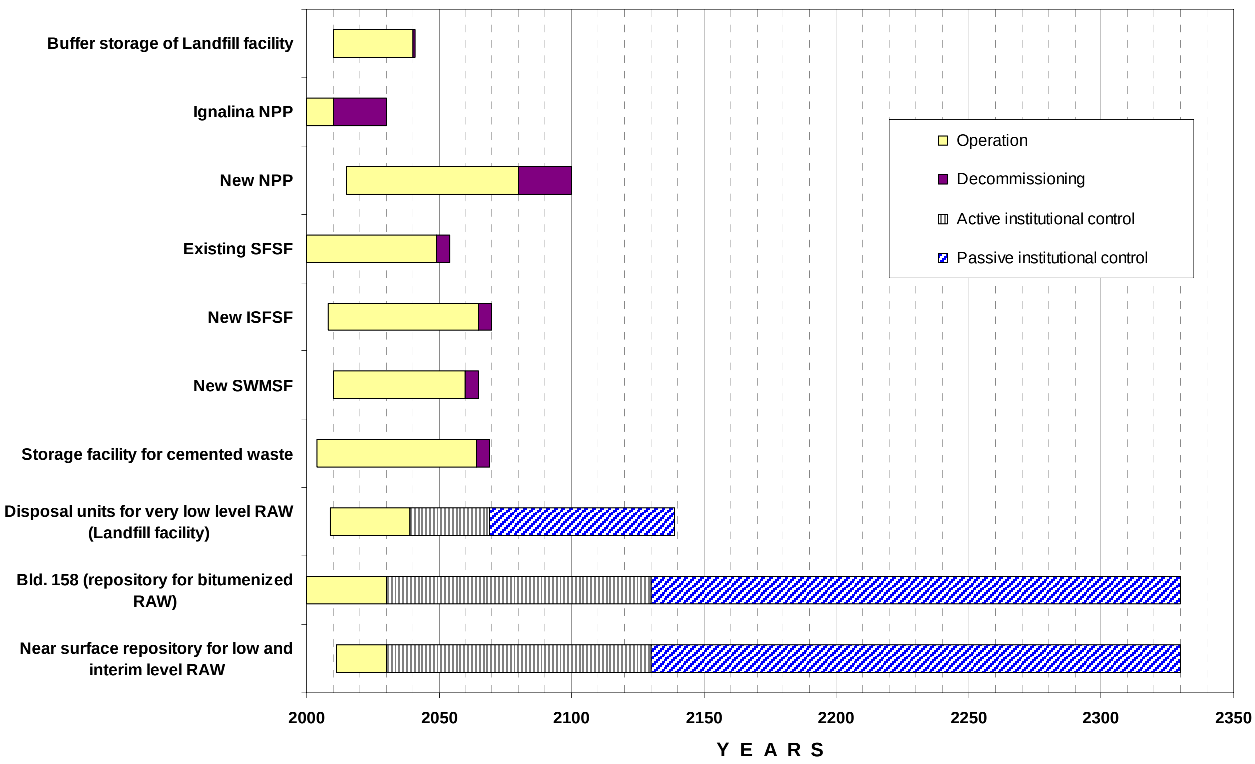


Figure 3.47. Main activity phases of the existing and planned nuclear facilities, located in the existing Ignalina NPP sanitary protection zone of 3 km radius

It is demonstrated in Figure 3.47, that the INPP decommissioning activity will be finished after the active institutional control period of the *Landfill* disposal facility. The institutional control of the repository of bituminized RAW, institutional control period of surface repository for low and interim level RAW as well as operation of the new NPP will be going on within passive institutional control period of the *Landfill* disposal facility

3.4.9.3.6.1 Assessment of Potential Impact during Operation Period of the *Landfill* Disposal Facility

Impact of Radionuclide Releases

Radionuclide Releases from the Existing Facilities in the SPZ of INPP

According to the data in the report [33], doses due to the waterborne release to Lake Druksiai and airborne release from the NEO in the INPP site are presented in Figure 3.48. 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 [20]). 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).

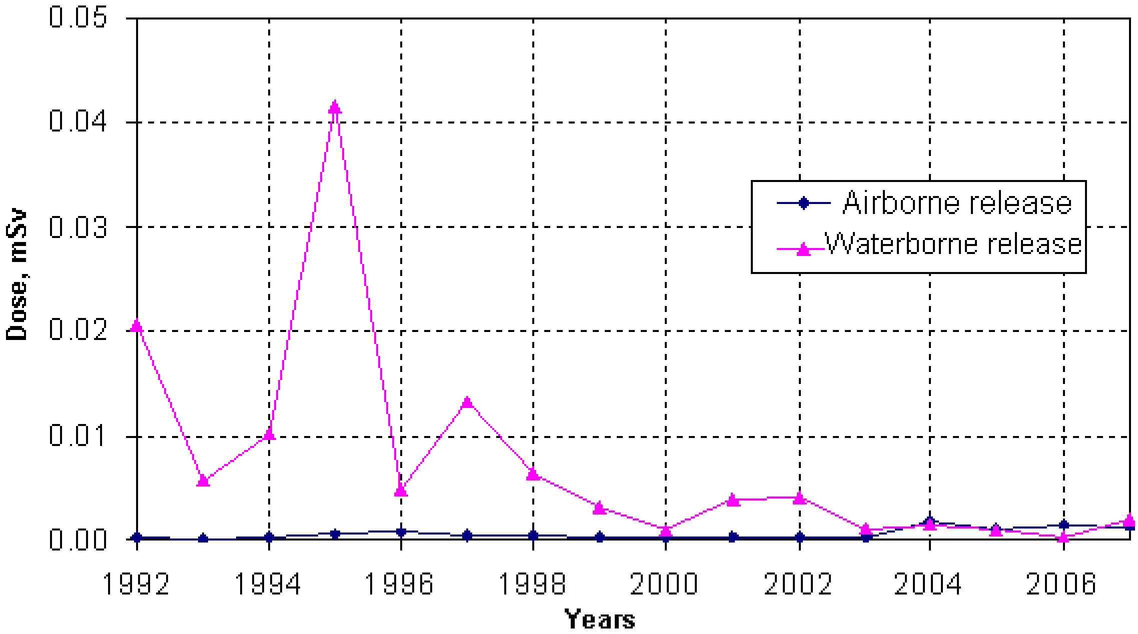


Figure 3.48. Annual effective dose to the critical group member of population due to radionuclide releases (airborne emissions and waterborne discharges) from the nuclear facilities located in the SPZ of INPP for time period 1992 – 2007 [33]

It is 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 emission is 1.9E-03 mSv (year 2004 dose), and due to waterborne releases is 4.19E-03 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) [52]. The U1DP0 activities are planned to be implemented in years from 2005 to 2012;
- Operation of the new Cement Solidification Facility for liquid radioactive waste solidification and of the Interim Storage Building for the storage of solidified waste [53]. 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 discharges from the existing nuclear facilities in the SPZ of INPP is summarized in Figure 3.49. It can be seen that the doses due to airborne emissions and liquid discharges from the existing nuclear facilities in the SPZ of INPP are low. The observed dose maximum (9.69E-03 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 (3.69E-03 mSv) and the assumption that the doses resulting from the operation of INPP (6.09E-03 mSv) are still relevant.

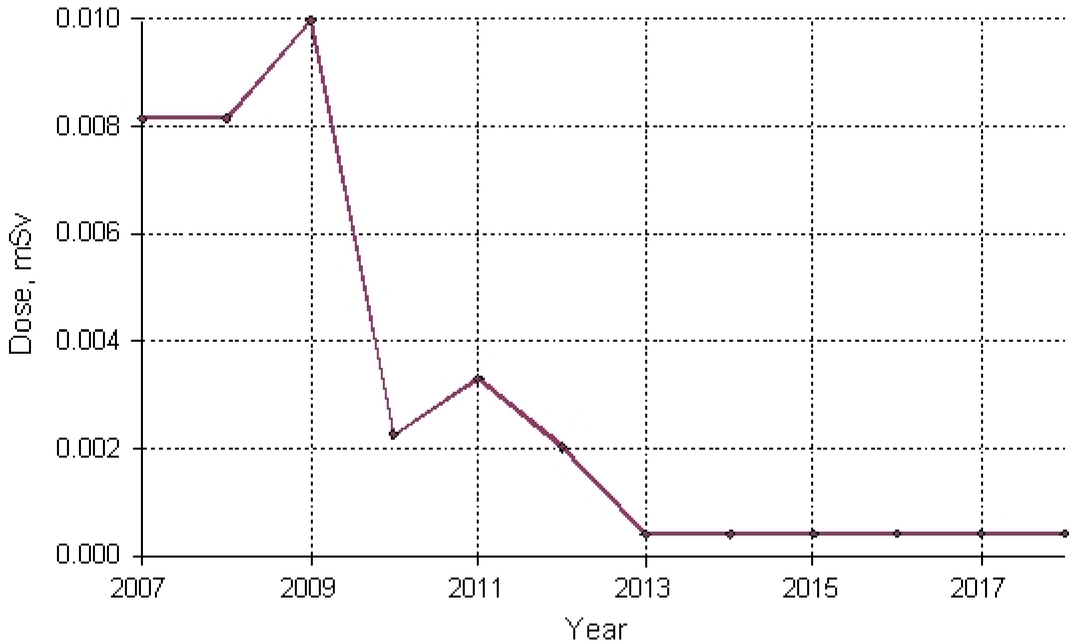


Figure 3.49. Forecast for the dose to the critical group member of population due to radionuclide releases (airborne emissions and waterborne discharges) from the nuclear facilities located in the SPZ of INPP

The dose forecast as presented in Figure 3.49 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 radionuclide 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 the Reactor Unit 2 in several years after the final reactor shutdown. In comparison to activities at the Reactor Unit 1, the equipment in-line decontamination at the Reactor Unit 2 could start in shorter time after the final reactor shutdown. Therefore the activity of the released radionuclides (short-lived Mn-54, Fe-55, Co-58, Co-60, Cs-134, etc.) will be higher and could result in higher doses as compare to the doses from the similar U1DP0 activities. It is anticipated that equipment in-line decontamination at the Reactor Unit 2 can stipulate approximately two times higher annual dose to the critical group member of population (i.e. up to 8.00E-03 mSv). Therefore it is forecasted that during years 2008–2018 the annual effective dose due to airborne emissions and liquid discharges from the existing nuclear facilities in the SPZ of INPP will be below 1E-02 mSv.

No dose estimations due to radionuclide releases during further decommissioning projects for existing INPP facilities are available at the moment. EIA Program of INPP decommissioning [54], provides that every subsequent environmental impact assessment shall take into account the results of previous reports.

Impact due to Radionuclide Releases from the Newly Planned Facilities in the INPP SPZ

This chapter presents estimation of radionuclide releases from the newly planned facilities in the INPP SPZ during operation of the *Landfill* facility and considers radionuclide releases from this proposed economic activity (*Landfill* facility), the new Solid Waste Management and Storage Facility (SWMSF), the new Interim Spent Nuclear Fuel Storage Facility (ISFSF) and the newly planned nuclear power plant.

The estimation of doses resulting from airborne emissions from the **buffer storage** is presented in Chapter 3.4.9.3.3. The conservatively estimated annual effective dose to the critical group member of population due to radionuclide releases from the buffer storage is lower than 2.54E-06 mSv.

Impact assessment due to discharges from the ***Landfill* disposal units** is presented in Chapter 3.4.9.3.3. Annual effective dose to a member of the critical group of population, caused by radionuclide releases from the disposal units, will be below 6E-07 mSv.

The impact from **SWMSF** is assessed in the EIA Report for SWMSF [55]. The conservatively estimated annual effective dose to the critical group member of population due to radioactive airborne emissions is about 7.79E-03 mSv.

The impact from **ISFSF** is assessed in the EIA Report for ISFSF [56]. The conservatively estimated annual effective dose to the critical group member of population due to radioactive airborne emissions stipulated by the SNF handling at the Reactor Units and ISFSF will not exceed 4.15E-04 mSv. It is planned that by the year 2016 the 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 in the FIHC of ISFSF additional exposure of up to 1.46E-04 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 probable. The cask will be designed as double-barrier welded system for the 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.

"Lietuvos Energija AB" in year 2007 has initiated an environmental impact assessment procedure aiming to assess the environmental impact of the proposed economic activity "New nuclear power plant (new NPP) in Lithuania". The total electricity production of new nuclear power plant would be at most 3400 MW. Possible technological alternatives for the new nuclear power plant are as follows: boiling water reactors, pressurized water reactors or pressurized heavy water reactors. It is planned that at least the first unit of the new nuclear power plant is in operation not later than 2015. The operation of the new reactors would last about 60 or more years.

The new NPP impact has been estimated in the EIA report [57]. The impact on a member of the critical group of the population has been estimated using the dose conversion factors, presented in the appendix of the normative document LAND 42-2007. Depending on the type of the reactor, capacity and quantity of the units of the new nuclear power plant the annual dose of a member of the critical group of the population due to the activity of environmental (airborne and waterborne) radionuclide releases varies from 0.0042 to 0.033 mSv.

<u>Summary of the Expected Impact of the Radionuclide Releases</u>

Forecast of the maximal annual effective dose to the critical group member of population due to radionuclide releases (airborne emissions and liquid discharges) from the existing and planned nuclear facilities located in the SPZ of INPP is summarized in Table 3.27.

Table 3.27 lent. Forecast of the radionuclide releases impact

NEO	Dose due to radionuclide releases, mSv/y
Landfill disposal units	5.6E-07
Buffer storage	2.54E-06
SWMSF	7.79E-03
ISFSF	4.15E-04

NEO	Dose due to radionuclide releases, mSv/y
SNF reloading at ISFSF	1.46E-04
New NPP	3.30E-02
INPP	1.00E-02
Total:	**5,14E-02**

It is demonstrated in Table 3.27, that the most contribution to the total dose resulted from the radionuclide releases is due to INPP decommissioning activity in the INPP industrial site and due releases from the planned new NPP.

<u>Impact due to Direct Irradiation</u>

The monitoring of radiation fields performed in the INPP industrial site and its surroundings shows that increase in ionizing radiation dose rates is observed locally and only close to some of radioactive material handling facilities. Only in exceptional cases the increase of ionizing radiation dose rate is measured outside the border of INPP industrial site. Locally increased radiation fields are also registered around the existing SNF storage facility.

Potential changes in ionizing radiation fields resulting from modifications of the presently existing nuclear facilities and from construction of new nuclear facilities are discussed below.

It can be noted that during decommissioning of INPP the radioactive materials (spent nuclear fuel, radioactive waste, etc.) will be removed from the buildings and storage facilities located at the INPP site. Therefore with the reactors final shutdown and progress in decommissioning the radiation fields in the INPP industrial site should only to decrease.

<u>*Landfill* Buffer Storage facility</u>

The external irradiation dose rate values from the radioactive waste in the buffer storage are presented in Chapter 2.4.9.3.4. It was demonstrated that the annual effective dose to a member of the critical group of population due to direct irradiation from the buffer storage structure on a border of the INPP industrial site in the shortest distance (i.e. 100 m) is about 3.6E-2 mSv assuming that the buffer storage is fully loaded with radioactive waste (220 half-height ISO containers for the whole year) and a member of the critical group of population will stay in a certain place of the INPP SPZ 730 hours per year. Considering the distance between the *Landfill* disposal facilities and the buffer storage facility (approx. 1 600 m), it is foreseen no impact to the radiological situation of the *Landfill* disposal facility due to operation of the buffer storage facility (impact assessment resulted from radionuclide releases to the atmosphere as well as from direct irradiation of the buffer storage facility see section 2.4.9.3).

<u>New Nuclear Power Plant</u>

The *Landfill* facility is foreseen to be arranged in the INPP sanitary-protection zone. The location for the new nuclear power plant is provided near to the INPP industrial site, within the same SPZ. The impact of direct radiation from the new nuclear power plant on a member of the critical group of the population has been estimated in the Environmental Impact Assessment Report of the new nuclear power plant [57], on the basis of the measurement data of the sensors of "Skylink" system presented in the INPP monitoring reports. On the basis of the measurements of this system, it can be seen that the doses registered within the INPP SPZ do not differ from the exposure due to the natural radiation. This is also confirmed by the measurements in the environments of power plants of other countries, where the registered doses do not differ from the natural background of ionising radiation. Therefore, as the document [57] affirms, the impact of direct irradiation is not significant and is not further considered.

Bituminised Waste Disposal Facility

The radiation fields monitoring data show that increase in ionizing radiation dose rate is observed only in some spots close to the Bituminized Waste Storage Facility building structure. No impact from ionizing radiation is present outside the INPP industrial site.

At present the storage facility is filled up to about of 60% of the design volume. Operational experience shows that filling of the storage facility with the waste results in insignificant changes of radiation fields.

New Interim Storage Facility for Solidified Radioactive Waste

New Cement Solidification Facility for liquid radioactive waste solidification (spent ion-exchange resins and filter aid (perlite) deposits) was started to operate in year 2006. A new Interim Storage Facility for solidified waste is located behind the bituminised waste disposal facility which is functioning as a shielding from ionising radiation in this case. Taking into account the distance from the new interim storage facility for solidified radioactive waste to the buffer storage (what makes about 1 km), it is not expected that the further operation of the new interim storage facility for solidified radioactive waste could influence the radiological situation at the buffer storage site.

New Interim Spent Nuclear Fuel Storage Facility (ISFSF) and New Solid Waste Management and Storage Facility (SWMSF)

Planned ISFSF and SWMSF will be constructed next to the site of *Landfill* disposal facility. The estimated annual effective doses for members of critical group due to direct irradiation from ISFSF and SWMSF towards *Landfill* facility equals to 0,08 mSv [55]. The exposure duration of 2 000 hours per year and the distance of 50 m from the protective fence around facilities under consideration is assumed.

Existing Spent Nuclear Fuel Storage Facility

Considering the distance between the Spent Nuclear Fuel Storage Facility and the site of the *Landfill* disposal units (approx. 1 km) it is foreseen no impact on present radiological situation of the SNFSN due to operation of the *Landfill* disposal facility.

Near-surface Repository for Low and Intermediate Level Short-lived Radioactive Waste in Stabatiske Site

The proposed location for the near-surface repository for low and intermediate level short-lived radioactive waste – Stabatiske site – is to the east from the site of the *Landfill* disposal facility, see Figure 3.46. The public exposure due to direct irradiation during operation phase of the near surface repository (i.e., during the disposal of radioactive waste packages) is estimated in the document [57]. A sanitary protection zone of up to 300 m distance around the near surface repository is foreseen. Outside the SPZ the impact of direct ionizing radiation may not further be taken into consideration. Taking into account the distance between the near-surface repository and the *Landfill* disposal facility, it is foreseen no impact to radiological situation at the *Landfill* facility due to operation of the near-surface repository.

The potential radiological impact within operation period of the *Landfill* disposal units is presented in Table 3.28.

Table 3.28. Summary of the total potential maximal radiological impacts from existing and planned nuclear facilities in the SPZ of the INPP

Nuclear facilities in the SPZ of the INPP	**Annual effective dose, mSv**
Exposure due to airborne releases from disposal units site	5.60E-7
Direct irradiation from the *Landfill* disposal facility	3.10E-8
Total dose resulted from the *Landfill* disposal units	**5.91E-7**
Total dose due to operation of the Buffer storage facility[1]	3.60E-2
External and internal exposure due to airborne releases from SNF handling at INPP (related to operation of ISFSF) [2]	4.15E-4
External and internal exposure due to airborne releases from SNF reloading at ISFSF [3]	1.46E-4
External and internal exposure due to radionuclide release from existing nuclear facilities of INPP[4]	1.00E-2
External and internal exposure due to radionuclide releases from the SWRF and SWTSF sites [5]	7.79E-3
External and internal exposure due to radionuclide release from the new NPP[6]	3.30E-02
Total dose from proposed economic activity together with other existing and planned activities	**8.74E-2**

[1] Data taken from section 2.4.9.3.5 of this document.
[2] Data taken from the document [56], section 5.1.5.2. and represents the maximal exposure values for the most conservative scenario – “One year maximal effective dose due to handling of all leaking fuel”.
[3] Data taken from the document [56] section 5.2.2.2.
[4] Estimation is presented in section 3.4.9.3.6.
[5] Data taken from the document [55] section 4.9.2.2.1.
[6] Data taken from the document [57] section 7.10.2.2.

3.4.9.3.6.2 Assessment of the impact during the period after the closure of the disposal units

It is showed in Figure 3.47 that the exposure during the period will be caused by all nuclear facilities under consideration except for the *Landfill* buffer storage facility and the INPP after the closure of the planned *Landfill* disposal units.

During the safety analysis of the planned disposal facility for very low level waste, in terms of different types of analyzed scenarios, namely scenarios of evolution of the disposal facility and scenarios of unintentional intrusion, basically two types of the members of critical group of population have been defined:

Critical group type 1 is defined for scenarios of evolution of the disposal facility. It is represented by the local residents - farmers using water for daily needs from the well, arranged at the distance of 50 m from the edge of the disposal facility, or from Lake Druksiai, or from the drainage channel, as well as consuming fish caught in the lake. It is estimated (see section 3.4.9.3.2) that the member of the critical group can receive the maximum dose of 0.0018 mSv per year in case of water consumption from the drainage channel during the period after the closure of the disposal facility. For the group there will be a time interval when the exposure will be caused by all nuclear facilities under consideration, except for the buffer storage and the INPP.

Critical group type 2 is defined for scenarios of unintended intrusion. It is represented by the residents living in a house, which is constructed in the territory of the disposal facility, 100 years after the closure of the disposal facility, i.e. after the period of both active and passive institutional control. It is estimated (see section 3.4.9.3.5.1) that the member of the critical group can receive the maximum dose of 0.022 mSv per year. For the critical group the exposure will be only due to the disposal facility of bituminized waste, the repository for low and intermediate level RAW as well as due to the planned *Landfill* disposal units since the remaining nuclear facilities under consideration will no longer exist.

The estimated maximal doses for the member of critical group 1, i.e. local resident-farmer, resulted from the near surface repository for low and interim level RAW are presented in the document [57]. The value of the total maximal dose equals to approx. 0.009 mSv per year, regarding consumption of the contaminated water from Lake Druksiai as well as consumption of the fish caught in the lake. No doses are estimated for the member of critical group type 2 in case of the near surface repository.

The estimated maximal exposure doses for the member of the critical group type 1, i.e. local resident-farmer, caused by the disposal facility of bituminized waste is presented in the document [59]. The of the total exposure dose equals to approx. 0.01 mSv per year assuming the consumption of the contaminated water from Lake Druksiai as well as of consumption of fish caught in the lake. The estimated dose caused by the near-surface disposal facility of the bituminized RAW for the member of critical group type 2 is approximately 0.18 mSv per year.

A summary of the maximum values of the total doses caused by simultaneous operation of the nuclear facilities under consideration for the members of the critical groups type 1 and type 2 during the period after the closure of the *Landfill* disposal facility is presented in Table 3.29.

Table 3.29. Summary of the potential impact resulted from the planned nuclear facilities at the territory of INPP during period after closure of the *Landfill* disposal units

Nuclear facility	**Value of the total exposure dose to a member of the critical group of the population, mSv/year**	
	Group Type 1 (evolution scenarios)	**Group Type 2** (unintended intrusion scenarios)
Landfill disposal facility	0.0018	0.022
Facilities under operation after the closure of the Landfill disposal units (see Table 3.28) except INPP and the buffer storage facility	0.0414	-
Repository for bituminized RAW	0.01	0.18
Near-surface repository for low and intermediate level RAW	0.009	-
Total:	**~0.062**	**~0.2**

The estimations presented in Table 3.29 demonstrate that due to total impact of the nuclear facilities the total maximum exposure doses for the member of the critical group type 1, i.e. the local resident-farmer, is about 0.062 mSv per year in case of consumption of contaminated water from the drainage channel. The value of the total dose remains approx. a factor of three less than the value of the dose constraint 0.2 mSv per year [17].

The estimated total dose caused by the impact of the nuclear facilities received by the member of the critical group type 2, i.e. the resident living in the house constructed at the territory of the disposal facility, is approximately 0.2 mSv per year and remains by approximately 50 times less than the dose of 10 mSv per year used for such cases and, based on clause 91 of document [20], accepted according to the recommendations of document [21].

3.4.9.3.7 Summary of the radiological impact and conclusions

The estimation of potential radiological impact on the population health is carried out considering the maximum possible radiological impact on different components of the environment during the planned economic activity under conditions of normal operation, namely:

- The releases of airborne radioactive materials from the *Landfill* disposal units;
- The releases of waterborne radioactive materials from the *Landfill* disposal units;
- The exposure due to direct irradiation from the disposal units.

Also the analysis of the total radiological impact resulted from the existing and planned nuclear facilities within the present INPP SPZ is carried out.

The results of the estimations have demonstrated that the impact from the planned *Landfill* disposal units as well as the total impact caused by the planned economic activity and by the existing and planned nuclear facilities within the SPZ of the Ignalina NPP, i.e. the exposure doses received by the member of the critical group, are below the constraints established by the normative document of Republic of Lithuania [17], hence, the requirements of radiation protection will be satisfied.

3.4.9.4 Impact Mitigation Measure

Since non radiological as well as radiological impact to the public health resulted from the proposed economic activity under normal operational conditions is estimated to be very low, no specific means for impact mitigation in addition to the foreseen in the project concept are foreseen.

Radiological situation of the environment will be controlled by a constant monitoring of radiological situation in the INPP region will be performed.

3.4.9.5 Sanitary Protection Zone

The proposed economical activity will be implemented within sanitary protection zone (SPZ) of Ignalina NPP of radius of 3 km.

A potential non radiological as well as radiological impact to the components of the environment as well as to the public health resulted from the proposed economic activity under normal operational conditions is estimated as negligible. The proposed economic activity The proposed economical activity will not adversely change the existing radiological situation outside the INPP sanitary protection zone. Reconsideration of existing INPP sanitary protection zone boundaries or its status is not necessary. However, it is recommended to establish a separate SPZ for the *Landfill* disposal facility with the distance of 50 m from the edge of the disposal units as the SPZ of Ignalina NPP will be cancelled after the completion of decommissioning activity of INPP.

3.4.9.6 Summary of Impact on Public Health

Following the Regulations for Impact on Public Health Assessment [60] the main factors and impacts of the proposed economic activity are identified and evaluated in this report. The direct and indirect impacts of the proposed economic activity on factors influencing the public health are summarized in Table 3.30.

Potential impact on groups of the population is summarized in Table 3.31 and the estimation of peculiarities of the impact is presented in Table 3.32.

Table 3.30. Direct and indirect impacts resulted from the proposed economic activity on factors influencing the health

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
1. Factors of behaviour and lifestyle (nutrition habits, alcohol consumption, smoking, consumption of narcotic and psychotropic drugs, safe sex and other)	Construction, operation and institutional control period of the *Landfill* facility	Not foreseen				The proposed economic activity will be implemented within existing sanitary protection zone of INPP. There is no permanently living population. The INPP personnel will be used for the operation of the *Landfill* facility. The working conditions will be assured in accordance with requirements of regulations in force.
2. Factors of physical environment						
2.1. Air quality	Traffic of heavy vehicles, airborne releases	The ambient air quality will be directly affected by NO_X, SO_2, dust, CO, CO_2 and unburned carbohydrates C_xH_x, generated by the road	(–)	Impact on the air quality during the construction and operation of the disposal facility will be temporal. The affected area will include the area of the disposal facility or the road and their direct	The transportation route will be in the territory of the INPP sanitary protection area and will not cross the populated areas. All the works will be performed in the free air so that the natural air circulation will allow avoiding the accumulation	

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
		transfer of construction materials and by the road transfer and handling of RWP.		environment in a range of about 100 m. The affected area will be limited by the INPP sanitary protection zone. No impact on the health.	of significant concentrations of the pollutants. Since the predicted level of traffic will be low, its impact will within permissible range both during the construction and operation of the *Landfill* facility.	
2.2. Water quality	INPP sanitary waste water system and the drainage system of the *Landfill* facility, the *Landfill* facility after its closure	Possible slight controlled pollution due to sewage release to the environment	(–)	During the construction and operation of the disposal facility the drinking water will be supplied by “Visagino Energija”. During the operation waste water will be gathered in the collection tank and according to the measurement results will be directed to the existing liquid waste treatment facility or to the sanitary waste water sewage for uncontaminated waste water. The analysis of possible contamination of the underground water and Lake Druksiai after the closure of the disposal facility is presented in section 3.4.1. The water supply facility of Visaginas town will not be	The INPP sanitary waste water system follows the requirements of normative document [85]. The INPP surface drain water collection system follows the requirements of normative document [60]. In case of accidental spilling of oil products during transport operations, the procedures established in the normative document LAND 9-2002 [86] will be used.	Survey boreholes (wells) for monitoring of underground run-off water will be installed around the site of the *Landfill* facility (see Section 3.7 “Monitoring”). After closure of the disposal facility in order to check the integrity of the disposal facility and permeability of the disposal units the volume the water released from the disposal facility will be measured and the control of radionuclide content will be carried out.

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
				impacted. Considerable impacts or changes of the existing environment are not expected. Changes of health factors are not expected.		
2.3. Food quality	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				Planned economic activities will be carried out within the existing INPP sanitary protection zone. There is no permanently living population and economic activities are limited. Possible unintended intrusion after the institutional control period is analyzed in section 3.4.9.3.5. It has been demonstrated that the dose for the member of the critical group of the population will be below the limits established by the normative documents.

Factors influencing the health	**Kind of activity or means, contamination sources**	**Impact on factors influencing the health**	**Impact on health: pos. (+) neg. (-)**	**Forecasted changes of the analyzed indicators**	**Possibilities to mitigate (to eliminate) the negative impact**	**Comments and remarks**
2.4. Soil	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen		The site of the *Landfill* facility was technogenically damaged in the past. Changes of health factors are not expected.	No contamination of soil is foreseen during normal operation of the planned economic activity.	The constant monitoring will be carried out in the territory of the site.
2.5.1. Non-ionizing radiation	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
2.5.2. Ionizing radiation	Operation of the *Landfill* facility, the *Landfill* facility after its closure	1. Radionuclide releases from the *Landfill* facility after its closure. The expected activity of the released radionuclides into the atmosphere are presented in section 3.4.2. The expected activity of the released radionuclides into the water component are presented in section 3.4.1. 2. Direct irradiation from the *Landfill* facility during its operation and after its closure. The expected	(–)	Radionuclide releases from the *Landfill* facility after its closure and direct irradiation from the *Landfill* facility during its operation and after its closure have been estimated as extremely low and their impact on health factors is not expected.	Direct irradiation from the *Landfill* facility during its operation and after its closure will be local. Around the disposal facility site there will be established the sanitary protection zone where economic activities will be limited.	Monitoring of the ionising radiation impact and possible changes of the environment will be carried out (see section 3.7 “Monitoring”).

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
		irradiation is presented in section 3.4.9.3.				
2.6. Noise	Construction and operation of the *Landfill* facility	Increase of noise level	(–)	There is no inhabitants within the sanitary protection zone (in the distance of 3 km around INPP), so that there will be no particular perception of noise or vibration. The impact on health factors is not expected.	The construction and disposal campaigns will be carried out relatively in short term (1-2 months) and rarely (1 campaign per 1-2 years). The noisy activities will be carried out during daytime only.	
2.7. Home conditions	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
2.8. Safety	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	The disposal of RAW in a suitable manner will increase the radiation safety. However, the new nuclear facility is related to a possibility of accidents. The risk analysis and estimation is presented in Section 3.8.	(+/–)	Very low level waste will be disposed of in the *Landfill* facility. The management of all radioactive materials will be carried out according to the Lithuanian norms and regulations, as well as IAEA principles and according to the proven practice in other member countries of the European Union. The impact on health factors is not expected.		The *Landfill* facility will be designed taking into account external risks to the safety.

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
2.9. Transport	Construction and operation of the *Landfill* facility	Possible temporary traffic increase.		Impact on the health factors is not expected.	The route of the RAW transportation will be in the territory of the INPP sanitary protection area. It will not cross the populated areas. The transportation will be carried out during daytime only.	
2.10. Territory planning	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen		There will be no land use changes. Impact on the health factors is not expected.		
2.11. Waste management	Management of waste produced during the construction and operation of the *Landfill* facility.	Generation of operational waste and waste from construction of the facility	(–)	Amounts of generated waste will be low. No hazardous waste will be generated. Impact on the health factors is not expected.	Waste will be managed in accordance with the requirements of waste management legislation and regulations in force and Permission on integrated prevention and control of pollution.	
2.12. Power appliance	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
2.13. Risk of misadventures	Construction and operation of the *Landfill* facility, the *Landfill* facility	Not foreseen				

Factors influencing the health	**Kind of activity or means, contamination sources**	**Impact on factors influencing the health**	**Impact on health: pos. (+) neg. (-)**	**Forecasted changes of the analyzed indicators**	**Possibilities to mitigate (to eliminate) the negative impact**	**Comments and remarks**
	after its closure					
2. 14. Passive smoking	Operation of the *Landfill* facility	Not foreseen		Smoking is forbidden in the case of handling of radioactive substances. Impact on the health factors is not expected.		
2.15. Other	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
3. Social and economic factors						
3.1. Culture	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
3.2. Discrimination	Construction and operation of the *Landfill* facility	Not foreseen				
3.3. Property	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
3.4. Income	Construction and operation of the *Landfill* facility	Increase of the population income	(+)	Several working places will be created. Impact on the health factors is not expected.		The project is financed by the EU direct investment for the INPP decommissioning.
3.5. Education possibilities	Construction and operation of the *Landfill* facility	Not foreseen				
3.6. Employment, labour market, business opportunities	Construction and operation of the *Landfill* facility	Workplace creation	(+)	Local companies, among others, will be involved in the project. Impact on the health factors is not expected.		
3.7. Criminality	Construction and operation of the *Landfill* facility	Not foreseen				
3.8. Leisure, recreation	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
3.9. Movement	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
3.10. Social security (social contact and welfare)	Construction and operation of the *Landfill* facility	Not foreseen				
3.11. Sociality, sociability, cultural contact	Construction and operation of the *Landfill* facility	Not foreseen				
3.12. Migration	Construction and operation of the *Landfill* facility	The employment will reduce the emigration	(+)	Impact on the health factors is not expected.		
3.13. Family constitution	Construction and operation of the *Landfill* facility	Not foreseen				
3.14. Other	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
4. Professional risk factors						
4.1 Chemical	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
4.2. Physical	Construction and operation of the	Ionizing radiation. The risk analysis and	(–)	Very low level waste will be disposed of in the *Landfill*	The risk of the accidents can be eliminated or reduced by means of	The *Landfill* facility will be designed taking

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
	Landfill facility, accidental situations	assessment are presented in section 3.8.		facility. The personnel exposure will be below the established limits under normal operational conditions and extreme working conditions (in case of beyond design basis accidents). The ALARA principle will be also kept. Impact on the health factors is not expected.	corresponding design solutions. The management of all radioactive materials will be carried out according to the Lithuanian normative documents and regulations as well as IAEA principles and according to the proven practice in other countries.	into account external risks to safety.
4.3. Biological	Construction and operation of the *Landfill* facility	Not foreseen				
4.4. Ergonomic	Construction and operation of the *Landfill* facility	Not foreseen				
4.5. Psychosocial	Construction and operation of the *Landfill* facility	Not foreseen				
4.6. Manual work	Construction and operation of the *Landfill* facility	Not foreseen				
5. Psychological factors						

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
5.1. Aesthetical appearance	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Impact on the landscape	(–)	The construction of the *Landfill* facility close to the INPP will not have a significant impact on the landscape and will not disturb the balance between natural and anthropogenous territories. The disposal facility will look like a natural hill after closure of the disposal facility and formation of a vegetative layer on the top. Changes of health factors are not expected.	The site will be reduced to the minimum size necessary for construction work and operation of the disposal facility.	
5.2. Comprehensibility	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
5.3. Capability to hold the situation	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				
5.4. Significance	Construction and operation of the *Landfill* facility, the *Landfill* facility	Not foreseen				

Factors influencing the health	Kind of activity or means, contamination sources	Impact on factors influencing the health	Impact on health: pos. (+) neg. (-)	Forecasted changes of the analyzed indicators	Possibilities to mitigate (to eliminate) the negative impact	Comments and remarks
	after its closure					
5.5. Possible conflicts	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Possible population discontent and distrust	(–)	Psychological impact is stipulated by changes in the existing nuclear practice (shutdown and decommissioning of INPP) and construction of new nuclear objects. Significant changes of health factors are not expected	Psychological impact can be mitigated explaining necessity, goals and benefits from the planned economic activity.	
6. Social and health services (acceptability, suitability, succession, efficiency, protection, availability, quality, self-help technique)	Construction and operation of the *Landfill* facility, the *Landfill* facility after its closure	Not foreseen				

Table 3.31. Possible impact of proposed economic activity on public groups

Public groups	**Kind of activity or means, contamination sources**	**Group size**	**Impact: positive (+) negative (-)**	**Comments and remarks**
1. Public groups (local population) in the zone of activity impact	Ionizing radiation during operation of the *Landfill* facility and after its closure	There is no permanently living population in the sanitary protection zone. An economical activity is limited in the SPZ.	(–)	Impact within the sanitary protection zone will be minimal and will not exceed the limits prescribed by radiation protection requirements (see Section 3.4.9.3 and 3.8). The impact can be considered as insignificant outside the sanitary protection zone.
2. Personnel	Ionizing radiation during operation of the *Landfill* facility	The INPP personnel	(–)	Personnel exposure due to the planned economic activity will be controlled and limited at the working places using individual monitoring and work planning as well as taking into account the ALARA principle.
3. Consumers of the activity products	Not relevant			
4. Persons with slender income	Not relevant			
5. The jobless	Not relevant			
6. Ethnical groups	Not relevant			
7. Persons sick with same diseases (dependence on drugs, alcohol etc.)	Not relevant			
8. Disables	Not relevant			
9. Single persons	Not relevant			
10. Refugees, emigrants and persons seeking political asylum	Not relevant			
11. The homeless	Not relevant			
12. Other population groups (arrestees, persons of special occupations, manual hard workers etc.)	Not relevant			
13. Other groups (single persons)	Not relevant			

Table 3.32. Assessment of the impact peculiarities

Impact induced by factor	**Impact peculiarities**									**Comments and remarks**
	Number of persons under the impact						**Duration**			
	< 500	**501–1000**	**> 1001**	**Clear**	**Probable**	**Possible**	**Short (< 1 yr)**	**Medium (1–3 yrs)**	**Long (> 3 yrs)**	
1. Airborne releases due to the flow of traffic	X					X			X	Impact on the air quality during the construction and operation of the disposal facility will be temporal. The affected area will include the area of the disposal facility or the road and their close environment in a range of about 100 m. The affected area will be limited by the INPP sanitary protection zone.
2. Water quality	X				X				X	The analysis of possible contamination of the ground water and Lake Druksiai after the closure of the disposal facility is presented in section 3.4.1. The water supply facility of Visaginas town will not be impacted. Sanitary waste water sewage will be transferred for purification to the enterprise "Visagino energija".
4. Ionizing radiation			X	X (personnel)	X (population)				X	Local impact on the INPP personnel is possible. Potential exposure does not exceed the radiation protection requirements. Outside the sanitary protection zone impact of the planned economic activity can be considered as insignificant.

Impact induced by factor	**Impact peculiarities**									**Comments and remarks**
	Number of persons under the impact						**Duration**			
	< 500	**501–1000**	**> 1001**	**Clear**	**Probable**	**Possible**	**Short (< 1 yr)**	**Medium (1–3 yrs)**	**Long (> 3 yrs)**	
5. Noise increase	X			X					X	There is no inhabitants within the sanitary protection zone (in the distance of 3 km around INPP), so there will be no particular perception of noise or vibration. Local impact on the personnel in the vicinity of the disposal facility during a disposal campaign is possible.
6. Safety			X			X			X	Radiation safety will increase disposing RAW in a suitable manner the. However, the planned nuclear facility is related to a possibility of accidental situations.
7. Generation of operational waste and waste from construction of the facility	X			X					X	Waste will be managed in accordance with the requirements of waste management legislation and regulations in force and Permission on integrated prevention and control of pollution.
8. Income increase	X			X					X	
9. Employment, labour market, business opportunities	X			X					X	
10. Migration decrease	X				X				X	

Impact induced by factor	Impact peculiarities									Comments and remarks
	Number of persons under the impact						Duration			
	< 500	501–1000	> 1001	Clear	Probable	Possible	Short (< 1 yr)	Medium (1–3 yrs)	Long (> 3 yrs)	
11. . Impact on landscape	X			X					X	The construction of the *Landfill* facility close to the INPP will not have a significant impact on the landscape and will not disturb the balance between natural and anthropogenous territories. The disposal facility will look like a natural hill after closure of the facility and formation of a vegetative layer on the top.
12. Possible conflicts	X					X			X	

3.5 Potential Impact to Neighbouring Countries

Two countries, i.e. the Republic of Belarus and the Republic of Latvia, are relatively close to the INPP site. The state border Lithuania–Belarus is in about 5 km to the east and southeast from the INPP Power Units. The state border Lithuania–Latvia is in about 8 km to the north from the INPP Power Units.

Other countries (Russia, Poland) are at a distance of at least hundred kilometres away from the INPP site and will not be affected by the proposed economic activity.

3.5.1 General Information on Neighbouring Countries

The Daugavpils region of Latvia and the Braslav region of Belarus are in the immediate vicinity of the INPP (Figure 3.50).

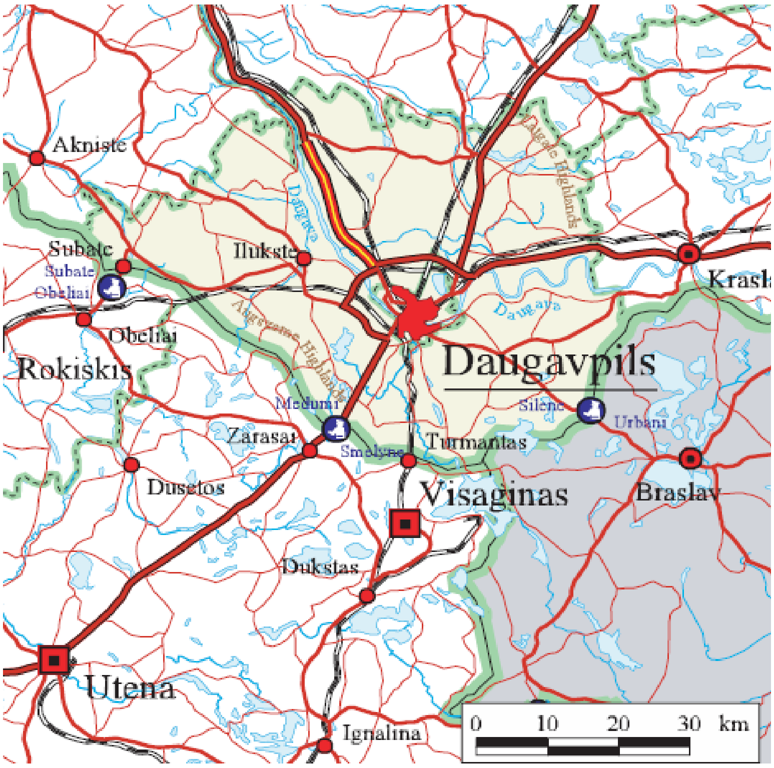


Figure 3.50. Daugavpils region of Latvia and the Braslav region of Belarus

3.5.1.1 Daugavpils Region

Daugavpils region borders with Lithuania and Belarus. Total area of the Daugavpils region is 2598 km^2.

Land use of the region is as follows: farm lands – 48 %, wooded areas – 34 % and other uses – 18 %. However, agriculture does not significantly contribute to the economic output of the region, as Daugavpils region can be considered as an industrial one. Though there is a lot of land fit for cultivation, the conditions for farming are not very advantageous. The hilly terrain is not conducive to cultivating large fields.

Total population of the Daugavpils region is 159 000 (population census in 2000). Population density is 61 inhabitants per km^2. Daugavpils, the second big city in Latvia after Riga, is an independent structural unit with 115 300 inhabitants in 2000 and 112 000 in 2004. In the region there are 24 small rural areas and 2 towns (Ilukste – 3 177 inhabitants and Subate – 1 013 inhabitants). Approximately 75 % of the inhabitants of the Daugavpils region live in urban areas. Population density in rural areas is low and the population is rather old.

There are good road and rail connections from Daugavpils region to Riga and also with Lithuania, Belarus and Russia. Most important are the Warsaw-Vilnius-Daugavpils-St Petersburg connection and the railroad to Riga. The national major road Riga-Daugavpils, as well as the road connection to Zarasai in Lithuania and the route Daugavpils-Rezekne-Pskov in Russia have international significance.

A number of historical monuments provide good background for the development of tourism. The most popular objects in the region are Daugavpils fortress from the 17th century, Peter-Paul Cathedral, a fortress from the beginning of the 19th century and Vaclaiciena Palace. One unique object is the Duke Jacob's Channel in Asare (500 m long), built in 1667–1668 to link the two rivers, Vilkupe and Eglaine, to connect Daugava and Lielupe water routes.

Latvia's largest river, the Daugava flows through the region from Belarus towards the Gulf of Riga. The length of the Daugava river is 1040 km (367 km in the territory of the Republic of Latvia). Watershed area is 87 900 km^2; average water yield is 678 m^3/s. The Daugava river meanders throughout all the territory of the Daugavpils region, making 10 loops from Kraslava to Krauja and running calmly from Liksna and Nicgale. There are 194 lakes in Daugavpils region. Some lakes (Skujines, Medumu, Bardinska, Sventes etc.) are the nature reserves.

Daugavpils region has plenty of attractive natural landscapes. The Daugava's stretch from Kraslava to Daugavpils, where the river flows in a primeval hollow, which is almost 40 metres deep, is sometimes called the Switzerland of Latgale. Two significant highland areas – the Augszeme and Latgale highlands are located in Daugavpils region. Latvia's biggest boulder (174 m^3) is in Nicgale.

3.5.1.2 Braslav Region

Braslav region is administrative part of Vitebsk district. The only town in the region is Braslav with 10 thousand inhabitants. Other settlements are Vidzy, Pliusy and smaller villages (Figure 3.51). Braslav town is on a shore of Lake Driviaty, in a distance of 30 km from railway station Druia, 220 km from Minsk and 238 km from Vitebsk. There are factories of building materials, greengrocery production etc. in the town.

National park "Braslav Lakes" occupies 69.1 thousand hectares or about one third of Braslav region territory. The most picturesque and precious areas around the Braslav town forms a core of the national park. Extension of the park from north to south is 56 km and the width varies from 7 to 29 km. There are more than 60 lakes in the national park; they occupy 17 % of its territory. The first-rate lakes are Driviaty, Snudy, Strusto, Boginskoie (Figure 3.52). The Lake Volos South is the deepest in the park and region; it is as deep as 40.4 m.

Figure 3.51. The Braslav region of Belarus

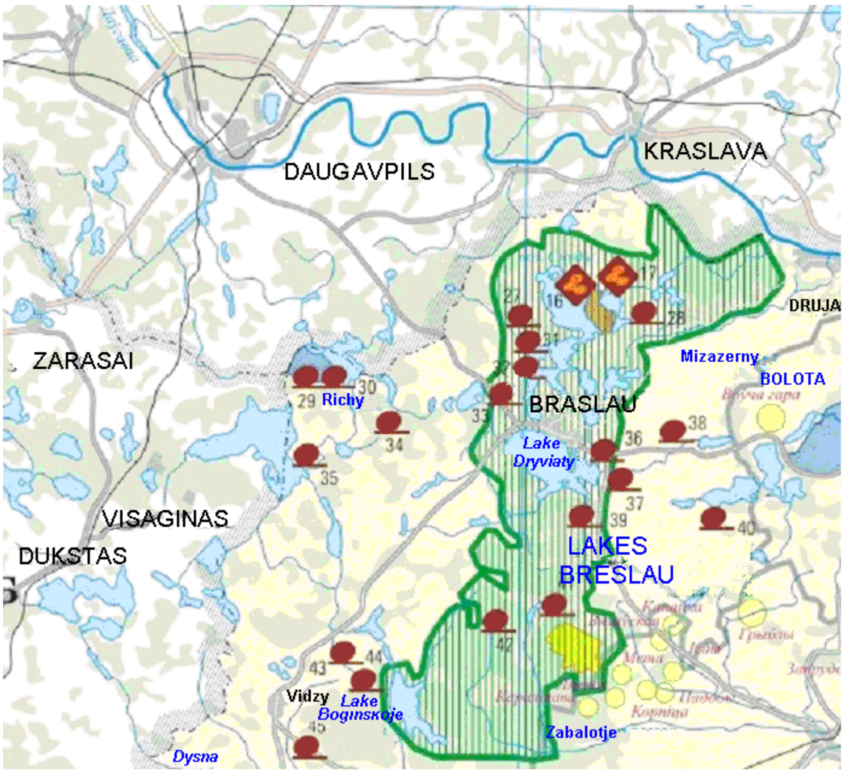


Figure 3.52. The national park "Braslav Lakes"

There are 4 functional zones in the national park "Braslav Lakes":

- The reserved zone – 3452 hectares (4.9 %). This zone is in the most precious area of forest tract Boginskoie. The purpose of the reserved zone is preservation in untouched condition of typical and unique ecosystems and a gene pool of flora and fauna;
- The zone of controllable use – 27746 hectares (39.0 %). The purpose of this zone is studies of restoration, moving forces and trends of inviolate ecosystems;
- The recreational zone – 12103 hectares (17.0 %). This zone is assigned for allocation of units and buildings for rest and tourism, for actions on cultural work among the masses and for car parking management;
- The zone for economical activity – 25815 hectares (36.3 %). This zone is assigned for allocation of park visitors' service units, living quarters and for economical activities.

The territory of national park "Braslav Lakes" presents the most peculiar natural complex of the Republic of Belarus. Unique combination of hills, lakes, marshlands and river valleys make this land extraordinary picturesque.

The typical forest inhabitants are elk, wild boar, deer, squirrel, mountain hare, brown hare, fox etc. The rare species from the Red Book of Belarus are badger, lynx and brown bear. There are about 200 species of birds in the national park "Braslav Lakes". The rare species are black stork, crane, herring gull, ptarmigan, dunlin etc.

3.5.2 Potential Impact and Impact Mitigation Measures

3.5.2.1 Water

The management of liquid radioactive waste is described in the section 3.3 "Waste". There will be no uncontrolled waterborne releases into the environment during construction as well as operation period of the *Landfill* disposal units.

Only the non-radioactive liquid waste can be released to the sanitary-technological waste water system. The sanitary waste water is transferred to State Enterprise "Visagino energija" under an agreement.

The INPP surface water drainage system meets the requirements of the regulation [17]. Surface water drainage system of the *Landfill* disposal facility will comply with the requirements of the document [17].

SPZ of waterworks for Visaginas town is distant about 3 km to south-west from the INPP. The water is extracted from Sventoji – Upininkai aquifer complex of upper and middle Devonian formations. The site of the disposal units is outside the boundaries of the sanitary protection zone of the waterworks [10]. A conservative estimation of the potential release of contaminants to the groundwater demonstrated that no significant impact on the waterworks for Visaginas town is expected [10]. Waterworks for Braslav region in Belorussia as well as for Daugavpils region in Latvia are much far in comparison to Visaginas waterworks.

The analysis of the potential impact on environmental water after the closure of *Landfill* disposal facility is presented in sections 3.4.1 and 3.4.9. It is estimated that the maximum of the effective dose received by the member of the critical group of the population due to possible releases of radionuclides into the water environment and consumption of contaminated water from the drainage channel distant from the edge of the *Landfill* disposal facility 50 m should be below 0,002 mSv, i.e. a factor of 100 less in comparison to the dose constraint of 0,2 mSv per year indicated in the normative document [20]. The dose resulted from the consumption of the contaminated water from the lake should be by two orders of magnitude less comparing with the case of water consumption from the drainage channel. No impact to the environmental water of neighbour countries is expected.

3.5.2.2 Environmental air (atmosphere)

Releases of non-radioactive contaminants

The environmental air pollution is possible from the mobile sources during the construction period of the *Landfill* facility and during the disposal campaigns. The environmental air quality will be directly affected by NO_X, SO_2, dust, CO, CO_2 and unburned carbohydrates C_xH_x, released by the vehicles transferring and handling the containers with the waste. The affected area will include the area of the disposal facility or the road and their close environment in a range of about 100 m and will be limited by the INPP sanitary protection zone. Therefore the planned economic activity will not cause significant releases to environmental air and will not make any considerable impact on the environmental air of Braslav region in Belorussia as well as Daugavpils region in Latvia.

Radionuclide releases

A potential radiological impact on the environmental air of the neighbouring countries resulted from the proposed economical activity under normal operation conditions should be expected due to airborne releases of the radioactive substances.

The radiological impact due to airborne releases as well as due to direct irradiation depends on the recipient distance from the source. The estimation of the releases into the environmental air during the operation of the *Landfill* disposal units (see sections 3.4.2 and 3.4.9) demonstrates that exposure doses to the member of critical group should be 5.6E-07 mSv per year, i.e. negligible in comparison to dose constraint 0.2 mSv per year indicated in the Hygiene Norm [20]. The estimated dose resulted from the direct irradiation from the *Landfill* facility (see section 3.4.9) on the boundary of SPZ of INPP equals 6.6E-09 mSv per year, i.e. negligible.

It is concluded, no significant impact on population of Belorussia and Latvia is expected due to the radionuclide releases from the *Landfill* disposal units during construction and operation period of the facility.

3.5.2.3 Soil

The site of the *Landfill* disposal units is located in the southern part of the territory of the Ignalina NPP. The site should be deforested as well as a lot of the excavation works should be carried out for the construction of the *Landfill* disposal units.

The surface of the site has been artificially changed in the past (during the construction of INPP). The filled-up ground is found under the vegetative layer in the site. The layer of the fertile soil will be removed during smoothing the surface of the site.

No soil pollution is foreseen under normal operation conditions of the proposed economic activity. The radiological monitoring of the site area will be carried out permanently. No significant impact is expected outside the INPP territory.

3.5.2.4 Underground (geology)

The proposed economic activity will not affect the underground component of the environment. The disposal units will be constructed on the ground surface and the impact on the ground geological structure will be insignificant.

The site for the *Landfill* facility has been chosen outside the established areas of tectonic faults. Seismic characteristics of the site will be taken into consideration during development of the Technical Design. No any considerable impact on geological environment of Braslav region in Belorussia as well as Daugavpils region in Latvia is expected.

3.5.2.5 Biodiversity

As Braslav region in Belorussia and Daugavpils region in Latvia are distant approx 6 km from INPP site no impact (noise, exhaust gases) on the biodiversity of indicated areas is expected.

3.5.2.6 Landscape

The *Landfill* facility will be constructed in the INPP vicinity within SPZ of INPP. During preparation of the site for the construction of the disposal units it will be necessary to cut down bushes and trees in the territory of the site, it will be necessary to do a considerable amount of the excavating works for the smoothing of the site surface. A soil layer will be formed on the top of the *Landfill* disposal units and the not deeply rooted plants will be planted after the closure of the facility. The impact on landscape will be of local significance and negligible. No impact on residential zones and recreational areas of the neighbouring countries is expected.

3.5.2.7 Ethnic and Cultural Conditions, Cultural Heritage

No interactions between proposed economic activity and ethnic and cultural conditions as well as cultural heritage zones of Latvia and Belorussia are identified.

3.5.2.8 Social and economic environment

The proposed economic activity will be distant from permanently living population of Latvia and Belarus. No impacts or evident changes of social and economical environment are foreseen.

The proposed economic activities will be performed in accordance with the modern environmental requirements using state-of-the-art technologies. The proposed economic activity represents the EU direct investment for the INPP decommissioning. The installation of the *Landfill* disposal facility will be performed in compliance with the radioactive waste management principles of the IAEA and in compliance with good practices in other European Union Member States.

However, population discontent and distrust is possible in Latvia and Belarus. Such a psychological impact is stipulated by changes in existing nuclear practice (shutdown and decommissioning of INPP), which results in construction of new nuclear objects. Psychological impact can be mitigated explaining necessity, goals and benefits from proposed economic activity:

- The proposed economic activity is inevitable and must be performed for imperative reasons of overriding public interest, including those of a social and economic nature. Zero alternative will stipulate irrational expenditure of both material and human resources and in the worst case inadmissible negative impact on the environment as well as population health;
- Proposed economic activity is financed under the EBRD managed International Ignalina Decommissioning Support Fund;
- The calculations and assessments performed in this EIA Report have clearly shown that the proposed economic activity will not produce significant impacts, neither of radiological nature nor of non-radiological nature, which could physically affect public health and environment.

The proposed economic activity will be carried out under the strict control of national regulatory authorities. These government institutions enforce state regulations that are based on the European Union practices, as well as on guidelines and conventions established by international organisations, such as the International Atomic Energy Agency (IAEA).

3.5.2.9 Total radiological impact on the neighbouring states due to the existing and planned nuclear facilities within the territory of INPP

The total radiological impact due to the existing and planned nuclear facilities on the territory of INPP is assessed within the SPZ of INPP (of 3 km radius), and outside the impact is considered negligible. Table 3.28 states, that the overall impact would be about 8.74E-02 mSv per year, i.e., about 3 times lower than the value of the dose constraint 0.2 mSv per year during operational period of the disposal units. Dose, which potentially could be received after the closure of the repository (see Table 3.29, Critical group Type 1), would be approx. 3 times below the dose constraint 0.2 mSv per year.

The dose during operational period of the disposal units would be stipulated by such components as direct exposure from the planned Buffer Storage, airborne and waterborne releases from the nuclear facilities located within the SPZ of INPP, as well as radionuclide releases from the planned new NPP. It should be noted that the values of these components are inversely proportional to the distance. Therefore, considering the distance from the INPP SPZ to the nearest foreign countries (about 2 km to Belarus and about 5 km to Latvia), it can be stated that the total impact on the population of foreign countries will be negligible.

3.6 Analysis of the Alternatives

3.6.1 Zero Alternative

In the analysis of a zero alternative the situation if the *Landfill* disposal facility for very low level waste would not be built at all is considered.

It is planned that during the operation and decommissioning of the Ignalina NPP approximately 60 000 m^3 of very low level waste will be generated. If no measures on handling and disposal of such waste are taken, there should be a potential danger of the environmental contamination by radioactive materials and at the same time negative impact on the population health (ionising radiation exposure). Therefore the disposal of very low level waste is necessary, and it is defined by the requirements specified in the standard document [63].

In the case of rejection of construction of the *Landfill* disposal facility the generated very low level waste should be disposed in the planned disposal facility for short-lived low and intermediate level waste, which is provided to be constructed at Stabatiske site. In this case some unfavourable aspects can be identified:

1. Since it is not foreseen to dispose of the very low level waste in the repository for short-lived low and intermediate level waste (at Stabatiske site), it would be necessary to estimate additionally, will be enough space for the disposal of very low level RAW in the repository, will be the possibility for its enlargement and how it would affect the environment.
2. The duration of the institutional control of the near-surface repository for short-lived low and intermediate level waste should be up to 300 years. The period of the institutional control is foreseen up to 100 years for the *Landfill* facility.
3. The period for the construction of the near-surface repository for short-lived low and intermediate level waste should be longer in comparison with the period necessary for the construction of the *Landfill* facility. It should be necessary to install rather simple engineering barriers for the *Landfill* facility during construction phase. In case of disposal of very low level waste in the near-surface repository for short-lived low and intermediate level waste the p works related to the decommissioning of the INPP should be postponed and therefore more complicated.

4. Such a decision should be obviously unfavourable from the economical point of view. Very low level waste can be disposed in a *Landfill* disposal facility [6]. The *Landfill* disposal facility should have simple engineering barriers and protective layers on the top in order the long term safety should be assured. The construction of the repository for short-lived low and intermediate level waste is considerably complicated and, hence, much expensive.

Taking into account the reasons listed above it is concluded that the construction of the *Landfill* facility is the more favourable case for the handling of very low level RAW considering the radiation protection. In the case installation of the *Landfill* disposal facility an economic benefit as well as more advanced planning and management of the overall process of the INPP decommissioning should be achieved.

3.6.2 Site Alternatives

After survey stage [13], siting process based on the criteria recommended by IAEA for near surface disposal facilities [64] and the reference design of the *Landfill* disposal facility two alternative locations were screened out within the Ignalina NPP area. The location of the sites called north and south is presented in Figure 3.53.

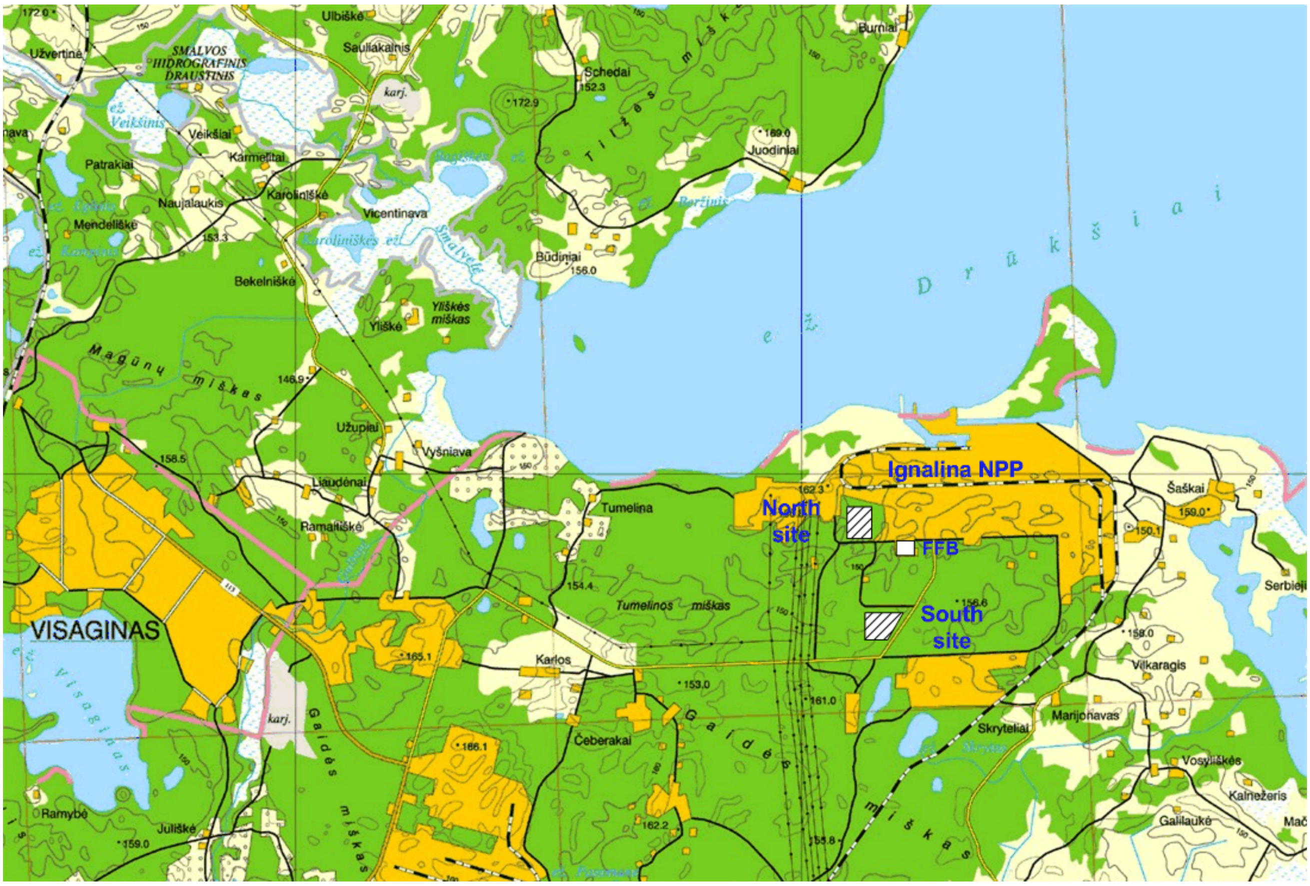


Figure 3.53. Surroundings of Ignalina NPP. Two alternative sites proposed for *Landfill* facility close to INPP. FFB – location of the fire-fighting brigade

The north site is located at the west border side of Ignalina NPP territory, close to the industrial zone installations. The western border of the site coincides with the border of Ignalina NPP territory. The south site is located at the southwest border side of Ignalina NPP area, to the south from the sites of the new Spent Nuclear Fuel Storage Facility (Project B1) and new Solid Waste Treatment and Storage Facilities (Projects B3/4).

The estimation of suitability of the sites to install the *Landfill* disposal facility as well as its comparison is presented in the report [65]. The environmental conditions of the sites as well as the impact due to potential radionuclide release are taken into account in the sites assessment.

The assessment of environmental conditions of north and south sites is based on IAEA recommendations [64] and is in brief summarized in Table 3.33. In the report [65] the assessment of various features of the sites environment was given using three levels of ranking: 2 - acceptable, 1 - medium, 0 - unacceptable and a mark "-" was used if the feature was not relevant in a particular case. Certainly, various characteristics do not have the same weight, therefore the estimation of the site acceptance has been carried out taking into account only crucial aspects of the sites, such as water run-off (flooding), hydrogeological conditions (path length of potential radionuclide migration and water flow rate), as well as stability (possibility of the Earth crust faults). The estimations also considered the conceptual design of the repository.

Table 3.33. Summary of the assessment of environmental conditions of the Southern and Northern sites

Characteristic	**Class** (**2**=acceptable, **1**=medium, **0**=unacceptable, **-**=not relevant)	
	Northern site	**Southern site**
1. Geological conditions		
1.1. Engineering geology conditions	**1**	**1**
1.2. Geomorphology	**1**	**1**
1.3. Geotechnical conditions	**2**	**2**
2. Hydrogeological conditions		
2.1. Shallow groundwater	**1**	**1**
2.2. Groundwater	**1**	**2**
2.3. Basic points of discharge	**1**	**1**
2.4. Direction of water pathway, velocity of groundwater flow	**1**	**2**
2.5. Surface water bodies	**1**	**2**
2.6. Feeding of groundwater	**2**	**2**
3. Geochemical conditions		
3.1. Sorption/solubility conditions of radionuclides	**1**	**1**
3.2. pH of the groundwater	**2**	**1**
3.3. Natural colloids and organic materials	**1**	**1**
3.4. Corrosiveness of groundwater towards the concrete	**2**	**-**
4. Tectonics and seismicity		
4.1. Tectonics	**1**	**2**
4.2. Estimation of seismicity	**1**	**1**
4.3. Neotectonic processes	**1**	**2**

Characteristic	**Class** (**2**=acceptable, **1**=medium, **0**=unacceptable, **-**=not relevant)	
	Northern site	**Southern site**
4.4. Liquefaction of soil	**1**	**1**
5. Surface processes		
5.1. Flooding	**1**	**1**
5.2. Landslides	**2**	**2**
5.3. Erosion	**2**	**2**
6. Meteorology		
6.1. Precipitation	**-**	**-**
6.2. Wind	**-**	**-**
7. Man-induced events		
7.1. Pipelines	**1**	**1**
7.2. Airports and air tracks	**2**	**2**
7.3. Hazardous and special installations	**2**	**2**
8. Transportation of radioactive waste		
8.1. Existing routes	**2**	**2**
8.2. Possibility of radioactive waste transportation	**2**	**2**
9. Land use		
9.1. Land use	**2**	**2**
10. Population distribution		
10.1. Population distribution	**2**	**2**
11. Protection of the environment		
11.1. Impact on areas *of significant public values*	**2**	**2**
11.2. Damage to public water supplies	**2**	**2**

According to the list of the criteria recommended by IAEA most environmental aspects have been evaluated as acceptable (14 items for the north site, 17 items for the south site) or medium acceptable (15 items for the north site, 11 items for the south site).

The Report [65] indicates that the problem of the north site is that it is located in the area of the tectonic faults. The installation of reinforced concrete slab that could withstand the Earth crust faults and thus secure the integrity of the repository's foundation therefore is recommended. As the problem concerning the both sites the Report [65] indicates the possibility of the partial flooding of the sites. Therefore the filling up with gravel and sand all over the area where the *Landfill* facility will be located as well as the installation of effective drainage layer and the reinforced concrete slab are recommended. In order to improve the complex engineering geology conditions on the sites the relief should be levelled and "weak" organogenic soils removed (excavated) in the location of the repository's construction.

The evaluation and comparison of the environment of the sites in the Report [65] have been also performed based on site acceptance criteria that are specific for *Landfill* type facilities and presented in Studvik report [25]. Basically these criteria correspond to the criteria, given in the IAEA document [64].

The assessment of the potential radiological impact in the Report [65] has been carried out according to the ISAM methodology [19] recommended by IAEA for safety assessments of near surface facilities, as well as considering the IAEA recommendations, given in document [22]. For the comparison of the sites the scenarios of two types have been analysed:

- Scenario of waste leaching from the facility. The geological and hydrogeological characteristics of each site can be assessed when analysing the leaching scenario;
- Fire scenario. Radionuclide activities dispersed in the air can be assessed when analysing the fire scenario.

In case of the scenario of waste leaching from the repository maximum volumetric activities of radionuclides and time of their occurrence in the boreholes at a distance of 100 m from the repository, as well as in the point of the aquifer discharge (in Lake Druksiai) have been estimated. According to the estimation results maximum volumetric activities would appear later in the borehole of the Southern site than on the Northern site (due to lower velocity of the groundwater flow). The maximums in the Southern site should be higher by a factor of 2-2.5. The maximum values of volumetric activity in the point of the aquifer discharge (in the lake) would appear later in case of the Southern site as the underground water flow velocity is lower and location of the site is more distant from the lake. The maximums for separate radionuclides would be 2-5 times lower.

In case of the fire scenario volumetric activities of radionuclides in the air within the territory of the 1st command of the Fire-fighting brigade (FFB) have been estimated. In this case volumetric activities in the air on the Northern site, in the location of the critical group, are higher by a factor of 4 than in case of the Southern site.

Summarising the results of the radiological assessment the Report [65] states that from the point of view of radiological assessment of the sites the difference between the alternative sites is not significant and is of the same order for the both sites.

According to the report [65] it has been concluded, that both sites called north and south are acceptable for the construction of the *Landfill* disposal facility with respect to the key requirements for the sites acceptance, namely run-off (flooding), hydrogeological conditions (flow rate and path length of potential radionuclide migration) as well as stability (geological movements) as well as taking into account the results of preliminary assessment of the potential radiological impact on environment as well as the reference design of the facility.

The south site should be more suitable for the construction of the *Landfill* facility as:

- Hydrogeologic, seismologic and tectonic conditions for construction of the repository are more favourable in the south site;
- The results of assessment of potential radiological impact are of the same order for both candidate sites, however the conditions for the radionuclide migration are more restrictive in the south site due to lower flow velocity and more distant discharge point of aquifer (Lake Druksiai).

3.7 Monitoring

3.7.1 Supporting Documents and Investigations

Since start-up of operation the INPP performs monitoring of environment within 30 km radius monitoring zone around the power units. The monitoring is performed in accordance with regulatory approved environment monitoring program. The monitoring program is originated on the base of Lithuanian radiation protection standards [44], Lithuanian legislation and regulations on environment monitoring [66, 67] and regulatory documents on the environment [2, 68]. Monitoring data is being summarized and submitted to competent institutions annually.

The INPP Environment Monitoring Programme [69] specifies requirements for:

- Monitoring of water quality in the lake and of groundwater (physical – chemical parameters);
- Monitoring of radionuclide concentration in the air and atmospheric fallouts;
- Monitoring of radioactivity of sewage and drainage water from the INPP site;
- Monitoring of radionuclide release into the air;
- Meteorological observations;
- Monitoring of radionuclide concentration in the lake and underground water;
- Dose and dose rate monitoring in the sanitary protective area (3 km) and radiation control area (30 km);
- Monitoring of radionuclide concentration in the fish, algae, soil, grass, sediments, mushrooms, leaves;
- Monitoring of radionuclide concentration in food products (milk, potatoes, cabbage, meat, grain-crops).

The chemical content of sanitary waste water discharges from the industrial site of INPP is controlled by "Visagino energija".

The radiological measurements performed according to the INPP current environment monitoring Programme [69] are summarized in Table 3.34.

The planned *Landfill* facility will be constructed within environmental monitoring zone of INPP. The monitoring of the *Landfill* disposal facility is not included into monitoring program of Ignalina NPP at present time. The integration of the monitoring of the *Landfill* facility environment into monitoring system of Ignalina NPP will be worked out in detail during development of the Technical design.

Table 3.34. Summary of radiological measurements performed according to the INPP environment monitoring Programme [69]

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
			Volumetric activity 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.	$0.74\div1.85\times10^{8}$ Bq/l
			Sr-89, Sr-90	Radiometric	1 per month – water, discharged by reactor and turbine compartments.	$0.1\div3\times10^{3}$ Bq/l
			Total α activity	Radiometric	1 per month – water, discharged from Bld. 150.	$0.01\div10^{3}$ 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.	$0.01\div10^{3}$ Bq/l
			Volumetric activity of radionuclides 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 per week – releases of gases/aerosols from Bld. 150 through installation 153.	$1.85\div3.7\times10^{5}$ Bq/l

No.	Component of monitoring	Number of measuring points	Measured parameters	Measuring method	Monitoring object / location and periodicity	Measuring limits / detecting limit*)
			Volumetric activity of radionuclides of radioactive aerosols	Spectrometric	1 per day, per week and 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; 1 per month – from Bld. 130, from Bld. 156; 1 per quarter – from Bld. 157.	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.	$0.1\div3\times10^{3}$ 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.	$0.1\div3\times10^{3}$ Bq/l
			Volumetric activity of radionuclides	Spectrometric	1 per two weeks– water from installation 141; 1 per quarter – water of heating networks.	$0.74\div1.85\times10^{8}$ Bq/l
4.	The air and atmospheric precipitation	9	Activity of γ nuclides	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.	$1.5\times10^{-6}\div15$ Bq/m^3
			Sr-90	Radiometric	2 times per year (in winter and summer) - atmospheric air at points of permanent surveillance.	$3\times10^{-5}\div3\times10^{2}$ 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 nuclides	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 Druksiai lake; 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 Druksiai lake; 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 , 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 3.54	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;	1×10^{-6}–1×10^{-1} Sv/h
					Constantly – SkyLink system.	2×10^{-8}÷10 Sv/h
			γ radiation dose	Radiometric, TLD	2 times per year (in spring, autumn) – dose at locations of TLD in SPZ and SA.	2.5×10^{-4}÷5 Sv
7.	Sludge from storage area	1	Activity of γ nuclides	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 Druksiai lake	10 Sampling points in Lake Druksiai are indicated in Figure 3.55	Activity of γ nuclides	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
			Activity of γ nuclides of upper layer (2 cm)	Dried, concentrated sample. Spectroscopic	1 per year (in spring) – at sampling points of Druksiai lake.	15 Bq/kg
			Sr-90 in upper layer (2 cm)	Burning and radiochemical segregation	1 per year (in spring) – at sampling points of Druksiai lake.	30 Bq/kg
			Distribution profile of gamma nuclides (3-10 cm)	Radiochemical segregation	1 time in 5 years – at sampling points of Druksiai lake.	15 Bq/kg
			Distribution profile of Pu isotopes (3-10 cm)	Radiochemical segregation	1 time in 5 years – at sampling points of Druksiai lake.	300 Bq/kg
9.	Aquatic vegetation of Druksiai lake	11 Sampling points in Lake Druksiai are indicated in Figure 3.55	Activity of γ nuclides	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 Druksiai lake.	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 Druksiai lake.	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 nuclides	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 an in Grikiniskes peninsula; 2 times per year (in spring, autumn) – fish of Druksiai lake; 1 per year (in summer) – organisms of aquatic environments (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 Grikiniskes peninsula, mushrooms and moss at locations of Vilkaragis, 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 an in Grikiniskes peninsula.	3 Bq/kg
					1 per year (in spring) – fish of Druksiai lake; 1 per year (in summer) – organisms of aquatic environments (molluscs); 1 per year (in August) – cabbage in Tilze; 1 per year (in autumn) - milk in Tilze.	0.3 Bq/kg
					1 per year (in autumn) – soil at points of permanent surveillance an in Grikiniskes peninsula.	30 Bq/kg
			Activity of α nuclides	Radiochemical segregation	1 per year (in summer) – organisms of aquatic environments (molluscs).	3 Bq/kg

*) Detecting limit indicated in the table corresponds to the lowest measuring activity of the sample with 95% confidence. The lower activities could be measured with lower confidence. Samples of the same type may by different in composition (for e.g. samples of soil may be different in granulometric) therefore detecting limits of samples will be different. Conservative (maximum) meanings of the detecting limits are presented in the table.

Abbreviations presented in the table:

Bld. 150 – is liquid radioactive waste treatment and bituminisation 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.

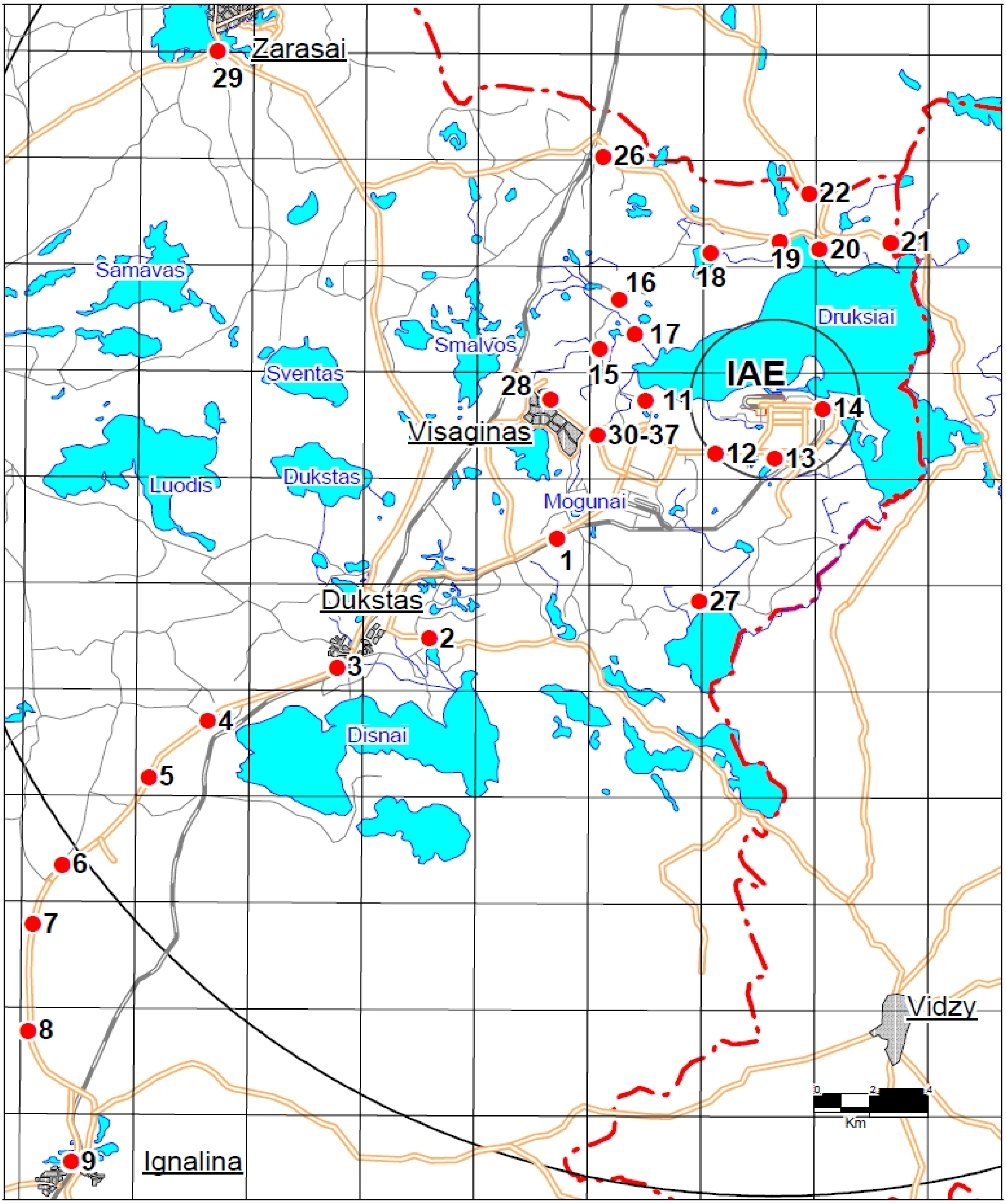


Figure 3.54. Location of thermoluminescent dosimeters around the INPP [69]

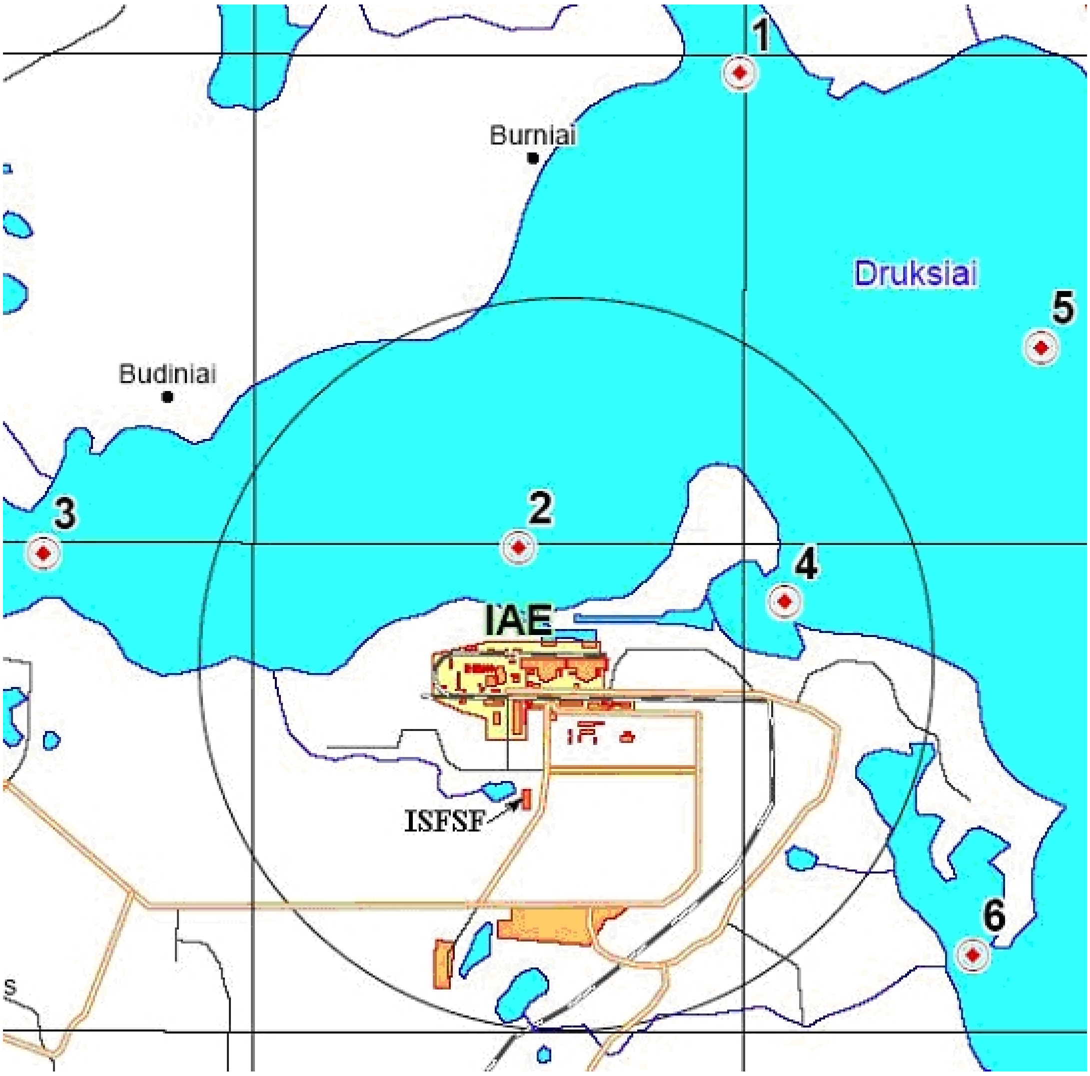


Figure 3.55. Sampling positions in Lake Druksiai [69]

3.7.2 Updating of the INPP Monitoring Program due to Operation of the *Landfill* Disposal Facility

The updating of the INPP monitoring program [69] due to operation of the *Landfill* disposal facility is summarized in Table 3.35.

Table 3.35. Updating of the INPP environment monitoring program due to operation of the *Landfill* disposal facility

No.	Monitoring object	Requirements	Need of the additional monitoring	Comments
Environment monitoring during operation period of the *Landfill* disposal facility				
1.	Meteorological monitoring in the INPP region	Par. 41 in the document [2]	Not required	Meteorological monitoring is already realized by INPP. The existing monitoring system allows measuring of meteorological parameters for all operating conditions and measured meteorological conditions.
2.	Radionuclide releases from the INPP	Pars 43-50 in the document [2]	Additional monitoring of discharges into the water environment in the territory of the *Landfill* facility. Additional monitoring of airborne radionuclide releases is not planned; potential gaseous emissions (^{14}C) from the *Landfill* facility are estimated by calculations.	Will be performed by periodic sampling and sample measurement in laboratory.
3.	Radionuclide concentration in the air	Par. 54 in the document [2]	Additional monitoring of airborne radionuclide releases is not planned; potential gaseous emissions (^{14}C) from the *Landfill* facility are estimated by calculations.	
4.	Radionuclide concentration in the precipitation	Par. 54 in the document [2]	Additional monitoring of the specific activity in the precipitation within territory of the *Landfill* facility	Will be performed by periodic sampling and sample measurement in laboratory.
5.	Radionuclides concentration in the aquatic environment	Par. 55 in the document [2]	Not required	The monitoring of chemical parameters (toxic substances) of Lake Druksiai, the monitoring of the water quality of Lake Druksiai as well as the monitoring of

No.	Monitoring object	Requirements	Need of the additional monitoring	Comments
				drainage water to Lake Druksiai are already realized by INPP.
6.	Radionuclides concentration in the water of the monitoring wells	Pars 4 and 12.5 in the document [70]; Par. 54 in the document [2]	Additional monitoring of the specific activity in the water of the monitoring wells installed around the *Landfill* disposal facility	The wells for the monitoring of the ground water will be installed around the site of the *Landfill* facility.
7.	Chemical content of the water of the monitoring wells	Par. 12 in the document [70]	Additional monitoring of the chemical content in the water of the monitoring wells installed around the *Landfill* disposal facility	The wells for the monitoring of the ground water will be installed around the site of the *Landfill* facility.
8.	Radionuclide concentration in the soil	Par. 54 in the document [2]	Additional monitoring of the radionuclide concentration in the soil around the *Landfill* disposal facility	Will be performed by periodic sampling and sample measurement in laboratory.
9.	Radionuclides concentration in the bottom sediments	Par. 55 in the document [2]	Not required	Necessary measurements are already realized by INPP.
10.	Radionuclides concentration in the plants and food stuff	Par. 54 in the document [2]	Not required	Necessary measurements are already realized by INPP.
11.	Dose rate, dose	Par. 51 in the document [2]	Additional monitoring of the dose rate as well as around the *Landfill* disposal facility	The TLD will be located around the site of the *Landfill* disposal facility.
Environment monitoring after closure of the *Landfill* disposal facility (period of the active institutional control)				
12.	Meteorological monitoring in the	Par. 41 in the document [2]	Not required	Meteorological monitoring is already realized by INPP. The existing monitoring

No.	Monitoring object	Requirements	Need of the additional monitoring	Comments
	INPP region			system allows measuring of meteorological parameters for all operating conditions and measured meteorological conditions.
13.	Radionuclide releases from the INPP	Pars 43-50 in the document [2]	Additional monitoring of discharges into the water environment in the territory of the *Landfill* facility. Additional monitoring of airborne radionuclide releases is not planned; potential gaseous emissions (^{14}C) from the *Landfill* facility are estimated by calculations.	Will be performed by periodic sampling and sample measurement in laboratory.
14.	Radionuclide concentration in the air	Par. 54 in the document [2]	Additional monitoring of airborne radionuclide releases is not planned; potential gaseous emissions (^{14}C) from the *Landfill* facility are estimated by calculations.	
15.	Radionuclide concentration in the precipitation	Par. 54 in the document [2]	Additional monitoring of the specific activity in the precipitation within territory of the *Landfill* facility	Will be performed by periodic sampling and sample measurement in laboratory.
16.	Radionuclides concentration in the aquatic environment	Par. 55 in the document [2]	Not required	The monitoring of chemical parameters (toxic substances) of Lake Druksiai, the monitoring of the water quality of Lake Druksiai as well as the monitoring of drainage water to Lake Druksiai are already realized by INPP.
17.	Radionuclides concentration in the water of the monitoring wells	Pars 4 and 12.5 in the document [70]; Par. 54 in the document [2]	Monitoring of the specific activity in the water of the monitoring wells installed around the *Landfill* disposal	The monitoring of the specific activity in the water of the monitoring wells installed around the *Landfill* disposal facility will be continued.

No.	Monitoring object	Requirements	Need of the additional monitoring	Comments
			facility	
18.	Chemical content of the water of the monitoring wells	Par. 12 in the document [70]	Monitoring of the chemical content in the water of the monitoring wells installed around the *Landfill* disposal facility	Monitoring of the chemical content in the water of the monitoring wells installed around the *Landfill* disposal facility will be continued.
19.	Radionuclide concentration in the soil	Par. 54 in the document [2]	Monitoring of the radionuclide concentration in the soil around the *Landfill* disposal facility	Will be performed by periodic sampling and sample measurement in laboratory.
20.	Radionuclides concentration in the bottom sediments	Par. 55 in the document [2]	Not required	Necessary measurements are already realized by INPP.
21.	Radionuclides concentration in the plants and food stuff	Par. 54 in the document [2]	Not required	Necessary measurements are already realized by INPP.
22.	Dose rate, dose	Par. 51 in the document [2]	Additional monitoring of the dose rate as well as around the *Landfill* disposal facility	The TLD will be kept around the site of the *Landfill* disposal facility.
23.	Integrity of the disposal facility and check of permeability of the disposal units			The volume of effluent water from the disposal facility will be measured and the control of radionuclide content will be carried out using laboratory spectrometric equipment.

Note: The monitoring will be stopped during the passive institutional control period of the *Landfill* disposal facility.

The type and frequency of measurements will be in correspondence to the present monitoring program of INPP. No supplements are planned at the present stage. The detailed updating of the program is planned after the updating of *Integrated Permission of Pollution Prevention and Control for State Enterprise Ignalina NPP*.

3.8 Risk Analysis and Assessment

Emergency situations (emergencies) potentially resulting from the proposed economic activity and which could potentially cause an impact on the environment are addressed in this section. The risk analysis of potential emergency situations is performed in accordance with the recommendations presented in the document [71]. The assessment of the consequences of the possible emergency situations as well as the risk level and the impact prevention/mitigation measures are presented in the section.

3.8.1 Identification and Assessment of Potential Emergency Situations

The emergency situation will be possible only after the waste transportation into the disposal facility and the disposal of the RAW have started. Two periods can be distinguished:

- Operation period (the waste disposal) and,
- Period after closure of the *Landfill* disposal facility (institutional control period and the period after institutional control).

The emergency situations during operation period are related to the transportation of the containers with RAW to the disposal facility as well as to the waste handling in the site. The risks regarding the breakdown of the equipment and its components are mostly related to the conceptual solutions of the proposed economic activity which will be accepted during development of the Technical design.

Just highly unlikely events as well as force majeure are included into the list of risks after the closure of the *Landfill* disposal facility as the RAW handling will not be carried out during this period.

The results of the risk analysis are summarized in Table 3.36. The structure and content of the table is in correspondence with recommendations of normative document [71]. The requirements for the classification of the consequences of a potential accident (for life, environment and property), the accident development speed and the probability of accident occurrence are explained in Table 3.37. More detailed explanations can be found in the document [71].

Table 3.36. Risk analysis of the potential emergency situations during performance of the proposed economic activity

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	E	P	S	Pb	Pr		
Container with RAW	Container transfer	Wrong delivery of container (wrong class of the RAW).	Personnel	Direct exposure to the personnel	2	1	1	5	**1**	**B**	Visual identification of container type. Check of documentation Reception control at the buffer storage facility.	
		Container drop	RAW, environment, personnel, population	Drop, spread of waste, direct exposure to personnel and public	2	2	1	5	**2**	**B**	Speed restriction. Excellent qualification of the driver. Appropriate container fixing to the trailer Locking of the container cover.	
Container with RAW	Container unloading from a vehicle, its placing in a dedicated place	Collision, drop	RAW, environment, personnel, population	Drop, spread of waste, direct exposure to personnel and public	2	2	1	5	**2**	**B**	The type of the fork-lift truck corresponding to container. Personnel qualification	
Container with RAW	Disposal of containers	Fire	RAW, environment, personnel, population	Exposure to the personnel and public	1	2	2	5	**2**	**B**	Appropriate measures for fire fighting and for fire extinguishing	

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	**E**	**P**	**S**	**Pb**	**Pr**		
Landfill facility		Damage of the waterproof layer	Containers with RAW	Humidity in the disposal facility, corrosion and degradation of the containers, possible early releases of radionuclides.	1	2	2	1	**2**	**B**	Check of integrity of the disposal facility and permeability of the disposal units. Additional waterproof barriers are installed if necessary.	Monitoring of the volume of effluent water from the disposal facility and its radionuclide content.
		Flooding	Containers with RAW	Humidity in the disposal facility, corrosion and degradation of the containers, possible early releases of radionuclides.	2	2	2	1	**2**	**B**	Installation of the drainage system in the site	
		Earthquake	Excluded									Probability of a design basis earthquake - 10^{-2}, and a beyond design basis earthquake - 10^{-5}. The reinforced concrete bottom slab of the disposal facility will be designed to resist a 7-force earthquake.
		Aircraft crash (intended sabotage by a worker (e.g., with use of	Disposal facility. Packages with RAW	Damage to the construction, fire, radionuclide releases, exposure to population.	3	3	4	5	**1**	**C**	a) The activity of the stored/disposed waste is very low, therefore it is unlikely, that they could be the target of terrorists, since consequences of the terrorist act would be insignificant and easily eliminated,	Beyond design basis accident

Operation	Hazard	Risk	Threatened object	Consequences	Seriousness				Risk level		Preventive measures	Remarks
					L	E	P	S	Pb	Pr		
		explosives), case of intended intrusion, terrorist act, potential conflicts)									b) The waste do not contain materials which could be used for preparation of large-scale terrorist acts (a "dirty" radioactive bomb). c) The storage facility will be arranged on the well protected industrial site of INPP, the disposal units will also be constructed within the protected zone and provided with necessary measures of physical protection. d) For prevention of terrorist acts and diversions, and also for liquidation of possible consequences "Comprehensive Plan of Protection Against Terrorist Acts" has been developed and has been in force at INPP. e) Extremely low probability ($<10^{-7}$) of an aircraft crash.	

Table 3.37. Classification of consequences for life and health (L), environment (E), property (P), accident development speed (S), accident probability (Pb) and prioritization of consequences (Pr) according to recommendations [71]

Classification of consequences for life and health (L)

ID	Class	Characteristic
1	Unimportant	Temporary slight discomfort
2	Limited	A few injures, long lasting discomfort
3	Serious	A few serious injuries, serious discomfort
4	Very serious	A few (more than 5) deaths, several or several tenths serious injuries, up to 500 evacuated
5	Catastrophic	Several deaths, hundredths 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	Simple contamination, localized effects
3	Serious	Simple 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		
3	Medium	Some spreading, small damage
4		
5	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

Prioritization of consequences (Pr)

ID	Characteristic of consequences
A	Unimportant
B	Limited
C	Serious
D	Very serious
E	Catastrophic

3.8.2 Assessment of Potential Emergency Situations

The assessment of consequences resulted from the screened potential emergency situations is presented in the section assuming that the accident conditions should be caused. The accident conditions are supposed as the deviations from the normal operation more severe than anticipated operational occurrences, including design basis accidents and beyond design basis severe accidents.

Design basis accidents – are accident conditions against which a nuclear facility is designed according to established design criteria. The consequences and the release of radioactive material are kept within authorized limits in this case.

The dose constraint of 0.2 mSv per year during operation and decommissioning of the nuclear facility is prescribed in the normative document [20]. The exposure dose limit of 10 mSv to the population in case of design basis accidents is indicated in the par. 90 of the document [20].

According to the risk analysis, see section 3.8.1, the potential impact is analyzed for the identified emergencies as follows:

- Drop of container, spread of waste;
- Fire in the disposal facility, ignition of the combustible waste packages.

The analysis of potential radiological consequences must provide the assessment of the exposure to a member of the population due to passing through of a radioactive cloud. It is impossible to decrease the consequences due to rapid dispersion of the radionuclides in the atmosphere. Appropriate measures shall be implemented immediately after the accident (especially within the existing SPZ) to assess contamination zones and to mitigate potential consequences due to external exposure from deposited radionuclides on the ground and from ingestion of contaminated foodstuff.

The aircraft crash upon the *Landfill* disposal facility as the beyond design basis accident is screened out for more detailed analysis. The probability of the accident is extremely low ($< 10^{-7}$). The effective dose to the member of critical group in case of the beyond design basis accident is estimated assuming the same pathways of both internal and external exposure as in case of the design basis accident.

3.8.2.1 Drop of Container

In each case of drop of container (i.e. a container, a half-height container or a single package with RAW) waste will be spread and personnel as well as population will receive an additional exposure dose. The spread of the waste is possible after drop due to breakdown or wrong closing of the container.

3.8.2.1.1 Modelling

The container shielding (i.e. the walls of the containers) is not taken into account when modelling the spread of the RAW. Therefore the whole amount of the RAW is assumed as the source of direct irradiation.

For modelling of the radiation source (RAW is put into a container, half-height container or single package) the waste is homogenized and described as a rectangular parallelepiped (Figure 3.56) with dimensions corresponding to inner dimensions of a container or half-height container.

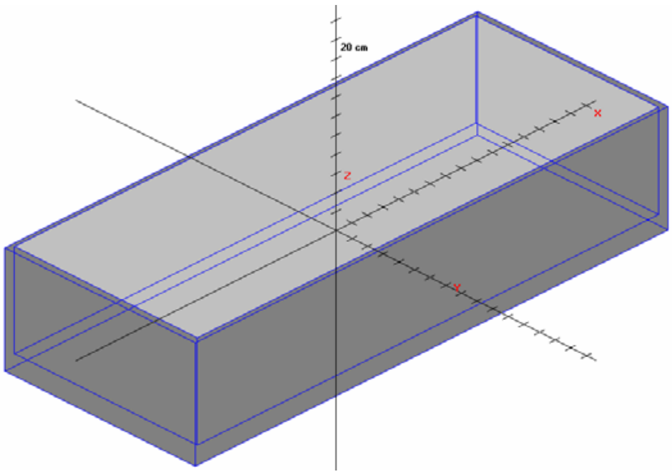


Figure 3.56. 3-D model of radiation source

As the most part of non-combustible waste consists of metal waste, for the drop of a half-height container with non-combustible waste the equivalent material of non-combustible RAW is considered to be steel with equivalent density calculated according to mass of non-combustible waste in a half-height container (15 t, estimated according to the total mass and volume of RAW to be disposed of) and its inner dimensions (15.5 m^3). Source activity is determined according to the specific activity and mass (15 t) of the waste inside the container.

For modelling of combustible RAW, composed of mixed waste (paper, wood, clothes, etc.) the equivalent material is water.

For modelling of container with combustible RAW, equivalent density is calculated according to mass of waste in the 24 packages and assuming they fill up the whole inner volume of the container (32.8 m^3). Source activity is determined according to the specific activity and mass of waste inside the container (21.6 t).

For estimation of the dose rate, the dose recipient is oriented towards the surface of the parallelepiped that represents RAW, i.e. to the side (longer) wall of the container.

For the assessment of the dose rate resulted from gamma radiation the computer software VISIPLAN [50] is used. The programme is used to calculate gamma dose rate for three-dimensional, simple or complex geometry. Calculation of dose rate from ionizing radiation sources with this programme is performed with the help of division into point sources method ("point-kernel"). The main entry data of VISIPLAN is geometry of the analysed system (radioactive sources, shields, etc.), material composition and density, radiation source parameters and coordinates of points where dose rate must be estimated.

Various tests were performed in order to validate gamma shielding algorithms installed in the VISIPLAN programme. Validation is based on comparison of the results received with the help of VISIPLAN with standard calculations according to the ANSI/ANS standard [72]. Comparison is also performed for the 1st ESIS task [73]

Calculations with VISIPLAN with the aim of validation demonstrated that the installed algorithms were acceptable for evaluation of the dose determined by radiation transfer through intermediate protective materials. More detailed information about validation of VISIPLAN is presented in document [50].

3.8.2.1.2 Dose assessment

The dose rates against distance that personnel would receive after the drop of the container with waste is presented in Figure 3.57 and Figure 3.58

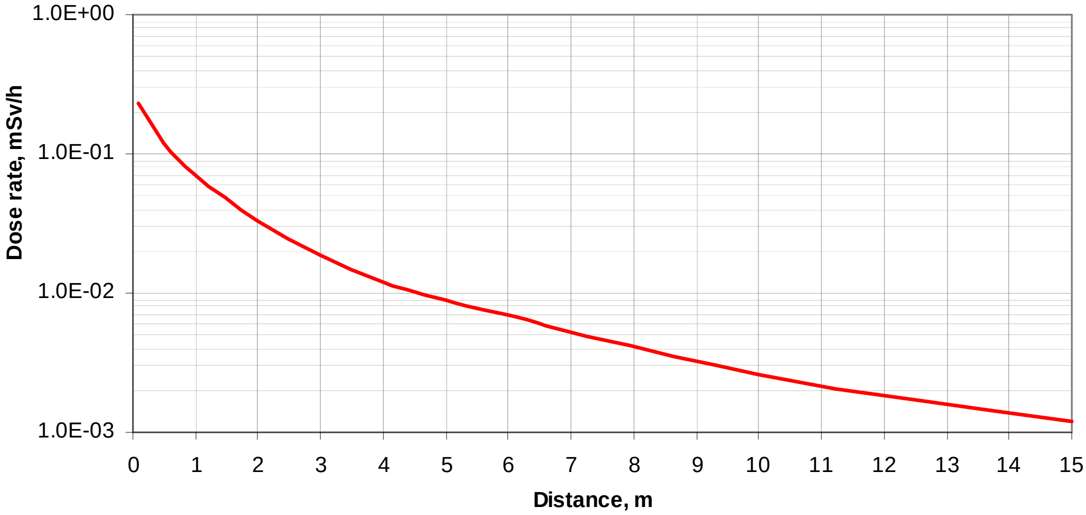


Figure 3.57. Dose rate r after the drop of one half-height container with incombustible RAW

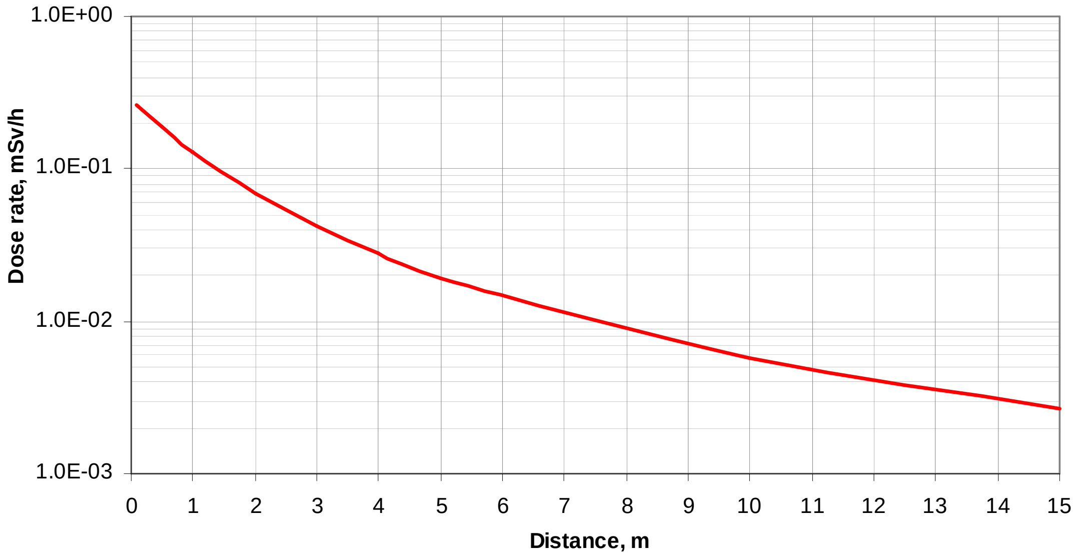


Figure 3.58. Dose rate after the drop of one container with combustible RAW (24 packages)

The rapid decrease of the dose rate with the increase of the distance is demonstrated in Figure 3.57 and Figure 3.58. The dose rate equals to 1.2E-03 mSv per hour at the distance of 15 m from the drop point of the half-height container with incombustible RAW. The dose rate equals to 2.7E-03 mSv per hour at the distance of 15 m after drop of the container with combustible RAW (24 packages). Regarding the protective fence surrounding the site it is unlikely that the member of critical group of population will be closer than 50 m from the *Landfill* facility. Therefore the dose rate should be negligible the member of critical group of population. The safety will be assured during transportation of the containers with RAW by speed limiting, excellent qualification of the driver as well as proper fixing of the container on the trail, etc.

3.8.2.2 Fire

The fire is estimated under accident conditions in the *Landfill* disposal facility during disposal campaign. The combustion of total amount of combustible waste available during one disposal campaign (i.e. the amount of combustible waste located in the buffer storage facility) is assumed. The fire due to combustible waste disposed during previous campaigns should be impossible as they are covered by engineering barrier. The radioactive materials released during fire will cause the exposure to the population.

3.8.2.2.1 Methodology for Assessment of Public Exposure Determined by Airborne Radioactive Materials

In case of accidents with release of airborne activity, the calculation of the atmospheric dispersion and the calculation of public exposure are based on the methodology recommended by German incident guideline [74]. This methodology is in accordance with requirements of European [75] and international normative documents [76]. This methodology has been successively applied in assessing of potential emergency consequences for the new INPP cement solidification facility and solidified waste interim storage project [53]. The dispersion modelling methodology used in [74] is described and recommended by IAEA Safety Series publication [77].

The dispersion and deposition of airborne material is calculated, using the short-term two-dimensional Gaussian distribution formula for a source which also may be elevated to a certain height above ground. Gaussian distribution central axis radionuclide concentration is used for assessment of maximal potential radiological consequences. Building wake effect is assumed if the release point is within the building wake influence zone. The terrain in the vicinity of the INPP up to distances of several tens of kilometres is sufficiently flat, so it can be stated that the dispersion is not influenced by the orography.

In general, accidents can happen at any time of the day and during unfavourable weather conditions. The most unfavourable factors for fallout and washout were defined to be representative for the investigated situations. The calculations were performed assuming no rain and heavy rain conditions (amount of rain of 5 mm/h). The calculations were performed for all different atmospheric stability conditions from class A (very unstable conditions) to class F (very stable conditions). The wind speed data for the height of 10 m used in the calculations are presented in Table 3.38.

Table 3.38. Wind speed parameters according to atmospheric stability class

Atmospheric stability class	A	B	C	D	E	F
Wind speed at the height of 10 m, m/s	1	2	4	5	3	2

The effective dose due to design basis accidents is calculated for a member of the population considering both the external and internal exposure pathways as follows:

- External exposure:
  - Exposure due to gamma radiation of the passing radioactive cloud (gamma submersion);
  - Exposure due to beta radiation of the passing radioactive cloud (beta submersion);
  - Exposure due to gamma ground radiation of the radioactive fallout and washout (exposure due to radioactive material on ground surface);
- Internal exposure:
  - Exposure due to radioactive intake by respiration (inhalation);
  - Exposure due to radioactive intake by consumption of foodstuffs (ingestion), such as milk, meat, green vegetables and other plant products (grain, grain products, root vegetables, potatoes, fruit, fruit juice).

The main parameters used for assessment of human exposure under design and beyond design basis accidents are presented in Table 3.39.

Table 3.39. Main parameters used for assessment of exposure to a member of population during accident conditions [74]

Parameter	Value	Remark
Adult breathing rate, m^3/s	3.8E-04	Conservative value for short time exposure
Annual exposure duration within SPZ, h	730	-
Annual exposure duration outside SPZ, h	8766	Conservative value
Annual intake of crop products (grain, grain products, potatoes, root vegetables), kg/a	610	Conservative value, 95% percentile
Annual intake of fresh (sheet) vegetables, kg/a	39	Conservative value, 95% percentile
Annual intake of milk and milk products, l/a	390	Conservative value, 95% percentile
Annual intake of meat and meat products, kg/a	180	Conservative value, 95% percentile
Amount of feed consumed by milk/meat produced animal, kg/d	65	Fresh mass
Average time between slaughter and human consumption of meat and meat products, d	20	Generic value
Food crops exposure period (growing season), d	60	Generic value
Yield (fresh mass) of pasture grass, kg/m^2	0.85	Generic value
Yield (fresh mass) of sheet vegetable, kg/m^2	1.6	Generic value
Yield (fresh mass) of other products, kg/m^2	2.4	Generic value
Surface dry weight of the pasture soil (depth of 10 cm), kg/m^2	120	Generic value
Surface dry weight of the plough land (ploughshare depth of 20 cm), kg/m^2	280	Generic value

Radiation dose coefficients for inhalation and ingestion are taken from the normative document [44]. The fractions of the released radionuclides into environmental air are provided in Table 3.40 following IAEA document [22].

Table 3.40. Radionuclide release fractions in case of fire [22]

Radionuclide	Release fraction
C, I	1.0
Zn, Cs	0.1
Ag	0.01
Other radionuclides	0.001

3.8.2.2.2 Assessment of Radiological Consequences

The design basis accident is estimated considering the specific of INPP SPZ. The annual presence of a member of the population within the SPZ is assumed to be the same as in case of normal operation conditions and is limited to 730 h per year. No restrictions are imposed outside the boundary of the SPZ. The design basis accident consequences are calculated assuming no changes in the daily life outside the SPZ border. The annual exposure time is assumed to be 8766 h per year. The production and the consumption of food products are not specially limited.

The radionuclide release height equals to the height of stack of the containers with waste (~7 m) it is assumed for the estimation of the radionuclide dispersion. The structure of the disposal facility is also taken into account.

The summary of the dose estimations is presented in Table 3.41. The critical atmospheric stability class is E (with rain). The maximum of effective dose due to radioactive cloud should be 0.33 mSv at the distance of 25 m. It should decrease with the distance and equals to 1.8E-03 mSv at the boundary of INPP SPZ. The maximum estimated dose to the member of critical group of population resulted from the ingestion of foodstuff should be below 0.52 mSv.

Table 3.41. Exposure dose to the member of critical group of population resulted from the radionuclide releases in case of fire in the *Landfill* disposal facility

Exposure type	Effective dose, mSv/year at the distance from the release point, m		
	25 [1)]	1 200 [2)]	5 500 [3)]
Due to radioactive cloud (gamma, beta submersion, inhalation)	3.33E-01	1.80E-03	1.61E-04
Due to radionuclides deposited on the ground surface	1.29E-1	5.62E-02	1.70E-2
Due to ingestion (consumption of contaminated foodstuff)	-	5.17E-01	1.41E-01
Total:	**4.62E-01**	**5.75E-01**	**1.58E-01**

[1)] At the protection fence of the site of the disposal units.
[2)] At the boundary of INPP SPZ.
[3)] At the state boundary with Belarus.

It is concluded that the radiological consequences due to fire in the *Landfill* disposal facility, i.e. the dose to population should be below dose limit of 10 mSv determined in case of design basis accidents.

3.8.2.3 Aircraft Crash

As Beyond Design Basis Accident the aircraft crash (including other accident situations by its consequences, e.g., intended sabotage by a worker, terrorist act, etc.) upon the *Landfill* disposal facility after the operation period of the facility is considered. All amount of very low level waste intended, for the disposal should be disposed of. It is assumed that the fire occurs after the aircraft crash. The amount of the combustible waste (25% of total waste amount) available in the disposal facility will combust.

The heat released during fire should cause the increase of the effective emissions height. However this is conservatively not taken into account. The decrease of the effective emission height should be caused after measures of the fire fighting have been taken. Therefore it is assumed the release height equals to the height of the stack of containers in the facility (~7 m). The structure of the disposal facility is also taken into account. The assessment methodology is presented in section 3.8.2.2.1.

The summary of the dose estimations is presented in Table 3.42. The critical atmospheric stability class is E (with rain).

Table 3.42. Exposure dose to the member of critical group of population resulted from the radionuclide releases in case of aircraft crash upon *Landfill* disposal facility

Exposure type	**Effective dose, mSv/year at the distance from the release point, m**		
	25 [1])	**1 200 [2])**	**5 500 [3])**
Due to radioactive cloud (gamma, beta submersion, inhalation)	4.78	2.58E-02	2.30E-05
Due to radionuclides deposited on the ground surface	1.85	8.04E-01	2.43E-01
Due to ingestion (consumption of contaminated foodstuff)	-	7.40	2.02
Total:	6.63	8.23	2.27

1) At the protection fence of the site of the disposal units.
2) At the boundary of INPP SPZ.
3) At the state boundary with Belarus.

The effective dose due to radioactive cloud should be 4.78 mSv at the distance of 25 m. It should decrease with the distance and equals to 2.58E-02 mSv at the boundary of INPP SPZ.

The effective dose due radionuclides deposition should be below 1.9 mSv at the distance of 25 m from release source assuming that 730 h/year should be spent in that point. The effective dose equals approx. to 0.8 mSv at the distance of 1 200 m assuming year around spent in that point.

The maximum estimated dose to the member of critical group of population resulted from the ingestion of foodstuff should be approx. 7.4 mSv on the boundary of INPP SPZ.

The dose to member of critical group of population should be below dose limit of 10 mSv determined in case of design basis accidents.

The assessment of the radiological consequences demonstrates that in case of the beyond design basis accident the impact mitigation measures should be taken immediately in order to determine the contamination zones as well as to decrease the doses resulted from the external exposure due to radionuclides deposition as well as due to consumption of the contaminated foodstuff.

3.9 Conclusions

Summarising the obtained estimation results of the environmental impact resulted from the construction of the *Landfill* disposal facility the conclusions can be drawn as follows:

1. Under the normal operational conditions of the disposal units no uncontrolled releases into the water component of the environment will occur, therefore no potential impact is foreseen.
2. Releases of both, non-radioactive contaminants and radionuclides into the atmosphere during normal operation of the disposal units are negligible and negative impact on the environment is not expected.
3. The additional impact raising the present damage level of the soil is not expected during the proposed economic activity. The removed fertile layer of the soil during smoothing the site surface will be kept and used after closure of the disposal facility for forming of a vegetative layer at the top of the disposal facility.
4. Impact on underground (geological) components of the environment due to the planned economic activity it is not expected.
5. During the construction phase as well as during the disposal campaigns an impact on reproduction of birds is possible. To preserve the site vicinities as living environments of birds, the disposal campaign can be carried out after the hatching period. In order to avoid unnecessary harm to vegetative communities and functions of the habitats the construction area in the site will be reduced to the minimum sizes necessary for carrying out the construction works as well as the operation of the disposal facility.
6. The *Landfill* disposal units will be constructed and operated in the territory close to the INPP industrial site. Impact on the landscape will be local and negligible.
7. No negative impact or obvious changes of the social and economic environment is expected. Moreover, the implementation of the project will decrease the social and economic effects due to final shutdown of Ignalina NPP as the work force with a high skill level associated with work in the nuclear industry will be used
8. The identified immovables and areas of the cultural heritage will not be affected by the construction of the disposal units as they are located away from the planned economic activity.
9. Negligible radiological impact on health of the population due to the disposal units is expected.
10. No significant potential radiological impact on population caused by the radionuclide releases from the disposal units into the aquatic environment is expected under normal operational conditions as well as during the period after closure of the disposal facility. The dose to the members of the critical group of the population in case of water consumption for daily needs is estimated approximately to 0.002 mSv per year, i.e. by two orders of magnitude below the value of the dose constraint – 0.2 mSv per year [20].
11. Potential radiological impact on the members of the critical group of the population caused by release of airborne radioactive substances from the disposal units under normal operational conditions should be below 5.6E-07 mSv per year and therefore is negligible.
12. Potential radiological impact on the members of the critical group of the population due to direct irradiation at the minimum distance of 25 m from the disposal facility, assuming exposure duration 730 hours per year would be approximately 3.1E-08 mSv/year and is estimated as negligible.

13. Potential radiological impact on the health of the population resulted from the disposal units after the institutional control period in case of unintended intrusion into the disposal facility is estimated to 0.022 mSv per year, i.e. much below the value of 10 mSv per year, used for such cases and, based on clause 91 of document [20], accepted according to the recommendations of document [21].
14. No negative impact on the environment and the health of the population of the neighbouring countries is expected during normal operation of the disposal units.
15. The analysis of the zero alternative as well as site alternative demonstrates that the construction of the disposal units is necessary and the site chosen for the construction of the disposal facility corresponds to the safety criteria taking into consideration the conceptual design of the disposal facility as well as the peculiarities of the site.
16. The assessment results in case of design basis and beyond design basis accidents reveal that the exposure dose to the member of the critical group of the population will be below permissible values.
17. The construction of the disposal units will not cause any significant negative impact either on the environment or on the population health.

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4 GENERAL CONCLUSIONS

Summarizing the results obtained after the assessment of the environmental impact from the proposed economic activity, both for the construction of the Buffer Storage and for the Disposal Units for very low level waste, it can be concluded that no components of the environment will be impacted significantly.

To mitigate the impact on such components as the soil and the biodiversity, corresponding mitigation measures will be taken during the construction and operation of the disposal units.

Impact on the population health is much below the limits established by the normative documents of the Republic of Lithuania both in case of normal operation of the planned nuclear facilities and in the period after closure of the disposal units, therefore for the planned economic activity the impact is estimated as negligible.

In case of implementation of the planned economic activity the common impact from the nuclear facilities located in the INPP sanitary protection zone also remains within the permissible limits.

During normal operation of both the Buffer Storage and the Disposal Units negative impact on the environment and the population health of the neighboring states is not expected.

The estimation results of the dose to the members of the critical group of the population in case of design basis and beyond design basis accidents have revealed that the exposure will be below the maximum permissible effective dose established by the normative documents of the Republic of Lithuania.

Both the construction of the Buffer Storage and the Disposal Units for very low level waste will not have a significant negative impact either on the environment or on the population health.

5 DESCRIPTION OF DIFFICULTIES

No difficulties (technical or practical) have been encountered by the developers while performing EIA and preparing the EIA Report.

6 DOCUMENTS OF PUBLIC INFORMATION AND PARTICIPATION IN EIA PROCESS

6.1 Conclusions of the relevant parties

The EIA report, revision 3, issue date October 22, 2008, has been presented for the relevant parties consideration in accordance with requirements of the Law on the Environmental Impact Assessment of Planned Economic Activity [1]. The EIA report has been submitted to the following institutions:

- State Nuclear Power Safety Inspectorate (VATESI);
- Ministry of Health of LR;
- Radiation Protection Centre;
- Department of Fire Protection and Rescue under the Ministry of Inner Affairs;
- Utena Regional Department of Cultural Heritage under the Ministry of Culture;
- Environment Protection Department of Utena Region of the Ministry of Environment;
- Administration of Utena District Head;
- Visaginas Municipality Administration.

The Ministry of Environment has coordinated the EIA programme under condition that the EIA report would include reasoned estimation of comments and proposals of foreign countries.

The copies of the EIA programme coordination letter of the Ministry of Environment, the letters from foreign countries (the Republic of Belarus and the Republic of Latvia), as well as of official answers from EIA relevant parties with comments and conclusions are included in Appendix 1 (in the Lithuanian version of the EIA report only):

- Copy of the letter of the Ministry of Environment No. (1-15)-D8-7808 of 08-09-2008, 1 page;
- Copy of the letter of the Ministry of Environment No. (1-15)-D8-8315 of 23-09-2008 with copies of the letter of the Ministry of Environment of the Republic of Latvia No. 2.1-03/6719 of 15-09-2008 and the letter of the Ministry of Natural Resources and Environment of the Republic of Belarus No. 14-09/3678-BH of 17-09-2008, 5 pages;
- Copy of the letter of the State Nuclear Power Safety Inspectorate No. (12.6.17)-22.1-1027, dated 003-12-2008, 1 page. 10 remarks were received;
- Copy of the letter of the Ministry of Health of LR No. 10-7118, dated 28-11-2008, 2 pages. 6 remarks were received;
- Copy of the letter of the Radiation Protection Centre No. 03-28-2410 of 07-11-2008, 1 page;
- Copy of the letter of the Department of Fire Protection and Rescue under the Ministry of Inner Affairs No. 9.4-3857 (9.20), dated 25-11-2008, 2 pages. 11 remarks were received;
- Copy of the letter of Utena Regional Department of Cultural Heritage under the Ministry of Culture No. 2U-365, dated 17-11-2008, 1 page. No remarks to be considered were received;
- Copy of the letter of the Environment Protection Department of Utena Region of the Ministry of Environment No. (5.1)-s-1944, dated 25-11-2008, 1 page. No remarks to be considered were received;
- Copy of the letter of the Administration of Utena District Head No. (1.50)-6-1863, dated 11-11-2008, 1 page. No remarks to be considered were received;
- Copy of the letter of Visaginas Municipality Administration No. (4.17)-1-4242, dated 17-11-2008, 1 page. 4 remarks were received;

- Remarks of the experts of the RPC technical support organisations. LT PI.05.01.02, Sub-task 1.4 EIAR review report, 1st draft, 05 January, 2009.

Answers to the remarks of the foreign countries, the EIA relevant parties and the experts of the technical support organisations are included in Appendix 2 (in the Lithuanian version of EIA report only):

- Answers to the remarks and proposals to the EIA programme of the foreign countries. S/14-PI.05.02.02.01.0001/EIAR-CR-01-UZSIENIS, issue date 09-01-2009, 7 pages;
- Answers to the remarks of VATESI. S/14-PI.05.02.02.01.0001/EIAR-CR-01-VATESI. Issue date 16-12-2008, 15 pages;
- Answers to the remarks of the Ministry of Health of LR. S/14-PI.05.02.02.01.0001/EIAR-CR-01-SAM. Issue date 15-12-2008, 8 pages;
- Answers to the remarks of the Department of Fire Protection and Rescue under the Ministry of Inner Affairs. S/14-PI.05.02.02.01.0001/EIAR-CR-01-PAGD. Issue date 16-12-2008, 10 pages;
- Answers to the remarks of the experts of the RPC Technical Support Organisations. S/14-PI.05.02.02.01.0001/EIAR-CR-01-RSC. Issue date 30-01-2009, 17 pages.

Based on the answers of the relevant parties (see Appendix 2) the EIA report has been updated and amended. The copies of official letters from the EIA relevant parties with conclusions about this updated EIA report are included in Appendix 3 (in the Lithuanian version of EIA report only):

- Copy of the letter of the State Nuclear Power Safety Inspectorate No. (12.6.17)-22.1-24, dated 09-01-2009, 1 page. 2 remarks were received;
- Copy of the letter of the Ministry of Health of LR No. 10-7, dated 05-01-2009, 1 page. Updated report has been approved;
- Copy of the letter of the Department of Fire Protection and Rescue under the Ministry of Inner Affairs No. 9.4-13 (9.4), dated 06-01-2009, 1 page. Updated report has been approved;
- Copy of the letter of the RPC No. 10-981, dated 18-02-2009, 1 page. Updated report has been approved.

Answers to the remarks of the EIA relevant parties to the updated EIA report are included in Appendix 4 (in the Lithuanian version of EIA report only):

- Answers to the additional remarks of VATESI. S/14-PI.05.02.02.01.0001/EIAR-CR-02-VATESI. Issue date 30-01-2009, 5 pages.

The copies of official answers from the EIA relevant parties with conclusions about the additionally updated EIA report (see Appendix 4) are included in Appendix 5 (in the Lithuanian version of the EIA report only):

- Copy of the letter of the State Nuclear Power Safety Inspectorate No. (12.6.41)-22.1-110, dated 09-02-2009, 1 page. Updated report has been approved.

Revision 4 of the EIA Report has been prepared, date of issue March 4, 2009, with the comments of the EIA subjects and foreign countries estimated, and submitted for approval to the responsible institution (LR Ministry of Environment). The Ministry of Environment in the letter No. (1-15)-D8-5503 of 22-06-2009, 3 p., presented 16 comments. The copy of the letter is given in Appendix 6 (only in the version in Lithuanian).

The answers to the Ministry of Environment comments and suggestions are presented in

Appendix 7 (in the Lithuanian version of EIA report only).

Additional conclusions of the EIA relevant parties to the EIA report regarding the possibilities of implementation of the proposed economical activity are included in Appendix 8 (in Lithuanian version of EIA report only).

6.2 Public informing documents

In accordance with requirements of Law of Republic of Lithuania on Assessment of the Impact on the Environment of the Planned Economic Activities [1] as well as Order of Informing the Public and the Public Participation in the Process of Environment Impact Assessment [2] the 2nd revision of the EIA report was presented for the public acquaintance.

The public was informed about the possibility to acquaint with the EIA report as well as about the intended public presentation more than 10 days before the planned meeting with the public. The announcements have been published as follows:

- in national daily newspaper “Lietuvos Rytas”, issued September 18, 2008;
- in town Visaginas newspaper “Sugardas”, issued September 18, 2008;
- in Ignalina regional newspaper „Zarasu krastas“, issued September 19, 2008;
- in Ignalina regional newspaper “Nauja Vaga”, issued September 20, 2008.

Copies of public informing announcements, 4 pages, are included in Appendix 9 of the report (in the Lithuanian version of EIA Report only).

It was possible to acquaint with the EIA report in the building of local governing at Visaginas town as well as in the Visitors centre of INPP. The EIA report was also available through INPP website (http://www.iae.lt).

The public presentation and the discussions on the EIA report was held in October 3, 2008 at the building of local governing at Visaginas town. The time convenient for the public (time off) was planned for the meeting.

Minutes of meeting has been prepared and signed in October 3, 2008. No comments or objections concerning minutes of meeting were obtained.

No motivated (justified) proposals concerning planned economic activity are obtained from the public until the issue date of the EIA report.

The copy of the Minutes of meeting held in October 3, 2008 with the appendix (presentation of the EIA report on planned economic activity), 13 pages, is included in Appendix 10 of the report (in the Lithuanian version of EIA Report only).

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1. 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).
2. 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).