INPP Unit 1 Decommissioning Project for Defuelling Phase Environmental Impact Assessment Report (U1DP0 EIAR)

For A1.4/ED/B4/0006

Issue 07

The Client of the Proposed Economical Activity is:	**State Enterprise Ignalina Nuclear Power Plant (INPP)**
The Provider of the EIA Report is:	**Ignalina NPP Decommissioning Service**
	Released: **S. Urbonavičius**

2007

LIST OF AUTHORS

Author, Organization	Phone	Chapters prepared	Signature
JP. Tack, Belgatom	+32 2 773 81 04	1-5, 7-9	
V. Georges, Belgatom	+32 2 773 75 63	3, 7-9	
V. Kachka, INPP	+370 386 243 88	2, 3, 7-9	
B. Centner, Belgatom	+32 474 840 410	6	

AMENDMENT RECORD

Issue	Description of Amendment	Originator	Checker	Approver	Date
Issue 01	First issue	B. Centner V. Georges V. Kachka J.P. Tack	J-C. Naisse	M. Tyrrell	06/08/2004
Issue 02	Integration of the comments received on Issue 01	B. Centner V. Georges V. Kachka J.P. Tack	J-C. Naisse	M. Tyrrell	28/10/2004
Issue 03	Review on the basis of comments made by the Ministry of Health Care and VATESI	B. Centner V. Kachka J.P. Tack	J-C. Naisse	M. Tyrrell	16/11/2004
Issue 04	Needed documents were added to second part of the Report	B. Centner V. Kačka J.P. Tack	J-C. Naisse	M. Tyrrell	03/12/2004
Issue 05	Integration of the comments received from Ministry of Environment and consulted parties on Issue 04	B. Centner V. Kachka J.P. Tack	J-C. Naisse	M. Tyrrell	08/12/2005
Issue 06	Integration of INPP comments on Issue 05	V. Kachka J.P. Tack	J-C. Naisse	B. Rodionov	04/14/2006
Issue 07	Integration of the comments received from Ministry of Environment to Issue 06	V. Kachka J.P. Tack	J-C. Naisse	S. Abdulajev	07/21/2006

Table of Contents

List of Tables

List of Figures

List of Appendices

Abbreviations

ALARA	As Low As Reasonably Achievable
ALS	Accident Localization System
DP	Decommissioning Project
DSAR	Decommissioning Safety Assessment Report
EBRD	European Bank of Reconstruction and Development
EIA	Environmental Impact Assessment
EIAP	Environmental Impact Assessment Programme
EIAR	Environmental Impact Assessment Report
EU	European Union
FDP	Final Decommissioning Plan
HOB	Heat Only Boiler Plant
IAEA	International Atomic Energy Agency
IIDSF	Ignalina International Decommissioning Support Fund
INPP	Ignalina Nuclear Power Plant
INPP-DP	Ignalina NPP Decommissioning Project
INPP-DPMU	Ignalina NPP Decommissioning Project Management Unit
INPP-FDP	Ignalina NPP Final Decommissioning Plan
INPP-PDP	Ignalina NPP Preliminary Decommissioning Plan
ISFSF	Interim Spent Fuel Storage Facility
LLA	Long Lived Aerosol
MWe	Electrical Mega Watt (Power Production)
MWth	Thermal Mega Watt (Thermal Production)
MWTP	Municipal Wastewater Treatment Plant
RAW	Radioactive Waste
RFS	Reactor Final Shutdown
RPD	Radiation Protection Department
RSS	Rain Sewerage System
SAR	Safety Analysis Report
SB	Steam Boiler Plant
SF	Spent Fuel
SWMSF	Solid Waste Management and Storage Facility
TRU	Transuranics
VATESI	The State Nuclear Power Safety Inspectorate
WAC	Waste Acceptance Criteria

Part I EIA Data and Results

Non Technical Summary

General Information

The Seimas of the Republic of Lithuania approved the National Energy Strategy on 5th October 1999. One of the main elements of the National Energy Strategy is the plan for the decommissioning of Ignalina NPP. In November 2002, the Government of the Lithuanian Republic decided to implement the Immediate Dismantling Strategy “in order to prevent the heavy long-term social, economical, financial and environmental consequences”.

The decommissioning of the Ignalina Nuclear Power Plant (INPP) is to be considered as an economical activity for which, according the Lithuanian legislation, performing an Environmental Impact Assessment (EIA) process is mandatory. The EIA Lithuanian legislation complies with the EU EIA Directive and EBRD practices; therefore the Lithuanian procedures are used.

To comply with this requirement an EIA Programme has been prepared and approved successively by the concerned Lithuanian Authorities and the Ministry of Environment (May 2004). The EIA Programme is a scoping document on the basis of which are determined the main environmental issues to be considered in the forthcoming EIA Reports. The whole INPP decommissioning is split in several Decommissioning Projects (DPs). Each of these DPs is subject to a license for which a specific Environmental Impact Assessment Report is to be produced.

The first Decommissioning Project, **(the so-called U1DP0),** to which the present EIA Report is associated concerns all the decommissioning activities (except for dismantling and decontamination of dismantled equipment) that will take place during the **Unit 1 Defuelling Phase , i.e. from Unit 1 Reactor Final Shutdown until complete defuelling (estimated by December 2012)**.

This EIA Report does not cover in detail the new facilities to be erected to support the implementation of the INPP Decommissioning (such as new energy production plants, new waste treatment and storage facilities), as they are subject to their own separate licensing and EIA processes.

However, the radiological impact assessment presented in this EIA Report takes into account an estimation of the environmental impact of these new facilities.

This EIR Report takes also into account the environmental impact of Unit 2 (in operation until end 2009 and in decommissioning until 2012).

Pure decommissioning works (dismantling and decontamination of equipment and structures) are subject to other, forthcoming Decommissioning Projects for which associated EIA Reports will be produced.

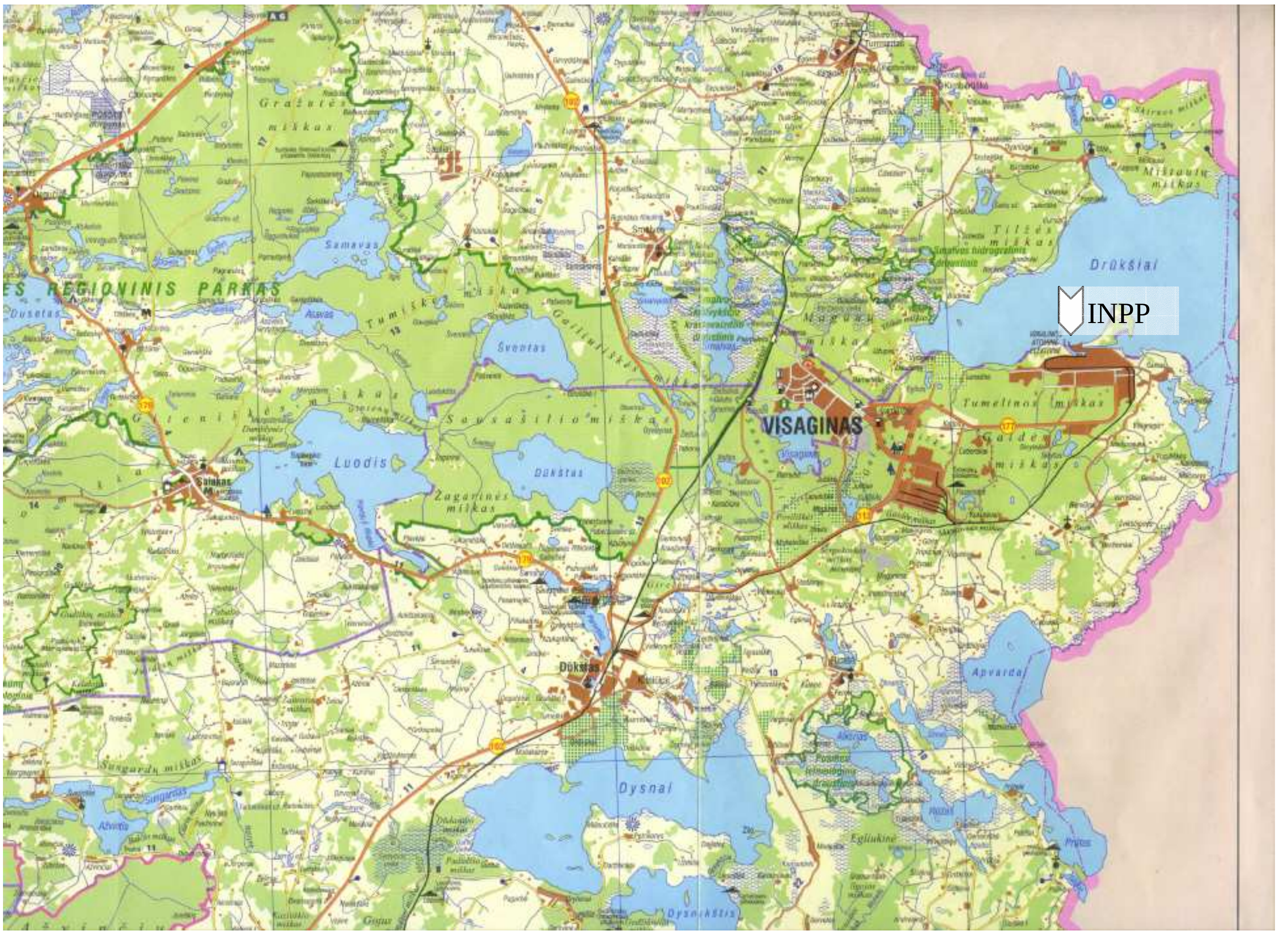
Information about the Location of the Project

The INPP is located on the north-east edge of Lithuania, close to the Latvian and Byelorussian borders, on the shore of the Lake Drukshiai. The Plant is part of the so-called INPP region which covers the Ignalina and Zarasai districts (part of the Utena County) and is located on the territory of the Visaginas municipality. The nearest major cities are Vilnius at 130 km (553,000 inhabitants) and Daugavpils in Latvia at 30 km (126,000 inhabitants).

The INPP location is illustrated on Map 1.

Preliminary construction of the NPP began in 1974, and its related town Visaginas began to rise several kilometres from the NPP site. In 1979, the population of the Ignalina district was 37,800, it is nowadays 73,900 (28,800 in Visaginas). A particularity of the city is the high rate of Russians and Russian speakers, with about 85%.

Map 1 Location of INPP



Environmental baseline

The EIA Report describes the INPP existing environment during current operation. This is the baseline against which the environmental consequences of the U1DP0 project are then evaluated.

Socio-economical Issues

From the economic point of view the INPP region is an insufficiently developed region in Lithuania (the town of Visaginas making the exception). At present, business and industry potential existing in INPP region is practically not employed and region is losing competitive activity for investment attraction.

In average, the population in Visaginas is rather young, with a good level of education, a great variety of professional training, less unemployment and better income than in the neighbour regions. It is however at the beginning of developing relationships with other parts of the country. Foreign investments are low. The opinion of the population within the INPP Region, on the INPP closure, is negative, in particular in Visaginas (92% against).

Climate and Air Quality

Winds are blowing mainly in the direction of east (Belarus) and north (Latvia).
The snow cover in the region is present for about 120 days per year.
The quality of air is good.

Geology, Soil Characteristics and Hydrogeology

In the area of Ignalina NPP the surface sediments are very inhomogeneous: the marsh, lake-marsh, lake-glacial and water-glacial sediments are located near the surface and at the level of the building foundations and other constructions. They all contain groundwater, at little depth (0.2 to 7 m), which flows toward north and northeast (in the direction of the Lake Drukshiai). There are active water exchanges with the next in-depth aquifers and other lateral groundwater catchments; the extraction in the Visaginas town waterworks exerts a local influence on these exchanges.

Hydrology

The Lake Drukshiai is the largest (49 km²) of Lithuania, with a part of it (6.7 km²) in Byelorussian territory. It receives the inflow of 11 rivers and outflows into the Prorva river (Byelorussia). The water regime of the lake is formed by the conjunction of:

- natural factors (precipitations, evaporation from the lake and its watershed) and
- man-made factors (i.e. the control of discharge by the hydro-engineering complex on the Prorva river and the yearly use of water for the operation of INPP, which is 9 times the volume of the lake and 27 times the natural influx of water to the lake).

The water circulation in the lake is mainly influenced by the wind regime and the lake bottom pattern.

Direct releases to the lake come from the INPP (cooling, industrial and run-off water) and Visaginas (household wastewater and surface (rain) water). The INPP sanitary wastewater is sent to the State Enterprise “Visagino Energija”for treatment. This municipal wastewater treatment plant (MWTP) has to be enhanced to comply with EU standards (further nutrients[1] removal).

The thermal releases remain globally acceptable in comparison with the Lithuanian applicable standard (for cyprinid waters). Though it is rare, the norm for water temperature can be exceeded in particular unfavourable conditions (no wind, high air temperature, both units in operation).

[1] Such as nitrogen and phosphorus that favor the eutrophication of the lake.

The natural evaporation process is intensified by the thermal releases and the permanent ice cover on the lake in winter is reduced compared to pre-INPP conditions.

Before the start of INPP, the lake underwent some inputs of nutrients from the town's household sewage discharges. It is still the case today. Since the start of INPP, the eutrophication process was accelerated with the increase of population in the area. Nowadays, the lake water quality has changed from a mesotrophic state to an almost autrophic type, so that it is today rather in line with the Lithuanian (EU compatible) cyprinid[2] type water quality.

The thermal and chemical changes that occurred induced evolutions in the lake biodiversity.

Fauna and flora

Since 1979, when the construction of the INPP started, a State level Research has been conducted by Lithuanian research and academic institutions on the evolution of the local ecosystems (lake, terrestrial habitats).

For what concerns radioactive elements, it was shown that the first source of ^{137}Cs present in plants was the global fallout (of which INPP accounts for 21%). The main inputs of ^{60}Co and ^{54}Mn in the Lake Drukshiai could occur with industrial wastewaters. Biological accumulation of ^{90}Sr and mechanical sedimentation were recorded. However, those influences remain very low, as the dose to exposed individuals is less than 2% of the annual dose limit.

Natura 2000 areas are in the proposal stage to the EU Commission. The lake and neighbour areas are proposed as Natura 2000 areas.

The non-radiological influences on the lake water quality are due to pre-INPP anthropogenic influences, the thermal releases from INPP and the eutrophicating releases (from Visaginas household sewage discharges and small villages surrounding the lake).

As the lake evolved from the mesotrophic type to the almost eutrophic type, the functional and structural changes in the lake mostly caused by thermal and chemical pollution affected biodiversity. There was a decrease in the number of species (plankton, fish, aquatic plants, etc.) though there was an increase in total biomass.

Some terrestrial habitats were affected by the construction of INPP and by the influence of the growing population.

The gathering of mushrooms and berries is widespread and amateur fishing is very developed.

Cultural Heritage

The landscape of the region is characterised by the relief formed during glacial periods, consisting of picturesque mountain ridges, ravines, lakes, and plains as well as by pine forests and vast water meadows. It has been affected by the building of INPP, Visaginas and related infrastructures.

Some protected territories are present within a radius of 10km, for hydrographical and landscape interest reasons.

[2] Type of fish that develops in calm water bodies such as lakes or water courses mildly oxygenated.

Radiological conditions

Nuclide[3] content in the air and the precipitations in the INPP monitoring zone (30 km) are determined mainly by ^{137}Cs and ^{60}Co. It was shown that better operation and effluent purification procedures are at the basis of a part of the decrease observed for more than 10 years. Nowadays, the yearly average dose rate within the zone is not different than in other regions of the country; the operation of INPP has insignificant effect (less than 1%).

Brief Description of the U1DP0 Project

Having chosen to go for Immediate Dismantling of the INPP Units, the ultimate goal of the decommissioning is the safe, environmental friendly and cost-effective removal of all inventories (non-radioactive, radioactive and hazardous) from the units buildings and territory according to a process that, once started, should progress in an uninterrupted way until green field conditions are reached. For a large part of INPP site, this is foreseen around 2030. In order to achieve this goal, several projects have to be implemented.

The first one, the U1DP0 Project covers the period between Unit 1 Reactor Final Shutdown (RFS) and the total defuelling of the Unit (estimated by end of 2012).

After reactor final shutdown, many systems and components will stay in operation because the spent fuel and all other radioactive inventory will remain in place at that time. Ensuring continuous safety will require further operation of most of the systems. In the course of the relocation of the Fuel Assemblies from the core to the pools and from the pools to the Interim Spent Fuel Storage Facility and, later on also, after removal of the radioactive media from the components, the systems can be shut down step by step. Other systems, which are needed for further operational purposes or which, for dismantling purposes, should remain in operation will be modified if needed.

The Reactor Final Shutdown involves the elimination of the specific risks associated with a nuclear power plant in operation. The removal of the nuclear fuel involves the elimination of the specific risks related to the presence of nuclear fuel in the core and in the pools. Some in-line decontamination operations will be realised. Generic, preparatory, procurement activities will also be carried out. The time schedule is presented in the following table.

Period	Activities
2006	Authorisation for Reactor Final Shutdown
2006 – 2008	Reactor Defuelling - transfer of Fuel to Unit 2
2008	Reactor Defuelling - transfer of Spent Fuel to pools
2009	In-line decontamination activities
2008 – 2012	Unloading Spent Fuel from pools to Interim Storage Facility

Alternatives Considered

The Decommissioning of INPP is a strong commitment between the Republic of Lithuania and the European Union. Though three strategic alternatives were considered in the preliminary phases of the Decommissioning of INPP (Immediate, Deferred Dismantling, Entombment), the Lithuanian Government decided to go further with the Immediate Dismantling Strategy. The design of the Decommissioning Plan and the Decommissioning Projects is carried out accordingly. Therefore, one of the tasks of the Decommissioning Project Management Unit

[3] Radioactive elements.

attached to the INPP is to optimise the activities to be carried out in order to keep personnel and critical members of the public doses as low as possible (ALARA principle).

Radiological Environmental Impacts

The environmental impacts due to gaseous releases, the radionuclide content in the discharged water and solid radioactive wastes production, resulting from all U1DP0 activities, were assessed.
The efforts successfully implemented by INPP during this last decade to reduce the discharges of gaseous and liquid radioactive waste will be continued during the defuelling phase of Unit 1.

The predicted yearly effective doses to the critical members of the public resulting from the gaseous discharges will be, in function of the considered year, lower by a factor 2-3 than those resulting from routine. The predicted effective dose due to the radionuclide content in the discharged water will be lower by a factor 2-8 than those resulting from normal operation.

The global effective dose, for both types of releases, amounts to about 1 % of the current exposure limit for all INPP installations (0.2 mSv/y).

Taking into account the presence of long half-life nuclides in the above releases and the long time needed to observe variations of the nuclides activity in some bio-indicators (sediments), it is recommended to maintain the current environmental monitoring programme until the final shutdown of Unit 2.

During the works carried out along the U1DP0 Project, radioactive wastes will be produced. The conditioned decommissioning waste, as well as the conditioned operational waste, must comply with a set of Waste Acceptance Criteria (WAC) including, among others, strict limitations on the inventories of critical nuclides.

The radiological consequences of postulated accidents and incidents, that could result from the implementation of the U1DP0 Project, were assessed. The most critical one reaches 12 % of the annual regulatory limit pertaining to all radioactive releases from INPP site (0.2 mSv/y). An emergency plan exists, in order to keep the radiation exposure of the public and of the plant personnel under the limits fixed by the Authorities. The Department of Civil Defence is responsible for the emergency plan; it is recommended to adapt it to take into account the progressive phase out of the nuclear risk.

Non Radiological Environmental Impacts

Socio-economical Issues

The implementation of the U1DP0 Project could create socio-economical problems, due to the increase of unemployment at the INPP and for indirect activities (about 1,800 jobs could be lost at the horizon 2010). This could lead to possible social regression and emigration from Visaginas; the impact could be very important if no alternative activities are developed and implemented in the region for maintaining a coherent social and economical framework.

Air Quality

No direct impact on the air quality is predicted (gaseous pollutants or dust); indirect impact are related to the combustion gases from the new Heat Only Boiler (HOB) and Steam Boilers (SB)

Stations (treated in a distinctive EIA Process); these are constructed in strict compliance with the EU requirements on air pollutant releases.

Geology, Soil Characteristics and Hydrogeology

The underground waters are geologically exposed to infiltration of harmful substances; precautions should be taken during the handling and storage of such harmful substances. INPP workers receive specific training to the proper handling of hazardous wastes. This objective is not different as it is prior to the Decommissioning.

Hydrology

There will be a decrease of thermal heat discharges into the lake Drūkšiai. It could present subsequent changes in the global lake ecosystem. The existing eutrophication of the lake Drūkšiai and the changes that already happened in the living community, especially in the fish population, are almost irreversible processes: the original situation will not be restored. However, there could be some evolution due to the decrease of thermal releases; the continuation of the monitoring of temperature and chemical characteristics with time is recommended.

The decrease of nutrient discharges into the lake Drūkšiai is expected through the foreseen upgrade of the MWTP of Visaginas.

Cultural Heritage

As the U1DP0 Project does not contain any dismantling or demolition works, there will be no visual impacts. No protected area or monument will be affected.
The construction of buildings housing support activities to the Decommissioning Project will, in a first time, increase the industrial character of the INPP site.

Noise

The noise issue for the U1DP0 Project is not relevant; possible nuisances caused by the traffic of trucks transporting heavy loads of civil works wastes are out of scope.

Transboundary Issues

Neighbour countries are Byelorussia and Latvia, the closest one being Byelorussia, located at 4.5 km from the INPP. At this point, the highest effective dose for an hypothetical receptor located at this place, will be somewhat lower (10-15%), this difference being not significant from the radiological point of view: the global effective dose amounts to about 1 % of the current exposure limit for all INPP installations.

As the Lake Drukshiai is partly on the Byelorussian territory, the thermal and qualitative aspects of the lake water concern this country. The impacts will obviously be the same as on the Lithuanian territory. The quality of the Prorva River should be positively influenced with the evolution of the lake water.

A notification was made to Latvia regarding the procedure and environmental impacts of the Project, according to the EIA law and the dispositions of the Espoo Convention. Information was sent to Byelorussia (which is not part to the Convention) upon their request

Impact Minimisation and Mitigation Measures

The following measures are proposed when additional improvement can be achieved beyond the simple implementation of the U1DP0 Project.

For social and economic issues:

- Training programmes for INPP personnel (decommissioning works, Lithuanian language);
- The development of local or regional initiatives such as the INPP Regional Development Agency (2002), Business Information Centres and Business Incubator (2002), that should be also oriented toward sustainable development so that projects would integrate economical, social and environmental aspects together with a view for long term efficiency;
- Proposals were made already (through an EU funded study) to increase knowledge of people (particularly of the national language) and favour personal initiatives in the creation of businesses;
- To make the local image better in order to attract potential investors;
- To favour the creation of a Euro-region with Latvia and, possibly, with Belarus;
- To carry out the local social and economic monitoring proposed a few years ago.

For Soils and Groundwater:

- The prevention of soil contamination by radionuclides is part of the Decommissioning Project; intervention means will be adapted to the works to be carried out during the implementation of the U1DP0;
- Recommendations are made for the proper storage and handling of hazardous or polluting substances, as well as wastes;
- Training of workers (INPP and subcontractors) for environmental protection during works is to be provided.

For Water:

- The minimisation of the radionuclide content in the discharged water results from several choices made in the design of the different activities of the U1DP0;
- The minimisation of the production of demineralised water in order to decrease the use of regeneration reagents;
- The prevention of spills of polluting substances on the INPP site plays a role in the prevention of surface water pollution.

Environmental Monitoring Programme

According to the assessment of environmental impacts due to the implementation of the Project, it appears that the current environmental monitoring programme carried out by the INPP should be continued until the Reactor Final Shutdown of Unit 2. In the meantime, it is recommended to regularly review the programme with the results obtained and decide, with the Ministry of Environment, on the adaptation of the monitoring programme.

Moreover, the evolution of the environment (mainly the Lake Drukshiai) presents much interest on a scientific point of view. Some recommendations for continuing the scientific monitoring of the environment were made by the Lithuanian research institutes in their State Reasearch final report. These proposals could be reviewed and, if funding is made available, implemented.

1 General Information

1.1 Introduction

1.1.1 Context of the U1DP0 Project and Related EIAR

The Seimas of the Republic of Lithuania approved the National Energy Strategy on 5 October 1999. One of the main elements of the National Energy Strategy is the plan for the decommissioning of Ignalina NPP.

In November 2002, the Government of the Lithuanian Republic decided to implement the Immediate Dismantling Strategy “in order to prevent the heavy long-term social, economical, financial and environmental consequences”.

In the Lithuanian Environmental Impact Assessment (EIA) process, the EIA Programme (EIAP) is the scoping phase during which are identified environmental impacts that are most likely to be significant and therefore require investigation during the EIA study (the result of which being an EIA Report or EIAR).

According to the Lithuanian Law, the following projects are subject to a full EIA process:

- “3.2. Nuclear power stations and other nuclear reactors including decommissioning of such power stations or reactors”;

- “9.5. Installations for processing, usage, storage and disposal of radioactive waste, including the decommissioning of such installations”.

The EIA Programme was agreed to be considered together with (and integrated in) the INPP Final Decommissioning Plan. The EIA Programme is related only to direct INPP Units 1&2 decommissioning activities (such as defuelling, dismantling, decontamination, decommissioning waste management, etc.).

Considering the whole process of INPP Decommissioning, the EIAP can be considered as an umbrella document under which the EIA Reports further assess the environmental impacts and the necessary measures to be taken to reduce them.

An **EIA Report** is established for each major stage of the INPP Decommissioning, as described in detail in the Final Decommissioning Plan (FDP [8], see Chapter 5): in the present case, the INPP decommissioning is split in several Decommissioning Projects (DPs). Each of these DPs is a process containing a scope, an identification of activities, an analysis of these activities that serve as input for programming activities, studying their safety related aspects and assessing their environmental impacts through individual EIA procedures. The provisional schedule of projects is presented in Figure 1-1.

In support to the pre-decommissioning and decommissioning activities, several new installations will be implemented for which, when applicable, separate EIA Programmes and Reports as well as Safety Analysis Reports will be prepared within the associated projects.

The present impact assessment is completed as necessary with estimates of the impacts due to:

- the new installations (e.g. B1 – the new spent fuel interim storage facility, the B2/3/4 – the solid radioactive waste retrieval, management and interim storage facility, B5 – the reliable back-up steam and hot water boilers, B8[4] – re-used fuel transportation from Unit 1 to Unit 2, the resins, perlites and sediments cementation facility);
- the existing installations (e.g. the liquid waste treatment facility);
- the Unit 2 Decommissioning Project (U2DP0)[5].

Within the whole INPP Decommissioning Programme, several projects are subject to a full EIA. A summary of the processes to be developed in the INPP Decommissioning Programme, are listed in the Table 1-1, with mention of the mandatory EIA procedure or not, and an estimate of the period during which the procedures will be carried out. **The present EIAR covers the U1DP0 project only, with mention to some elements of other projects.**

Aside the environmental issues considered in the EIAR, safety issues are covered by a Safety Analysis Report (SAR). The approval processes for the two documents are different: the SAR is finally approved by the State Nuclear Power Safety Inspectorate (VATESI) while the EIAR is finally approved by the Ministry of Environment. Both documents accompany the DP documents (dealing e.g. with the regulatory framework, the description of the INPP Facilities at the start of the Decommissioning Stage, the radiological and hazardous materials inventories, the decontamination activities, the Decommissioning activity analysis, description and schedule, the radiation protection, the waste management, the Decommissioning costs and manpower requirements).

Therefore, the EIA Report deals mainly with environmental impacts, outside of the INPP site. This assessment is based among others on the DP documents and SAR as listed above, which are prepared in parallel to the EIAR, on environmental data gathered by INPP and on available bibliography.

The licensing process for Decommissioning Project (including associated DSAR and EIA Report) is presented in Figure 1-2.

The organisation of the different DPs has been approved by VATESI in early 2004.

In short, the Project to be considered in the present EIA Report (= the scope of the EIAR) covers the period of time for Unit 1 Reactor Final Shutdown and Defuelling. The associated timeline goes to the end of 2012, as shown on Figure 1-1.

The activities considered in this Decommissioning EIA Report are:

- **those covered by U1DP0:**
  - **modification, isolation and post-operation of systems;**
  - **construction of new facilities (B1, B2/3/4, B5, B8);**
  - **defuelling of Unit 1 (with a.o. operation of B1 and B8);**
  - **retrieval of solid waste (i.e. operation of B2/3/4;**

[4] Radiological environmental impact of B8 is described in paragraph 6.6.2. B8 will not have any significant non radiological environmental impacts.

[5] Though the support and U2DP0 projects are subject - for some of them - to separate EIA procedures. The Decontamination and Dismantling Projects (D&D) are not considered at this stage.

- **operation of other existing waste treatment facilities;**
- **in-line decontamination of MCC.**

- **The operation of Unit 2 until end of 2009;**

- **The activities covered under U2DP0 and that take place until 2012.**

Remarks:

1. **This Decommissioning EIA Report encompasses thus all activities (but the dismantling and hard decontamination) that will occur at INPP Site during the period of time of Unit 1 defuelling.**

2. **This Decommissioning EIA Report takes into account the environemtnal impact of normal operation of the B1, B2/3/4, B5, B8 facilities through estimations based on the specifications produced for these projects. These projects will undergo their own separate EIA screening/process that will review their environmental impact through estimations based on their design for:**

   - **normal operation,**
   - **incidents/accidents.**

The present EIAR is based on available information to which reference is made with the format [ref. number]. These references can be found at the end of each chapter.

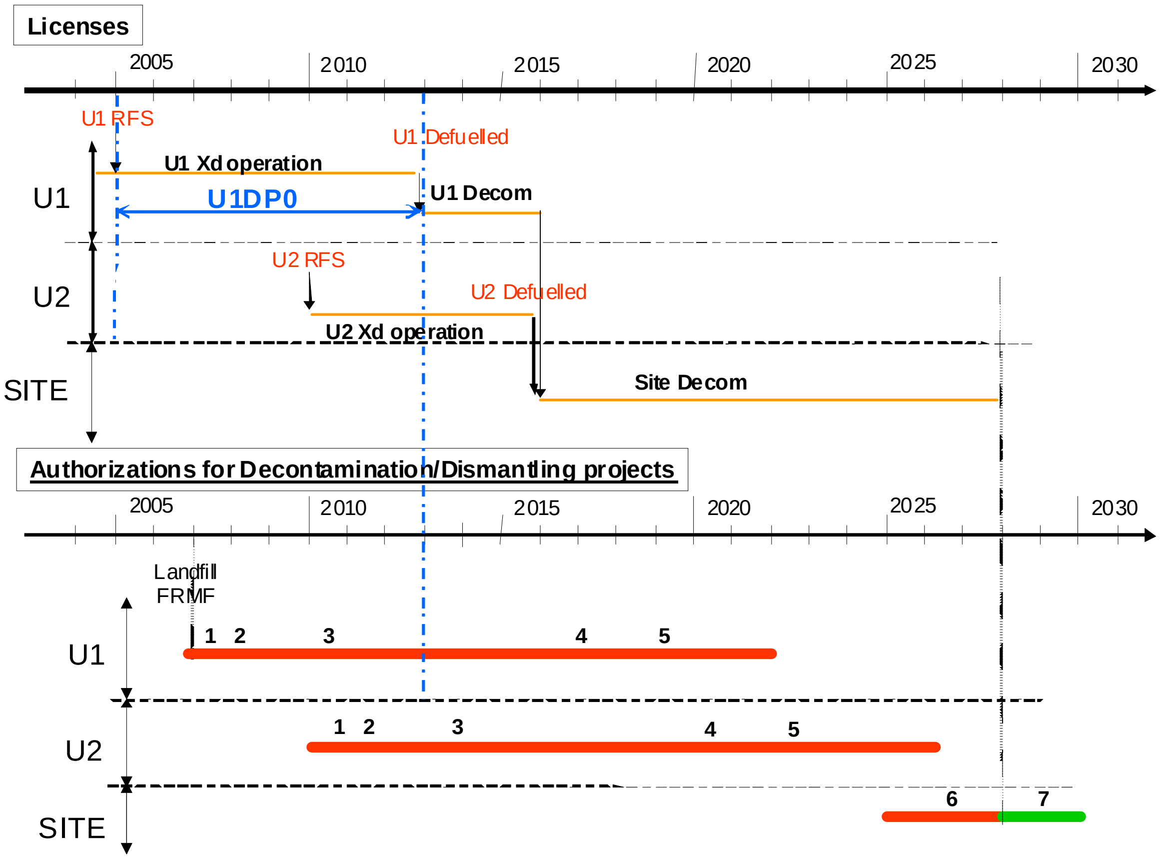
In assessing the importance of impacts, comparison with environmental norms and / or (when no applicable norms exist) appropriate reference limit values are made where impacts can be quantified (example: releases of radionuclides in the discharged water and the air, doses to the critical members of the public). For more subjective impacts (e.g. landscape impacts) qualitative assessments are undertaken.

Table 1-1 List of Projects under the INPP Decommissioning Programme, subject to the EIA Process (M = Mandatory) and Other Projects not subject to Mandatory EIA

Project code	Subject to EIA	Project title	EIA schedule	Implementation schedule
U1DP0	Y (M)	Unit 1 Reactor Final Shutdown and Defuelling	2004 – 2006	2005 – 2012
U2DP0	Y (M)	Unit 2 Reactor Final Shutdown and Defuelling	2009	2010 – 2015
B1	Y (M)	Design and Construction of an Interim Storage Facility for Spent Nuclear Assemblies	2005 - 2006	2005 - 2010
B2/B3/ B4	Y (M)	Design and Construction of new Solid Waste Management and Interim Storage Facilities (SWMSF)	2005 - 2006	2005 - 2009
B5	N	Design and construction of a new reliable heat and steam production facility	EIA screening was performed in 2003	2003 - 2005
B6	N	Modernisation of the existing technical documentation archive	-	2003 - 2005
B7	N	Cadastral Survey and Technical Inventory of the Buildings and Construction	-	2003 - 2005
B8	Y	Transportation of partially burnt nuclear Fuel Assemblies from Unit 1 to Unit 2 for re-use in the reactor of Unit 2	Elements are given together with the present EIAR	2002 - 2006
B9/0	Y (M)	Engineering of the Decontamination and Dismantling activities relating to equipment of building 117/1	2006	2007
B9/1	Y (M)	Engineering of the Decontamination and Dismantling activities in turbine hall G1	2006 - 2007	2008 - 2012
B9/2	Y (M)	Engineering of the Decontamination and Dismantling activities in buildings A1, B1 and V1.	2007 - 2008	2009 - 2012
B18	Y (M)	Implementation of a Melting Unit	To be determined[6]	To be determined[6]
B19	Y (M)	Implementation of a landfill for short-lived and very low level waste	2006	2006 - 2007
B20	Y (M)	Upgrade of the bituminised waste vaults into a final disposal	To be determined[7]	To be determined[7]

[6] Economic justification of the Melting Unit is still to be demonstrated.
[7] Feasibility study for upgrade is started.

Figure 1-1 The INPP Decommissioning Licensing Strategy and Schedule



Legend of Figure 1-1

Licenses:

- U1 Xd Operation = INPP Unit 1 Extended Operation License.
- U2 Xd Operation = INPP Unit 2 Extended Operation License.
- U1 Decom = INPP Unit 1 Decommissioning License.
- Site Decom = INPP Site Decommissioning License.

Authorizations to be given under the licenses:

- Under the INPP Unit 1 (U1) Extended Operation License:

  3. D&D Project 1: Decontamination and Dismantling activities in the turbine hall G1,

  4. D&D Project 2: Decontamination and Dismantling activities, in the reactor building A1 and in buildings V1 and 117/1, allowed while fuel is still present in the reactor,

  5. D&D Project 3: Decontamination and Dismantling activities, in the reactor building A1 and in building B1, allowed while fuel is still present in the pools of Unit 1;

- Under the INPP Unit 2 (U2) Extended Operation License:

  1. D&D Project 1: Decontamination and Dismantling activities in the turbine hall G2,

  2. D&D Project 2: : Decontamination and Dismantling activities, in the reactor building A2 and in buildings V2 and 117/2, allowed while fuel is still present in the reactor,

  3. D&D Project 3: Decontamination and Dismantling activities, in the reactor building A2 and in building B2, allowed while fuel is still present in the pools of Unit 2;

- Under the INPP Unit 1 Decommissioning License:

  4. D&D Project 4: Decontamination and Dismantling activities in Buildings A1, B1, V1 (reactor excluded),

  5. D&D Project 5: Decontamination and Dismantling of the Unit 1 reactor activated components;

- Under the INPP Site Decommissioning License:

  4. Unit 2 D&D Project 4: Decontamination and Dismantling activities in Buildings A2, B2, V2 (reactor excluded),

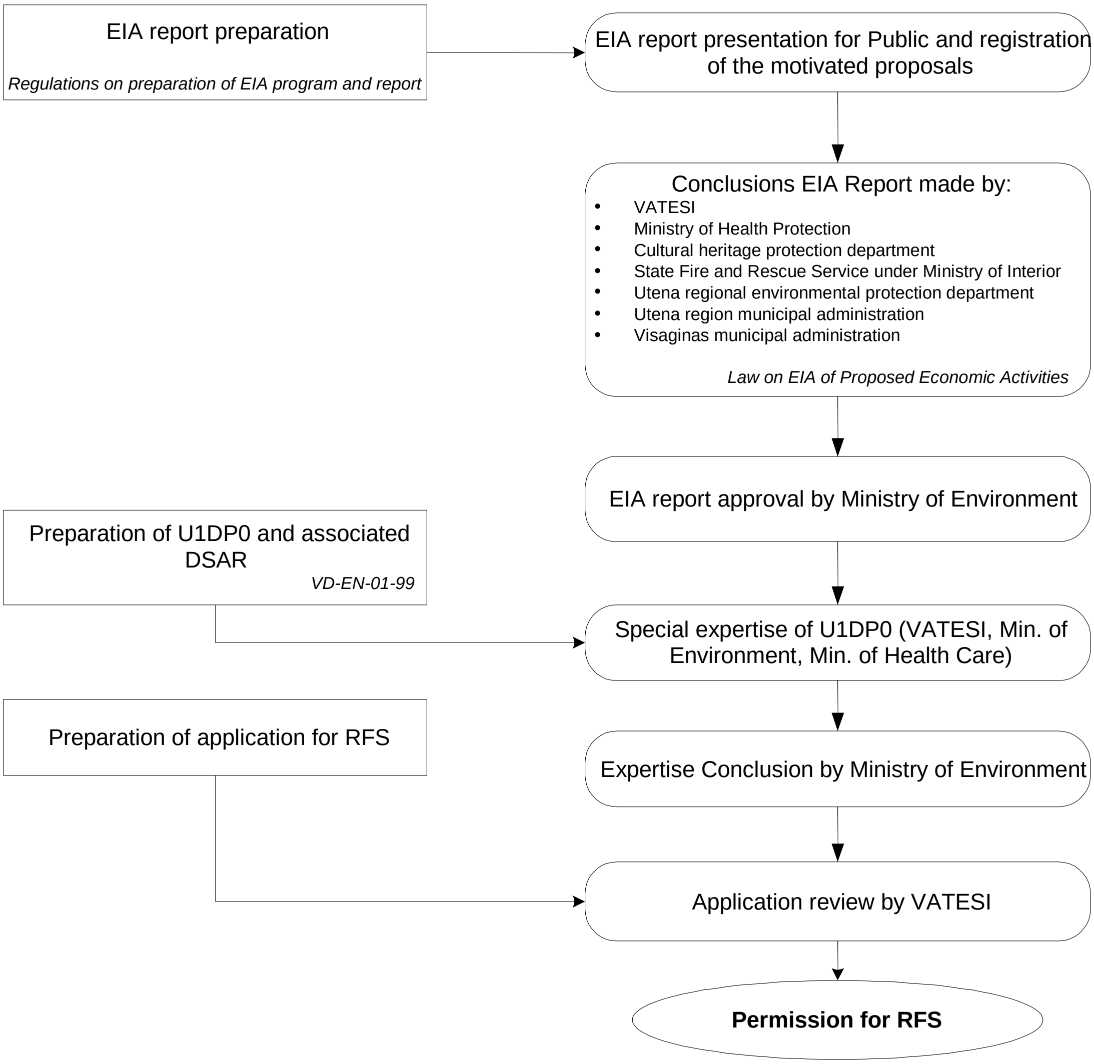
  5. Unit 2 D&D Project 5: Decontamination and Dismantling of the Unit 2 reactor activated components,

  6. Site D&D Project 6: Decontamination and Dismantling activities in buildings D0, D1, D2, in the remaining buildings on the site, and removal of the Units 1 and 2 stacks,

  7. Site D&D Project 7: INPP Buildings conventional demolition, for which VATESI is no longer the competent administration, it becomes the Ministry of Environment.

We can see on Figure 1-2 that the EIAR, the SAR and the DP documents are prepared in parallel. The EIAR has to be approved first before accompanying the other documents in the licensing procedures.

Figure 1-2 Licensing Process for Decommissioning Project (including associated DSAR and EIA Report)



The present EIA Report provides information on the likely environmental consequences of the proposed project and mitigation measures that can be implemented in order to prevent, decrease or cease environmental consequences, with a view to provide information for the decision-making process. The EIA process provides a tool for communication and consultation with the public. Because the results of the EIA process may play a role in defining and modifying the proposed development it becomes an essential part of the overall INPP Decommissioning. The EIA results are therefore incorporated into the overall project from the initial stage of conceptual design, not as a subsequent exercise to be superimposed on it.

The early stages of the EIA process require efforts to be made to identify and involve the key stakeholders, including the general public. A fundamental requirement is that the outcomes from the EIA process are applied to the ongoing design activity, e.g. so that stakeholder views and concerns expressed during the preliminary stages can be taken into account by project designers. The nature of public involvement will be a dialogue, i.e. a two-way flow of information, with the overall objective of developing and implementing a decommissioning that carries broad public support.

The characteristics of the main environmental components in the area of the INPP site (Demographics, Economic Activities and Infrastructure, Socio-Economic Issues, Climate and Air Quality, Hydrology, Geological characteristics and Seismology, Hydrogeology, Soil, Biodiversity, Cultural Heritage and Landscape, Noise and Vibrations, Radiological conditions) are presented in Chapter 3. Transboundary issues to be considered are presented as well.

The Description of Operations, Techniques and related environmental aspects of the U1DP0 Project are presented in Chapter 4.

The alternatives considered for U1DP0, from the environmental impact point of view, are discussed in the Chapter 5.

Radiological Environmental Impact is analysed in the Chapter 6. Key environmental criteria, impact prediction and assessment methods, evaluations of possible accidents/major accidents and extreme cases (possible forecast of accidents, accident elimination plans, etc.), radiological exposure of the critical members[8] of the public, solid waste production, characteristics and conditioning techniques with respect to the final disposal, radiological consequences for the critical members of the public of the postulated incidents/accidents as well as impact minimization and mitigation measures are presented in this Chapter.

Non Radiological Environmental Impact is analysed in the Chapter 7, for each component of environment discussed in Chapter 3. It is of course focused on U1DP0 principal effects on environment. Some words are said about occupational hazards and industrial safety.

Impact prevention, minimization and mitigation measures are analysed in the Chapter 8.

Chapter 9 describes the environment monitoring programme during the implementation of the U1DP0 Project. In essence, it will continue to be regularly adapted by the INPP staff as it is today according to the changing regulatory requirements.

1.1.2 General Methodology for the U1DP0 EIAR

The content of the present EIAR is based as well on the EIA Programme as on the Manual for Environmental Impact Assessment in Lithuania [1]. The table of contents has been adapted to take into account the guidelines set up in application of the Lithuanian EIA law and subsequent regulations. As far as possible, the “Recommended Structure and Scope of the Environmental Impact Assessment Report” (as established in the Order of the Minister of the Environment of the Republic of Lithuania No. 262 June 30, 2000, see in [1]) was followed.

Radiological issues are addressed according to Article 37 of the EURATOM Treaty [4].
Other publications were used (see lists of references at the end of each chapter), among which the EC funded study “Environmental Impact Assessment for the Decommissioning of Nuclear Installations” [2].

[8] A critical group of the public is a group of members of the public which is reasonably homogenous with respect to its exposure for a given radiation source and given exposure pathway and is typical of individuals receiving the highest effective dose or equivalent dose (as applicable) by the given exposure pathway from given source.

The reader must keep in mind that the U1DP0 contemplates the period of time associated to the defuelling of INPP Unit 1 (basically 2005-2012) and takes into account all decommissioning activities that will be implemented (but not the dismantling and decontamination activities that will be covered by specific DPs and associated EIA Reports).

As a consequence, U1DP0 considers mainly:

- **modification and post-operation of the INPP existing systems within the existing buildings (i.e. without heavy civil works);**
- **defuelling operations;**
- **retrieval, conditioning and interim storage of the operational waste and spent fuel.**

1.2 Information about the Organiser (Developer)

The Client (organizer) of the proposed economical activity is:

Organisation:	State Enterprise Ignalina Nuclear Power Plant (INPP)
Address:	Ignalina NPP, LT-31500, Visaginas, Lithuania
Contact person:	Mr. Saulius Urbonavičius
Telephone:	+37038624466
Fax:	+37038624387
E-mail:	us@ent.lt

1.3 Information about the Preparer of EIAR

The Provider of the EIA Report is:

Institution:	INPP-DPMU
Address:	Ignalina NPP, LT-31500, Visaginas, Lithuania
Contact person:	Mr. Mike Tyrrell
Telephone:	+37061006427
Fax:	+37038624387
E-mail:	mike.tyrrell@ent.lt

1.4 Name and Description of the Project

1.4.1 Name of the Project

The Project is named:

INPP Unit 1 Decommissioning Project for Defuelling Phase

1.4.2 Description of the Project

The project consists in the following activities, after the Unit 1 Reactor Final Shutdown (which, as such, implies effects, as the decrease of thermal releases and radioactive releases, job cuts and other indirect effects):

- **Decommissioning Generic Activities (not significant on an environmental point of view** as they cover general administration, Project management, Engineering & licensing documentation, Administrative finalization, Health physics, Conventional security);

- **Decommissioning Preparatory Activities**, among which the significant one is:

  - Separation of Unit 1 and Unit 2:

    Preparatory activities to determine which safety functions and systems can be definitively isolated and shut down,

    Special attention to be paid to systems that must remain in operation for Unit 2,

    During the period during which Unit 1 is “definitively stopped” and Unit 2 remains in operation, a third aspect to be considered is the physical separation between areas of units 1&2 for which it will be requested to control and to restrict entrance and exit of personal,

  - Decontamination and/or cleaning activities in areas where works are to be carried out mainly for ALARA purpose,

- **Decommissioning Procurement Activities (not significant on an environmental point of view as they cover the installation of new equipment in the plant);**

- **Post-Shutdown Activities (among which are support projects, some of which having their own EIA procedure):**

  - Systems isolation and modification activities;

  - Operation and maintenance of remaining systems;

  - Support Projects: removal of nuclear fuel from the core and transport activities (sent to Unit 2 for further use = B8 Project) or to the Interim Spent Fuel Storage Facility (B1 Project), when available, or to fuel pools):

- After the cool down of the fuel in the core, the fuel assemblies are moved from the core with fuel handling machines to the fuel pools,
- Assemblies that can still be used in Unit 2, are removed from the core and transferred through a shielded vertical channel (inside the Reactor Building) to a container for fuel assemblies transport; the container is mounted on a wagon,
- The container is sealed hermetically and controlled for radioprotection,
- Then the wagon is moved from Unit 1 to Unit 2;

- Removal of the coolants, gases and other materials of the systems, and appropriate management and treatment;
- In-line decontamination of systems / equipment (Main Circulation Circuit, Purification and Cooling System, Refuelling Machine), using appropriate methods and reagents;
- Operational waste management activities, according to legal procedures;
- Radiological samplings and measurements.

More information on the U1DP0 Project is available in the present EIA in Chapters 4 (Description of Operations, Techniques and associated environmental Aspects), 5 (Mains Alternatives considered and Discussion of the Choice made) and 6 (Radiological environmental Impact). Detailed information is available in the DP documents.

1.4.3 Duration of Phases

The existing operation license for INPP Unit 1 was extended in 2004 till the complete defuelling of Unit 1. It covers the defuelling, i.e. the core defuelling and the pools defuelling, until the estimated date of 31st December 2012.
The next table gives a summary of the major phases' schedule.

Table 1-2 Schedule for the Main Phases of U1DP0

Period	Activities
2006	Reactor Final Shutdown
2006 – 2008	Reactor Defuelling - transfer of Fuel to Unit 2
2008	Reactor Defuelling – Spent Fuel transfer to pools
2009	In-line decontamination activities
2008 – 2012	Unloading Spent Fuel from pools to Interim Storage Facility

When all fuel is removed from Unit 1 (scheduled at the end of 2012), a new license, called "Decommissioning License", can be introduced in order to perform the next decommissioning activities, because safety functions and regulatory context are rather different than previously.

1.4.4 Relation between EIAP and EIAR

The EIAP covers the whole INPP Decommissioning Plan.
The EIAR must be based on reliable and sufficiently detailed data in order to produce a sound environmental impact assessment. Therefore, it was agreed with the Ministry of Environment and other competent bodies among which VATESI, to prepare several EIA Reports, for the main phases of the INPP Decommissioning.

The first main phase is the Unit 1 Reactor Final Shutdown and subsequent defuelling and related activities (see description in 1.4.1).

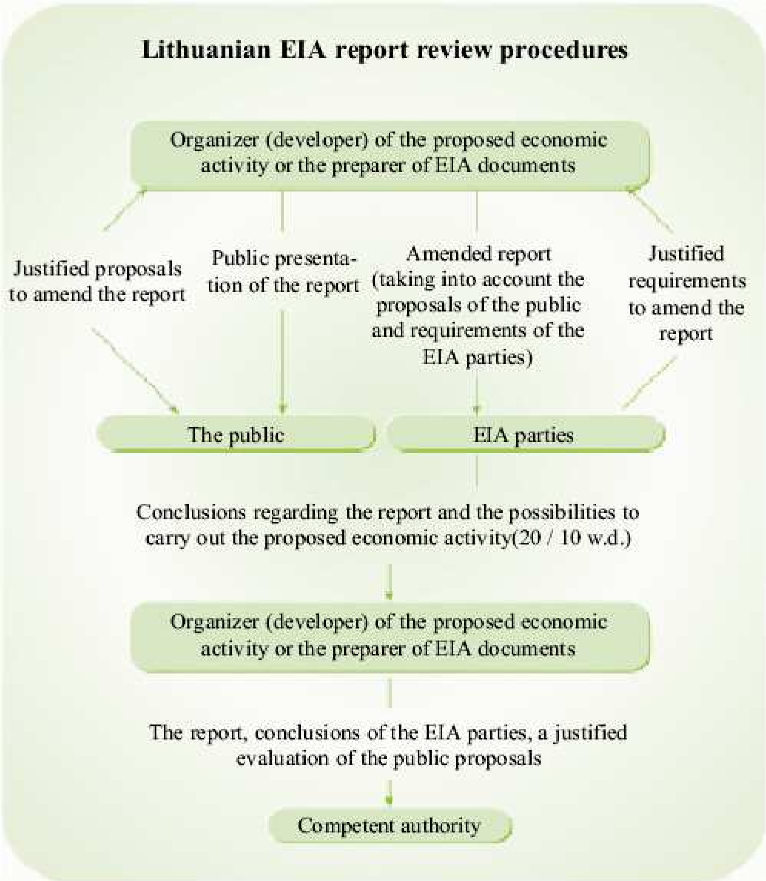
The applicable legal framework for EIA Report preparation and approval is described in the next section (1.4.5).

1.4.5 Applicable Lithuanian EIA Legal Framework

The INPP decommissioning Environmental Impact Assessment process is carried out in accordance with Lithuanian legal framework as stated in [1] and other corresponding regulatory documents [3, 4]. The document [7] describes in detail the applicable legislation.

Because INPP is located close to state borders of the Republic of Latvia and the Republic of Belarus, Transboundary Conventions [5] will be taken into account.
The following figure summarizes the general EIA review process.

Figure 1-3 EIA Report Review Process



The EIA Report addresses the following elements:

- The determination of environmental baseline conditions at the time of the project (in the present case, the INPP being in full operation); it is used as a starting point for the prediction of likely impacts resulting from the project and of naturally-occurring changes in the environment.

- The impact prediction, analysis and determination of significance on the basis of issues identified during the EIA Programme phase; impact is defined as “anticipated change in the environment caused by the proposed economic activity"; these changes can be direct, indirect or cumulative and can be found at different ecological (species to ecosystem) and social (individual to community) levels, can vary over space and time, and can be either positive or negative. Once the impacts have been identified, the potential magnitude, extent and duration of each one must be predicted. Analysis of the interactions between impacts, particularly when considering cumulative impacts, should be also included in the impact prediction process.

- The analysis of alternatives examined by the Developer and the discussion of their environmental aspects.

- The mitigation of impacts, which is the application of design, construction or scheduling practices to lessen or avoid the adverse ecological, economic or socio-cultural effects. One must ensure that approved mitigation measures have been implemented and are working effectively.

- Therefore, a plan for environmental monitoring is proposed for the follow-up of environmental conditions, impacts and the efficiency of mitigation measures, in order to cover, among others, impacts that were not identified during the EIA Process or that appear more important than predicted.

Once the EIAR is edited, the developer must organize a public presentation according to the applicable legal provisions (see in [1]). During the hearing, the developer records justified proposals for amendments of the EIA and takes them into account for the revision of the Report. A specific evaluation of proposals of the public accompanies the EIAR.

The EIAR is submitted to relevant parties. These ones check whether the Report:

- contains sufficient information on the topics within their area of competence and provide the Developer with their conclusions;

- or needs amendments to be done.

They communicate their decision within 20 working days.

In case of re-submission of the Report, the decision is communicated within 10 working days.

The conclusions of the relevant parties of EIA are then to be submitted to the competent authority, together with the EIA report and the evaluation of the public proposals.

The competent authority then carries out a Quality Control of the EIAR, on:

- conformity of the EIA Process with legal procedures and EIA Programme;
- adequate assessment of environmental impacts and is of sufficient relevance and quality for decision-making;
- the fact that conclusions of stakeholders regarding the assessment and proposed activity were correctly taken into account;
- information is presented in a sound manner and can be understood by the public.

On the basis of the approved EIAR, the decision process runs according to the steps described in Figure 1-4.

1.4.6 The Participants of the EIA Drafting and Acceptance Process

The following organizations and individuals will be included in the EIA drafting and acceptance process:

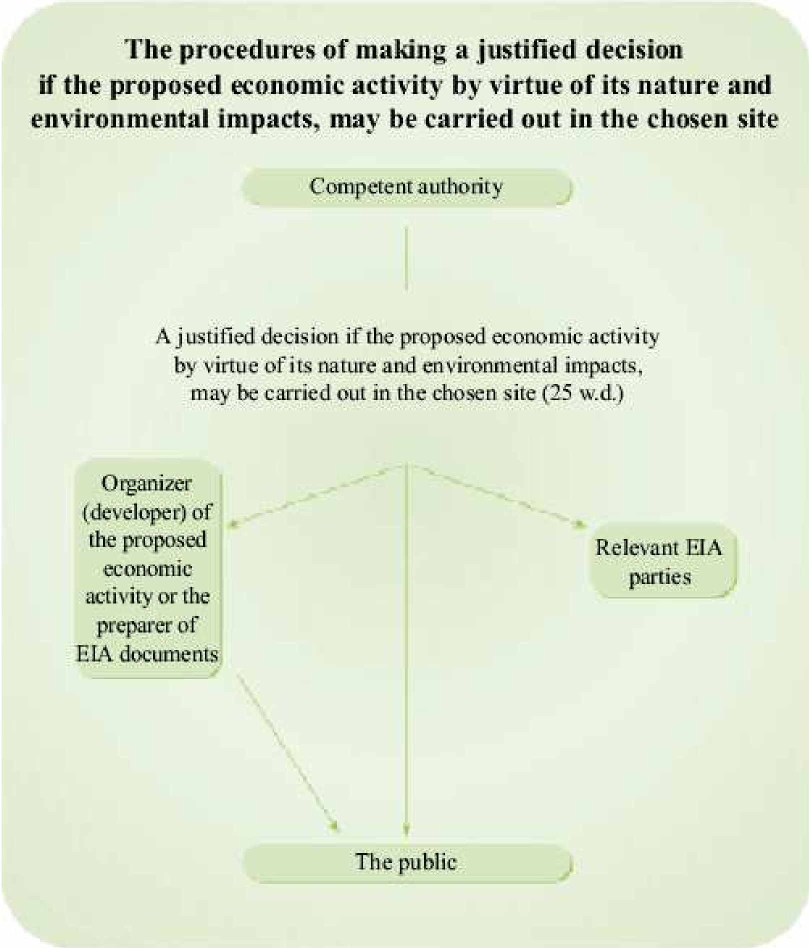
- State Enterprise Ignalina Nuclear Power Plant;
- INPP-DPMU;
- Ministry of the Environment;
- VATESI;
- Ministry of Health Protection, Radiation Protection Centre;
- Lithuanian Fire and Rescue Service;
- Utena Regional Environmental Protection Department of the Environment Ministry;
- Heritage protection department;
- Utena county administration;
- Visaginas municipal administration;
- EBRD[9];
- The public[10].

[9] EBRD was involved at the beginning of the INPP decommissioning EIA process when defining the table of content of EIA Programme and EIA Reports. Further involvement of EBRD will be at EIA Report stage by reviewing the document and making it electronically available on their website and by paper copy at EBRD premises in London and Vilnius.

[10] The public consultation process is described in section 1.4.7 hereafter. In addition, once the EIA Programme will be approved, the Ministry of Environment will ensure the required:

- Publicity among the interested parties (local residents, NGO's, trade Unions, …);
- Transboundary contacts with neighbouring countries Latvia and Belarus.

Figure 1-4 Decision Process and Publicity of the Decision



1.4.7 Functions and Responsibilities of the Different Organizations Involved in the INPP Operation and Decommissioning

- INPP, as plant owner and legally in charge for the decommissioning, takes responsibility for the preparation of the EIA Programme and the EIA Reports, respectively. INPP submits both the Programme and the Reports to the relevant parties for review and to the competent authority for approval.

- INPP-DPMU, as the developer of the EIA Programme and EIA Reports, identifies, characterizes and assesses the potential environmental impacts of INPP decommissioning.

- The Lithuanian Ministry of Environment, as a competent authority, co-ordinates the EIA process and ratifies the EIA Programme and EIA Reports. It also summarises the pleas of the public and conclusions issued by other relevant parties regarding the EIA Programme and the EIA Reports. On this basis, the Ministry issues a justified decision about the performance of the proposed economic activity.

- VATESI, the Lithuanian Ministry of Health Protection, the Lithuanian Fire and Rescue Service**,** Utena Regional Environmental Protection Department of the Environment Ministry, Utena county administration, Heritage protection department, the Visaginas municipality, as relevant parties of the EIA with respect to their competence, examine the

EIA documents and provide conclusions regarding the EIA Programme and the EIA Reports.

- EBRD, as manager of IIDSF, will supervise the compliance of the EIA Process with the valid EU regulations.

- Scientific Institutes are consulted by the Ministry of Environment to advice on the EIA Programme and subsequent EIA Reports.

1.4.8 Public Consultation Process

The framework of public participation in EIA process is given in [1].

INPP, as responsible provider of the EIA documents, informed the public by announcing information about the upcoming EIA Programme on decommissioning in the national press and in the regional press of Visaginas, Ignalina and Zarasai in June 2002. No comments were received following this information of the public. See Part II of the EIA Programme [6].

Once the first issue of the EIA Report is released, INPP organized a public meeting and invited the public through national and local press no later than 10 working days before the public meeting was planned to be commenced. Formally, INPP must register proposals of the public that are received in written form before or during this meeting, by using the form provided in [1]. Following this the preparer of the EIA documents must evaluate the public proposals using the form provided in [1] and amends the EIA Report accordingly.

1.5 Information about Production and Resources Used for Energy Production Purposes

The Project consists in the Decommissioning of Ignalina Nuclear Power Plant. Therefore, there will be a staged decrease in production and resources used.

The INPP power should evolve as presented in Table 1-3.

Table 1-3 Information about Production and Demand for Energy Resources

Production		**Resources used for energy production purposes**		
Name	Year / Maximum power	Name	Annual amount, fuel assemblies	Source
Thermal energy for electricity production, MWth	2004 / 8400	Uranium dioxide[11]	About 800	Import from Russia.
	2005-2009 / 4200		About 400	Import from Russia and reusing of FA from Unit 1.
	From 2010 / 0		0	

Remarks:

1. *Fuel (75 t diesel oil / year per unit) is used for diesel fired generators; however these generators are used for safety reasons, not for energy production (see Table 7-4).*

2. *Steam and heat productions in the Steam Boiler and Heat Only Boiler plants of INPP are covered by their own EIA and are out of the scope of the present EIA.*

The use of the main raw materials, chemical substances or preparations needed for the activities of U1DP0 is estimated in Table 1-3. The main activity related to decommissioning that need such substances is in line decontamination during defuelling.

The substances used for demineralization are also presented in the table, based on current yearly consumptions; these consumptions will decrease with time, up to the complete defuelling when they will become insignificant.

[11] ^{235}U initial enrichment was 2%. It is being changed to 2.4% (with 0.4% Erbium as burnable neutron absorber), 2.6% (0.5% Er) and 2.8% (0.6%), in order to increase the power throughput of the fuel.

Table 1-4 Information about Raw Materials, Chemical Substances or Preparations Used during Defuelling Activities

Name of the raw material, chemical substance or preparation	Annual amount (tons)	Classification and labelling of the chemical substance or preparation[12]	
		Classification	Labelling
For in line decontamination activities (in 2009 only)			
Permanganic acid ($KMnO_4$)	2.0	O; R8 Xn; R22 N; R50-53	Symb.: O, Xn, N R: 8-22- 50/53 S: (2-)60-61
Oxalic acid ($H_2C_2O_4$)	42.9	Xn; R21/22	Symb.: Xn R: 21/22 S: (2-)24/25
Nitric acid (HNO_3)	1.2	O; R8 C; R35	Symb.:O, C R: 8-35 S: (1/2-)23-26-36-45
For systems remaining in operation			
Reagents used for the conditioning of the heating plant and the regeneration of the resins of the plant water makeup system: H_2SO_4 (100%) NaOH	365.0 14.0	C; R35 C; R35	Symb.: C R: 35 S: (1/2-)26- 30-45 Symb.: C R: 35 S: (1/2-)26- 37/39-45

[12] According to the Law on Chemical Substances and Preparations (Žin., 2000, Nr. 36-987).

1.6 Information about Releases Generated by the Activity that Affect the Environment

The current condition of environment is described in “Chapter 3: The Environmental Baseline”.

In the “Chapter 4: The U1DP0 Project: Description of Operations, Techniques and Associated Environmental Aspects”, the sources of releases toward the environment are identified.

The radiological issues are addressed in the “Chapter 6: Radiological Environmental Impact”, the non-radiological ones in the “Chapter 7: Non Radiological Environmental Impacts”.

The pollution abatement measures, but also measures aimed at preventing pollution, are discussed in “Chapter 8: Impact Minimisation and Mitigation Measures”.

Electromagnetic radiations are due to electricity transmission through aerial lines. The 330 kV and 110 kV lines from the power grids are not modified by the decommissioning.

1.7 References

1. Manual for Environmental Impact Assessment in Lithuania, Ministry of the Environment of the Republic of Lithuania Finnish Environment Institute ISBN 9955-425-88-1.
2. Environmental Impact Assessment for the Decommissioning of Nuclear Installations, EC Contract B4-3040/99/MAR/C2, Cassiopee - The University of Wales, Aberystwyth - ECA Global, June 2001.
3. List of the Main Legal Acts Regulating Nuclear Power Safety in the Republic of Lithuania, VD-VP-01-2001.
4. Commission Recommendation on the application of Article 37 of the Euratom Treaty (of 6 Dec. 1999). Annex 2.
5. Convention on Environmental Impact Assessment in a Transboundary Context (ESPOO, 1991).
6. Ignalina NPP Decommissioning Environmental Impact Assessment Programme, State Enterprise Ignalina Nuclear Power Plant, May 2004.
7. Decommissioning Project U1DP0 - Chapter 2 – Decommissioning Regulatory Framework –A1.4/ED/B4/0006, INPP-DPMU, 2004.
8. Final Decommissioning Plan for Ignalina Units 1 & 2, Report A1.1/ED/B4/0006, INPP-DPMU, 2004.

2 Information about the Location of Proposed Economic Activity

2.1 Information about Alternative Locations of Proposed Economic Activity

As the project goes about the decommissioning of INPP, there is no alternative location to be considered. All works relating to U1DP0 will be carried out inside the site fences.

For what concerns decommissioning support projects (as briefly presented in 1.4), they are subject to their own EIA Programme and Report.

2.2 Topographic Map of the INPP Environs

Topographic Map of the INPP Environs is presented in Appendix 1 (III part of this Report).

2.3 Excerpt from the Territorial Planning Register

An excerpt is joined in Appendix 2.

2.4 Information about the Current Land Use

The current land use can be seen on the map joined in Appendix 3.

3 The Environmental Baseline

3.1 Introduction

Baseline information characterizes the conditions at the time the project is proposed and in function of the project characteristics. This baseline serves as a reference for all assessments as well as for the comparison of alternatives and mitigation measures. It is used as a starting point in the prediction of likely impacts resulting from the project and of naturally occurring changes in the environment.
Baseline information is determined considering existing local and scientific knowledge on the area including socio-economic issues [39].
Information on radioactivity in the physical environment is presented in a single chapter (3.10).

The Ministry of Environment, along with its approval of the EIA Programme [40], requested to include all environment monitoring data for the whole period of INPP operation. This will be done as far as it provides useful information for the purposes of the present EIA Report.

As advised in the EU funded study on EIA for the Decommissioning of Nuclear Installation [9]:
"As regards the scope and depth of the baseline description, and for economic reasons, the greatest use possible should be made of existing information, ensuring that it is accurate. The competent authorities and organisations in the affected area should be consulted to obtain the maximum amount of existing data thereby reducing the overall costs."

Experts from scientific institutions were contacted for the needs of the present EIA Report.

Reference [9] continues with:

"The scoping exercise carried out as part of the EIA will have identified those environmental factors which need the most attention at this stage and for the impact prediction stage which comes later. The main environmental factors which would be expected to be included in any baseline description are outlined below".

The scoping exercise was the subject of the EIA Programme. The main environmental factors which require the most attention were highlighted in the Programme. As a consequence, the following compartments of the environment have to be developed in the present chapter:

- Demography, as the closure of the INPP is a major socio-economic issue for Visaginas;

- Neighbour economic activities and infrastructures: they could allow for an economic redeployment if local appropriate actions are implemented (definition of valuable sectors of activities, promotion of investments, public financial support, etc.);

- Socio-economic situation: it could change significantly with the Decommissioning Project, depending on the possible economic redeployment in the area;

- Climate and air quality: average meteorological conditions are to be considered in the dispersion of pollution and nuisances coming from the site;

- Geology, hydrogeology and hydrology: a description of the relationships between surface and groundwater is to be made; the Unit 1 reactor shutdown will decrease the heated cooling water releases and influence temperature patterns of the Lake Drūkšiai;

- Fauna and flora: as there are neighbour Natura 2000 proposed territories, the present EIA must include an impact assessment of the U1DP0 Project on fauna and flora, therefore a description of habitats and important species is made, on the basis of existing data;

- Cultural Heritage: as the U1DP0 Project is not susceptible to harm protected areas and monuments, this section will be mainly descriptive;

- Noise and vibrations: will not be considered in detail in the present EIA Report;

- Radiological conditions: as the radiological releases from Unit 1 shall decrease with the decommissioning, it is important to determine the current baseline;

- Transboundary Issues: due to the localisation of INPP, there are legal obligations or political issues to be considered in terms of impact assessment and public enquiry.

3.2 Demography

3.2.1 Population Evolution in the INPP Region

Visaginas is part of the Ignalina district. The construction of the nuclear power plant made a big impact on the demography in this district. In 1979 the total population of the Ignalina district was 37,800, and then in 1989 it rose to 59,700, while the population in the country-side decreased from 21,600 to 18,200 [34].

The main cause of the increase of population in the Ignalina district was migration to Visaginas. This also led to a significant shift in the nationality of the population of the Ignalina district. In 1979 the percentage of Russians and Russian speakers was about 26 % in 1989 it had increased to about 53 %. This immigration was concentrated in the city of Visaginas which consisted of about 92 % Russians and Russian speakers [34].

In beginning of 2003 the total population of INPP region was 73,900 (in Visaginas - 28,600, in Ignalina and Zarasai districts accordingly 22,700 and 22,600). It was 40.4 % of Utena County and 2.1 % of Lithuania population.

In the town of Visaginas, the death rate is more than half as low as the average of the districts due to the younger age structure of the population, however, the birth rate is lower too and more rapidly decreasing than in the Ignalina and Zarasai districts; up to 2002, the population evolution (in terms of natural balance[13], not taking immigration/emigration into account) was positive in Visaginas, and negative in the Ignalina and Zarasai districts.

[13] Measured as the difference Birth Rate – Death Rate

Table 3-1 Birth and Death Rates, Population Evolution, 2000-2002

Territory	Birth Rate per 1000 residents			Death Rate per 1000 residents			Population evolution per 1000 residents		
	2000	**2001**	**2002**	**2000**	**2001**	**2002**	**2000**	**2001**	**2002**
Lithuania	9,8	9,1	8,6	11,1	11,6	11,8	-1,3	-2,5	-3,2
Utena county.	8,8	8,1	7,1	13,5	13,7	14,5	-4,7	-5,6	-7,4
Visaginas	7,3	8	6,2	5,5	6,2	5,2	1,8	1,8	1
Ignalina district.	9	7,6	7,8	17,1	17,8	21,4	-8,1	-10,2	-13,6
Zarasai district	10,3	8,9	8,3	18,9	16,2	18	-8,6	-7,3	-9,7

During the last years, a decrease of population in the INPP region is observed. In the year 2002 the total population of the region decreased by 1,400 (1.9 %), since 1999 – even 10,100 (12 %). During 2002-2003 the most population decreased in Visaginas – 400 (1.4 %).

Two processes – natural population evolution and migration, determine this population decreasing. In the year 2002, 501 people more died as was born in INPP region (in the year 2001 – 358). During the last years, a clear tendency of emigration is observed in the INPP region.

The emigration had the greatest effect on the population of Visaginas that decreased by 436 people in 2002.

3.2.2 Current Population Distribution

The distribution of population is important for nuclear activities, as potential radiological impacts may affect wide areas.

The nearest major cities to the plant are Vilnius at 130 km with about 553,000 inhabitants, and Daugavpils in Latvia at 30 km away with 126,000 inhabitants. The city of Visaginas, about 28,800 inhabitants and residence of the Ignalina nuclear power plant personnel, is located at 6 km from the plant (seeFigure 3-1).

Ignalina NPP region includes the territories of Visaginas, Ignalina and Zarasai municipalities (see map on Figure 3-1). The region under consideration forms a part of Utena County. This is the territory within the observation zone of Ignalina Nuclear Power Plant (beginning of 2004):

- the municipality of Visaginas – 59 square kilometres, 28.8 thousand inhabitants;
- the Ignalina district – 1 496 square kilometres, 22.0 thousand inhabitants;
- the Zarasai district – 1 334 square kilometres, 22.0 thousand inhabitants.

As many as 2.3 per cent of the population of the country lives in this region.
The main information about the population distribution in the region of 30 km is presented in Table 3-2 and Figure 3-2 [14].

Figure 3-1 Location of the Ignalina NPP (local scale) in the INPP Region


Lake Sartų
Dusetos
Baltic States
Zarasai
Turmantas
ZARASAI
LITHUANIA
INPP
Visaginas
Lake Luodžio
113
Dokštas
Lake Dysnų
Lake Tauragnų
102
Aukštaitijos N.P.
111
Ignalina
IGNALINA

Table 3-2 Population Distribution (thousands)

Direction of segment / Radius of circle	N	NE	E	SE	S	SW	W	NW	Amount of inhabitants in the ring	Amount of inhabitants in the circle
30 km	38.9	0.8	8.8	1.4	1.8	2.4	2.3	0.9	57,3	135.9
25 km	1.4	1.1	2.5	2.6	4.7	1.6	1.4	8.7	24.0	78.6
20 km	0.5	0.4	1.4	1.3	1.3	2.9	0.9	0.7	9.4	54.6
15 km	0.6	0.8	1.0	0.9	0.9	1.3	0.4	1.0	6.9	45.2
10 km	0.5	0.6	0.7	0.5	1.0	0.5	34.0	0.3	38.1	38.3
5 km	-	-	-	-	0.1	-	-	0.1	0.2	0.2
3 km	-	-	-	-	-	-	-	-	-	-
Amount of inhabitants in the segment	41.9	3.7	14.4	6.7	9.8	8.7	39	11.7	Total 135.9	

About 38 thousands of inhabitants of Daugavpils (Latvia) have to be included into the 30 km radius zone because 30% of territory of Daugavpils stretches at a distance from 27 to 30 km from INPP (Fig. 3.3). Within the 30 km radius the density of population is about 48 people/km^2. This is lower than the nominal density of population of 56.7 people/km^2 in Lithuania. In fact, population density in the INPP region is one of the lowest in Lithuania.

Apart the city of Visaginas itself, made essentially of multi-level buildings, there are some small villages in the vicinity of the plant, such as Mačyonis and Vyšniava.

Within the sanitary protected zone (established for emergency planning purposes, R = 3 km) there are neither farmsteads nor inhabitants.

3.2.3 Definition of the critical member of the public

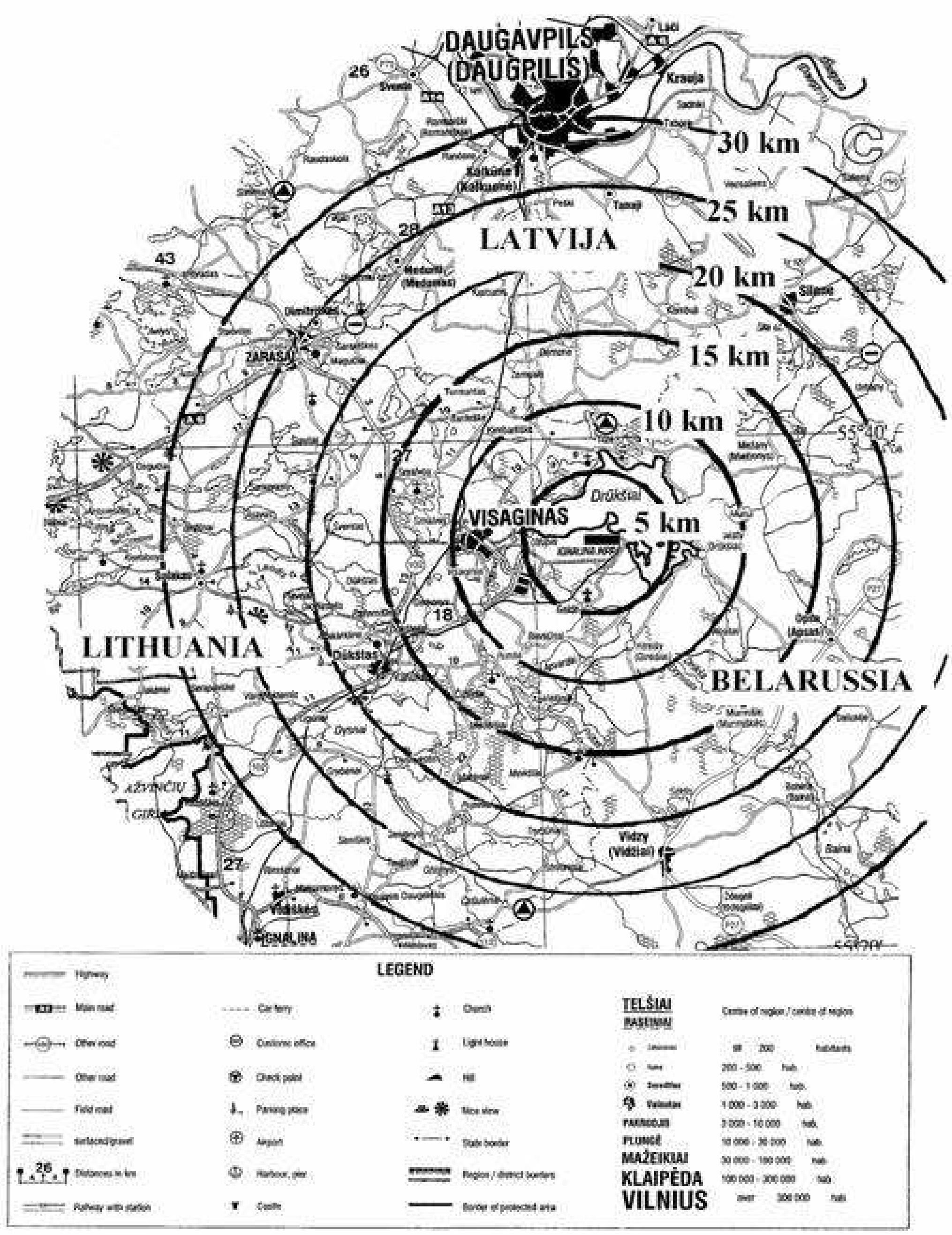
For the purpose of assessing radiation doses to the critical groups or the hypothetically critical individuals, the information needed is specific. This information is based on a scientific assessment made recently [77]. See also section 6.9.

Site-specific routine-release conversion factors and maximum annual effective dose for the dominant radionuclides, including all relevant pathways of external and internal exposure, have been evaluated separately for the atmospheric and radionuclides content in the discharged waters.

The routine-release conversion factors and maximum annual effective dose are specific to a hypothetical farmer and fisherman, taking into account all significant exposure pathways (immersion in the radionuclide plume, inhalation, external exposure from the surface, ingestion of contaminated food). The radionuclide-specific routine-release conversion factors are calculated for the location of the highest predicted radionuclide concentration in air and, for the radionuclide content in the discharged waters, in the dilution zone of heated effluent water.

Based on these data and the determination of the critical member of the public made in the scientific assessment [77], the LAND 42-2001 [76] method was established (thus specific to the INPP region and its consumption pathways).

Figure 3-2 Population Distribution in 5, 10, 15, 20, 25 and 30 km Zones [14]



3.3 Economic Activities and Infrastructures

3.3.1 Economic Activities

From the economic point of view the INPP region is an insufficiently developed region in Lithuania (the town of Visaginas makes the exception). Agriculture and forestry of low intensity dominate in the region (for example, the intensity of cattle breeding is about 1.4 times lower than on the average in Lithuania). No important minerals (with the exception of quartz sand) are found in the region. The turnover of the retail trade in the region is 1.5, and the volume of services is more than 2.5 times lower than on the average in the country.

Apart the INPP, other large-scale industrial enterprises are absent in the INPP region. Joint-stock company ‘Business News’ annually publishes a list of Lithuanian business leaders. Only INPP (8^{th} position) and clothes/garment factory ‘Visatex’ (296^{th} position) are in the list (400 positions) of year 2003. The other enterprises present in the region are mainly small and medium enterprises.

Within the 10 km radius (see Figure 3-2) there are no large commercial pursuits. At the 5 km distance to the southwest direction with respect to Ignalina NPP there is the former construction-industrial establishment. In the vicinity of this establishment there are, among others, training centre of frontier guard, fire protection service.

INPP region municipalities’ aggregative index of manufacturing is presented in Table 3-3 (source: [64]). The index takes into account industry, agriculture, building and service, it analyses produced products in all sectors. The index calculation includes these indicators (per inhabitant): industrial production, realized building works, agricultural products and rendered services. These indicators have weight numbers according their importance: industry – 0.3, building and service – 0.25 and agriculture – 0.2.

Table 3-3 INPP Region Municipalities Aggregative Index of Manufacturing, 2001

	Sold industrial production, Lt per inhabitant	Realized building works, Lt per inhabitant	Sold agricultural products, Lt per inhabitant	Rendered service, Lt per inhabitant	Aggregative production index	Position of municipality in Lithuania
Lithuania	6319	789	459,6	1424	1,00	
Visaginas	2180	1173	1,2	732	0,60	41
Ignalina district	696	461	221,1	472	0,36	55
Zarasai district	745	251	398,3	470	0,37	54

At present business and industry potential existing in INPP region is practically not employed and region is losing competitive activity for investment attraction. A positive factor for business development in the region is the infrastructure created for business support. This business support system is oriented to services of local small and medium enterprises.

3.3.2 Amenities

Water supply of INPP is made by Lake Drūkšiai which provides for service water. Drinking water used on the site is produced from underground water wells of Visaginas.

Power supply comes from the INPP production in normal operation. When necessary (revision, shutdown, etc.), reserve station provides power to installations. An industrial heating boiler provides heat to the buildings.

Power transport lines send electricity to the distribution network.

Near the INPP, there is a municipal treatment plant for sewage water (MWTP). It is located one km to the south from the Ignalina NPP. Household effluents from INPP and Visaginas arrive in this plant.

Lake Skripki is a part of the MWTP. The effluents are delivered to lake Drukshiai from Skripki through a brook (the Vosyliškiai streamlet). Initially it was planned to use lake Skripki as an additional biological purification, but since the MWTP design had no provisions for purification of effluents from nitrogen and phosphor, the bottom slurry of the lake became a source of secondary contamination with time.

3.3.3 Transport

The site was chosen near the railway line Leningrad – Vilnius – Kuznica, which was of paramount importance at the time of the Soviet regime. Currently this railway line is not too busy.

The nearest highway passes 12 km to the west of the Ignalina NPP. This highway joins the city of Ignalina with those of Zarasai, Dukstas and has an exit to the highway connecting Kaunas - St. Petersburg. The entrance of the main road from the Ignalina NPP to the highway is near the town of Dukstas (see Figure 3-3). The extension of the road from Ignalina NPP to Dukstas is about 20 km.

Figure 3-3 Road and Railway Network

The main railroad line Vilnius - St. Petersburg passes 9 km to the west of the Ignalina NPP. A single track extends from Visaginas to Dukstas.

3.4 Socio-economic Issues

3.4.1 Social Characteristics of the Population in the INPP Region

The settlement

The construction of the town of Visaginas was started in 1975 as a settlement for the employees of Ignalina NPP. Visaginas was built as a multi-storied town. In 1983, when half of the first residential area of the town of Visaginas was built, a second residential area was begun to be built. In 1995 Visaginas was granted the status of town.

As a result of this former Soviet Union major investment, the population is currently still particular in terms of nationalities: the majority is made of Russians (80%); Lithuanians are represented by about 15%, the remaining being made of Poles, Latvians, etc.

Particular socio-economical position of Visaginas

The direct attraction of Visaginas with other parts of the region is rather small (only 3 neighbouring economic units of local administration and Dūkštas) [42].

After the decision on the decommissioning of INPP, a Socio-Economic Monitoring has been proposed for the INPP region [41].

The Ignalina district of which the Visaginas municipality is a part, presents different social situations whether considering the INPP region or not. Some social indicators may appear contradictory. For example [41]:

- Though the Ignalina municipality takes one of the leading positions in Lithuania (including the NPP), it can also be considered as the most backward municipalities (not considering the NPP);
- Some health indicators highlight a high sickness rate for Visaginas, but this is due to the attraction of the town for its qualified medical services, that drains many people coming from rural districts.

As a result of the lower average age of the population in Visaginas compared to its neighbouring areas, the social support given to the population is lower in Visaginas than in the Ignalina and Zarasai district, as can be seen on Table 3-4.

Table 3-4 Recipients of Social Support and the Disabled in 2000 (source: ref. [43])

	Visaginas town	**Ignalina district**	**Zarasai district**
The number of the recipients of social benefit	413	966	675
Disabled adults	920	1 250	1 854

The town of Visaginas is the centre of the purchasing power of the whole region. In the year 2000, annual income from work amounted to approximately 8 075 Litas per person in Visaginas, as compared to 2 687 Litas in Ignalina district and 3 790 Litas in Zarasai district.

On the other hand, the turnover of the retail trade in the town of Visaginas is not large and it amounts to as little as 1 469 Litas a year per person in Ignalina district –1 749 Litas, in Zarasai district –1 965 Litas (these data include the shops of a corresponding town/district). Thus, the conclusion can be drawn that the inhabitants of the town of Visaginas buy goods of primary necessity, foodstuffs, in particular, in the market or directly from the producers of foodstuffs in the neighbouring districts rather than in the town of Visaginas.

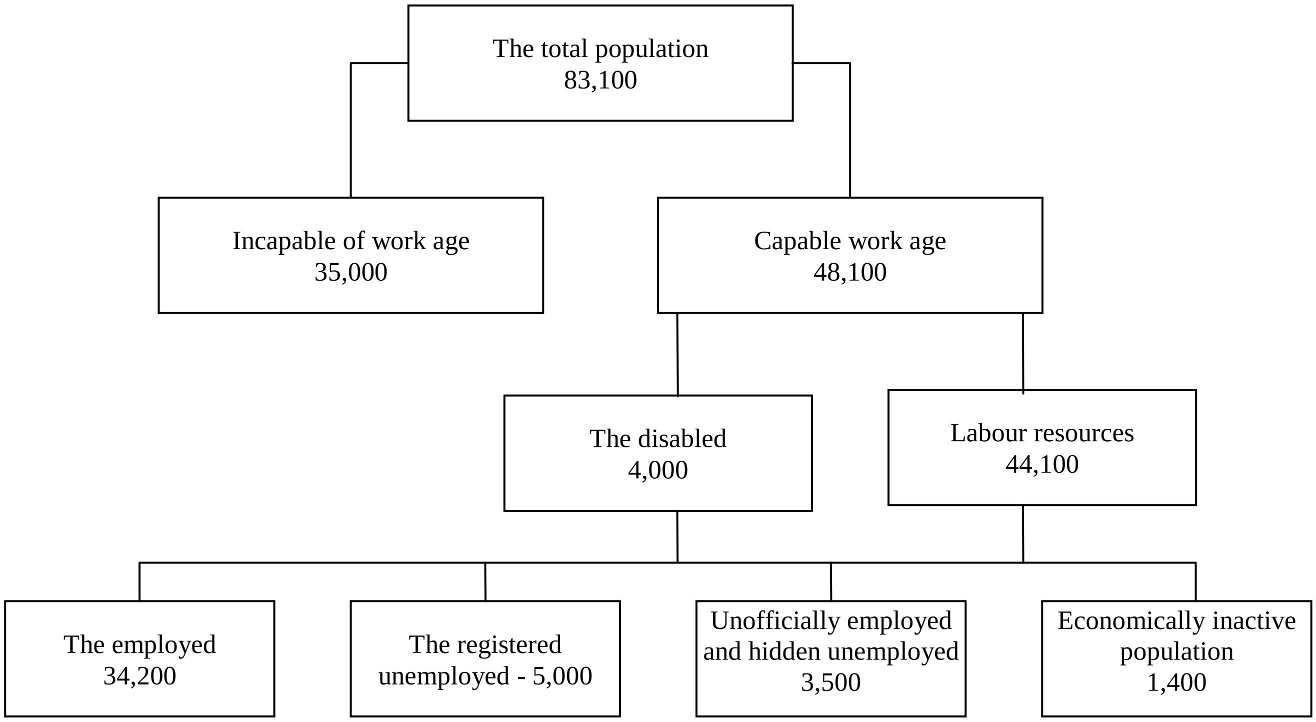
Evolution of the labour force

The town of Visaginas has an urban type labour force – a younger age structure (residents under 41 years of age account for 67%), better educated people and greater variety of professional training. Ignalina and Zarasai districts have a rural type labour force – an older age structure, lower education and a small variety of professional training. Individuals capable of working within working age in the town of Visaginas account for 66%, that is, 22.2 thousand people; in Ignalina district - 52%, that is, 12.9 thousand people and in Zarasai district - 53% (13 thousand people).

Every year 950 young people in the region reach the working age and the number of people reaching the retiring age amounts to about 500 individuals. Due to a natural movement of the labour force, labour resources increase most in the town of Visaginas and decrease in Zarasai district [10]. However, available job vacancies cannot answer to work demand, so that Visaginas unemployment is a bit higher than actual Lithuania’s unemployment level [43].

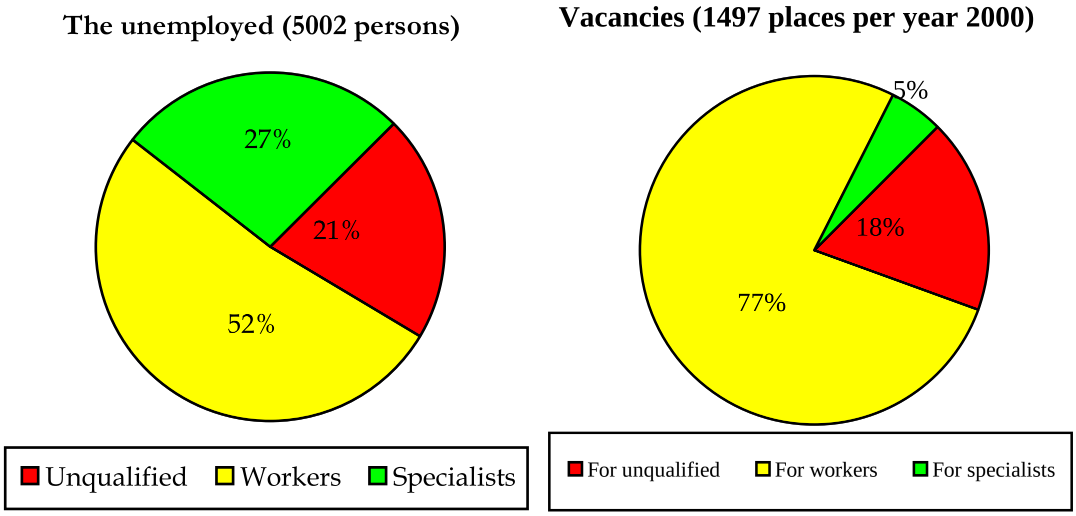
Wages is also a subject for differentiation of Visaginas. The average salary is 1.9 times higher than in Lithuania and 2.1 – 2.8 times higher than in the surrounding territories.
According to it, the INPP region is a zone with a higher level of regulation of social and economical life, due to the operating nuclear power plant.

Figure 3-4 Distribution of the Population in the Ignalina NPP Region at the Beginning of 2001 (source: ref [43])



For what concerns labour market demand and offer, there is a discrepancy between the education profiles, as shown in Figure 3-5.

Figure 3-5 Balancing of the Labour Market in the Town of Visaginas at the Beginning of 2001 (source: ref. [43])

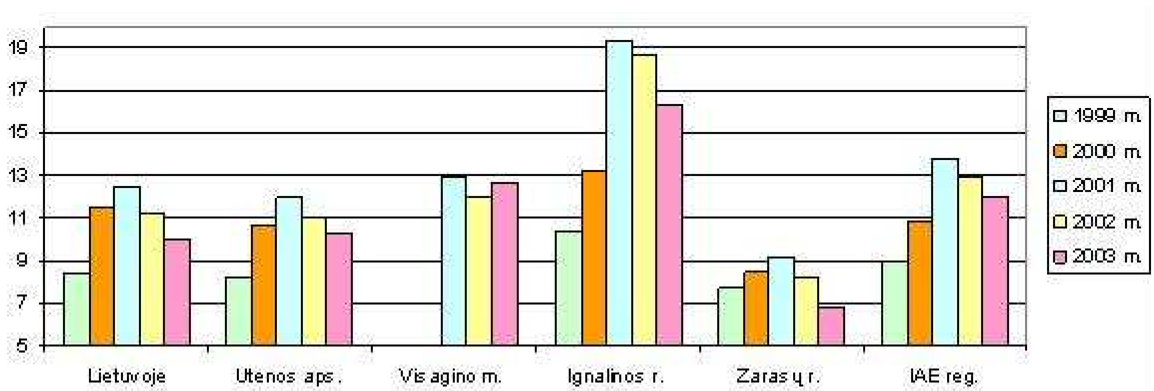


Physicians, psychologists, teachers of the English language, social pedagogues and employees, as well as accountants were in greatest demand among the specialists, whereas dress-makers, sales assistants and wood processing machine operators were in big demand among the workers. The IT sector is also growing up.

Unemployment

According to the professional indicators, high structural unemployment prevails in Ignalina NPP region, and poorly qualified and non-qualified workers dominate among the unemployed. Most of them are not prepared for the labour market: with a long break in their work record, have a profession that does not match market demands or have no qualification altogether. In relative terms, as for Lithuania in general, there is still a too high percentage of specialists, compared to vacancies [42]. The decrease in unemployment is a very recent phenomenon: it began in 2002 and confirmed in 2003. Visaginas took very little advantage of this trend (see Figure 3-6).

Figure 3-6 Unemployment Evolution for the Period 1999 – 2003 (Source: Department of Statistics, 2004)

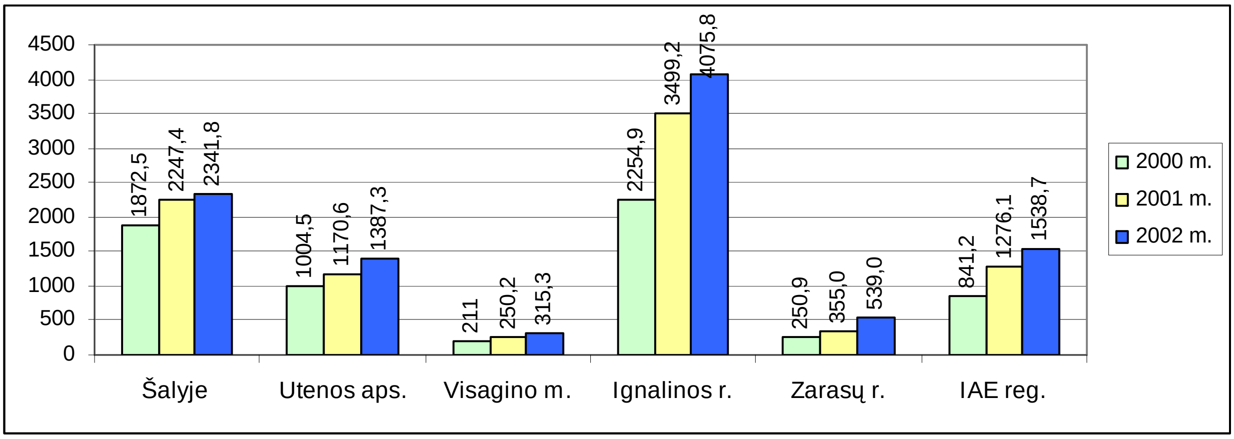


Duomenų šaltiniai: Statistikos Departamentas prie LRV ir Lietuvos darbo birža

Local investments

Here follow several figures and tables showing the recent investment evolution in the INPP region:

Figure 3-7 Material Investments per Resident in the period 2000-2002 (in Litas)



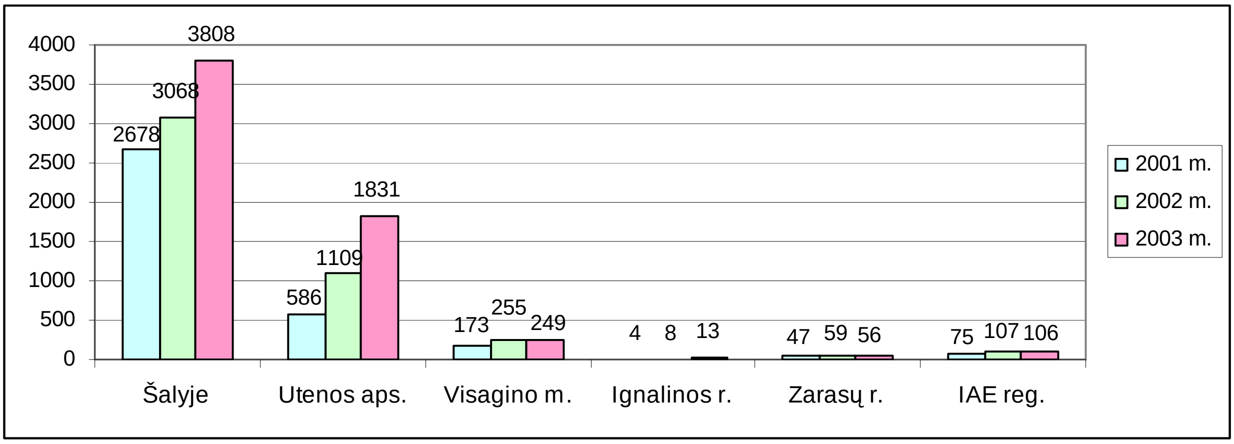
This figure shows there is a continuous, significant increase of material investments since 2000, which is slightly above the national average. However, material investments in the INPP region remain under the country average.

Table 3-5 Direct Foreign Investment in Utena County and INPP region, 1999 – 2003 (x1,000 Litas)

	1999 m.	2000 m.	2001 m.	2002 m.	2003 m.
Utena County	**91 212**	**95 217**	**109 268**	**204 975**	**335 274**
Visaginas municipality	-	-	5 134	7 413	7 135
Ignalina region	19	214	85	187	304
Zarasai region	660	894	1080	1337	1265
INPP region	**679**	**1 108**	**6 299**	**8 937**	**8 704**
INPP region compared to the Utena county, in %	**0,7**	**1,2**	**5,8**	**4,4**	**2,6**

This table shows a particular evolution as there was a rapid increase in foreign investments during the period 1999 – 2001. Then a decrease is shown since 2002. It does not reflect the general trend for the country and for the Utena County, as shown on Figure 3-8.

Figure 3-8 Direct Foreign Investments per Resident in Lithuania, Utena County and INPP Region, 2001 – 2003 (Lt)



Migration and nationalities

Migration is another issue to be considered, as it is a major aspect in the social processes and development. There was an active immigration until 1993, then it lowered; emigration is almost stable since 1997 (about 600 – 700 persons a year). In the last years, there was a replacement of international migration by the internal one [42].

Another aspect to consider is a recent trend for Visaginas inhabitants to apply for renouncement of citizenship. In 2000, the number of applications for renouncement was 28 while in 2001 it reached 127. It highlights people expectations about the social development in the future [41]. One of the explanations could be that a Lithuanian passport would be an obstacle for Russians to find back a similar job in Russia. We must also take into account that some emigration already happened in the past: after the declaration of independence of Lithuania, then after the announcement of the INPP closure.

Due to insufficient knowledge of the state language, the residents of the town of Visaginas (the majority being Russian or Russian speakers) almost make no use of the system of upgrading their qualifications and professional development. Only 3% of the employees of Ignalina NPP can speak the state language sufficiently well. Ignorance of the state language makes the integration of the employees dismissed from Ignalina NPP into other districts of Lithuania quite complicated and difficult, especially in seeking to fill higher posts.

As a consequence of the nationalities' representation in Visaginas and the language issue, there seem to remain some social and cultural isolation from other parts of the country; this is also due to Visaginas localization in the country and its youth. These causes have lead to a rather closed society. Permanent social links are just at the stage of formation [41].

The socio-economical issues were addressed already by several authors. Some references are given; see [10], [12] and [13].

3.4.2 Opinion of INPP Region Population on the INPP Closure

In 2002, the Geology and Geography Institute released a paper on the Social-economic Monitoring of Ignalina NPP Region [42].

Table 3-6 Opinion of INPP Region Population on the INPP Closure

Indicator, %	**Ignalina and Zarasai municipalities**	**Visaginas town**
Opinion on the INPP closure: negative opinions	62	92
Social psychological discomfort due to INPP operation: population part worried by INPP safety	19	4

As there will be a strong impact of INPP closure on the Visaginas inhabitants as well, mitigation measures have to integrate the city together with the plant personnel.

3.4.3 Social Aspects Linked to the Possible Evolution of Visaginas

Some structural characteristics and recent trends are to be considered in the assessment of possible socio-economic impacts of the INPP closure.

The industrial potential of the region is weak, there are no important economic resources that can give competitive advantages for the companies in the region, with the exception of recreational resources (nature tourism mainly) [42]. Therefore, a majority of people currently employed by the INPP would not find a similar job in the industrial sector in the region or it would be with significantly lower wages. The state language issue is also an obstacle to migrate to other regions of the country.

The accession of Lithuania to the European Union can also influence the evolution of population. On one hand, there seem to be a general trend for emigration. On the other hand, accession should favour foreign investments in the country that could increase employment and well being.

More locally, there are great social differences between the whole Utena district and Visaginas city, as seen in section 3.4.1, so that the city of Visaginas can be characterised as a closed society, only at the beginning of developing relationships with other parts of the country. The town of Visaginas distinguishes itself by its high quality potential of labour resources, the level of computerisation, and ethics of work on the one hand, and marked disposition towards isolation, a low level of business, on the other hand.

On an economical point of view, the city is more and more interrelated with the economies of different settlements in Utena district and in other Lithuanian cities: Visaginas serves as an important market for their enterprises. Unfortunately, the city is located in the state border area, far from economically dynamic regions and cities, including Latvia and Belarus.

Questions are:

- What are the social impacts that can be awaited during the decommissioning of INPP?
- Is there potential for the redeployment of economic forces in Visaginas, as almost all economic activity in Visaginas is connected with INPP or services of the INPP workers?
- What are the strength and weaknesses to take into account?

These questions will be addressed in the impact assessment section (see 7.2).

3.5 Climate and Air Quality

The Lithuanian climate is characterised by middle climatic zone. The region concerned is located in the continental East Europe climate area. In comparison with other Lithuanian areas, this area is marked by big variations of air temperature over the year, colder and longer winters with abundant snow cover, and warmer, but shorter summers. Average precipitation is also higher.

The most useful climatic and meteorological data used for the EIA purposes are based on measurements performed by Ignalina NPP meteorological station, located approximately at a distance 5.5 km to the west of INPP site.
The atmospheric dilution coefficient (s/m^3) to assess the radiological impact of aerosols routine releases is included in the nuclide dose-contamination conversion factors given in LAND 42-2001 [76].

The atmospheric dilution coefficient (s/m^3) to assess the radiological impact of aerosols accidental releases ("puff releases" or short duration releases) is based on the following conservative assumptions:

- The distance of the critical individual to the stack is minimum, i.e. 3000 m;
- Short duration release, i.e. ≤ 8 hours;
- Most penalising meteorological conditiones corresponding to PASQUILL stability class B and wind velocity = 2 m/s [31];
- The height of releases is 150 m;
- The critical individual is located along the axis of the plume, i.e. the horizontal standard deviation σ_y (x) is minimised;
- Dry weather condition, i.e. the washout of aerosols by rainfalls between the stack and the critical individual is neglected to maximise the inhalation dose.

  The accumulation of the hereabove conservative assumptions leads to $\frac{X}{Q} = 1.4\times10^{-6}$ s/m^3.

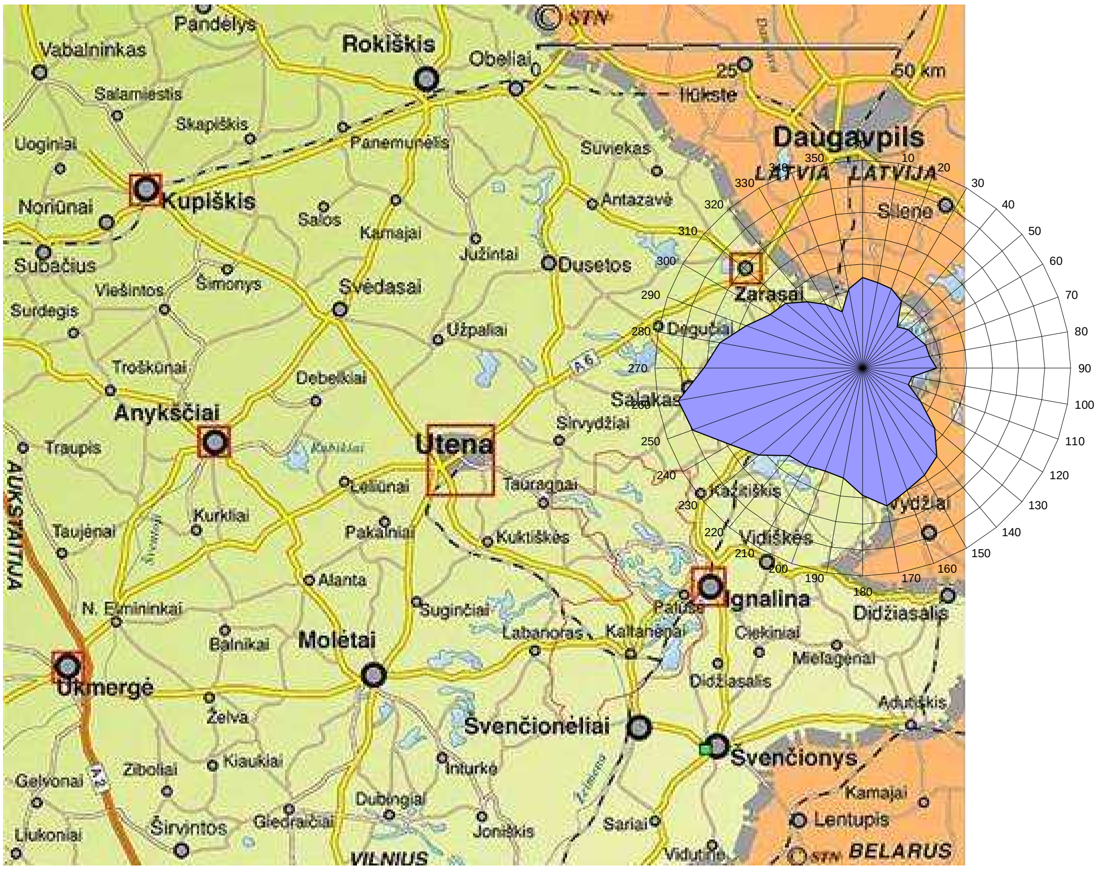
Regarding **air quality**, there are less pollution sources in the INPP region than in other areas of the country, as industrial activity is not very developed and there is almost no use of fossil fuels for electricity and heating in Visaginas (apart the back-up HOB in the town). The main source of pollution comes from personal vehicles, as their average age is high; low octane fuels are also used (80, 92) together with higher ones (95, 98).

3.5.1 Wind Regime

Western and southern winds predominate. The strongest winds have western and south - east directions. The average annual wind speed is 3.5 m/s, and maximal (gust) speeds can reach 28 m/s. No-wind conditions are observed on the 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 [16].

Wind rose at INPP region, based on local wind measurements [24 to 30], is presented in Figure 3-9.

Figure 3-9 Wind Rose (Average Values for the 1997 – 2003 Period) Reported on the Road Map



3.5.2 Hurricanes and Spouts [8, 24]

Spouts near the Ignalina NPP do not exceed class F-2 according to Fujita classification [21].

The following data is normally used for calculations:

a) maximal rotation speed of the spout wall is 105 m/s;
b) pressure differential between centre of the funnel and the fringe region of the spout is 135 kPa.

3.5.3 Air Temperature

Monthly average temperatures in the INPP region are given in theTable 3-7.

Table 3-7 Monthly Averaged Air Temperatures (°C) for the INPP Region

Meteorological station and observation period	Month (s)												01 - 12
	01	02	03	04	05	06	07	08	09	10	11	12	Average
Dukstas, 1961 - 1990	-6.8	-5.9	-1.9	5.2	12.1	15.5	16.8	15.9	11.2	6.2	0.9	-3.8	5.5
Utena, 1961 - 1990	-6.0	-5.2	-1.2	5.5	12.2	15.6	16.8	15.9	11.4	6.6	1.4	-3.2	5.8
INPP, 1988 - 1999	-2.5	-2.2	0.3	6.6	12.4	16.5	17.9	16.5	11.3	6.0	-0.1	-3.1	6.6
INPP, 2000 - 2003	-3.5	-3.5	0.7	7.5	12.9	15.5	19.6	17.3	11.8	6.2	2.0	-4.2	6.9

The monthly averaged air temperature variation in the warm season (April-October) and the beginning of the cold season (November-December) during the last decade (1988-1999) does not differ from long-term (1961-1990) observations. However the second half of the cold season (January-March) was warmer during the last decade and the average air temperature for this period is higher by 4.3-2.3 °C. The average monthly temperatures on the period 2000 – 2003 seem to indicate a slight increase from March to November. The seven successive warm winters (1988/1989 to 1994/1995) are identified as a unique climatic phenomenon for Lithuania [17].

3.5.4 Atmospheric Precipitation

Monthly averages of precipitation for the INPP region in the long-term observation period (1961-1990) [23], pre-operational monitoring period [22] and last decade (1988-2000) period [24 – 27] are presented in Table 3-8. The last decade annual precipitation and average annual variation of precipitation monthly averages for INPP meteorological station are presented also in Table 3-8.

Table 3-8 Monthly Averaged Precipitation (mm) for the INPP Region

Meteorological station and observation period	Month (s)												Total for months		
	01	02	03	04	05	06	07	08	09	10	11	12	01-12	11-03	04-10
Dukstas, 1961-1990	32	25	28	43	58	69	75	66	64	50	42	40	592	167	425
Utena, 1961-1990	39	31	37	47	53	69	73	75	66	50	57	53	650	217	433
Zarasai, 1961-1990	45	36	39	42	59	72	75	66	66	55	60	56	671	236	435
INPP, 1988 - 1999	41	41	46	33	55	84	60	64	70	66	58	57	676	244	432
INPP, 2000 - 2003	43	43	39	46	57	79	92	72	32	59	59	44	665	229	437

Results in the period 2000-2003 at INPP do not show significant differences in precipitations compared to the 1988-2000 period.

Average annual precipitation in the INPP region is about 650 mm. As shown on Figure 3-10, there are important variations from year to year in the region. 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). Minimum precipitation occurs in January-March (40 mm per month) and maximum in June-August (70 mm per month).

Recorded extremes (maximum per-day precipitation for individual months) are presented in Table 3-9. Average per-day maximum for the INPP region is about 50 - 60 mm.

Figure 3-10 Annual Precipitation at INPP for 1988-2003

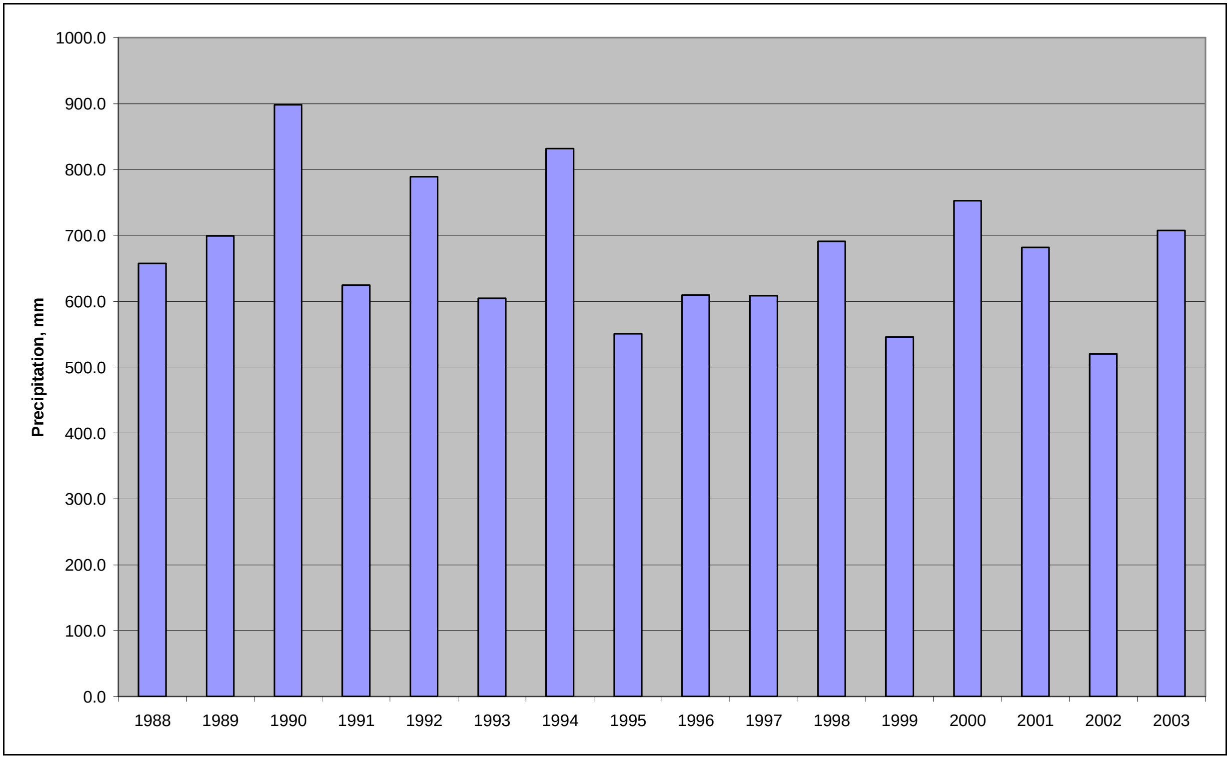


Table 3-9 Maximum-recorded per-day Precipitation (mm) for Individual Months

Meteorological station	Months												Max
	01	02	03	04	05	06	07	08	09	10	11	12	
Dukstas	18.8	13.2	23.4	19.2	52.4	42.4	28.6	48.8	35.2	30.7	20.2	11.4	52.4
	1989	1976	1979	1985	1980	1987	1987	1979	1978	1974	1983	1988	
Utena	17.1	18.1	24.2	34.7	45	99.0	54.2	67.6	37.9	41.6	36.2	23.0	99.0
	1958	1950	1930	1979	1982	1950	1960	1948	1953	1974	1960	1945	
Zarasai	22	21.6	34.3	40.7	55.9	52.6	55.5	82.7	60.1	44.3	46.8	23.7	82.7
	1959	1957	1979	1985	1955	1980	1955	1962	1950	1974	1930	1925	

The snow cover in the region is present for about 120 days per year. Permanent snow cover usually starts in the second half of December and ends in the second half of March. The average thickness of snow cover is about 40 cm [22], [16].

3.5.5 Fog and Oscillation of Atmospheric Impurities

In the Ignalina NPP area, fog can be observed any day of the year. The average number of days with fog is 45 and the maximum – 62 days. Fog absorbs different impurity (noxious gases, smoke and dust) and, combined with high humidity, increases corrosion intensity, reducing the distance of visibility and impeding transportation [34].

The maximum dusting is observed in May, and the minimum – in December. The oscillations of the total sulphur compounds in the atmosphere have the following annual distribution: the lowest values are observed in the summer and autumn and highest ones – during the cold period of the year [34].

3.5.6 Ground Freezing

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

3.5.7 Microclimate

The development of a microclimate is linked to the presence of the lake, whose evaporation can increase local humidity which can cause more fog episodes and increase the air temperature locally. A near shore microclimate is reported [15].

It is considered that the natural yearly evaporation from the ground amounts 500 mm, and from the lake (mainly in the April – November period) 600 mm, with a natural variation of 15% and no influence from the INPP. During the May-October period, the average evaporation is 540 mm.

The influence of the INPP on the evaporation is shown in the next table [20]:

Year	Evaporation (May-October)	Difference with pre-INPP conditions
1984	627 mm	16%
1985	720 mm	33%
1986	712 mm	32%
1987	684 mm	27%
1988	788 mm	46%

The near shore water temperature during the period May-October increased with the operation of Unit 1 then Unit 2, successively by about 1°C [67].
The other side of the effect of Ignalina NPP to the amount of evaporation from the surface of Lake Drūkšiai is the lengthening of the active evaporation time, because of the extended period during which no ice forms on Lake Drūkšiai. During the cold period the evaporation process persists in the zone, which is adjacent to the exit of the discharge channel.
Other phenomena influence local climate because of the lake presence, such as radiative exchange.

As the temperature of the lake increased with thermal releases from the INPP, with subsequent increase in evaporation and local temperature, it is possible that the microclimate linked to the lake has changed significantly since the INPP operation.

3.5.8 Air Quality

Lithuania is not a country that currently has a large air pollution problem. Since 1991, the estimated air emissions of the main pollutants from stationary and mobile sources in Lithuania have decreased on average by a factor of 2. Three automatic monitoring stations are located in Vilnius, which provide data on the Internet in order to inform public rapidly [44], and other stationary stations are located in the most influenced areas. Like in other countries, the air quality is largely determined by long-range transboundary air pollution: polluted air masses are usually brought from industrial regions of Western and Central Europe [45].

In regions where pollutant emissions are significant, typical concentrations in major cities of the country are presented in Table 3-10 [45]. One must bear in mind that the situation is certainly better in Visaginas and surroundings because of less industrial activities and average population number than in urban areas.

Table 3-10 Comparison between Annual Mean Concentration of Major Pollutants and Applicable Standards

Pollutants	**Annual mean concentrations in µg/m³**	**Applicable standards EU directive 1999/30/CE**
Nitrogen oxides	30	40
Sulphur dioxides	2	20 *for the protection of ecosystems*

Therefore, the air quality is supposed to be good, in terms of classic air pollutants. Radiological issues are presented in section 3.10.

No air quality measurements for classic pollutants are carried out by INPP or other bodies in the vicinity. Hence, INPP does measure atmospheric effluents from its Heat Only Boiler (used as support for the heating of installations). Measures indicate that authorized emission limits are respected for carbon monoxide, nitrogen oxides, and solid particles; the limit set up for sulphur dioxide was not respected at the beginning of 2004 (1 700 mg/Nm³) though the previous one (3 400 mg/Nm³) was respected in 2003. Additional measures were made in 2004 by a competent laboratory on the main emission sources (63 sources) of the INPP site; the efficiency of the pollution abatement equipment was checked.

3.6 Geology, Soil Characteristics, Hydrogeology and Hydrology

3.6.1 Introduction

This chapter concerns the geology, soils characteristics, hydrogeology and hydrology in the area of the Ignalina NPP site. It describes the characteristics of the subsoil, the soil and the underground and surface water.

The first step of the analysis consists in a description of the situation as existing prior to the implementation of the U1DP0 Project. This part of the job is based on existing information and data that have been gathered through a bibliographical and web research.

The initial situation serves as a reference to assess the potential impacts of the project on the subsoil and the waters.

Based on the impact assessment, prevention, minimisation and mitigation measures are proposed when necessary in order to achieve an acceptable level of nuisance.

3.6.2 Geology and soil characteristics

Geological, tectonic and hydrogeological conditions vary considerably in Lithuania. Especially high heterogeneity of genesis and lithological composition of the Quaternary deposits is reflected in drastic changes both in vertical and lateral distribution of sediments.

The surface of the Ignalina NPP area is rough. Their absolute elevation-marks change from 150 m to 180 m and more. At the surface exist glacial Quaternary sediments within a depth from 60 to 200 m, which are supported from below by Pre-Quaternary, Devonian, Silurian, Ordovician, Cambrian and Upper Proterozoic sediment variety. Imbedded metamorphic and Crystal sediments of Upper Proterozoic and Archei exist at the depth of 700-750 m (see Figure 3-11).

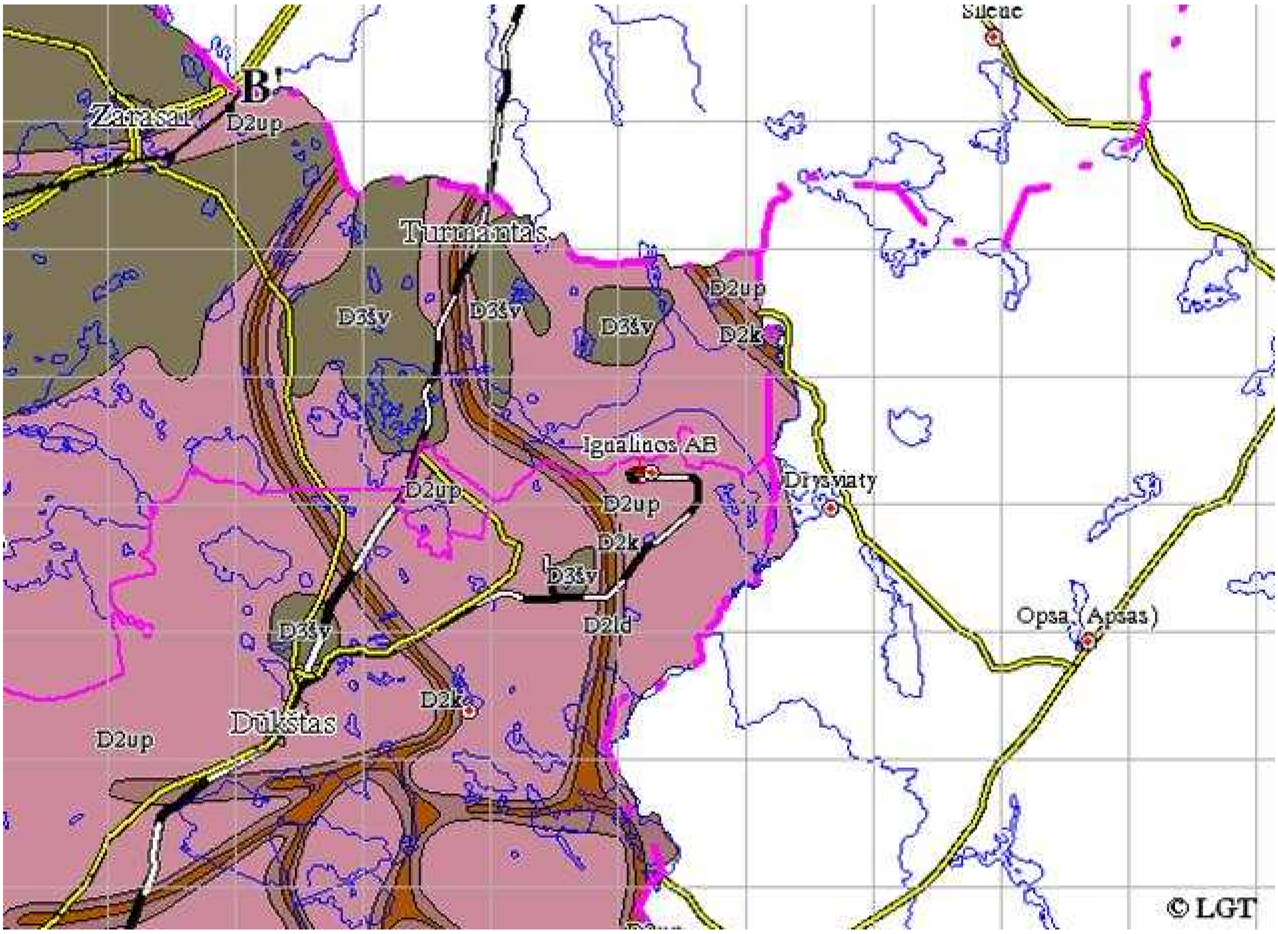
In the area of Ignalina NPP the surface sediments are very inhomogeneous. They were formed during the retreat of the last glacier, as results of different glacial and water-glacial processes. Later on, alluvial, marsh and lake-sediments were formed.

The lithological structure, the filtration and engineering-geological properties of separate genetic types of surface sediments are not equal. Most prevalent, are the permeable water-glacial sediments, which are located in direct proximity of Lake Drūkšiai and the Ignalina NPP (see Figure 3-12). All surface sediments contain underground water, which range in depths from 0.2 to 7 m. The marsh, lake-marsh, lake-glacial and water-glacial sediments are located near the surface and at the level of the building foundations and other constructions. By lithological classification, this is peat, sand, gravel, loam and clay [22].

The complexity of engineering-geological conditions of the platform in question consists of:

- Heterogeneity of grounds;
- Availability of weak grounds, especially, peat;
- Availability of numerous cradles, lenses and interbeds in the sand-gravel sediments;
- Availability of swamps.

Figure 3-11 Pre-Quaternary Geology Map (Source: Lithuanian Geology Service Internet Site; Consultation 22nd June 2004)



Legend: see next page

Legend of Figure 3-11

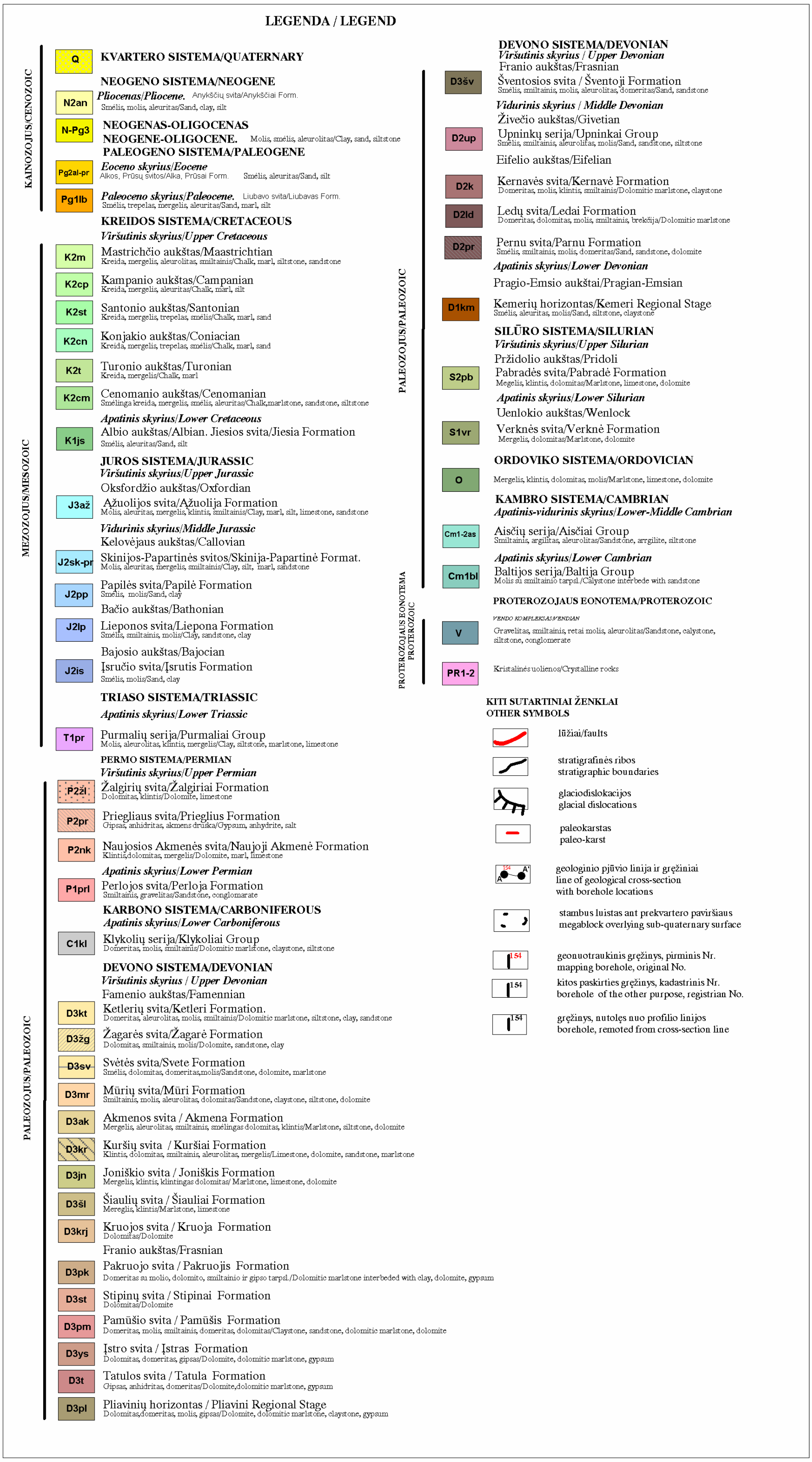
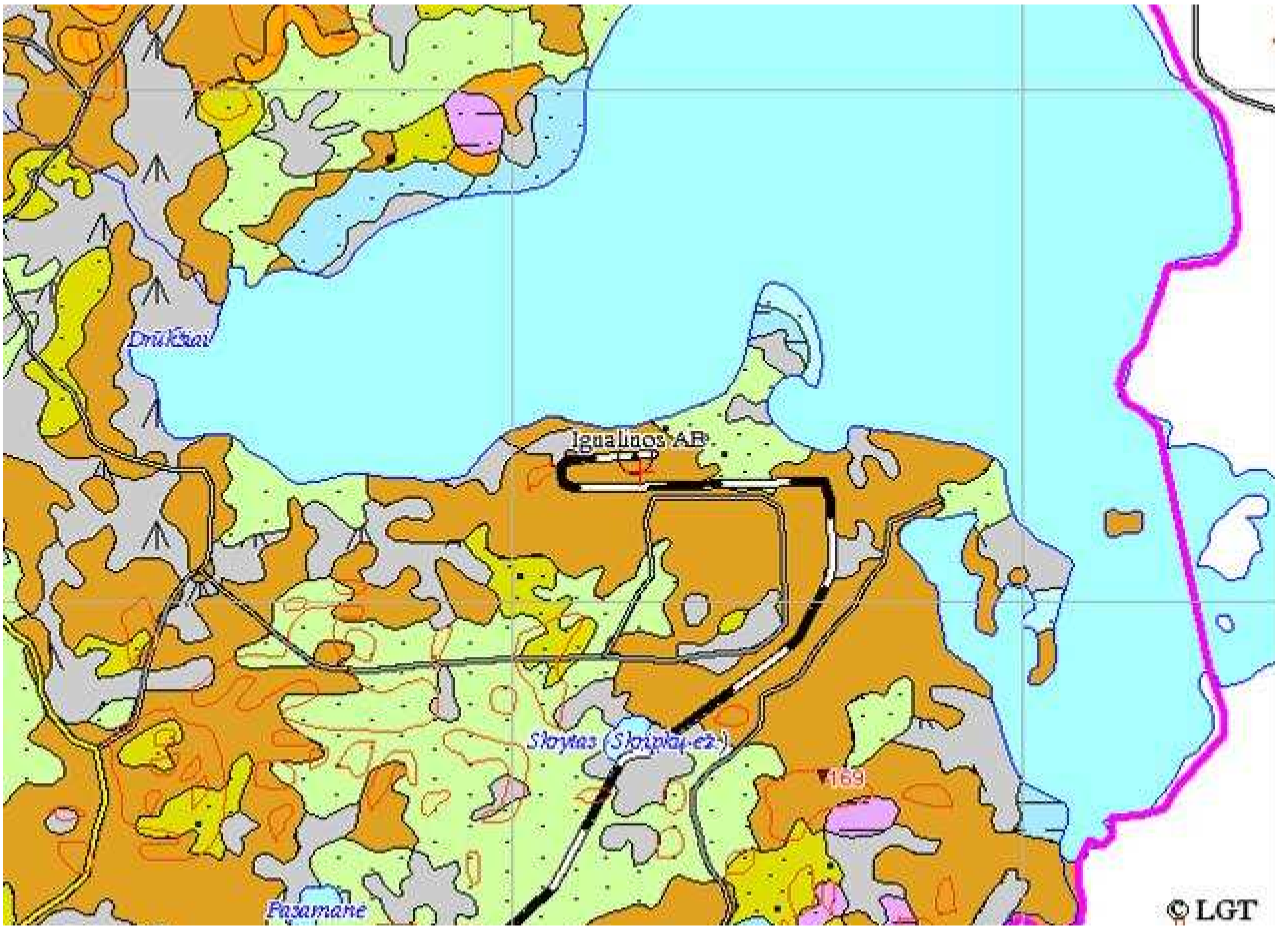


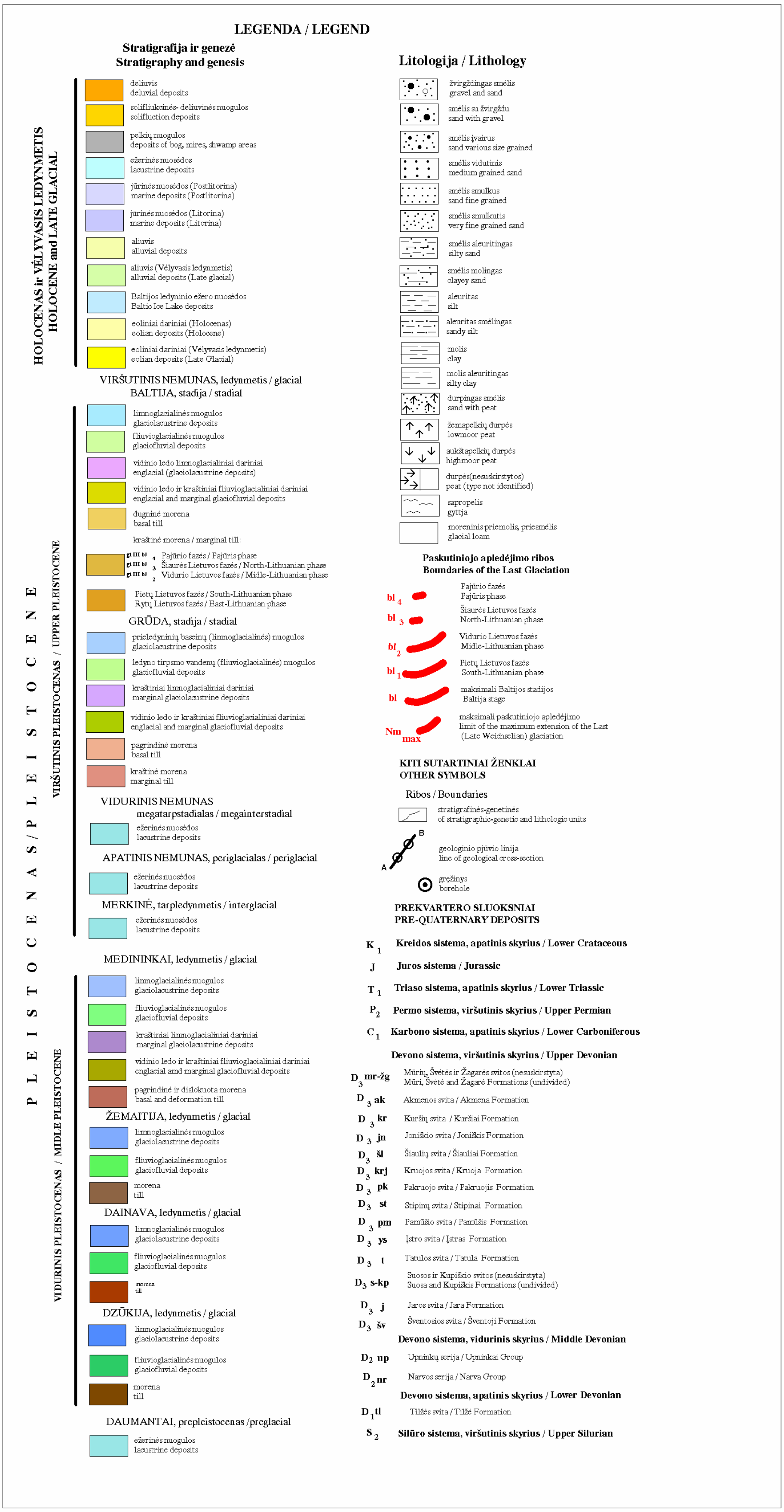
Figure 3-12 Quaternary Geology Map (Source: Lithuanian Geology Service Internet Site; Consultation 22nd June 2004)



Legend: see next page

All these factors have an influence to the settlement of buildings and constructions in the area. The deformation of the split slabs can be considerable – from 50 to 1000 mm – and can be highly irregular. This is out of the scope of the present EIAR, as neither particular construction nor demolition is foreseen on this project. Specific EIA processes relate to construction projects, such as the support systems (Interim Storage Facility for Spent Fuel, new Heat Only Boiler, etc.).

Legend of Figure 3-12



3.6.3 Seismology

The Ignalina NPP is located in the area of the East-European platform, on the joint connection of two large structure elements: Baltic syncline and Mazur-Belarus anticline. The earth's crust is pulsating, even experiencing perceptible shocks. The predicted intensity of neotectonic motion in the area is 3.5 mm/year. Therefore, the crystal bedding and sediment beds have fissures induced by tectonic system's cracks [34]. The area of the Ignalina NPP extends within the limits of the Daugavpils seismic zone. The zone is encountered by the isoseismal line that indicates the intensity of the seismic events (earthquakes) of 7 grades (according to the MSK-64 scale); it means that for such seisms, there can be damages to buildings, objects can be moved, cracks can appear in the walls.

3.6.4 Hydrogeology

3.6.4.1 Groundwater dynamics

The area of INPP is in the recharge area of the Baltic artesian basin. An artesian basin is a complex of naturally limited aquifers and aquitards, territorially separated from other regions, determined by features of unanimous geological structure and hydrodynamic conditions. Taking into account the top part of crystalline basement, up to 20 aquifer layers are identified. These belong to hydrodynamic zones of active (above the regional Narva aquitard[14]), slow (above the regional silurian-ordovic aquitard) and especially slow (below the regional silurian-ordovic aquitard) water circulation. An active exchange of underground water occurs in the Quaternary and Upper-Middle-Devonian formations (zone up to 250 m of thickness, see Figure 3-13 and Figure 3-14).

The quaternary aquifer complex consists of groundwater aquifer and five (or more) confined or subconfined (having greater pressure than the atmospheric) aquifers in sandy loam sediments and Upper-Middle Devonian aquifers of aquiferous sand and sandstone.

The characterisation of the Lake Drūkšiai catchment dynamics is quite complicated. In summary, the hydrodynamic situation is as follows:

- the active circulation area including groundwater and Sventosios-Upninku aquifers receives 99% of the total circulating underground water volume. Natural circulation amounts to 132.5 m³/day (approximately 2.9 l/ (s.km^2). 1/3 of this volume reaches Sventosios-Upninku aquifer and outflows outside the lake Drūkšiai catchment.

- The average intensiveness of groundwater infiltration in the catchment makes up 70 mm per year and vertical flow to Sventosios-Upninku aquifer amounts approximately to 27 mm per year. The lake Drūkšiai, rivers and lakes in its catchment drain approximately 77.800 m³/day of the underground water, i.e. underground run-off makes up 26% of the average multiyear lake outflow.

- Extraction of water in the Visaginas town waterworks from Sventosios-Upninku aquifer forms depressions of this catchment and piezometric surfaces and thus influences increase (20-30%) in the exchange with adjacent aquifers (in the majority from above) and reduction of lateral flow. Extraction of underground water in the Visaginas town waterworks considering the current (25 000 m³/day) and projected extraction

[14] Aquitard: a geologic stratum or formation of low permeability that impedes the flow of water between 2 aquifers; Aquifer: a permeable geological stratum or formation that is capable of both storing and transmitting water. A confined aquifer is where an upper layer of low permeability confines groundwater in the aquifer under greater than atmospheric pressure; an unconfined aquifer is where the upper surface of a saturated zone forms a water table within the water-bearing stratum.

(40.000 m³/day) reduces underground flow to rivers by about 10%-15%, loss to overall river outflow is 4 times less.

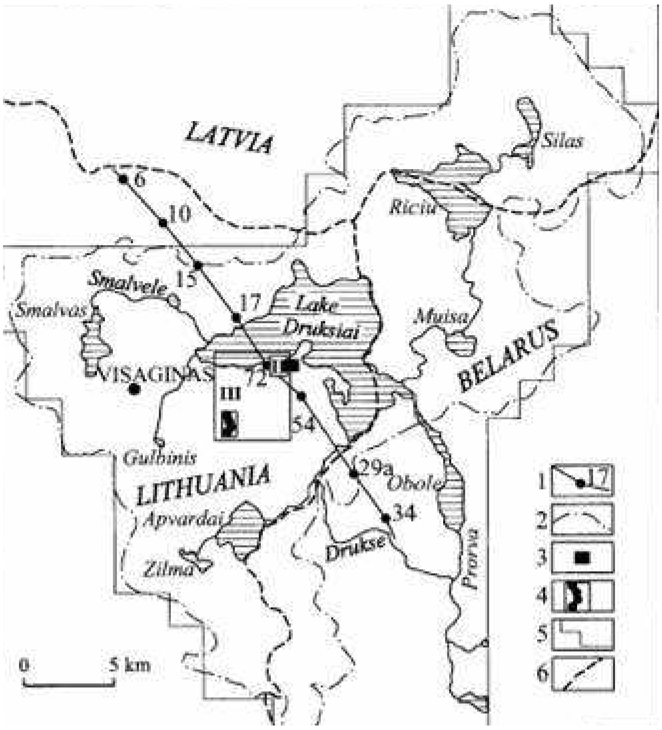
As the used water returned into the Lake Drūkšiai the extraction of groundwater has no appreciable influence to surface run-off. Based on modelling data, the lake Drūkšiai feeds groundwater aquifers only in case if Visaginas town waterworks are operated in intensive mode and the lake water inflow rate is very insignificant (0.1 to 0.7 m³/s). The vertical velocity of the lake water underground flow should not exceed 0.1 to 0.5 m per year.

The construction and operation of the Ignalina NPP essentially widen the spectrum of technogenic influence on the geologic environment. The character and scales of the consequences depends on the geological situation: filtration and capacitive properties of its variety and from drainage conditions of underground aquifer. From this point of view the territory of Ignalina NPP is located in unfavourable conditions. The depth of aeration zone is from 1-2 m to 5-8 m and is insufficiently safe to protect the underground waters. It is composed of fine sands, which have the following characteristics [34]:

	Fine sand	**Sandy loam**
filtration coefficient	5-20 m/day	0.01-2 m/day
water-yield coefficient	0.05-0.35	0.001-0.1

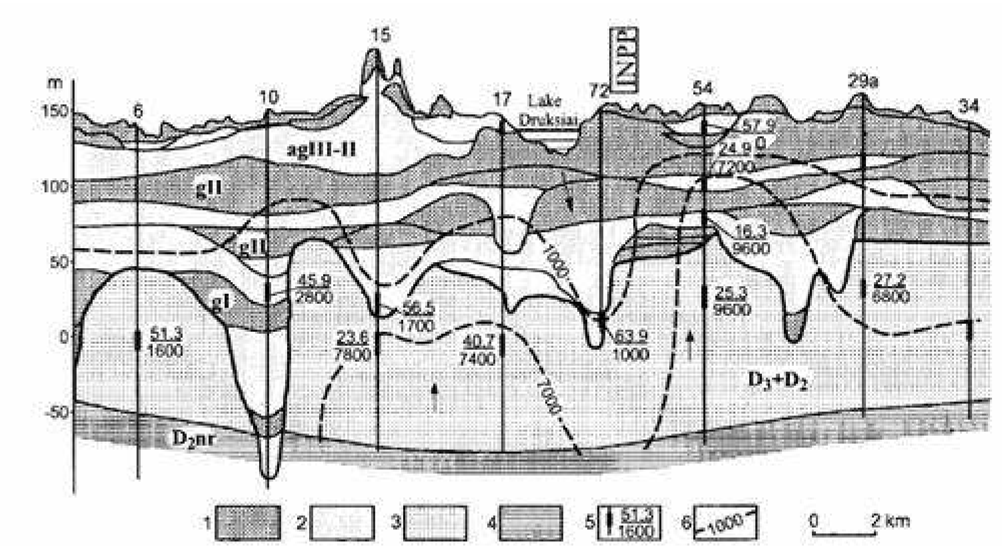
The groundwater level in boreholes 10 m deep, which were established during the investigation of the site in 1973, was only 0.75-1.75 m below the soil surface. The groundwater flow of upper water-bearing horizons is directed to the north and northeast towards Lake Drūkšiai (see Figure 3-15). The relief of the site was changed in the process of smoothing away during the construction of Ignalina NPP. The swampy accretions (peat, slimy sand) were shovelled away, the relief was made even and large amount of ground and gravel was transported into the site. This is the main reason for which the groundwater level is slightly deeper now than in 1973. Rainwater drainage and other systems constructed in the site are another reason for this [14].

Figure 3-13 Location of the Territory



1- line of geological-hydrogeological cross-section; 2- boundary of lake Drūkšiai catchment; 3- INPP location; 4- well field of Visaginas town waterworks.

Figure 3-14 Geological-hydrogeological Cross-section of Ignalina NPP Region Interpreted according to Marcinkevicius et al.) with Isolines of Groundwater Radiocarbon Age



1- local aquitards (till deposits, loam); 2- Quaternary interglacial aquifers (sand with gravel); 3- Devonian aquifer Sventosios Upninku (sand); 4- Devonian regional Narva aquitard (domerite, dolomite and marl); 5- monitoring well and its number: in numerator, radiocarbon concentration (in pmC) and in denominator, radiocarbon age (in years); 6- isolines of radiocarbon age (in years).

Figure 3-15 Schematic Chart of Absolute Groundwater Levels of the Site in 1973 (before Construction of INPP)

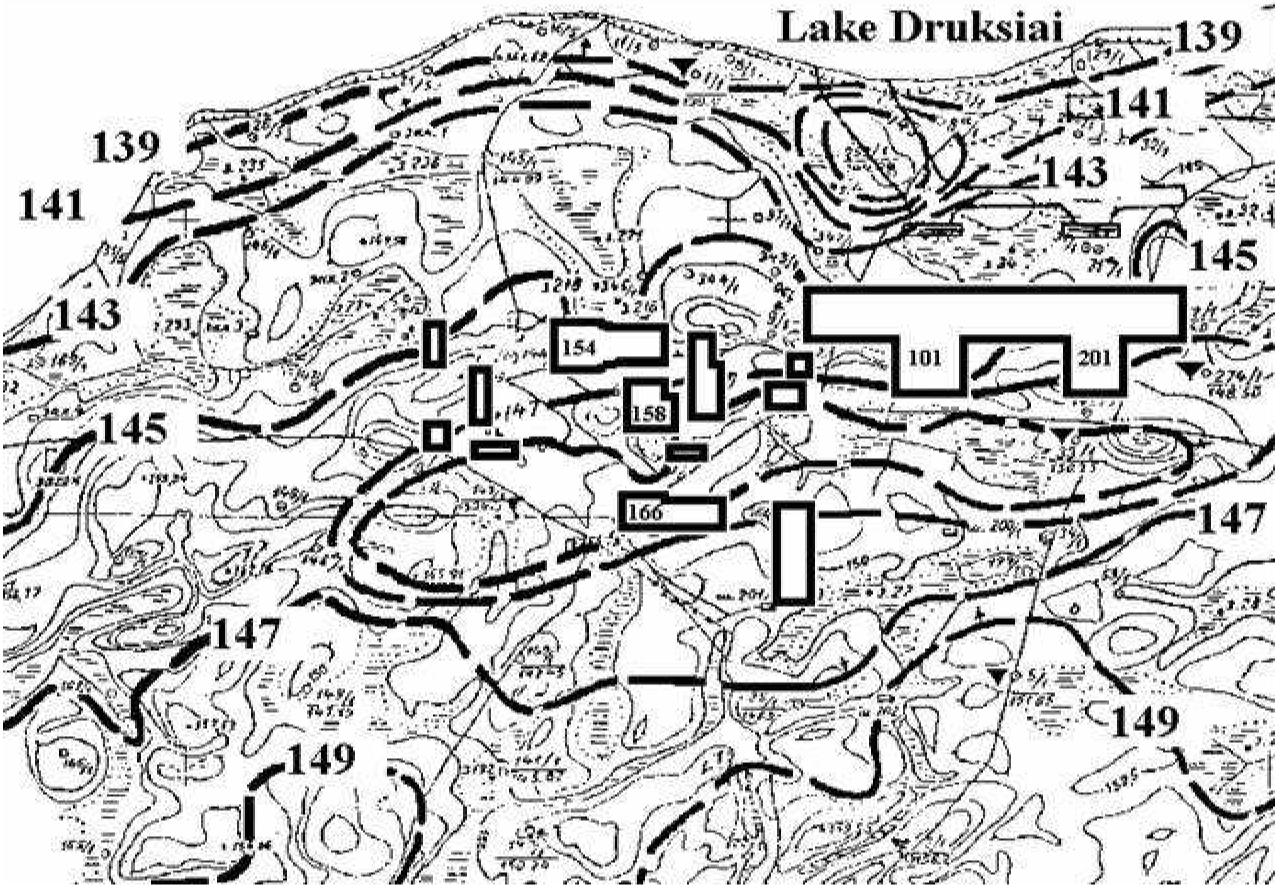
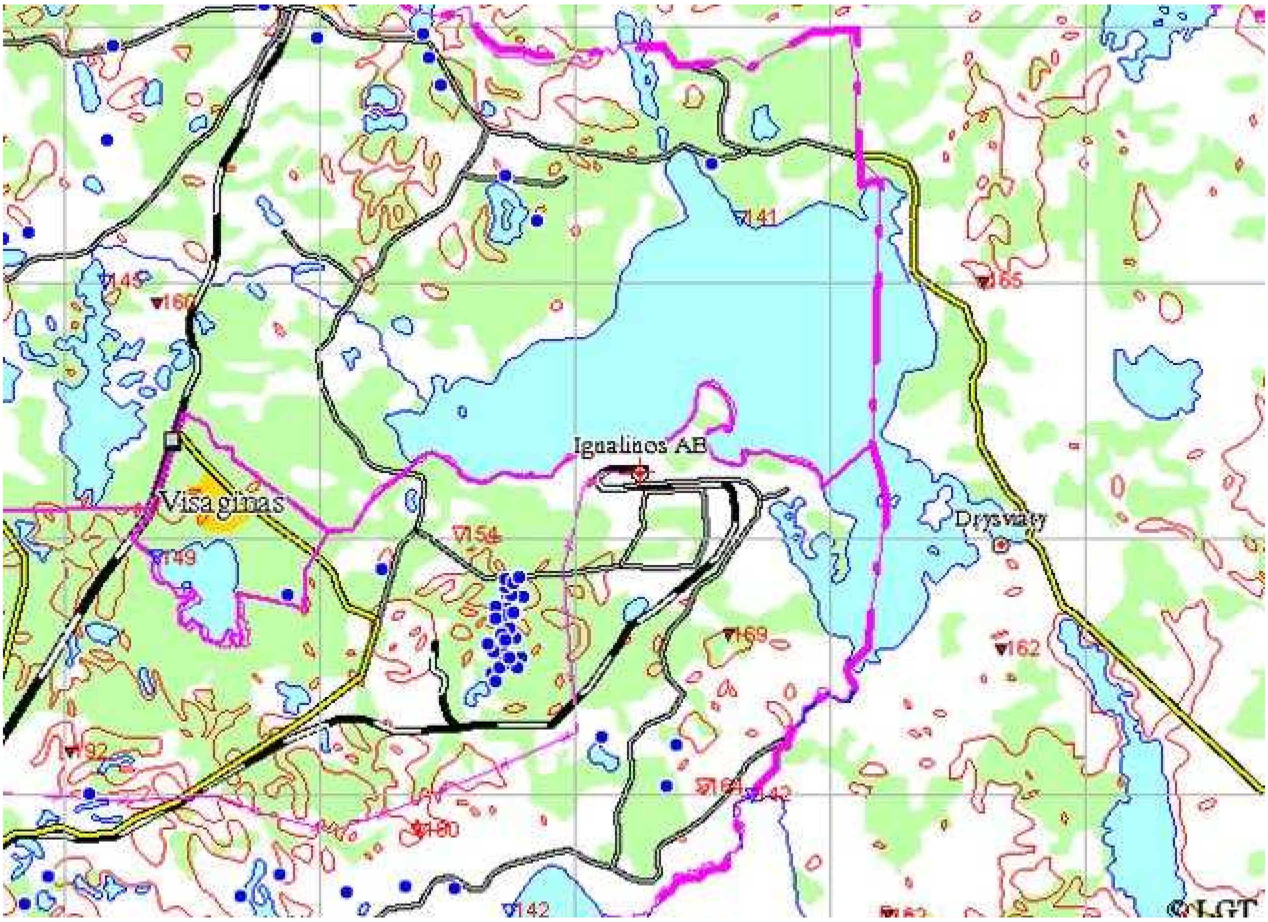


Figure 3-16 Operational Underground Water (Artesian) Wells (Blue Circles) (Source: Lithuanian Geology Service Internet Site)



The outflow of the lake finally reaches the Gulf of Riga of the Baltic Sea through a long and complex pathway of approximately 550 km [46].

3.6.4.2 Groundwater quality at the INPP

The INPP performs the monitoring of the groundwater.

The results from the INPP environmental monitoring are shown in the Table 3-11. Samples are taken at different sampling points and several times a year.

The results in Table 3-11 show the very good quality of groundwater.

Table 3-11 Results for the Quality of Groundwater (source: INPP Environmental Monitoring)

Parameter	2002	2003	2004	Comments
Specific conductivity ($\mu S.cm^{-1}$)	534	543	558	Very good according to the quality requirements
	21	21	20	
	16	18	16	
	0.26	0.27	0.25	
	0.03	0.01	0.03	
	0.11	0.16	0.19	

3.6.5 Site Hydrology

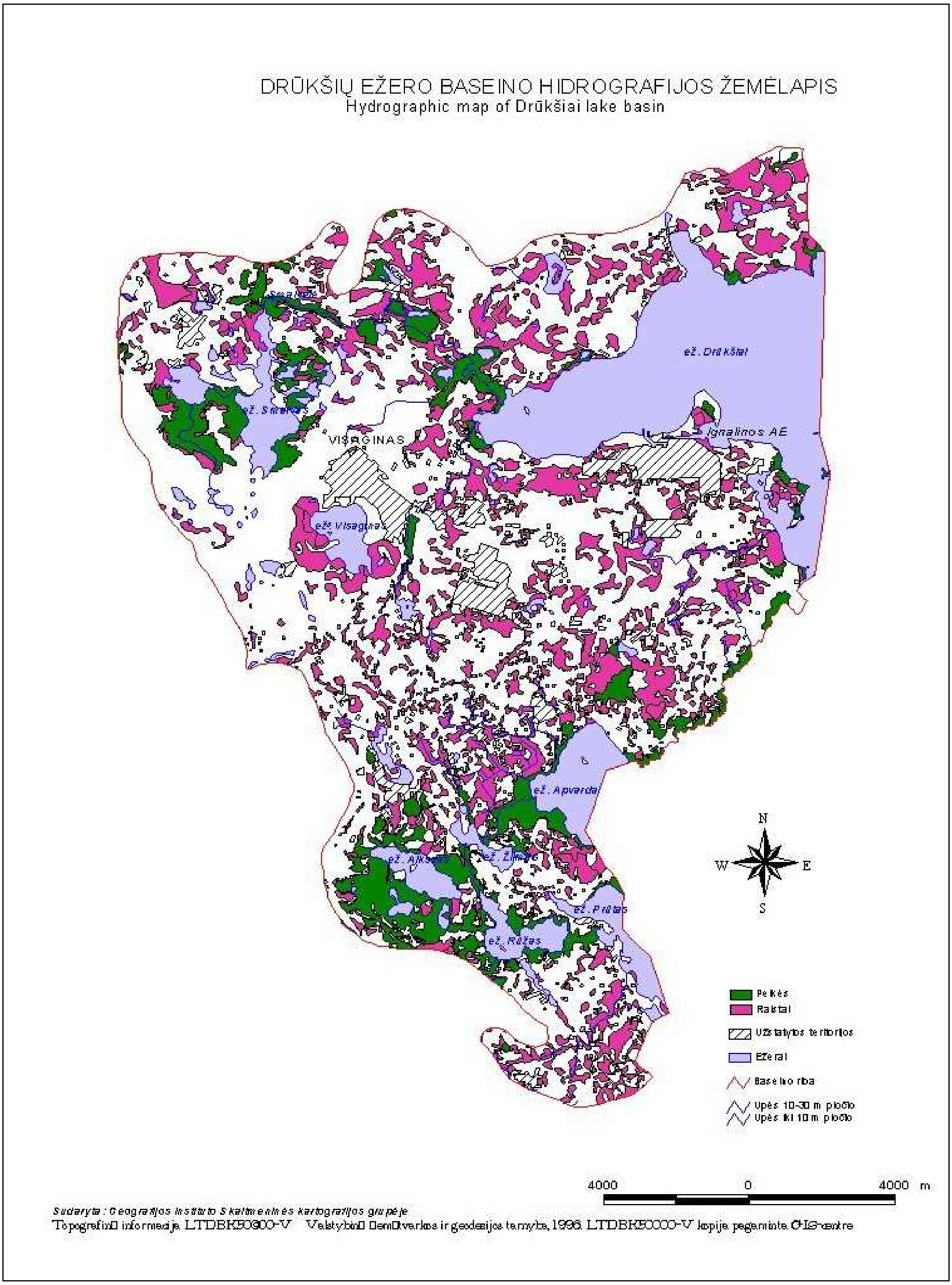
3.6.5.1 Lake Drūkšiai and Related Water Bodies

The lake Drūkšiai is the biggest lake in Lithuania, lying on the northeast border between Lithuania and Byelorussia at an altitude 141.6 m above the Baltic Sea level. Its eastern part belongs to Belarus.

Seasonal amplitude of water level fluctuations on the lake is about 100 cm, the average daily fluctuation amplitude - 2.3 cm, the maximum - 5 cm, and the minimum 0.5 cm.

The lake is situated in the basin of the Prorva river, the left tributary on the Drūkša river draining to the Dysna river. The catchment basin of the lake is located near the foot of the east slope of the Baltic ridge, which is bordered by Svencionys upland from the south and by Latgal upland from the north. The Lake Drūkšiai watershed (on the Lithuanian territory) is shown on Figure 3-17.

Figure 3-17 Hydrographic map of the Lake Drūkšiai watershed (on the Lithuanian territory) [36]



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). This area can be subject to changes; observations in the past showed that the lake area was about 45 km^2 [17].

In 1953 a hydroelectric power station was constructed at the Prorva River draining from the lake (in Byelorussian territory). The hydro-engineering complex regulates the level of the lake. After the construction of the power station the water level of the lake rose up to 1m. This has resulted in the submerging of the lowered floodplain part of the wetland.

Annual fluctuation of the lake water level, depending on the changes of filling, is up to 0.9 m [47]. As a result, the surface area of the lake decreases to 42 km^2, and the volume of water - to 326×10^6 m^3.

The maximum depth of the lake is 33.3 m, with an average of 7.6 m, and a dominant value of 12 m. The largest depths are located in the middle of the lake (maximum: 29 m). The length of the lake is 14.3 km, the maximum width is 5.3 km, and the perimeter is 60.5 km. Drainage area of the lake is only 613 km^2. Total volume of water is about 369x10^6 m^3. Some characteristics of the lake are given in Table 3-12.

Table 3-12 Main Data of Hydrologic and Hydrothermal Regime of Water Cooling Reservoir of the INPP [22]

1.	Drūkšiai lake watershed area, km^2	613
2.	Water area of lake at normal affluent level, km^2	49
3.	Multiyear flow rate of water from lake, m^3/s	3.19
4.	Multiyear discharge from lake, m^3/year	100.5x10^6
5.	Multiyear quantity of atmospheric precipitation, mm/year	638
6.	Multiyear value of evaporation from water surface, mm/year	600
7.	Normal affluent level of lake, m	141.6
8.	Minimum permissible lake level, m	140.7
9.	Regulating volume of lake, m^3	43x10^6
10.	Permissible drop of lake level, m	0.90

The hydrographical schematic of Lake Drūkšiai is presented in Figure 3-17.

There are many lakes in the area of the Ignalina NPP. Their total area of water surface is 48.4 km^2 (without Lake Drūkšiai). The net density of rivers is 0.3 km/km^2. There are 11 tributaries to the lake and 1 river that outflows it (the Prorva). The main rivers which flow in Lake Drūkšiai are Ricianka (watershed area: 156.6 km^2), Smalva (watershed area: 88.3 km^2) and Gulbine (watershed area: 156.6 km^2).

3.6.5.2 Water Regime

Nearly all surface discharge (74%) flows to the south part of Lake Drūkšiai by way of the rivers Ricianka and Drūkša. The rest of the surface discharge goes to the west ridge from the tributaries of the rivers Smalve and Gulbine. Discharge from the lake goes by way of the river Prorva through the south ridge of the water reservoir. Warm coolant water of the NPP is discharged into the same place. So, the most intensive water exchange takes place in the south part of the lake.

The water regime of Lake Drūkšiai is formed by the correlation of natural and anthropogenic factors. The main natural factors are the climatic conditions of the region: precipitations onto the surface of the water reservoir and natural evaporation from the lake surface and watershed. The anthropogenic factors, which have an influence on INPP operation, are the control of discharge by the hydro-engineering complex and yearly amount of water circulated through the INPP which is 9 times the volume of the lake and 27 times the natural influx of water to the lake [47]. However, it was shown that wind and bathymetry remain the major factors determining the current hydrodynamic regime, while INPP has little impact on the overall water dynamics of the Lake Drūkšiai [61]; the influence of the thermal releases from INPP is discussed in 3.6.5.4 and the evolution of the chemical composition of the lake water is discussed in section 3.6.5.6.

A sketch of anthropogenic water releases is presented in Figure 3-18.

The Ignalina NPP operation has no visible influence on the amount of atmospheric precipitation and on the water inflow into the lake.

The NPP thermal releases have an influence on the evaporation from the water surface. The evaporation processes from the water surface of Lake Drūkšiai are very important. The net losses of water from the lake depend on the amount of evaporation. In conditions of limited water resources, this amount can limit the power of the NPP. For this reason the natural and additional evaporation from the water surface is monitored carefully [34].

Figure 3-18 Lake Drūkšiai and Location of the Ignalina NPP [14]

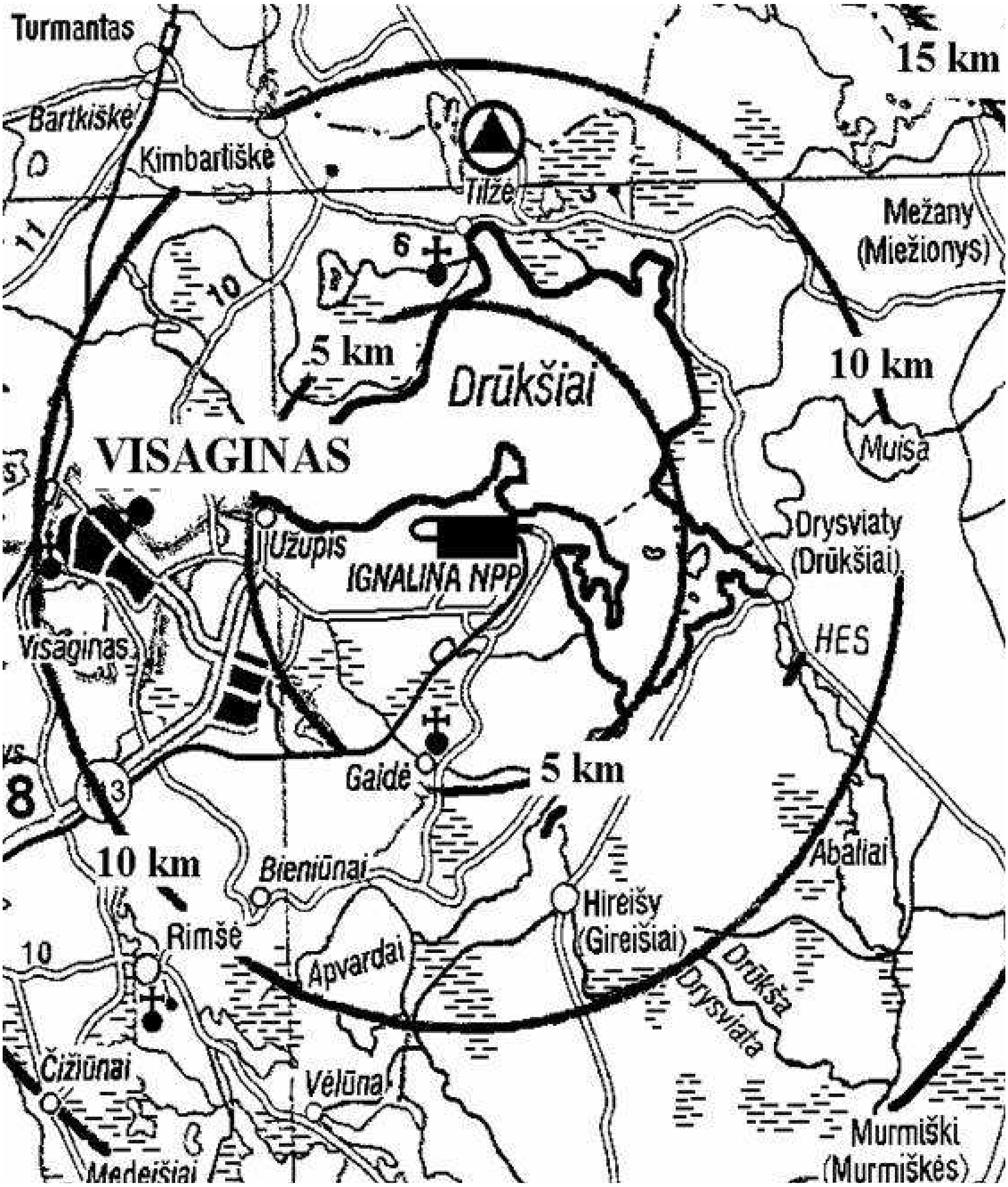
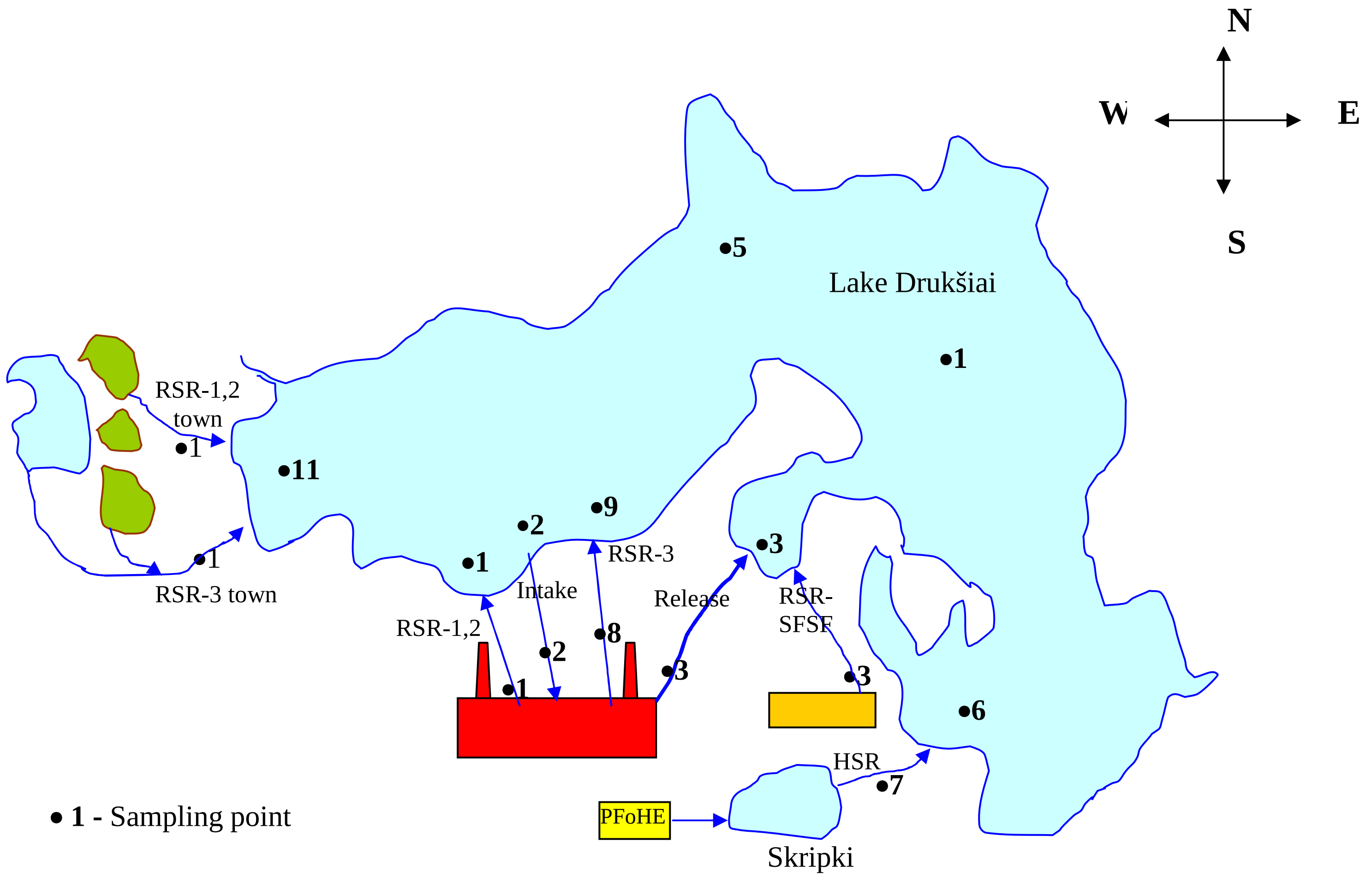


Figure 3-19 Inputs of Cooling Water and Household Wastewaters in Lake Drūkšiai



Legend:

RSR – rain sewage release, Intake - cooling water intake, Release - cooling water release, PFoHE - purification facility of the household effluents of INPP and Visaginas, HSR – household sewerage release after treatment, SFSF - Spent Fuel Storage Facility.

3.6.5.3 Legislation and Local Context

Directive 2000/60/EC establishing a framework for the Community action in the field of water policy (the so-called framework directive for water)

This Directive establishes a new integrated approach to the protection, improvement and sustainable use of EU's rivers, lakes, estuaries, coastal waters and underground water. It requires from Member States to achieve ‘good ecological status’ and ‘good chemical status’ for all surface and underground waters. That means, among others, that river basin authorities (responsible for a geographical and hydrological unit approach) have to set quality standards and establish rules for wastewater discharge permits.

The measures provided for in the river basin management plan seek to:

- prevent deterioration, enhance and restore bodies of surface water, achieve good chemical and ecological status of such water and reduce pollution from discharges and emissions of hazardous substances;

- protect, enhance and restore all bodies of groundwater, prevent the pollution and deterioration of groundwater, and ensure a balance between astraction and recharge of groundwater;

- preserve protected areas.

Quality of water is protected through protection of the aquatic ecology, specific protection of unique and valuable habitats, protection of drinking water (Directive 98/83/EC), protection of bathing water (Directive 76/160/EEC), protection of waters against pollution caused by nitrates from agricultural sources (Directive 91/676/EEC), protection of the environment from the adverse effects of urban wastewater discharges and discharges from certain industrial sectors (Directive 91/271/EEC).

Directive 91/271/CEE concerning urban waste water treatment

The Directive lays down uniform emission standards, or percentage reductions in pollutant concentrations, for discharges from sewage treatment works serving a population equivalent[15] of 2,000 or more (see Table – 3-12).

[15] Population equivalent (p.e.) =

- According to the EU Directive = measure of the pollutant load entering a sewage treatment work; 1 p.e. corresponds to 80 g of suspended matters, an organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g oxygen per day, 15 g of nitrogen, 4 g of phosphorus, and 150 to 250 liters of water.
- According to Lithuanian regulations = relative quantity of population, calculated accordingly to amount of pollutants in a sewage water (70 g BOD7/day.person).

Table 3-13 Requirements for Discharges from Urban Wastewater Treatment Plants Designed for 10,000 to 100,000 Population-equivalents

Parameter	Directive 91/271/EEC		Lithuanian requirements [68]	
	Concentration	**% Abatement**	**Concentration**	**% Abatement**
BOD5	25 mgO_2/l	70-90	25 mgO_2/l	70-90
COD	125 mgO_2/l	75	125 mgO_2/l	75
Total suspended solids	35 mg/l	90	25 mg/l	90
Total phosphorus	2 mgP/l	80	2 mgP/l	80
Total nitrogen ($N_{organic}+NH_3+NO_3^- +NO_2^-$)	15 mgN/l	70-80	15 mgN/l	70-80

Sewage normally receives primary (involving settlement of solids) and secondary (biological) treatment, but discharges into areas designated as 'sensitive' requires more stringent treatment, for example the removal of nutrients (such as nitrogen and phosphorus). It is particularly the case when natural dispersion is limited, like discharge into a lake (e.g. Lake Drūkšiai).

The Directive requires that a body of water is to be identified as 'sensitive' if it is eutrophic [16] or is at risk of becoming eutrophic if not protected. Sewage discharged from areas with a p.e. above 10,000 into areas designated as sensitive – lake Drūkšiai should be considered as sensitive, as a process of eutrophication is under way – will require more stringent treatment than secondary, to limit the concentrations of nutrients. Discharges are exempted where nitrogen and phosphorus loads entering sewage treatment works are each reduced by at least 75%.
The characteristics of the sanitary sewage treatment plant of Visaginas are shown in (Table 3-14).

Table 3-14 Average Annual Characteristics of the Sanitary Sewage Treatment Plant of Visaginas (data source: sanitary sewage treatment plant of Visaginas)

Treatment capacity	**Volume**	
Treatment capacity	12 to 15,000 m³/day	
Maximum design treatment capacity	21,000 m³/day	
Efficiency	**% abatement**	**Concentration in effluent**
BOD7	95-98%	2-3 mgO_2/l
Total suspended solids	95-99%	2-3 mg/l
Total nitrogen	50%	18 mgN/l
Total phosphorus	20-30%	4.5 mgP/l

The sanitary sewage treatment plant of Visaginas is not entirely efficient for nitrogen and phosphorus abatement. Renovation of the plant design is already foreseen to include further nitrogen and phosphorus removal, in order to comply with the Directive.

[16] Eutrophication = enrichment of the water by nutrients, especially compounds of nitrogen and/or phosphorus.

Directive 78/659/EEC on the quality of fresh waters needing protection or improvement in order to support fish life

The lake Drūkšiai is important for commercial and free-time fisheries, especially in its Byelorussian part. Hence, it is important to preserve the water quality of the lake in order to support fish life. The Directive sets up limit values corresponding to certain physical and chemical parameters. The Directive makes the distinction between salmonid waters which support fish belonging to species such as salmon (Salmo salar), trout (Salmo trutta), grayling (Thymallus thymallus) and withefish (Coregonus), and cyprinid waters which support fish belonging to the cyprinids (Cyprinidae) or other species such as pike (Esox lucius), perch (Perca fluviatilis) and eel (Anguilla anguilla). Limit values are imperative values (I) that must be respected, or guide values (G) that should be complied with (see Table 3-15) if lake Drūkšiai is designated by the Lithuanian authorities as cyprinid water (as hydrological and current ecological characteristics of lakes do not favour salmonid species). The Lithuanian authority may derogate from the Directive in particular conditions if it can be proved that this will not affect the balanced development of fish communities.

Table 3-15 Quality of Freshwaters in order to Support Fish Life – Limit Values

Parameter	Directive 78/659/EEC				Lithuanian norms [69]	
	Salmonid waters		Cyprinid waters		Salmonid waters	Cyprinid waters
	G	I	G	I		
Temperature (°C) *downstream the point of the thermal discharge (limit of the mixing zone)*		+1.5°C		+3°C	+1.5°C	+3°C
		Max. 21.5°C		Max. 28°C	Max. 21.5°C	Max. 28°C
	During 98% of the time				-	-
Dissolved oxygen (mgO_2/l) *(% of time)*	50% ≥ 9	50% ≥ 9	50% ≥ 8	50% ≥ 7	50% ≥ 9	50% ≥ 8
	100% ≥ 7		100% ≥ 5		100% ≥ 7	100% ≥ 5
pH		6-9		6-9	6-9	6-9
Total suspended solids (mg/l)	≤ 25		≤ 25		-	-
BOD_5 (mgO_2/l)	≤ 3		≤ 6			
BOD_7 (mgO_2/l)					≤ 4	≤ 6
$Phosphorus_{total}$ (mgP/l)	≤ 0.2		≤ 0.4		-	-
Nitrites ($mgNO_2/l$)	≤ 0.01		≤ 0.03		-	-
Ammonia ($mgNH_3/l$)	≤ 0.005	≤ 0.025	≤ 0.005	≤ 0.025	≤ 0.025	≤ 0.025
Ammonium ($mgNH_4/l$)	≤ 0.04	≤ 1	≤ 0.2	≤ 1	≤ 1	≤ 1
$Chlorine_{residual\ total}$ (mgHOCl/l)		≤ 0.005		≤ 0.005	-	-
$Zinc_{total}$ (mgZn/l)		≤ 0.3		≤ 1.0	-	-
$Copper_{total}$ (mgCu/l)	≤ 0.04		≤ 0.04		-	-

3.6.5.4 Thermal Aspects

The lake Drūkšiai is the cool water source for the Ignalina NPP.

Water intake and discharge channels are common for both units. The hydro-engineering structures of the open-loop cooling system include the water intake area with protective dams, the inlet channel, the discharge channel and the water intake warm-up canal. The warm-up canal is intended to prevent freezing of water in the inlet channel at low water temperatures in the lake. The warm water flow rate from the discharge channel is controlled by opening gates upstream the warm-up canal.
About 80 m^3/s of water from the lake is used to cool each NPP unit. The designed water consumption for the plant cooling system is 4.1×10^9 m^3/year. The real measured water consumption for recent years is about 3×10^9 m^3. During the operation of one unit, the heat load to the lake amounts to 60 W/m^3 (i.e. $8.7x10^{15}$ J/month); it amounts to about 120 W/m^3 during the operation of the two units.
The maximum temperature elevation in the heat exchangers is in the range of 7 to 10 °C.

Warming process

The follow-up of the hydrothermal regime of Lake Drūkšiai shows changes since it became the cool water source for the Ignalina NPP. During the period 1981-1998, the hydrologists from the Lithuanian Energy Institute investigated the thermal state of the lake under wide range of different weather and INPP capacity conditions.

It was shown that with one reactor in operation, the temperature in the warm period of the year increased on the average 0.6°C and by 1.2°C in July; with the two reactors in operation, it increased 2.5°C both during the warm period and in July [68]. When one reactor of the INPP was in operation, the average water temperature on the hottest summer days reached 23-25°C, whereas the highest temperature was registered to 26.8°C [71].

The distribution of the overheated water is uneven, and it depends on the particular conditions, surch as wind conditions (direction, speed) [48].

Operation of the plant at maximum power output raises the average monthly temperature of the lake by 3 to 5 degrees:

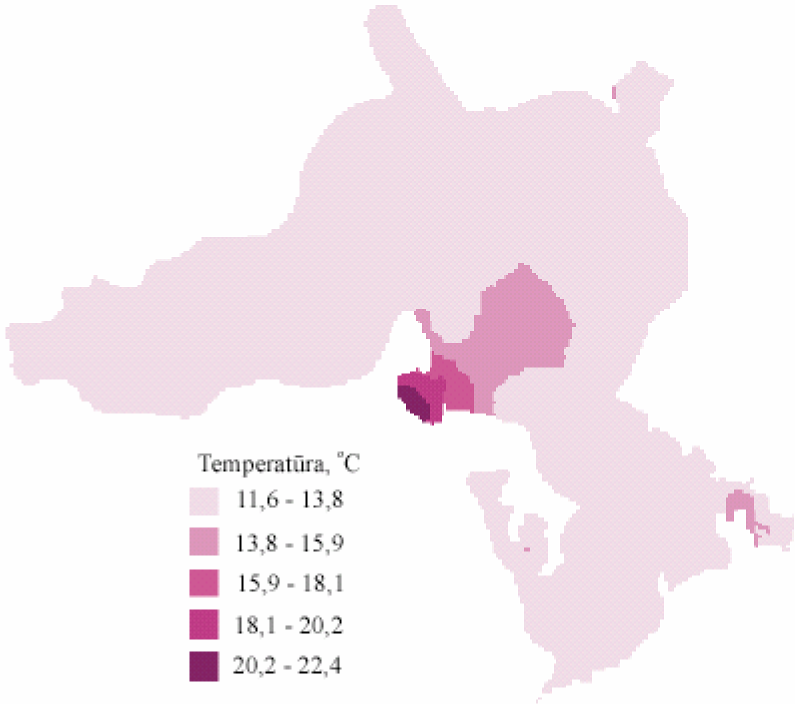
- 3°C on approximately 18 km^2 in summer;
- 5°C on approximately 13.5 km^2 in winter.

Despite of this, the thermal releases remain globally acceptable (considering monthly averages) in comparison with the Lithuanian standard “Norms of admissible warming up of the lake Drūkšiai and temperature monitoring technique”, which amounts to 24.5 °C, admissible for recreation and domestic water basins, and 28°C, admissible for fish (cyprinid type). However, peaks of water temperature can exceed the limit values, as shown on Figure 3-21.

Several maps, created on the basis of the great amount of data gathered during the 18 years period of systematic observation, show the evolution of temperature profiles induced by the operation of the INPP plant [48, 49].

For example, Figure 3-20 shows the influence of the thermal releases on the lake water temperature, on the 16th May 1984. The air temperature was 13°C.

Figure 3-20 Surface Temperature Distribution in the Lake with One Unit Operating (May 1984)

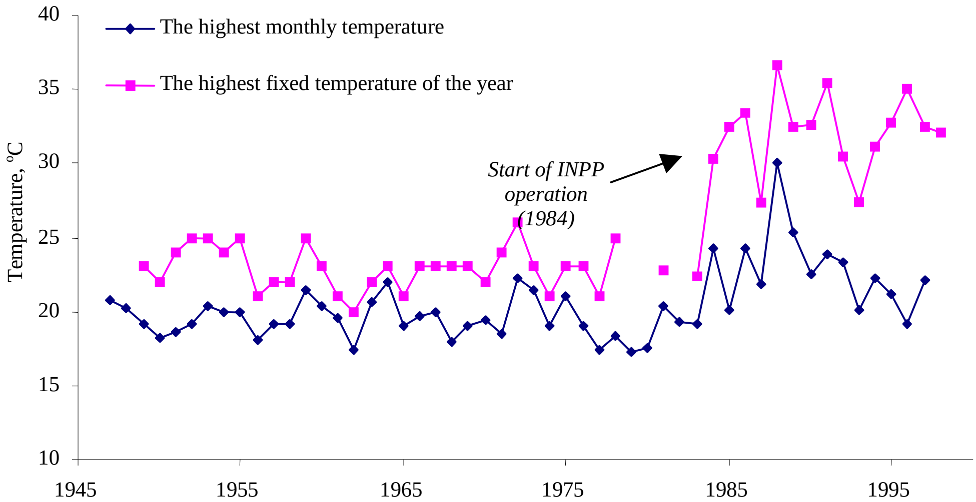


Influence in case of extreme atmospheric conditions

Extreme atmospheric conditions can happen in summer, when there is no or little wind and air temperatures are high. The Figure 3-21, extracted from a scientific publication [48] for the period 1947-1997, shows the influence of the INPP operation on highest temperatures.

The presented maps are representative of summer days with low or no wind, which are the most unfavourable conditions for surface water temperature in the lake. Further data can be found in the thesis realised by Mrs. D. Šaraukiené [49]. Several situations are presented.

Figure 3-21 Surface Water Temperatures of Lake Drūkšiai before and after Ignalina NPP Started to Operate [48] (period 1947 – 1997)



Natural surface temperature distribution in the lake in summer 1983 (see Figure 3-22)

At that time, only the natural factors had an influence on the lake thermal regime: the temperatures were distributed according to the bathymetry, shape and tributaries' inflows (low wind velocity can be neglected). The main determinants for daily, seasonal and annual surface water temperature were the air temperature and absorbed sun heat.

Surface temperature distribution in the lake with one turbine operating at 788 MW (see Figure 3-23)

The structure of the lake thermal field was the combined result of natural conditions (no wind), position of the inlet and outlet of cooling water, and discharge of overheated water into the lake. Temperatures fluctuated from 22.1°C in the western part of the lake to 27.9°C within 1-1.5 km radius from the power plant discharge channel. The area with temperatures higher than 25.5°C reached 17% of total lake surface area.

Surface temperature distribution in the lake with 2 units operating (see Figure 3-24)

The response of the lake at high air temperature (25.9°C) and still wind conditions showed that the average surface temperature reached 30.1°C, and 36.6°C in the area of overheated water discharge. Thermal area with temperature higher than 28°C covered 86% of the total lake surface area, while temperature higher than 25.5°C covered 100% of the total area.

Survey has shown that southern and eastern winds are unfavourable to the cooling capacity of the lake, while winds from the north and the west turn the stream of hot water to the southern part of the lake and hence increase its cooling capacity.

Figure 3-22 Natural Surface Temperature Distribution in the Lake (03/08/1983)

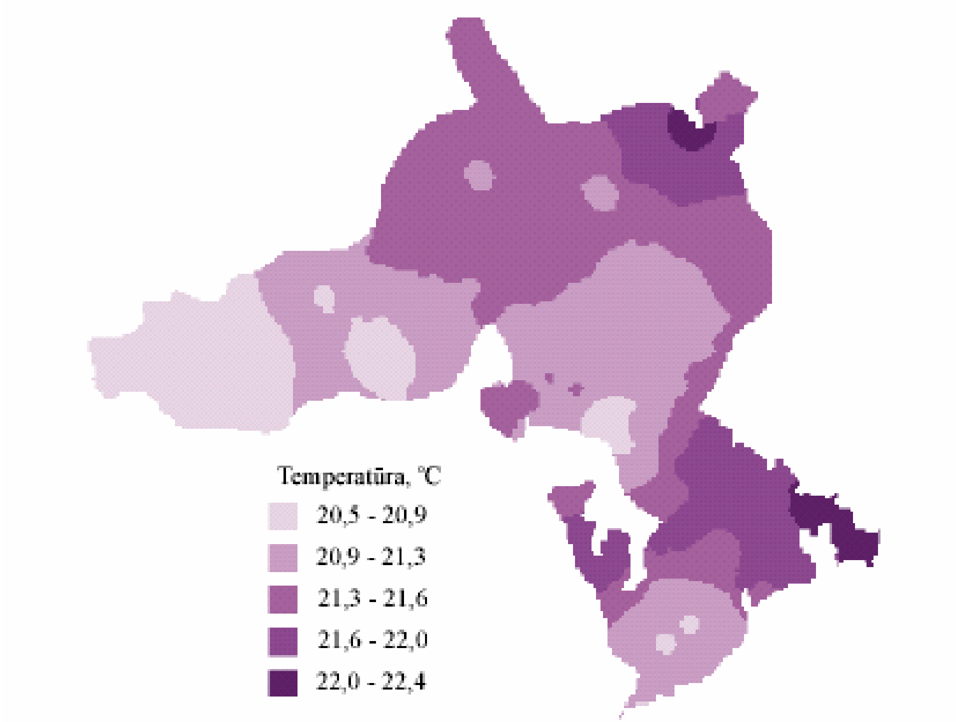


Figure 3-23 Surface Temperature Distribution in the Lake with One Turbine Operating at 788 MW (05/08/1984)

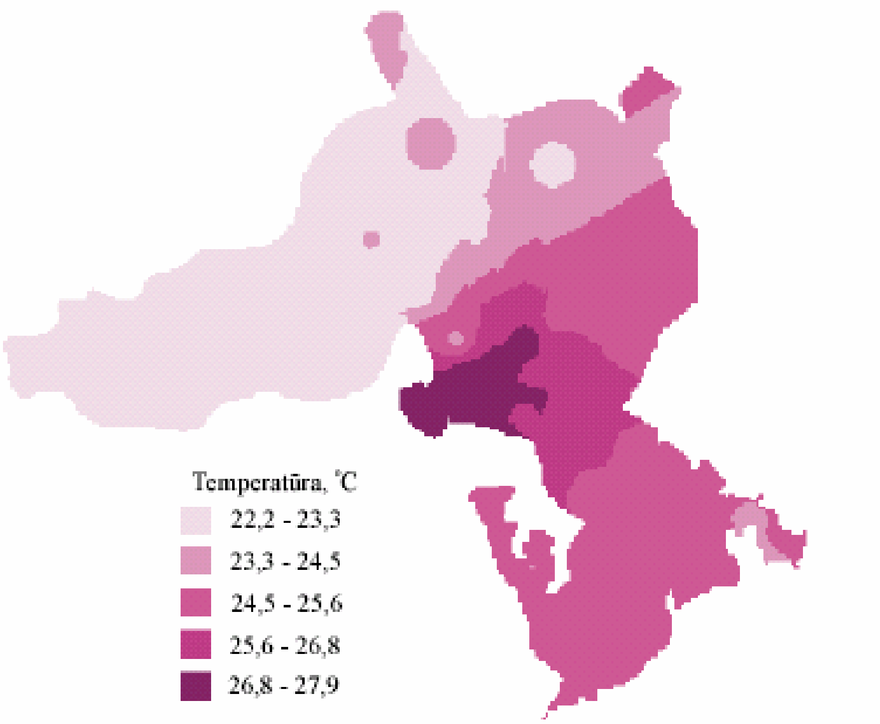
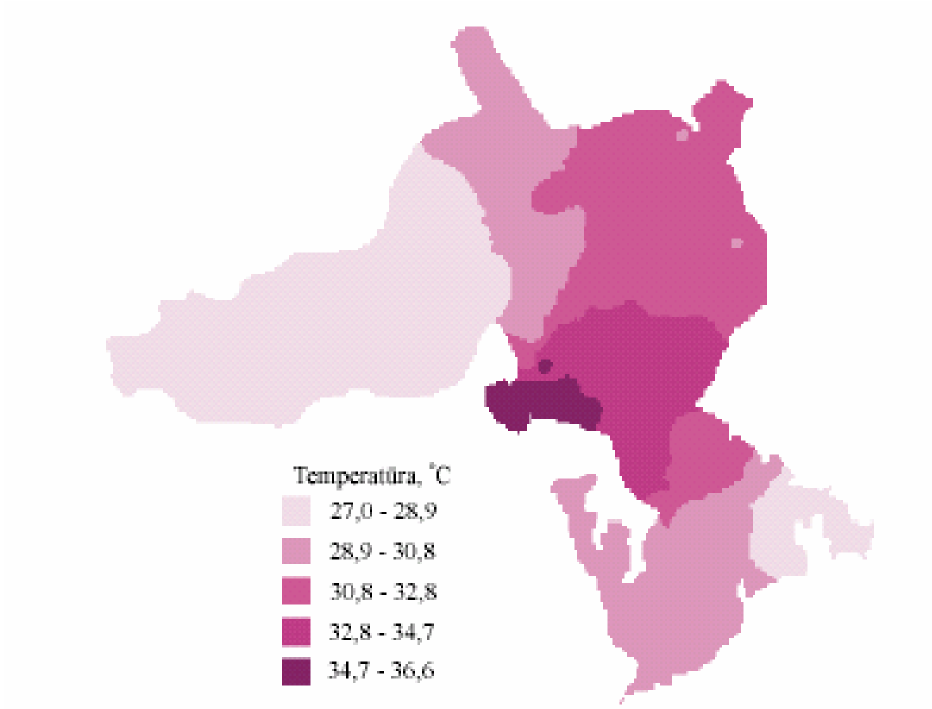


Figure 3-24 Surface Temperature Distribution in the Lake at Operating Capacity of 1262 MW (15/07/1988)



In conclusion:

- the commissioning of the INPP induced significant changes in the temperature profile of surface water of the lake and at greater depth (see also discussion on the fish populations in section 3.7.3.2); it speeded up the eutrophication process (induced by inputs of domestic wasterwater in the watershed)

- operation of the plant (two units) at full load increases the average monthly temperature of the lake by 3-5 degrees (maximum allowed: 3°C);

- the lake temperature generally stays under the 28°C (limit value for cyprinid waters), although it sometimes rises above that value under particular summer conditions (maximum allowed: 2% transgression in time)

- although critical events occur in the year, the water temperature of the Lake Drūkšiai usually respects the limit values set up for cyprinid waters quality (but not those for salmonid waters)

At the INPP, temperature measurements are made every day at the intake channel. The following rule is applied:

- If the temperature at the intake channel is equal or exceeds 24.5°C (the limit value for the intake water temperature), then additional measurements are made all around the lake (more than 30 measurements):

  - If 80% of measurements[17] < 28°C then it is acceptable,
  - In other cases, the INPP must inform the competent authorities which will decide of appropriate actions to be undertaken.

3.6.5.5 Water Balance

In this section we describe:

- the inputs of water to the INPP,
- important circuits related to the use of water,
- the collection of water on the site and treatments of wastewater before release,
- the outputs from the INPP

Origin of the water

The INPP uses lake water and water from the distribution network. More precisely:

- Lake water (without treatment) is used for cooling purposes (called "service water"):

  The service water system provides mainly cooling for the thermo-mechanical equipment of the plant (pumps, diesel generators, the control rod cooling circuit (cooling of control rods, fission chambers and metering devices), etc.) and the equipment in the auxiliary buildings [34]. The service water system consists of the water intake and the water discharge channel, common to both power units. That water does not undergo any kind of treatment.

[17] More precisely, it is 80% of the lake surface; this can be assimilated to measurements as they are numerous.

The “Permission for Pollution Integral Prevention and Control, TV(2)-3” allows for the following water intake and consumption:

Water source	Maximum amount of water allowed to get			Activity where water will be used
	m^3/year	m^3/day	m^3/hour	
Drūkšiai lake water intake No 1	2 650 000 000	6 000 000	250 000	To cool process equipment
Drūkšiai lake water intake No 2	758 300	2446	128	For heat only boiler station
No 3 (SE «Visagino energija»)	1 643 655	4504	188	For induatrial, household and other needs
Well in Training Support Division area	18 250	50	8	For household needs

Moreover, drainage water and rain water flow through the INPP site. Drainage water is collected in order to keep the groundwater table at an acceptable level. Rain water is collected on the site through the rain sewerage system (the yearly collected volume depending on the rain falls).

Water Purification System

The water purification system ensures that the properties of the coolant are maintained. It is intended to eliminate corrosion products, lubricants and soluble salts from the water. The system comprises a mechanical filter and an ion-exchanger:

- Mechanical perlite filter beds (4 per reactor) remove corrosion particles and lubricants (mineral oils). The beds are regenerated every ten days during normal operation mode and daily during transient operation modes when the fouling rate of the coolant increases. Treatment capacity of the perlite filters is 30 to 100 m^3/h.

- Combined ion exchangers (2 per reactor) remove dissolved salts and fission product contamination. The two filters are loaded with strong acidic cationite and strong alkaline anionite. The H-cationite and OH-anionite beds are designed for the nuclear industry (KU-2-8ChS and AB-17-8ChS beds). They filter-out all electrolytes (chloride, sodium, copper, iron…) and silica acids, and remove the water hardness due to calcium. The treatment capacity of the ion exchange filter is 120 m^3/h [34].

The nominal capacity of the demineralised water purification facility is 80 m^3/h with a maximum capacity of 100 m^3/h. For indicative purpose, the implementation of a Plant Water Balance programme enabled to reduce the makeup of fresh demineralised water down to some 30,000 m^3/y (average of 3 m^3/h), i.e. a small fraction of the Makeup Water Production Plant capacity. The turbine condensers are also equipped with similar desalination filters.

The regeneration of the perlite filter beds is achieved by washing the beds with clear water (filtrated water). The washing waters contain residual corrosion particles and mineral oil.

The regeneration of the resins is achieved with sulphuric acid ($H2SO_4$) and sodium hydroxide (NaOH) at a concentration of 100%. The INPP actually uses about 80 t/y H_2SO_4 and 3 t/y NaOH.

Water collection and treatment

- The cooling water goes untreated mainly to the discharge channel and some of it to the outlet №1.

- For what concerns the regeneration wastewater from the water purification system:

  The washing water used during the regeneration of the perlite filter beds are evacuated into the rain sewerage system, which is equipped with oil/grease separators;

  After regeneration of the demineralisation resins, the spent reagents are neutralised one another in a specific tank (pH brought between 6 and 9). After neutralisation, they are discharged into the rain sewerage system of the site, together with dissolved salts (among which SO_4^{2-} is significant).

- The maintenance and household wastewaters go to the sanitary sewerage system.

- The drainage and rain sewage water, together with industrial sewage water, goes to the rain sewerage system.

Water releases

The releases from INPP (see also Figure 3-19) are:

- The discharge channel to the Lake Drūkšiai (for heated cooling water)

- The Rain Sewerage and Drainage Systems

  The rain sewerage system (RSS) is designed to collect rain water from the buildings' roofs and all the impermeable areas like roads, parkings …). Run-off water contains particles and can also be contaminated with hydrocarbons.

  The rain sewerage system is also intended to receive industrial sewage water, including the regeneration effluents from the water purification system and some service water. The rain sewerage water is therefore fit out with mud/oil separators. The water is afterwards discharged via covered headers into the lake. There are three discharge points at INPP site (see Figure 3-19). The "Permission for Pollution Integral Prevention and Control, TV(2)-3" allows the discharge of:

  - outlet №1 - RSS 1&2: 41,479,000 m³/year or 113,640 m³/day; estimates of releases are a little below this limit;

  - outlet №4 - RSS 3: 1,314,000 m³/year or 3,600 m³/day; actual releases are about 750,000 m³/y;

  - outlet №7 - RSS of the interim spent nuclear fuel storage facility site: 1,935,000 m³/year or 5,300 m³/day; actual releases are about 1,350,000 m³/y;

  - service water discharge channel - 2 140 000 000 m³/year or 5 871 233 m³/day.

According to measurements for the first semester of 2005, a significant decrease of releases is observed.

Drainage water is discharged to outlet №4 - RSS 3.

- The Maintenance and Household Wastewaters

The wastewater from routine maintenance, from labs, and domestic wastewaters from the INPP site are collected in the sanitary sewerage system of the site. This sytem is connected to the wastewater treatment plant of Visaginas, located 1 km to the south from the Ignalina NPP (see details in sections 3.3.2 and 3.6.5.3).

The sewage volume produced is approximately 1,300,000 m^3/y (2004)[18].

Waters which could be contaminated with radioactive substances go to a specific sewerage system which goes to the treatment facility for the radionuclide content of the discharged water.

Other inputs into the Lake Drūkšiai

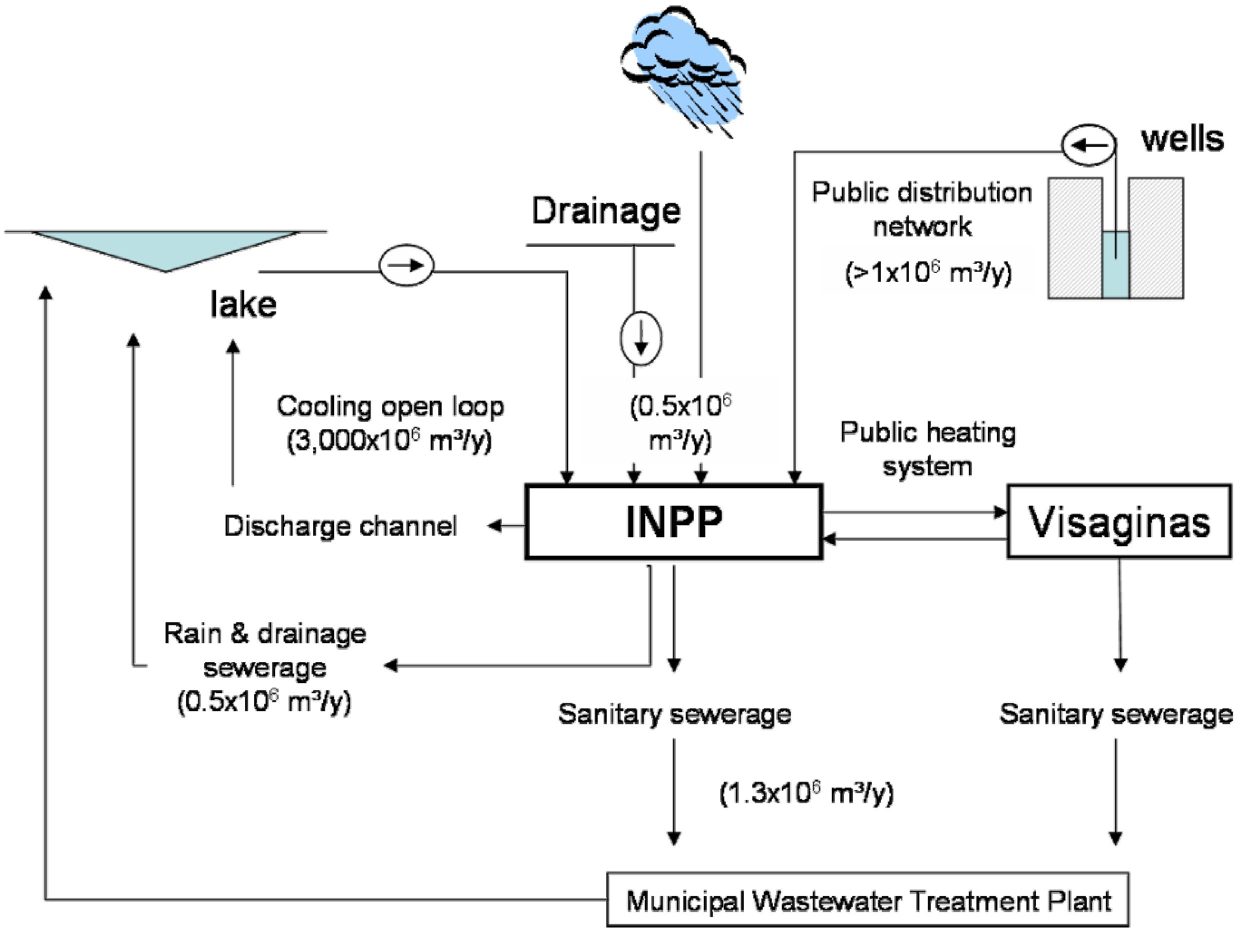
The lake Drūkšiai also receives non-treated domestic wastewater discharges from villages and isolated habitations, located in the vicinity of the lake such as Tilžė (about 50 inhabitants), Vyšniava, Yliškės miškas, Budiniai, Juodiniai, Burniai or Raipolė. Another input of pollution into the lake is the discharge of the tributary rivers, and the run-off from fields and farms.

To be noted the presence of a forest belt of approximately 1 km wide that surrounds the lake. This forest is important from the point of view of water protection, as it protects the surrounding soils from erosion and somewhat keeps the agricultural activities away from the direct vicinity of the lake.

[18] The figures for the three first quarters in 2005 show that the sanitary sewage releases are significantly reduced, so that the INPP sewage releases constitute about ¼ of the total treated water at the Visaginas wastewater treatment plant, instead of ⅓ in 2004.

The Figure 3-26 summarizes the water flows. It should be noted that a part of the input cooling water is used for technical applications and released as industrial sewage water (in the rain and drainage sewerage system).

Figure 3-25 Diagram of the Water Flows (based on 2003 and 2004 values)



3.6.5.6 Chemical Aspects

The analysis of the chemical composition of the discharged water and of surface water is performed by INPP in accordance with the "Environmental Monitoring Programme". Control is regularly made by the Ministry of Environment.

The INPP performs a survey of 21 non radioactive parameters at 6 points of the lake 3 times a year. Results of the monitoring of the effluents are presented in Appendix 9 for information

A hydrochemical monitoring programme was conducted from 1979 until 1997 in the framework of the State Scientific Research Programme "Atomic Energy and Environment" [36]. The measurement campaign was made once a month at several sampling points around the lake.

Evolution with time of the chemical composition of Lake Drūkšiai water is given by the comparison of multi-year average results from public survey. Multi-year average indicators for the period 1991-1997 are compared with multi-year average values of concentration in the start-up period (1979-1983) and in post-commissioning period (1984-1990) [36]. The results are summarized in Table 3-16. **Error! Reference source not found.**.

The statistics of the INPP monitoring programme are presented in Table 3-17 [37]. The differences in the ranges of values between the past scientific survey and the INPP monitoring programme probably come from differences in the sampling and analytical methods[19]. To compare the results of survey, performed according to two programmes, it is also necessary, besides sample taking methods and performing analysis, to analyse the location of sample taking points, number of points, number of samples, seasonality of measurements, etc., which is not possible at the moment. However, the trends (e.g. increase of pollutants concentration in the lake water) show to be the same.

According to the summary results of the Lake Drūkšiai chemical composition in INPP pre-start up and commissioning periods, the following changes occurred:

- The total water mineralization increased;
- The concentration of phosphorus and dissolved orthophosphates, nitrites and nitrates, biological oxygen demand (BOD) increased;
- The concentration of chlorides, sodium, potassium, sulphates, magnesium increased.

The results are compared to the limit values set up by the Directive 78/659/EEC concerning the quality of fresh waters needing protection or improvement to support fish life. This survey indicates that the examined parameters respect the imperative or guide *(in italic*) values set up by the directive.

[19] The laboratory of INPP is accredited by the Ministry of Environment.

Error! Reference source not found. **Table 3-16 Multi-year Average Long-term Values of the Chemical Composition of Lake Drūkšiai Water (source: [36])**

No	Indicators	1979-1983	1984-1988	1989-1993	1994-1997	Limit value (78/659/EEC)	Lithuanian norms [69] Salmonid	Cyprinid
1.	pH	8.2	8.0	8.4	8.1	6-9	6-9	6-9
2.	Ammonium nitrogen (mgNH_4^+/l)	0.22	0.35	0.21	0.20	1	1	1
3.	Nitrites (mgN/l)	0.001	0.002	0.002	0.003	*0.03*	-	-
4.	Nitrates (mgN/l)	0.050	0.060	0.070	0.080	-	-	-
5.	Total nitrogen (mgN/l)	1.29	1.53	1.14	1.26	-	-	-
6.	Dissolved orthophosphates (mg/l)	0.002	0.005	0.015	0.018	-	-	-
7.	Total phosphorus (mgP/l)	0.061	0.050	0.072	0.146	*0.4*	-	-
9.	Permanganate oxidation (mgO/l)	5.5	6.1	6.9	11.0	-	-	-
10.	BOD_5 (mgO_2/l)	1.34	1.63	1.97	1.75	6	4 (BOD7)	6 (BOD7)
11.	Chlorides (mgCl^-/l)	8.8	9.9	10.7	9.8	-	-	-
12.	Sulphates (mgSO_4^{2-}/l)	8.9	12.6	18.6	19.3	-	-	-
13.	Calcium (mgCa^{2+}/l)	39.3	35.8	36.8	35.8	-	-	-
14.	Magnesium (mgMg^{2+}/l)	10.0	10.9	12.9	13.8	-	-	-
15.	Sodium (mgNa^+/l)	4.6	6.3	7.0	6.9	-	-	-
16.	Potassium (mgK^+/l)	1.8	2.7	3.0	2.9	-	-	-
17.	Dissolved carbonates (mgHCO_3^-/l)	160.5	150.4	157.6	159.4	-	-	-
18.	Dissolved oxygen (%saturation)	100	100	106	105	-	-	-
19.	Total Dissolved Salts (mg/l)	233.9	228.6	246.6	247.9	-	-	-

Error! Reference source not found. Table 3-16 Multi-year Average Long-term Values of the Chemical Composition of Lake Drūkšiai Water (source: [36])

No	Indicator	1991-2000			2001	2002	2003
		Average	Min	Max			
1.	pH	7.9	7.0	8.4	8.1	7.9	8.6
2.	Ammonium nitrogen ($mgNH_4^+/l$)	0.24	0.00	0.76	0.14	0.11	0.01
3.	Nitrites (mgN/l)	0.004	0.000	0.029	0.007	0.017	0.006
4.	Nitrates (mgN/l)	0.040	0.000	0.200	0.010	0.030	0.020
5.	Total nitrogen (mgN/l)	0.54	0.30	1.02	0.79	0.69	0.89
6.	Dissolved orthophosphates (mg/l)	0.037	0.000	0.200	0.028	0.042	0.053
7.	Total phosphorus (mgP/l)	0.070	0.020	0.330	0.040	0.050	0.070
8.	Dissolved mineral iron (mgFe/l)	0.01	0.00	0.07	0.040	-	-
9.	Permanganate oxidation (mgO/l)	6.9	32.3	9.7	6.4	6.7	7.0
10.	BOD_7 (mgO_2/l)	2.8	0.8	4.7	3.2	4.4	2.1
11.	Chlorides ($mgCl^-/l$)	16.4	12.8	27.4	15.1	16.8	14.6
12.	Sulphates ($mgSO_4^{2-}/l$)	16.5	10.7	21.5	17.4	16.4	20.2
13.	Calcium ($mgCa^{2+}/l$)	38.3	32.5	47.4	51.8	-	-
14.	Magnesium ($mgMg^{2+}/l$)	16.5	10.9	24.1	11.8	-	-
15.	Total dissolved salts (mg/l)	259.0	164.0	345.0	286.0	292.0	301.0

These changes of the lake Drūkšiai chemical composition were caused by numerous anthropogenic activities:

- the discharge of organic components from agricultural facilities to the lake;
- the runoff from agricultural fields (fertilizers, herbicides, insecticides and soil particles);
- the release of treated effluents of the Visaginas sewerage system;
- the release of secondary pollution to Lake Drūkšiai from the pond originally aimed at the additional biological purification of household wastewater;
- the increased evaporation of water due to the water warming up and the evolution of the lake water level; in 2004, after the final shutdown of Unit 1 (and therefore less lake water evaporation) and following a great amount of precipitations, the water level increased;
- the evolution in the water quality of the tributary rivers;
- the discharge of neutralization effluents from the demineralization process (regeneration of demineralised water production lines), containing sulphates (from sulphuric acid) and sodium (from soda).

It shall be noted that changes of Drūkšiai lake water chemical content are conditioned not by INPP activity, but by the discharges of Visaginas household sewerage system.

Adding to the discharge of waters enriched in nutrients, the thermal pollution that began in 1984 accelerated the processes of chemical pollution. The increased temperature of the lake and the subsequent decrease of cold water volume and transparency, had an influence on the colour of the water, illustrating the progressive tendency to stimulate acceleration of eutrophication of the lake Drūkšiai, and an increase in the amount of thin sedimentary materials settling[20] (in thickness and area). As a consequence, some essential changes took place in lake water from 1979 to now on. The complex pollution of Lake Drūkšiai was the main reason for its trophic status changes: during 20 years it has changed from a mesotrophic type lake *(with medium concentration of nutrients and biological production)* in the prestarting period of Ignalina NPP operation, to an almost eutrophic type *(with high concentration of nutrients and biological production)*. The evolution of the N_{total}/P_{total} annual mean ratio from 21:1 (1983) to 8:1 (1997) shows the hydrochemical corroboration of eutrophication. According to the results in the last years (2001-2003), this ratio is around 15:1. The most polluted area is in the south-east part of the lake [50].

One can also mention some inputs of heavy metals in the lake. However, the concentration of copper, lead, chrome, cadmium and nickel did not exceed the allowable values for the water quality [59]. As regards the concentration of manganese mentioned in ref. [59], its presence is probably due to natural conditions (the input water flows through naturally manganese-contaning rocks and ground) and its concentration remains under the standard for drinking water. According to the macrozoobenthos study, the contamination of bottom sediments of lakes was insignificant and belonged to quality classes II (= clean) –III (= slightly polluted).

In conclusion, eutrophication, the increase of salts content and warming of the lake water interact to influence the habitats and ecosystems of the lake. Changes of habitats end ecosystems are further developed in the part related to fauna and flora.

[20] We can also mention the impact on the erosion of the lakeshores, resulting from the construction of a dam on the Prorva River in the pre-operation period of INPP. As a consequence, the lake water level increased, producing an enhanced erosion of its shores. The settling of this material was one of the first significant impacts on the water quality.

3.7 Fauna and Flora

3.7.1 Introduction

Local surface and lake habitats are considered in this section, as both are influenced by INPP operation and decommissioning.

The main causes that can modify the lake ecosystems are:

- Thermal releases from the INPP;
- Other inputs, such as the municipal waste water or waste waters from other activities.

The presence of radionuclides contents in the discharged water and gaseous releases from the INPP are also discussed.

Since 1979, when the construction of Ignalina NPP started, a group of specialists from Lithuanian research and academic institutions began to investigate both the lake Drūkšiai and the neighbouring area. The investigations were aimed not only at monitoring the environmental consequences of Ignalina NPP but also at forecasting changes of the ecosystems [36].

The hydrochemical monitoring of Lake Drūkšiai was started in 1979. Pollution with municipal wastewater from Visaginas began earlier and initiated some essential changes in lake water. Thermal pollution began in 1984 with the commissioning of the INPP and it accelerated the process of chemical pollution.

In the pre-starting period of Ignalina NPP operation the situation of pollution of Lake Drūkšiai with organic matter was low. It is mediate at present.

For what concerns the accumulation of radionuclides in biota, the Lithuanian State Scientific Research carried out in the period 1993-1997 [19] indicates, for the Lake Drūkšiai, that:

- Bottom sediments reflect the permanent integral radioecological state of the lake system.

- ^{137}Cs is the main radionuclide found in the sediments (together with ^{134}Cs, ^{54}Mn, ^{60}Co, ^{90}Sr, and presenting less activity) though the influence of INPP amounts only to about 21% of global fallout (fallout from the Chernobyl accident being the main contributor).

- The radioecological situation of the lake is not stable, depending on sources of radionuclides getting into the lake and their quantity, which is changing constantly. It is the result of thermal and chemical pollution which disturbs the biological processes of radionuclide migration and changes their distribution in the ecosystem.

- The largest amounts of radionuclides coming from INPP get into the lake with heated water and industrial-rain sewerage outflows.

- The hydrophytes, as the first barrier catching radionuclides in a water basin, reflect more efficiently than bottom sediments the input of radionuclides in the period of vegetation.

- It was indicated that radionuclide concentration levels in plants growing on the bank of Lake Drūkšiai and Ignalina NPP region depend on the species and biotope considered. ^{137}Cs concentrations were found in plants located close to the INPP, and even higher concentrations were found in plant indicators at a further distance from INPP. ^{90}Sr and ^{60}Co were found too.

- Samplings of $^{239,\ 240}Pu$ in sediments and water plants indicated some bioaccumulation though the activities measured remain by far lower than those of ^{137}Cs, which is the main significant radionuclide to be considered.

As a conclusion, it was determined that the source of ^{137}Cs in plants is the atmosphere and in most cases it was related to the global fallout. The main input of ^{137}Cs, ^{60}Co and ^{54}Mn in the bank zone of Lake Drūkšiai could occur with industrial wastewaters [19].

Besides the biological ^{90}Sr accumulation in biota, the eutrophication of the lake causes an active mechanical sedimentation. Moreover, the saturation of water with $CaCO_3$ plays a role in the accumulation of radionuclides: calcium inlay forms on the leaves of water plants, with ^{90}Sr joining in non soluble carbonate structure.
Finally, it was determined that on the higher trophic level of fish, the role of food is more important for ^{137}Cs accumulation. This effect was not detected for ^{60}Co and ^{54}Mn.

For what concerns effect on man, the calculated overall individual committed dose due to INPP effluents is much less than the dose limit (less than 2% of the annual dose limit on the basis of conservative assumptions) and reduces significantly with the distance from the release point. Among individuals exposed, adult fishermen are the most exposed group to liquid radioactive effluent, the doses for the children of their families being much less lower [63] – see Table 6.9.

3.7.2 Natura 2000 Habitats

NATURA 2000 is a network of important protected areas in the European Union covering fragile and valuable natural habitats and species of particular importance for the conservation of biological diversity within the territory of the European Union.

The creation of the NATURA 2000 network is a very important and difficult task. In order to carry out this work successfully, the Member States (and the former Candidate Countries) have to pass the following three stages in dialogue with the European Commission:

- Preparation of national lists of candidate Natura 2000 areas;
- Identification of territories important for the protection of habitats ;
- Identification of territories important for the protection of birds.

A large part of the lake Drūkšiai and some territories (a part of the Smalvos hydrographical protected territory and two areas along the Drūkša River) are proposed as Natura 2000 areas (see Figure 3-25). Other such zones are also proposed, but they are located far from INPP (the Smalvos landscape protected territory – at about 10 km from INPP, and the Pusnies protected territory – at about 12 km from the INPP).

The proposed Drūkšiai Natura territory covers 3,612.33 ha, in which the various habitats are described in the Table 3-18. Species of ornithological importance are:

- As qualifying species: the Bittern (*Botaurus stellaris*, Didysis baublys);

- As additional Annex I species: *Gavia arctica* (Juodakaklis naras), *Circus aeruginosus* (Nendrinė lingė), *Porzana porzana* (Švygžda), *P.parva* (Plovinė vištelė), *Chlidonias niger* (Juodoji žuvėdra), *Luscinia svecica* (Mėlyngurklė)*;*

- As of national importance: 18 breeding species (Great Crested Grebe (*Podiceps cristatus*) the colonies of which include hundreds of nests, mainly in the Belarussian side. The breeding density of the Coot (*Fulica atra*, Laukys) the Black-throated Diver (*Gavia arctica*, Juodakaklis naras), Bittern (*Botaurus stellaris*, Didysis baublys), Goldeneye (*Bucephala clangula*, Klykuolė), Mute Swan (*Cygnus olor*, Gulbė nebylė), Red-necked Grebe (*Podiceps grisegena*, Rudakaklis kragas), Dunlin (*Calidris alpina*, Juodkrūtis bėgikas), Red-breasted Merganser (*Mergus serrator*, Vidutinis dančiasnapis), Goosander (*Mergus merganser*, Didysis dančiasnapis), Little Crake (*Porzana parva*, Plovinė vištelė), Oystercatcher (*Haemotopus ostralegus*, Jūrinė šarka), Short-toed Eagle (*Circaetus gallicus*, Gyvatėdis), White-tailed Eagle (*Haliaeetus albicilla*, Jūrinis erelis), Crane (*Grus grus*, Gervė), Curlew (*Numenius arquata*, Didžioji kuolinga), Kingfisher (*Alcedo atthis*, Tulžys), Bluethroat (*Luscinia svecica*, Mėlyngurklė); *Phalacrocorax carbo* (Didysis kormoranas).

The threats mentioned are the overgrowing of the islands present on the lake, predation and recreational developments.

Additionaly, Lake Drukshiai is listed as a territory important for the protection of birds (along with other 38 territories), by Governmental decision dated 8 April 2004 No.399 “Ratification of the list of territories (or their parts) important for protection of birds and establishment of the boundaries of such territories” (Žin., 2004, Nr. 55 - 1899). The information on this territory was submitted to the European Commission on the accession day.

Figure 3-26 Natura 2000 Proposed by the Lithuanian Government to the European Commission (perimeters in red)

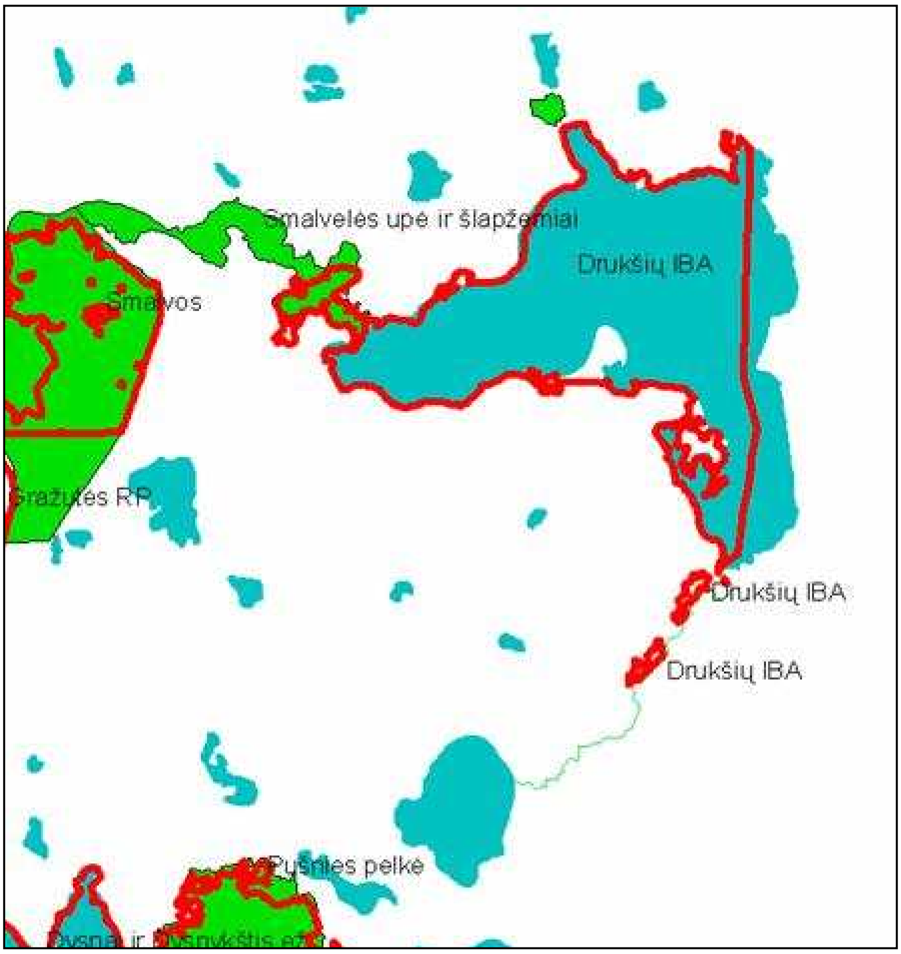


Table 3-17 Habitats in the Drūkšiai Natura 2000 Territory

Corine land cover Kodas/Code	Žemės dangos pavadinimas	Land cover	ha	%
2.1.1.	Nedrėkinamos dirbamos žemės	Non irrigated arable land	10.87	0.30
2.4.2.	Kompleksiniai žemdirbystės plotai	Complex cultivation patterns	7.75	0.21
2.4.3.	Dirbamos žemės plotai su natūralios augalijos intarpais	Land principally occupied by agriculture, with significant areas of natural vegetation	26.79	0.74
3.1.1.	Lapuočių miškas	Broad leaved-forest	17.92	0.50
3.1.3.	Mišrus miškas	Mixed forest	34.68	0.96
3.2.4.	Pereinamosios miškų stadijos ir krūmynai	Transitional woodland-scrub	69.02	1.91
4.1.1.	Kontinentinės pelkės	Inland marshes	4.63	0.13
5.1.2.	Vandens telkiniai	Water bodies	3440.66	95.24

Habitats and species encountered in and around the lake are presented hereafter.

3.7.3 Lake Habitats

3.7.3.1 Flora

Before the development of significant activities in the area, Lake Drūkšiai was of the mesotrophic type. The addition of thermal and sanitary wastewater releases made the lake water quality evolve to an almost eutrophic state and different ecological zones have formed in Lake Drūkšiai.

Studies were conducted on this large scale phenomenon, among which the Lithuanian State Research [19] was an in-depth assessment of INPP impact on the local ecology.

69 water macrophyte species were found during the investigations of Lake Drūkšiai in 1996-1997. Among them 58 Angiosperms[21], 8 Charophytes[22], 3 Bryophyta[23] species were listed. 16 species were not found in this lake earlier [19].

The following vegetation associations (with mention of the CORINE[24] and *EUNIS*[25] code and protection status[26] as appropriate) are found:

- Helophytes, with the *Phragmitetum australis* (common reed beds, 53.11, *C3.21*) and the *Scirpetum lacustris* (common clubrush beds, 53.12, *C3.22*), usually at small water depth;

- Aquatic associations such as the *Potamogetonetum lucentis and Potamogetonetum perfoliati* (large tall pondweed beds in free, deep water, 22.421, *C1.33*), the *Potamogetonetum friesii* (small pondweed communities in less deep, usually sheltered waters, 22.422, *C1.33*);

- Limneids, with the *Nitellopsidetum obtusae* (floating yet rooted vegetation, 22.442, *C1.33*, non prioritary) develop very well in the littoral of the lake.

The communities rare for Lithuanian water bodies were found as follows:

- *Scolochloetum festucaceae* (water-fringe grass beds, in eutrophic waters, 53.15, *C3.25*);

- *Nitelletum opacae* (eutrophic river vegetation in Palaearctic regions, 24.44, *C2.34*, non prioritary);

- *Zanichellietum palustris* (typical of brackish waters, 23.211, *C1.54*).

The presence of some associations typical of eutrophic, and even brackish water, confirm the ecological effect of wastewater releases (both organic and minerals releases) on the Lake water quality and subsequent biological changes.

---

[21] Plants with flowers, in which the ovum is completely included in a closed ovary

[22] Vegetal species intermediate between algae and mosses.

[23] Charophytes are nonflowering plants characterized by rhizoids (rather than true roots) and having little or no organized vascular tissue; bryophyta include mosses.

[24] CORINE = **CO**-o**R**dination of **IN**formation on the **E**nvironment, established in 1985.

[25] EUNIS = European Nature Information System.

[26] There can be: no particular status, non prioritary or prioritary status of protection.

Abundance of filamentous green algae was also registered. Sometimes macrophyte communities are being shocked by these algae. In comparison with the data from the earlier investigation, macrophyte species content has not changed extremely but a significant decrease of areas covered by charophytes and an increase of areas overgrown by helophytes and other aquatic species was observed.

The biggest changes in macrophyte vegetation were noticed in the littoral of lake Drūkšiai near Ignalina NPP were *Charophyta* are totally extinct and just species common to eutrophicated water bodies (*Phragmites australis*, *Glyceria maxima*, *Ceratophyllum demersum*, *Myriophyllum spicatum*) are still growing.

According to the complex hydrobiological investigations on Lake Drūkšiai about the great changes in planktonic organism community, tendencies of those changes in different ecological zones were evaluated in 1993-1997 [19]. The normal seasonal succession of planktonic organisms' abundance and biomass became undetermined because of anthropogenic impact.

The amount of species of most dominant planktonic organisms in 1993-1997 decreased 2-3 times in comparison with pre-INPP operation: phytoplankton – from 116 to 40-50, zooplankton – from 233 to 139. The amount of benthic algae species in littoral zone was 215.

The primary production of phytoplankton in Lake Drūkšiai increased from 22-50 mgC/m^3/day in 1993 to 470-590 mgC/m^3/day in 1997. The highest intensity of primary production (1290 mgC/m^3/day) was determined in the south-eastern part of the lake, eutrophicated by the releases from the Visaginas Municipal Wastewater Treatment Plant. The amount of chlorophyll "a" increased as well and reached 70-113 mg/l in 1996-1997. There is a large scale fluctuation in amino acids and organic acids material, indicating instability in the ecosystem.

3.7.3.2 Lake Fauna

The abundance and biomass of fish increase from the oligotrophic towards the eutrophic state. They decrease in dystrophic[27] lakes. During the process of eutrophication, fish communities are rapidly changing: the number of Salmonidae and Coregonidae fish decreases, whereas the abundance and biomass of Percidae and Cyprinidae fish increase [52].

The ecosystem of Lake Drūkšiai already underwent an active anthropogenic impact before INPP commissioning. Even then there were found higher concentration of nitrogen in the south-western bay of the lake where sewerage from Visaginas was discharged[28] [19].

The zoobenthos also changed. Once the INPP entered into operation, there was a massive outspread of *Dressina polymorpha* [57].

The factors that have an effect on the evolution of fish populations are:

- Inputs of sedimentary substance (from the increase of the lake water level due to the construction of a dam on the Prorva river and, consequently, an active erosion of the lake banks);
- Water temperature, in particular the optimum temperature for fish populations;
- The average biomass of phytoplankton;
- The average concentration of dissolved nitrogen and phosphorus.

The season of the year, the ecological features of the fishes, the time of the day, the abundance of nutrition organisms, and season and day migrations determine also the areas of location and concentration of fishes [62].

With the increased sedimentation of terrigenic[29] materials and organic substances (particularly in deep water areas of the lake), anaerobic conditions increased in the sediments. This phenomenon allowed the production of sulphide and sulphurous hydrogen, which are toxic to many hydrobionts[30] [53]. Dissolved oxygen decreases were also observed, in particular during summer periods and at depth over 15 m [54].

On the basis of research data obtained in 1981 – 1982, it was possible to determine the average biomass of zoobenthos in the lake was about 3.2 g/m^3 [22]. The resources of forage were rather low [55].

In the observation period before the launch of INPP (1950 – 1984), 26 species of fish from 11 families as listed in Table 3-19. They are common or rather common in Lithuania [56].

Sheatfish were on the brink of extinction before the beginning of the INPP construction [55]. At that time, about 40% of the biomass of ichthyocenosis was made of stenothermic[31] fish species (smelt and vendace) [35] and about 55% of the fish population was made of bleak, perch, bream and roach. Roach was prevailing. The average biomass was 108 kg/ha.

---

[27] Habitats that have a moderate nutritive capacity are defined as mesotrophic, those with a little capacity are said oligotrophic and finally those with a toxic capacity are dystrophic.

[28] The MWTP is operated since the late seventies.

[29] Coming from the soil (after works, from erosion phenomena, ...)

[30] Organisms living in water

[31] Capable of living or growing only within a limited range of temperature

The evolution of fish species populations at the end of the construction of INPP (in 1983 with, as a result, a deteriorated gas regime of the near-bottom layer) was such as:

- The biomass of smelt decreased three times;
- The biomass of Vendace decreased more than 130 times.

The total biomass of all fishes increased up to 122.6 kg/ha.

In the first years of INPP operation (in 1984-1986), the total biomass remained almost the same though sharp changes occurred in the biomass of some fish species:

- The biomass of smelt decreased 50 times since the last period;
- The biomass of bleak, bream and pike decreased by 10 – 50%;
- The biomass of perch increased by 25%;
- The biomass of roach increased by 100%, as a result of an increase in their growth rate.

Table 3-17 Lake Drūkšiai Fishes Inventoried in the Pre-operating Period of INPP (Red Data Book Species is Highlighted in Bold) and during the Research Period of 1993 - 1999

Families	Species	
	In the pre-operating period	During the period 1993-1999
Cyprinidae	Roach (Rutilus rutilus) **Bleak** (Alburnus alburnus) **Belica** (Leucaspius delineatus) **Dace** (Leuciscus leuciscus) Carp (Cyprinus carpio) Ide (Leuciscus idus) **Rudd** (Scardinius erythrophthalmus) **Minnow** (Phoxinus phoxinus) **Tench** (Tinca tinca) Silver bream (Blicca bjoerkna) Bream (Abramis brama) Crucian carp (Carassius carassius) **Gudgeon** (Gobio gobio)	Roach (Rutilus rutilus) **Bleak** (Alburnus alburnus) *no more observed* *no more observed* in little proportion in little proportion **Rudd** (Scardinius erythrophthalmus) *no more observed* **Tench** (Tinca tinca) Silver bream (Blicca bjoerkna) Bream (Abramis brama) in little proportion **in little proportion**
Percidae	Perch (Perca fluviatilis) Ruff (Gymnocephalus cernuus) **Pike-perch** (Stizostedion lucioperca))	Perch (Perca fluviatilis) Ruff (Gymnocephalus cernuus) *no more observed*
Coregonidae	**Vendace** (Coregonus albula) **European whitefish** (Coregonus lavaretus)	**Vendace** (Coregonus albula) *no more observed*
Osmeridae	**Smelt** (Osmerus eperlanus m. relicta)	**in little proportion**
Esocidae	**Pike** (Esox lucius)	**Pike** (Esox lucius)
Cobitididae	Loach (Cobitis taenia)	in little proportion
Gadidae	**Four-bearded rockling** (Lota lota)	**in little proportion**
Anguillidae	Common eel (Anguilla anguilla)	*no more observed*
Cottidae	**Sculpin** (Cottus gobio)	*no more observed*
Gasterosteidae	Three-spined stickleback (Pungitius pungitius)	*no more observed*
Siluridae	**Sheatfish** (Silurus glanis)	*no more observed*

With the start of the second reactor (in 1987-1989), the thermal load of the lake increased again and the total biomass reached 140 kg/ha. The total biomass increase was due to the increase in the biomass of such previously not abundant eurythermal[32] and thermophile[33] fish species as roach and others.

The species observed during the period 1993-1999 are listed in Table 3-19; about 99% of the ichthyomass of the lake was made of the populations of 10 fish species: roach, perch, silver bream, bream, Vendace, bleak, rudd, ruff, pike and tench [55]. The biomass varied between 150.3 and 172.1 kg/ha. Since 1950, the total biomass increased by 50%.
Eurythermal species such as perch and previously non abundant species such as silver bream, rudd and tench greatly increased, on the detriment of stenothermal cryophilic[34] fish species. The total biomass of stenothermal fish species decreased about six times compared to the period 1950-1975.
In the period 1994-1999, the average biomass of eurythermal fishes increased by 2.3 times compared to the pre-INPP period. On the opposite, the relative biomass of stenothermal species was on the average only 4.3% of the total fish biomass of the lake [55]. The smelt population abundance has become so reduced that it is on the brink of elimination from the lake [62].

The changes occurred mainly after the first years of INPP operation, and then the successive changes slowed down. During the last years the lake fish community has changed insignificantly. The partially stable state of the lake fish community is fragile and in most cases depends on the Ignalina NPP operation regime [55].

There were also some adaptations among some species populations. Vendace population partially adapted to the changed environmental conditions and its abundance in the recent years is quite high and constant. The survival and partial rehabilitation of Vendace (stenothermal fish) indicates that some fish species may become acclimated to the disrupted thermal and eutrophic conditions in the lake [62].

Effects on the gonads production were observed on 40% of the fish population and even 2% of the fishes became hermaphrodites [60].

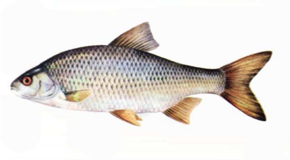
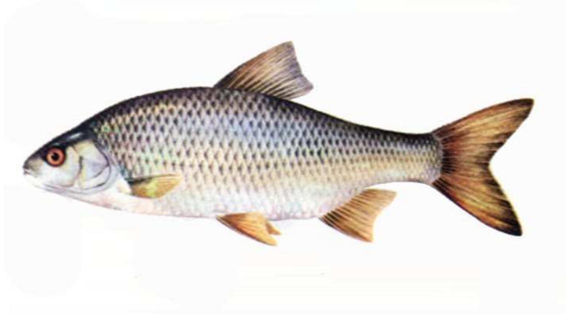
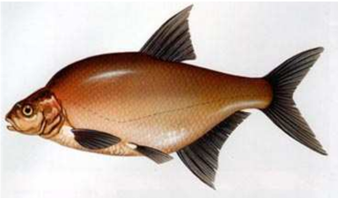
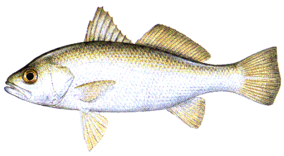
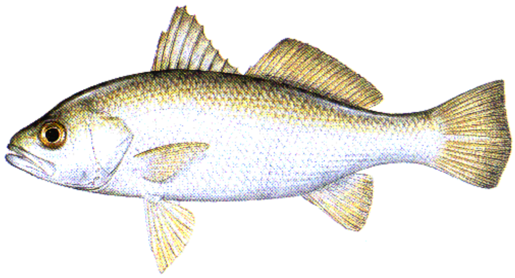
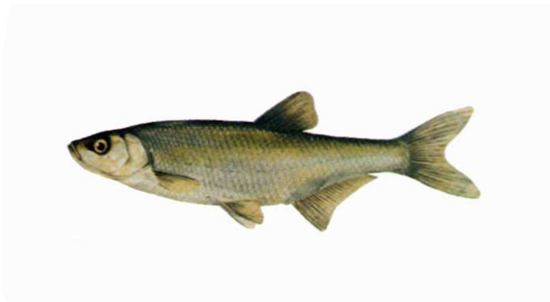
The result of the fish population evolution is illustrated on Figure 3-27.

It was found out that the frequency of cytogenetic damage, emerged as a specific radionuclide-caused effect in aquatic organisms inhabiting Lake Drūkšiai, is slightly above the background level and is 5 times lower than the same damage in Swiss Lake Murten in the surroundings of which there are 2 nuclear power plants in function. The effect of Ignalina NPP on reproductive system of fish present in Lake Drūkšiai is much lower than it is in fish from the environs of Forsmark and Oskarshamn NPPs in Sweden. According to the values of studied ecotoxicity parameters, Lake Drūkšiai belongs to the category of weak toxicity water bodies, where biological effects can be compensated by the adaptation mechanisms of living organisms.

The research data of many years (1989-1996) on biotesting of Ignalina NPP waste waters, the water of Lake Drūkšiai and its bottom sediments have shown that discharges waters entering the lake are more or less harmful to hydrobionts. The wastewater from municipal sewerage is the most polluting. The toxicity of Lake Drūkšiai water depends not on radioactive but chemical substances constantly entering with waste waters.

[32] Fish species that can tolerate a wide range of temperatures
[33] Organisms that can live in warm conditions
[34] That have an affinity for or growing at low temperatures

Figure 3-27 Fish Population Evolution before and after INPP Construction and Operation – the Size of the Picture of One Specie is Proportional to the Specie Population Evolution and the Order of Pictures is the Order of Relative Biomass of Species

Before	Nowadays
Dominant specie  *Roach*	
Important species  *Bream*  *Perch*	 
Significant species  *Bleak*   	   (Smelt on the brink of elimination)

As a conclusion, it was determined that the functional and structural changes in lake Drūkšiai biota **are mostly caused by thermal and chemical pollution**.

After INPP Units final shutdown the thermal heat discharges will be ceased to the lake, but discharges of municipal sewerage could not change significantly (depending on the evolution of Visaginas during and after the decommissioning process).

3.7.4 Surface Habitats

Habitats pertaining to the proposed Natura 2000 area of Lake Drūkšiai are presented in Table 3-18.

During the State Research, a survey of the flora associations was made in the Lake Drūkšiai watershed. The mapping of these associations is illustrated at

Figure 3-28.

The following description provides further information on the different vegetation associations encountered in the watershed of the lake (see Table 3-20).

The watershed holds several species of mammals, protected in Lithuania and in the EU. Birds of more than 140 species have been found in the site. 27 breeding species listed in the Annex I of the EU Birds Directive were recorded in the site in recent years.

Figure 3-28 Vegetal Associations in the Lake Drūkšiai Watershed [36]

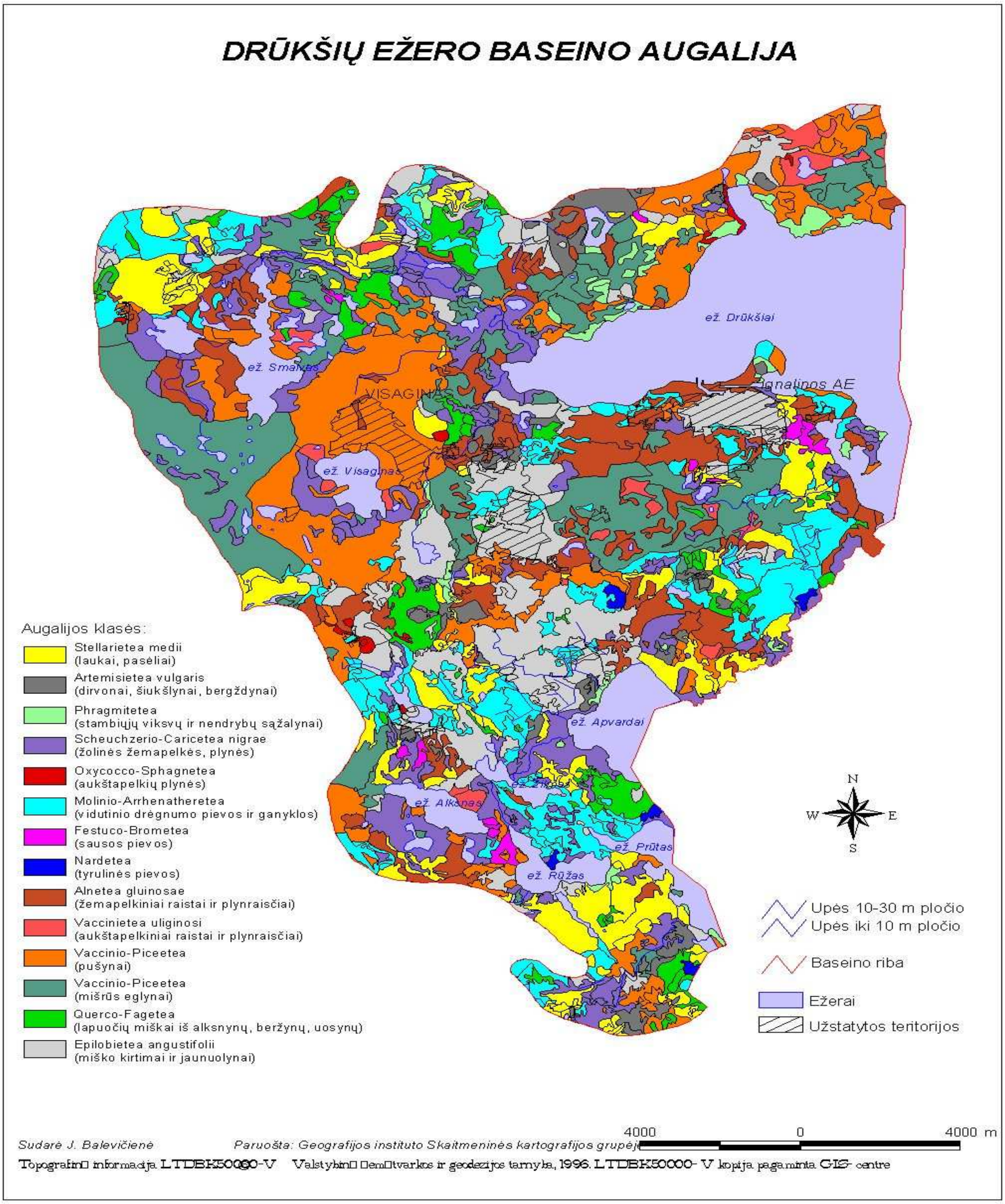


Table 3-18 List of Vegetation Association Inventoried in the Watershed of Lake Drūkšiai

Legend nr.	**Vegetation class** **vegetation order** ***Rem: habitats included in the habitat EU directive[35] are highlighted in bold in the table***	**Area (ha)**	**Representation (%)**
I	Stellarietea medii *Aperion spicae-venti* *Digitario-setarion*	2490.96	10.10
II	Artemisietea vulgaris *Dauco-melilotion* *Convolvulo-agropyrion repentis* *Onopordion acanthii*	774.55	3.13
III	Phragmitetea australis *Caricion elatea Pignatii* *Phragmition australis*	400.82	1.62
IV	Scheuchzerio-caricetea nigrae *Caricion nigrae* *Caricion lasiocarpae* ***Caricion davallianae***	2915.27	11.78
V	Oxycocco-Sphagnetea *Sphagnion magellanici*	79.52	0.32
VI	**Molinio-Arrhenetheretea elatioris** *Calthion palustris* *Cynosurion cristati* *Arrhenaterion elatioris*	2759.48	11.15
VII	**Festuco-Brometea erecti** *Mesobromion erecti*	186.58	0.75
VIII	Nardetea strictae *Violion caninae*	72.16	0.29
IX	Alnetea glutinosae *Alnion glutinosae* *Salicion cinereae*	2738.09	11.07
X	**Vaccinietea uliginosi** *Ledo-Pinion* *Betulion pubescentis*	386.84	1.56
XI-1	**Vaccionio-Piceetea** *Dicrano-Pinion sylvestris*	3905.44	15.79
XI-2	**Vaccionio-Piceetea** *Vaccinio-Piceion abietis*	3826.23	15.47
XII	Querco-Fagetea sylvaticae ***Alno-Padion avii***	1054.96	4.26
XIII	Epilobietea angustifolii *Carici piluliferae – Epilobion angustifolii*	3143.53	12.72

[35] Habitats included in the Directive 92/43/EEC are subject to particular conservation rules for fauna and flora, in the so-called Areas of Special Conservation, currently in the process of designation under the Natura 2000 Network.

In more details (with mention of the CORINE code and protection status as appropriate):

- The Stellarietea medii are composed of nitrogen rich meadows, that result from fallow manure practices, quite common in Lithuania, with :
    - the *Aperion spicae-venti* order = arable land occupied by ruderal species,
    - the *Digitario-setarion* order = ruderal[36] species that accompany cultivated land, on nitrogen rich soils;
- The Artemisietea vulgaris are habitats of xerophile (dry) fallow land, in which:
    - the *Dauco-melilotion* = semi-xerophile habitat for perennial species,
    - the *Convolvulo-agropyrion repentis* = fallow land for perennial, ruderal, meso-xerophile, psychrophilic (cold weather with extremes) species,
    - the *Onopordion acanthi* = xerophile fallow land for perennial[37] species;
- The Phragmitetea australis are usually marshes covered with reed or related species (as Carex sp.), present on the northern bank of the lake Drūkšiai, in which:
    - the *Caricion elatea Pignatii* = large peaty areas containing Carex species,
    - the *Phragmition australis* = stabilized reed populations;
- The Scheuchzerio-caricetea nigrae are holarctic (from the botanical north boreal region) bog lowlands, dominant on the south-west bank of the lake Drūkšiai and also present on the south-east bank, in which:
    - the *Caricion nigrae* = on acid, little aerated soils,
    - the *Caricion lasiocarpae* = primary bog where vegetation grows at the surface of oligrotrophic or meso-oligotrophic water,
    - the *Caricion davallianae* = on alkaline soils (**alkaline fens, 54.2, *D4.1E*, non prioritary**);
- The Oxycocco-Sphagnetea are psychrophilic heath areas, more or less peaty, with:
    - the *Sphagnion magellanici* = highland bogs on acid soils;
- The Molinio-Arrhenetheretea elatioris are European meadows **(lowland hay meadows, 38.2, *E2.2*, non prioritary)**, present on the south-east bank of the lake, in which:
    - the *Calthion palustris* = hygrophile, event shortly inundable meadows on middle altitudes,
    - the *Cynosurion cristati* = semi-dry, pastured,

[36] A plant that grows on wasteland, old fields, waysides, etc.

[37] Species that remain continuously during all seasons (like trees or plants that survive thanks to its roots during winter)

- the *Arrhenaterion elatioris* = meadows with high herbs on fresh and humid soil, in plains and hills;

- The Festuco-Brometea erecti are alkaline meadows, in which:

  - the *Mesobromion erecti* = semi-dry and semi-thermal calcareous meadows, potentially rich in orchids **(34.3222, *E1.26*, prioritary);**

- The Nardetea strictae are middle-european and boreal-alpine acidophilic meadows, with:

  - the *Violion caninae* = psychrophilic meadows in plains and hills;

- The Alnetea glutinosae are hydric thickets with shrubs, in plains and hills, on peaty soils, in which are the *Alnion glutinosae* and the *Salicion cinereae*; this formation is dominant on the south-east bank of the lake;

- The Vaccinietea uliginosi **(44A, *G1.51*, prioritary)** are bog woodlands, psychrophilic heath areas, more or less peaty, in the boreal and mountain regions with:

  - the *Ledo-Pinion* = coniferous dominated woods of bogs,

  - the *Betulion pubescentis* = forests of birch colonizing bogs of reduced peat activity in the boreal, sub boreal zones;

- The Vaccionio-Piceetea are boreal-alpine evergreen, needle-tree woods, dominant on the north and north-west bank of the lake, and present on the south-west bank, with:

  - the *Dicrano-Pinion sylvestris* **(42.521, *G3.42*)** = thermal pine yards on siliceous soils, in slopes and ravines,
  - the *Vaccinio-Piceion abietis* **(42.2, *G3.1*)** = coniferous forests dominated by spruce;

- The Querco-Fagetea sylvaticae semi-hygrophile forests, in which:

  - the *Alno-Padion avii* **(44.3, *G1.2*, prioritary)** = alder and ash-tree alluvial forests on soils regularly inundated though correctly aerated;

- The Epilobietea angustifolii are pre- or post-sylvan shrubs in the Atlantic or middle-European region, with:

  - the *Carici piluliferae – Epilobion angustifolii* = forest clearings on acid soils occupied by herbs such as fireweed and Carex pilulifera.

The State Research [19] showed negative changes in the vegetation of the Ignalina nuclear power plant region. Anthropogenous changes were observed: the invasion of alien plant species showing instability of native communities; many places overgrown with pyrogenic and ruderal flora were noticed instead of former natural meadows and forests. These changes were mostly registered in the surroundings of Lake Drūkšiai.

3.7.5 The Use of Biological Resources

Visaginas municipality’s territory has increased to 5841 hectares: 69 hectares – private property, 2 hectares – one individual property, 1488 hectares – national forests and water, and almost 833 hectares – property for privatisation.

Dot wood manufacturing, light industry and agriculture developed over the years. New foreign companies are coming to Visaginas to establish their offices, because of cheap manpower and good infrastructure.

With the construction and start-up of the INPP, the consumption of agricultural products of the region increased. But the impact was not very important because Visaginas has no enterprises of agricultural products processing. The INPP directly encourages the producers and processors of agricultural products by buying up their products [51].

After the building of Visaginas and INPP, the distribution of surrounding forests into protective categories has changed. The INPP and Visaginas directly possess 1250 ha of forests. There were an attempt to pass these forests to the Ignalina local department of forestry but the latter declined because of the bad status of these forests.

New plans are to develop new agriculture, forestry and fishery.

The hunting economy of the region was little affected: the pasturing and hunting areas of game animals were slightly decreased. Visaginas has 30 – 40 hunters, which is a small number for such a town.

However, gathering of mushrooms (e.g. chanterelles) and forest fruits (berries) is very popular in the region and feeds local markets.

Fishing is widespread in the region; amateur fishing is authorized in the lake. Annual catches were estimated at 18 tons per year in the pre-operating period and to 41 tons per year in the period 1986-1990 [58].

3.8 Cultural Heritage

This chapter covers the landscape, of which the INPP is part, as well as objects of cultural interest among which protected areas and monuments that can be impacted by the project.

3.8.1 Landscape

The INPP region covers two districts – Zarasai and Ignalina districts.

The landscape of the region is characterised by the relief formed during glacial periods, consisting of picturesque mountain ridges, ravines, lakes, and plains as well as by pine forests and vast water meadows (see

Figure 3-29).

The landscape in the Lake Drūkšiai watershed has degraded because of the building and exploitation of INPP, Visaginas town and related infrastructure. According to the State Research [19], it was determined that 1.43% of the watershed (not taking the lake into account) was damaged irreversibly. There are abandoned farming lands (1.56%) and a reduction of the forest area (3.83%). Figure 3-30 illustrates damages to the initial landscape.
Today, the landscape can be characterized as industrial near the INPP: power production units, ancillary facilities, partly build third unit (industrial ruin), spent fuel storage facility, domestic wastewater treatment plant, ducts for the urban warming system of Visaginas and the electricity transmission lines.

At greater distance, landscape is mainly composed of forests and wetlands. Residential areas are made of small villages with traditional houses. The lake Drūkšiai is a major natural landscape element, with associated activities (fishing, recreational).

A photographic report is presented in Appendix 4. The location of picture shots is shown on the map in Appendix 5. It shows views of significant objects pertaining to the INPP and some typical landscape elements in the region.

The most valuable and closer landscape areas are located at some distance from INPP, with the Gražute Regional Park which covers more than 2.8 thousand hectares and is aimed at preserving the landscape of the Šventoji River basin with its lakes, forests, its natural ecosystem as well as the cultural heritage values, maintaining them and rationally using them. Pine forests (72%) and birch forests (17%) prevail in the Park. The average forest age is 65 years.

The Smalvos protected hydrological territory (at the west of INPP) also presents landscape value with its undulated relief and particular ecological formations.

Figure 3-29 Landscapes Types in the Lake Drūkšiai Watershed [36]

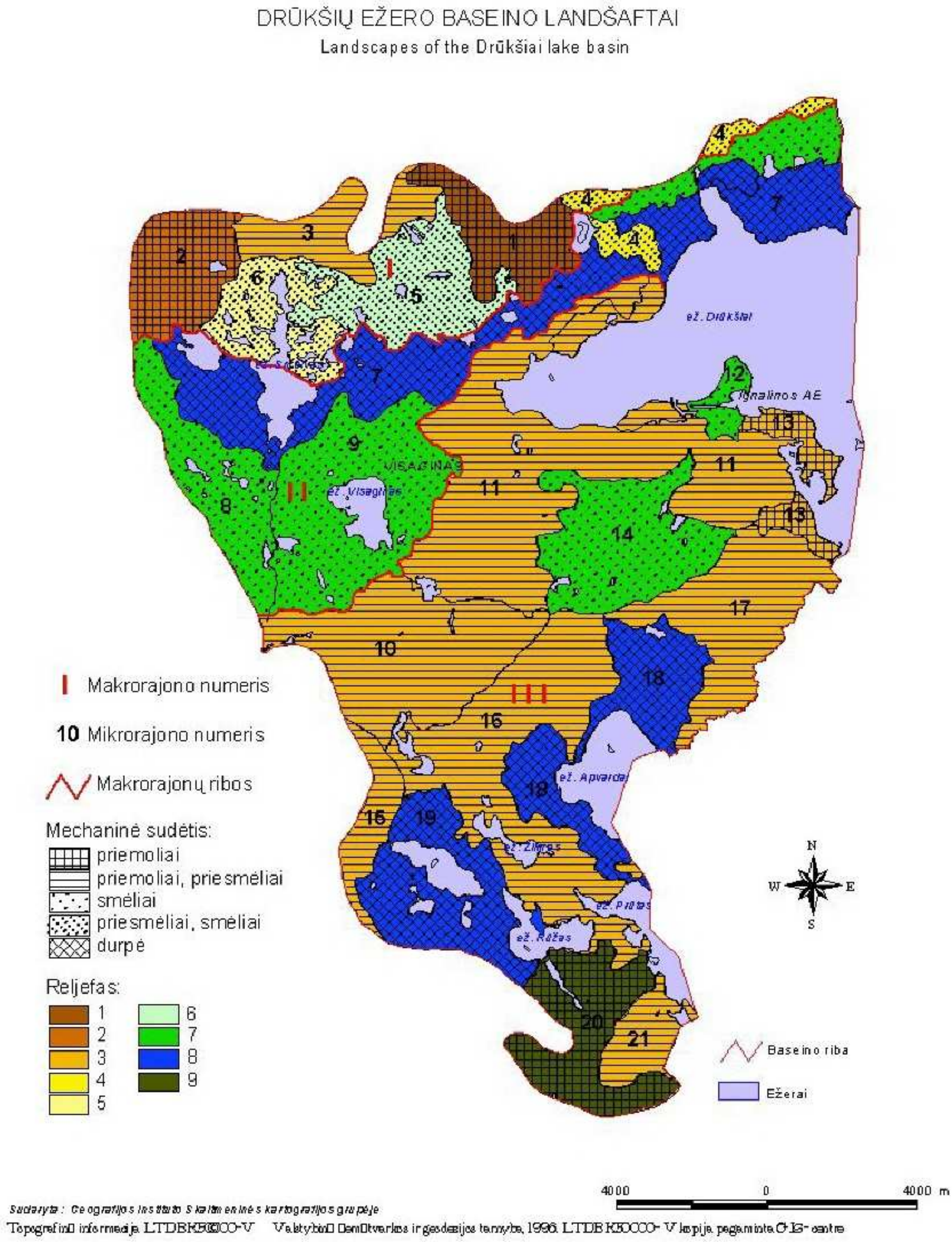
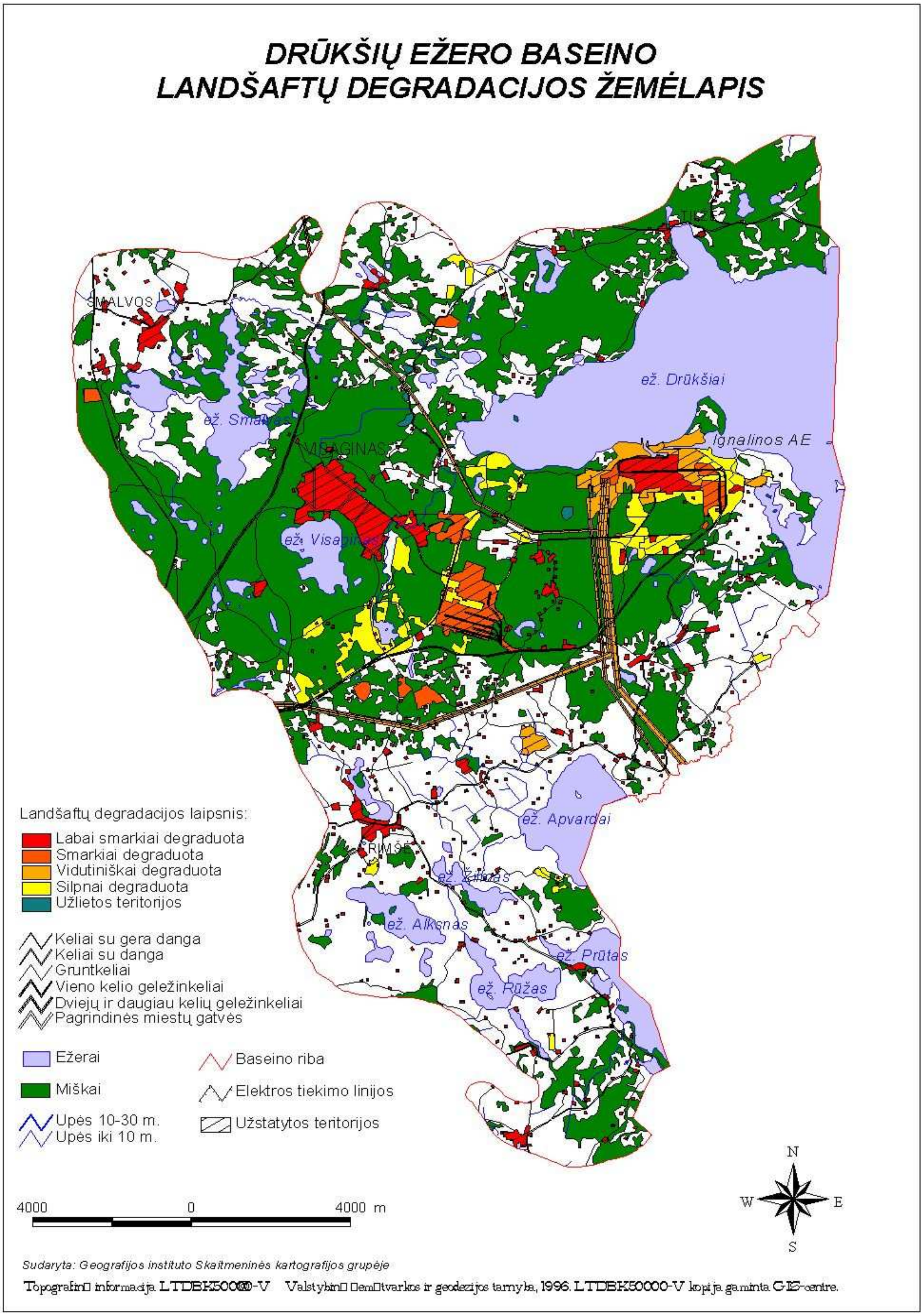


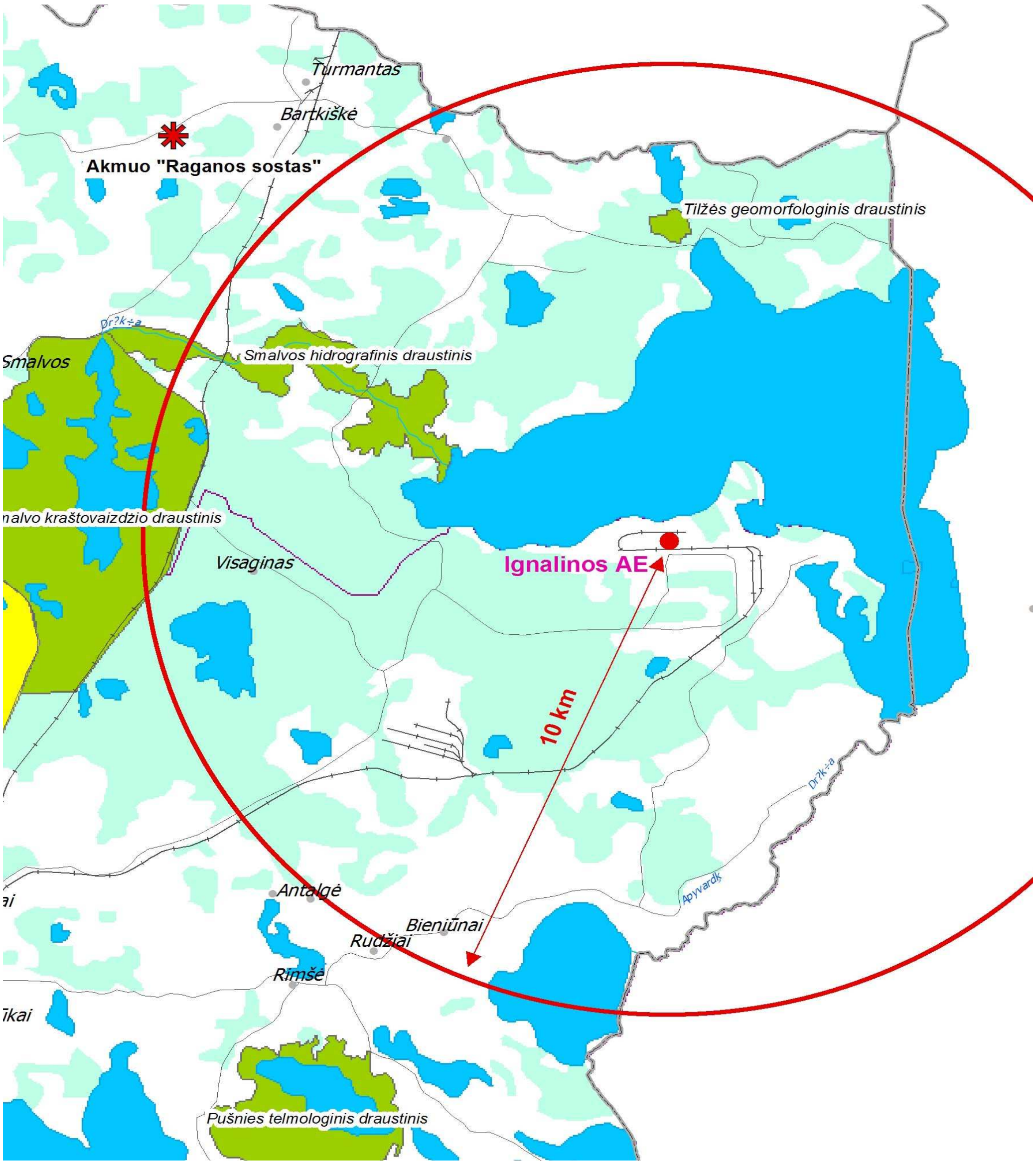
Figure 3-30 Deteriorated Landscape in the Lake Drūkšiai Watershed [36]



3.8.2 Protected Territories

The Department for Protected Areas released a map with protected territories in a radius of 10 km around the INPP (see Figure 3-31).

Figure 3-31 Protected Territories around the INPP, Indicated in Green (April 2004)



Additionally to these protected territories, Natura 2000 areas were proposed by the Authorities. Once approved by the European Commission, these areas shall be considered as protected territories as well.

3.8.3 Objects of Cultural Interest

During the construction of INPP, the site located within the boundaries of the plant underwent large excavations works and earth movements that revealed, no outstanding elements as regards the architectural and archaeological heritage were revealed within the boundaries of the plant. As a result, there is assurance that no possible elements of the archaeological heritage will be affected by the decommissioning. There are no objects of cultural heritage, ethnic or cultural conditions that could be negatively impacted by the decommissioning of Ignalina NPP.

3.9 Noise and Vibrations

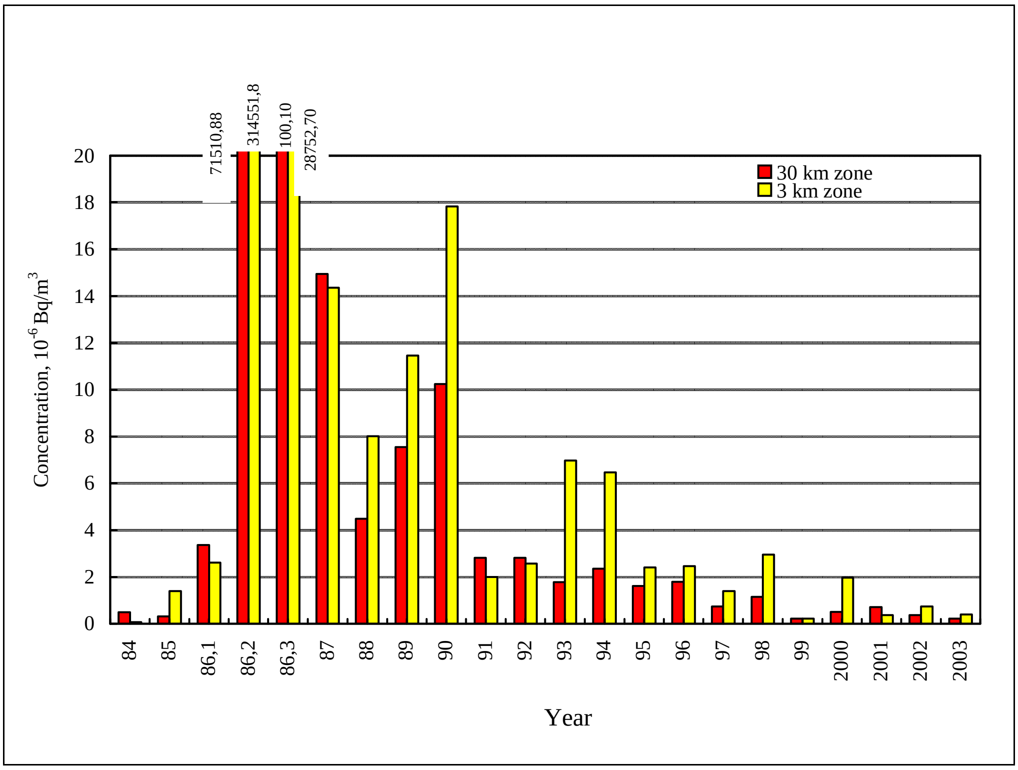
The activities at INPP are not an important source of noise or vibrations. Moreover, there is no inhabitant within a zone of 3 km of radius, so that there is no particular perception of noise or vibrations. This subject is not relevant for INPP Decommissioning, apart for possible nuisances caused by the traffic of trucks transporting heavy loads of civil works wastes. But this issue is out of the scope of the U1DP0 Project.

3.10 Radiological Conditions

3.10.1 Radioactivity in the Air and Precipitations

Nuclide content in the air and precipitations of INPP site is determined mainly by presence of ^{137}Cs and ^{60}Co (not considering naturally existing nuclides, i.e. Be^7 for the air activity and $Be^7 + K^{40}$ for the precipitations (soil surface) activity). The average concentration of nuclides in atmospheric air in the year 2002 for the 30 km radius monitoring zone was 0.37×10^{-6} Bq/m^3. The annual variations of nuclides concentration in atmospheric air and nuclides amount in precipitation are presented in Figure 3-32 and Figure 3-33.

Figure 3-32 Annual Variation of Yearly Averaged Technogenic Nuclide Concentration in the Air in the 3 and 30 km Radius Monitoring Zone of INPP (naturally occurring Be^7 excluded)



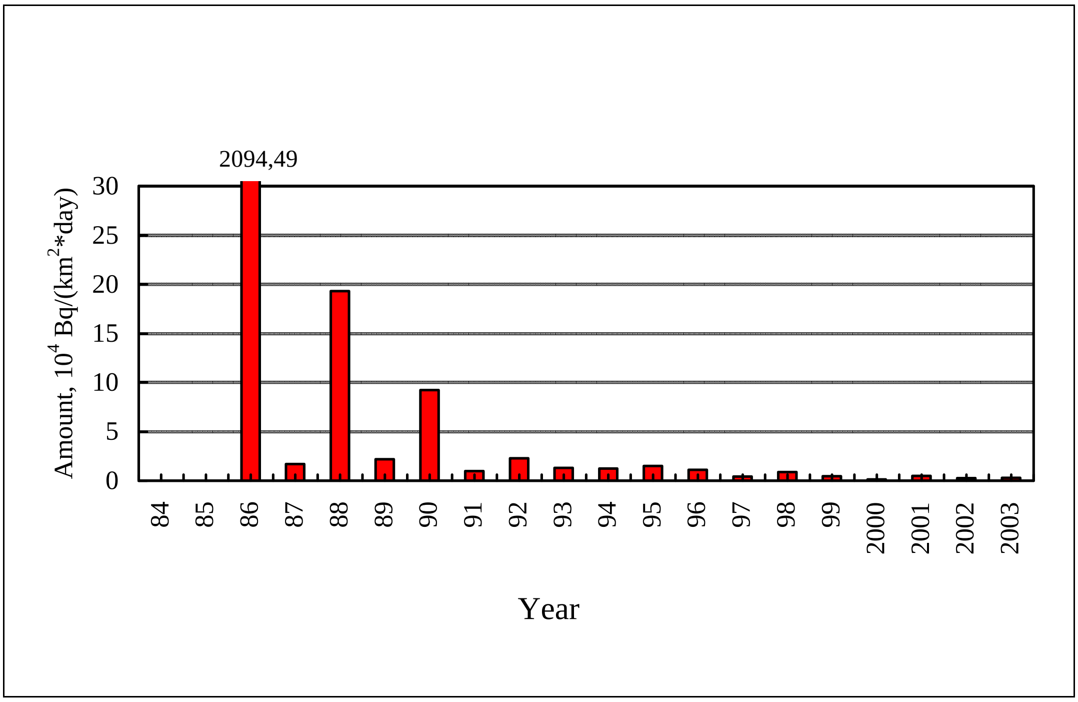
Peaks observed during period April-September 1986 are related to the Chernobyl NPP accident fallout (mainly Cs^{137}). In the nineties, better operation and effluent purification procedures are at the basis of a part of the observed decrease (see section 3.10.4).

For the impact assessment of the Decommissioning, the last five years (1999-2003) are used as reference (see chapter 6). In this period, we can see on Figure 3-32 that there is an increase in 2000 compared to 1999 and 2001. This may come from increased releases of aerosols measured in 2000, which were twice those of 1999 and 20% higher than in 2001. Despite of this, the current figures are in the same order of magnitude than in 1984 (INPP Unit 1 was start up by the end of 1983).

The yearly external exposure dose (including natural background) based on measurements using TL-dosimeters located inside the 30 km monitoring zone for the year 2002 was 0.41 mSv on average. The yearly average dose rate within the above-mentioned zone for the same period was 0.087 μSv/h. The measured external yearly doses during last few years have slightly decreased (from 0.61 mSv in 1997) [24-29]. This results from the use of improved TLD dosimeters (Skylink System), characterised by improved detection limits in very low ambient backgrounds.

The general conclusion based on the radiological investigations in the INPP region [29] is that radiological conditions in the region are determined by natural background, the operation of INPP having insignificant effect.

Figure 3-33 Annual Variation of Yearly Averaged Technogenic Nuclide Amount in the Precipitation of 30 km Radius Monitoring Zone of INPP (naturally occurring $Be^7 + K^{40}$ excluded)



This conclusion is supported by independent measurements performed by Radiation Protection Centre in the period November 1999 – May 2000 [32]. The measurements were performed in INPP region and Kupiskis municipality, located in about 100 km to the northwest from INPP. The Kupiskis municipality was chosen due to the absence of big industrial facilities and other objects using ionizing irradiation sources. The measured exposure doses (including natural background) during the investigation period in both regions were about 0.4 mSv. The conclusion is made that external exposure doses in both regions are the same.

This conclusion is also confirmed by a research carried out by an international experts' team made recently [77], in which it is shown that the influence of INPP is very little compared to the contribution of natural background and medical exposures to the annual radiation dose.
Dose rate in the INPP industrial site as well as inside controlled zone is monitored and controlled. The 25 m radius distance from buildings 157/1, 157, 155/1, 155, 151/154, 150, 158 156 (radioactive waste treatment and storage buildings area) is specified as zone for contamination and radiation exposure control. The dose rate in these areas is controlled to be below 12 μSv/h [33]. The real dose rate at 1 m from building 158 northern side is in the range of 0.2 – 0.3 μSv/h.

The accumulation of technogenic radionuclides in water, soils and natural components is described in related sections.

The general conclusion based on the radiological investigations in the INPP region [27] is that, if the current yearly releases of aerosols from INPP are not significantly exceeded, radiological conditions in the region are determined by large by natural background and operation of INPP has insignificant effect (less than 1%). The same result is expected after INPP Units final shutdown (see chapter 6.3.2).

Note:

Be^7 activity in the ambient air typically varies between 200×10^{-6} - 1500×10^{-6} Bq/m^3 in function of the year [30]. The Be^7 + K^{40} activity on the soil surface typically varies between 50×10^4 - 300×10^4 Bq/km^2 ×day [30].

3.10.2 Radioactivity in the Soil

Anthropogenic nuclide content in the soil of INPP region is determined mainly by presence of ^{137}Cs and ^{134}Cs (=not considering naturally existing nuclides): in the year 2000, the average concentration in the region of nuclides in the soil was 6.7 Bq/kg. The total average concentration of nuclides (considering also naturally existing ones) was the same year about 700 Bq/kg [27]. Therefore, the soil in the region of INPP presents only little technogenic contamination compared to natural radioactivity. Moreover, the radiocesium background is also due to the Chernobyl accident fallout [33].

3.10.3 Radioactivity in the Lake Drūkšiai Aquatic Plants

Radionuclides can be found in the lake sediments and in aquatic plants as well.
A radiogeochemical mapping of the lake bottom sediments was made in the years 1995-1996 [19]. It was established that bottom sediments reflect better the long term past changes in the radio-ecological state of the lake than the short term present operative seasonal changes. It was shown also that the radioecological state of the lake is not stable and is changing constantly as a result of thermal and chemical pollution which disturb the biological processes of radionuclide migration and changes in their distribution in the ecosystem.

The largest amounts of radionuclides get into the lake with cooling water and industrial and rain water releases, INPP being the main contributor for the presence of Co^{60} and Mn^{54}, and a significant contributor for Cs^{137} and Sr^{90}. The influence of the Chernobyl accident was highlighted, mainly for Cs^{137}.

The eutrophication of the lake favoured the bioaccumulation of Sr^{90} and active mechanical sedimentation. $Pu^{239,240}$ was also observed in some bottom sediment samples.

Among aquatic plants sampled, the largest amount of $Pu^{239,240}$ was observed in 1996-1997 in *Myriophyllum spicatum* (1.39 Bq/kg in dry weight) while in other plants it ranged from 0.38 to 0.71 Bq/kg. The hydrophytes, as the first barrier catching radionuclides in a water basin, reflect more efficiently than bottom sediments the input of radionuclides getting in the period vegetation. Sr^{90} concentration reached 15 Bq/kg. Co^{60} was observed in plants growing on the bank of Lake Drukshiai. The main source of the presence of Cs^{137}, Co^{60} and Mn^{54} in the bank zone of the lake could occur with industrial waters [19]. Cs^{137} accumulates through the trophic levels, what is not the case for Co^{60} and Mn^{54}.

The efforts implemented by INPP to reduce the discharges of gaseous waste (Section 3.10.1) also led to a reduction of the liquid waste discharge after 1990 (see 3.10.4). This was reflected by a steady decrease of the lake sediments activity in Co^{60} and Mn^{54}, i.e. two nuclides that are specific to INPP operation[38].

The reduction of the radionuclides discharges anticipated during the defuelling phase of Unit 1 will further confirm the above trend, i.e. the reduction of the sediments, aquatic plant and fish contamination by nuclides specific to INPP operation (see section 6.4.2.2).

3.10.4 Operational Measures Implemented to Reduce the Liquid and Atmospheric Discharges into the Environment

During the years 1990s, several operational measures and design modifications were implemented at INPP, which led to a progressive reduction of both the radioactive liquid and atmospheric discharges into the environment. These are summarized hereafter:

a) Limitation of the fuel cladding defect (leakage) rate, i.e. withdrawal from the reactor of the fuel assemblies, the cladding of which exhibits significative leakage rates. This measure enabled to reduce the Cs^{137} specific activitiesin the main coolant circuit to levels < 5000 Bq/l and even, several times, to levels < 100 Bq/l (see section 6.2.2 of [8]) and, in parallel, to reduce the specific activities of the fission products (noble gases, iodine, Cs^{134}) and of the TRU nuclides (Pu, Am, Cm nuclides) in the main coolant circuit.

b) Implementation of a "Plant Water Balance" programme in order to reduce the liquid discharges. In the frame of this programme:

   - 2 tanks of 5000 m^3 each were installed to collect the liquid waste and to maximalise their recycling in the plant (instead of their discharge) – see also item c) hereafter;

   - operational limitations of liquid waste production were assigned to each department during normal operation and maintenance outages. This measure led to a reduction of

[38] Accumulation of Technogenic Radionuclides in the Environment of INPP – D. Marčiulionis and others – Institute of Botanics, Radio-ecology Laboratory; Vilnius, 2001.

the annual liquid waste volume to be processed by the evaporators of the Liquid Waste Processing Systems;

- definition of stringent radionuclides annual discharge objectives. For indicative purpose, the implementation of the above Plant Water Balance programme enabled to reduce the makeup of fresh demineralised water down to some 30,000 m^3/y, i.e. a small fraction of the Makeup Water Production Plant capacity (up to 100 m^3/h).

c) Modifications of some liquid streams filters:

- the perlite filters upstream of the deep mixed bed ion exchange resins of the PCS (purification circuit of the Main Circulation Circuit) were replaced by precoat filters ("Powdex Resins"). This modification enabled , for example, to improve the filtration efficiency of the insoluble particulates (mainly Co^{60}, Mn^{54} oxydes) in the Main Circulation Circuit and, therefrom, to improve the decontamination efficiency of the the downstream deep mixed bed resins which are designed to remove the chemical and radiological impurities in soluble form;

- similarly, the original filters of the evaporators distillate were also replaced by precoat filters ("Powdex Resins"). This modification enabled to improve the quality of the purified condensate ("clean condensate") and, thus, to maximise the volume of recycled waste;

- implementation of the upcore process (back flow process) in the Low Salt Water filters.

d) Modification of the Condensate Purification mechanical filters regeneration procedure. The Condensate Purification System of each turbo-generator consists of:

- 6 cation bed resins operating in parallel and acting as mechanical filters, i.e. to collect the cruds and suspended materials from the condensate,

- 5 mixed bed resins operating in parallel to collect the chemical and radio-chemical species in soluble form.

As a result of the modified regeneration procedure of the cation beds (mechanical filters), only the spent regeneration solution is routed to the liquid waste, while rinsing volume is routed back to the condenser and mixed with the condensate (initially , the rinsing volume was also routed back to the liquid waste processing system.

e) Use of new detergent types in the Laundry System, i.e. us of low foaming agents requiring less water for cleaning.

3.11 The Transboundary Issues to be considered

Lithuania ratified the Convention on Environmental Impact Assessment in a Transboundary Context, done at Espoo on 25 February 1991. Latvia and European Union are Parties to this Convention, but Byelorussia did not ratify it.

Among Parties to the Espoo Convention, a notification must be made to potentially affected Parties in the case of activities that are likely to cause an adverse transboundary impact. The notification must include information on the proposed activity and its expected impacts during normal operation and anticipated fault conditions, as well as an invitation to express their interest to participate in the decision making process. If an interest is expressed, relevant information regarding the EIA must be provided. The affected Party must ensure that its own general public are informed of the process and given an opportunity to express their comments or objections. Consultations must take place between the Parties, after completion of the EIA and submission of the EIA Report, concerning the potential transboundary impacts and the measures to reduce or eliminate such impacts.

The above notifications are in line with the requirements of Appendix 2 of Article 37 of EURATOM Treaty, applicable to the INPP decommissioning activities [38]. The implementation of the Article 37 of the treaty is made through the resolution of the Government dated 3rd December 2002, n° 1872, concerning data regarding plans relative to radioactive waste disposal.

With non Parties to the Convention, as Byelorussia, information can be shared on a voluntary basis. Byelorussia expressed interest in the Project. Information was sent, among which on the availability of data regarding the Project (for example on the INPP website, on which the present EIA Report is available).

The 1998 Aarhus Convention (The Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters), which came into effect on 30th October 2001, goes beyond the EU legislation on access to environmental information and public participation. The Aarhus Convention aims to ensure that everyone has access to environmental information and gives ordinary citizens a voice in decision-making that affects the environment. It also provides for judicial mechanisms for redress in the case of infringement of rights and for enforcement of the law to the public (individuals and non-governmental organisations).

3.12 References

9. Environmental Impact Assessment for the Decommissioning of Nuclear Installation, Guidance for undertaking an EIA of Proposals for Decommission a Nuclear Power Plant, EC Contract B4-3040/99/MAR/C2, 2001 (in English).
10. Technical Assistance for Study on Social Costs of Decommissioning of Ignalina Nuclear Power Plant - Study on Social Costs & Ignalina Region Regeneration Strategy and Outline of Development Plan, IMC Consulting Ltd, UK et al. - EU Phare Project No. LI9806.02, 2001 (in English).
11. Economical and social development of East Lithuanian districts, Statistical Department of Lithuanian Government, Vilnius, 1992 (In Lithuanian).
12. Plan to Measures for the Economic and Social Restructuring of the Ignalina Nuclear Power Plant Region, Reasearch Report by Lithuanian Regional Reasearch Institute.
13. Strategy for the Creation of New Job Opportunities and Employment in the Region of the Ignalina Nuclear Power Plant, Kabaila A., Šileika A., Gruževskis B., Misiūnas A.
14. Analysis of date for safety assessment of radioactive waste storage facilities at Ignalina NPP: Part 6. Human environment surrounding the site. LEI Report DRL/T12-13/991231. Kaunas, Lithuanian Energy Institute, 1999.
15. Geographical and ecological aspects of the strategy of balanced development of the Ignalina nuclear power station region, Baubinas R., Taminskas J., Balevičiene J., Paškauskas R., Geographic Annual Review, T. 31, pp. 331-368, 1998.

16. Thermal power generation and environment: Hydrophysical basis state in lake Drūkšiai, Mokslas publishers, Vilnius, Vol. 8, 1989 (In Russian).
17. Hydrography of Druksiai region, Jurgelevičiene I., Lasinskas M., Tautvydas A., 1983.
18. Evaluation of long-term influence of Ignalina NPP radioactive waste storage onto natural waters, Jakimaviciute V., Mazeika J., Petrosius R., Zuzevicius A., Geologija, Vilnius, N° 28, pp. 78-92, 1999 (in Lithuanian).
19. Ignalina Nuclear Power Plant and the Environment, Lithuanian State Research Programme (1993-1997).
20. Thermal power generation and environment: Basic state and aquatic animal populations and communities in lake Drūkšiai, Mokslas publishers, Vilnius, Vol. 5, 1986 (In Russian).
21. Fujita T.T., Proposed characterization of tornadoes and hurricanes by area and intensity, SMPP Res. Pap., University of Chicago, Nr. 91, 1971.
22. Radiological-ecological investigation of Ignalina NPP region in the preoperational period. Final report 1-05-03-01-033 160-126. 1985 (In Russian).
23. Reference book of Lithuanian climate. Temperature. Vilnius. 1993 (In Lithuanian).
24. Report on radiological monitoring results at the INPP region for year 1997. INPP. PTOOT-0545-5 (In Russian).
25. Report on radiological monitoring results at the INPP region for year 1998. INPP. PTOOT-0545-6 (In Russian).
26. Report on radiological monitoring results at the INPP region for year 1999. INPP. PTOOT-0545-7 (In Russian).
27. Report on radiological monitoring results at the INPP region for year 2000. INPP. PTOOT-0545-8 (In Russian).
28. Report on radiological monitoring results at the INPP region for year 2001. INPP. PTOOT-0545-9 (In Russian).
29. Report on radiological monitoring results at the INPP region for year 2002. INPP. PTOOT-0545-10 (In Russian).
30. Report on radiological monitoring results at the INPP region for year 2003. INPP. PTOOT-0545-11 (In Russian).
31. Reference book of Lithuanian climate. Precipitation. Vilnius, 1991 (In Lithuanian).
32. Activity of Radiation Protection Center in 2000. Yearly report. Vilnius, RPC, 2001 (In Lithuanian).
33. Instruction on maintenance of radiological monitoring at INPP, PTOed-0512-5B7 (In Russian).
34. Almenas K., Kaliatka A., and Uspuras E. Ignalina RBMK-1500. A Source Book. Extended and updated version. Prepared by Lithuanian Energy Institute. Publisher Lithuanian Energy Institute, Kaunas, 1998.
35. Thermal power generation and environment: Ecosystem of the water - cooling reservoir of Ignalina nuclear power station at the initial stage of its operation, Academia publishers, Vilnius, Vol.10, 1992 (In Russian).
36. Final Report of State Scientific Research Programme “Atomic Energy and Environment”, Vilnius, 1998 (In Lithuanian).

37. Results of chemical analysis of lake Druksiai water according to “Environment Monitoring Programme”, 1998-2003.

38. Commission Recommendation on the application of Article 37 of the Euratom Treaty (of 6 Dec. 1999). Annex 2.

39. Manual for Environmental Impact Assessment in Lithuania, Ministry of the Environment of the Republic of Lithuania - Finnish Environment Institute, ISBN 9955-425-88-1.

40. Letter (1-15)-D8-4270 of the Ministry of Environment of the Republic of Lithuania concerning the approval of EIA Programme, dated 27th May 2004.

41. The socio-economic monitoring in the Ignalina Nuclear Power Plant region: methodology, programme, implementation, R. Baubinas, D. Burneika, V. Daugirdas, Geografija, T. 38(2), 2002.

42. Social consequences of closing the INPP, R. Baubinas, D. Burneika, Geografija, T. 37(1), 2001.

43. Population statistics, Department of Statistics.

44. Johannesburg Summit 2002 – Lithuania – Country Profile, United Nations.

45. National Report on Sustainable Development, Republic of Lithuania, Vilnius, 2002.

46. Modelling the transfer of Ignalina NPP radionuclide discharges into an aquatic system; Mazeika J., Motiejunas S. Environmental and Chemical Physics (2002) v.24 (2) p.61-72.

47. UN/ECE Working Group on Monitoring and Assessment – Monitoring of International Lakes; Pietiläinen O.P., Heinonen P. (eds). Helsinki (2002).

48. Thermal regime database of Ignalina Nuclear Power Plant cooler – Lake Druksiai; Sarauskiené D.; Laboratory of Hydrology, Lithuanian Energy Institute, Kaunas, Lithuania (2001).

49. Tezes: Druksiu ezero hidrologinios rezimo analize ir modeliavimas; Sarauskiené D.; Laboratory of Hydrology, Lithuanian Energy Institute, Kaunas, Lithuania (2002).

50. Ignalina Nuclear Power Plant and the environment – Lithuanian State Scientific Research Programme – 1993-1997. The state and development of the ecosystems in the region of Ignalina Nuclear Power Plant and prognoses.

51. The analysis of influence of Visaginas town and INPP on the structure of economy and economic relations in the region, D. Burneika, E. Kriaučiūnas, Geografijos metraštis, 30 t. (1997).

52. Changes in the structure of fish communities or the eutrophicated water body, Reshetnikov Yu.S. et al., Moscow: Nauka (1982).

53. Sulphate reduction - Functioning of hydrobiocenosis in the cooling pond of the Ignalina atomic power plant in the prestarting period: 59-63, Kučinskiene A., Jankevičius K. (1987).

54. Activity of the fixation of molecular nitrogen in Lake Drūkšiai of the Lithuanian SSR, Saradov A.I., Krylova I.N., Paškauskas R.A., Functioning of Lake Ecosystems 5: 164 – 176 (1983).

55. Changes in fish biomass under impact of a thermal effluent and eutrophication of Lake Drūkšiai, Bernotas E., Acta Zoologica Lituanica, Vol. 12, Nr. 3, 242 – 253 (2002).

56. Red Data Book of the Baltic and Nordic Region, Red List of fish, version Dec 2002:1.

57. Species composition abundance and biomass of zoobenthos, Grigelis A., Thermal Power Generation and Environment 10 (2): 105-109 (1993).

58. Lake Drūkšiai: A view on the lakeshore, in World Lake Database – www.ilec.or.jp/database/eur/eur-48.html , internet consultation of 7th July 2004.

59. Ministry of Environment: Annual Report 2000, pp. 87-88.

60. Virbickas J., personal communication, 9th June 2004.

61. Modelling the current structure of Lake Drūkšiai using the hydrodynamic module of MIKE 21 modelling system, Šarauskiene D., Rimavičiūte E., Energetika Nr.3 (2002).

62. The impacts of the Ignalina Nuclear Power Plant effluent on fishes in Lithuania, Astrauskas A, Bernotas E., Didrikas T., Ital. J. Zool., 65, Suppl: 461-464 (1998).

63. Evaluation of aquatic routine radioactive releases from the INPP, Mažeika J., Motiejūnas S., Ekologija, Nr. 4 (2003).

64. INPP Region Development Plan, 2004.

65. The Analysis of Water (in French), J. Rodier, 1984.

66. Guide for the Analysis of Drinking Water (in French), 1993.

67. Bernotas E., Effects of Thermal Effluent and Eutrophication on the Functioning of Vendace (Coregonus Albula L.) Population in Lake Drukshiai, Acta Zoologica Lituanica, Volumen 12, Numerus 2 (2002).

68. Aplinkosaugos reikalavimai nuotekoms tvarkyti, 2001 m. spalio 5 d. Aplinkos ministro įsakymas Nr. 495.

69. Paviršinio vandens telkinių klasifikavimo tvarka ir kokybės normos, 2001 m. spalio 25 d. Aplinkos ministro įsakymas Nr. 525.

70. Gailiušis B., Thermal regime and water balance of Lake Drūkšiai and characteristics of river’s flow in NP region, Collection of Scientific Reports of the State scientific programme “Ignalina Nuclear Power Plant and the Environment” 1:3-34 (in Lithuanianà, 1997.

71. Janukėnienė R. and Jakubauskas V., Seasonal and spatial hydrothermal characteristics in 1984 – 1988, Thermal Power Generation and Environment 10 (1): 54 – 69 (in Russian), 1992.

4 The U1DP0 Project: Description of Operations, Techniques and Associated Environmental Aspects

4.1 Description of INPP Plant

4.1.1 Introduction and Historical Context

The Ignalina NPP contains two similar RBMK-1500 reactors. This is the most powerful design of the RBMK type reactor (actually the only two of this type that were built). "RBMK" is a Russian acronym for "Channelized Large Power Reactor". Compared to the Chernobyl NPP, the Ignalina NPP is more powerful (1500 MW versus 1000 MW), and is provided with an improved ALS (Accident Localisation System). In most other respects, the plants are quite similar to their predecessors. They have two cooling loops, a direct cycle, fuel clusters are loaded into individual channels rather than in a single pressure vessel, the neutron spectrum is thermalized by a massive graphite moderator block. The plant can be refuelled on line and uses slightly enriched nuclear fuel.

The power plants were built not to meet Lithuania's needs, but as part of the Soviet Union's North - West Unified Power System. The first unit of Ignalina NPP went into service at the end of 1983, the second unit in August 1987. Their design lifetime was projected out to 2013 – 2017 respectively. A total of four units were originally planned on this site. The construction of the third unit was abandoned in 1989 due to political pressure.

RBMK - type reactors were not exported, and were built exclusively in the territory of the former Soviet Union. There are presently plants at Saint Petersburg (Sosnovy Bor), Kursk, Smolensk and Chernobyl. A total of 17 such reactors have been built and 13 are currently still in operation.

Lithuania declared its independence in March of 1990, but the Ignalina NPP remained factually in the jurisdiction of the Soviet Union until August 1991. Supervision was carried out by that country's regulatory authority, the State Atomic Supervision. After the political events of August 1991 (the collapse of the former Soviet Union), Ignalina NPP finally came under the authority of the Lithuanian Republic. The Lithuanian Ministry of Economy now controls it administratively. The Lithuanian State Atomic Energy Safety Inspectorate (VATESI) exercises regulatory control.

4.1.2 General Description

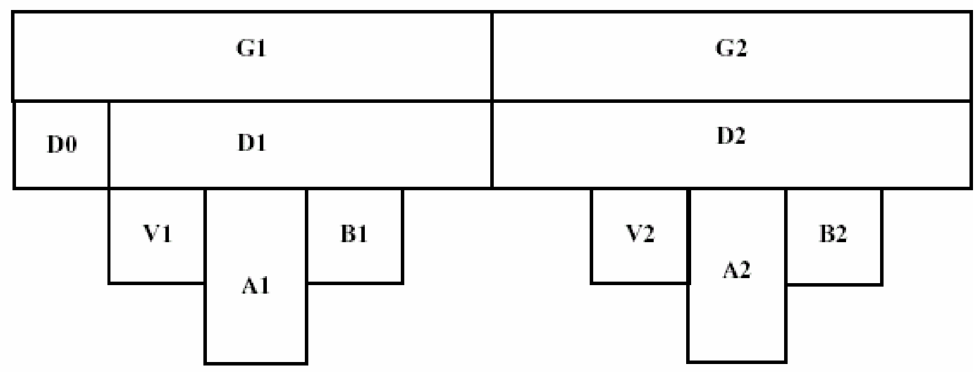
The general Ignalina NPP panorama is shown on Appendix 6. The State Enterprise INPP owned territory covers a total of 2644 ha. The buildings take about 22 ha. Locations of existing and new Spent Fuel Interim Storage (B1) Facilities and new solid radioactive waste retrieval, management and interim storage facility (B2/3/4) are shown on Appendix 7.

As shown on Figure 4-1, each unit consists of five construction buildings; namely, buildings designated as A, B, V, G and D. Reactor buildings A1 and A2 are adjacent to a common building D1 and D2 housing the control rooms, the electric instrumentation rooms and the de-aerator rooms. D buildings are adjacent to a common turbine hall G. The main buildings of the plant are situated about 400-500 m from the banks of Lake Drūkšiai.

Both units have the following common facilities: low-activity waste storage (buildings 155, 155/1, 157, 157/1), medium - and high-activity waste storage (buildings 157, 157/1), liquid - waste storage (buildings 151 and 158), a 110/330 kV distribution system, nitrogen and oxygen manufacturing facility (building 137) and other auxiliary systems. The building 111 which houses the 12 diesel-generators (six diesel-generators per unit) for emergency power supply is physically separated from other buildings. A separate water-pump service station is also built for each unit, serving the needs of uninterrupted supply of water.

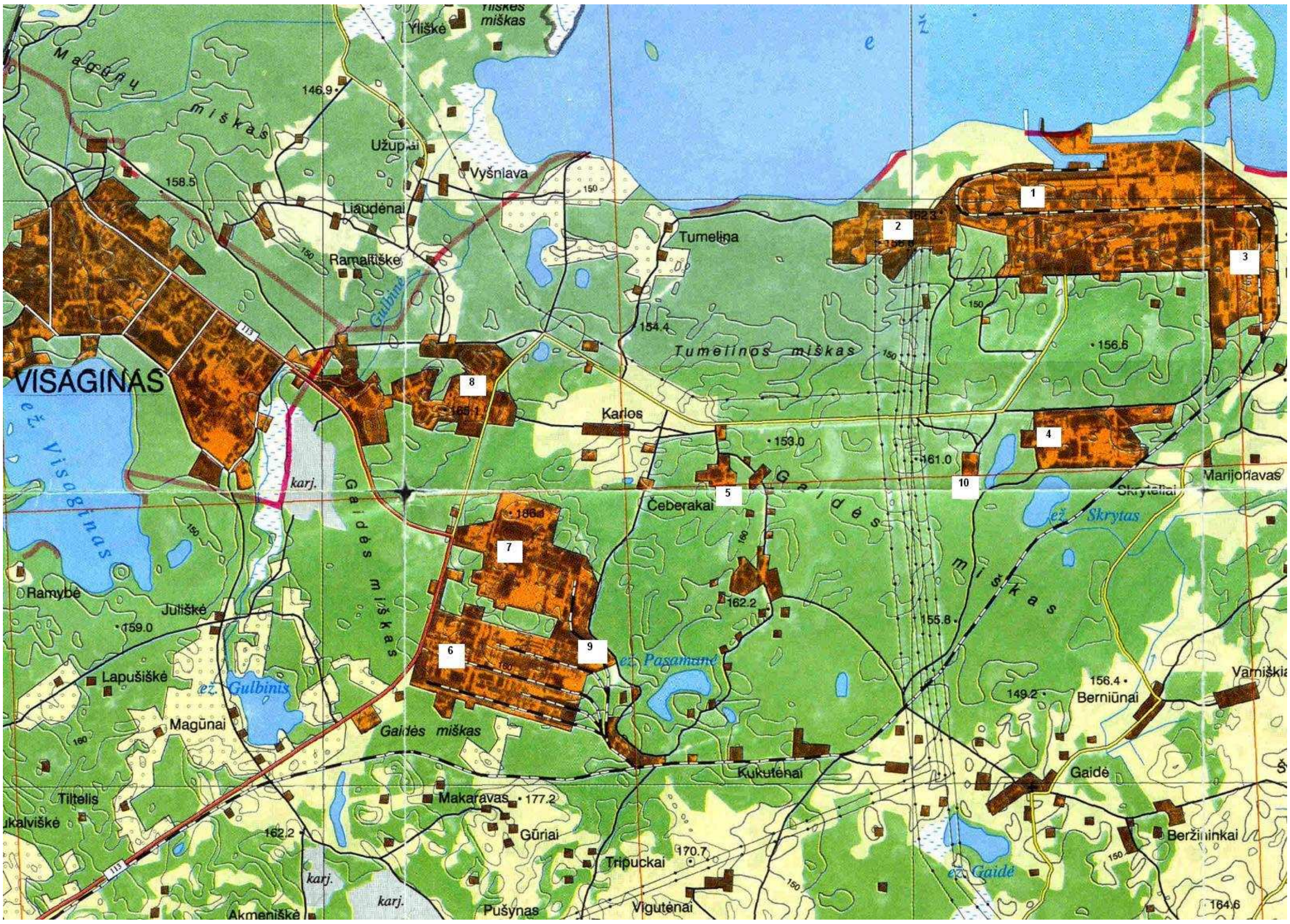
A panorama of the auxiliary services for the Ignalina NPP is shown on Figure 4-2.

Figure 4-1 General Units Arrangements



A1, A2 - reactor buildings; B1, B2 - demineralised water treatment facilities of the MCC; V1, V2 - reactor gas circuit and special venting system;, G1, G2 - turbine generators with auxiliary systems, feed facilities and heat supply facilities; D1, D2 - control, electrical and de-aerator rooms; D0 - heat pipe service and fire fighting facilities.

Figure 4-2 Panorama of Auxiliary Services



1 - NPP site, 2 - open distributive system, 3 - supply base, 4 – sewage purification constructions, motor transport department, 5 - artisan well site, 6 - construction base, 7 - industrial construction base, 8 - military base, health clinic, 9 - heat boiler station, 10 – Visaginas dumpsite.

4.1.3 Plant Layout

The structure and layout of the main buildings of Ignalina NPP are subordinate to the peculiarity of the requirements of the RBMK-1500 reactor operation. Figure 4-3 shows the top view of the buildings. Cross-sections A-A and B-B through the building are displayed in Figure 4-4and Figure 4-5, respectively.

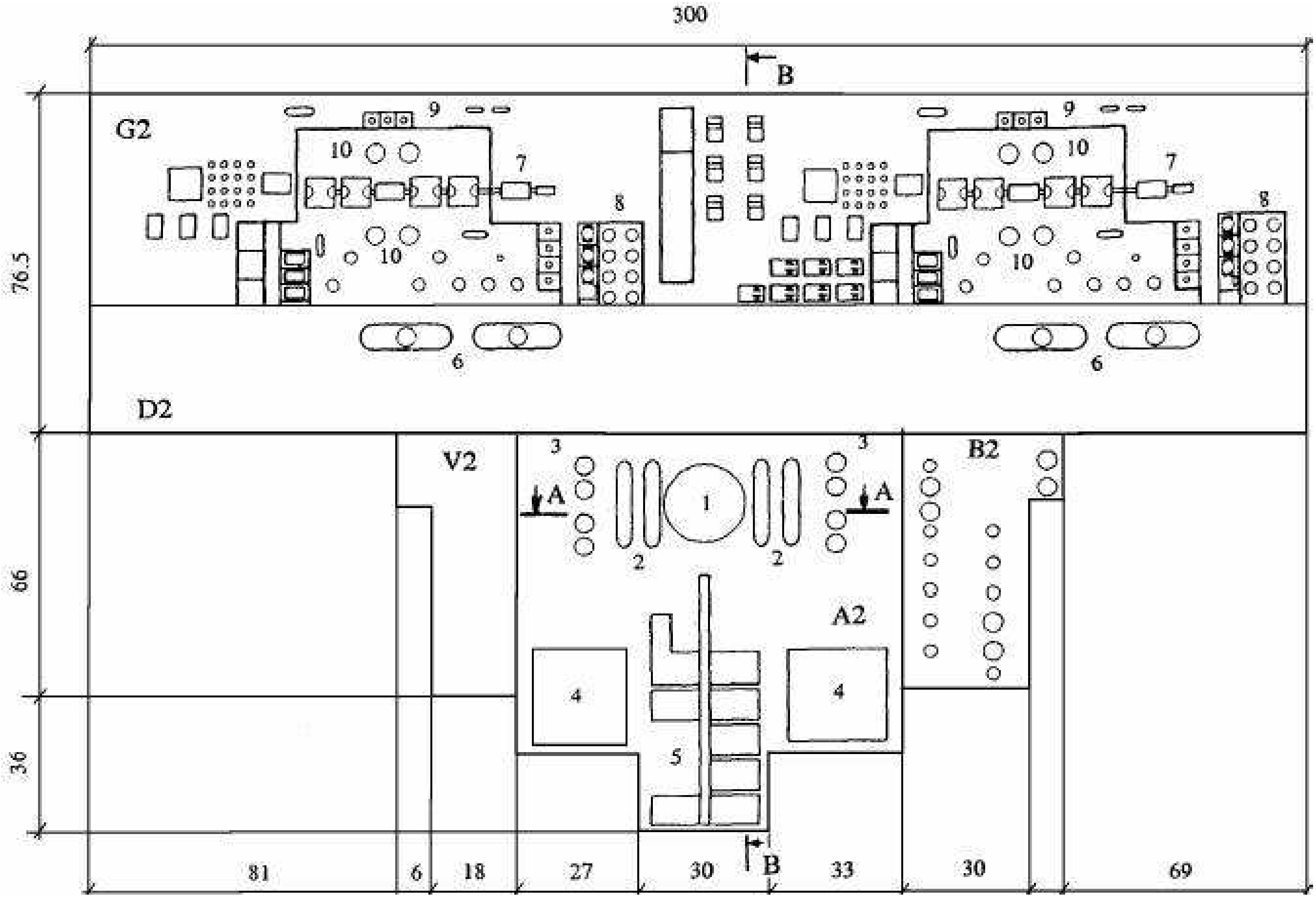
Building A contains an RBMK-1500 reactor with a Main Forced Circulation Circuit (MCC), and the following main auxiliary systems of the reactor: Emergency Core Cooling System (ECCS), Accident Localization System (ALS) and Control and Protection System (CPS). The hall above the reactor is a large open workspace housing the refuelling machine. The spent fuel storage pond is situated in an adjacent hall, but separated from the reactor hall. The reactor compartment consists of a rectilinear structure, the horizontal cross-section of which is 90 m x 90 m and a height of about 53 m.

Building B houses the primary coolant purification system and the demineralised water treatment facilities. The reactor gas circuit and the special venting system are located in building V. The building area for the special water treatment has dimensions of 66 m x 36 m, and the building for the gas circuit of the reactor measures 66 m x 25 m. Both of these buildings have a height of about 31 m.

Building D houses the main control room, the electrical instrumentation and deaerator rooms. This common building for both units has an area of 600 m x 25.5 m and a height of about 44 m.

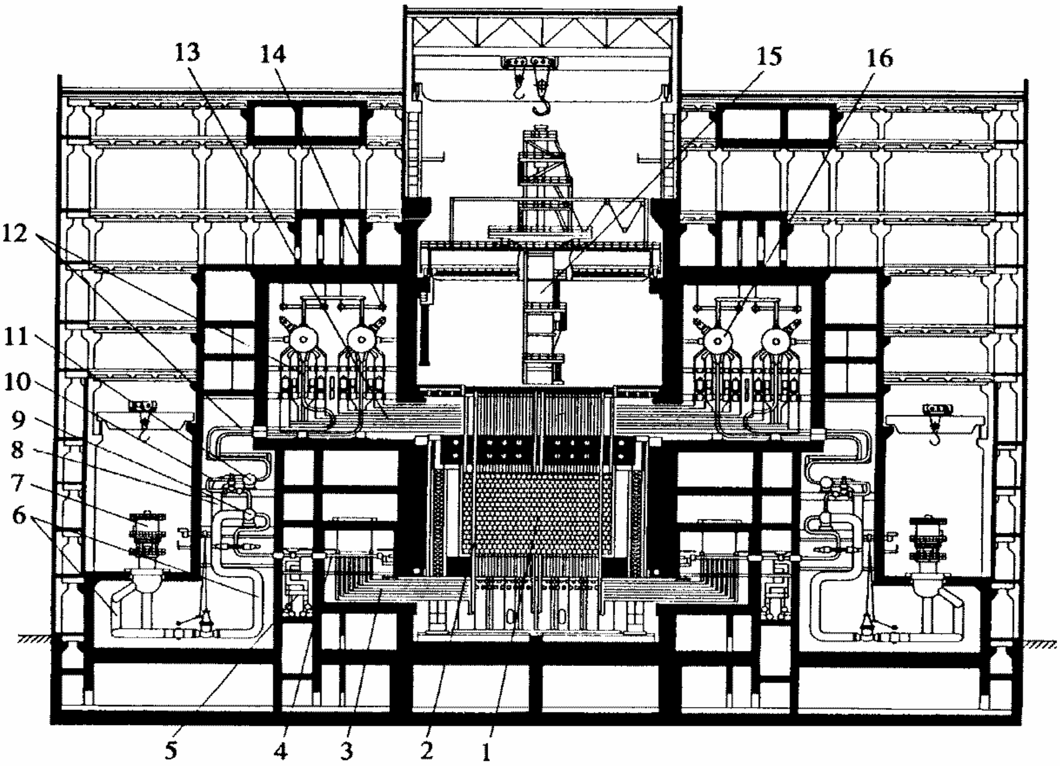
Building G houses the turbine generators with auxiliary systems, the feed and heat supply facilities. The turbine hall is common to both units and houses the four 750 MW turbine and their respective AC generators. Each turbine is assembled on a single shaft with 5 (1HP + 4 LP) cylinders. The first floor of the turbine hall contains condensers, separator-reheaters, evaporators, condensate pumps and components for heat extraction to the district-heating system. The entire building measures 600 m x 51 m and is about 28 m high.

Figure 4-3 Plan of the Ignalina NPP Main Buildings



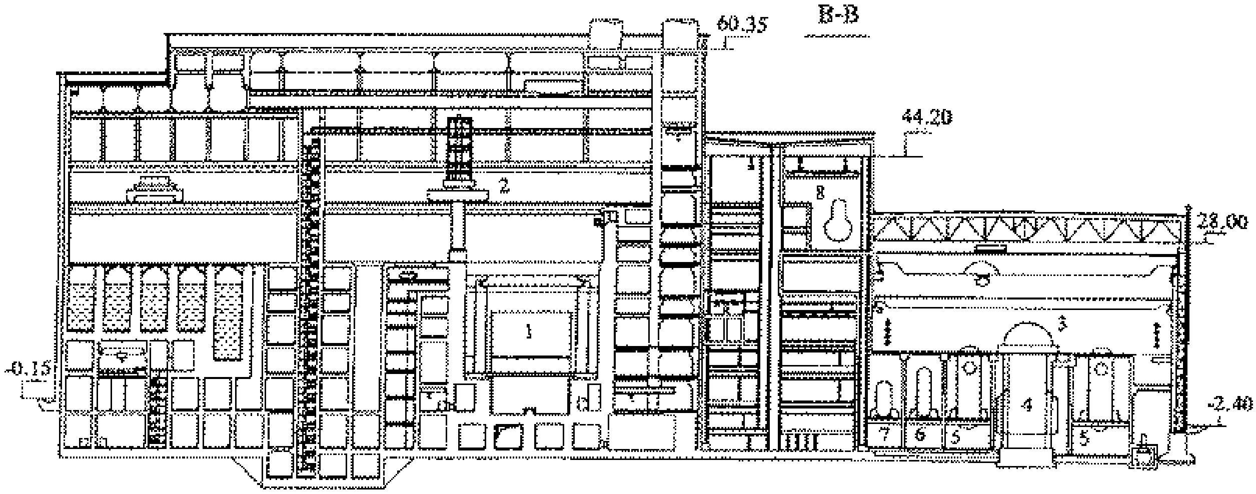
1 – Reactor;
2 - Pressure and suction headers;
3 - Main circulation pumps;
4 - Accident confinement system;
5 - Spent fuel compartment;
6 – Deaerators;
7 - Turbine generators;
8 - Condensate cleaning filters;
9 - First stage condensate pumps;
10 - Separator - reheater.

Figure 4-4 Cross-section A-A of One Unit of the Ignalina NPP



1 - reactor	6 - pressure pipes	12 - downcomers
2 - fuel channel feeder pipes	7 - main circulation pump	13 - steam and water pipes
3 - water pipes	8 - suction pipes	14 - steam pipes
4 - distribution header	9 - pressure header	15 - refuelling machine
5 - emergency core cooling pipes	10 - bypass pipes	16 - separator drum
	11 - suction header	

Figure 4-5 Cross-section B-B of One Unit of the Ignalina NPP



1 - reactor, 2 - refuelling machine, 3 - turbine, 4 - condenser, 5 - separator - reheater, 6 - evaporator, 7 - first stage of the condensate pump, 8 – deaerator.

4.1.4 Power Plant Parameters

The Ignalina NPP belongs to the category of "boiling water" reactors, a simplified thermal diagram of which is provided on Figure 4-6. As it passes through the reactor core the cooling water is brought to boiling and is partially evaporated. The steam - water mixture is then routed to the large separator drums (3), the elevation of which is above the reactor. Here, the water settles down, while the steam proceeds to the turbines (4). The condensate is returned via the de-aerator (8), by the feed pump (9) to the water of the same separator drum (3). The coolant mixture is returned by the main circulation pumps (10) to the core, where part of it is again converted to steam.

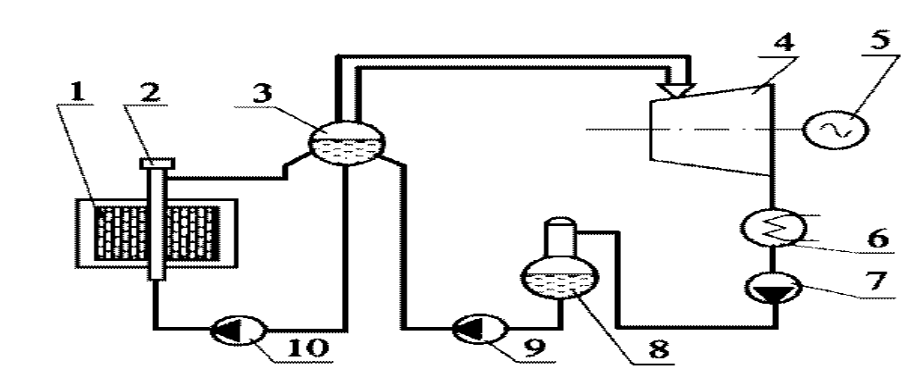
This fundamental heat cycle is identical to the Boiling Water Reactor (BWR) cycle extensively used throughout the world, and is analogous to the cycle of thermal generating stations. However, compared to BWRs used in Western power plants, the Ignalina NPP and other plants with the RBMK-type reactors have a number of unique features. The most important features are discussed in the subsequent sections.

The Ignalina NPP uses an RBMK – channel-type reactor. This means that each nuclear fuel assembly is located in a separately cooled fuel channel (pressure tube). There are a total of 1661 of such channels and the cooling water flow rate must be equally divided among associated feeder pipes. After crossing the core, these pipes are brought together to feed the steam-water mixture to the above - mentioned separator drums. Main plant parameters are presented in Table 4-1.

The RBMK reactors belong to the thermal neutron reactor category. Due to the large number of metal piping in the core of this type of reactor, the neutronic characteristics of the reactor are degraded. To improve the neutronic characteristics, the reactors of Ignalina NPP use graphite to moderate the fast fission neutrons. This requires a large amount of graphite, so that the graphite stack of the reactor becomes its dominant component, at least by volume.

The nuclear fuel assemblies of the Ignalina NPP are changed without shutting down the reactor. This is possible only for channel type reactors. Since there are many channels, it is possible to disconnect one of them at a time from the reactor cooling system, change the fuel assembly, and then reconnect the channel.

Figure 4-6 Heat Cycle Diagram



1 - reactor, 2 - fuel assembly, 3 - separator drum, 4 - turbine, 5 - generator, 6 - condenser, 7 - condensate pump, 8 - deaerator, 9 - feedwater pump, 10 - main circulating pump.

Table 4-1 Most Important Plant Parameters per Unit

Coolant	water (steam-water mixture)
Heat cycle configuration	single circuit
Power, MW:	
• thermal (design)	4800
• thermal (actual)	4200
• electrical (design)	1500
Core dimensions, m:	
• height	7
• diameter	11.8
Thickness of reactor's graphite reflector, m:	
• end	0.5
• side	0.88
Lattice pitch, m	0.25 x 0.25
Number of channels:	
• fuel	1661
• control and shutdown system	235
• reflector-cooling	156
Fuel	uranium dioxide
Initial fuel enrichment for ^{235}U, %	2.0 *
Nuclear fuel burnup, MW·days/kg	21.6**
Number of main circulation pumps	8
Capacity of main circulation pumps, m^3/s (m^3/h)	1.805 - 2.22 (6500 - 8000)
Temperatures, ^oC:	
• maximum acceptable temperature at centre of fuel pellet	2600
• maximum acceptable graphite stack temperature	760
• maximum acceptable fuel cladding temperature	700
• maximum acceptable fuel channel temperature	650
Coolant temperature at fuel channel inlet ***	260 - 266
Feed water temperature ***	177 - 190
Pressures, kgf/cm^2:	
• at separator drum	67
• at pressure header	86.6
Coolant flow rate through reactor, m^3/s (m^3/h)***	10.83 - 13.33 (39000 - 48000)
Steam produced in reactor, kg/s (t/h)***	2056 - 2125 (7400 - 7650)
Steam fraction at reactor outlet, weight %	23 - 29
Maximum fuel channel parameters:	
• fuel channel power, kW	4250
• coolant flow rate through fuel channel, m^3/s (m^3/h)	0.0111 (40)
• steam fraction at fuel channel outlet, weight %	36.1

* Now the fuel is being changed to 2.4 % and 2.6 % enrichment fuel with erbium as burnable neutron absorber.
** At 2% ^{235}U fuel enrichment.
*** At 4200 MW(th).

When analysing emergency conditions and establishing safety measures, the RBMK-1500 design is based on the following safety criteria:

a) with the reactor at nominal power, breaking of the maximum diameter pipe with discharge of coolant from both ends is considered to be the Design Basis Accident (DBA);

b) first design limit of fuel element failure under normal operating condition:

I. 1% of fuel elements with gas leakage-type defects,
II. 0.1% of fuel elements having defects resulting in direct contact between coolant and fuel;

c) second design limit on fuel failure:

I. fuel cladding temperature less than 1200^{o}C,
II. local depth of fuel cladding oxidation less than 18% of initial clad thickness,
III. fraction of zirconium oxidation less than 1% of fuel cladding weight in one group distribution header channels (about 40 of such channels).

4.1.5 Primary Masses

According to the data of INPP Preliminary Decommissioning Plan, Table 4-2 contains the results of the collection of the primary mass, grouped by buildings. The result, in total about 129,100 tons, covers only masses of the equipment and material to be decommissioned and of already stored waste. It does not take the building structures into account.

Table 4-2 The Results of the Collection of the Primary Mass, Grouped by Buildings

Building	Name	Unit 1 [ton]	Unit 2 [ton]
		Common [ton]	
A	Main building, block A. Reactor building	29,652	29,652
B	Main building, block B. Low-salt water facility and bypass water treatment facility of the MCC	1,625	1,625
D0	Main building, block D0.Heat pipe service and fire fighting facility	974	
D	Main building, block D. Control, electrical and deaerator rooms	7,132	7,132
G	Main building, block G. turbine generators with auxiliary systems	19,575	19,575
V	Main building, block V. Reactor gas circuit and special venting	728	728
117	Pressurised tank of the ECCS	1,031	1,031
119	Heat supply station	1,917	
130	Repair building	1,020	
135	Gas holding chamber	2	2
140	Recreational facility	57	57
150	Liquid waste treatment building	2,166	
151/154	Waste water tanks / Operational water reservoirs	874	
152	Low-salt water tanks	118	118
153	Venting stack	346	346

Building	**Name**	**Unit 1 [ton]**	**Unit 2 [ton]**
		Common [ton]	
154	Operational waste reservoirs	387	
155	Solid low-level waste storage facility	121	
157	Solid radioactive waste storage facility	149	
158	Bituminised radioactive waste storage facility	266	
	Other Buildings (Fresh fuel storage, galleries, cable tunnels, sanitary passageway, gas holding chambers)	696	
	Total Unit 1 / Unit 2	60,265	60,265
	Total Common Buildings	8,570	
	Grand Total	129,100	

A rough estimation of the INPP civil engineering structures, i.e. inventories of concrete, steel bars and steel beam masses of the Buildings of INPP site has been made.

From this estimation, the dismantling of the civil works at INPP site will result in global amounts of concrete/steel waste of about:

- For the INPP Units: 730,000 m^3 of concrete and 170,000 tons of steel;

- For the INPP ancillary facilities (Building 158, Bitumen compound storage, excluded): 430,000 m^3 of concrete and 60,000 tons of steel.

For what concerns U1DP0 Project, there will be no removal of such masses.

4.2 U1DP0 Project Content

The U1DP0 Project covers the period between Unit 1 Reactor Final Shutdown (RFS) and the total defuelling of the Unit.

After RFS, many systems and components will stay in operation because the spent fuel and all other radioactive inventory will remain in place at that time. Ensuring continuous safety will require further operation of most of the systems. In the course of the relocation of the Fuel Assemblies from the core to the pools and from the pools to the Interim Spent Fuel Storage Facility and, later on also, after removal of the radioactive media from the components, the systems can be shut down step by step. Other systems, which are needed for further operational purposes or which, for dismantling purposes, should remain in operation will be modified if needed.

It is reasonable and underlined by worldwide experience that, systems modifications and isolations, all fuel related activities and associated maintenance, must be carried out by existing operational staff and covered by operational license.

During this project the following activities will be completely carried out or will be started:

- Systems isolation and modification activities;
- Removal of nuclear fuel from the core and from the pools;
- Removal of the coolants, gases and other materials from the operating circuits;
- Removal of the combustible and toxic materials of the systems;
- In-line decontamination of systems / equipment;

- Decontamination and / or cleaning activities (of the “housekeeping” type, i.e. by vacuum cleaner, etc.);
- Operational waste management activities.

Also decommissioning needs preparation activities regarding:

- Decommissioning generic activities;
- Decommissioning preparatory activities;
- Decommissioning procurement activities.

U1DP0 integrates those activities and analyses them with respect to manpower and investment needs, doses to the personnel and the public, waste, safety of Unit systems configuration.

In order to achieve this result and allow for further decontamination and dismantling activities (D&D Projects), it is necessary to carry out the following activities.

4.2.1 Unit 1 Reactor Final Shutdown

The Reactor Final Shutdown involves the elimination of the specific risks associated with a nuclear power plant in operation.
A systems analysis identifies which safety functions, and therefore which safety systems can be definitively isolated taking into account the fact that Unit 1 will never restart and that Unit 2 remains in normal operation for a period of 5 years. Very few safety systems will be affected by this new configuration of the plant.

It is proposed to definitively isolate, on an irreversible way, those systems which are for sure not anymore needed; the aim to be pursued by executing definitive isolation is to eliminate, as soon as possible, unnecessary risks associated to these systems.

Beside isolation of specific systems of Unit 1, special attention must be devoted to systems that are common to Units 1&2 and which must remain in operation for Unit 2. The analysis will allow listing the systems which will not be modified or which will be modified.

During the 5 year period during which Unit 1 is “definitively stopped” and Unit 2 remains in operation (should its final shutdown take place end of 2009), a third aspect to be considered is the physical separation between areas of units 1&2 for which it will be requested to control and to restrict entrance and exit of personnel.

4.2.2 Unit 1 Defuelling

The removal of the nuclear fuel from the plant involves the elimination of the specific risks related to the presence of nuclear fuel in the core and in the pools.

The remaining safety functions are:

- to prevent criticality;
- to cool down the fuel;
- to prevent any fuel handling accident;
- to avoid spread of contamination;
- to maintain adequate radiation protection.

The nuclear fuel will be removed under the extended operation license, according to the existing and the new transfer and transportation procedures; the operation will be done in two stages, the first one being the core de-fuelling and the second one being the pool de-fuelling.

The reactor core defuelling could start after RFS, the Spent Fuel Assemblies (SFA) being transferred to the pools, at least for those not to be reused in Unit 2. The amount of SFA transported in pools (before B1[39] and B8[40] are made available) will depend on the free space in the pools.

The systems analysis has to identify for core de-fuelling and for pool de-fuelling which safety functions are no more requested, and therefore which safety systems could be definitively isolated, knowing that fuel will never be reloaded in the core, or loaded in the pools.

Operations related to the fuel removal and its transportation outside the limits of INPP Unit 1, must be separately analysed, because they are non usual but specific to the decommissioning project (see Remark hereafter).

A further particular operation concerns the removal of parts from damaged fuel assemblies. The activities included in this particular operation are described in the frame of the B1 investment projects.

After fuel removal from Unit 1, the radiological risks remaining are only related to the presence of radioactive materials. The main safety functions disappearing are related to the criticality control, to the cooling and to the handling of the fuel assemblies.

Remark: Unit 1 Defuelling

The defuelling pattern of Unit 1 reactor has not been confirmed yet by INPP by the time of issuing U1DP0 and its associated EIA. However, on the basis of the currently available information the following defuelling programme has been taken into account for U1DP0 preparation:

- period July 2006 – December 2008: progressive transfer of 1300 fuel assemblies from Unit 1 reactor for recycling into Unit 2 reactor, the commissioning of B8 being scheduled in June 2006;

- period September 2008 – December 2008: defuelling of the remaining 361 fuel assemblies, not recycled in Unit 2, according to the usual procedures – transfer to the uncut fuel assemblies spent storage pools, to the cutting cell and to the cut spent fuel assemblies storage pools, the commissioning of B1 being scheduled in January 2008.

The production of gaseous and liquid waste and the corresponding releases into the environment are addressed in chapter 6 of this EIA on the basis of the technical information already gained on B1 and B8, and of operational data related to the current defuelling operations (see also U1DP0 Appendices 3.26 and 3.43 for more details).

[39] **B1:** design and Construction of an Interim Storage Facility for RBMK Spent Nuclear Assemblies for INPP Units 1 and 2.

[40] **B8:** Transportation of partially burnt nuclear Fuel Assemblies from Unit 1 to Unit 2 for re-use in the reactor of Unit 2.

The plant personnel exposure (individual and collective doses) is also addressed in the same Appendices, in chapter 7of U1DP0 and summarised in section 6.10 of this EIA.

The radiological consequences of incidents/accidents will be addressed in the SAR and EIAR associated to B1, B8 and Unit 1 Reactor Defuelling Projects.

4.2.3 In-line Decontamination Activities

In particular, U1DP0 covers the in-line decontamination of the Main Circulation Circuit, the Purification and Cooling System and the Refuelling Machine. These operations can start after the complete defuelling of Unit 1 reactor. These operations, together with the decontamination waste conditioning, can start on January 2009 and are scheduled over a 6 month period for MCC + PCS and the refuelling machine.

4.2.4 Other Related U1DP0 Activities

4.2.4.1 Decommissioning Generic Activities

These activities include:

- General administration of the site;
- Project management;
- Engineering & licensing documentation, under which there are:
    - Preparation of the technical concept, which describes the main aspects of the decommissioning project, variants, etc.,
    - Selection of appropriate technologies,
    - Calculation of the needed personnel capacity,
    - Calculation of the cost,
    - Collection of inventory data,
    - Radiological calculations,
    - Sampling and dose rate measuring programme;
- Administrative finalization = the completion and the approval of the elaborated documentation concerning the decommissioning activities from the previous phase and the check of the achieved status;
- Health physics, which includes:
    - Radiological surveillance,
    - On-site measurements,
    - Radiological laboratory,
    - Environmental surveillance,
    - Health physics documentation,
    - Waste documentation;
- Conventional security: This work package will deal with precautions and actions to be taken in order to ensure the conventional security of the workers. It also takes into account the staff needed to prepare and document those actions and to control that they are correctly implemented.

These activities have **no significant environmental impacts**, though environmental surveillance and waste documentation are of course important as environmental management and monitoring.

4.2.4.2 Decommissioning Preparatory Activities

These activities include:

- DPMU Engineering and Investments, under which are to be implemented:
  - A1 / Engineering, safety and licensing documentation,
  - B1 / Interim Spent Fuel Storage Facility,
  - B2/3/4 / Solid Waste Management and Storage Facilities,
  - B5 / Steam and heat plant,
  - B6 / Technical archive;
- INPP Engineering and Investments, with:
  - Facilities for retrieval and cementation facilities of spent resins and perlites and interim storage facility for corresponding conditioned waste,
  - B8/ Transport of partially burnout Fuel Assemblies from Unit 1 to Unit 2 for re-use;
- INPP DS detailed Engineering and Investments:
  - B7/ partial restoration of INPP territory,
  - Exhaustive data bases,
  - Procedures preparation,
  - Landfill design and construction,
  - NSR design and construction,
  - Training center adaptation for decommissioning purposes;
- Site preparatory activities:
  - Radiological mapping; radiological sampling & measurements,
  - Physical separation of Unit 1 and Unit 2,
  - Other physical separation measures,
  - Modifications will be made to utilities distribution. For example, after RFS, the shutdown Unit will electrically be fed from the grid. The need to keep in operation one or several emergency diesel generator(s), or to decommission the existing ones and put new ones in service will be further assessed.

These activities have **no significant environmental impacts**, as it covers preparatory and engineering activities (see also section 6.3).

4.2.4.3 Decommissioning Procurement Activities

These activities include:

- Installation of new equipment in the plant; this working package includes following items (non exhaustive list):

    - Stationary band saw, hydraulic shears devices, external cutters, laser cutting units;
    - Mobile air extraction and filter systems;
    - High pressure water cutting unit (with ancillaries);
    - Concrete shavers, breakers;
    - Measuring station for drums and containers dose rates (pre-characterization of dismantling work);
    - Materials radioactivity measurement facilities (to control the free release levels) to further use the materials not applying the radiation control;
    - Lifting devices;
    - Facilities for chemical and mechanical decontamination;
    - The system for treatment of radioactive liquid waste and liquid secondary[41] waste resulting from the decontamination processes (mobile systems may possibly be applied), should this waste not be conditioned by the existing or planned facilities (see also section 6.4).

    The major preparation works are related to the dismantling of the activated components of the reactor as well as for the radioactive layers of the biological shield. These refer to the installation of the remote handling devices and the necessary shielding (cf. decommissioning projects Unit 1&2).

These activities have **no significant environmental impacts**, as it goes about equipment transport to INPP and installation.

4.2.5 Duration of Phases

The operation license was extended in 2004 till the complete de-fuelling of Unit 1. It will cover the defuelling, i.e. the core defuelling and the pools defuelling, until the estimated date of 31st December 2012. The next table gives a summary of the major phases' schedule.

Table 4-3 Schedule for the Main Phases of U1DP0

Period	Activities
2006	Reactor Final Shutdown
2006 – 2008	Reactor Defuelling - transfer of re-used Fuel to Unit 2
2008	Reactor Defuelling - transfer of Spent Fuel to pools
2009	In-line decontamination activities
2008 – 2012	Unloading Spent Fuel from pools to Interim Storage Facility

When all fuel is removed from Unit 1 (scheduled at the end of 2012), a new license, called "Decommissioning License", can be introduced in order to perform the next decommissioning activities, because safety functions and regulatory context is rather different than previously.

[41] Secondary waste is waste which is generated during handling, treatment and disposal of waste.

4.3 Project Characteristics that Impact the Environment

4.3.1 Identification of the Technical and Operational Features that will impact the Environment

4.3.1.1 Masses of Equipment and Structures that are contaminated or potentially contaminated

For both units, the overall mass inventories of the main equipment and structure located in the controlled zone of the plant are as following:

a) Carbon steel, stainless steel equipment (tanks, pipe system, valves, heat exchangers) = 63000 tons;
b) zirconium channels = 214 tons;
c) graphite (moderator) = 3600 tons;
d) structural materials, steel girders, stair doors = 33422 tons;
e) electrical equipment = 12731 tons;
f) cables = 3378 tons;
g) thermal insulation + sheathing materials 2018 tons

The levels of contamination of the above equipment and materials widely vary in function of their location and operational conditions. A data base and radiological characterization was prepared in the FDP.

4.3.1.2 Routine Contamination of the Main Circulating Fluids and of the Corresponding Circuit, of the Operational and Decommissioning Waste

The contamination of the Main Cooling Circuit (MCC) as well as of the nuclear auxiliary circuits functionally linked to the MCC result from the following phenomena:

a) the in-core activation of the erosion-corrosion products of the MCC pipe system, equipment (drums-separators, main coolant pumps, headers) and of the in-core channels;
b) the presence of fission products (FP), including the U and TRU nuclides[42], as a result of the tramp U235 fission and of release of those nuclides via the fuel cladding defects.

The MCC contamination levels of the activated corrosion products, of the FP, U and TRU nuclides determine:

a) the contamination of the operational process and technological waste;
b) the contamination of the decommissioning waste, i.e. the contamination of the to be dismantled equipment and, when relevant, of their spent decontamination solutions, of the contaminated process[43] and technological[44] waste generated during the different phases of the decommissioning.

[42] U and TRU = Nuclides of the Uranic and trans-Uranic groups (U235, U238, Pu, Am and Cm isotopes).
[43] Process waste = spent filters, ion-exchange resins and perlite, evaporator concentrates.
[44] Technological waste =all the miscellaneous solid waste.

A. Activated corrosion products

The short term contamination of the operational and decontamination waste will be governed by short lived γ emitters (such as: Mn^{54}, Co^{58}, Co^{60}, Fe^{59}, Zr^{95} and Nb^{95}), while the long term activity of this waste will be governed by weak β-γ emitters (such as: C^{14}, Ni^{59}, Ni^{63} and Nb^{94}). These latter nuclides belong to the so-called category of "difficult – to – measure" critical nuclides (DTM critical nuclides).

The methodology developed to assess the inventories of these DTM critical nuclides in the operational and decommissioning waste is detailed in Chapter 6 of the FDP.

B. Fission products (FP), U and TRU nuclides

The contamination of the MCC and of the nuclear auxiliary circuits by FP, U and TRU nuclides result from the occurrence of the following phenomena:

a) The fission of tramp U^{235}, taking place outside of the fuel elements, i.e. the fission of uranium particulates deposited on the external walls of the fuel cladding and of uranium particulates present in the MCC and circulated through the core. The presence of short lived I^{134} in the MCC is an indicator of tramp uranium fission;

b) The release of FP from the fuel pellets by diffusion via the cladding defects.

The above mechanisms lead to quite different spectra of FP in the MCC and in the nuclear auxiliary circuits. Their contribution to the overall contamination of this circuit is detailed in Chapter 6 of FDP. A particular attention has been paid to the assessment of the long lived and DTM critical nuclides (such as: Sr^{90}, Te^{99}, I^{129}, Cs^{135}, Cs^{137}, U^{235}, U^{238}, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{241}, Am^{241}, Pu^{242} and Cm^{244}) inventories in the MCC and in the auxiliary circuits, in the operational and decommissioning waste.
The methodology developed to assess the inventories of the FP, U and TRU nuclides in the operational and decommissioning waste is given in Chapter 6 of the FDP.

4.3.1.3 Events during INPP Operations that can produce Impacts on the INPP Decommissioning Programme

The concern is to identify the operational events that may have a significant impact on the contamination levels of the operational and of the future decommissioning waste and/or that may lead to the implementation of special cleaning decontamination and dismantling techniques, such as:

a) excessive contamination levels of the circuit by fission and activated corrosion products;

b) spillage of contaminated fluids on the floors;

c) leakages from the spent fuel pools cladding and contamination of the concrete structures;

d) contamination of the soils outside of the INPP main and auxiliary (waste treatment facilities) buildings as a result of leaks;

e) incidents/accidents during the fuel handling operations;

f) long term accumulation of contaminated sludge onto the bottom of tanks of large reservoirs (spent fuel pools) with poor circulation ("dead zone").

It is worth to point out that, in order to maintain good working conditions and to comply with the ALARA objectives, INPP has implemented several "good practice" rules in the operational procedures.

For what concerns excessive Contamination of the MCC by FP, U, TRU and activated corrosion products (see also Chapter 6 of FDP):

I. The specific activity of Cs^{137} in the MCC remains often below the detection limits. Upon occurrence of noticeable fuel cladding defects, the Cs^{137} specific activity is usually kept in the range of $1 \cdot 10^{-7}$ - $1 \cdot 10^{-6}$ Ci/l ($3.7 \cdot 10^{6}$ – $3.7 \cdot 10^{7}$ Bq/t), i.e. never exceeds $1 \cdot 10^{-6}$ Ci/l ($3.7 \cdot 10^{7}$ Bq/t). Fuel assemblies developing excessive cladding defects are systematically removed from the core and stored in dedicated casks. It is also worth to mention that the specific activities of short lived iodine nuclides (I^{131}, I^{133} and I^{134}) remain usually very low (i.e. lower by 2-3 orders of magnitude than the design values), confirming thereby the low rate of fuel cladding defects and the low inventory of tramp uranium in the MCC.

II. Similarly, the MCC specific activities of the activated corrosion products remain generally very low. So, the specific activity of Co^{60}, i.e. the γ emitter governing the equipment dose rates at steady state is, usually, $< 1 \cdot 10^{-7}$ Ci/l ($3.7 \cdot 10^{6}$ Bq/t).

III. Further the MCC purification rate is kept at a high flow rate, i.e. 400 t/h. This leads to about 400t/h/1,000t = 0.4 change per hour of the MCC water mass inventory (1,000t). For indicative purpose, in VVER 440 and 1000, the purification rate of the primary circuit is such that water inventory change rate is lower than or equal to $0.1h^{-1}$.

As a conclusion, it can be stated that, up to now, the radioactive contamination of the MCC has always been kept at a low level.

Spillage of Contaminated Fluids on the Floors

In accordance with operational procedures the radiological conditions in the INPP compartments are measured on a regular basis. Should the contamination level exceed the relative operational limit, the necessary corrective measures are taken as soon as possible. These measures can include: decontamination of equipment, rooms' floors and walls, removal of contaminated concrete, installation of additional shielding etc. The results are controlled by health physicists. The limits of INPP compartments contamination for different zones are given in the Table 4-4 [72], [73].

Table 4-4 The Limits of INPP Compartments Contamination for Different Zones

Controlled parameters	III	II
Dose rate	<12 μSv/h	12 ÷ 56 μSv/h
Surface contamination	< 4 Bq/cm^2	4 ÷ 40 Bq/cm^2
Aerosols	185 Bq/cm^3	185 ÷ 1110 Bq/cm^3

In category II areas, the working time is regulated by the Radiation Protection Department of INPP. For example, for a γ dose rate of 24 μSv/h, the working time is limited to 50% (3 hours) of the total effective working time. In the category III area, the working time is normal working time.

In case of leakages, the measures on localisation or elimination (if possible), prevention of contamination spreading, preliminary decontamination are carried out by operational personnel. The further thorough decontamination and contaminated structures removal, down to the radiological operational limits, can take place if necessary [74]. The most significant events concerning concrete construction contamination and which took place at INPP are:

- The contamination of box 051A1 and adjacent corridors resulting from leakage through the refuelling machine drainage filter. The contaminated layer of concrete floor under the PVC sheets was removed over a surface area of ~60 m^2. The contaminated concrete was transferred to the radioactive waste storage facility. Such event occurred several times.

- The contamination of floor in the box 012B1 resulting from leakages from low salt water purification system pumps and damaged PVC sheets. The concrete floor under PVC sheets was contaminated over a surface area more than 100 m^2. The contaminated layer of concrete was removed; the plastic sheets were replaced by a stainless steel lining.

- The contamination of concrete structures of leak-tight compartments. All leak-tight compartments of INPP have metal floor lining for collecting of equipment leakages. Defects in the floor lining result into contamination of concrete structures in case of leakages. It is impossible to carry out measurements in these structures during exploitation, but taking into account that dose rate from the concrete structures cooling ventilation system ducts reached 0.3mSv/h, a significant contamination of the concrete under floor lining has to be expected. Aforesaid is also true for Accident Localisation System constructions and compartments of Primary Circuit Purification System.

The other possible source of building constructions contamination consists of drainage pipelines, which are installed inside the walls of buildings. In case of leakage, the contamination of surrounding concrete will occur.

It's important to note, that there is no database of events, connected with spilling of contaminated liquids, at INPP. So, at present it is practically impossible to state what the residual activity was after completion of the decontamination works.

The above concerned contaminated areas will require a careful radiological monitoring. Indeed, the experience has shown, for example at Greifswald NPP (Germany) that is now under decommissioning, that significant concrete contamination could occur over depths such as 15-20 cm under surface layer, and this despite of an apparent good condition of the soil protective epoxy.

Leakages from the Spent Fuel Pools Walls

There is a special system for collecting leakages from spent fuel pools liner. It consists of layer of porous concrete, metal tray and equipment for leakage flow measuring.

During operation period there were 14 cases of spent fuel assemblies' (SFA) drop. All these assemblies were lifted later, and significant damages of some fuel elements were observed. Because of lack of historical records, it is impossible to ascertain quantity of other items (additional absorbers, suspensions, power density sensors, etc.) dropped into the spent fuel pools, but such events took place repeatedly. However, only one FA drop led to damages of the pool liner.

In May 1989, penetration of bottom of pool 236A1 occurred as a result of a fuel assembly drop. Leakage flow was $3m^3/h$. The hole was pressurized by special rubber plaster in short time, and the leakage was eliminated.

Currently, it is reasonable to assume, that whole porous concrete construction is contaminated.

Contamination of the Soils outside of the INPP Main and Auxiliary Buildings

The dose rate of INPP site is regularly monitored. Some local contaminations were revealed nearby transport gates and along waste transportation ways. In most cases, contamination was caused by very small particles blown down during waste containers transportation and/or unloading. In all cases contaminated soil was removed to the waste storage immediately after the contamination was observed.

The most significant event occurred on 15/05/2001 as a result of waste container drop during transportation. Approximately 0.3 m^3 of solid waste spilled on a surface area of 30 m^2. The decontamination by vacuum cleaners was carried out during the evening of same day. Finally, the road asphalt was removed over the depth of 10 cm at places, where decontamination was not successful. The residual dose rate has not exceeded 0.4 μSv/h [74]. This incident was classified as level 1 on the INES scale.

So, it is possible to state, that there is no contamination at INPP site outside of the controlled area.

Incident/Accident during the Fuel Handling Operations

There were no accidents except those mentioned above in paragraph C). All dropped spent fuel assemblies were lifted, but significant damages of some fuel elements were observed and therefore some quantity of fuel pellets fragments can be presented in the sludge on the spent fuel pools bottom.

Long-term Accumulation of Contaminated Sludge onto the Bottom and of Tanks and of Large Reservoirs with Poor Circulation

Although no specific data are available at INPP, it has to be expected, based on the experience gained in other NPPs, that sludge deposits have accumulated during the plant operation in these low circulation zones (bottom of the spent fuel pools, of large tanks…). This sludge:

I. usually consists of corrosion products oxides;

II. may exhibit significantly high specific activities;

III. are present in quantities that may significantly vary from plant to plant and in function of the concerned areas (i.e. from < 100 kg up to several 100 kg);

IV. will require specific tools and equipment for their removal. Immersed pumps coupled to filtering units operating under the water level of the pools (or large tanks) have been frequently used in western NPPs for this type of application (see Chapter 9 of FDP).

Impact of Operational Events on the Operator Exposure

Due to the lack of operational records by the time of the events occurrence, a detailed analysis of their impact on the decommissioning activities has not been possible.

However, the potential impact of these operational events on the operator exposure during the future decommissioning activities is taken into account in the preparation of the Data Base Sheets (DBS) of each decommissioning activity (see also chapter 6 and Appendix 3 of U1DP0). Indeed, for each decommissioning activity:

- Task 030 includes the establishment of the dose mapping in the areas concerned by the activity, in order to enable the preparation of the ALARA analysis.

- Task 050 deals with the needed preparatory works to be implemented as a result of the above ALARA analysis.

  Examples:

  - decontamination of equipment (system), floors, walls;
  - installation of local (mobile) shielding (e.g. lead wool sheets);
  - installation of additional scaffoldings and/or demolition of structures to ease the access and working conditions of the personnel;
  - installation of handling devices, additional highting systems, local ventilation units and airborne contamination confinement systems.

- Task 090 deals with the training of the personnel involved in the activity:

  - theoretical part including job description, review of procedures and of ALARA objectives, work organisation;
  - practical part including use of tools, training on mockups (when relevant), walk down in the concerned areas with foremen, etc.

4.3.1.4 Spent Fuel Management after RFS of Unit 1 Including the Possible Recycling of Some FA in Unit 2

INPP Unit 1 is to be shut down by 31 December 2004. At this time Unit 2 will still be in normal operation. Prior to starting the decommissioning operations of the reactor, it is necessary to have it unloaded. Any delay for the unloading operations would lead to the same delay for the reactor availability for decommissioning. First task is to unload the reactor and second – to unload decay pools of Unit 1.

So, we can consider two stages after RFS of Unit 1:

- stage 1: unloading all FA from the reactor, placing into the spent fuel pools or reuse part of them in the reactor of Unit 2;
- stage 2: unloading all FA from the SF pools into the interim spent fuel storage facility (ISFSF).

According to real filling of spent nuclear fuel pools, capacity of the existing interim spent nuclear fuel storage facility and operation forecast for a new interim spent nuclear fuel storage facility by the beginning of 2008, duration of stage 1 can be determined as follows: from 1 January 2005 to 31 December 2008, stage 2 – from beginning of 2008 to 31 December 2012.

After the final shutdown of Unit 1 (31/12/2004), about 1660 partially burnt FA will remain in the core and approximately 1300 of them will show burn-up allowing for possible reuse in Unit 2. By redirecting those FA into the core of Unit 2, a saving of 670 equivalent new FA could be achieved and the required storage capacity of the new Interim Spent Fuel Storage Facility reduced accordingly. In order to minimize the risks linked to fuel assemblies handling, the partially burnt FA will be transferred from reactor to reactor without intermediate storage in decay pools.

For Unit 2 if final shutdown is to occur on 31/12/2009, the reactor will be free of fuel by the end of 2010. The fuel decay pools of Unit 2 will be free of fuel by the end of 2015.

4.3.2 Operations and Storages Involving Hazardous Non-radioactive Substances

Even after RFS, several operational activities will be continued, such as:

- Water demineralization, using sulphur acid (H_2SO_4) and sodium hydroxide (NaOH) for ion exchange resins regeneration:
  - Storage of H_2SO_4,
  - Storage of NaOH;
- Emergency diesel-fired generators, tested each month, with diesel oil storage;
- Maintenance activities, using Lubricants.

Decontamination activities will need oxalic acid ($H_2C_2O_4$), permanganic acid ($KMnO_4$) and nitric acid (HNO_3). Sodium hydroxide (NaOH) will also be needed for the neutralisation of the acidic spent solutions prior to their conditioning.

4.3.3 Summary of Activities at the Origin of Significant Releases to the Environment

The different U1DP0 activities and their related significant releases are presented in the Table 4-5.

Table 4-5 U1DP0 Significant Releases

Period	Activities	Significant releases
2005 - 2012	Reactor Shutdown	Radioactive: • Decrease of atmospheric releases in a short period of time (see details in section 6.3) Non radioactive: • Decrease of thermal releases • Domestic and industrial wastes • *Releases due to HOB and SBP plants (indirect effect, covered by B5 Project)* • *Indirect effects due to additional fossil fuel combustion in other areas of Lithuania, in order to replace the INPP production, at least partly (assessed in related EIA processes)*
2008	Reactor Defuelling and transfer to pools	Radioactive: • During period 2005-2012, no release of noble gases, of I^{131} and drastically reduced releases of C^{14}

2006	Beginning of resins, perlite and sediments retrieval activities	• Some increase of aerosols releases and further decrease of radionuclide content in the discharged water (see details in section 6.3 and 6.4, Tables 6.2 and 6.5, Figures 6-3 and 6-4), proportional to the decrease of activity of fuel assemblies Non radioactive: • Decrease of sanitary water releases (with the decrease of personnel) from INPP • Decrease of the chemicals consumption for demineralised water production • Domestic and industrial wastes
2006 – 2008	Transfer of Spent Fuel to Unit 2	see hereabove
2009	In-line decontamination activities Beginning of operational solid waste retrieval and conditioning activities	Radioactive: • Production of radioactive waste, increase of aerosols releases (limited to 1.1×10^{10} Bq), increase of radionuclide content in the discharged water (however limited to 1.0×10^{9}) during activities – see Figures 6-3 and 6-4, Tables 6.2.5 and 6.5.5. • Other releases: discharge of about 0.065 ton of neutralised salts in the lake.
2008 – 2012	Unloading pools to Interim Spent Fuel Storage Facility	Radioactive: during this period, further decrease of radionuclide content in the discharged water (see Figure 6-4), small increase of aerosols releases (limited to 1.3×10^{10} Bq) due to the retrieval and conditioning of operational waste Non radioactive: • Decrease of the chemicals consumption for demineralised water production • Domestic and industrial wastes

<u>Note:</u>

Sections 6.3 and 6.4 include a detailed quantative assessment of the discharged aerosols and of the radionuclide content in the discharged waters on a year-by-year basis.
During this period, some operations will remain almost the same (water demineralisation, maintenance activities, use and storage of hazardous non-radioactive substances …). They are at the source of some intermittent releases or present possibilities of accidental releases of hazardous or polluting substances.

The resulting Impact Identification Matrix is presented on

Table 4-6.

Table 4-6 Impact Identification Matrix for U1DP0 Project (out of U1DP0 Scope Projects, Covered by Their Own EIA Process, are in Italic)

		U1DP0 ACTIVITIES WITH POTENTIAL ENVIRONMENTAL IMPACTS								
		Shutdown of the plant	*Construction of new buildings (mainly out of scope of the present EIA process)*	Handling of hazardous materials (radioactive and toxic)	Controlled releases of liquid and gaseous effluents	*Interim storage of radioactive waste (new ISFSF out of scope)*	Occurrence of fires	Incidental/accidental releases of contaminated liquids and gases	Personnel accidents	Structural failures due to the action of external agents (earthquake, flooding, sabotage)
ENVIRONMENTAL COMPONENTS		A1	*A4*	A9	A10	*A11*	A12	A13	A14	A15
NATURAL ENVIRONMENT	E1 AIR	**x**	***x***	**x**	**x**	***x***	**x**	**x**		**x**
	E2 LAND AND SOIL		***x***	**x**	**x**			**x**		**x**
	E3 WATER	**x**	***x***	**x**	**x**	***x***	**x**	**x**		**x**
	E4 FLORA	**x**	***x***	**x**	**x**		**x**	**x**		**x**
	E5 FAUNA	**x**	***x***	**x**	**x**		**x**	**x**		**x**
	E6 LANDSCAPE		***x***			***x***	**x**	**x**		
SOCIO-ECON. ENVIRONMENT	E7 LAND USE					***x***		**x**		
	E8 CULTURAL									
	E9 INFRASTRUCTURE									
	E10 HEALTH	**x**		**x**	**x**	***x***	**x**	**x**	**x**	**x**
	E11 POPULATION & ECONOMY	**x**								

The Impact Identification Matrix, as shown in Table 4-6, allows for the definition of the significant potential impacts to be further investigated (see sections 6 and 7).

4.4 References

72. Зональность зданий, сооружений и помещений, относящихся к зоне строгого режима. ПТОэд-0516-1.
73. Инструкция по радиационной безопасности на ИАЭС. ПТОэд-0512-2.
74. Ограниченное воздействие на площадке в результате падения контейнера с радиоактивными отходами средней активности во время транспортировки в хранилище. Отчет о необычном событии на ИАЭС. ПТОот-0345-185.

5 Main Alternatives Considered and Discussion for the Choice Made

5.1 Dismantling Alternatives and Choice Made

In accordance with worldwide practices, the following Dismantling strategies were envisaged for INPP and developed in the INPP Preliminary Decommissioning Plan (INPP-PDP) [75]:

- Immediate Dismantling;
- Deferred Dismantling (with four variants for the Safe Enclosure - SE: successively Restricted; Small; Extended and Maximum SE corresponding in turn to reactor core; hermetic zone of the Accident Localization System; reactor building A and all A, B, V, G and D buildings);
- Entombment.

Aside these possibilities usually envisaged as dismantling alternatives, other alternatives, such as the “no action” alternative (i.e. maintaining the reactor in a state where it is shut down but can be restarted as a power generator) need to be proven feasible in terms of technical, safety and environmental characteristics. For example, based on our knowledge, the “no action” alternative has not been implemented yet. An essential criterion is safety, under which the removal of fuel from the core of Unit 1 deletes the risks associated with nuclear power production in a RBMK reactor.

All above options were first assessed in the INPP Preliminary Decommissioning Plan (INPP-PDP).

In the next step of the Decommissioning preparation, INPP and its Decommissioning Project Management Unit (DPMU) did not consider the Entombment as a strategy valuable for further investigation in the case of INPP decommissioning.

Main reasons were that:

a) entombment option for decommissioning of nuclear fuel cycle facilities that are contaminated with long lived nuclides, implies that radioactive materials will be kept inside engineered structures for a very long period (~ 200 years), whereas IAEA recommends not to dispose of such waste in near surface facilities;

b) a 200 years storage period before final dismantling, conditioning and packaging of waste is unlikely to be accepted in Lithuania either by the public, the green organizations and the Authorities; and makes it almost impossible to predict evolution of costs, technology and Waste Acceptance Criteria (WAC).

To reach a final decision on the INPP dismantling strategy that encompasses the global Lithuanian socio-economic situation, the Lithuanian Government complemented the technical and financial elements presented in the above strategy selection support document with due consideration on more general social, political and economic grounds.

On the 26th of November 2002, in its decree No 1848, the Government of the Lithuanian Republic stated that: "… in order to prevent the heavy long-term social, economical, financial and environmental consequences… Decommissioning of Unit 1 of the State Enterprise Ignalina NPP shall be planned and implemented in accordance with the Immediate Dismantling Strategy".

This Strategy was further investigated and prepared, the result of this work being the INPP Final Decommissioning Plan (FDP), issued in 2004 and officially approved on 14th May 2004.

Hence, there is little or no room for the consideration of alternatives in the present EIA as the decision on the alternatives issue has be taken officially. The whole process is also subject to international political commitments and arrangements for appropriate financial support

All we can discuss is the optimization of activities to be conducted under this Immediate Dismantling Strategy. The optimization is led by safety, environmental and costs considerations based on the ALARA principle.

5.2 Optimization of Activities under the Immediate Dismantling Strategy

5.2.1 Fuel Management

Among the 1661 Fuel Assemblies, it is estimated that about 300 have reached their normal lifetime. They will be brought to the pool adjacent to the Reactor Building then cut in two and stored in another pool. Their destination is then the Interim Spent Fuel Storage Facility (ISFSF - B1 Project).

The other 1360 will be used in Unit 2. This is the object of the B8 Project.

By doing so, the Fuel Assemblies of Unit 1 are used up to their final lifetime. Hence, there is an economy of new Fuel Assemblies for Unit 2. This is an economy in the total amount of Fuel Assemblies and a rational use of energy contained in the Fuel Assemblies present on the site.

Otherwise, a large amount of still productive Fuel Assemblies should have to be sent to the ISFSF, which is difficult because it will not be ready in time after Unit 1 final shutdown. It would also be a waste of potential energy still contained in the Fuel Assemblies.

In summary, recycling of fuel assemblies in Unit 2 complies with both economic and environmental impact minimisation objectives (by reducing overall number of spent fuel assemblies to be interim stored and, later on, disposed of into a deep geological repository).

The specific environmental impacts of these practices are included in the assessment made in Chapter 6. The safety issues are the object of separate Safety Analysis Report (B1 SAR and B8 SAR).

5.2.2 Waste Management

5.2.2.1 Radioactive Waste

The option of Immediate Dismantling is, in comparison with Deferred Dismantling, at the source of more activity to be dealt with. There is less time for the natural decay of radioactive materials than in the Deferred Dismantling.

The Radioactive Waste Management is therefore designed so as to minimize exposition to workers and the environment.

Issues dealt with under this item are:

- the radioactive operational waste inventories, characterisation and classification;
- the production of the radioactive primary and secondary[45] waste associated to the different activities performed during the Post-shutdown and Defuelling Phase, including the retrieval and conditioning of part of the already stored radioactive waste, their characterisation and classification;
- the radioactive waste management strategy including:
    - the practical means to be implemented to achieve the minimization of both the decommissioning waste volume production and the conditioned decommissioning waste volumes to be disposed of,
    - for the operational waste: the collection and segregation of the to be produced waste, the retrieval of the already accumulated liquid/solid waste, the characterization of the radioactive waste, the conditioning techniques, the conditioned waste volumes, characterization and disposal routes,
    - for the decommissioning waste: the collection, the segregation and characterization of the raw waste in function of the activities covered by the different decommissioning phases/projects, the conditioning techniques, the conditioned waste volumes and characterization, the disposal routes;
- the spent fuel issue;
- the non radioactive hazardous waste inventories, characterization and management.

Radioactive wastes inventories, activities and classification are presented and discussed in Chapter 6.

The important decontamination activity to be performed in the frame of the present U1DP0, namely the in-line decontamination of the MCC – PCS (see section 5.2.3), is justified by the significant reduction of the collective dose that this operation allows. Nevertheless, that operation will result in an increase of the waste volume to be disposed of, mainly the volume of the bituminized spent decontamination solutions (~ 350 m^3) to be disposed of in Building 158.

[45] Secondary waste is waste which is generated during handling, treatment and disposal of waste.

The liquid waste resulting of the present decommissioning phase will be treated by the existing facilities at the Plant, basically by evaporation and the resulting evaporator concentrates by bituminization, i.e. allowing conditioned waste volume minimization.

In the frame of the present U1DP0, no significant volume of solid decommissioning waste will be produced. That waste will be treated in the new SWMSF i.e. taking advantage of the volume reduction factors of the main treatment processes of that facility.

Spent IER, Perlite and Sediments stored in Tanks TW18B01 and TW18B02 will be retrieved and processed in the Cement Solidification Facility and the corresponding conditioned waste packages will be stored in the Temporary Storage Building associated to the Cement Solidification Facility.

The waste being stored in the Buildings 155, 155/1, 157 and 157/1 will be retrieved, radiologically characterized and treated and/or packaged in the new Solid Waste Management and Storage Facility (Project B2/3/4).

The operational/decommissioning waste that will be produced after hot start-up of SWMSF (supposed to take place on 01.08.2008) would not be any more sent to Buildings 155, 155/1, 157 and 157/1 but transferred to SWMSF for treatment/conditioning.

A total of 7143 Spent Sealed Sources will also be recovered. They will be separated from the other types of waste at the sorting level. They will be packaged in appropriate durable containers and stored in the SWMSF. At this stage, on basis of the available information, three concrete container (internal free volume = 4.1m^3/container) should be able to accommodate the 7143 recovered SSS.

Uncertainties exist on the disposal acceptability, for a future licensed landfill, of (part of) operational waste. The base case considered in this document assumes that 80% of the operational wastes come into consideration for landfill disposal. The remaining part (20 %) is treated by incineration. Furthermore, a very small fraction constituted by filters media with relatively high activity content, is considered as being not acceptable for Near Surface Disposal. They are compacted in drums, placed in containers for interim storage, waiting for further processing that waste acceptance levels for geological disposal are made available.
For operational activities or for Post-shutdown and Defuelling Phase, the solid waste to be produced after SWMSF hot start-up will be sent to the SWMSF without transit via one storage compartment.

The main issues related to the Spent Fuel management during the period covered by U1DP0 are the removal of spent fuel from the core of Unit 1 and the complete Defuelling of that Unit by the end of 2012.
Therefore, two projects are being developed, namely B1 and B8:

- B8 consists of the detailed design study, the equipment purchase and the needed modifications completion at the power units in order to allow the transportation of partially burnt nuclear Fuel Assemblies from Unit 1 to Unit 2 for re-use in the reactor of Unit 2.

- B1 consists of the Design and Construction of an Interim Storage Facility for RBMK Spent Nuclear Assemblies for INPP Units 1 and 2, for a period of not less than 50 years, on a land owned by INPP, just outside the controlled area of INPP.

5.2.2.2 Non-radioactive Waste

For what concerns **non-radioactive waste**, INPP's waste management activities are performed in accordance with "Non-radioactive waste management manual", code PTOed-0412-1, developed in line with the requirements of "Waste management rules". The objective of works performance is the protection of environment, the decrease of quantity of waste to be disposed of and safe waste storage.

Most of the types of hazardous waste produced at INPP are delivered to external companies performing its management. These companies have permission for such activities and are registered in the State Register.

It is expected that the kinds of non-radioactive hazardous waste to be produced during the decommissioning should be comparable to those produced during the normal operation of the Plant. Nevertheless, further investigation will be needed at the beginning of the Decommissioning Project to assess this issue.

Different options are available for the processing of the spent oils:

a) removal and conditioning by external companies in as already performed with operational waste (for the not contaminated oils);
b) incineration in the facility to be supplied under the SWMSF (B2/B3/B4 project);
c) combination of a) and b).

5.2.3 Decontamination

5.2.3.1 Criteria and Goals

The option of Immediate Dismantling is, in comparison with Deferred Dismantling, at the source of more activity to be dealt with.

The methodology followed, based on the FDP and subsequent results of the radiological characterisation of INPP systems and equipment, is as follows:

- Identify systems to be decontaminated during the decommissioning of INPP, in the frame of the Decommissioning project U1DP0;

- Select the most appropriate decontamination processes and tools in function of pre-established sets of criteria;

- Identify the auxiliary systems needed to carry out the activities;

- Address the work preparation and execution organisational aspect;

- Address the waste management issues.

The decontamination associated to circuits/equipment can be conducted either "in-line", when the decontamination solutions are circulated inside the circuits to be decontaminated, or as "batch", when the dismantled equipment/components are decontaminated in an external installation.

In-line decontamination: After the circuit is isolated, it is decontaminated by an in-line soft process, i.e. by circulating the solution in the circuit to be decontaminated. The objective is to reduce the dose rate by a factor >10 (typical Decontamination Factors - DF > 10-20). The residual surface contamination is, however, such that the unconditional free release levels are largely exceeded. But, pending upon the initial surface contamination levels, the residual activity may comply with the landfill disposal criteria (see example hereafter).

In the frame of U1DP0, the decontamination activities are considered to enable:

- The modification, when needed, of the circuits that will be kept in operation after the RFS during the defuelling phase of the unit;
- The maintenance/repair works of the circuits, kept in operation after the RFS;
- The future dismantling of the circuits, which are not longer needed neither for safety nor for operational purposes.

The decontamination operations require manpower and investments, generate wastes that need to be treated, conditioned and disposed of, and induce radiological exposures.

Aside to technical criteria used for the choice of Systems to be decontaminated in-line, there are goals to be achieved by these activities:

- Reduce the ambient γ dose rates (and, as result, the individual and collective doses) in the rooms and areas to be accessed by the personnel involved in the decommissioning/dismantling task and to warrant compliance with the ALARA objectives;
- Minimise the risks of surface (i.e. transferable) contamination spreading during the dismantling activities;
- Minimise the radiological source terms in case of incidents or accidents during the decommissioning operations;
- Minimise the overall volume of conditioned decommissioning waste to be disposed of in near-surface repositories and to maximise the quantities of structures and equipment that may be free released;
- Possibly “de-categorise” radioactive waste allowing its disposal in a Licensed Landfill (near-surface repository for very low level waste) rather than in a near-surface repository designed for low and intermediate radioactive level waste.

To avoid restrictions imposed by the future operation of the system on the decontamination process selection (and, as a consequence, on the decontamination efficiency), the in-line decontamination will be executed after the system will be taken out of operation. So, systems coming into consideration for in-line decontamination must belong to the class III(d), in accordance with the classification principles described in Chapter 7 of FDP.

5.2.3.2 Systems Selection

The system analysis, performed in the frame of the Decommissioning SAR preparation, shows that all major turbine systems like Main Condensate and Feed Water System (MCFW), Live Steam Line System (LSL), Steam Withdrawal and House Supply Steam (SWHSS) will be available for dismantling after RFS. Also, after reactor defuelling, the MCC, PCS, CPS cooling circuit and refuelling machine can be object of in-line decontamination.

The systems to be in-line decontaminated during Unit 1 Defuelling Phase are:

- The MCC and PCS;
- The PM (Defuelling-Refuelling Machine).

According to the cost-benefit analysis made in the Unit 1 Decommissioning Project Studies, the in-line decontamination operations of the turbine systems and the CPS are not economically justified (see U1DP0 chapter 5).

5.2.3.3 Process Selection

The chemical environment and the materials of INPP main circuits are comparable to those of a BWR. The oxide layers built up at the surface of the equipment inner surfaces, and containing the deposited radionuclides, exhibit similar properties in both the BWR and RBMK plants. Therefore, the CORD (Siemens) process has been selected, as this latter has been proven to be extremely efficient (DF >> 20) during decontaminations carried out in several European, US and Japanese BWRs for both routine operations and decommissioning purposes. This process involves a chemical oxidation by $KMnO_4$ (0.5 g/l) in an acidic environment (pH~1.0) followed by a dissolution step with oxalic acid (10 g/l). The decontamination is carried out at ~ 90 ºC.
Then, the spent decontamination solution is processed by the existing evaporators. The evaporator concentrates are bituminised by the exisiting installations.

5.2.4 Radiological Environmental Impact of Unit 2 during Unit 1 Defuelling Phase

A preliminary assessment of Unit 2 radiological environmental impact during Unit 1 defuelling phase is given in sections 6.3.2.2-E) and 6.4.3.

5.3 References

75. INPP Preliminary Decommissioning Plan – NIS/SGN/SKB – PHARE Project 4.08/94.

6 Radiological Environmental Impact

6.1 Introduction – Scope

This Chapter addresses the following issues:

a) the key environmental radiation protection criteria applicable during the different phases of the INPP units 1 and 2 decommissioning;

b) the short and long term[46] radiation protection of the public;

c) the measures implemented to minimize the radiological impact for the critical members of the public and for the plant personnel during normal deconmmissioning activities and anticipated fault conditions;

d) the exposure of the plant personnel;

e) the methodology implemented to address the above issues.

6.2 Methodology: Key Environmental Radiation Protection Criteria - Radiological Impact Assessment Methods

6.2.1 Environmental Radiation Protection Criteria

The basic ALARA principles governing the routine operation remain applicable during the different phases of the plant decommissioning. This means, among others, that, on a short term basis:

a) the operational and maximum allowable discharge limits of liquid and gaseous radioactive waste may not be exceeded;

b) the maximum allowable dose to the critical members of the public, resulting from all liquid and atmospheric discharges of all INPP installations, may not exceed the limit dose of 0.2 mSv/y above the background.

On a medium term basis, the radiation exposure of the public must be ensured as far as the interim storage of spent fuel is concerned. This aspect will be covered in the EIA of associated project for ISFSF.

On a long term basis, the radiation exposure of the critical members of the public shall be warranted by limiting the critical nuclides activity inventory in the conditioned solid waste disposed of into the future near-surface repository site(s). For the waste storage facilities which will remain on the site after INPP decommissioning completion (landfill disposal site, upgraded bitumenised waste storage vaults), the critical nuclides inventories must be limited to a level warranting that the critical individual exposure does not exceed the current allowable limit (0.2 mSv/y, taking into account the releases from all facilities remaining on the INPP site).

[46] Short term: during active decommissioning, i.e. systems operation, modification and isolation after the RFS, decontamination and dismantling of equipment, demolition of buildings, treatment of waste.
Long term: when active decommissioning is finished and when all radioactive waste are safely stored or disposed of.

6.2.2 Radiological Impact Assessment Methodology

The assessment of the effective dose to the critical members of the public implies:

a) the assessment of the radiological source terms, i.e. the released activities via the liquid and gaseous waste discharges, including the routinely measured nuclides (Co^{58}, Co^{60}, Mn^{54}, $Cs^{134}$and Cs^{137}) and the critical nuclides (long lived β-γ emitters and TRU nuclides). The releases of these latter will be assessed on the basis of their appropriate Scaling Factors (SF) and of their physical-chemical behavior in the waste processing installations;

b) the assessment of the resulting effective dose to the critical members of the public, due to the direct and indirect exposure pathways. For this purpose, the methodology recommended by [76] will be implemented.

The critical nuclides that have am minor contribution to the global dose (ex. Fe^{55}, Ni^{59}, Ni^{63}, Nb^{94}, Tc^{99}) are neglected by the LAND-42 that does not indicate associated dose-contamination conversion factors (Sv/Bq). For the sake of U1DP0/DSAR/DEIAR, thse factors ar estimated following the approach described in section 6.8 relying on in [77] and [78].

These assessments, prepared for U1DP0, are presented and discussed hereafter.

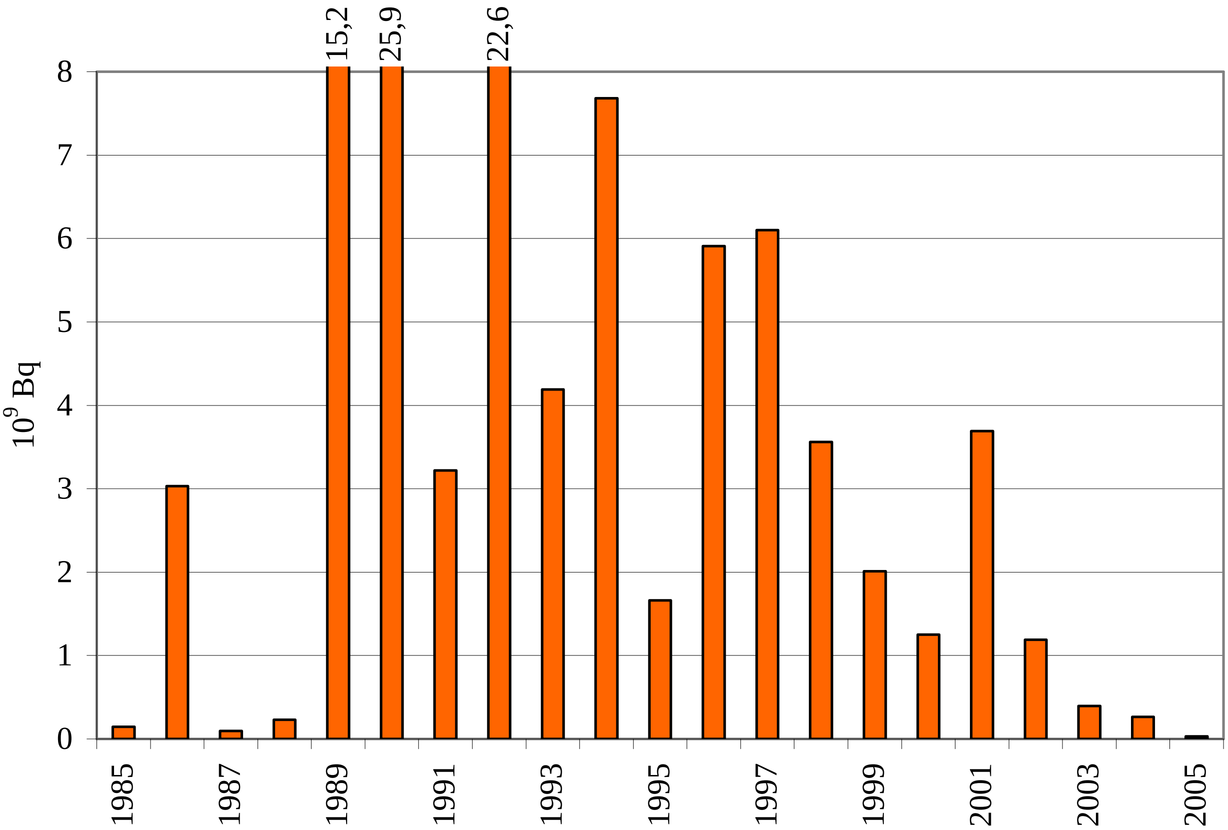
6.3 Radionuclide Content in Waters Surrounding INPP

6.3.1 Radionuclide Content in INPP Wastewater and Surrounding Waters

γ-emitters – nuclides ^{137}Cs, ^{60}Co, ^{54}Mn and beta emitters - nuclides ^{3}H and ^{90}Sr prevail in INPP wastewater from the man-caused radionuclides.

The total γ nuclide discharge diagram presented in Figure 6-1 illustrates the dynamics of variation of discharges into the Lake Drukshiai during1985-2005.

Figure 6-2 Total γ Nuclide Discharges into the Lake Drukshiai during1985-2005



Nuclide content in discharges to the Lake Drukshiai during 1992-2005 is presented in Table 6-1. As it could be seen, the total radionuclide discharge into the Lake Drukshiai decreases starting from the year 2001. In 2005 γ nuclide discharges into the Lake Drukshiai were conditioned by ^{137}Cs and ^{60}Co in discharges from the INPP industrial rain sewerage, their specific concentrations almost reached recording limits, approximately 0.001 Bq/l. The discharged tritium amount exceeds by some orders of magnitude amounts of other radionuclides discharged into the Lake Drukshiai during 2005 and it amounts to $3.24 \cdot 10^6$ MBq. The average tritium concentration in the outlet channel by deducting concentration in the inlet channel was 0.03 Bq/l, PLK-1 – 24.8 Bq/l, PLK-3 – 40.5 Bq/l. Plutonium isotopes in the water of inlet and outlet channels were not detected.

Table 6-1 Nuclide Content in Discharges to Lake Drukshiai during 1992-2005

Years	Radionuclide activity, 10^6 Bq											
	^{137}Cs	^{134}Cs	^{54}Mn	^{58}Co	^{60}Co	^{59}Fe	^{51}Cr	^{95}Zr	^{95}Nb	^{131}I	^{140}La	Viso
1992	2620	7,80	5650	354	8110	798	659	804	1740	407	0	21100
1993	707	122	424	4,40	1530	23,3	12,2	10,0	3,00	0	0	2830
1994	2650	5,60	1120	0,40	2630	9,6	74,0	433	5,20	163	0,40	7090
1995	6490	2720	1110	655	3940	66,6	143	65,5	38,1	911	0	16100
1996	1570	4,10	607	0	299	0	0	0	0	0	0	2480
1997	4510	1,90	22,6	2,60	606	35,9	62,2	71,4	87,3	0	0	5400
1998	2160	0	0	0	170	0	0	0	0	0	0	2330
1999	933	0	47,9	0	89,1	3,70	0	0	0	0	0	1070
2000	45,5	0	0,30	0	39,9	0	0	0	0	0	0	85,7
2001	512	1,20	67,6	15,4	424	92,1	79,9	83,8	129	0	0	1400
2002	1190	0	0,40	0	8,10	0	0	0	0	0	0	1190
2003	386	0,20	2,40	0,40	0,90	1,90	0,90	0,40	0,70	0	0	394
2004	245	0	0,60	0	17,9	0	0	0,20	0,30	0	0	264
2005	21,4	0	0,09	0	10,7	0	0	0	0	0	0	**32,1**

The average radionuclide concentrations in INPP waters measured during the year 2005 are presented in Table 6-2. Radionuclide concentrations are just a little more significant in waters from household sewerage and industrial waste ground trench. Tritium measurement results attract the greatest attention. Tritium concentration in the industrial waste ground trench exceeds the concentration in Lake Drukshiai by three orders of magnitude.

Table 6-2 Average Radionuclide Concentration in INPP Waters during the Year 2005

Sampling place	Radionuclide activity in water, Bq/l									
	^{137}Cs	^{54}Mn	^{58}Co	^{60}Co	^{59}Fe	^{95}Zr	^{95}Nb	^{90}Sr	^{3}H	Total without ^{3}H*
Point No1, L.Drukshiai	0	0	0	0	0	0	0	$9{,}37 \cdot 10^{-3}$	4,9	$9{,}37 \cdot 10^{-3}$
Point No 2, L.Drukshiai	0	0	0	0	0	0	0	$1{,}01 \cdot 10^{-2}$	6,0	$1{,}01 \cdot 10^{-2}$
Point No 3, L.Drukshiai	0	0	0	0	0	0	0	$9{,}31 \cdot 10^{-3}$	5,4	$9{,}31 \cdot 10^{-3}$
Point No 4, L.Drukshiai	$9{,}59 \cdot 10^{-3}$	0	0	$1{,}03 \cdot 10^{-2}$	0	0	0	$7{,}65 \cdot 10^{-3}$	4,1	$2{,}75 \cdot 10^{-2}$
Point No6, L.Drukshiai	0	0	0	0	0	0	0	$9{,}54 \cdot 10^{-3}$	4,9	$9{,}54 \cdot 10^{-3}$
Household sewerage before treatment plant	$1{,}18 \cdot 10^{-2}$	$4{,}86 \cdot 10^{-3}$	$3{,}81 \cdot 10^{-5}$	$1{,}68 \cdot 10^{-2}$	$1{,}82 \cdot 10^{-3}$	$5{,}51 \cdot 10^{-4}$	$2{,}22 \cdot 10^{-3}$	$1{,}83 \cdot 10^{-3}$	18	$3{,}99 \cdot 10^{-2}$
Household sewerage after treatment plant	$2{,}74 \cdot 10^{-3}$	0	0	$1{,}74 \cdot 10^{-4}$	0	0	0	$1{,}96 \cdot 10^{-3}$	27	$4{,}87 \cdot 10^{-3}$
Site household sewerage	$3{,}33 \cdot 10^{-2}$	$1{,}43 \cdot 10^{-2}$	$1{,}19 \cdot 10^{-3}$	$6{,}55 \cdot 10^{-2}$	$7{,}57 \cdot 10^{-3}$	$2{,}44 \cdot 10^{-3}$	$8{,}47 \cdot 10^{-3}$	$2{,}23 \cdot 10^{-3}$	22	$1{,}35 \cdot 10^{-1}$
Drainage of building 120/1	0	0	0	0	0	0	0	$4{,}59 \cdot 10^{-3}$	18	$4{,}59 \cdot 10^{-3}$
Drainage of building 120/2	$1{,}26 \cdot 10^{-3}$	$3{,}33 \cdot 10^{-4}$	0	0	0	0	0	$5{,}02 \cdot 10^{-3}$	39	$6{,}61 \cdot 10^{-3}$
Industrial waste ground trench	$2{,}20 \cdot 10^{-3}$	0	$7{,}83 \cdot 10^{-4}$	$1{,}05 \cdot 10^{-2}$	0	0	0	$4{,}28 \cdot 10^{-3}$	9300	$1{,}78 \cdot 10^{-2}$

* - Total concentration is presented without ^{3}H, as contribution of other radionuclides to the total water activity is impossible to be assessed due to tritium concentration in the background.

Data on the presence of tritium in INPP waters during 1998-2005 are provided in Table 6-3. The provided measurement results indicated that accumulation of tritium in Lake Drukshiai is via IRS-1, IRS-3 and household sewerage channels. The average tritium concentrations in the outlet, inlet channels and zero background points remain at the same level and practically do not changes since 1998. In total, as based on the conservative estimation model $3.2 \cdot 10^{12}$ Bq of tritium was discharged into Lake Drukshiai during the year 2005 (considering water flow rates).

Table 6-3 Average Annual Tritium Concentrations in Waters of the INPP Region and Site, Bq/l

Sampling place	1998	1999	2000	2001	2002	2003	2004	2005
Inlet channel	4,9	5,9	6,0	4,7	5,5	4,0	7,5	6,0
Outlet channel	3,3	5,5	6,1	6,0	6,9	4,5	7,6	6,0
IRS-1	14	24	25	25	30	22	22	25
IRS-3	19	24	31	25	24	12	12	41
Household sewerage before treatment plant	22	18	33	25	45	18	11	18
Drainage of building 120/2	12	43	30	44	66	47	35	39
Drainage of building 120/1	31	18	40	21	34	61	30	18
Site household sewerage	25	28	30	27	-	37	19	22
Household sewerage after treatment plant	16	42	21	20	31	19	24	27
Zero background points, lake Drukshiai	-	5,2	4,9	7,3	5,5	6,3	4,1	5,1
Industrial waste ground trench	46	310	1200	3300	6800	8200	9800	9300

The results obtained during 1998-2005 indicate that the tritium concentration in the trench water considerably increases during spring months. In April 1999 the concentration increased in average by 200 Bq/l, in May 2000 - by 800 Bq/l, in May 2001 – by 1500 Bq/l, in May 2002 – by 3500 Bq/l. Starting since 2003 the significant increase of the tritium concentration in the industrial waste ground trench was not observed. Currently (during 2006) the tritium concentration in the industrial waste ground trench remains within the level of $9.3 \cdot 10^{3}$ Bq/l. In order to estimate the probable consequences of tritium concentration increase in the ground waters, the likely effective dose due to tritium peroral absorption (with food) by the human body was conservatively estimated. In compliance with the publication of the European Commission "Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment" (Table 5.3) the grown-up person annually drinks 600 l in average. In case of the tritium concentration of $9.3 \cdot 10^{3}$ Bq/l, the annual tritium access to the human body would constitute $5.58 \cdot 10^{6}$ Bq. The annual tritium effective dose for the population using the water from the indicated bores as the only source for drinking which is estimated on the basis of „Main Radiation Protection Measures HN 73:2001" would not exceed 100 μSv.

In order to monitor the radionuclide access to the ground water, 50 boreholes are arranged within the territory of INPP site of 10 to 30 meters depth. Gamma-spectrometric and radiometric measurements (performed in 2005) of the radionuclide concentrations in water of the survey boreholes indicated that mainly natural radionuclide ^{40}K with the concentration less than 1 Bq/l is present in the water of boreholes. The measured radionuclide concentrations of ^{137}Cs, ^{60}Co, ^{54}Mn, ^{95}Nb, ^{90}Sr and ^{3}H in boreholes are presented in Table 6-4.

Table 6-4 Radionuclide Concentrations Measured in Water of Boreholes Arranged within the INPP Site during 2005

Borehole No	Radionuclide concentration, Bq/l					
	^{137}Cs	^{54}Mn	^{60}Co	^{95}Nb	^{90}Sr	^{3}H
29201	0	0		0	$5,0\cdot10^{-3}$	380
29202	0	0	$1,5\cdot10^{-3}$	0	$4,7\cdot10^{-4}$	15
29205	0	0	$1,9\cdot10^{-1}$	0	$4,5\cdot10^{-4}$	460
29206	0	0	0	0	$2,0\cdot10^{-3}$	5,2
29208	0	0	0	0	$1,3\cdot10^{-3}$	31
29210	0	0	0	0	$3,4\cdot10^{-4}$	5,8
29214	0	0	0	0	$4,5\cdot10^{-4}$	1,6
29216	$9,5\cdot10^{-4}$	0	0	0	0	64
29217	0	0	$1,7\cdot10^{-3}$	0	$2,5\cdot10^{-3}$	110
29218	$1,3\cdot10^{-3}$	0	$5,3\cdot10^{-3}$	0	$3,8\cdot10^{-3}$	12
29219	0	0	$1,1\cdot10^{-2}$	0	0	47
29222	0	0	$2,7\cdot10^{-3}$	0	$1,6\cdot10^{-3}$	2,1
29223	$4,1\cdot10^{-3}$	0	$5,6\cdot10^{-3}$	0	$1,8\cdot10^{-3}$	19
29522	$1,0\cdot10^{-3}$	0	$8,3\cdot10^{-3}$	0	0	0,9
29523	0	0	0	0	$6,1\cdot10^{-4}$	2,7
29524	0	0	0	0	$1,1\cdot10^{-3}$	62
29525	$3,3\cdot10^{-3}$	0	$2,1\cdot10^{-3}$	0	$2,2\cdot10^{-3}$	290
29526	$1,5\cdot10^{-3}$	0	0	0	$4,4\cdot10^{-4}$	4,7
29527	0	0	0	0	$1,9\cdot10^{-3}$	8,8
29528	0	0	0	0	$1,3\cdot10^{-3}$	9,7
29529	0	0	0	0	$7,3\cdot10^{-4}$	5,6
29530	0	0	0	0	0	6,6
29531	0	0	$4,8\cdot10^{-3}$	0	$1,8\cdot10^{-3}$	5,2
29532	0	0	0	0	0	13
29533	0	0	$3,6\cdot10^{-1}$	0	$2,2\cdot10^{-3}$	90
29534	0	0	$6,3\cdot10^{-3}$	0	$1,4\cdot10^{-3}$	4,7
29535	0	0	$9,2\cdot10^{-1}$	0	0	4100
29536	0	0	1,3	0	$2,7\cdot10^{-3}$	3100
29537	0	0	$4,9\cdot10^{-3}$	0	0	130
29538	0	0	$8,2\cdot10^{-4}$	0	0	16
29539	$4,1\cdot10^{-4}$	0	$1,1\cdot10^{-2}$	0	$6,1\cdot10^{-3}$	62
29540	$8,5\cdot10^{-4}$	0	$1,7\cdot10^{-3}$	0	$3,8\cdot10^{-3}$	401
29541	$5,9\cdot10^{-4}$	0	$3,8\cdot10^{-2}$	0	$4,9\cdot10^{-4}$	2400
29542	0	0	$3,5\cdot10^{-3}$	0	$1,1\cdot10^{-2}$	44
29543	0	0	$4,0\cdot10^{-3}$	0	$5,5\cdot10^{-4}$	2,3
29544	$6,1\cdot10^{-4}$	0	0	0	$1,7\cdot10^{-3}$	20
29545	0	0	0	0	0	6,1
29546	0	0	0	0	$4,3\cdot10^{-3}$	5,4
29547	$5,7\cdot10^{-4}$	0	0	0	$2,1\cdot10^{-2}$	5,8
29548	0	0	0	0	$6,2\cdot10^{-3}$	7,6
29549	$6,5\cdot10^{-4}$	0	0	0	$8,8\cdot10^{-3}$	6,8
29550	0	0	0	0	$6,8\cdot10^{-3}$	5,7
29551	$3,3\cdot10^{-4}$	0	$2,0\cdot10^{-3}$	0	$5,7\cdot10^{-4}$	5,7

Borehole No	Radionuclide concentration, Bq/l					
	^{137}Cs	^{54}Mn	^{60}Co	^{95}Nb	^{90}Sr	^{3}H
29552	3,8·10-4	0	0	0	1,9·10-3	6,7
29553	0	0	0	0	7,9·10-4	47
29554	8,8·10-4	0	0	0	8,1·10-4	13
29555	0	0	0	0	2,3·10-3	5,6
29556	0	0	0	0	2,9·10-3	3,4
29557	0	0	1,1·10-3	0	7,9·10-4	2,8
29558	1,6·10-3	0	0	0	6,5·10-3	4,2

Gamma nuclides and ^{90}Sr concentrations do not exceed the background level values; similar concentrations were measured in earlier years. The significant tritium specific concentration fluctuations in boreholes are observed. Multi-annual tritium concentration fluctuation results in survey boreholes are provided in Table 6-5.

Table 6-5 Tritium Concentration in Water of the Site Survey Boreholes during 1998-2005

Borehole No	Average values, Bq/l									
	95-96	1997	1998	1999	2000	2001	2002	2003	2004	2005
29201	980	700	360	620	180	3,1	550	200	120	380
29202	-	-	-	-	10	3,1	43	5,3	8,9	15
29205	-	-	-	-	-	-	19	53	83	460
29206	-	-	-	-	-	-	28	16	5,1	5,2
29208	-	-	-	-	-	-	35	35	45	31
29210	-	-	-	-	-	-	3,7	14	36	5,8
29214	-	-	-	-	-	-	2,1	0,8	8,8	1,6
29216	25	1,5	2,1	1,5	4,5	3,7	-	40	95	64
29217	-	-	-	-	-	-	290	250	230	110
29218	-	-	-	-	-	-	28	3	19	12
29219	-	-	-	-	-	-	95	28	46	47
29222	4,1	3,8	0,9	2,1	1,7	6,8	5,9	1,5	3,9	2,1
29223	46	74	250	520	16	-	124	28	14	19
29522	22	1,8	2,5	40	340	-	4,8	nv*	0,4	0,9
29523	12	2,1	0,9	1,3	2,5	3,1	11	4,9	0,9	2,7
29524	430	-	-	-	-	-	59	88	79	62
29525	5,3	-	-	-	-	-	18	260	190	290
29526	14	-	-	-	-	-	10	3,9	5,2	4,7
29527	28	-	-	-	-	-	17	35	14	8,8
29528	27	-	-	-	-	-	24	10	10	10
29529	11	2,5	3,7	6,5	7,7	17	10	62	38	5,6
29530	34	6,1	5,1	5,9	6,2	16	4,2	4,1	14	6,6
29531	75	18	11	14	11	-	-	3,3	8,8	5,2
29532	13	1,4	-	-	-	-	7,2	5,2	8,2	13

Borehole No	Average values, Bq/l									
	95-96	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
29533	-	-	-	-	-	-	42	48	10	90
29534	-	-	-	-	-	-	12	5,2	2,3	4,7
29535	-	-	-	-	-	-	530	170	2300	4100
29536	24	4,6	5,0	14	120	230	230	3300	1000	3100
29537	17	1,3	1,2	4,3	4,8	7,9	22	199	95	130
29538	31	9,3	4,1	25	14	6,4	26	19	36	16
29539	17	-	0,6	3,2	6,2	8,4	-	nv	280	62
29540	2300	870	330	450	650	510	670	43	580	400
29541	-	-	-	-	-	-	3900	3700	3800	2400
29542	880	3,8	3,0	6,3	13	10	1000	nv	380	44
29543	54	0,7	-	-	0,7	1,8	-	16	31	2,3
29544	0,2	-	0,2	-	1,7	3,6	58	11	26	20
29545	15	0,0	1,5	1,6	1,2	1,4	6,0	8,0	2,8	6,1
29546	-	-	-	-	-	-	nv	7,8	14	5,4
29547	-	-	-	-	-	-	5,1	4,8	8,9	5,8
29548	-	-	-	-	-	-	8,0	8,8	7,1	7,6
29549	-	-	-	-	-	-	nv	6,7	4,3	6,8
29550	-	-	-	-	-	-	nv	4,1	9,1	5,7
29551	-	-	-	-	-	-	nv	nv	5,7	5,7
29552	-	-	-	-	-	-	4,3	9,2	4,4	6,7
29553	-	-	-	-	-	-	40	27	18	47
29554	-	-	-	-	-	-	-	1,7	2,6	13
29555	-	-	-	-	-	-	1,3	3,5	1,5	5,6
29556	-	-	-	-	-	-	5,9	4,4	3,6	3,4
29557	-	-	-	-	-	-	1,6	2,7	-	2,8
29558	12	0,3	0,6	0,8	2,2	0,5	4,3	0,0	0,4	4,2

* - nv- no water.

The greatest tritium concentration is detected in boreholes No29541, 29535, 29536. The borehole No 29541 is close to the industrial waste ground trench, boreholes 29535, 29536 are approximately 150 m to the south-east from it. The probable cause of tritium concentration increase in these boreholes is the increased tritium concentration in the water of the industrial waste ground perimeter channel. In order to estimate the probable consequences of tritium concentration increase in the ground waters, the likely effective dose due to tritium peroral absorption (with food) by the human body was conservatively estimated. In case of the tritium concentration of 4100 Bq/l, the annual tritium access to the human body would constitute $2.46 \cdot 10^6$ Bq. The annual tritium effective dose for the population using the water from the indicated bores as the only source for drinking which is estimated on the basis of „Main Radiation Protection Measures HN 73:2001“ would not exceed 44.3 μSv. It should be noted that due to excess of the tritium volume activity established in the Lithuanian Hygiene Standard HN 24:2003 „Requirements for Safety and Quality of Potable Water“ which is equal to 100 Bq/l, it is prohibited to use underground water from adjacency of boreholes 29201, 29205, 29217, 29525, 29535, 29536, 29537, 29540, 29541 as potable water and hot water used for household purposes (except the case when legal entities and physical bodies provide themselves with water individually, when the daily intake of water does not exceed 10 m^3 or less than 50 people are provided with water and the received water is not used for economic – commercial activity).

6.4 Radionuclide Content in the Discharged Gaseous Effluents during U1DP0 Activities and Environmental Impacts

6.4.1 Origin of the Radionuclide Content in the Discharged Gaseous Effluents during INPP Unit 1 Defuelling Phase.

During the defuelling phase of Unit 1 (period 2005-2012), the releases of radioactive gaseous waste into the environment originate from:

(a) the modification and isolation of the systems kept/not kept in operation after the RFS;

(b) the post-shutdown operation of the systems kept in operation after the RFS, including periodic testing, maintenance and repair activities;

(c) the defuelling operation of Unit 1 reactor and of the spent fuel storage pools and the transfer of the low burnup fuel assemblies from Unit 1 to Unit 2, for for re-use in the reactor of this latter unit;

(d) the startup of the retrieval and conditioning activities of the on-site accumulated operational waste :

- the spent ion-exchange resins, perlite and sediments,
- the miscellaneous types of solid waste;

(e) the processing of Unit 1 radionuclides produced during the defuelling phase;

(f) specific activities to be carried out during the defuelling phase not covered by items (a) to (e), such as the drain down of some circuits and, most of all, the in-line decontamination of the primary circuit and of its associated purification circuit (MCC+PCS), of the refueling/defuelling machine.

In the frame of Project U1DP0, there are no dismantling activities and therefore neither production nor releases of radionuclides from these activities.

As shown in the following sections, the releases to the atmosphere predicted to occur during the defuelling phase of Unit 1 exhibit some significant differences by comparison to those prevailing during the routine operation:

- the nature, i.e. the type of released nuclides and the average values of the releases, as well as the origin of the release points;

- the contribution of the different activities to the global effective dose. During Unit 1 defuelling phase, this latter will largely be governed by the releases from activities (d), (e) and (f).

<u>Remark:</u>

The design of B2/3/4 facilities has not been finalized yet. However, the technical information found in the Technical Specification for the procurement of the B2/3/4 facilities and in the received bids, together with the operation experience of similar installations (e.g. incinerator) in other countries, enable to make predictive assessments of the releases. More details can be found in the DBS and associated deliverables pertaining on the B2/3/4 facilities operation in chapter 6 of U1DP0.

6.4.2 Assessment of the Radionuclide Content in the Discharged Gaseous Effluents during INPP Unit 1 Defuelling Phase

6.4.2.1 Radionuclide Content in the Discharged Gaseous Effluents during INPP Routine Operation – Public Exposure

During normal operation of INPP, the yearly releases of the noble gases, I^{131}, aerosols and their respective contribution to the yearly effective dose of the public members are typically as follows [92]:

Table 6-6 Yearly Atmospheric Releases and Public Exposure during INPP Normal Operation – Average Values for Period 1999 - 2003

Nuclide	Releases (Bq/y – 2 Units)	Effective dose from (mSv/y)	
		INPP	Unit 1
Noble gases I^{131} Aerosols – C^{14} excluded	$7.9*10^{13}$ $2.3*10^{9}$ $1.1*10^{9}$	$4.8*10^{-5}$ $1.3*10^{-4}$ $3.6*10^{-5}$ (*)	$2.4*10^{-5}$ $7.0*10^{-5}$ $1.8*10^{-5}$(*)
C^{14} H^{3}	$1.3*10^{11}$ $2.4*10^{12}$	$5.6*10^{-5}$ $4.4*10^{-6}$	$3.0*10^{-5}$ $2.0*10^{-6}$
Total		$2.7*10^{-4}$	$1.4*10^{-4}$

In the above table, the releases of noble gases, I^{131} and aerosols are actual average values for period 1999 - 2003, while the releases of C^{14} and H^{3} are predicted values taken from [83] (i.e. these nuclides are not routinely measured in the discharged gaseous effluents).

(*) Among which Cs^{137} = 40 % and $C0^{60}$ = 45 % of the corresponding effective dose.
Practically 99 % of the public exposure result from the emissions via the main stack (H=150 m).

<u>Remark: C^{14} Atmospheric Discharges</u>

Table 6-1 shows that the annual effective dose resulting from the predicted C^{14} atmospheric discharges exceeds that of all the other aerosols and amounts to some 20 %, i.e. a non-negligible value, of the total effective dose resulting from all the atmospheric discharges (noble gases + I^{131} + aerosols (C^{14} excluded) + C^{14} + H^{3}). As the predicted values [83] usually involve some conservatism a specific measurement programme of the C^{14} atmospheric discharges during the remaining operation years of Unit 2 could be implemented. Actual measured data would then enable a more accurate assessment of the effective dose to the critical members of the public (a-posteriori re-calculation of the public radiological exposure).

6.4.2.2 Radionuclide Content in the Discharged Gaseous Effluents during Unit 1 Defuelling Phase – Public Exposure

By comparison with the INPP routine operation, the post-shutdown releases exhibit the following differences:

- absence of noble gases emissions soon after the RFS;
- absence of short lived iodine nuclides (I^{131}, I^{133});
- drastic reduction of the yearly H^3 and C^{14} releases after the RFS (see hereafter);
- progressive modification of the aerosols release spectrum i.e. further reduction of the short half-life nuclides (Mn^{54}, Fe^{55}, Co^{58}, Fe^{59}, Cs^{134}…) contribution to the global effective dose (this contribution being already low during plant operation);
- increase of the alpha (α) activity, especially during the period corresponding to the in-line decontamination;
- modification of the different stacks releases contribution to the public effective dose after the RFS:
    - the releases via the main stack will significantly drop;
    - the releases via the intermediate height stacks (assumed 75 m for the cementation and B2/3/4 facilities) will increase mainly due to the management of the retrieved operational wastes;
    - the releases at low elevation (assumed 10 m for the solid operational waste retrieval activities and the landfill site activities) will increase.

A) Assessment of the aerosols releases and of the public exposure

The aerosols releases were assessed by application of the decommissioning DBS (Data Base Sheets) production software for each activity carried out during the defuelling phase of Unit 1 (see chapter 6 and Appendix 3 of U1DPO and [95]).

For the whole defuelling period of Unit 1, the global aerosols releases amount to some 6.0×10^{10} Bq. The histogram of the aerosols releases to the atmosphere (see Figure 6-3) shows that the monthly and yearly releases vary in function of the considered period:

- from January 2005 to end 2008, the monthly releases are of about 290 MBq/month, i.e. 14 GBq for the considered period. These releases result from the post-shutdown operation of the systems kept in operation, from the fuel handling operations and from the operation of the resins, perlite and sediments conditioning facilities;
- from January 2009 to December 2012, the monthly releases increase to about 0.96 GBq/month, leading to a global release of 46 GBq for the considered period. In addition to the above mentioned activities, this period is characterised by the startup of the B2/3/4 facility (in 2009) and by some specific activities such as the in-line decontamination of the MCC (first quarter of 2009).

B) Methodology for assessment of public radiological exposure

The annual effective dose to the members of the public is given by:

$$Dt = \sum_i Di = \sum_j R_{Co}{}^{60}{}_{,j} * K * \sum_{APi} SF_{APi,j} * D_{1,\,Api} * 10^3 + \sum_j R_{Cs,}{}^{137}{}_{,j} * K * \sum_{FPi} SF_{FPi,j} * D_{1,\,FPi} * 10^3 \qquad (1)$$

D_t = total effective dose for the considered year (mSv/y)

D_i = nuclide i effective dose for the considered year (mSv/y)

$R_{Co}{}^{60},j$, $R_{Cs}{}^{137},j$ = atmospheric releases of Co^{60} and Cs^{137} (source terms) associated to nuclide vector j (spectrum j) during the considered year (Bq/y) – see examples in section 6.11.

K = multiplicative factor taking into account the average release height for the calculation of the effective dose (see hereafter).

$SF_{Api,j}(t)$ = spectrum j activation product i scaling factor (linked to Co^{60}) during the considered year
(the activation products taken into account are: C^{14}, Mn^{54}, Fe^{55}, Co^{60}, Ni^{59}, Ni^{63} and Nb^{94})

$SF_{Fpi,j}(t)$ = spectrum j fission product i scaling factor (linked to Cs^{137}) during the considered year
(the fission products taken into account are: Sr^{90}, Tc^{99}, I^{129}, Cs^{134}, Cs^{137}, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{241}, Am^{241} and Cm^{244}).

The values of $SF_{Api,j}$ and $SF_{Fpi,j}$ by the time of the RFS and their evolution with time after the RFS are given in [86] – see also hereafter Tables 6-2 and 6-3.

$D_{1,APi}$, $D_{1,FPi}$ = atmospheric release dose –contamination conversion factor for activation/fission product i (Sv/Bq) – see LAND-42-2001

This regulatory normative document is supported by several references, among which [94] introducing the mathematical models used to assess the behaviour of the released nuclides in the miscellaneous components of the trophic chain. Key parameters values used to calculate the dose-contamination conversion factors, including the critical individual habits, are given in section 6.9 hereafter.

Remark: for Fe^{55}, Ni^{59}, Ni^{63}, Nb^{94}, Tc^{99}, Pu^{238}, Pu^{241} and Am241, LAND-42 does not mention the dose-contamination conversion factor. For those nuclides, the conversion factors were derived from ICRP-72 data corresponding to the adult and are given in section 6.8.

For the considered year, the releases of nuclide i are given by:

$$Ri = \sum_j R_{Co}{}^{60}{}_{,j} * SF_{APi,j}{}^{(t)} \text{ for activation product i (Bq/y)}$$

$$Ri = \sum_j R_{Cs}{}^{137}{}_{,j} * SF_{FPi,j}{}^{(t)} \text{ for fission product i (Bq/y)}$$

Information pertaining to the source term assessment for different activities can be found in section 6.11.

C) Results of radionuclides releases and public radiological exposure assessment

The histogram of the aerosols global discharges (see Figure 6-3) shows that the highest yearly discharges are predicted to occur during period 2009 - 2012.

April 2009 is assumed to correspond to the startup of the operational waste retrieval and processing activities. Further, the in-line decontamination operations of the reactor main circulation circuit are scheduled in the early 2009.

Tables 6-7.1 and 6-7-8 hereafter present data for each nuclide and in the considered year:

- the releases (Bq) of Co^{60} and Cs^{137} cumulated on all DBS and splitted between the various spectra (under “Key isotopes activities releases”);
- the releases of each nuclide i resulting from all activities characterised by a given nuclide vector (spectrum j) are given under “Related isotopes activities releases”;
- the total release of each nuclide i is given under “Related isotopes activities releases” (column total);
- the dose-contamination conversion factor (under $D_{1,i}$ – Sv/Bq);
- the effective dose for each nuclide (under D_i – mSv/y);
- the global effective dose for the considered year (under “Public Exposure” – mSv).

Remark: for details on the various scaling factors and spectra used, see U1DP0 chapter 9, Appendix 9.1.

In those tables, the releases associated to:

- spectrum S_1 mainly results from decontamination and cleaning operations prior to system isolation/modifications;

- spectrum S_4 results from operational Group E (3) solid waste retrieval and processing operations;
- spectrum S_2 results from the other activities carried out during Unit 1 defuelling phases, such as:

    - post-operation of the systems remaining in service after the RFS,
    - modifications and/or isolation of systems,
    - retrieval and conditioning of the operational spent resins, perlite and sediments,
    - retrieval and processing of operational Group 1, 2 (A, B, C) solid waste,
    - defuelling activities.

Spectra (or nuclide vectors) validation measurement campaigns were already, are currently and will be conducted by Vilnius Institute of Physics. So, for examples:

- Spectrum S_1 has already been validated [112];
- Spectrum S_2 has been validated for very low active waste [96] and for spent resins/perlite/sediments [112], [113].

Prior to starting the operational solid waste retrieval and conditioning operations, measurement campaigns will be carried out.

Table 6-7 Public Exposure due to Release in 2005-2012 (Aerosol)

Table 6-7.1 Public Exposure due to Release in 2005 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	9.48E+03	1.91E+08	0.00E+00	0.00E+00	0.00E+00
Cs-137	2.15E+03	7.74E+08	0.00E+00	0.00E+00	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2005	
end	31/12/2005	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I	Dose Di
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL	[Sv/Bq]	[mSv]
Co-60	9.48E+03	1.91E+08	0.00E+00	0.00E+00	0.00E+00	1.91E+08	5.70E-17	5.55E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	5.56E+01	1.03E+06	0.00E+00	0.00E+00	0.00E+00	1.03E+06	4.40E-19	2.32E-09
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	6.25E+03	1.65E+08		0.00E+00	NC	1.65E+08	3.20E-18	2.69E-06
Fe-55	3.60E+04	7.92E+08	0.00E+00	0.00E+00	0.00E+00	7.92E+08	5.50E-18	2.22E-05
Co-58	1.63E+02	8.68E+06	0.00E+00	0.00E+00	0.00E+00	8.68E+06	0.00E+00	NC
Ni-59	1.19E+01	2.18E+05	0.00E+00	0.00E+00	0.00E+00	2.18E+05	1.10E-18	1.22E-09
Ni-63	2.79E+03	5.19E+07	0.00E+00	0.00E+00	0.00E+00	5.19E+07	2.50E-18	6.62E-07
Nb-94	2.27E+01	4.14E+05	0.00E+00	0.00E+00		4.14E+05	2.90E-17	6.12E-08
Cs-137	2.15E+03	7.74E+08	0.00E+00	0.00E+00	0.00E+00	7.74E+08	1.20E-16	4.73E-04
Sr-90	1.29E+02	4.64E+06	0.00E+00	0.00E+00	0.00E+00	4.64E+06	7.00E-17	1.66E-06
Tc-99	9.01E+00	3.17E+05	0.00E+00	0.00E+00	0.00E+00	3.17E+05	5.90E-18	9.53E-09
I-129	7.91E-03	2.85E+03	0.00E+00	0.00E+00	0.00E+00	2.85E+03	1.20E-15	1.74E-08
Cs-134	1.88E+03	7.91E+08	0.00E+00	0.00E+00	0.00E+00	7.91E+08	8.30E-17	3.35E-04
Pu-241	1.97E+04	1.21E+06	0.00E+00	0.00E+00	0.00E+00	1.23E+06	4.40E-17	2.75E-07
U-235	3.52E-03	2.14E-01	0.00E+00	0.00E+00	0.00E+00	2.17E-01	0.00E+00	NC
U-238	1.08E-01	6.33E+00	0.00E+00	0.00E+00	0.00E+00	6.44E+00	0.00E+00	NC
Pu-238	2.18E+02	1.34E+04	0.00E+00	0.00E+00	0.00E+00	1.36E+04	3.50E-16	2.42E-08
Pu-239	5.93E+01	3.48E+03	0.00E+00	0.00E+00	0.00E+00	3.54E+03	3.80E-16	6.86E-09
Pu-240	1.41E+02	8.71E+03	0.00E+00	0.00E+00	0.00E+00	8.85E+03	3.80E-16	1.71E-08
Am-241	3.61E+02	2.08E+04	0.00E+00	0.00E+00	0.00E+00	2.12E+04	3.00E-16	3.24E-08
Cm-244	5.92E+01	3.58E+03	0.00E+00	0.00E+00	0.00E+00	3.64E+03	1.80E-16	3.34E-09
TOTAL	7.94E+04	2.78E+09	0.00E+00	0.00E+00	0.00E+00	2.78E+09		8.91E-04

(black cell) : not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] 8.91E-04

Table 6-7.2 Public Exposure due to Release in 2006 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	3.99E+05	7.35E+08	0.00E+00	0.00E+00	0.00E+00
Cs-137	1.69E+06	1.08E+09	0.00E+00	0.00E+00	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2006	
end	31/12/2006	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	3.99E+05	7.35E+08	0.00E+00	0.00E+00	0.00E+00	7.35E+08	5.70E-17	2.14E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	2.68E+03	4.56E+06	0.00E+00	0.00E+00	0.00E+00	4.56E+06	4.40E-19	1.02E-08
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	1.33E+05	3.21E+08		0.00E+00	NC	3.21E+08	3.20E-18	5.25E-06
Fe-55	1.33E+06	2.69E+09	0.00E+00	0.00E+00	0.00E+00	2.69E+09	5.50E-18	7.54E-05
Co-58	2.22E+02	1.08E+06	0.00E+00	0.00E+00	0.00E+00	1.08E+06	0.00E+00	NC
Ni-59	5.70E+02	9.55E+05	0.00E+00	0.00E+00	0.00E+00	9.56E+05	1.10E-18	5.36E-09
Ni-63	1.33E+05	2.26E+08	0.00E+00	0.00E+00	0.00E+00	2.26E+08	2.50E-18	2.88E-06
Nb-94	1.09E+03	1.81E+06	0.00E+00	0.00E+00		1.82E+06	2.90E-17	2.69E-07
Cs-137	1.69E+06	1.08E+09	0.00E+00	0.00E+00	0.00E+00	1.08E+09	1.20E-16	6.60E-04
Sr-90	1.01E+05	6.44E+06	0.00E+00	0.00E+00	0.00E+00	6.54E+06	7.00E-17	2.34E-06
Tc-99	7.27E+03	4.51E+05	0.00E+00	0.00E+00	0.00E+00	4.58E+05	5.90E-18	1.38E-08
I-129	6.38E+00	4.06E+03	0.00E+00	0.00E+00	0.00E+00	4.06E+03	1.20E-15	2.49E-08
Cs-134	1.08E+06	8.04E+08	0.00E+00	0.00E+00	0.00E+00	8.05E+08	8.30E-17	3.41E-04
Pu-241	1.51E+07	1.64E+06	0.00E+00	0.00E+00	0.00E+00	1.68E+07	4.40E-17	3.76E-06
U-235	2.84E+00	3.04E-01	0.00E+00	0.00E+00	0.00E+00	3.14E+00	0.00E+00	NC
U-238	8.69E+01	9.01E+00	0.00E+00	0.00E+00	0.00E+00	9.59E+01	0.00E+00	NC
Pu-238	1.74E+05	1.89E+04	0.00E+00	0.00E+00	0.00E+00	1.93E+05	3.50E-16	3.45E-07
Pu-239	4.79E+04	4.96E+03	0.00E+00	0.00E+00	0.00E+00	5.28E+04	3.80E-16	1.02E-07
Pu-240	1.13E+05	1.24E+04	0.00E+00	0.00E+00	0.00E+00	1.26E+05	3.80E-16	2.44E-07
Am-241	3.15E+05	3.21E+04	0.00E+00	0.00E+00	0.00E+00	3.47E+05	3.00E-16	5.32E-07
Cm-244	4.60E+04	4.90E+03	0.00E+00	0.00E+00	0.00E+00	5.09E+04	1.80E-16	4.67E-08
TOTAL	2.07E+07	5.86E+09	0.00E+00	0.00E+00	0.00E+00	5.89E+09		1.31E-03

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] 1.31E-03

Table 6-7.3 Public Exposure due to Release in 2007 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	5.12E+05	7.35E+08	0.00E+00	0.00E+00	0.00E+00
Cs-137	3.20E+06	1.08E+09	0.00E+00	0.00E+00	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2007	
end	31/12/2007	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	5.12E+05	7.35E+08	0.00E+00	0.00E+00	0.00E+00	7.36E+08	5.70E-17	2.14E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	3.96E+03	5.24E+06	0.00E+00	0.00E+00	0.00E+00	5.25E+06	4.40E-19	1.18E-08
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	8.67E+04	1.63E+08		0.00E+00	NC	1.63E+08	3.20E-18	2.66E-06
Fe-55	1.51E+06	2.37E+09	0.00E+00	0.00E+00	0.00E+00	2.37E+09	5.50E-18	6.64E-05
Co-58	9.27E+00	3.52E+04	0.00E+00	0.00E+00	0.00E+00	3.52E+04	0.00E+00	NC
Ni-59	8.34E+02	1.09E+06	0.00E+00	0.00E+00	0.00E+00	1.09E+06	1.10E-18	6.11E-09
Ni-63	1.93E+05	2.56E+08	0.00E+00	0.00E+00	0.00E+00	2.56E+08	2.50E-18	3.27E-06
Nb-94	1.59E+03	2.07E+06	0.00E+00	0.00E+00		2.07E+06	2.90E-17	3.06E-07
Cs-137	3.20E+06	1.08E+09	0.00E+00	0.00E+00	0.00E+00	1.08E+09	1.20E-16	6.60E-04
Sr-90	1.91E+05	6.43E+06	0.00E+00	0.00E+00	0.00E+00	6.62E+06	7.00E-17	2.36E-06
Tc-99	1.40E+04	4.61E+05	0.00E+00	0.00E+00	0.00E+00	4.75E+05	5.90E-18	1.43E-08
I-129	1.23E+01	4.15E+03	0.00E+00	0.00E+00	0.00E+00	4.16E+03	1.20E-15	2.55E-08
Cs-134	1.49E+06	5.87E+08	0.00E+00	0.00E+00	0.00E+00	5.89E+08	8.30E-17	2.49E-04
Pu-241	2.79E+07	1.60E+06	0.00E+00	0.00E+00	0.00E+00	2.95E+07	4.40E-17	6.61E-06
U-235	5.48E+00	3.11E-01	0.00E+00	0.00E+00	0.00E+00	5.79E+00	0.00E+00	NC
U-238	1.68E+02	9.22E+00	0.00E+00	0.00E+00	0.00E+00	1.77E+02	0.00E+00	NC
Pu-238	3.34E+05	1.91E+04	0.00E+00	0.00E+00	0.00E+00	3.54E+05	3.50E-16	6.31E-07
Pu-239	9.25E+04	5.07E+03	0.00E+00	0.00E+00	0.00E+00	9.75E+04	3.80E-16	1.89E-07
Pu-240	2.19E+05	1.27E+04	0.00E+00	0.00E+00	0.00E+00	2.32E+05	3.80E-16	4.49E-07
Am-241	6.54E+05	3.52E+04	0.00E+00	0.00E+00	0.00E+00	6.89E+05	3.00E-16	1.05E-06
Cm-244	8.55E+04	4.83E+03	0.00E+00	0.00E+00	0.00E+00	9.03E+04	1.80E-16	8.29E-08
TOTAL	3.64E+07	5.20E+09	0.00E+00	0.00E+00	0.00E+00	5.24E+09		1.21E-03

■ : not applicable for defined isotopic spectrum
NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] **1.21E-03**

Table 6-7.4 Public Exposure due to Release in 2008 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	7.33E+05	7.43E+08	0.00E+00	0.00E+00	0.00E+00
Cs-137	3.60E+06	1.08E+09	0.00E+00	0.00E+00	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2008	
end	31/12/2008	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	7.33E+05	7.43E+08	0.00E+00	0.00E+00	0.00E+00	7.43E+08	5.70E-17	2.16E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	6.51E+03	6.09E+06	0.00E+00	0.00E+00	0.00E+00	6.09E+06	4.40E-19	1.37E-08
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	6.30E+04	8.35E+07		0.00E+00	NC	8.36E+07	3.20E-18	1.36E-06
Fe-55	1.90E+06	2.11E+09	0.00E+00	0.00E+00	0.00E+00	2.11E+09	5.50E-18	5.92E-05
Co-58	4.31E-01	1.15E+03	0.00E+00	0.00E+00	0.00E+00	1.15E+03	0.00E+00	NC
Ni-59	1.36E+03	1.25E+06	0.00E+00	0.00E+00	0.00E+00	1.26E+06	1.10E-18	7.04E-09
Ni-63	3.13E+05	2.93E+08	0.00E+00	0.00E+00	0.00E+00	2.93E+08	2.50E-18	3.74E-06
Nb-94	2.60E+03	2.38E+06	0.00E+00	0.00E+00		2.39E+06	2.90E-17	3.53E-07
Cs-137	3.60E+06	1.08E+09	0.00E+00	0.00E+00	0.00E+00	1.08E+09	1.20E-16	6.61E-04
Sr-90	2.15E+05	6.43E+06	0.00E+00	0.00E+00	0.00E+00	6.64E+06	7.00E-17	2.37E-06
Tc-99	1.62E+04	4.72E+05	0.00E+00	0.00E+00	0.00E+00	4.88E+05	5.90E-18	1.47E-08
I-129	1.42E+01	4.25E+03	0.00E+00	0.00E+00	0.00E+00	4.26E+03	1.20E-15	2.61E-08
Cs-134	1.23E+06	4.29E+08	0.00E+00	0.00E+00	0.00E+00	4.30E+08	8.30E-17	1.82E-04
Pu-241	3.06E+07	1.56E+06	0.00E+00	0.00E+00	0.00E+00	3.22E+07	4.40E-17	7.22E-06
U-235	6.32E+00	3.19E-01	0.00E+00	0.00E+00	0.00E+00	6.64E+00	0.00E+00	NC
U-238	1.93E+02	9.44E+00	0.00E+00	0.00E+00	0.00E+00	2.03E+02	0.00E+00	NC
Pu-238	3.83E+05	1.94E+04	0.00E+00	0.00E+00	0.00E+00	4.02E+05	3.50E-16	7.18E-07
Pu-239	1.07E+05	5.19E+03	0.00E+00	0.00E+00	0.00E+00	1.12E+05	3.80E-16	2.17E-07
Pu-240	2.53E+05	1.30E+04	0.00E+00	0.00E+00	0.00E+00	2.66E+05	3.80E-16	5.15E-07
Am-241	8.02E+05	3.83E+04	0.00E+00	0.00E+00	0.00E+00	8.40E+05	3.00E-16	1.29E-06
Cm-244	9.48E+04	4.76E+03	0.00E+00	0.00E+00	0.00E+00	9.96E+04	1.80E-16	9.14E-08
TOTAL	4.03E+07	4.75E+09	0.00E+00	0.00E+00	0.00E+00	4.79E+09		1.14E-03

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] **1.14E-03**

Table 6-7.5 Public Exposure due to Release in 2009 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	2.12E+07	6.27E+08	0.00E+00	1.53E+09	0.00E+00
Cs-137	9.61E+05	4.08E+08	0.00E+00	4.55E+04	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2009	
end	31/12/2009	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	2.12E+07	6.27E+08	0.00E+00	1.53E+09	0.00E+00	2.17E+09	5.70E-17	6.32E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	2.16E+05	5.91E+06	0.00E+00	1.19E+07	0.00E+00	1.80E+07	4.40E-19	4.05E-08
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	9.24E+05	3.58E+07		0.00E+00	NC	3.67E+07	3.20E-18	5.99E-07
Fe-55	4.85E+07	1.57E+09	0.00E+00	4.96E+09	0.00E+00	6.57E+09	5.50E-18	1.84E-04
Co-58	4.04E-01	3.16E+01	0.00E+00	0.00E+00	0.00E+00	3.20E+01	0.00E+00	NC
Ni-59	4.49E+04	1.21E+06	0.00E+00	1.23E+07	0.00E+00	1.36E+07	1.10E-18	7.62E-08
Ni-63	1.02E+07	2.80E+08	0.00E+00	1.36E+09	0.00E+00	1.65E+09	2.50E-18	2.11E-05
Nb-94	8.56E+04	2.29E+06	0.00E+00	2.35E+07		2.59E+07	2.90E-17	3.83E-06
Cs-137	9.61E+05	4.08E+08	0.00E+00	4.55E+04	0.00E+00	4.09E+08	1.20E-16	2.50E-04
Sr-90	5.73E+04	2.43E+06	0.00E+00	2.72E+03	0.00E+00	2.49E+06	7.00E-17	8.90E-07
Tc-99	4.42E+03	1.83E+05	0.00E+00	2.04E+02	0.00E+00	1.88E+05	5.90E-18	5.64E-09
I-129	3.88E+00	1.65E+03	0.00E+00	1.84E-01	0.00E+00	1.65E+03	1.20E-15	1.01E-08
Cs-134	2.40E+05	1.19E+08	0.00E+00	1.14E+04	0.00E+00	1.19E+08	8.30E-17	5.04E-05
Pu-241	7.96E+06	5.75E+05	0.00E+00	3.81E+05	0.00E+00	8.92E+06	4.40E-17	2.00E-06
U-235	1.72E+00	1.23E-01	0.00E+00	8.17E-02	0.00E+00	1.93E+00	0.00E+00	NC
U-238	5.28E+01	3.66E+00	0.00E+00	2.50E+00	0.00E+00	5.90E+01	0.00E+00	NC
Pu-238	1.04E+05	7.47E+03	0.00E+00	4.91E+03	0.00E+00	1.16E+05	3.50E-16	2.07E-07
Pu-239	2.91E+04	2.01E+03	0.00E+00	1.38E+03	0.00E+00	3.25E+04	3.80E-16	6.30E-08
Pu-240	6.90E+04	5.03E+03	0.00E+00	3.27E+03	0.00E+00	7.73E+04	3.80E-16	1.50E-07
Am-241	2.32E+05	1.57E+04	0.00E+00	1.10E+04	0.00E+00	2.58E+05	3.00E-16	3.95E-07
Cm-244	2.49E+04	1.77E+03	0.00E+00	1.18E+03	0.00E+00	2.79E+04	1.80E-16	2.56E-08
TOTAL	9.09E+07	3.05E+09	0.00E+00	7.89E+09	0.00E+00	1.10E+10		1.15E-03

(black cell) : not applicable for defined isotopic spectrum
NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] **1.15E-03**

Table 6-7.6 Public Exposure due to Release in 2010 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	1.31E+05	6.41E+08	0.00E+00	2.12E+09	0.00E+00
Cs-137	8.25E+05	4.15E+08	0.00E+00	6.34E+04	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2010	
end	31/12/2010	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	1.31E+05	6.41E+08	0.00E+00	2.12E+09	0.00E+00	2.76E+09	5.70E-17	8.04E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	1.54E+03	6.94E+06	0.00E+00	1.91E+07	0.00E+00	2.60E+07	4.40E-19	5.84E-08
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	2.90E+03	1.85E+07		0.00E+00	NC	1.85E+07	3.20E-18	3.03E-07
Fe-55	2.65E+05	1.42E+09	0.00E+00	6.08E+09	0.00E+00	7.50E+09	5.50E-18	2.10E-04
Co-58	8.13E-05	1.05E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+00	0.00E+00	NC
Ni-59	3.17E+02	1.41E+06	0.00E+00	1.96E+07	0.00E+00	2.10E+07	1.10E-18	1.18E-07
Ni-63	7.19E+04	3.24E+08	0.00E+00	2.15E+09	0.00E+00	2.47E+09	2.50E-18	3.15E-05
Nb-94	6.05E+02	2.67E+06	0.00E+00	3.73E+07		4.00E+07	2.90E-17	5.91E-06
Cs-137	8.25E+05	4.15E+08	0.00E+00	6.34E+04	0.00E+00	4.16E+08	1.20E-16	2.55E-04
Sr-90	4.92E+04	2.47E+06	0.00E+00	3.77E+03	0.00E+00	2.53E+06	7.00E-17	9.02E-07
Tc-99	3.88E+03	1.91E+05	0.00E+00	2.91E+02	0.00E+00	1.95E+05	5.90E-18	5.86E-09
I-129	3.41E+00	1.72E+03	0.00E+00	2.62E-01	0.00E+00	1.72E+03	1.20E-15	1.05E-08
Cs-134	1.50E+05	8.83E+07	0.00E+00	1.15E+04	0.00E+00	8.85E+07	8.30E-17	3.74E-05
Pu-241	6.67E+06	5.71E+05	0.00E+00	5.18E+05	0.00E+00	7.76E+06	4.40E-17	1.74E-06
U-235	1.52E+00	1.29E-01	0.00E+00	1.16E-01	0.00E+00	1.76E+00	0.00E+00	NC
U-238	4.64E+01	3.81E+00	0.00E+00	3.56E+00	0.00E+00	5.38E+01	0.00E+00	NC
Pu-238	9.04E+04	7.73E+03	0.00E+00	6.94E+03	0.00E+00	1.05E+05	3.50E-16	1.87E-07
Pu-239	2.56E+04	2.10E+03	0.00E+00	1.96E+03	0.00E+00	2.96E+04	3.80E-16	5.75E-08
Pu-240	6.06E+04	5.24E+03	0.00E+00	4.65E+03	0.00E+00	7.05E+04	3.80E-16	1.37E-07
Am-241	2.14E+05	1.72E+04	0.00E+00	1.64E+04	0.00E+00	2.48E+05	3.00E-16	3.79E-07
Cm-244	2.11E+04	1.78E+03	0.00E+00	1.62E+03	0.00E+00	2.45E+04	1.80E-16	2.25E-08
TOTAL	8.58E+06	2.92E+09	0.00E+00	1.04E+10	0.00E+00	1.34E+10		1.35E-03

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] 1.35E-03

Table 6-7.7 Public Exposure due to Release in 2011 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	1.31E+05	6.41E+08	0.00E+00	2.12E+09	0.00E+00
Cs-137	8.25E+05	4.15E+08	0.00E+00	6.34E+04	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2011	
end	31/12/2011	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	1.31E+05	6.41E+08	0.00E+00	2.12E+09	0.00E+00	2.76E+09	5.70E-17	8.04E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	1.77E+03	7.98E+06	0.00E+00	2.19E+07	0.00E+00	2.99E+07	4.40E-19	6.71E-08
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	1.47E+03	9.41E+06		0.00E+00	NC	9.41E+06	3.20E-18	1.54E-07
Fe-55	2.34E+05	1.25E+09	0.00E+00	5.36E+09	0.00E+00	6.61E+09	5.50E-18	1.85E-04
Co-58	2.64E-06	3.40E-02	0.00E+00	0.00E+00	0.00E+00	3.40E-02	0.00E+00	NC
Ni-59	3.62E+02	1.60E+06	0.00E+00	2.23E+07	0.00E+00	2.39E+07	1.10E-18	1.34E-07
Ni-63	8.14E+04	3.67E+08	0.00E+00	2.43E+09	0.00E+00	2.80E+09	2.50E-18	3.57E-05
Nb-94	6.90E+02	3.05E+06	0.00E+00	4.25E+07		4.55E+07	2.90E-17	6.74E-06
Cs-137	8.25E+05	4.15E+08	0.00E+00	6.34E+04	0.00E+00	4.16E+08	1.20E-16	2.55E-04
Sr-90	4.91E+04	2.47E+06	0.00E+00	3.77E+03	0.00E+00	2.52E+06	7.00E-17	9.01E-07
Tc-99	3.98E+03	1.95E+05	0.00E+00	2.98E+02	0.00E+00	1.99E+05	5.90E-18	6.00E-09
I-129	3.49E+00	1.76E+03	0.00E+00	2.68E-01	0.00E+00	1.76E+03	1.20E-15	1.08E-08
Cs-134	1.10E+05	6.45E+07	0.00E+00	8.44E+03	0.00E+00	6.46E+07	8.30E-17	2.74E-05
Pu-241	6.50E+06	5.57E+05	0.00E+00	5.05E+05	0.00E+00	7.57E+06	4.40E-17	1.70E-06
U-235	1.55E+00	1.32E-01	0.00E+00	1.19E-01	0.00E+00	1.80E+00	0.00E+00	NC
U-238	4.75E+01	3.90E+00	0.00E+00	3.65E+00	0.00E+00	5.51E+01	0.00E+00	NC
Pu-238	9.17E+04	7.85E+03	0.00E+00	7.04E+03	0.00E+00	1.07E+05	3.50E-16	1.90E-07
Pu-239	2.62E+04	2.15E+03	0.00E+00	2.01E+03	0.00E+00	3.03E+04	3.80E-16	5.88E-08
Pu-240	6.20E+04	5.36E+03	0.00E+00	4.76E+03	0.00E+00	7.21E+04	3.80E-16	1.40E-07
Am-241	2.29E+05	1.84E+04	0.00E+00	1.76E+04	0.00E+00	2.65E+05	3.00E-16	4.06E-07
Cm-244	2.08E+04	1.75E+03	0.00E+00	1.59E+03	0.00E+00	2.41E+04	1.80E-16	2.21E-08
TOTAL	8.37E+06	2.76E+09	0.00E+00	1.00E+10	0.00E+00	1.28E+10		1.32E-03

■ : not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] **1.32E-03**

Table 6-7.8 Public Exposure due to Release in 2012 (Aerosol)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	1.28E+05	7.29E+08	0.00E+00	1.16E+09	0.00E+00
Cs-137	8.03E+05	4.38E+08	0.00E+00	3.47E+04	0.00E+00

Type of release	A	→ Aerosol
Period of release : start	01/01/2012	
end	31/12/2012	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	1.28E+05	7.29E+08	0.00E+00	1.16E+09	0.00E+00	1.89E+09	5.70E-17	5.50E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	1.98E+03	1.04E+07	0.00E+00	1.38E+07	0.00E+00	2.42E+07	4.40E-19	5.43E-08
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	7.28E+02	5.42E+06		0.00E+00	NC	5.42E+06	3.20E-18	8.85E-08
Fe-55	2.01E+05	1.25E+09	0.00E+00	2.59E+09	0.00E+00	3.84E+09	5.50E-18	1.08E-04
Co-58	8.34E-08	1.26E-03	0.00E+00	0.00E+00	0.00E+00	1.26E-03	0.00E+00	NC
Ni-59	4.01E+02	2.08E+06	0.00E+00	1.39E+07	0.00E+00	1.60E+07	1.10E-18	8.97E-08
Ni-63	8.98E+04	4.72E+08	0.00E+00	1.51E+09	0.00E+00	1.98E+09	2.50E-18	2.52E-05
Nb-94	7.66E+02	3.95E+06	0.00E+00	2.65E+07		3.05E+07	2.90E-17	4.50E-06
Cs-137	8.03E+05	4.38E+08	0.00E+00	3.47E+04	0.00E+00	4.39E+08	1.20E-16	2.69E-04
Sr-90	4.77E+04	2.60E+06	0.00E+00	2.06E+03	0.00E+00	2.65E+06	7.00E-17	9.48E-07
Tc-99	3.96E+03	2.11E+05	0.00E+00	1.67E+02	0.00E+00	2.15E+05	5.90E-18	6.47E-09
I-129	3.47E+00	1.90E+03	0.00E+00	1.50E-01	0.00E+00	1.90E+03	1.20E-15	1.16E-08
Cs-134	7.81E+04	4.97E+07	0.00E+00	3.37E+03	0.00E+00	4.98E+07	8.30E-17	2.11E-05
Pu-241	6.17E+06	5.73E+05	0.00E+00	2.69E+05	0.00E+00	7.01E+06	4.40E-17	1.57E-06
U-235	1.54E+00	1.42E-01	0.00E+00	6.67E-02	0.00E+00	1.75E+00	0.00E+00	NC
U-238	4.73E+01	4.21E+00	0.00E+00	2.04E+00	0.00E+00	5.36E+01	0.00E+00	NC
Pu-238	9.06E+04	8.41E+03	0.00E+00	3.91E+03	0.00E+00	1.03E+05	3.50E-16	1.84E-07
Pu-239	2.61E+04	2.32E+03	0.00E+00	1.13E+03	0.00E+00	2.95E+04	3.80E-16	5.72E-08
Pu-240	6.17E+04	5.79E+03	0.00E+00	2.67E+03	0.00E+00	7.02E+04	3.80E-16	1.36E-07
Am-241	2.38E+05	2.08E+04	0.00E+00	1.03E+04	0.00E+00	2.69E+05	3.00E-16	4.11E-07
Cm-244	1.99E+04	1.82E+03	0.00E+00	8.58E+02	0.00E+00	2.26E+04	1.80E-16	2.07E-08
TOTAL	7.96E+06	2.97E+09	0.00E+00	5.31E+09	0.00E+00	8.28E+09		9.81E-04

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) 5.1

Public exposure [mSv] **9.81E-04**

D) <u>Discussion</u>

The yearly effective doses are predicted to fall in the range $8.9*10^{-4}$ – $1.4*10^{-3}$ mSv/y. The results are obtained on a somewhat conservative basis, i.e. considering that 95 % of the aerosols releases occur via a 75 m height stack (i.e. the height of the existing stack of the liquid waste treatment facilities and the assumed height of the stack to be built for B2/3/4 facility) and 5 % of the discharge occur at a 10 meter elevation. This leads to a value of K = 5.1 in relationship (1). Further, some conservatism has been included in the radiological source term assessment (see section 6.11).

An examination of Tables 6.7.1 to 6.7.8 shows that the calculated yearly effective dose does not significantly vary during the considered period (see herabove). However, both the global aerosol releases and the contribution of the main nuclides to the global releases and to effective dose significantly vary in function of the considered year (or group of years):

- the aerosol predicted global annual discharges vary from 2.8×10^{9} Bq (2005) to 1.3×10^{10} Bq (2010, 2011);

- the effective dose is governed by Cs^{137} during period 2005-2008 and by Co^{60} during period 2009-2012. This mainly results from the startup of the solid waste retrieval and conditioning activities in April 2009;

- the nuclide vector of the fission product discharges is always governed by spectrum S_2 for the whole considered period, while the nuclide vector of the activation product discharges is governed by spectrum S_1 during period 2005-2008 and by spectrum S_4 during period 2009-2012. Here again, this results from the startup of the solid waste and, more particularly, from Group E (3) waste retrieval and conditioning activities.

The contribution of the TRU to the total effective dose remains quite low (<< 1 %).

It must be recalled, here, that the discharges resulting from the retrieval and conditioning of the spent resins, perlite and sediments (activity started in 2005) and from the retrieval and conditioning of the solid waste (activity started in 2009), i.e. the activities of which contribution to the global discharges are, by far, the most important have been “allocated” to Unit 1.

For indicative purpose, the predicted global aerosol discharges from Unit 1 post-shutdown activities only (system post-operation, modification, isolation, fuel handling operations) amount to less than 10 % of the global releases (6.0×10^{10} Bq) during the considered period (2005-2012),

E) <u>Contribution of Unit 2 to the global atmospheric releases during Unit 1 Defuelling Phase</u>

During period 2005 – 2012, the contribution of Unit 2 to the global atmospheric releases includes:

(a) the releases during operation period 2005 – 2009;
(b) the releases during the reactor post-shutdown phase (period 2010 – 2012).

(a) Releases during Operation Period

On the basis of the data in Table 6-1, the predicted atmospheric releases and the corresponding effective dose to the critical members of the public are as follows (see Table 6-8):

Table 6-8 Unit 2 Predicted Atmospheric Releases and Public Exposure during Operation Period (2005 – 2009)

Nuclides	Releases (Bq/y)	Effective dose to the critical members of the public (mSv/y)
Noble gases	4.0×10^{13}	2.4×10^{-5}
I^{131}	1.2×10^{9}	7.0×10^{-5}
Aerosols (C^{14}, H^3 excluded)	5.5×10^{8}	1.8×10^{-5}
C^{14}	6.5×10^{10}	3.0×10^{-5}
H^3	1.2×10^{12}	2.0×10^{-6}
Total		1.4×10^{-4}

The above effective dose corresponds thus to some 11 % - 16 % of Unit 1 effective dose during period 2005-2009.

As hereabove indicated, Unit 1 yearly effective doses are largely governed by the retrieval and conditioning of the accumulated operational waste.

(b) Releases during the Reactor Post-Shutdown Period

The detailed environmental impact of Unit 2 post-shutdown activities during period 2010 – 2012 will be given in the EIA Report associated to U2DP0. These activities include:

- for period year 2010:
  - the operation of the systems kept in service,
  - the defuelling of the reactor,
  - the modifications and the isolation of the systems kept/not kept in service;
- for period 2011 -2012:
  - the operation of the systems kept in service,
  - the beginning of the pools defuelling operation,
  - the modifications and the isolation of the systems kept/not kept in service;
  - the in-line decontamination activities (MCC+PCS, Refuelling Machine).

For Unit 2, a preliminary assessment can be given extrapolating the results pertaining to the corresponding activities of Unit 1.

Year 2010

Activity	Aerosols releases[47] (preliminary estimates), Bq
• Unit 2 Stage 1 post-operation of systems kept in service • Reactor defuelling • Unit 2 system modifications/isolation	1.93×10^9 6.0×10^6 5.0×10^6
Total	1.94×10^9

The corresponding effective dose to the critical members of the public is estimated to 1.9×10^{-4} mSv (preliminary assessment).

Year 2011

Activity	Aerosols releases[45] (preliminary estimates), Bq
• Unit 2 Stage 2 post-operation of systems kept in service • In-line decontamination (MCC+PCS, Refuelling Machine) • Unit 2 system modifications/isolation • Pools defuelling	9.1×10^7 2.3×10^8 2.0×10^6 7.7×10^6
Total	3.3×10^8

The corresponding effective dose to the critical members of the public is estimated to 3.3×10^{-5} mSv (preliminary assessment).

Year 2012

Activity	Aerosols releases[45] (preliminary estimates), Bq
• Unit 2 Stage 2 post-operation of systems kept in service • Unit 2 system modifications/isolation • Pools defuelling	9.1×10^7 2.0×10^6 7.7×10^6
Total	1.0 (8)

The corresponding effective dose to the critical members of the public is estimated to 1.0×10^{-5} mSv (preliminary assessment).

F) Conclusions

During Unit 1 defuelling phase (period 2005 – 2012), the predicted contribution of Unit 2 operation and post-shutdown operation to effective dose resulting from the atmospheric releases varies in function of the considered year and is found to lay in the range 1.0×10^{-5} mSv/y to 1.9×10^{-4} mSv/y (preliminary assessment). Combining the discharges of both Units during the above mentioned period leads to the following dose assessment:

[47] C^{14} included.

Table 6-9 Atmospheric Releases Radiological Impact from INPP Site during Unit 1 Defuelling

Year	Unit 1 (mSv/y)	Unit 2 (mSv/y)	Total Site (mSv/y)
2005	8.9×10^{-4}	1.4×10^{-4}	1.0×10^{-3}
2006	1.3×10^{-3}	1.4×10^{-4}	1.4×10^{-3}
2007	1.2×10^{-3}	1.4×10^{-4}	1.3×10^{-3}
2008	1.1×10^{-3}	1.4×10^{-4}	1.2×10^{-3}
2009	1.2×10^{-3}	1.4×10^{-4}	1.3×10^{-3}
2010	1.4×10^{-3}	1.9×10^{-4}	1.6×10^{-3}
2011	1.3×10^{-3}	3.3×10^{-5}	1.3×10^{-3}
2012	9.8×10^{-4}	1.0×10^{-5}	9.9×10^{-4}

The contribution of Unit 2 to the effective dose resulting from the site atmospheric releases ranges from 1 % to about 14 %, in function of the considered year. As hereabove shown, the effective dose resulting from INPP site atmospheric releases are largely governed by the operation of the new waste retrieval and conditioning facilities, the releases of which have been attributed to Unit 1.

G) Transboundary effects

The closest distances to the boarders of Bielorussia and Latvia are of about 4.5 and 7 km respectively, i.e. distances longer than that (3 km) taken into account for the assessment of the radiological exposure of the critical members of the public in Lithuania. It results therefrom that, assuming the same contamination transfer pathways as those considered for the members of the public in the vicinity of INPP, the radiological exposure of the members of the public at the boards of the neighbouring countries will be somewhat (10 - 20 %) lower than that predicted for individuals at the vicinity of INPP. Such differences are not significative from the radiological standpoint and the transboundary effects can thus be considered equal to those calculated for the critical members of the public in Lithuania.

6.5 Radionuclide Content in the Discharged Water during U1DP0 Activities and Environmental Impacts

6.5.1 Origin of the Radionuclide Content in the Discharged Water during INPP Unit 1 Defuelling Phase

During the defuelling phase of Unit 1, the releases of radionuclides into the lake originate from the same sources (activities) as those listed for the releases of gaseous waste (§ 6.3.1).

6.5.2 Assessment of the Radionuclide Content in the Discharged Water during INPP Unit 1 Defuelling Phase

6.5.2.1 Radionuclide Content in the Discharged Water during INPP Routine Operation – Public Exposure

During routine operation of INPP [95], the yearly discharges of radionuclides into the lake typically amounts to 8.3×10^{8} Bq for both units (H^3 excluded) – average value for period 1999 - 2003.

The main contributors are: Cs^{137} – 74 %, Mn^{54} – 3 %, Co^{60} – 14 %, Zr^{95} + Nb^{95} – 5 %.

The corresponding annual effective dose to the members of the public amounts to 1.7×10^{-3} mSv (H^3 excluded) for both units, i.e. 8.5×10^{-4} mSv/y for Unit 1.

The main contributors are: Cs^{137} -89 %, Co^{60} – 8 %, Nb^{95} – 3 %.

Note: Sr^{90} and H^3 Content in the Discharged Water

H^3 and Sr^{90} contents in the discharged water are not mentioned in [95] because the specific activity of these nuclides is lower than or equal to the natural background. Therefore, the content of these nuclides in the discharged water and the corresponding effective doses were assessed as follows:

Sr^{90}

Ratio $\frac{Sr^{90}}{Cs^{137}}$ in the releases = 0.06 (see chapter 4 of U1DP0), this value being conservative.

Applying the same ratio to the measured Cs^{137} content in the discharged water leads to the following annual release (average value):

- Sr^{90} content in the discharged water (both Units) = $0.06\times0.74\times8.3\times10^8 = 3.7\times10^7$ Bq/y;
- Corresponding effective dose = $\frac{3.7\times10^7}{8.1\times10^8}\times1.54\times10^{-3}$ = 7.0×10^{-5} mSv/y, where:
  - 0.06, 0.74 and 8.3×10^8 Bq/y: see hereabove,
  - 8.1×10^8 = planned annual release of Sr^{90} for both Units [85],
  - 1.54×10^{-3} = Sr^{90} planned annual release effective dose (mSv/y) [85].

For Unit 1, Sr^{90} effective dose amounts thus to 3.5×10^{-5} mSv/y.

H^3

The planned H^3 content in the discharged water amounts to 7.8×10^{11} Bq/y and the corresponding effective dose is 2.7×10^{-5} mSv/y (Table 9 of [83]).

For Unit 1, H^3 effective dose amounts thus to 1.4×10^{-5} mSv/y.

As it can be inferred from Table 9 of [83], the planned releases exceed the actual ones. The above H^3 effective dose is thus to be considered as conservative.

Conclusion

The annual effective dose resulting from the nuclide content in the discharged water during routine operation is equal to 9.0×10^{-4} mSv for Unit 1 (H^3 and Sr^{90} included).

6.5.2.2 Radionuclide Content in the Discharged Water during INPP Unit 1 Defuelling Phase – Public Exposure

By comparison with the INPP routine operation, the post-shutdown releases are predicted to exhibit the following differences:

- progressive reduction of the short half-life nuclides after the RFS (Mn^{54}, Co^{58}, Cr^{51}, Fe^{59}, I^{131}, Zr^{95}, Nb^{95}), these nuclides having already a low contribution to the effective dose during normal operation;

- progressive reduction of the H^3 releases, this nuclide having already a low contribution to the effective dose (some 0.7 %);

- increase of the TRU nuclides releases, especially during the in-line decontamination operations.

A) <u>Assessment of the radionuclide content in the discharged water and of the public exposure</u>

The discharges of water into the lake were assessed by application of the decomissioning DBS (Data Base Sheets) production software for each activity carried out during the defuelling phase of Unit 1 (see chapters 5 and 6 of U1DP0 and [95]).

For the whole defuelling period of Unit 1, the global radionuclide inventory of the discharged water is predicted to amount to $2.3*10^9$ Bq.

The histogram of the radionuclide content in the discharged water (see Figure 6-4) shows that the anticipated monthly and yearly radionuclide discharges are rather constant (some $1.3*10^7$ Bq/month) with major exceptions during the year 2009. The peaks observed during the first months of this year are linked to the conduct of the in-line decontamination of the primary circuit (MCC) and of its purification circuit (PCS).

<u>Remarks:</u>

1) A monthly discharge of some 1.3×10^7 Bq/month means a yearly discharge of 1.6×10^8 Bq, i.e. about 31 % of the yearly discharge of Unit 1 (5.1×10^8 Bq, Sr^{90} included and H^3 excluded – see section 6.4.2.1).

2) It must be mentioned, here, that the DBS software does not take into account the recycling of the purified liquid waste evaporator condensates, i.e. that the DBS software considers that, after purification by the ion-exchange resins, the evaporator condensates are discharged into the lake. Actually, during normal operation, this cleaned condensate is recycled to the largest possible extent. This practice will still be applied during the decommissioning. This means that the actual releases will still be lower than the hereabove predicted values (see also section 3.10.4-b).

B) Methodology for assessment of public radiological exposure

The annual effective dose to the members of the public is given by:

$$D_t = \sum_i Di = \sum_j R_{Co}{}^{60}{}_{,j} * \sum_{APi} SF_{APi,j} * D_{1,\,Api} * 10^3 + \sum_j R_{Cs}{}^{137}{}_{,j} * \sum_{FPi} SF_{FPi,j} * D_{1,\,FPi} * 10^3 \qquad (2)$$

D_t = total effective dose for the considered year (mSv/y)
D_i = nuclide i effective dose for the considered year (mSv/y)

$R_{Co}{}^{60}$,j , $R_{Cs}{}^{137}$,j = Co^{60} and Cs^{137} content in the discharged water (source terms) associated to nuclide vector j (spectrum j) during the considered year (Bq/y) – see examples in section 6.11.

$SF_{Api,j}$(t) = spectrum j activation product i scaling factor (linked to Co^{60}) during the considered year
(the activation products taken into account are: C^{14}, Mn^{54}, Fe^{55}, Co^{60}, Ni^{59}, Ni^{63} and Nb^{94})

$SF_{Fpi,j}$(t) = spectrum j fission product i scaling factor (linked to Cs^{137}) during the considered year
(the fission products taken into account are: Sr^{90}, Tc^{99}, I^{129}, Cs^{134}, Cs^{137}, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{241}, Am^{241} and Cm^{244}).

Remark: the values of $SF_{Api,j}$ and $SF_{Fpi,j}$ by the time of the RFS and their evolution with time after the RFS are given in [86].

$D_{1,APi}$, $D_{1,FPi}$ = liquid release dose–contamination conversion factor for activation/fission product i (Sv/Bq) – see LAND-42-2001 (see also section 6.9 hereafter).

Remark: for Fe^{55}, Ni^{59}, Ni^{63}, Nb94 and Tc^{99}, LAND-42 does not mention the dose-contamination conversion factor. For those nuclides, the conversion factors were derived from ICRP-72 data corresponding to the adult [78].

10^3 = conversion factor (mSv/Sv)
For the considered year, the releases of nuclides i are assessed by the DBS software (see hereafter).

C) Results of assessment of public radiological exposure

The histogram of the radionuclide global content in the discharged water (see Figure 6-4) shows that the highest yearly exposure is predicted to occur during year 2009, including the in-line decontamination of the MCC+PCS[48].

[48] Note:
The liquid waste produced by the in-line decontamination of the MCC (+PCS) are, after neutralisation, processed by the evaporators of the liquid waste treatment building. The evaporator distillate (condensate) is then purified by ion-exchange resins. The so-obtained clean condensate is discharged into the lake. Actually, during routine operation of the units, the clean distillate is recycled, to the largest possible extent, in function of the plant needs. After the RFS of Unit 1 and especially during stage 2 of the defuelling, when many important systems will no longer be used and drained, the need for recycling will be lower than during normal operation, and the need to recycle the clean

The corresponding global discharge into the lake amounts to 9.93×10^8 Bq (H^3 excluded).

Tables 6-10.1 to 6-10.8 hereafter show for each nuclide i and for period 2005 – 2012:

- the releases (Bq) of Co^{60} and Cs^{137} cumulated on all DBS and splitted between the various spectra (under "Key isotopes activities releases");
- the releases of each nuclide i resulting from all activities characterised by a given nuclide vector (spectrum j) are given under "Related isotopes activities releases";
- the total release of each nuclide I is given under "Related isotopes activities releases" (column total);
- the dose-contamination conversion factor (under $D_{1,i}$ – Sv/Bq);
- the effective dose for each nuclide (under D_i – mSv/y);
- the global effective dose for the considered year (under "Public Exposure" – mSv).

Remark: for details on the various scaling factors and spectra used, see U1DP0 chapter 9, Appendix 9.1.

In those tables, the releases associated to:

- spectrum S_1 mainly results from decontamination and cleaning operations prior to system isolation/modifications;
- spectrum S_4 results from operational Group E (3) solid waste retrieval and processing operations;
- spectrum S_2 results from the other activities carried out during Unit 1 defuelling phases, such as:

    - post-operation of the systems remaining in service after the RFS,
    - modifications and/or isolation of systems,
    - retrieval and conditioning of the operational spent resins, perlite and sediments,
    - retrieval and processing of operational Group 1, 2 (A, B, C) solid waste,
    - defuelling activities.

The results of the measurement campaigns already carried out to validate the spectra (nuclide vectors) are addressed in section 6.3.2.2 –c).

condensate is predicted to decrease. Anyway, the no-recycling option maximises the discharge of nuclides into the lake and is thus a conservative approach.
The overall decontamination factor (DF) of the liquid waste processing system is conservatively limited to 10^5 including:

- a DF = 10^3 for the evaporator condensate/incoming feedstream, a DF = 10^4 – 10^5 being likely more realistic;
- a DF = 10^2 for the ion-exchange resins.

Should the specific activity of the clean condensate exceed the discharge limit (2.0×10^{-10} Ci/l or 7.4 Bq/l), a recycle of this latter upstream of the evaporators is possible for a second evaporation step.

Table 6-10 Public Exposure due to Release in 2005-2012 (Liquid)

Table 6-10.1 Public Exposure due to Release in 2005 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	1.82E+03	1.18E+07	0.00E+00	0.00E+00	0.00E+00
Cs-137	1.21E+04	5.57E+07	0.00E+00	0.00E+00	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2005	
end	31/12/2005	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	1.82E+03	1.18E+07	0.00E+00	0.00E+00	0.00E+00	1.18E+07	1.20E-15	1.41E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	1.07E+01	6.36E+04	0.00E+00	0.00E+00	0.00E+00	6.36E+04	3.10E-15	1.97E-07
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	1.20E+03	1.02E+07		0.00E+00	NC	1.02E+07	8.20E-17	8.33E-07
Fe-55	6.91E+03	4.88E+07	0.00E+00	0.00E+00	0.00E+00	4.88E+07	1.20E-16	5.86E-06
Co-58	3.13E+01	5.35E+05	0.00E+00	0.00E+00	0.00E+00	5.35E+05	0.00E+00	NC
Ni-59	2.29E+00	1.34E+04	0.00E+00	0.00E+00	0.00E+00	1.34E+04	2.20E-17	2.95E-10
Ni-63	5.36E+02	3.20E+06	0.00E+00	0.00E+00	0.00E+00	3.20E+06	5.30E-17	1.70E-07
Nb-94	4.36E+00	2.55E+04	0.00E+00	0.00E+00		2.55E+04	6.00E-16	1.53E-08
Cs-137	1.21E+04	5.57E+07	0.00E+00	0.00E+00	0.00E+00	5.57E+07	2.40E-15	1.34E-04
Sr-90	7.28E+02	3.34E+05	0.00E+00	0.00E+00	0.00E+00	3.34E+05	1.90E-15	6.36E-07
Tc-99	5.10E+01	2.28E+04	0.00E+00	0.00E+00	0.00E+00	2.28E+04	1.20E-16	2.74E-09
I-129	4.48E-02	2.05E+02	0.00E+00	0.00E+00	0.00E+00	2.05E+02	3.60E-15	7.39E-10
Cs-134	1.06E+04	5.70E+07	0.00E+00	0.00E+00	0.00E+00	5.70E+07	7.40E-15	4.22E-04
Pu-241	1.11E+05	8.69E+04	0.00E+00	0.00E+00	0.00E+00	1.98E+05	1.40E-16	2.78E-08
U-235	1.99E-02	1.54E-02	0.00E+00	0.00E+00	0.00E+00	3.53E-02	0.00E+00	NC
U-238	6.09E-01	4.56E-01	0.00E+00	0.00E+00	0.00E+00	1.07E+00	0.00E+00	NC
Pu-238	1.23E+03	9.61E+02	0.00E+00	0.00E+00	0.00E+00	2.19E+03	8.50E-17	1.87E-10
Pu-239	3.36E+02	2.51E+02	0.00E+00	0.00E+00	0.00E+00	5.86E+02	5.20E-16	3.05E-10
Pu-240	7.96E+02	6.27E+02	0.00E+00	0.00E+00	0.00E+00	1.42E+03	5.30E-16	7.54E-10
Am-241	2.04E+03	1.50E+03	0.00E+00	0.00E+00	0.00E+00	3.54E+03	1.10E-15	3.89E-09
Cm-244	3.35E+02	2.58E+02	0.00E+00	0.00E+00	0.00E+00	5.93E+02	4.70E-16	2.79E-10
TOTAL	1.50E+05	1.88E+08	0.00E+00	0.00E+00	0.00E+00	1.88E+08		5.77E-04

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **5.77E-04**

Table 6-10.2 Public Exposure due to Release in 2006 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	2.74E+05	1.81E+07	0.00E+00	0.00E+00	0.00E+00
Cs-137	8.95E+04	7.35E+07	0.00E+00	0.00E+00	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2006	
end	31/12/2006	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	2.74E+05	1.81E+07	0.00E+00	0.00E+00	0.00E+00	1.84E+07	1.20E-15	2.21E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	1.85E+03	1.13E+05	0.00E+00	0.00E+00	0.00E+00	1.14E+05	3.10E-15	3.55E-07
Cl-36	■	■	0.00E+00	■	0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	9.17E+04	7.93E+06	■	0.00E+00	NC	8.02E+06	8.20E-17	6.58E-07
Fe-55	9.17E+05	6.63E+07	0.00E+00	0.00E+00	0.00E+00	6.72E+07	1.20E-16	8.06E-06
Co-58	1.53E+02	2.67E+04	0.00E+00	0.00E+00	0.00E+00	2.69E+04	0.00E+00	NC
Ni-59	3.92E+02	2.36E+04	0.00E+00	0.00E+00	0.00E+00	2.40E+04	2.20E-17	5.27E-10
Ni-63	9.14E+04	5.58E+06	0.00E+00	0.00E+00	0.00E+00	5.67E+06	5.30E-17	3.01E-07
Nb-94	7.49E+02	4.48E+04	0.00E+00	0.00E+00	■	4.55E+04	6.00E-16	2.73E-08
Cs-137	8.95E+04	7.35E+07	0.00E+00	0.00E+00	0.00E+00	7.36E+07	2.40E-15	1.77E-04
Sr-90	5.36E+03	4.40E+05	0.00E+00	0.00E+00	0.00E+00	4.45E+05	1.90E-15	8.46E-07
Tc-99	3.84E+02	3.08E+04	0.00E+00	0.00E+00	0.00E+00	3.12E+04	1.20E-16	3.74E-09
I-129	3.37E-01	2.77E+02	0.00E+00	0.00E+00	0.00E+00	2.77E+02	3.60E-15	9.98E-10
Cs-134	5.73E+04	5.49E+07	0.00E+00	0.00E+00	0.00E+00	5.49E+07	7.40E-15	4.07E-04
Pu-241	8.00E+05	1.12E+05	0.00E+00	0.00E+00	0.00E+00	9.12E+05	1.40E-16	1.28E-07
U-235	1.50E-01	2.08E-02	0.00E+00	0.00E+00	0.00E+00	1.71E-01	0.00E+00	NC
U-238	4.59E+00	6.16E-01	0.00E+00	0.00E+00	0.00E+00	5.21E+00	0.00E+00	NC
Pu-238	9.22E+03	1.29E+03	0.00E+00	0.00E+00	0.00E+00	1.05E+04	8.50E-17	8.93E-10
Pu-239	2.53E+03	3.39E+02	0.00E+00	0.00E+00	0.00E+00	2.87E+03	5.20E-16	1.49E-09
Pu-240	5.99E+03	8.46E+02	0.00E+00	0.00E+00	0.00E+00	6.84E+03	5.30E-16	3.63E-09
Am-241	1.67E+04	2.19E+03	0.00E+00	0.00E+00	0.00E+00	1.89E+04	1.10E-15	2.07E-08
Cm-244	2.43E+03	3.35E+02	0.00E+00	0.00E+00	0.00E+00	2.76E+03	4.70E-16	1.30E-09
TOTAL	2.37E+06	2.27E+08	0.00E+00	0.00E+00	0.00E+00	2.29E+08		6.16E-04

■ : not applicable for defined isotopic spectrum
NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **6.16E-04**

Table 6-10.3 Public Exposure due to Release in 2007 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	5.67E+04	1.81E+07	0.00E+00	0.00E+00	0.00E+00
Cs-137	1.35E+05	7.32E+07	0.00E+00	0.00E+00	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2007	
end	31/12/2007	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	5.67E+04	1.81E+07	0.00E+00	0.00E+00	0.00E+00	1.81E+07	1.20E-15	2.17E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	4.39E+02	1.29E+05	0.00E+00	0.00E+00	0.00E+00	1.29E+05	3.10E-15	4.01E-07
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	9.61E+03	4.00E+06		0.00E+00	NC	4.01E+06	8.20E-17	3.29E-07
Fe-55	1.67E+05	5.82E+07	0.00E+00	0.00E+00	0.00E+00	5.83E+07	1.20E-16	7.00E-06
Co-58	1.03E+00	8.64E+02	0.00E+00	0.00E+00	0.00E+00	8.65E+02	0.00E+00	NC
Ni-59	9.24E+01	2.68E+04	0.00E+00	0.00E+00	0.00E+00	2.68E+04	2.20E-17	5.91E-10
Ni-63	2.14E+04	6.29E+06	0.00E+00	0.00E+00	0.00E+00	6.31E+06	5.30E-17	3.34E-07
Nb-94	1.76E+02	5.08E+04	0.00E+00	0.00E+00		5.10E+04	6.00E-16	3.06E-08
Cs-137	1.35E+05	7.32E+07	0.00E+00	0.00E+00	0.00E+00	7.33E+07	2.40E-15	1.76E-04
Sr-90	8.09E+03	4.38E+05	0.00E+00	0.00E+00	0.00E+00	4.46E+05	1.90E-15	8.47E-07
Tc-99	5.94E+02	3.14E+04	0.00E+00	0.00E+00	0.00E+00	3.20E+04	1.20E-16	3.84E-09
I-129	5.22E-01	2.82E+02	0.00E+00	0.00E+00	0.00E+00	2.83E+02	3.60E-15	1.02E-09
Cs-134	6.33E+04	3.99E+07	0.00E+00	0.00E+00	0.00E+00	4.00E+07	7.40E-15	2.96E-04
Pu-241	1.18E+06	1.09E+05	0.00E+00	0.00E+00	0.00E+00	1.29E+06	1.40E-16	1.80E-07
U-235	2.32E-01	2.12E-02	0.00E+00	0.00E+00	0.00E+00	2.53E-01	0.00E+00	NC
U-238	7.10E+00	6.27E-01	0.00E+00	0.00E+00	0.00E+00	7.73E+00	0.00E+00	NC
Pu-238	1.42E+04	1.30E+03	0.00E+00	0.00E+00	0.00E+00	1.55E+04	8.50E-17	1.31E-09
Pu-239	3.91E+03	3.45E+02	0.00E+00	0.00E+00	0.00E+00	4.26E+03	5.20E-16	2.21E-09
Pu-240	9.27E+03	8.63E+02	0.00E+00	0.00E+00	0.00E+00	1.01E+04	5.30E-16	5.37E-09
Am-241	2.77E+04	2.39E+03	0.00E+00	0.00E+00	0.00E+00	3.00E+04	1.10E-15	3.31E-08
Cm-244	3.62E+03	3.29E+02	0.00E+00	0.00E+00	0.00E+00	3.94E+03	4.70E-16	1.85E-09
TOTAL	1.70E+06	2.00E+08	0.00E+00	0.00E+00	0.00E+00	2.02E+08		5.03E-04

(black cell) : not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **5.03E-04**

Table 6-10.4 Public Exposure due to Release in 2008 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	3.87E+05	3.32E+07	0.00E+00	0.00E+00	0.00E+00
Cs-137	2.52E+05	7.39E+07	0.00E+00	0.00E+00	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2008	
end	31/12/2008	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I	Dose Di
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL	[Sv/Bq]	[mSv]
Co-60	3.87E+05	3.32E+07	0.00E+00	0.00E+00	0.00E+00	3.36E+07	1.20E-15	4.03E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	3.45E+03	2.72E+05	0.00E+00	0.00E+00	0.00E+00	2.76E+05	3.10E-15	8.54E-07
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	3.33E+04	3.73E+06		0.00E+00	NC	3.77E+06	8.20E-17	3.09E-07
Fe-55	1.01E+06	9.43E+07	0.00E+00	0.00E+00	0.00E+00	9.53E+07	1.20E-16	1.14E-05
Co-58	2.28E-01	5.16E+01	0.00E+00	0.00E+00	0.00E+00	5.18E+01	0.00E+00	NC
Ni-59	7.20E+02	5.61E+04	0.00E+00	0.00E+00	0.00E+00	5.68E+04	2.20E-17	1.25E-09
Ni-63	1.66E+05	1.31E+07	0.00E+00	0.00E+00	0.00E+00	1.33E+07	5.30E-17	7.03E-07
Nb-94	1.37E+03	1.07E+05	0.00E+00	0.00E+00		1.08E+05	6.00E-16	6.48E-08
Cs-137	2.52E+05	7.39E+07	0.00E+00	0.00E+00	0.00E+00	7.42E+07	2.40E-15	1.78E-04
Sr-90	1.50E+04	4.42E+05	0.00E+00	0.00E+00	0.00E+00	4.57E+05	1.90E-15	8.68E-07
Tc-99	1.13E+03	3.24E+04	0.00E+00	0.00E+00	0.00E+00	3.36E+04	1.20E-16	4.03E-09
I-129	9.94E-01	2.92E+02	0.00E+00	0.00E+00	0.00E+00	2.93E+02	3.60E-15	1.05E-09
Cs-134	8.60E+04	2.95E+07	0.00E+00	0.00E+00	0.00E+00	2.96E+07	7.40E-15	2.19E-04
Pu-241	2.14E+06	1.07E+05	0.00E+00	0.00E+00	0.00E+00	2.25E+06	1.40E-16	3.14E-07
U-235	4.42E-01	2.19E-02	0.00E+00	0.00E+00	0.00E+00	4.63E-01	0.00E+00	NC
U-238	1.35E+01	6.49E-01	0.00E+00	0.00E+00	0.00E+00	1.42E+01	0.00E+00	NC
Pu-238	2.67E+04	1.34E+03	0.00E+00	0.00E+00	0.00E+00	2.81E+04	8.50E-17	2.39E-09
Pu-239	7.45E+03	3.57E+02	0.00E+00	0.00E+00	0.00E+00	7.81E+03	5.20E-16	4.06E-09
Pu-240	1.77E+04	8.91E+02	0.00E+00	0.00E+00	0.00E+00	1.85E+04	5.30E-16	9.83E-09
Am-241	5.60E+04	2.63E+03	0.00E+00	0.00E+00	0.00E+00	5.87E+04	1.10E-15	6.46E-08
Cm-244	6.63E+03	3.27E+02	0.00E+00	0.00E+00	0.00E+00	6.95E+03	4.70E-16	3.27E-09
TOTAL	4.21E+06	2.49E+08	0.00E+00	0.00E+00	0.00E+00	2.53E+08		4.52E-04

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **4.52E-04**

Table 6-10.5 Public Exposure due to Release in 2009 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	2.09E+08	2.03E+07	0.00E+00	1.97E+05	0.00E+00
Cs-137	1.34E+06	7.19E+07	0.00E+00	2.16E+03	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2009	
end	31/12/2009	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	2.09E+08	2.03E+07	0.00E+00	1.97E+05	0.00E+00	2.30E+08	1.20E-15	2.76E-04
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	2.14E+06	1.91E+05	0.00E+00	1.54E+03	0.00E+00	2.33E+06	3.10E-15	7.23E-06
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	9.13E+06	1.16E+06		0.00E+00	NC	1.03E+07	8.20E-17	8.44E-07
Fe-55	4.80E+08	5.08E+07	0.00E+00	6.40E+05	0.00E+00	5.31E+08	1.20E-16	6.37E-05
Co-58	4.00E+00	1.02E+00	0.00E+00	0.00E+00	0.00E+00	5.02E+00	0.00E+00	NC
Ni-59	4.44E+05	3.90E+04	0.00E+00	1.59E+03	0.00E+00	4.84E+05	2.20E-17	1.07E-08
Ni-63	1.01E+08	9.05E+06	0.00E+00	1.76E+05	0.00E+00	1.11E+08	5.30E-17	5.86E-06
Nb-94	8.47E+05	7.42E+04	0.00E+00	3.03E+03		9.24E+05	6.00E-16	5.54E-07
Cs-137	1.34E+06	7.19E+07	0.00E+00	2.16E+03	0.00E+00	7.32E+07	2.40E-15	1.76E-04
Sr-90	8.01E+04	4.29E+05	0.00E+00	1.29E+02	0.00E+00	5.09E+05	1.90E-15	9.67E-07
Tc-99	6.18E+03	3.23E+04	0.00E+00	9.68E+00	0.00E+00	3.84E+04	1.20E-16	4.61E-09
I-129	5.43E+00	2.90E+02	0.00E+00	8.72E-03	0.00E+00	2.96E+02	3.60E-15	1.06E-09
Cs-134	3.35E+05	2.09E+07	0.00E+00	5.38E+02	0.00E+00	2.13E+07	7.40E-15	1.57E-04
Pu-241	1.11E+07	1.01E+05	0.00E+00	1.81E+04	0.00E+00	1.13E+07	1.40E-16	1.58E-06
U-235	2.41E+00	2.18E-02	0.00E+00	3.87E-03	0.00E+00	2.44E+00	0.00E+00	NC
U-238	7.39E+01	6.45E-01	0.00E+00	1.19E-01	0.00E+00	7.46E+01	0.00E+00	NC
Pu-238	1.45E+05	1.32E+03	0.00E+00	2.33E+02	0.00E+00	1.46E+05	8.50E-17	1.24E-08
Pu-239	4.07E+04	3.55E+02	0.00E+00	6.54E+01	0.00E+00	4.11E+04	5.20E-16	2.14E-08
Pu-240	9.64E+04	8.87E+02	0.00E+00	1.55E+02	0.00E+00	9.75E+04	5.30E-16	5.17E-08
Am-241	3.24E+05	2.77E+03	0.00E+00	5.20E+02	0.00E+00	3.27E+05	1.10E-15	3.60E-07
Cm-244	3.48E+04	3.13E+02	0.00E+00	5.59E+01	0.00E+00	3.52E+04	4.70E-16	1.65E-08
TOTAL	8.17E+08	1.75E+08	0.00E+00	1.04E+06	0.00E+00	9.93E+08		6.90E-04

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **6.90E-04**

Table 6-10.6 Public Exposure due to Release in 20010 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	5.16E+03	2.30E+07	0.00E+00	2.74E+05	0.00E+00
Cs-137	3.44E+04	7.34E+07	0.00E+00	3.00E+03	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2010	
end	31/12/2010	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	5.16E+03	2.30E+07	0.00E+00	2.74E+05	0.00E+00	2.33E+07	1.20E-15	2.80E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	6.06E+01	2.49E+05	0.00E+00	2.46E+03	0.00E+00	2.52E+05	3.10E-15	7.80E-07
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	1.14E+02	6.66E+05		0.00E+00	NC	6.66E+05	8.20E-17	5.46E-08
Fe-55	1.04E+04	5.08E+07	0.00E+00	7.85E+05	0.00E+00	5.16E+07	1.20E-16	6.19E-06
Co-58	3.19E-06	3.77E-02	0.00E+00	0.00E+00	0.00E+00	3.77E-02	0.00E+00	NC
Ni-59	1.24E+01	5.05E+04	0.00E+00	2.53E+03	0.00E+00	5.31E+04	2.20E-17	1.17E-09
Ni-63	2.82E+03	1.16E+07	0.00E+00	2.77E+05	0.00E+00	1.19E+07	5.30E-17	6.32E-07
Nb-94	2.38E+01	9.60E+04	0.00E+00	4.81E+03		1.01E+05	6.00E-16	6.05E-08
Cs-137	3.44E+04	7.34E+07	0.00E+00	3.00E+03	0.00E+00	7.34E+07	2.40E-15	1.76E-04
Sr-90	2.05E+03	4.37E+05	0.00E+00	1.79E+02	0.00E+00	4.39E+05	1.90E-15	8.35E-07
Tc-99	1.62E+02	3.37E+04	0.00E+00	1.38E+01	0.00E+00	3.39E+04	1.20E-16	4.06E-09
I-129	1.42E-01	3.03E+02	0.00E+00	1.24E-02	0.00E+00	3.03E+02	3.60E-15	1.09E-09
Cs-134	6.27E+03	1.56E+07	0.00E+00	5.47E+02	0.00E+00	1.56E+07	7.40E-15	1.15E-04
Pu-241	2.78E+05	1.01E+05	0.00E+00	2.45E+04	0.00E+00	4.03E+05	1.40E-16	5.65E-08
U-235	6.31E-02	2.27E-02	0.00E+00	5.52E-03	0.00E+00	9.14E-02	0.00E+00	NC
U-238	1.93E+00	6.74E-01	0.00E+00	1.69E-01	0.00E+00	2.78E+00	0.00E+00	NC
Pu-238	3.76E+03	1.37E+03	0.00E+00	3.29E+02	0.00E+00	5.46E+03	8.50E-17	4.64E-10
Pu-239	1.07E+03	3.71E+02	0.00E+00	9.31E+01	0.00E+00	1.53E+03	5.20E-16	7.95E-10
Pu-240	2.52E+03	9.26E+02	0.00E+00	2.21E+02	0.00E+00	3.67E+03	5.30E-16	1.95E-09
Am-241	8.91E+03	3.04E+03	0.00E+00	7.79E+02	0.00E+00	1.27E+04	1.10E-15	1.40E-08
Cm-244	8.78E+02	3.14E+02	0.00E+00	7.67E+01	0.00E+00	1.27E+03	4.70E-16	5.96E-10
TOTAL	3.56E+05	1.76E+08	0.00E+00	1.38E+06	0.00E+00	1.78E+08		3.28E-04

(black cell) : not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **3.28E-04**

Table 6-10.7 Public Exposure due to Release in 20011 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	5.16E+03	2.31E+07	0.00E+00	2.74E+05	0.00E+00
Cs-137	5.16E+03	2.31E+07	0.00E+00	2.74E+05	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2011	
end	31/12/2011	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,I [Sv/Bq]	Dose Di [mSv]
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL		
Co-60	5.16E+03	2.31E+07	0.00E+00	2.74E+05	0.00E+00	2.34E+07	1.20E-15	2.80E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	6.96E+01	2.87E+05	0.00E+00	2.83E+03	0.00E+00	2.90E+05	3.10E-15	8.98E-07
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	5.78E+01	3.38E+05		0.00E+00	NC	3.38E+05	8.20E-17	2.77E-08
Fe-55	9.18E+03	4.49E+07	0.00E+00	6.92E+05	0.00E+00	4.56E+07	1.20E-16	5.47E-06
Co-58	1.04E-07	1.22E-03	0.00E+00	0.00E+00	0.00E+00	1.22E-03	0.00E+00	NC
Ni-59	1.42E+01	5.77E+04	0.00E+00	2.88E+03	0.00E+00	6.06E+04	2.20E-17	1.33E-09
Ni-63	3.20E+03	1.32E+07	0.00E+00	3.14E+05	0.00E+00	1.35E+07	5.30E-17	7.16E-07
Nb-94	2.71E+01	1.10E+05	0.00E+00	5.48E+03		1.15E+05	6.00E-16	6.91E-08
Cs-137	5.16E+03	2.31E+07	0.00E+00	2.74E+05	0.00E+00	2.34E+07	2.40E-15	5.60E-05
Sr-90	3.07E+02	1.37E+05	0.00E+00	1.63E+04	0.00E+00	1.54E+05	1.90E-15	2.92E-07
Tc-99	2.48E+01	1.08E+04	0.00E+00	1.29E+03	0.00E+00	1.22E+04	1.20E-16	1.46E-09
I-129	2.18E-02	9.76E+01	0.00E+00	1.16E+00	0.00E+00	9.87E+01	3.60E-15	3.55E-10
Cs-134	6.87E+02	3.58E+06	0.00E+00	3.65E+04	0.00E+00	3.62E+06	7.40E-15	2.68E-05
Pu-241	4.06E+04	3.09E+04	0.00E+00	2.18E+06	0.00E+00	2.25E+06	1.40E-16	3.16E-07
U-235	9.69E-03	7.32E-03	0.00E+00	5.15E-01	0.00E+00	5.32E-01	0.00E+00	NC
U-238	2.97E-01	2.17E-01	0.00E+00	1.58E+01	0.00E+00	1.63E+01	0.00E+00	NC
Pu-238	5.73E+02	4.36E+02	0.00E+00	3.05E+04	0.00E+00	3.15E+04	8.50E-17	2.67E-09
Pu-239	1.64E+02	1.19E+02	0.00E+00	8.69E+03	0.00E+00	8.97E+03	5.20E-16	4.67E-09
Pu-240	3.87E+02	2.98E+02	0.00E+00	2.06E+04	0.00E+00	2.13E+04	5.30E-16	1.13E-08
Am-241	1.43E+03	1.02E+03	0.00E+00	7.61E+04	0.00E+00	7.85E+04	1.10E-15	8.64E-08
Cm-244	1.30E+02	9.74E+01	0.00E+00	6.89E+03	0.00E+00	7.12E+03	4.70E-16	3.34E-09
TOTAL	6.72E+04	1.09E+08	0.00E+00	3.94E+06	0.00E+00	1.13E+08		1.19E-04

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **1.19E-04**

Table 6-10.8 Public Exposure due to Release in 20012 (Liquid)

Key Isotopes Activities releases [Bq]					
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5
Co-60	5.09E+03	3.42E+07	0.00E+00	1.51E+05	0.00E+00
Cs-137	3.39E+04	7.38E+07	0.00E+00	1.66E+03	0.00E+00

Type of release	L	→ Liquid
Period of release : start	01/01/2012	
end	31/12/2012	
Spectrum reference date	01/01/2005	

Related Isotopes Activities Releases [Bq]							D1,l	Dose Di
i / spectrum	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	TOTAL	[Sv/Bq]	[mSv]
Co-60	5.09E+03	3.42E+07	0.00E+00	1.51E+05	0.00E+00	3.44E+07	1.20E-15	4.13E-05
H-3	NC	NC	NC	NC	0.00E+00	0.00E+00	0.00E+00	NC
C-14	7.89E+01	4.89E+05	0.00E+00	1.79E+03	0.00E+00	4.91E+05	3.10E-15	1.52E-06
Cl-36			0.00E+00		0.00E+00	0.00E+00	0.00E+00	NC
Mn-54	2.89E+01	2.55E+05		0.00E+00	NC	2.55E+05	8.20E-17	2.09E-08
Fe-55	7.98E+03	5.87E+07	0.00E+00	3.36E+05	0.00E+00	5.91E+07	1.20E-16	7.09E-06
Co-58	3.32E-09	5.90E-05	0.00E+00	0.00E+00	0.00E+00	5.90E-05	0.00E+00	NC
Ni-59	1.60E+01	9.77E+04	0.00E+00	1.81E+03	0.00E+00	9.95E+04	2.20E-17	2.19E-09
Ni-63	3.57E+03	2.22E+07	0.00E+00	1.96E+05	0.00E+00	2.24E+07	5.30E-17	1.19E-06
Nb-94	3.05E+01	1.86E+05	0.00E+00	3.45E+03		1.89E+05	6.00E-16	1.13E-07
Cs-137	3.39E+04	7.38E+07	0.00E+00	1.66E+03	0.00E+00	7.39E+07	2.40E-15	1.77E-04
Sr-90	2.02E+03	4.39E+05	0.00E+00	9.86E+01	0.00E+00	4.41E+05	1.90E-15	8.38E-07
Tc-99	1.67E+02	3.55E+04	0.00E+00	7.98E+00	0.00E+00	3.57E+04	1.20E-16	4.28E-09
I-129	1.47E-01	3.19E+02	0.00E+00	7.18E-03	0.00E+00	3.20E+02	3.60E-15	1.15E-09
Cs-134	3.30E+03	8.38E+06	0.00E+00	1.61E+02	0.00E+00	8.38E+06	7.40E-15	6.20E-05
Pu-241	2.61E+05	9.65E+04	0.00E+00	1.29E+04	0.00E+00	3.70E+05	1.40E-16	5.18E-08
U-235	6.52E-02	2.40E-02	0.00E+00	3.19E-03	0.00E+00	9.24E-02	0.00E+00	NC
U-238	2.00E+00	7.10E-01	0.00E+00	9.77E-02	0.00E+00	2.80E+00	0.00E+00	NC
Pu-238	3.83E+03	1.42E+03	0.00E+00	1.87E+02	0.00E+00	5.43E+03	8.50E-17	4.62E-10
Pu-239	1.10E+03	3.90E+02	0.00E+00	5.38E+01	0.00E+00	1.54E+03	5.20E-16	8.03E-10
Pu-240	2.61E+03	9.75E+02	0.00E+00	1.28E+02	0.00E+00	3.71E+03	5.30E-16	1.97E-09
Am-241	1.00E+04	3.50E+03	0.00E+00	4.91E+02	0.00E+00	1.40E+04	1.10E-15	1.54E-08
Cm-244	8.40E+02	3.07E+02	0.00E+00	4.11E+01	0.00E+00	1.19E+03	4.70E-16	5.58E-10
TOTAL	3.35E+05	1.99E+08	0.00E+00	7.06E+05	0.00E+00	2.00E+08		2.91E-04

: not applicable for defined isotopic spectrum

NC : not calculated

K parameter (coefficient to take into account the aerosols release height) N/A

Public exposure [mSv] **2.91E-04**

D) Discussion

Tables 6-10.1 to 6-10.8 show that the effective doses resulting from the discharges of liquid RAW are predicted to fall in the range 1.2×10^{-4} – 6.9×10^{-4} mSv/y.

As indicated in section 6.11, some conservatism has been included in the radiological source term assessment.

- An examination of Tables 6.10.1 to 6.10.8 shows that the annual global liquid discharges into the lake are predicted to fall in the range 1.1×10^{8} to 9.9×10^{8} Bq (extreme variation of a factor 9), the maximum value being reached in 2009 and corresponding mainly to the discharges of the conservatively assumed non-recycled cleaned condensate generated by the processing of the spent decontamination solutions (see also section 3.10.4 –b). The effective doses exhibit an extreme variation of a factor of about 6, the highest value (6.9×10^{4} mSv) being also reached in 2009.

- With the exception of year 2009, Cs^{134} and Cs^{137} are the main contributors to the global effective dose and the nuclide vector of the global releases is governed by spectrum S_2 for both the activation and fission products.

- In year 2009, due to the impact of the in-line decontamination activities, leading to the removal of corrosion cruds and oxides, deposited on the inner walls of the equipment and mainly contaminated by insoluble activation products, Co^{60} becomes the dominant contributor to the global effective dose. The nuclide vector of the global releases is governed by spectrum S_1 for the activation products and by spectrum S_2 for the fission products.

- The contribution of the TRU to the global effective dose remains quite low (maximum value = 0.07 % in 2009).

E) <u>Conclusion of assessment of public radiological exposure</u>

The highest predicted yearly effective dose to the members of the public due to the radionuclide content (H^3 excluded) of the discharged water during the defuelling of Unit 1 is predicted to occur in 2009 and to be of $6.9*10^{-4}$ mSv, i.e. a value slightly lower than that resulting from the routine operation of Unit 1 (9.0×10^{-4} mSv – see section 6.4.2.1).

For the other years of the defuelling phase, the yearly exposure is predicted to be lower by a factor up to 7 than that assessed for routine operation, in function of the considered year.

As already mentioned in section 6.3.1 for the atmospheric releases, the radionuclide content of the discharged water due to the operation of the spent resins/perlite/sediments and of the solid waste retrieval and conditioning facilities are attributed to those of Unit 1 defuelling phase.

F) H^3 Releases

H^3 Releases via the Liquid Waste

Measurements made by the Institute of Physics [87] showed that the H^3 inventory in Unit 1 is of the order of 10 GBq or lower, most of the H^3 inventory being concentrated in the spent fuel pool waters.

After the RFS, H^3 will no longer be produced and it can be stated that the whole inventory of Unit 1 will progressively be released during Unit 1 defuelling phase. The average release of H^3 should not exceed 1.25 GBq/y, i.e. 0.32 % of yearly releases during routine operation of one unit [86].

The corresponding effective dose amounts to 4.4×10^{-8} mSv/y, i.e. a totally negligible value by comparison with the effective dose resulting from the liquid releases of the other nuclides.

H^3 Releases via the Gaseous Waste

During normal operation, the H^3 atmospheric releases essentially originate from the reactor gas circuit and, to much lower extent, from the evaporation of the water from the pools.

After the RFS, H^3 will no longer be released by the reactor gas circuit and the contribution of the H^3 discharge via the pool water evaporation to the aerosols effective dose will be totally negligible.

6.5.3 Contribution of Unit 2 to the Radionuclide Content of the Discharged Water

During period 2005 – 2012, the contribution of Unit 2 to the radionuclide content of the discharged water includes:

(a) the releases during operation period 2005 – 2009;
(b) the releases during the reactor post-shutdown phase (period 2010 – 2012).

(a) Releases during Operation Period

On the basis of the data in section 6.4.2.1, the predicted radionuclide content in the discharged water amounts to 4.4×10^{8} Bq/y (Sr^{90} included, H^3 excluded). The predicted H^3 content in the discharged water amounts to 3.9×10^{11} Bq/y (conservative value).
The corresponding effective dose to the critical members of the public amounts to 9.0×10^{-4} mSv/y.

(b) Releases during the Reactor Post-Shutdown Period

The detailed environmental impact of Unit 2 post-shutdown activities during period 2010 – 2012 will be given in the EIA Report associated to U2DP0. In this EIA, a preliminary assessment can only be given extrapolating the results pertaining to the corresponding activities of Unit 1.

Year 2010

Activity	Radionuclide content of the discharged water[49] (Bq)
• Unit 2 Stage 1 post-operation of systems kept in service • Reactor defuelling • Unit 2 system modifications/isolation	1.5×10^{8} 6.0×10^{6} 9.7×10^{6}
Total	1.66×10^{8}

The corresponding effective dose to the critical members of the public is estimated to 2.3×10^{-4} mSv.

Year 2011

Activity	Radionuclide content of the discharged water[47] (Bq)
• Unit 2 Stage 2 post-operation of systems kept in service • In-line decontamination • Unit 2 system modifications/isolation • Pools defuelling	6.4×10^{7} 2.3×10^{9} 1.7×10^{6} 3.3×10^{5}
Total	2.37×10^{9}

The corresponding effective dose to the critical members of the public is estimated to 1.5×10^{-3} mSv.

It must be noted that the in-line decontamination of the MCC+PCS is carried out only 1 year after the RFS of Unit 2, allowing thus much smaller decay time of the short-life nuclides inventories fixed in the inner wall oxide layers of the to be decontaminated equipment (Mn^{54}, Co^{58}, Fr^{55}, etc.). In Unit 1, this activity is carried out 4 years after the RFS, allowing thus much longer decay time of the short-life nuclides inventories in the to be decontaminated equipment.

Year 2012

Activity	Radionuclide content of the discharged water[50] (Bq)
• Unit 2 Stage 2 post-operation of systems kept in service • Unit 2 system modifications/isolation • Pools defuelling	6.4×10^{7} 1.7×10^{6} 3.3×10^{5}
Total	6.6×10^{7}

The corresponding effective dose to the critical members of the public is estimated to 9.1×10^{-5} mSv.

[49] Preliminary estimate.
[50] Preliminary value for Unit 2.

6.5.4 Conclusions

During Unit 1 defuelling phase (period 2005 – 2012), the contribution of Unit 2 operation and post-shutdown operation to effective dose resulting from the radionuclide content in the discharged water varies in function of the considered year and is found to lay in the range 9.1×10^{-5} mSv/y to 1.5×10^{-3} mSv/y. Combining the discharges of both Units during the above mentioned period leads to the following dose assessment:

Table 6-11 Radiological Impact of the Radionuclide Content in the Discharged Water from INPP Site during Unit 1 Defuelling

Year	Unit 1 (mSv/y)	Unit 2 (mSv/y)[48]	Total Site (mSv/y)
2005	5.8×10^{-4}	9.0×10^{-4}	1.5×10^{-3}
2006	6.2×10^{-4}	9.0×10^{-4}	1.5×10^{-3}
2007	5.0×10^{-4}	9.0×10^{-4}	1.4×10^{-3}
2008	4.5×10^{-4}	9.0×10^{-4}	1.4×10^{-3}
2009	6.9×10^{-4}	9.0×10^{-4}	1.6×10^{-3}
2010	3.3×10^{-4}	2.3×10^{-4}	5.6×10^{-4}
2011	1.2×10^{-4}	1.5×10^{-3}	1.6×10^{-3}
2012	2.9×10^{-4}	9.1×10^{-5}	3.8×10^{-4}

Unit 1 radiological impact includes the doses due to the radionuclide content in the discharged water from the spent resins/sediments and solid waste retrieval and conditioning facilities. However, due to the quite small water discharges from these facilities, their impact on Unit 1 effective dose remains also low, while the impact of the atmospheric releases from these facilities appears to govern the radiological impact of Unit 1 atmospheric releases (see section 6.3.2.1 – F).

The duration of Stage 1 for Unit 2 (1 year) is shorter than the corresponding one of Unit 1 (4 years). This means that, by the beginning of Stage 2, the radionuclide inventories of Unit 2 equipment will be higher that those of Unit 1, due to the smaller decay time of some short lived nuclides after the RFS (Mn^{54}, Fe^{55}, Co^{60}). This has a marked effect on the environmental impact of activities, such as in-line decontamination which are carried out at the beginning of Stage 2.

6.5.5 Summary

Table 6-12 summarises the predicted overall radiological environmental impact of INPP Site (D&D activities in Unit 1 excluded) during Unit 1 defuelling phase.

Table 6-12 INPP Site (D&D activities in Unit 1 excluded) Overall Radiological Impact during Unit 1 Defuelling Phase

Year	Critical individual effective dose (mSv/y)		
	Atmospheric discharges (INPP site)	Radionuclide content in the discharged water (INPP site)	Total (INPP site)
2005	1.0×10^{-3}	1.5×10^{-3}	2.5×10^{-3}
2006	1.4×10^{-3}	1.5×10^{-3}	2.9×10^{-3}
2007	1.3×10^{-3}	1.4×10^{-3}	2.7×10^{-3}
2008	1.2×10^{-3}	1.4×10^{-3}	2.6×10^{-3}
2009	1.3×10^{-3}	1.6×10^{-3}	2.9×10^{-3}
2010	1.6×10^{-3}	5.6×10^{-4}	2.2×10^{-3}
2011	1.3×10^{-3}	1.6×10^{-3}	2.9×10^{-3}
2012	9.9×10^{-4}	3.8×10^{-4}	1.4×10^{-3}

From above table it can be seen that effective doses to the critical member of the Public remain within the allowed limit for both atmospheric and water discharges (each at 0.1 mSv/y).

The overall radiological environmental impact of INPP site during Unit 1 defuelling phase is predicted to lay in the range 1.4×10^{-3} – 2.9×10^{-3} mSv/y, i.e. 0.7 to 1.5 % of the INPP site maximum allowed limit (0.2 mSv/y).

6.6 Solid Waste Production, Characterisation and Conditioning Techniques with Respect to the Final Disposal

6.6.1 Solid Waste Disposal Routes

The miscellaneous activities carried out during the defuelling phase of Unit 1 lead to the production of solid waste (SW) that complies with one of the following final disposal routes:

a) unconditional free release of non-conditioned SW (disposal into a conventional waste dumping site or incineration, melting, crushing, etc.). The implementation of a free release measurement facility to demonstrate the compliance of the concerned waste with the free release waste acceptance criteria is foreseen in the frame of U1DP0;

b) disposal of non-conditioned waste or pre-compacted waste (in case of compactable waste) into the to be built landfill site, i.e. a disposal site for very low level short-lived radionuclides (most of Group A waste or part of Group 1 waste);

c) disposal of conditioned waste packages into the to be built Near-Surface Repository (NSR), after interim storage in INPP specific facilities. The NSR is designed for the long term (several hundreds years) disposal of conditioned Group B+C waste or part of Group 1 waste not complying with the landfill WAC and the whole Group 2 waste;

d) interim sorage, without conditioning, of graphite (Group D) waste and of Group E waste (in-core activated materials), in INPP to be built specific facilities, awaiting upon further decision about the most appropriate conditioning techniques. After conditioning, this waste will be either disposed of into an intermediate depth cavity (graphite waste) or into a deep geological repository (Group E waste).

e) Disposal of the bitumenised waste in the to be upgraded existing storage vaults.

For disposal route (a), official radiological WAC are currently available [88]. For disposal routes (b) and (c), interim radiological WAC are available [89], [90].

The radiological WAC applicable to disposal route (a) restrict the radionuclides inventories in the concerned waste in order to limit the effective dose to the critical members of the public to 0.01 mSv/y [88].

The interim radiological WAC proposed for disposal route (b) restrict the global radiological inventory of the disposed waste, in order to limit the effective dose to the critical members of the public to ≤0.1 mSv/y, on the basis of conservative assumptions with respect to the radionuclides leakages after the closure of the site [89].

In order to obtain a rather even distribution of radionuclides in the waste, [89] also includes limitation of the specific activities (Bq/g) of the disposed waste.

Actually, on a long term basis, i.e. after the removal of the spent fuel interim storage facilities and after the conditioning and removal of the interim stored Group D and E waste, the nuclide leakages from the landfill and from the upgraded bitumenised waste storage vaults will be the remaining exposure sources for the hypothetical critical individual.

On a preliminary basis, it can thus be considered that the critical individual effective dose should not exceed 0.1 mSv/y for each of the hereabove exposure pathways.

The interim radiological WAC proposed for disposal route (c) restrict the global critical nuclides[51] inventory of the disposed conditioned waste, in order to limit the long-term effective dose to the critical members of the public on the basis of conservative assumptions with respect to nuclides leakage rates from the site and migration rates through the environment after the closure of the site surveillance [90].

Further, [90] also includes limitations of the critical nuclides[49] specific activities (Bq/m^3) in the conditioned waste, in order to limit the effective dose to the critical members of the public to ≤5 mSv/y in case of events with low probability (intrusion scenario, etc).

Remark: Other Disposal Routes

The current waste management practices at INPP also include the disposal of very low active waste (contact dose rate ≤ 0.6 μSv/h, β surface activity ≤ 8 Bq/cm^2), removed from the controlled area, into “Polygons” dumping sites located in the INPP controlled area. This practice will be stopped by 2007, i.e. by the time of the licensed landfill disposal site commissioning and industrial operation of the free release measurement facilities. A Project is due to be launched in 2007[52], to assess the future issue of the existing polygons, i.e.:

- either the conversion of the polygons into licensed long term landfill sites provided with appropriate monitoring programme, or
- the removal of the dumped waste, their conditioning and disposal via other routes (free release, disposal into a licensed landfill site, conditioning and disposal into a NSR).

[51] Critical nuclides: C^{14}, Ni^{59}, Ni^{63}, Co^{60}, Nb^{94}, Sr^{90}, Tc^{99}, I^{129}, Cs^{135}, Cs^{137}, U^{235}, U^{238}, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{241}, Am^{241}, Pu^{242}, Cm^{244}.

[52] INPP note: ПТОмр-1344-6: “Measures Concerning Industrial Waste Managementat INPP”.

6.6.2 Production and Characterisation of the Solid Waste during Unit 1 Defuelling Phase

As shown in § 6.5.1, the conditioned decommissioning waste, as well as the conditioned operational waste, must comply with a set of WAC, including, among others, strict limitations on the inventories of critical nuclides. The compliance with these WAC implies a detailed radiological characterisation of the different waste streams to be conditioned.
The methodology implemented in U1DP0 is summarised on Figure 6-2.

For each decommissioning activity carried out during Unit 1 defuelling, the DBS outputs include, among others (see chapters 5, 6 and Appendix 3 of U1DP0):

- the production of the different types of waste streams;
- the radiological characterisation;
- the compliance with the radiological WAC applicable to the selected disposal route.

Histograms enable then to globalise the production of each solid waste stream for all activities carried out during the defuelling phase of Unit 1.

Solid Waste to Free Release

The monthly production of solid waste, predicted by the DBS computer tool (see chapter 6 of U1DP0 and [98]) and complying with the unconditional free release radiological WAC, is predicted to amount to 1.1-1.4 tons. The production, integrated to Unit 1 defuelling, amounts to 112 tons (Figure 6-5). It consists mainly of spent clothes, packing materials and protection plastic sheets, i.e. a waste production related to the presence of personnel in the controlled area.

In addition to these types of waste, a variety of very low-level solid waste will be produced during Unit 1 defuelling phase, such as metal scraps, metallic components, wood, concrete, brickworks, wires, etc. Currently, this waste is sent to the INPP industrial waste storage sites ("polygons"). It is expected that a major fraction of this waste will comply with the unconditional free release criteria. However, the current INPP criteria (contact dose rate < 0.6 μSv/h and surface activity < 8 Bq/cm^2) do not enable to demonstrate the compliance with the free release criteria. Therefore, INPP has launched a characterisation programme, in order to:

- accurately define the radionuclide inventories of this waste and, more particularly, the content of key nuclides, such as Co^{60} and Cs^{137};

- measure the content of the "difficult-to-measure" long-lived β-γ and α emitters and to derive, therefrom, nuclide vectors;

- define practical criteria enabling INPP to free release the waste under concern.

This programme has been carried out by the Institute of Physics (Vilnius). The preliminary results are now available [96] and being evaluated by INPP for further practical implementation.

The existing very-low level waste storage polygons are practically completely filled up. An extension of the existing polygons will allow to dump 2500 m^3 of very low level industrial waste.
INPP has now acquired and is commissioning a free release measurement facility. Indstrial operation of this new facility is scheduled to start in 2005.

Solid Waste to Landfill

The monthly production of solid waste routed towards the landfill site is shown on Figure 6-6. The volume of waste, disposed of and integrated to Unit 1 defuelling phase, amounts to some 12600 m^3. The sharp increase of the monthly disposal rate in April 2009 corresponds to the startup of the operational waste retrieval and processing by the B2/3/4 facilities.

The monthly production rate observed during period 09/2005 – 05/2006 includes the retrieval of the condensate polishing spent ion-exchange resins (320 m^3 in total for turbo-generators 1 and 2). The landfill disposal site commissioning is scheduled in early 2007. Therefore, the waste complying with the landfill disposal waste acceptance criteria and produced during period 2005 – 2006 (about 1000 m^3) must be interim stored:

- the waste produced by Unit 1 in defuelling operation (spent resins of the condensate polishing system excluded), i.e. some 680 m^3, and by the continued operation of Unit 2, could be routed to the empty Group 1 waste storage vaults in building 157/1;

- after decontamination, the spent resins from the condensate polishing system of Unit 1 will be dewatered and separately[53] collected in specific glass fiber reinforced plastic containers designed for future disposal in the landfill (see chapter 6 of U1DP0, DBS 52.1 and 46.2 of Appendix 3). The volume amounts to 350 m^3; containers included and can be interim stored in the turbine hall until the beginning of 2007.

For the whole defuelling period (see Figure 6-7 and Figure 6-8), the non-decayed β-γ activity inventory of the waste disposed of into the landfill amounts to 2.3×10^{12} Bq, i.e. 23 % of the radiological capacity of the site (10 TBq – see [89]), while the α activity of the same waste amounts to 5.0×10^{8} Bq, i.e. 5 % of the radiological capacity of the site (10 GBq – see [89]).

Actually, the reference nuclide vectors of the waste are calculated by the assumed date of Unit 1 RFS (31.12.04) – see [86]. The DBS production software takes into account the evolution of the nuclide vectors in function of the waste production date, i.e. in function of the time elapsed after the RFS. However, once the waste is put in the landfill, no decay of its activity inventory is further taken into account. This means that the predicted global activity inventory by end of 2012 and shown on Figure 6-7 largely exceeds the actual one due to the decay of the short-lived nuclides (Mn^{54}, Fe^{55}, Co^{58}, Co^{60}, Cs^{134}) since the introduction of the waste into the landfill. Therefore, in order to better assess the landfill activity inventory which could lead to a long term radiological impact, the following corrections were brought to Figure 6-7:

1) Total non-decayed β-γ activity inventory without the contribution of Mn^{54}, Fe^{55}, Co^{58} and Cs^{134}. Figure 6-9 shows that, by end of 2012, the landfill global activity inventory reduces from 2.3×10^{12} Bq (Figure 6-7) down to 1.5×10^{12} Bq;

2) Total non-decayed β-γ activity inventory without the contribution of Mn^{54}, Fe^{55}, Co^{58} , Co^{60} and Cs^{134}. Figure 6-10 shows that, by end of 2012, the landfill global activity inventory further reduces from 1.5×10^{12} Bq down to 9.03×10^{11} Bq.

[53] To avoid cross-contamination of these weakly radioactive resins by the other spent resins and spent resins collection systems.

Environmental Impact

The long term radiological exposure of the critical members of the public will be addressed in the EIA Report to be issued in the frame of the Landfill Construction Project. However, some preliminary orientative calculations have been performed on the basis of the information and data found in [87], which show that, after the closure of the site, the long term radiological exposure of the critical members of the public are governed by only few long-lived critical nuclides:

- Cs^{137} and Ni^{63} due to the importance of their inventories in the landfill site;
- C^{14} and I^{129} due to their mobilities in the landfill site environment.

These preliminary results are summarised in the following table:

Table 6-13 Maximum Effective Dose to the Critical members of the Public due to Landfill

Nuclide	Activity inventory by completion of Unit 1 defuelling phase (Bq)	Annual leakage rate (% of the initial inventory /year)[54]	Effective dose peak value (mSv/y)
Cs^{137}	6.32×10^{10}	0.1	3.6×10^{-3}
C^{14}	6.88×10^{9}	1.0	5.6×10^{-2}
I^{129}	2.57×10^{5}	1.0	2.8×10^{-5}
Ni^{63}	3.22×10^{11}	0.1	3.0×10^{-3}
Nb^{94}	2.68×10^{9}	0.1	8.0×10^{-4}
Total			6.3×10^{-2}

As hereabove indicated, these results are to be considered as preliminary and purely indicative, as:

- the above activity inventories correspond to the end of Unit 1 defuelling phase and not to the completion of INPP decommissioning;

- the annual leakages from the landfill are likely (very) conservatrive according to [89].

The effective dose is governed by the C^{14} release.

Solid Waste to Near-Surface Repository (NSR)

The volume of conditioned waste to be disposed of in the to be built NSR amounts to some 22200 m^3 including:

- 20400 m^3 of conditioned spent resins, perlite and sediments produced during period January 2005 – December 2012, assuming that 8 drums (200 liters) containing the cemented mixture of resins/perlite and sediments are put into one FRA-ANP container, and that, after grouting, these containers can be disposed of into the NSR;

- 1800 m^3 of conditioned group A and B+C SW, produced during period April 2005 – December 2012.

[54] Conservative values according to [87].

The global activity inventory of the conditioned waste includes, by the time of the waste conditioning:

- 3.94×10^{14} Bq of Co^{60};
- 1.74×10^{14} Bq of Cs^{137}.

The volume of the conditioned waste to be disposed of in a NSR amounts to some 22 % of the to be built site capacity (≈100000 m^3), while the same waste will exhaust about 37 % of the NSR radiological capacity, taking into account the inventories of the critical long half-life nuclides scaled to Co^{60} and Cs^{137}.

Figure 6-11 shows the evolution of the NSR radiological capacity index I along with the progress of Unit 1 defuelling phase.

Radiological capacity Index I is defined as:

$$I = \sum_i \frac{A_i}{A_{i,\max}} \leq 1$$

A_i = global activity inventory of critical nuclide i (Bq).
$A_{i,\max}$ = maximum allowable critical nuclide i activity inventory in the NSR under consideration (Bq).

The $A_{i,\max}$ values are given by [90].

Remarks:

1. As the NSR is assumed to be commissioned in 2012 (see FDP and U1DP0), practically the whole production of conditioned waste dedicated to NSR disposal during Unit 1 defuelling stage will have to be interim stored either in the B2/3/4 interim storage building (operational solid waste) or in the temporary storage building of the Cementation and Solidification Facility (spent resins/perlite/sediments).

2. Group E (3) Waste

   During period April 2009 – December 2012, most of the Group E (3) highly active solid waste will be retrieved, put in containers and safely interim stored in a dedicated area of the new B2/3/4 facilities, awaiting upon a decision about the most appropriate conditioning type (VATESI requirement). For the considered period, some 1860 m^3 of Group E (3) waste will have to be interim stored. After appropriate conditioning, this waste will be disposed of into a geological repository.

6.6.3 Conclusions

During Unit 1 defuelling phase, the volumes of solid waste coming into consideration for disposal into a landfill site and into a NSR are largely governed by the conditioning of the operational waste accumulated on the site.

6.6.4 Bituminised Waste

The bituminised waste produced by the treatment of the liquid waste generated during Unit 1 defuelling phase will be disposed of into the existing vaults of building 158.

A feasibility study dedicated to the assessment of the long-term safety of the bituminised waste existing storage facility enabled to conclude that, provided that upgrading works be carried out[55], the existing storage facility could be converted into a long-term safe surface repository [91].

INPP has now launched a project to engineer these modifications and to obtain the licence from VATESI [92]. In the frame of U1DP0 preparation, it has been assumed that VATESI licence will, actually, be obtained by INPP, i.e. that the existing bituminised waste will actually be converted into a long-term surface repository.

The global production of bituminised waste amounts to some 1320 m^3 during Unit 1 defuelling phase (Figure 6-12), i.e about 13 % of the remaining storage capacity in August 2004 (10300 m^3). The average production is about 10 m^3/month, with 2 major exceptions, in early 2003, corresponding to the bituminisation of the in-line spent decontamination solutions. The interim radiological WAC developed for the NSR [90] were also assumed to be applicable for the disposal of bituminised waste[56], i.e. the minimum volume of bitumen required by the conditioning of the evaporators concentrates produced by each decommissioning activity was the highest of the following values:

- the minimum volume needed to keep the salt concentration $\leq$30 % (by weight) in the bituminised waste matrix;
- the minimum volume needed to keep the critical nuclide specific activity (Bq/m^3) in the waste matrix below the levels given by [90].

In that latter case, it was verified that the so-obtained specific activities did not exceed the project design values.

Environmental Impact

Very preliminary assessments show that the bitumenised waste storage vaults upgrading works should, at least, consist [91] of a multi-layer surface barrier application on the roof and along the lateral walls of building 158 and of the re-organisation of building 158 drainage system and drainage system monitoring.

[55] Example: Modification of the building drainage system – Modification of the building roof structures – Application of a multi–layer cover on the roof of the building by the end of INPP decommissioning.

[56] The radiological WAC developed for cemented waste are the only ones available in Lithuania. Currently, there is an uncertainty about the possible use of the WAC, developed for the cemented waste NSR disposal, for the disposal of bitumenised waste into the to be upgraded bitumenised waste storage vaults.
However, taking into account (see chapter 5.2.2 of U1DP0):
- the long term stability of the bitumenised waste matrices (i.e. over a few hundred years) on the basis of the chemical and radiochemical characteristics of the bitumenised waste,
- the confinement barriers of the upgraded bitumenised waste vaults (steel liner, thick concrete structures, application of a covering earth layer),

the radiological WAC, developed for the disposal of cemented waste, can reasonably also be used for the long term disposal of bitumenised waste. This assumption will have to be confirmed on the basis of the results of the safety analysis to be conducted in the frame of the future Bitumenised Waste Storage Vaults Upgrading Project (period 2005 – 2006).

The radiological impact of the bitumenised waste storage vaults will be assessed in the EIA Report to be issued in the frame of the bitumenised waste storage vaults Project [92]. However, some preliminary dose assessments for the critical members of the public can be found in [91] for the most conservative scenarios and sets of assumptions. The hypothetic receptor is a drinking water well located in the area between the bitumenised waste repository and the lake Drūkšiai. The ingestion dose assessment takes into account an annual water consumption of 0.6 m^3/y.

Scenario A: Nuclide Release via Building 158 Concrete Structure Fractures

Assuming that the nuclide release starts soon after the closure of the repository, i.e. 2027-2030, after the application of the multi-layer surface barrier, the peak values of the effective dose are predicted to occur about 10 years later and are of some 2-3 mSv/y (Cs^{137} is the dominant contributor to the effective dose), thus largely exceeding the current preliminary limit of 0.1 mSv/y. The calculations are impacted by several conservative assumptions, such as the number and the sizes of the concrete fractures (1 fracture every 10 m, fracture height 5 m, fracture width 1 mm), no sorption of the nuclides on the walls of the concrete fractures, no retention of the nuclides neither by the steel liner, nor by the natural barriers, i.e. by the region between the bitumenised waste repository and the hypothetical well (i.e. all the nuclides released from the repository are collected into the well).

A more in-depth safety case must thus be prepared to demonstrate the acceptability of the bitumenised waste long term storage on the INPP site. The safety case shall include an in-depth analysis of each step involved in the release and migration processes, starting from the source term assessment. Engineered and natural barriers, delaying the releases and/or reducing the migration rates, have major impacts on the exposure resulting from moderate half-life nuclides, such as cs^{137}. Such an in-depth safety analysis will be the start point of the bitumenised waste storage vaults upgrading Project [92].

Scenario B: Yearly Spring Flooding

This scenario considers that, once a year, the groundwater level will rise during the spring due to the snow melting, leading to a filling of the concrete fractures and to a water uptake by the bitumenised waste, promoting, therefore, the release of nuclides to the surroundings. During the institutional surveillance period of the repository, i.e. at least 100 years after the closure of the repository), the operation of the drainage system prevents from the occurrence of such a scenario. When the site is left from surveillance, the functionality of the drainage system cannot be guaranteed any longer and the above flooding scenario is possible. For a yearly flooding occurring 100 years after the repository closure, the peak values of the effective dose is of about 1.0×10^{-3} mSv/y, i.e. well below the acceptance criterion.

Conclusion:

On a preliminary basis, the mid-to-long term radiological impact of bitumenised waste storage vaults is governed by Cs^{137}.

The assessment of the corresponding effective dose for the critical members of the public will be addressed in the EIAR to be prepared in the frame of the bitumenised waste storage vault upgrading Project.

Remark

The preliminary analysis of [91] takes into account several nuclides in the bituminised waste inventory: Co^{60}, Cs^{134}, Cs^{137} and Pu^{239}. However, the initial inventory of Cs^{137} (4.8×10^{10} Bq/m^3) exceeds, by several orders of magnitude, those of Co^{60} (2.9×10^7 Bq/m^3), of Cs^{134} (6.1×10^7 Bq/m^3) and of Pu^{239} (2.9×10^4 Bq/m^3). Taking into account both the initial inventories and the short half lives of Co^{60} and Cs^{134}, the contribution of those 2 nuclides to the total effective dose remains negligible (< 1 %), even during the first years after the site closure. A period of 500 years after the site closure is needed before the contribution of Pu^{239} to the total effective dose begins to exceed that of Cs^{137}. However, at that time, the total effective dose is of some 1.0×10^{-7} Sv/y, i.e. a trivial value, in the worst case scenario.

6.6.5 Quality Assurance – Traceability

The waste management system must enable full traceability and retrievability of each conditioned package dedicated to final disposal.

A waste package characterisation record must contain the final quantification of the hazardous content of individual packages and determination that the radioactive waste package meets all the regulatory requirements set by public authorities for performance of operations with regards to it (lifting, transfer, etc.), its interim storage, transport and disposal. This means that each package must be provided with waste package characterization records containing, at least, the following information:

I. origin and type of the conditioned waste;
II. date of conditioning (identification of the conditioning campaign);
III. the total weight of the conditioned waste – type of the immobilization matrix;
IV. critical nuclides inventories in the conditioned waste by the time of conditioning;
V. contact (10cm) dose rate and dose rate at 1m by the time of conditioning;
VI. residual (if any) external α and β-γ surface contamination of the waste package;
VII. presence of toxic/hazardous materials (when relevant);
VIII. location in the interim storage facilities;
IX. date of evacuation to the final disposal site.

A computerized tracking system, enabling the entry and the storage of these data in a database, will be installed at INPP in the frame of the supply of the B2/3/4 Package.

6.7 Radiological Consequences of Postulated Incidents and Accidents for the Members of the Public

6.7.1 Introduction-Scope

After the RFS, the risk of incidents/accidents leading to large releases of fission products from the fuel is considerably reduced. However, the nature of the tasks to be carried out in view of the decommissioning is such that incidents/accidents leading to some contamination spreading in the plant and releases into the environment cannot be excluded despite the precautions taken during the preparation and the execution of the works.

The objectives of this Chapter are:

a) To identify the bounding sequences (scenarios) specific to [57]Unit 1 defuelling phase with respect to the exposition of the critical members of the public;
b) To identify the precautions that are taken to avoid the occurrence of such events;
c) To asses the radiological exposures (effective dose) of the critical members of the public;
d) To identify the counter measures that can be implemented to mitigate the radiological consequences of the identified incidents/accidents;
e) To demonstrate that the radiological acceptance criteria (regulatory requirements) are met, even when these analyses are based on conservative approaches (radiological source terms, meteorological conditions, atmospheric dilution factors…).

As a result of the safety analysis performed in chapter 3 of [93], there are two different kinds of accidents to be evaluated. One type is connected with the reactor and its reactions after RFS and cooling down especially in stage 1 of the decommissioning activities during the phase of defuelling, and the second type is connected with special decommissioning activities mainly executed during stage 2, when there is no more fuel in the reactor core but only in the spent fuel pools. So, under the conditions of the decommissioning stages 1 and 2, in compliance with the fault schedule in chapter 3 of [93], the following two main types of possible accidents must be analysed:

<u>Type 1</u>: Reactor related possible accidents after RFS and cooling down are:

- transients because of loss of reactivity control;
- loss of coolant accidents;
- damages caused by dropping equipment;
- accidents caused by mistakes in handling the fuel during the defuelling of the core;
- loss of essential supply systems;
- erroneous emptying of MCC parts during maintenance.

Indirectly connected to the operation of the reactor and also essential in the stages 1 and 2 are the following two possible accidents:

- loss of cooling to spent fuel pools;
- accidents caused by mistakes in handling the fuel during the defuelling of the spent fuel pools;

All these accidents/incidents will be commented in § 6.6.2.

<u>Type 2:</u> Possible accidents related to special decommissioning activities.

The accident sequences specific to the defuelling phase activities are identified in chapter 3 of [91]. With the exception of the loss of spent decontamination solution, these sequences lead to very low atmospheric releases, i.e. releases covered by the routine releases, or no release at all. The loss of spent decontamination solution accident, leading to the highest atmospheric releases, is thus discussed hereafter (§ 6.6.3). It must be noted that U1DP0 does not address any dismantling activities. The incidents/accidents related to these activities are thus not addressed in U1DP0 DSAR [91], and their environmental impact is not addressed in this EIA Report.

[57] Specific to the feduelling phase: i.e. the sequences which are not already covered by the operation licence of the Unit.

6.7.2 Reactor Related Possible Accidents after the RFS

As indicated in chapter 4.1 of [93], the Type 1 sequences (reactor related possible accidents after the RFS) are either already covered by the corresponding sequences during normal operation or do not lead to any significant releases, i.e. exceeding the routine operation releases.

The accidents specific to the operation of B1 and their environmental impacts will be addressed in the corresponding DSAR and EIAR.

Nuclear safety is provided for intra-plant transportation of RBMK-1500 fuel in transport cask from Unit 1 to Unit 2 in normal and accidental conditions [94]. The highest effective dose (including exposure with food) induced by design accidents will not be higher than 11 μSv. This is significantly less than the annual effective dose constraint of 200 μSv for the operation of INPP [94].

6.7.3 Accidents Specific to the Decommissioning Activities during Unit 1 Defuelling

Loss of the MCC Decontamination Solution

A) <u>Scenario</u>

In order to assess the upper value of the radiological consequences, the selected originating event is the one that maximises the loss of decontamination volume, i.e. the rupture of the MCPs suction header of one MCC loop[58]. This rupture leads, in the first stage, to the complete drain down of the water inventories of:

- 2 separator drums and their equilibrium lines;
- the down comers;
- the MCPs drum header.

However, after the occurrence of the rupture, it is conservatively assumed that the MCPs[59] will continue to operate, for some time, before being tripped off. This means that, after the occurrence of the breach at the suction header, the separator drums will still be fed by decontamination solution from the bottom feed water lines, from the reactor channels and from the steam-water lines. So, on a conservative basis, it must be considered that the whole water inventory of the MCC loop undergoing decontamination will be lost.

It must be noted that:

- The decontamination of the MCC is performed soon after the reactor defuelling, i.e. when the MCC components are tight and in good working conditions;
- The strains during the decontamination (i.e. pressure < 10 bar and temperature ≤ 100 ºC) are significantly lower than those prevailing during normal operation (p ≈ 70 bar and temperature ≈ 260 ºC).

Therefore, the probability of occurrence of such an accident is extremely low. However, this accident is analysed on a deterministic basis.

[58] For the reasons developed in chapter 5 of U1DP0, each loop of the MCC is decontaminated independently.
[59] 3 MCPs are kept in operation during in-line decontamination to provide the appropriate circulation rates and to keep the temperature of the decontamination solution at the required level (95ºC).

As MCC is, by far, the system with the highest contamination with respect to the decommissioning activities (i.e. not already covered by the design basis accidents), this accident leads to the highest inhalation effective dose of the critical individual at the boundary of the site during the defuelling phase of Unit1.

B) Accident Analysis

The detailed analysis of the accident, including the set of initial conditions and conservative assumptions, is given in chapter 4.2 of [93]. The results are discussed hereafter.

C) Results and Discussion – Conclusion (Compliance with the Radiological WAC)

Table 6-14.1 shows:

- The releases of the radiologically significant nuclides into the environment (Bq);
- The corresponding inhalation effective dose to the critical members of the public.

Table 6-14.1 Inhalation Effective Dose According to Loss of MCC Decontamination Solution

Nuclide i	Discharge to the atmosphere – R_i (Bq)	$H'_{eff\ i}$ Inhalation effective dose to (mSv):	
		teenager (15 y)	adult
C^{14}	3.13×10^{8}	2.6×10^{-6}	2.4×10^{-6}
Mn^{54}	3.04×10^{9}	7.6×10^{-6}	6.1×10^{-6}
Fe^{55}	9.68×10^{10}	1.2×10^{-4}	9.9×10^{-5}
Co^{58}	2.13×10^{4}	7.2×10^{-11}	6.1×10^{-11}
Ni^{59}	6.76×10^{7}	4.2×10^{-8}	3.8×10^{-8}
Co^{60}	3.67×10^{10}	1.6×10^{-3}	1.5×10^{-3}
Ni^{63}	1.56×10^{10}	2.6×10^{-5}	2.7×10^{-5}
Nb^{94}	1.28×10^{8}	8.7×10^{-6}	8.3×10^{-6}
Sr^{90}	1.20×10^{7}	2.5×10^{-6}	2.6×10^{-6}
Tc^{99}	8.99×10^{4}	1.7×10^{-8}	1.6×10^{-8}
I^{129}	7.97×10^{2}	4.93×10^{-11}	3.8×10^{-11}
Cs^{134}	6.72×10^{7}	2.0×10^{-6}	1.8×10^{-6}
Cs^{135}	7.21×10^{2}	8.7×10^{-12}	8.3×10^{-12}
Cs^{137}	2.02×10^{8}	1.1×10^{-5}	1.1×10^{-5}
Pu^{238}	2.20×10^{7}	2.8×10^{-3}	3.2×10^{-3}
Pu^{239}	5.92×10^{6}	8.3×10^{-4}	9.5×10^{-4}
Pu^{240}	1.41×10^{7}	2.0×10^{-3}	2.2×10^{-3}
Pu^{241}	1.73×10^{9}	4.9×10^{-3}	5.3×10^{-3}
Am^{241}	4.59×10^{7}	5.3×10^{-3}	5.7×10^{-3}
Cm^{244}	5.24×10^{6}	3.6×10^{-4}	3.8×10^{-4}
Total		$\mathbf{1.8\times10^{-2}}$	$\mathbf{1.9\times10^{-2}}$

The calculated inhalation effective doses are practically the same for the considered critical individuals (15 years old teenager and adult) and are of about 2.0×10^{-2} mSv (conservative assumptions). These doses are governed by the releases of Co^{60}, Pu and Am^{241} nuclides and amount to 10 % of the Lithuanian Regulatory Limit pertaining to the maximum annual exposureof the critical members of the public resulting from all radioactive discharges of INPP (0.2 mSv/y).

D) Remedial Actions

- Processing of the lost decontamination solution

  The lost spent decontamination will be collected by the sumps and the drainage system of room 409, transferred to the liquid storage tanks (TW13B01 or B02) in building 154 for evaporation. The floors and walls of the affected areas in room 409 will then be cleaned.

- Repair of the ruptured component and new decontamination cycle

  The need to repair the ruptured component (e.g. header), to make a tightness test and to proceed to a new decontamination cycle will depend on the MCC equipment residual dose rates measured at that time.

  A cost-benefit analysis, similar to that performed in chapter 5 of U1DP0 to justify the MCC in-line decontamination, will enable INPP to take a decision on the above concern.

E) Transboundary Effect

The effective inhalation dose, resulting from the accident, is calculated for an hypothetical receptor at the boundary of the exclusion zone (X = 3 km).

The distance to the closest board being about 4.5 km (Bielorussia), the highest effective dose for an hypothetical receptor, located at that place, will be somewhat lower (10-15 %), this difference being not significative from the radiological standpoint.

F) Other Exposure Pathways for the Critical Members of the Public

The other exposure pathways are:

(a) the ingestion of contaminated foodstuff;
(b) the external irradiation by the plume;
(c) the external irradiation by the aerosols deposited on the ground.

Comments:

(a) The ingestion dose that could result from the accident puff release is not calculated, as countermeasures can be implemented (withdrawal of the foodstuffs from the distribution routes) should the measured contamination levels exceed the permissible values. For the inhalation exposure pathway, no countermeasures can be taken in principle for short duration releases.

(b) The external irradiation by the plume (whole body and skin doses) is predicted to be trivial due to the very low nuclides integrated specific activity ($Bq \times s/m^3$) in the plume at the location of the critical individual.

(c) The external irradiation by the aerosols deposited onto the ground is also very low and negligible by comparison with the inhalation dose. For indicative purpose, the assessment of this exposure pathway is given in Table 6-14.2. The methodology is given in section 4.2.3.3 of [93].

Table 6-14.2 Critical Individual External Irradiation due to Aerosol Deposits

Nuclide i	R_i (Bq)	$R_i \times \frac{X}{Q} \times v_d$	$d'_{i,ext}$ (mSv/h/Bq/m^2)	$d_{i,ext}$ (mSv/d)
Mn^{54}	3.04×10^{9}	6.4×10^{0}	1.6×10^{-9}	2.5×10^{-7}
Co^{60}	3.67×10^{10}	7.7×10^{1}	4.6×10^{-9}	8.5×10^{-6}
Cs^{134}	6.72×10^{7}	1.4×10^{-1}	3.2×10^{-9}	1.1×10^{-8}
Cs^{137}	2.02×10^{8}	4.2×10^{-1}	1.1×10^{-9}	1.1×10^{-8}
Total				$\mathbf{8.8\times10^{-6}}$

$d_{i,ext}$ = daily external dose to the hypothetical receptor due to the deposition of nuclide i (mSv/d);

R_i = release of nuclide i to the atmosphere as a result of the accident (Bq – see Table 6-11.1);

$\frac{X}{Q}$ = atmospheric dilution coefficient for the critical individual and for a short duration release via the main stack (s/m^3);

v_d = aerosol deposition rate = 1.5×10^{-3} m/s [77];

t = stay time on the contaminated soil (hours);

$d'_{i,ext}$ = nuclide i deposited activity dose-contamination conversion factor (mSv/h/Bq/m^2) – see [97].

A time period of 24 hours is sufficient to implement countermeasures (e.g. the evacuation of the critical individual) should the measurements show an excessive dose rate from the contaminated ground.

The daily dose rate to the critical members of the public resulting from the deposits of aerosols on the ground, resulting from the loss of spent decontamination solution, is thus lower by 3 orders of magnitude at least than the corresponding inhalation dose (see Table 6-11.1).

6.8 Emergency Plans for Public Radiation Protection – Transboundary Aspects

6.8.1 Emergency Plans

The basic objective of the emergency plan is to initiate the appropriate counter-measures, in a timely way, in order to keep the radiation exposure of the public and the plant personnel under the limits fixed by the Authorities.

In emergency situation, the Ignalina NPP personnel is guided by special plant procedures, instructions, guidelines. These procedures describe actions to be taken for elimination and management of the accident and/or mitigation of the accident consequences. Established procedures provide a basis for a suitable operator response to abnormal event.

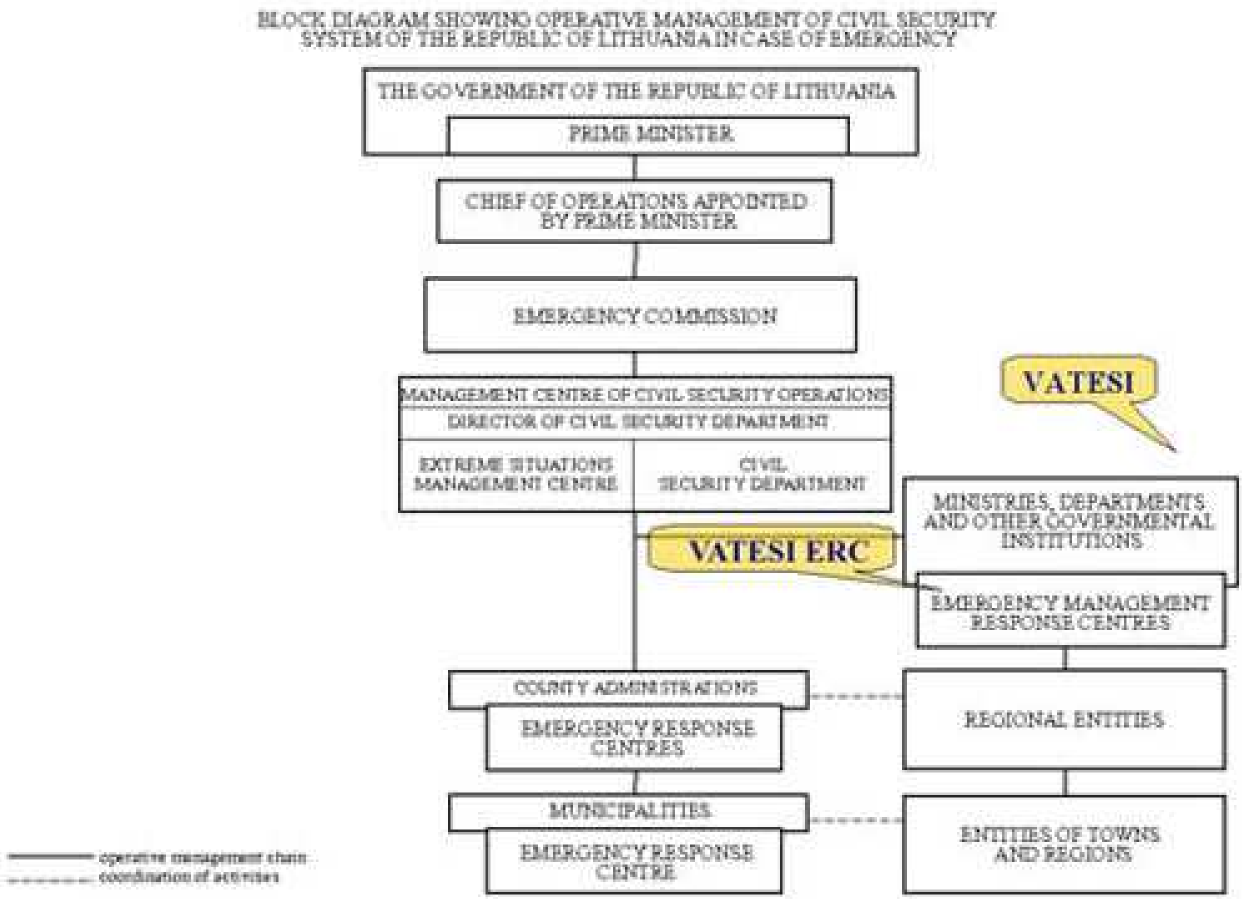
HN 99:2000 regulation “Protection of the Population in Case of Radiation or Nuclear Accident” that, in general, specifies what radiation protection measures of the public in the short and long terms must be implemented. According to these measures the emergency plans for public protection during decommissioning process should be prepared.

Moreover, an emergency response system exists at Ignalina NPP, which is meant to protect plant personnel and general public in case of an accident at the plant. INPP Emergency Response co-operates closely with the National Civil Defence that performs the following activities:

a) organizes accident termination activities for INPP;
b) coordinates activities of all institutions involved in accident termination at Ignalina;
c) periodically reports to the President, Seimas and Government on the progress in accident termination;
d) executes Governmental decisions and instructions related to the accident;
e) organizes public evacuation from the affected area;
f) informs interested organizations, including the concerned neighbouring countries, mass media, general public on accident termination measures and the risk of ionizing radiations.

The current INPP emergency plan, including the frequency of the emergency preparedness exercises, will remain applicable until the final shutdown of Unit 2. It will then be adapted to, take into account the progressive phase out of the nuclear risk (for example the distribution of iodine (KI) tablets is no longer a concern 3 months after RFS).

Management of emergencies and mitigation of impacts in the Republic of Lithuania are carried out at three levels, these of the state, counties and municipalities.

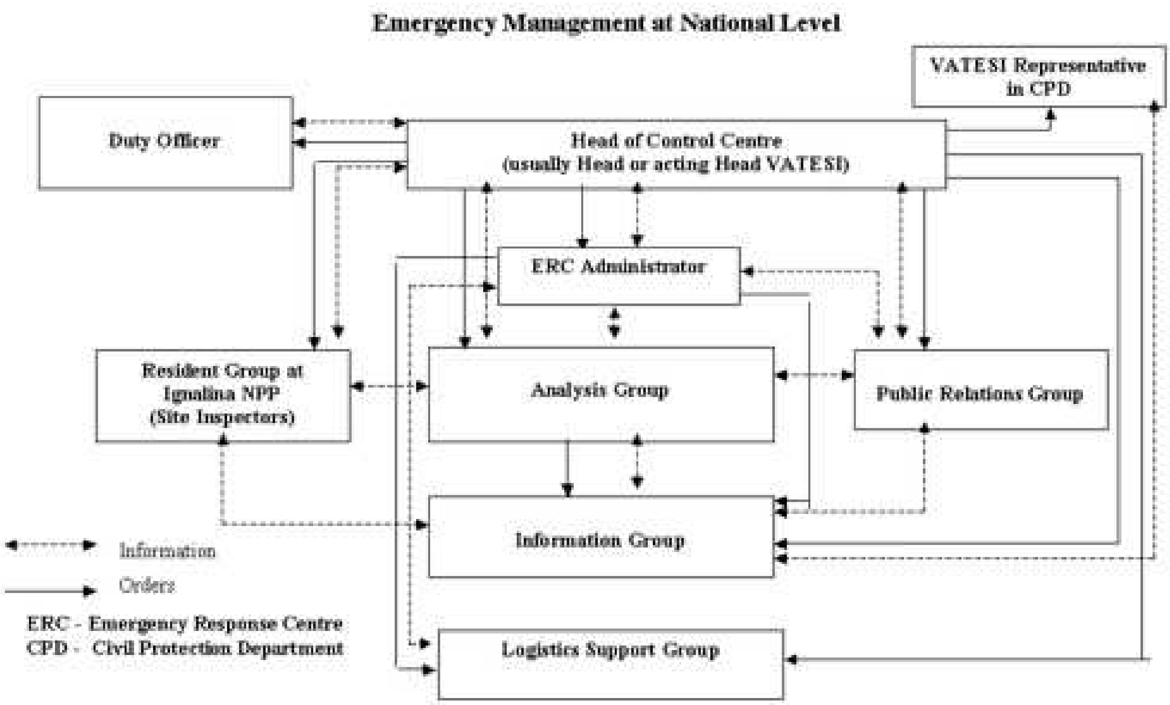


The state level comprises the Government of the Republic of Lithuania, the Emergency Commission, the Emergency Management Centre, the Civil Security Department, ministries, other governmental institutions, including VATESI, the Fire Protection Department under the Ministry of Internal Affairs, Coordination centres of Aerial Search and Rescue, and Marine Search and Rescue, as well as the forces of Regional Civil Security.

The county level comprises the County Head Administration, the County Emergency Response Centre, the Population Warning and Notification Services, as well as other Civil Security divisions.

The municipality level comprises the Municipal Administration, the Municipal Emergency Response Centre, the Fire Protection Service, the Population Warning and Notification Services, as well as other Civil Security divisions, economic entities, Civil Security forces.
To fulfil the above functions, the Emergency Response Centre was set up at VATESI, and the Emergency Preparedness Plan was approved.

The Emergency Response Centre of VATESI performs VATESI functions if an accident takes place. The structure of the Emergency Response Centre of VATESI is as follows:



6.8.2 Transboundary Aspects of Accidents

Here are to be considered the transboundary aspects of accidents with releases of radionuclides that can reach neighbour countries.
Such events fall into the framework of international conventions and treaties, as well as Lithuanian legislation. Here follows a summary of the provisions of the main applicable texts.

A) Lithuania is a Party to several international conventions, among which:

- The 1986 Convention on early Notification of a Nuclear Accident: this Convention establishes a notification system for nuclear accidents which have the potential for international transboundary release that could be of radiological safety significance for another State. It requires States to report the accident's time, location, radiation releases, and other data essential for assessing the situation.

- The Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency: this Convention sets out an international framework for co-operation among States Parties and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. It requires States to notify the IAEA of their available experts, equipment, and other materials for providing assistance. In case of a request, each State Party decides whether it can render the requested assistance as well as its scope and terms. Lithuania transposed the convention into national legislation through the Law No. VIII-1882 of 20 July 2000.

- The Convention on Environmental Impact Assessment in a Transboundary Context (ESPOO, 1991)) transposed into national legislation through the Law No. VIII-1351 of 7 October 1999.

B) <u>EURATOM Treaty</u>

The EURATOM Treaty, to which the Republic of Lithuania is bound, includes radiological protection of the work force and the public (Chapter III, Health and safety).

In its Article 37, it is stated that "*Each Member State shall provide the Commission with such general data*[60] *relating to any plan for the disposal of radioactive waste in whatever form as will make it possible to determine whether the implementation of such plan is liable to result in the radioactive contamination of the water, soil or airspace of another Member State.*"

Article 37 was appended by a EU recommendation, stating that "*any planned disposal or accidental release of radioactive substance associated with the dismantling of nuclear reactors and reprocessing plants*" are in the scope of Article 37.

C) Other EU legislation

The Directive 97/11/EC of 3 March 1997 (amending Directive 85/337/EEC of 27 June 1985 on the assessment of effects of certain public and private projects on the environment) specifies the minimum information to be provided by the developer and request the Member States to take the measures necessary to organize the EIA evaluation by the Authorities and the Public information, including requirements linked to possible transboundary impact. This information must be provided in good time, thus allowing the public to express their opinion before a decision is taken on whether to grant development consent.

---

[60] These data are defined in Article 30 of the Treaty, as being :

- maximum permissible doses compatible with adequate safety;
- maximum permissible levels of exposure and contamination;
- the fundamental principles governing the health surveillance of workers.

D) Lithuanian legislation

The key legal documents associated with the use of nuclear energy for peaceful purposes are the Law on Nuclear Energy, the Law on Radioactive Waste Management, and the Law on Radiation Protection. Based on the said Laws, the Government of the Republic of Lithuania and its institutions develop secondary legislation, with VATESI being responsible for establishing nuclear safety, nuclear materials accounting and control standards.
In case of an incident or accident, the notification to be done to the regulatory authorities is organized by the Regulation VD-E-04-98 "General Requirements for the event reporting system at a nuclear power plant". The organisation of emergency situations is described in previous section (6.8.1).

Nevertheless, it was shown in section 6.7.3 that the highest effective dose induced by accidents specific to the decommissioning should be somewhat lower than at the boundary of the exclusion zone. It is demonstrated in this section that the maximum effective dose to the considered critical individuals amounts to 0.4% of the Lithuanian Regulatory Limit for special circumstances (5 mSv).

6.9 Dose-Contamination Conversion Factors of Nuclides not mentioned in LAND 42-2001

The calculation of the dose-contamination conversion factors ($Sv/Bq_{released}$) implies the knowledge of the mathematical models used to assess the behaviour of the released nuclides in the environment (i.e. essentially in the trophic chain, as for the aerosols, the effective dose is essentially governed by the ingestion exposure pathway).

As these models are not available, the following approach has been implemented to assess the dose-contamination conversion factors not mentioned in LAND-42. This is done bearing in mind that, as these factors are related to the minor contribution nuclides, a precise estimation is not needed.

A) Activation Products (Fe^{55}, Ni^{59}, Ni^{63} and Nb^{94})

For each nuclide i, ratio do,i is calculated as:

$$d_{0,i} = \frac{D_i}{D_{Co^{60}}}) \text{ ingestion} \qquad (1)$$

D_i = nuclide i dose-contamination conversion factor (Sv/Bq) ingestion;
$D_{Co}{}^{60}$ = Co^{60} dose-contamination conversion factor (Sv/Bq) ingestion.

The values of D_i and $D_{Co}{}^{60}$ are given in ICRP-72 for the "adult" – see attached Table from [78].

The nuclide i dose-contamination conversion factor ($Sv/Bq_{released}$) is then assessed as:

$$D_{1,i} = d_{0,i} \times D_{1,Co}{}^{60} \qquad (2)$$

$d_{0,i}$ = see hereabove;

$D_{1,Co}{}^{60}$ = Co^{60} dose-contamination conversion factor ($Sv/Bq_{released}$) given by LAND-42, i.e. 5.7×10^{-17} Sv/Bq;

$D_{1,i}$ = nuclide i dose-contamination conversion factor for the release of nuclide i via the atmospheric discharges ($Sv/Bq_{released}$).

Examples:

i = Fe^{55}

(1) ICRP-72 gives (see attached table): $d_{0,Fe}{}^{55} = \frac{3.3\times10^{-10}}{3.4\times10^{-9}} = 9.71\times10^{-2}$;

(2) $D_{1,Fe}{}^{55} = 9.71\times10^{-2}\times5.7\times10^{-17} = 5.5\times10^{-18}$ ($Sv/Bq_{released}$).

i = Nb^{94}

(1) ICRP-72 gives: $d_{0,Nb}{}^{94} = \frac{1.7\times10^{-9}}{3.4\times10^{-9}} = 0.5$;

(2) $D_{1,Nb}{}^{94} = 0.5\times5.7\times10^{-17} = 2.9\times10^{-17}$ ($Sv/Bq_{released}$).

etc. for the other nuclides.

B) Fission Product (Tc^{99})

For Tc^{99}, $d_{0,Tc}{}^{99} = \frac{D_{Tc^{99}}}{D_{Cs^{137}}}$) ingestion (3)

$D_{Tc}{}^{99}$, $D_{Cs}{}^{137}$ = Tc^{99} and Cs^{137} dose-contamination conversion factor (Sv/Bq)ingestion – see ICRP-72 attached table.

$D_{1,Tc}{}^{99} = d_{0,Tc}{}^{99}\times D_{1,Cs}{}^{137}$ (4)

$D_{1,Cs}{}^{137}$ = Cs^{137} dose-contamination conversion factor ($Sv/Bq_{released}$) given by LAND-42, i.e. 1.2×10^{-16} Sv/Bq.

(3) ICRP-72 gives: $d_{0,Tc}{}^{99} = \frac{6.4\times10^{-10}}{1.3\times10^{-8}} = 4.9\times10^{-2}$;

(4) $D_{1,Tc}{}^{99} = 4.9\times10^{-2}\times1.2\times10^{-16} = 5.9\times10^{-18}$ ($Sv/Bq_{released}$).

C) TRU Nuclides (Pu^{238}, Am^{241} and Cm^{244})

$d_{0,i} = \frac{D_i}{D_{Pu^{239}}}$) ingestion (5)

D_1, $D_{Pu}{}^{239}$ = nuclide i and Pu^{239} dose-contamination conversion factor for the ingestion pathway (Sv/Bq) ingestion – see attached ICRP-72 table.

$D_{1,i} = d_{0,i}\times D_{1,Pu}{}^{239}$ (6)

$D_{0,i}$ = see hereabove;

$D_{1,Pu}^{239}$ = Pu^{239} dose-contamination conversion factor ($Sv/Bq_{released}$) given by LAND-42, i.e. 3.8×10^{-16} $Sv/Bq_{released}$;
$D_{1,i}$ = nuclide i (TRU) dose-contamination conversion factor for the release of nuclide i via the atmospheric discharges ($Sv/Bq_{released}$).
Examples:

<u>i = Pu^{238}</u>

(5) ICRP-72 gives: $d_{0,Pu}^{238} = \dfrac{2.3\times10^{-7}}{2.5\times10^{-7}} = 0.92$;

(6) $D_{1,Pu}^{239} = 0.92\times3.8\times10^{-16} = 3.5\times10^{-16}$ ($Sv/Bq_{released}$).

<u>i = Am^{241}</u>

(1) ICRP-72 gives: $d_{0,Am}^{241} = \dfrac{2.0\times10^{-7}}{2.5\times10^{-7}} = 0.8$;

(2) $D_{1,Am}^{241} = 0.8\times3.8\times10^{-16} = 3.0\times10^{-16}$ ($Sv/Bq_{released}$).

<u>i = Cm^{244}</u>

(5) ICRP-72 gives: $d_{0,Cm}^{244} = \dfrac{1.2\times10^{-7}}{2.5\times10^{-7}} = 0.48$;

(6) $D_{1,Cm}^{244} = 0.48\times3.8\times10^{-16} = 1.8\times10^{-16}$ ($Sv/Bq_{released}$).

<u>Remark: Pu^{241}</u>

Pu^{241} (β emitter) has been linked to Cs^{137} for the calculation of $d_{0,\,Pu}^{241}$ and not to Pu^{239} (α emitter).

The application of relationship (3) and (4) leads to:

$d_{0,Pu}^{241} = \dfrac{4.8\times10^{-9}}{1.3\times10^{-8}} = 0.37$ and

$D_{1,Pu}^{241} = 0.37\times1.2\times10^{-16} = 4.4\times10^{-17}$ ($Sv/Bq_{released}$).

ICRP-72 Dose-Contamination Conversion Factors for Ingestion Exposure Pathway

	ICRP 60 age classes					
	3 months	1 year	5 years	10 years	15 years	adult
Isotopes	Effective dose ingestion coefficients [Sv/Bq]					
C-14	1,40E-09	1,60E-09	9,90E-10	8,00E-10	5,70E-10	5,80E-10
Mn-54	5,40E-09	3,10E-09	1,90E-09	1,30E-09	8,70E-10	7,10E-10
Fe-55	7,60E-09	2,40E-09	1,70E-09	1,10E-09	7,70E-10	3,30E-10
Co-58	7,30E-09	4,40E-09	2,60E-09	1,70E-09	1,10E-09	7,40E-10
Co-60	5,40E-08	2,70E-08	1,70E-08	1,10E-08	7,90E-09	3,40E-09
Ni-59	6,40E-10	3,40E-10	1,90E-10	1,10E-10	7,30E-11	6,30E-11
Ni-63	1,60E-09	8,40E-10	4,60E-10	2,80E-10	1,80E-10	1,50E-10
Nb-94	1,50E-08	9,70E-09	5,30E-09	3,40E-09	2,10E-09	1,70E-09
Sr-90	2,30E-07	7,30E-08	4,70E-08	6,00E-08	8,00E-08	2,80E-08
Tc-99	1,00E-08	4,80E-09	2,30E-09	1,30E-09	8,20E-10	6,40E-10
I-129	1,80E-07	2,20E-07	1,70E-07	1,90E-07	1,40E-07	1,10E-07
Cs-134	2,60E-08	1,60E-08	1,30E-08	1,40E-08	1,90E-08	1,90E-08
Cs-135	4,10E-09	2,30E-09	1,70E-09	1,70E-09	2,00E-09	2,00E-09
Cs-137	2,10E-08	1,20E-08	9,60E-09	1,00E-08	1,30E-08	1,30E-08
Pu-238	4,00E-06	4,00E-07	3,10E-07	2,40E-07	2,20E-07	2,30E-07
Pu-239	4,20E-06	4,20E-07	3,30E-07	2,70E-07	2,40E-07	2,50E-07
Pu-240	4,20E-06	4,20E-07	3,30E-07	2,70E-07	2,40E-07	2,50E-07
Pu-241	5,60E-08	5,70E-09	5,50E-09	5,10E-09	4,80E-09	4,80E-09
Am-241	3,70E-06	3,70E-07	2,70E-07	2,20E-07	2,00E-07	2,00E-07
Cm-244	2,90E-06	2,90E-07	1,90E-07	1,40E-07	1,20E-07	1,20E-07

6.10 Radionuclides Behaviour in the INPP Environment

The dose-contamination conversion factors ($Sv/Bq_{released}$ via the atmospheric and liquid discharges) are those recommended by the Lithuanian Regulator and mentioned in “LAND 42” [76]. This normative document is supported by several references, one important among these being [97]. This document describes the mathematical models implemented to assess the behaviour of the released radionuclides in the miscellaneous components of the trophic chain and the critical individual habits.

For aerosols releases, the dose-contamination conversion factors were calculated for the hypothetical receptor (farmer) located at the boundary of the exclusion zone where the highest radionuclide concentration in the air is predicted. The exposure pathways include:

- inhalation;
- exposure from the ground surface deposits;
- ingestion of contaminated food.

External exposure due to plume immersion is totally negligible.

For the aquatic discharges, the highest radionuclide concentration is expected in the dilution zone of heated released water (discharge of condenser circulation water). The dose-contamination conversion factors are calculated for persons fishing in this zone and also for a hypothetical gardener using Lake Drūkšiai water for irrigation. For fishermen, the significant exposure pathways include:

- external exposure from the lake shore sediments;
- ingestion of contaminated fish.

In general, the dose-contamination factors for fishermen are higher than those for the hypothetical gardener.

Key parameters values used to calculate the dose-contamination conversion factor are listed in the following tables:

Table 6-15 Atmospheric Release Parameter Values (Food Consumption Based on Data from the Lithuanian Department of Statistics)

Parameter definition	Value
Stacks height (m)	150
Thickness of root zone	
Food crops, Grass (m)	0.3, 0.15
Density of root-zone soil (kg m^{-3})	1.46×10^{3}
Dry deposition velocities	
Elementary iodine (m s^{-1})	1.0×10^{-2}
Organic iodine (m s^{-1})	1.0×10^{-4}
Aerosols (m s^{-1})	1.5×10^{-3}
Washout coefficients	
Elementary iodine (s^{-1})	7.0×10^{-5}
Organically bound iodine (s^{-1})	7.0×10^{-7}
Aerosols (s^{-1})	7.0×10^{-5}
Yield (fresh weight)	
Grains, Potatoes (kg m^{-2})	0.4, 3.0
Other root crops (kg m^{-2})	0.4
Leafy vegetables (kg m^{-2})	0.7
Fruits (kg m^{-2})	1.0
Grass (kg m^{-2})	0.65
Usage rates (fresh weight)	
Grains (kg d^{-1})	0.60
Potatoes (kg d^{-1})	0.74
Other root crops (kg d^{-1})	0.36
Leafy vegetables (kg d^{-1})	0.10
Fruits (kg d^{-1})	0.15
Eggs (kg d^{-1})	0.13
Milk (L d^{-1})	2.58
Meat (kg d^{-1})	0.52
Fresh water fish (kg d^{-1})	0.06
Inhalation rate (m^3 d^{-1})	22.4

Table 6-16 Radionuclide-depended Atmospheric Release Parameter Values

Nuclide	Partition coefficient of radionuclide in root zone soils (m^3 kg^{-1})		The acculumation (over a period of 40 years) factors of radionuclides in soils (s kg^{-1})		Transfer coefficient for cow milk (d L^{-1})	Transfer coefficient for beef (d kg^{-1})
	Sand	Loam	Sand	Loam		
H^3	-	-	-	-	112.5[61]	87.5[52]
C^{14}	-	-	-	-	267.0[52]	800.0[52]
Cr^{51}	6.7×10^{-2}	3.0×10^{-2}	3.8×10^{-3}	3.8×10^{-3}	1.0×10^{-5}	9.0×10^{-3}
Mn^{54}	4.9×10^{-2}	7.2×10^{-1}	4.2×10^{0}	4.3×10^{0}	3.0×10^{-5}	5.0×10^{-4}
Fe^{59}	2.2×10^{-1}	8.1×10^{-1}	6.3×10^{-1}	6.3×10^{-1}	3.0×10^{-5}	2.0×10^{-2}
Co^{58}	6.0×10^{-2}	1.3×10^{0}	9.8×10^{-1}	9.3×10^{-1}	1.0×10^{-3}	1.3×10^{-2}
Co^{60}	6.0×10^{-2}	1.3×10^{0}	2.3×10^{1}	2.7×10^{1}	1.0×10^{-3}	1.3×10^{-2}
Sr^{89}	1.3×10^{-2}	2.0×10^{-1}	6.8×10^{-1}	7.0×10^{-1}	2.8×10^{-3}	8.0×10^{-3}
Sr^{90}	1.3×10^{-2}	2.0×10^{-1}	3.3×10^{1}	1.2×10^{2}	2.8×10^{-3}	8.0×10^{-3}
Zr^{95}	6.0×10^{-1}	2.2×10^{0}	9.1×10^{-1}	9.1×10^{-1}	5.5×10^{-7}	1.0×10^{-6}
Nb^{95}	1.6×10^{-1}	5.4×10^{-1}	4.8×10^{-1}	4.8×10^{-1}	4.1×10^{-7}	3.0×10^{-7}
Mo^{99}/Te^{99m}	7.4×10^{-3}	1.3×10^{-1}	3.8×10^{-2}	3.8×10^{-2}	1.7×10^{-3}	1.0×10^{-3}
I^{131}	1.0×10^{-3}	4.5×10^{-3}	2.8×10^{-1}	2.8×10^{-1}	1.0×10^{-2}	4.0×10^{-2}
I^{132}	1.0×10^{-3}	4.5×10^{-3}	3.2×10^{-3}	3.2×10^{-3}	1.0×10^{-2}	4.0×10^{-2}
I^{133}	1.0×10^{-3}	4.5×10^{-3}	3.0×10^{-2}	3.0×10^{-2}	1.0×10^{-2}	4.0×10^{-2}
Cs^{134}	2.7×10^{-1}	4.4×10^{0}	1.0×10^{1}	1.1×10^{1}	7.9×10^{-3}	5.0×10^{-2}
Cs^{137}/Ba^{137}	2.7×10^{-1}	4.4×10^{0}	1.3×10^{2}	1.5×10^{2}	7.9×10^{-3}	5.0×10^{-2}

Table 6-17 Radionuclide-independent Aquatic Release Main Parameter Values

Parameter definition	Mean value
Lake water volume (m^3)	3.69×10^{8}
Average lake depth (m)	7.6
Water outflow rate (m^3 y^{-1})	
average	9.4×10^{7}
maximum	1.6×10^{8}
Particle sink rate (kg m^2 y^{-1})	0.4
Particulate concentration (kg m^{-3})	0.002
Water volume in dilution zone (m^3)	1.5×10^{7}
Heated-water flow rate (m^3 s^{-1})	70
Fish consumption rate (kg y^{-1})	100
Time spent fishing (hr y^{-1})	1500
Irrigation rate (m^3 y^{-1})	300
Resuspension factor (m^{-1})	1×10^{6}
Time spent near lake (hr y^{-1})	4500
Time of rainy season (d y^{-1})	110
Time spent on the bank (hr y^{-1})	1500
Precipitation rate (cm y^{-1})	64
Silt accumulated rate (kg m^2 y^{-1})	0.5

[61] in Bq kg^{-1} per Bq m^{-3} (air conc.) (Simmonds and al., 1995).

Table 6-18 Radionuclide-dependent Aquatic Release Parameter Values

Nuclide	Radionuclide partition coefficient ($m^3\ kg^{-1}$)	Concentration factors for freshwater fish ($L\ kg^{-1}$)	Radionuclide transfer into water ($Bq\ m^{-3}$)/($Bq\ y^{-1}$)	Radionuclide concentration in the dilution zone ($Bq\ m^{-3}$)/($Bq\ y^{-1}$)	Radionuclide transfer from water to the bank sediments ($Bq\ m^{-2}$)/($Bq\ m^{-3}$)
H^3	0.0003	0.9	8.7×10^{-9}	4.5×10^{-10}	4.8×10^{0}
C^{14}	2	4550	7.5×10^{-9}	4.5×10^{-10}	1.2×10^{1}
Cr^{51}	20	40	2.6×10^{-10}	4.3×10^{-10}	3.3×10^{-2}
Mn^{54}	50	100	7.9×10^{-10}	4.5×10^{-10}	3.7×10^{-1}
Fe^{59}	10	100	4.3×10^{-10}	4.4×10^{-10}	5.5×10^{-2}
Co^{58}	20	300	5.6×10^{-10}	4.4×10^{-10}	8.4×10^{-2}
Co^{60}	20	300	1.9×10^{-9}	4.5×10^{-10}	2.3×10^{0}
Sr^{89}	2	60	5.0×10^{-10}	4.4×10^{-10}	5.9×10^{-2}
Sr^{90}	2	60	7.1×10^{-9}	4.5×10^{-10}	7.7×10^{0}
Zr^{95}	60	3.3	3.9×10^{-10}	4.4×10^{-10}	7.6×10^{-2}
Nb^{95}	0.1	30000	3.6×10^{-10}	4.3×10^{-10}	4.1×10^{-2}
I^{131}	0.3	200	8.5×10^{-11}	3.7×10^{-10}	9.5×10^{-3}
Cs^{134}	80[62]	2000	6.5×10^{-10}	4.5×10^{-10}	8.9×10^{-1}
Cs^{137}/Ba^{137}	80[53]	2000	6.9×10^{-10}	4.5×10^{-10}	7.8×10^{0}

The dominant exposure pathways for the hypothetical farmers (aerosols releases) and fisherman (water discharges) are summarised in Table 6-19.

Table 6-19 Dominant Exposure Pathways

Nuclide	Aerosols	Water discharge
H^3	Food chain, inhalation	Food chain
C^{14}	Food chain	Food chain
Mn^{54}	Ground-shine	Food chain
Co^{58}	Food chain, ground-shine	Food chain
Co^{60}	Ground-shine	Ground-shine
Fe^{55}	Food chain	Food chain
Ni^{59}	Food chain	Food chain
Ni^{63}	Food chain	Food chain
Nb^{94}	Food chain	Food chain
Sr^{90}	Food chain	Food chain
Tc^{99}	Food chain	Food chain
I^{129}	Food chain	Food chain
Cs^{134}	Food chain, ground-shine (Ba^{137m})	Food chain, ground-shine (Ba^{137m})
Pu+Am nuclides	Food chain	Food chain

[62] Estimated in situ (Mazeika, 1998); others K_d and B_F – generic.

6.11 Assessment of Personnel Exposure during Decommissioning Activities

6.11.1 Methodology

The DBS computer tool[63] allows establishing:

- the overall collective dose integrated on all the decommissioning activities;
- the distribution of the overall collective dose amongst groups of decommissioning activities;
- the evolution of the collective dose integrated on all the decommissioning activities in function of the decommissioning progress (see Figure 6-13).

The DBS tool allows also identifying and assessing all global or partial dose information of interest:

- by selecting:
  - part or all (groups of) decommissioning activities,
  - part or all tasks constituting each decommissioning activity;
- by considering part or all of the time period since the Unit 1 RFS until the completion of the Unit defuelling.

For each decommissioning activity, the estimate of the dose exposure is made for the different relevant tasks, for each of which the duration, the number of operators, the expected individual and collective doses are estimated.

More specially, for each decommissioning Activity, the tasks involving exposures are (see U1DP0 chapter 6 and Appendix 3):

- Task 030: dose rate mapping in the concerned areas prior to conducting the Activity (see Task 100);
- Task 050: preparatory works, system modifications in the areas concerned by the Activity;
- Task 090: personnel taining;
- Task 100: conduct of the Activity (system post-shutdown operation and maintenance, system modifications/isolation, decontamination, fuel handling operations, operational waste retrieval, sorting and pre-characterisation operations, etc.);
- Task 101: post-Activity works – removal of auxiliary equipment installed under Task 050, cleaning/decontamination of the concerned areas;
- Task 110: final dose rate mapping in the concerned areas, after completion of Task 100.

[63] Information related to the DBS Computer Tool Parameters are to be found in section 6.3.1 U1DP0 and in [98].

The following tasks address the management of the liquid and solid RAW generated by the Activity:

- Task 111: liquid waste evaporation and evaporator concentrates bitumenisation;
- Task 112: implementation of the free release procedures (for the relevant solid waste);
- Task 113: management of solid waste to be routed towards landfill;
- Task 114: conditioning of the non-combustible waste neither complying with the free release nor with the landfill waste acceptance criteria (pre-and-supercompaction, grouting);
- Task 115: incineration of the combustible waste that does not comply with the free release or with the landfill waste acceptance criteria and conditioning of the ashes.

When implementing a Decommissioning Activity on the field, doses may clearly be attributed to the DBS Tasks 030, 050, 090, 100, 101 and 110 associated to that Activity.

For tasks 111 to 115, related to the waste management, it seems more difficult in practice to establish (each time) the link between the Decommissioning Activity and the Secondary[64] Wastes being actually generated by this Activity. It is therefore difficult to make the link, and then their follow-up, of the doses associated to the waste management tasks with the Decommissioning Activity which has generated the corresponding wastes.

Therefore, for each (group of) Decommissioning Activity (-ies), the following collective doses may be considered:

- collective dose to perform all tasks of a that Activity, but excluding the tasks associated to the management of the generated wastes;
- collective dose associated to all the tasks related to the management of the wastes generated by the Decommissioning Activity.

6.11.2 Results

The overall collective dose integrated on all the decommissioning activities is estimated to about 16 Man.Sv (Figure 6-13).

The overall collective dose includes the collective doses related to the following groups of activities:

- Radioactive Waste Management (RAW), including B2/3/4 operation and the processing of the secondary waste generated by all the decommissioning activities;
- Spent Fuel Management (SFM);
- Post-operation of all operating systems during defuelling stages 1 and 2 (Post Oper.);
- Systems Isolation and Modification (Syst. Mod.);

[64] Secondary waste is waste which is generated during handling, treatment and disposal of waste.

- In-line Decontamination Activities (In-line Decont.);

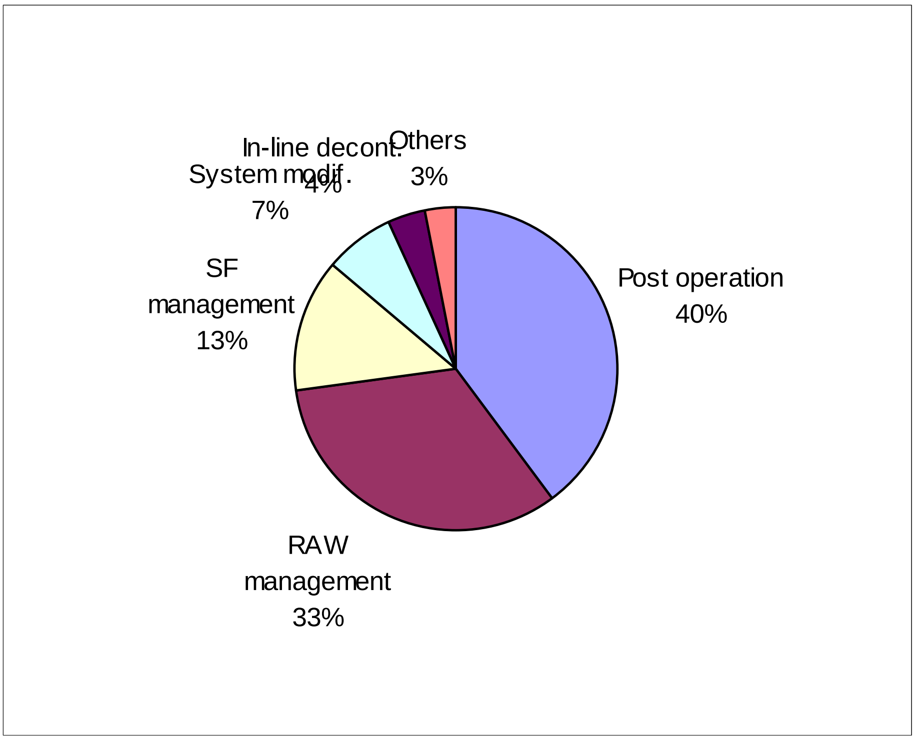
- Other remaining activities (Others).

As example, the collective dose evolution for personnel due to the post-operation of all operating systems including maintenance and repair, during the defuelling stages 1 and 2 is given on Figure 6-14 (total of outputs for tasks 030 to 110). The corresponding integrated collective dose amounts to 6.3 Man.Sv.

In addition, Figure 6-15 gives the evolution of the collective doses cumulated for all the activities to be performed under the Unit 1 Post-shutdown and defuelling phase, specifically incurred while performing the following waste management steps for the primary and secondary produced waste (total of outputs for tasks 111 to 115). The corresponding integrated collective dose amounts to 5.3 Man.Sv.

Figure 6-1 hereafter gives the distribution of the collective dose amongst these hereabove activity groups.

Figure 6-3 Collective Dose Distribution



The predicted average individual doses of the personnel during the activities covered by the present U1DP0 is about 3.4 mSv/year[65].

[65] Ratio between the predicted total collective dose and the estimated needed manpower in the controlled area (4720 man.years).

6.11.3 Discussion

- An examination of Figures 6-13 and 6-14 shows that, although the evolution of the global collective dose in function of the time elapsed since the RFS remains more or less constant (≈ 0.166 ManSv/month, with few deviations), the evolution of the collective dose due to the post-operation activities and to the RAW management exhibits significant variations.

Post-operation Activities

The volume of work to be carried out during stage 1 (period 2005-2008, reactor defuelling) significantly exceeds that of stage 2 (period 2009-2012, reactor defuelled and fuel in pools).

About 700 individuals are involved to these activities during stage 1, while this number reduces to some 480 individuals during stage 2. Furhter, the remaining activities are carried out in a lower ambient background.

The collective and average yearly individual doses vary as follows:

Stage No	Collective dose (Man.Sv)	Average individual dose (mSv/y)	Number of individuals in the controlled area
1 2	4.5 1.8	1.61 0.89	700 480
Total	6.3		

Raw Management

The situation is reversed: the volume of work during stage 2 significantly exceeds that of stage 1 due to the startup of the operational solid waste retrieval and conditioning activities (April 2009).

The collective and average yearly individual doses vary as follows in function of the considered defuelling stage:

Stage No	Collective dose (Man.Sv)	Average individual dose (mSv/y)	Number of individuals in the controlled area
1 2	1.25 4.01	13.0 10.9	24 92
Total	5.26		

The above predicted doses are to be considered as conservative. Indeed, during stage 1, in addition to the processing of the operational waste generated by the post-shutdown activities, the above results include the predicted doses due to the retrieval and the processing of the spent resins, perlite and sediments by the new cementation facility started in 2005.

Taking into account the lack of operational data, the operator exposure was calculated on the basis of the upper limit of the design value dose rates, these being usually conservative.

Similarly, during stage 2, in addition to the stage 1 activities, the predicted exposures take into account the design values of the B2/3/4 facilities (i.e. likely conservative values) to be started in 2009.

<u>Remark</u>

The DBS software limits the individual yearly exposure to 16 mSv (the current limit being of 20 mSv at INPP). This means that should the individual exposure exceed 16 mSv for a given and exceptional task, the DBS software will automatically increase the number of workers, in order to keep the individual exposure below the above limit, the collective dose remaining unchanged.

- The INPP annual collective dose integrated on all activities of both Units amounts, for year 2004 [111], to 4.5 ManSv (INPP personnel only) and to 6.8 ManSv (INPPP personnel + external companies). 85 % of the collective exposure result from the works carried out during the maintenance outages. The used INPP practice is that, each year, one Unit undergoes a small maintenance outage and the other Unit undergoes an extended maintenance outage (i.e. in that latter case, Unit 2 in 2004).

  During period 2001-2004, the yearly collective dose was found to lay in the range 3.0-4.0 ManSv for each Unit, all operational and maintenance activities included (in function of the extent of the maintenance/repair works carried out). During the same period, the average individual exposure was found to lay in the range 1.4-2.0 msv [111].

  In 2004, the collective dose associated to the liquid and solid waste treatment amounted to 0.56 ManSv (both Units), i.e. 12 % of the total INPP personnel collective dose. During the same year, the collective dose associated to the reactor shop operation (including the fuel handling operations), to the centralized workshop operation and to the metal control section amounted to 3.22 manSv (both Units), i.e. some 72 % of the total INPPpersonnel collective dose.

- On the basis of the hereabove information, Table 6-20 gives the evolution of the total collective dose during Unit 1 defuelling and of the collective dose resulting from the activity groups.

Table 6-20 Evolution of the Total Colective Dose during Unit 1 Defuelling and of the Collective Dose Resulting from the Activity Groups

Time period	Post-shutdown operation+ maintenance/ repair	RAW management	Spent fuel	Sustem isolation/ modification	In-line decontami-nation	Others	Total
Stage 1: 2005-2008	1.125	0.313	0.260	0.187	0.000	0.060	1.945
Stage 2: 2009	0.450	1.003	0.260	0.093	0.640	0.060	2.506
Stage 2: 2010-2012	0.450	1.003	0.260	0.093	0.000	0.060	1.866
Total[66]	6.300	5.264	2.080	1.120	0.640	0.480	15.884

6.11.4 Conclusions

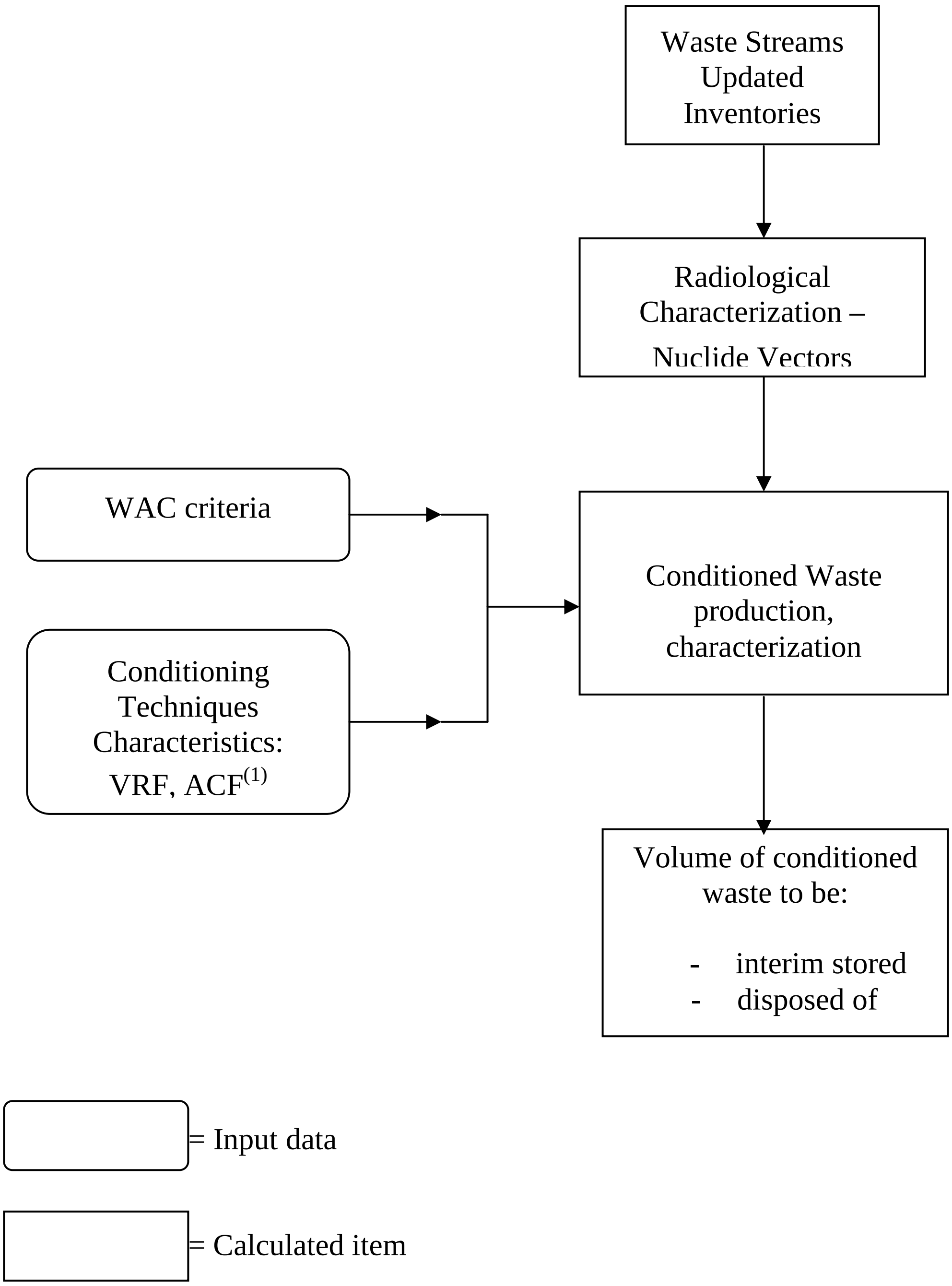
The annual global effective dose of Unit 1 personnel during defuelling varies, in function of the considered year, from 1.87 to 2.51 ManSv (predicted values). Taking into account the conservatism associated to the calculations, the actual collective doses are expected to be somewhat lower that the predicted ones. The Unit 1 yearly defuelling, personnel collective doses are thus lower than personnel collective dose during normal operation (3.0-4.0 ManSv/y).

The major difference with Unit 1 operational collective doses lays in the significant increase of the contribution of the RAW management doses, both in relative and in absolute values, during period 2009-2012. This results from the retrieval and conditioning of the operational solid waste, started in 2009.

As hereabove indicated, the radiological exposure due to the retrieval and processing of the site RAW (spent resins+perlite+sediments) has been attributed to Unit 1 personnel.

[66] Total dose = 4×dose stage 1 + 1×dose 2009 + 3×dose stage 2, 2010-2012

Figure 6-4 Decommissioning Waste Management Scheme



(1) VRF = Volume Reduction Factor, ACF = Activity Concentration Factor

Figure 6-5 Aerosols Discharges to Atmosphere

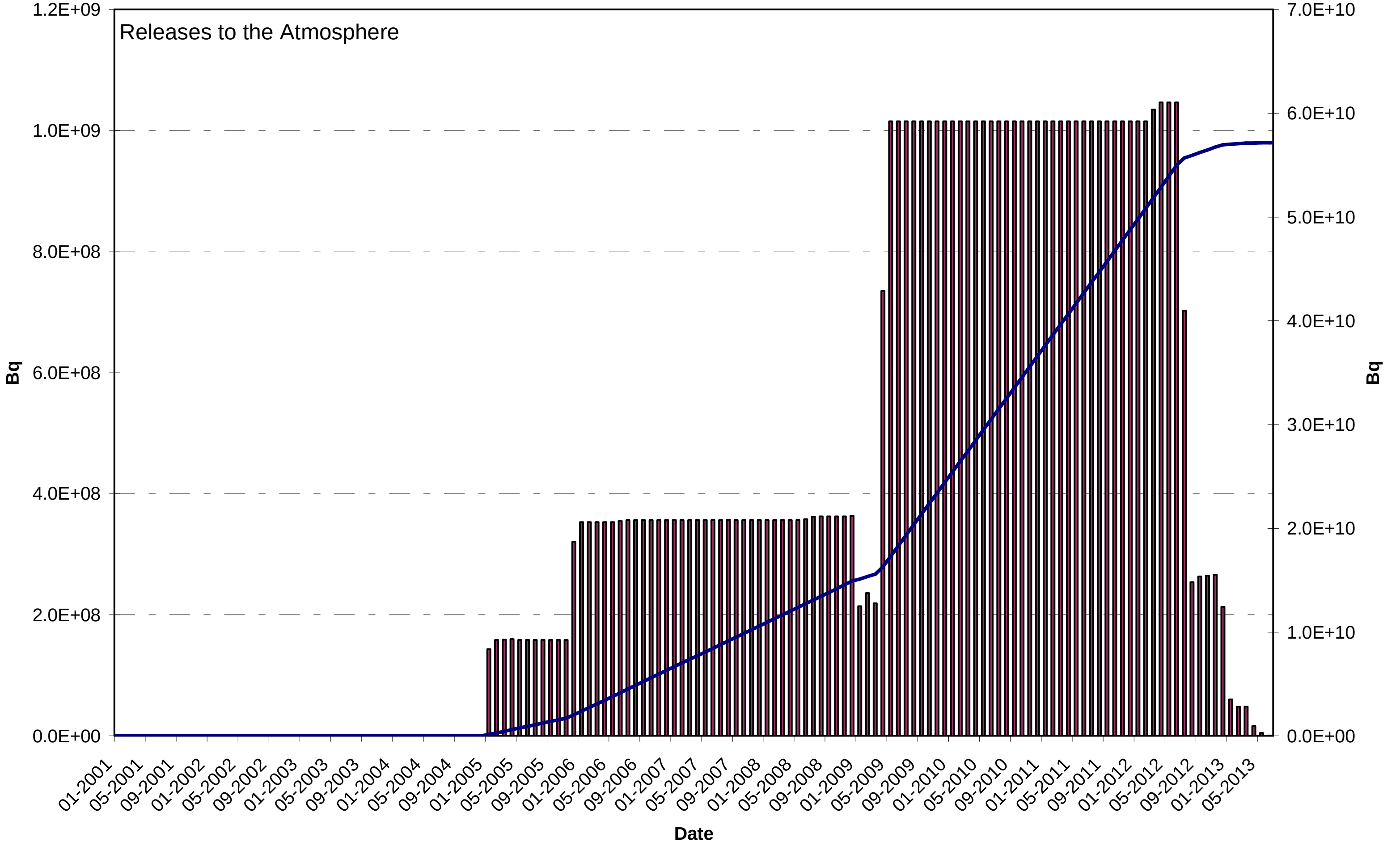


Figure 6-6 Radionuclide Content of the Water Discharged into the Lake

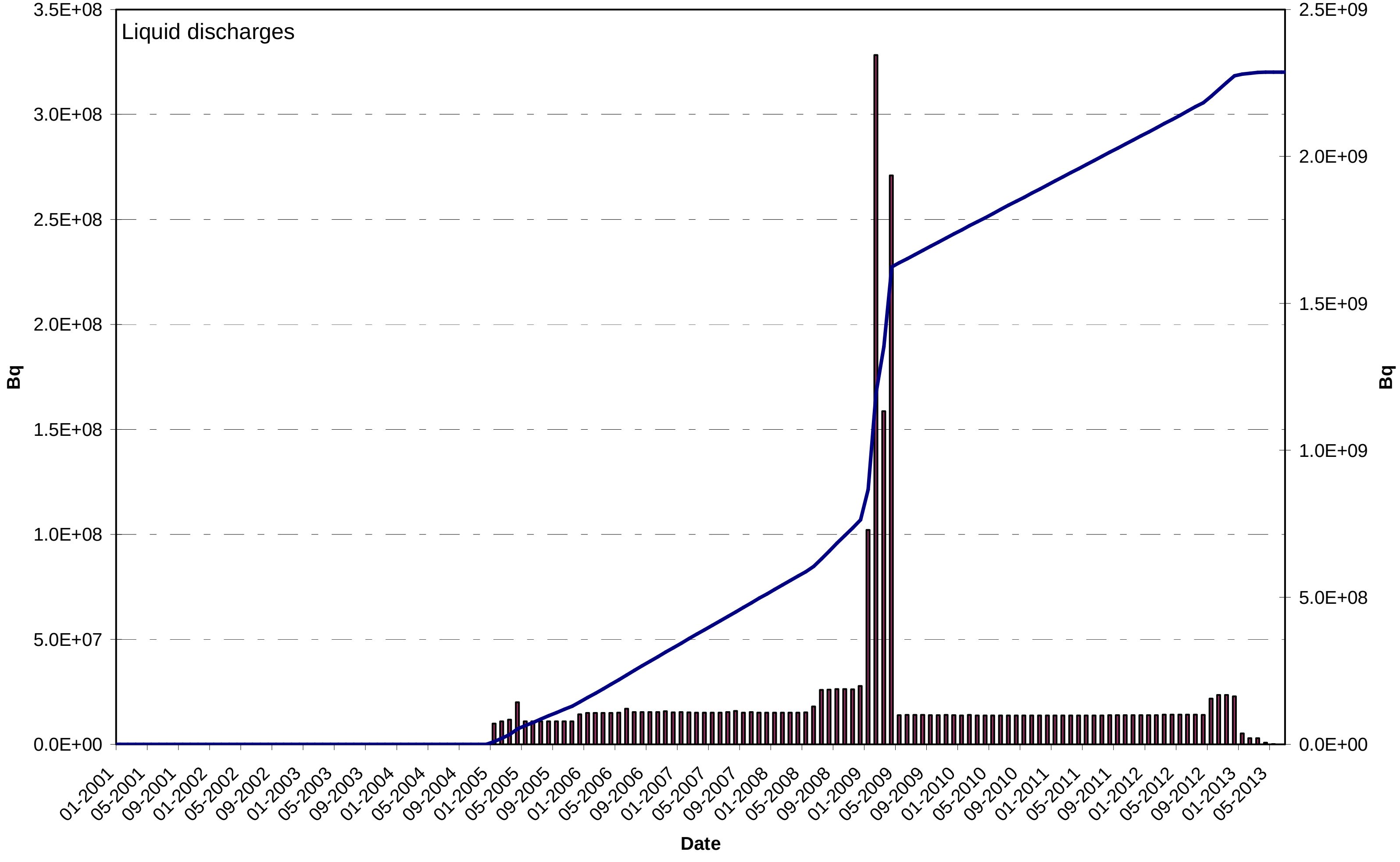


Figure 6-7 Solid to Free Release Mass

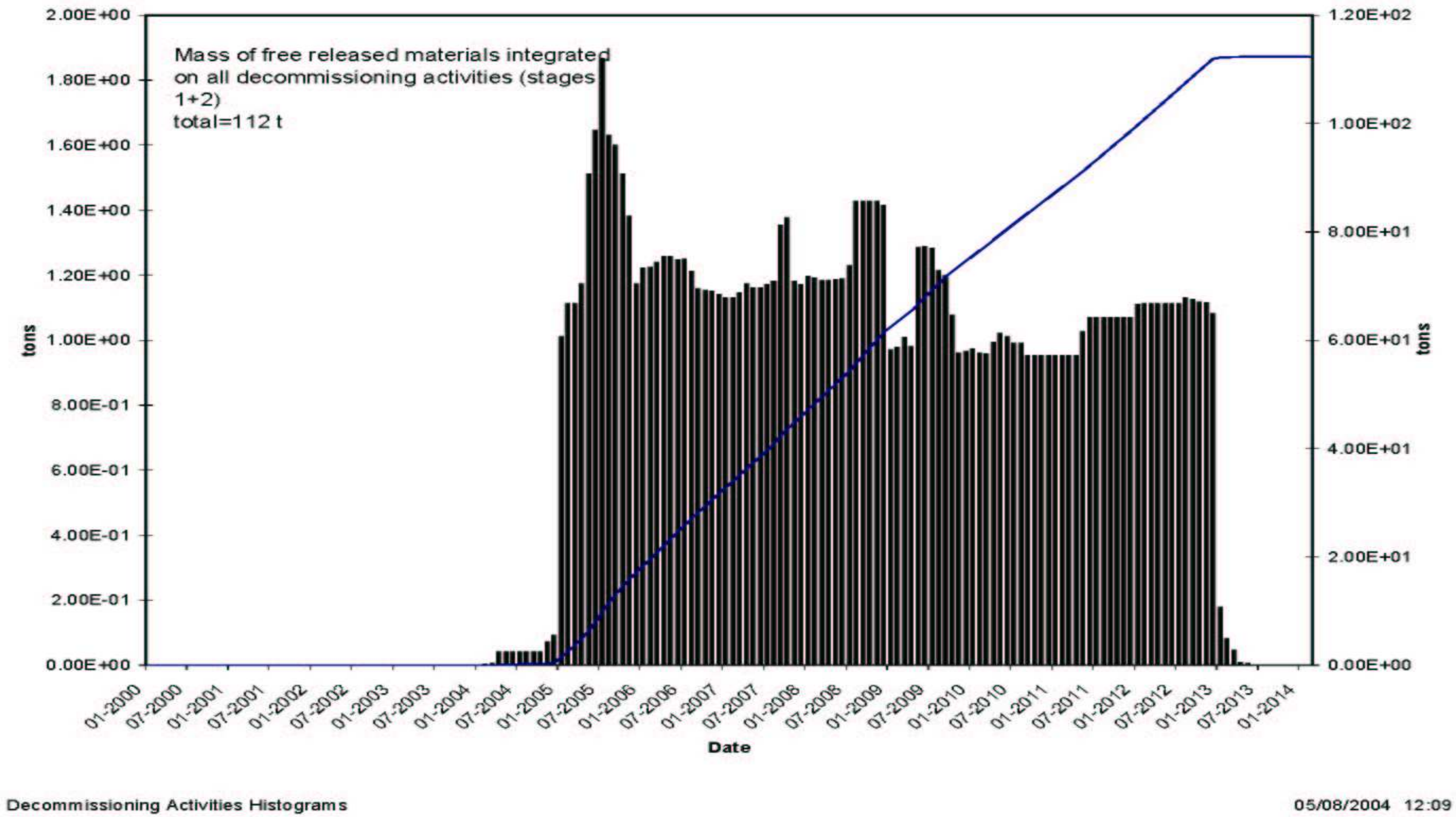
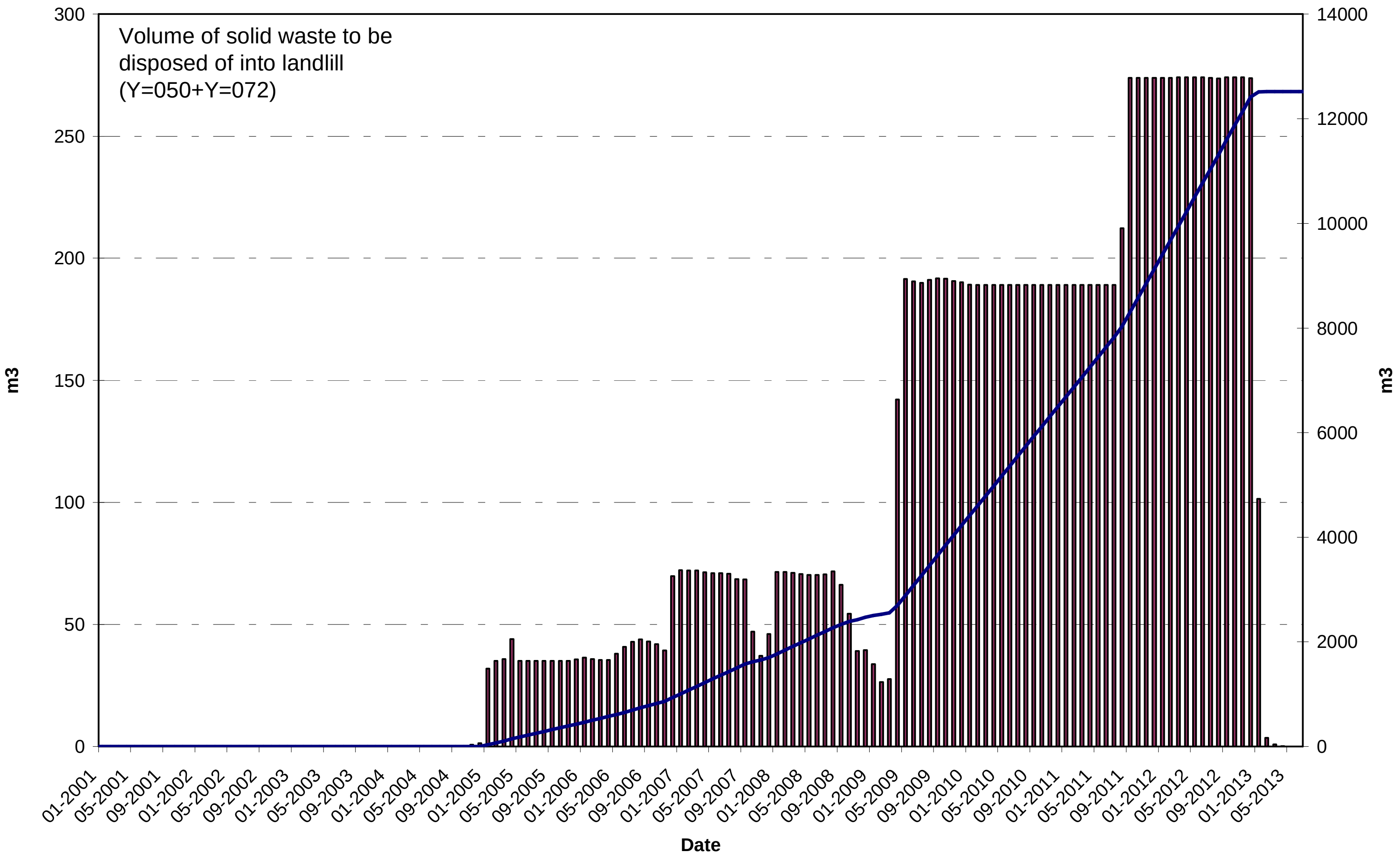


Figure 6-8 Landfill



Note: For period 2005 – 2006, see section 6.5.

Figure 6-9 Solid to Landfill β-γ tot (Non-decayed Activity Inventory)

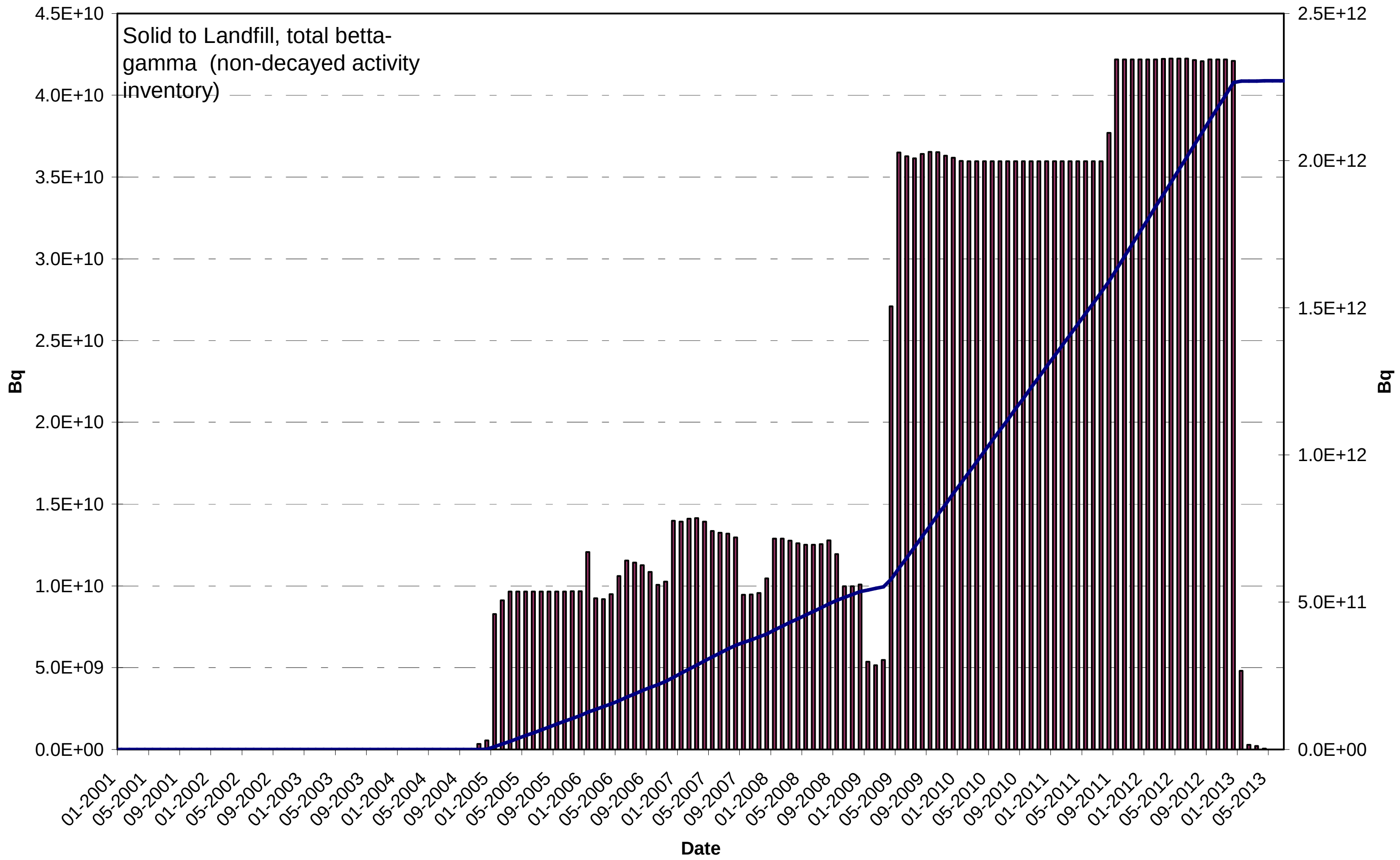


Figure 6-10 Solid to Landfill α tot

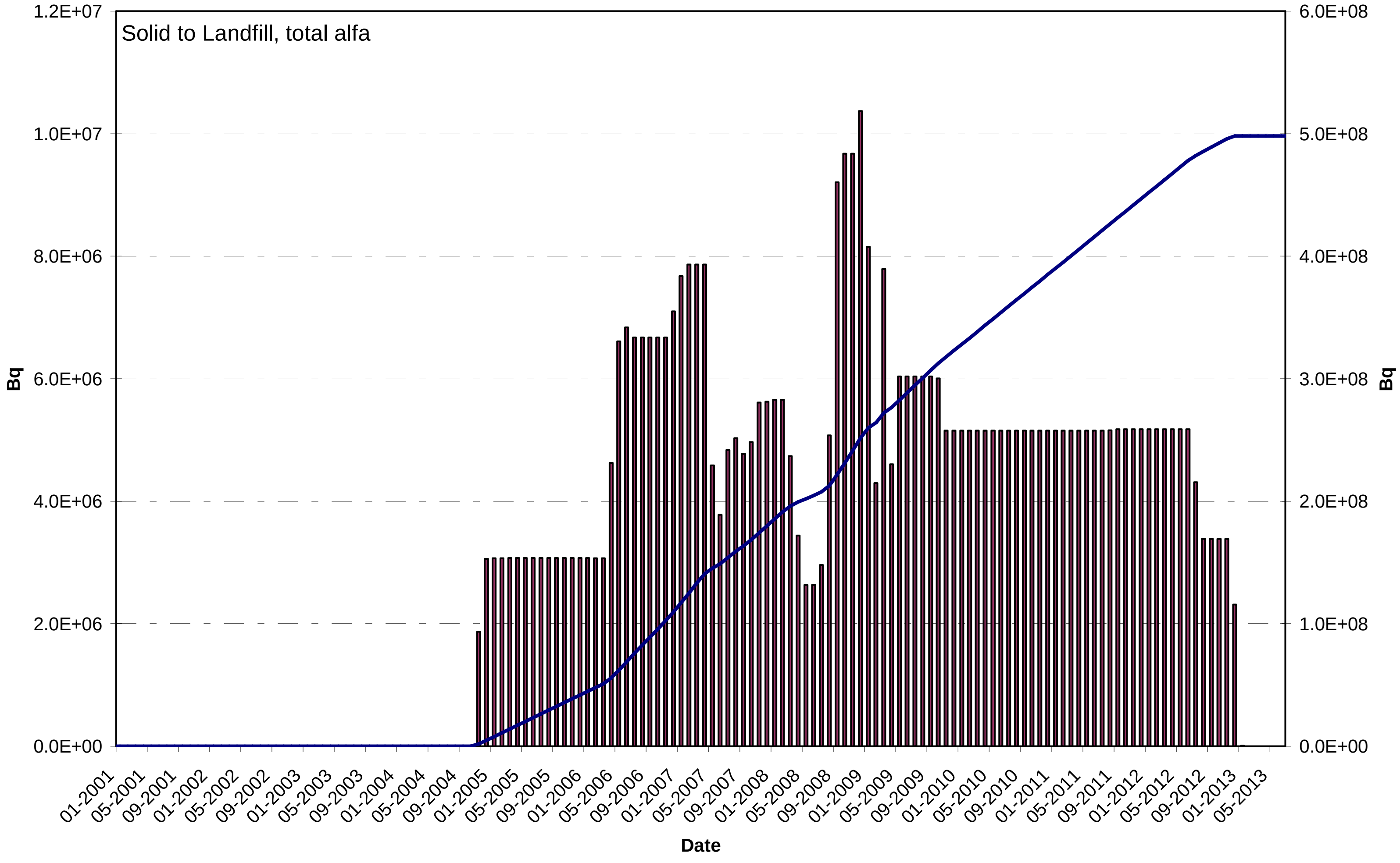


Figure 6-11 Landfill Non-decayed β-γ, tot Activity without Contribution of Mn^{54}, Fe^{55}, Co^{58} and Cs^{134}

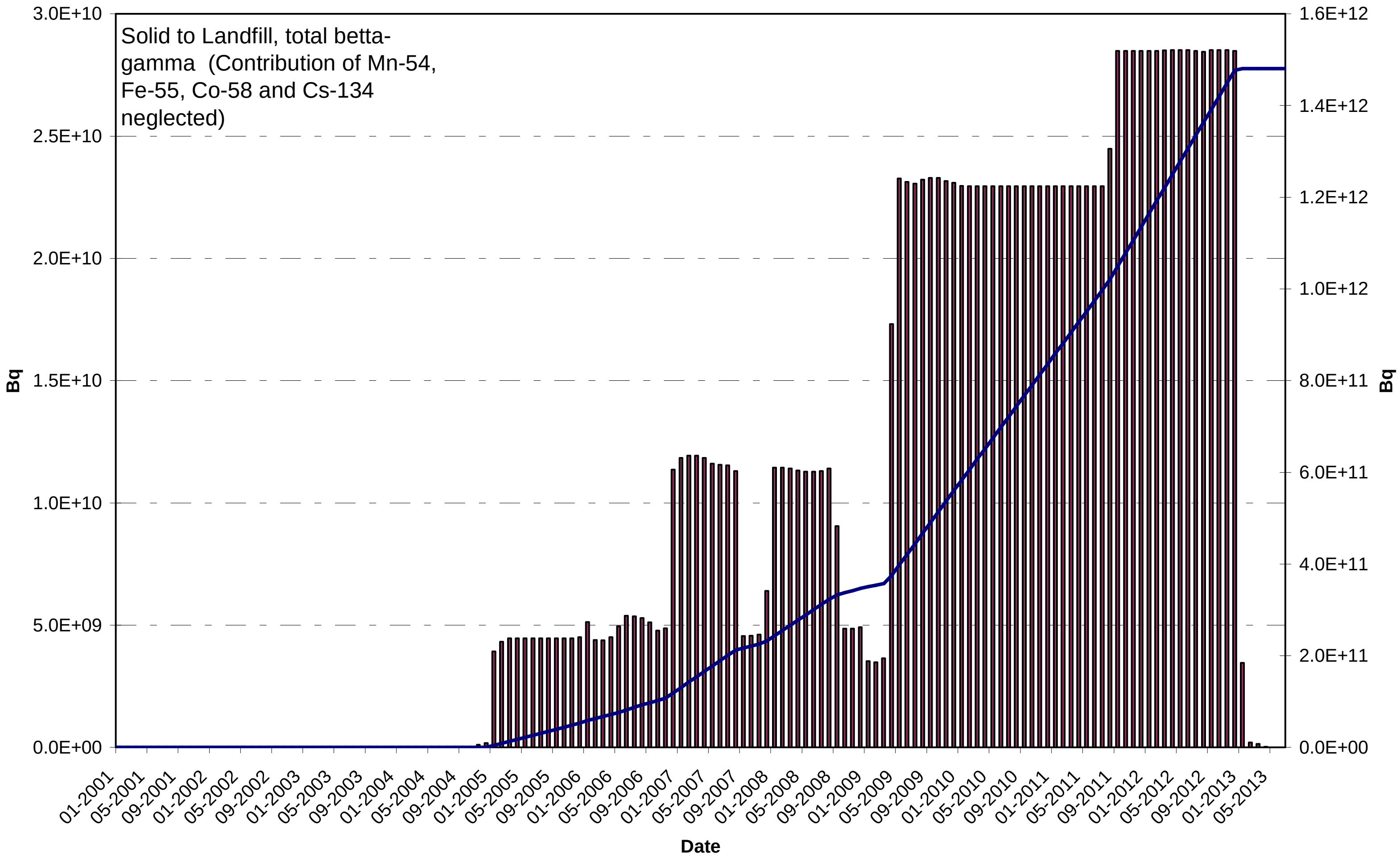


Figure 6-12 Landfill Non-decayed β-γ, tot Activity without Contribution of Mn^{54}, Fe^{55}, Co^{58}, Co^{60} and Cs^{134}

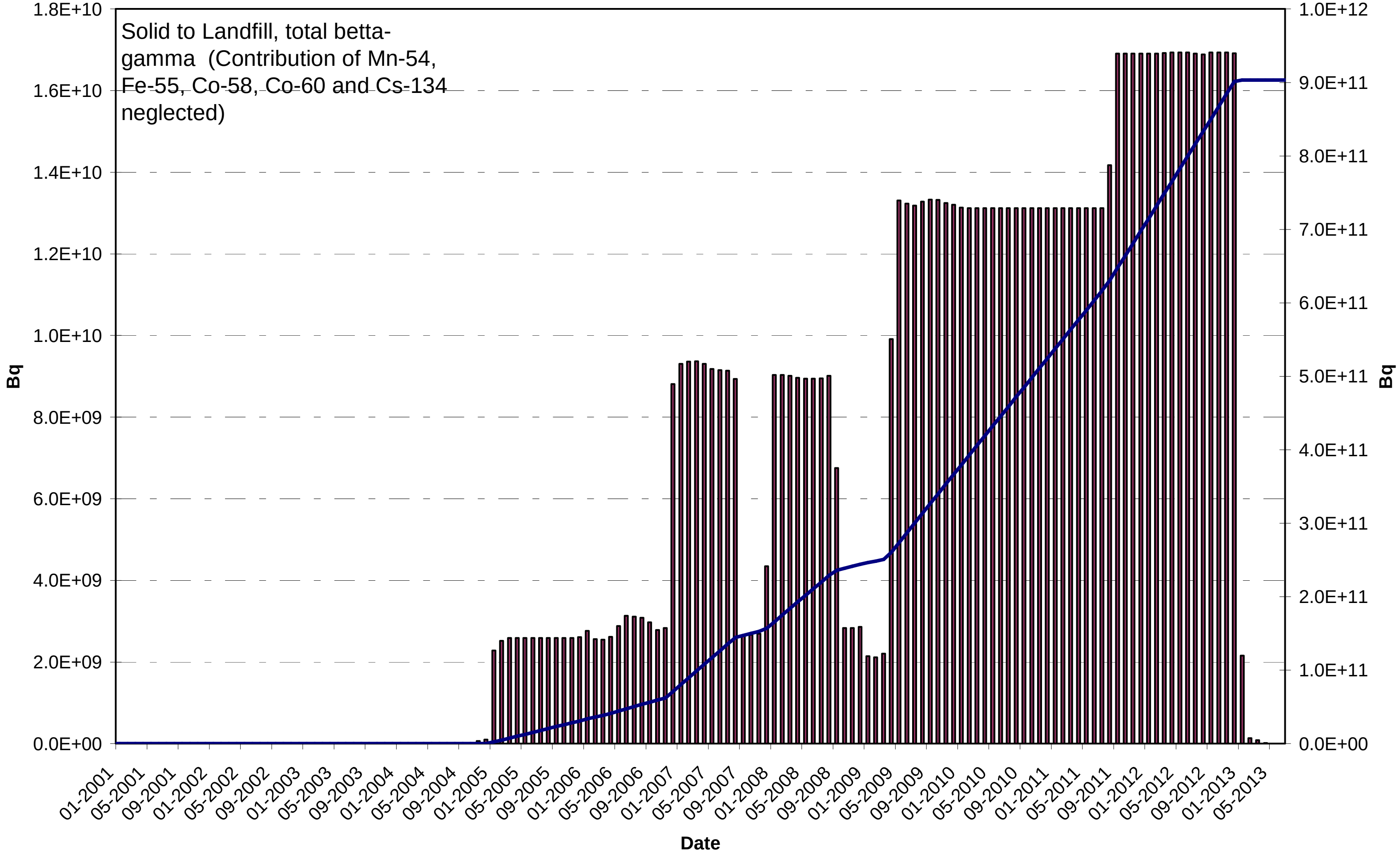


Figure 6-13 Solid Waste to NSR Radiological Capacity Index I

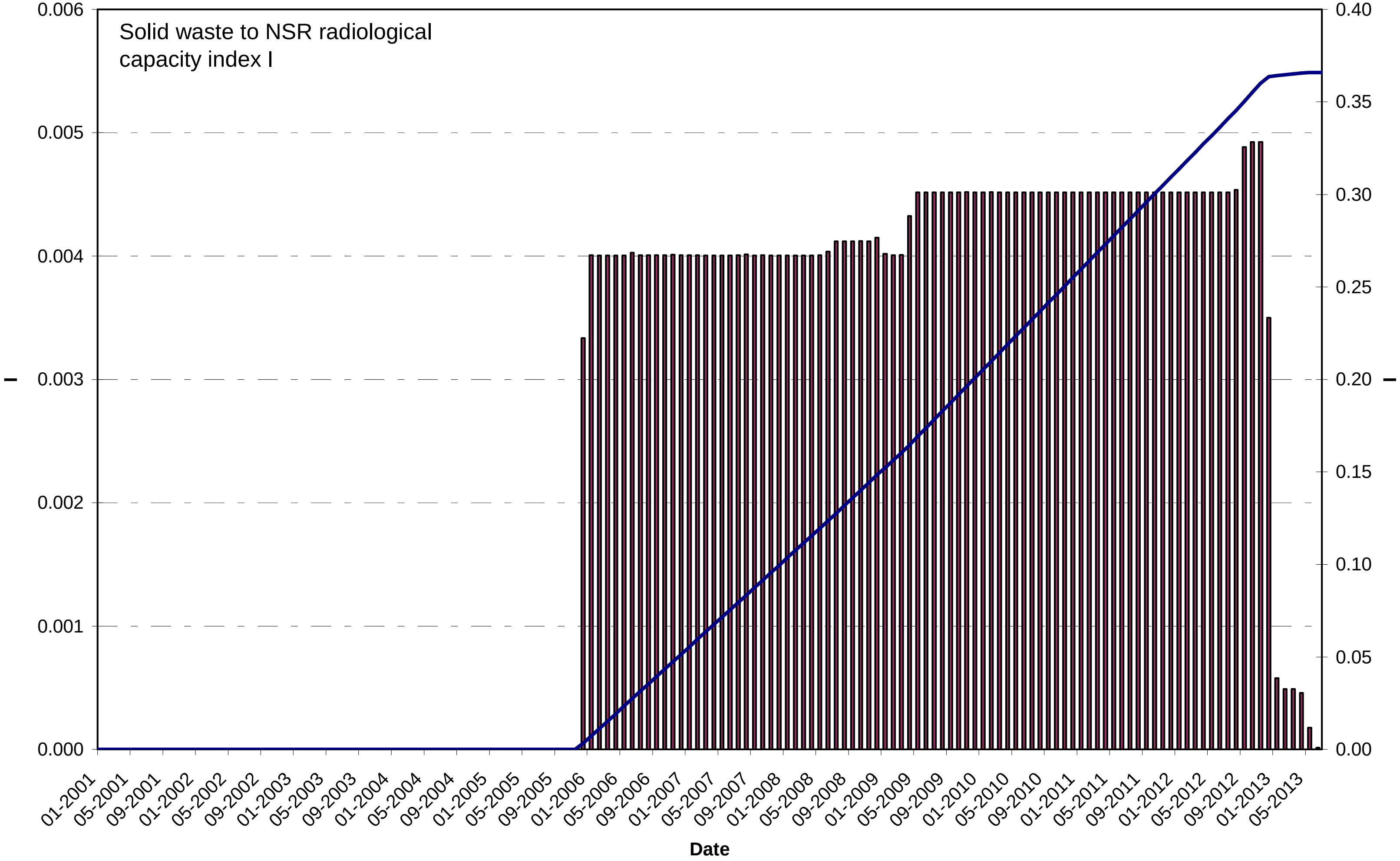


Figure 6-14 Bitumenised Waste. Volume

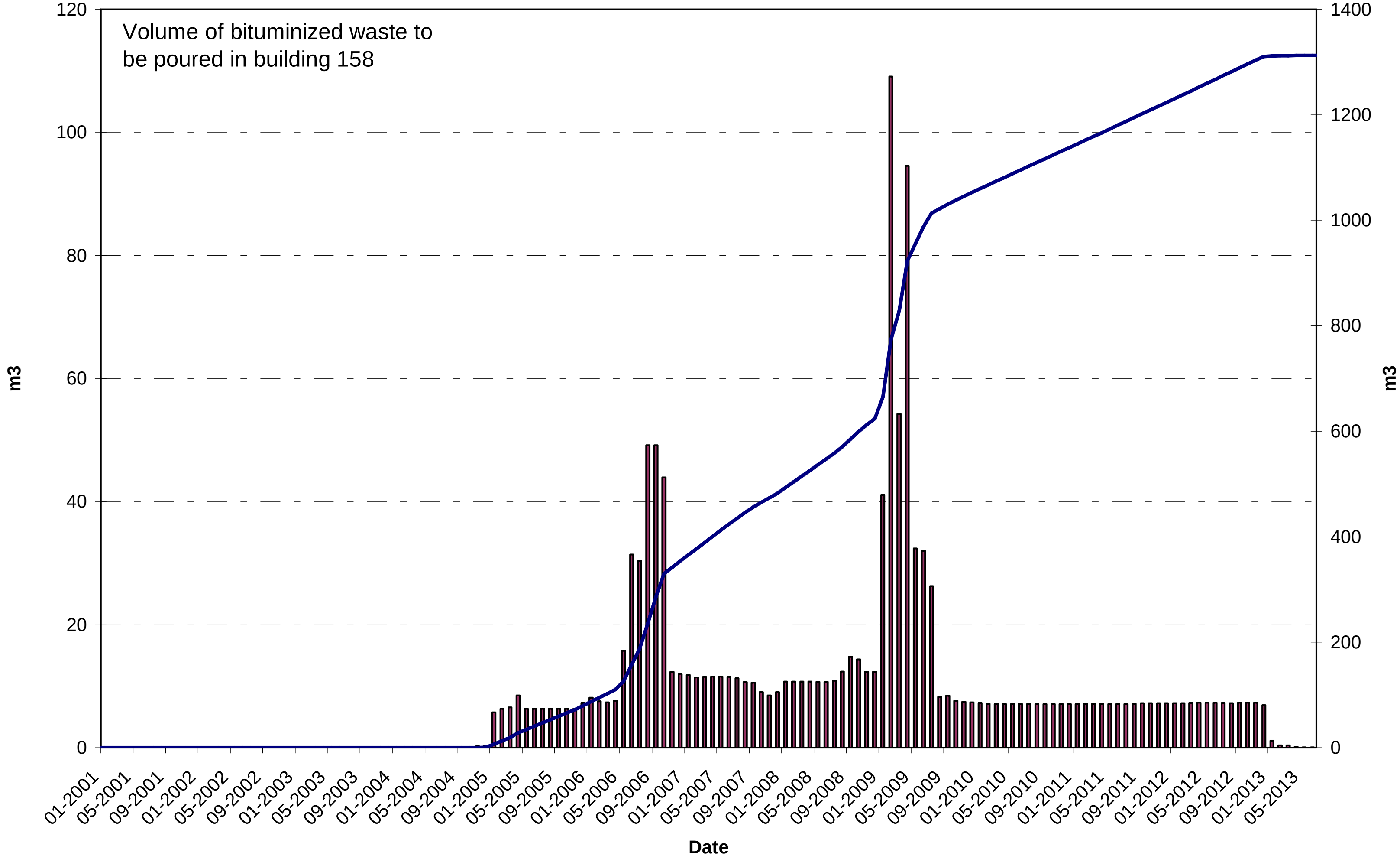


Figure 6-15 Personnel Collective Dose Integrated on All Decommissioning Activities

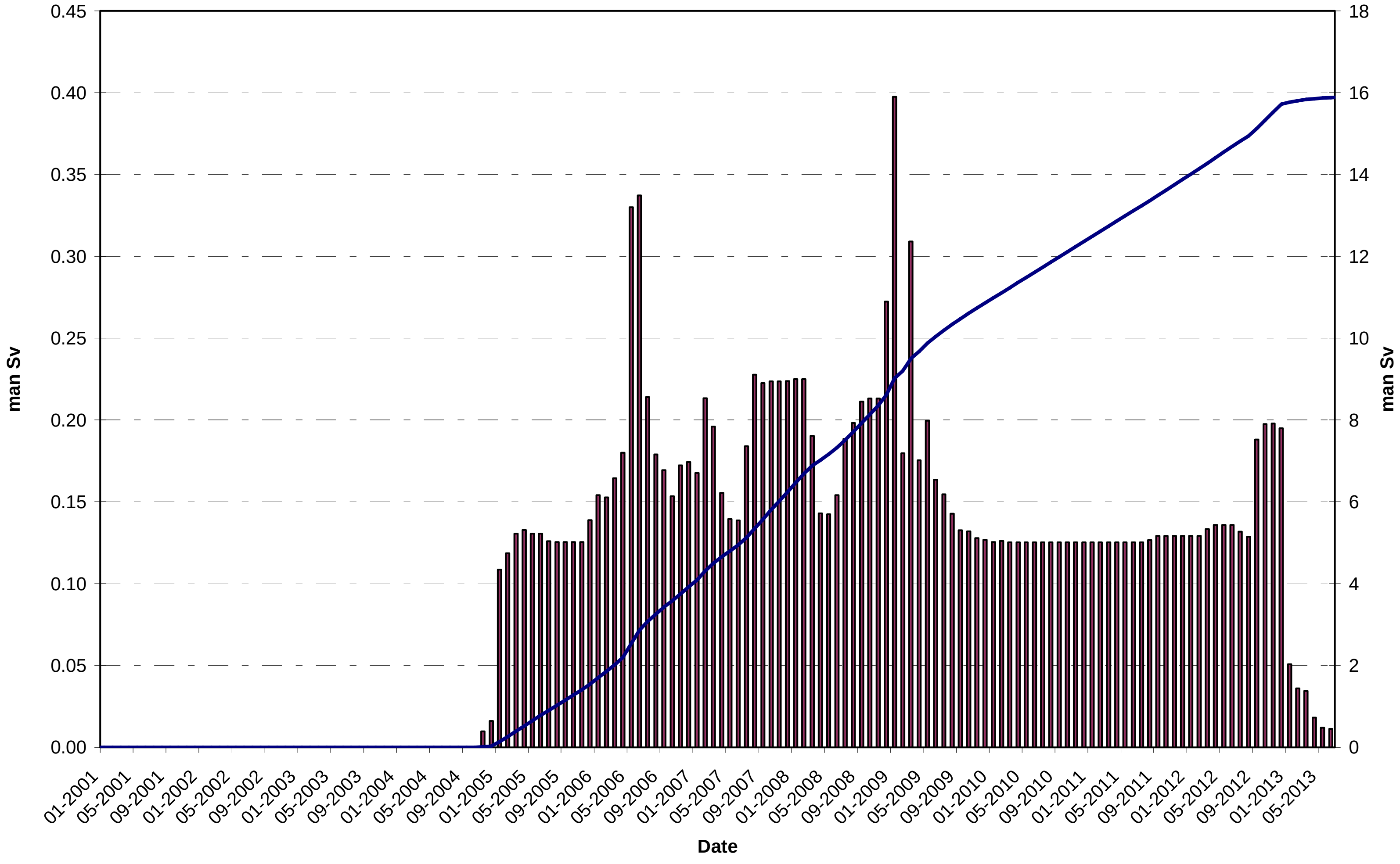


Figure 6-16 Collective Dose of Personnel for Post-operation of All Operating Systems during Stages 1 and 2

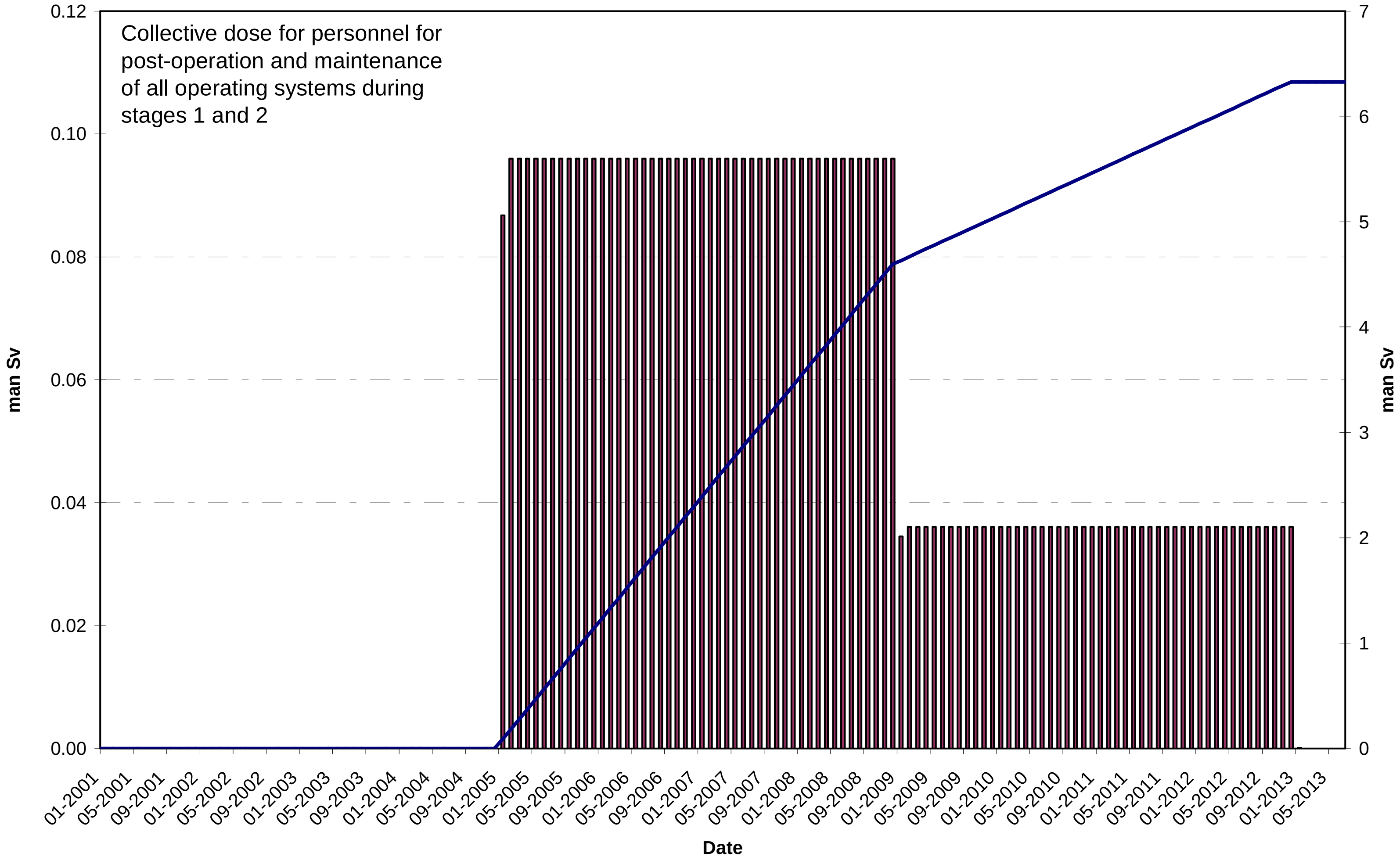
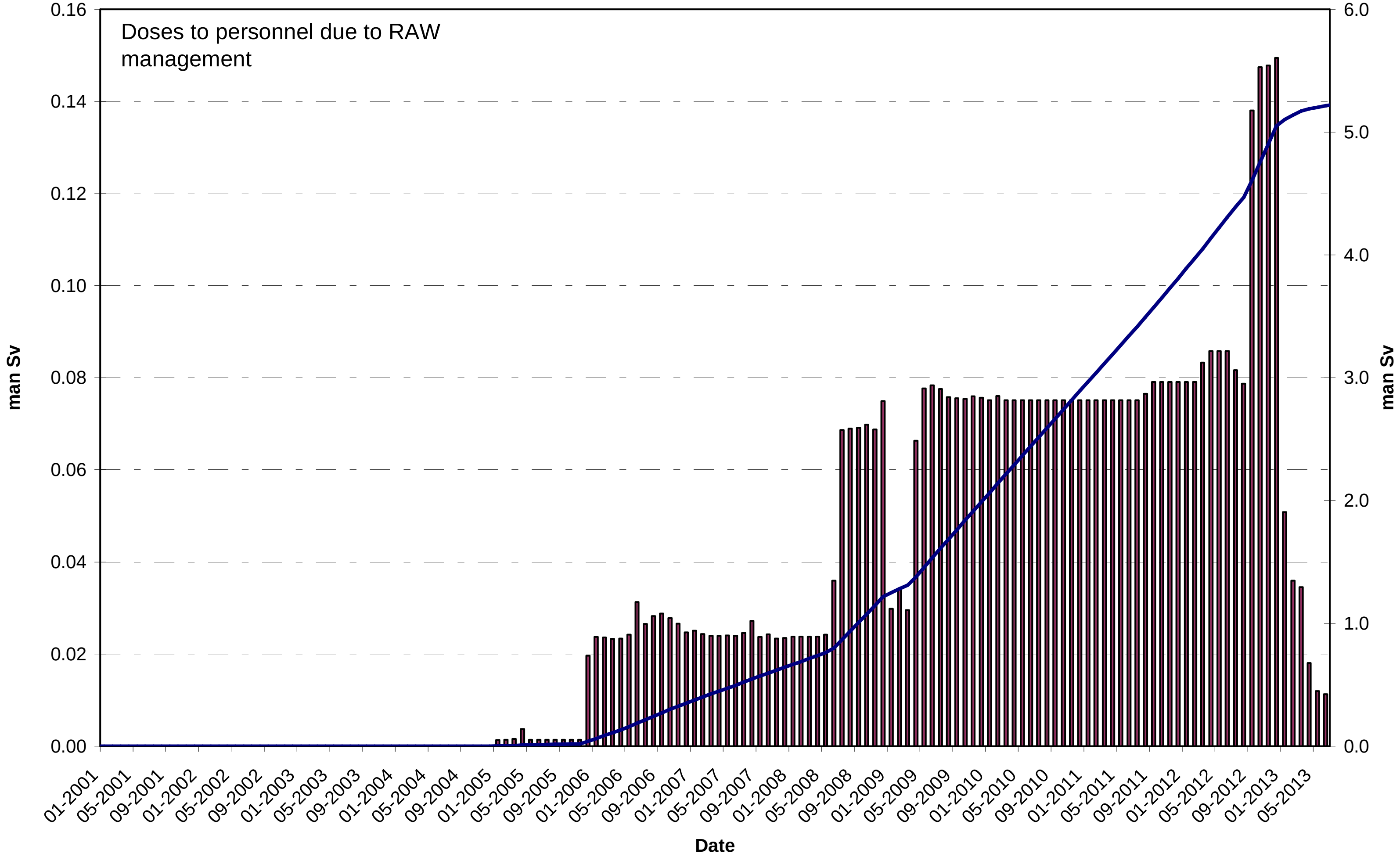


Figure 6-17 Collective Dose of Personnel due to RAW Management



6.12 Algorithms Developed to Assess the Environmental Impact of INPP Decommissioning

As indicated in chapter 6 and Appendix 3 of U1DP0, the defuelling of INPP Units has been broken down into basic activities, each activity being itself broken down into 18 elementary tasks. For each activity, 10 out of 18 tasks lead to environmental releases (radioactive aerosols, radioactive liquid discharges and chemical discharges into the lake). For each group of similar Activities[67], specific algorithms have been developed (see DBS or Data Base Sheets software) to assess the atmospheric and liquid discharges. Taking into account the high number of algorithms, it is not possible to reproduce all of these in the DEIAR. Therefore, in this section and for illustrative purpose, some algorithms of activities leading to amongst the highest aerosols/liquid releases will be discussed.

Should they deem it to be necessary, the external experts, involved in the DEIAR review process, may consult, at INPP, the DBS software design manual including the whole sets of algorithms pertaining to each task, as well as the numerical values of the software input parameters.

Example No 1 ***Liquid releases resulting from the in-line decontamination of the left loop of the reactor main coolant circulation***

Basis: All the liquid waste resulting from the in-line decontamination, i.e. the primary liquid waste produced by the collection of the spent decontamination and rinsing solutions together with the secondary liquid waste resulting from the preparatory works and the presence of the personnel in the controlled area (laundry and hot shower waste) are collected in large capacity tanks. After pH neutralisation, the liquid waste is evaporated. The concentrates are routed to the bituminisation facility, while the evaporator steam is condensed and purified by ion-exchange resins. The purified condensate is discharged into the lake. Actually, according to the INPP procedures, the cleaned condensate is recycled in function of the plant needs. This recycling is not taken into account by the DBS software. The direct discharge of the purified condensate maximises the nuclide releases (see also section 3.10.4).

The global discharge into the lake is given by:

Radionuclides discharge into the lake [Bq]:

$$R111{,}075 \equiv \frac{1}{DF^{O}\,111\_75} * \Big\{(I090{,}046 + I100{,}046) * \sum_{j=1}^{j=8} (SF^{o}\, j(dty)) + (I090{,}047 + I100{,}047) * \sum_{j=9}^{j=21} (SF^{o}\, j(dty))\Big\} \quad (1)$$

[67] -Examples of similar Activities:
- In-line decontamination, room (floor, wals) decontamination;
- Retrieval of the stored operational solid waste;
- Conditioning of the retrieval operational waste;
- Systems modifications/isolation;
- Fuel handling operations;
- Etc.

Index 111 relates to Task 111 of the Activity, i.e. the processing of the liquid waste generated by the decontamination.

DF^o111_45: Radionuclides overall decontamination factor resulting from:
evaporation: $DF_1 = 1\times10^3$;

- condensate purification ion-exchange unit $DF^o_2 = 1\times10^2$ (2 mixed beds in series), i.e. $DF^o_{111,45} = 1\times10^5$ (common parameter of the DBS software).

I090,046: Co-60 in Liquid waste arising from task 090 (Bq) (Tasl 090 = Training of the Operators)
I100,046: Co-60 in Liquid waste arising from task 100 (Bq) (Task 100 = Conduct of the In-line Decontamination)
I090,047: Cs-137 in Liquid waste arising from task 090 9Bq)
I100,047: Cs-137 in Liquid waste arising from task 100 (Bq)

The algorithms enabling to assess I090,46 to I100,47 are discussed hereafter.

$SF^oj(dty)$: (with j = 1 to 21), see relationship here under:
$SF^oj(dty) = SF^oj*\alpha^oj(dty)$

SF^oj (with j = 1 to 21): scaling factor (for every isotope j) in the deposits onto the inner walls of the equipment to be decontaminated by the time of the Reactor Final Shutdown (RFS).

The values of SF^oj are assessed on the basis of the methodology and of the algorithms given in chapter 4 of U1DP0 and chapter 6 of FDP and listed hereafter.

In relationship (1), nuclides j = 1 to j = 8 are the activation products scaled to Co^{60}, while nuclides j = 9 to j = 21 are the fission products, U and TRU nuclides scaled to Cs^{137}.

j	Nuclide j	SF_j^0
1	Co^{60}	$Co^{60}/Co^{60} = 1.0\times10^0$
2	C^{14}	$C^{14}/Co^{60} = 5.1\times10^{-3}$
3	Mn^{54}	$Mn^{54}/Co^{60} = 1.3\times10^0$
4	Fr^{55}	$Fr^{55}/Co^{60} = 4.3\times10^0$
5	Co^{58}	$Co^{58}/Co^{60} = 5.3\times10^{-1}$
6	Ni^{59}	$Ni^{59}/Co^{60} = 1.1\times10^{-3}$
7	Ni^{63}	$Ni^{63}/Co^{60} = 2.6\times10^{-1}$
8	Nb^{94}	$Nb^{94}/Co^{60} = 2.1\times10^{-3}$
9	Cs^{137}	$Cs^{137}/Cs^{137} = 1.0\times10^0$
10	Sr^{90}	$Sr^{90}/Cs^{137} = 6.0\times10^{-2}$
11	Tc^{99}	$Tc^{99}/Cs^{137} = 4.1\times10^{-3}$
12	I^{129}	$I^{129}/Cs^{137} = 3.6\times10^{-6}$
13	Cs^{134}	$Cs^{134}/Cs^{137} = 1.2\times10^0$
14	U^{235}	$U^{235}/Cs^{137} = 2.6\times10^{-6}$
15	U^{238}	$U^{238}/Cs^{137} = 4.9\times10^{-5}$
16	Pu^{238}	$Pu^{238}/Cs^{137} = 1.0\times10^{-1}$
17	Pu^{239}	$Pu^{239}/Cs^{137} = 2.7\times10^{-2}$
18	Pu^{240}	$Pu^{240}/Cs^{137} = 6.4\times10^{-2}$
19	Pu^{241}	$Pu^{241}/Cs^{137} = 9.4\times10^0$
20	Am^{241}	$Am^{241}/Cs^{137} = 1.5\times10^{-1}$
21	Cm^{244}	$Cm^{244}/Cs^{137} = 2.8\times10^{-2}$

The above scaling factors correspond to nuclide vector (Spectrum) S_1 by the time of the RFS, mentioned in reference [86] of DEIAR chapter 6 (Issue 03). As shown in [86], different sets of nuclide vectors have been prepared in function of considered decommissioning activities.

α°j(dty) is the function taking into account the evolution of nuclide j scaling factor in function of the time span dty (in years)elapsed between the RFS and the conduct of the decommissioning task (i.e. the in-line decontamination of the MCC).

For Unit 1 MCC in-line decontamination, dty = 4 years (input parameter of the code).
The α°j(dty) functions are given hereafter for each nuclide j:

j		**α°j(dty)**
1	^{60}Co	1
2	^{14}C / ^{60}Co	$e^{+0.1309 * dty}$
3	^{54}Mn / ^{60}Co	$e^{-0679 * dty}$
4	^{55}Fe / ^{60}Co	$e^{-0.126 * dty}$
5	^{58}Co / ^{60}Co	$e^{-3.428 * dty}$
6	^{59}Ni / ^{60}Co	$e^{+0.131 * dty}$
7	^{63}Ni / ^{60}Co	$e^{+0.1241 * dty}$
8	^{94}Nb / ^{60}Co	$e^{+0.131 * dty}$
9	^{137}Cs	1
10	^{90}Sr / ^{137}Cs	$e^{-1.197.10^{-3} * dty}$
11	^{99}Ti / ^{137}Cs	$e^{+2.299.10^{-2} * dty}$
12	^{129}I / ^{137}Cs	$e^{+2.299.10^{-2} * dty}$
13	^{134}Cs / ^{137}Cs	$e^{-0.3141 * dty}$
14	^{235}U / ^{137}Cs	$e^{+2.299.10^{-2} * dty}$
15	^{238}U / ^{137}Cs	$e^{+2.299.10^{-2} * dty}$
16	^{238}Pu / ^{137}Cs	$e^{+1.509.10^{-2} * dty}$
17	^{239}Pu / ^{137}Cs	$e^{+2.299.10^{-2} * dty}$
18	^{240}Pu / ^{137}Cs	$e^{+2.289.10^{-2} * dty}$
19	^{241}Pu / ^{137}Cs	$e^{-2.52.10^{-2} * dty}$
20	^{241}Am / ^{137}Cs	$3.133 e^{+2.139.10^{-2} * dty} - 2.133 e^{-2.52.10^{-2} * dty}$
21	^{244}Cm / ^{137}Cs	$e^{-1.54.10^{-2} * dty}$

The release of nuclide j, via the liquid discharges, is given by:

$$R^{j}_{111,75} = \frac{1}{DF_{111,75}{}^{0}}[I_{090,46} + I_{100,46}] * SF_j{}^{0}(dty) \qquad (2)$$

for the nuclides scaled to Co^{60} (i.e. j = 1, 2…8) and by

$$R^{j}_{111,75} = \frac{1}{DF_{111,75}{}^{0}}[I_{090,47} + I_{100,47}] * SF_j{}^{0}(dty) \qquad (3)$$

for the nuclides scaled to Cs^{137} (i.e. j = 9, 10…22).

The above nuclide j release, together with nuclide j releases from all other tasks carried out during the same year, are then used to assess the radiological exposure of the member of the public due to the annual release of nuclide j (see Examples in Tables 6-2 and 6-5 of DEIAR – chapter 6, Issue 05).

$I_{090,46}$ and $I_{100,46}$: inventory of Co^{60} (Bq) in the liquid waste generated by Tasks 90 (preparatory works and personnel training) and 100 (conduct of the in-line decontamination).

$I_{090,47}$ and $I_{100,47}$: inventory of Cs^{137} (Bq) in the liquid waste generated by Tasks 90 (preparatory works and personnel training) and 100 (conduct of the in-line decontamination).

$I_{100,46}$ is assessed by:

$$I_{100,46} = \{Co^{60}{}_{100,46} + Co^{60}{}_{90,46} \times MP_{100,20} \times X_{100,40} \times [KK_{10}{}^{0} + KK_{11}{}^{0} + KK_{12}{}^{0}]\} \times \beta^{0} \qquad (4)$$

$Co^{60}{}_{100,46}$ = Co^{60} activity inventory in the MCC left loop spent decontamination and rinsing solutions (i.e. input parameter of the code for this activity).
Ex: $Co^{60}{}_{100,46} = 1.34\times10^{13}$ Bq (see U1DP0 chapter 5 and FDP chapter 6).

$Co^{60}{}_{90,46}$ = Co^{60} specific activity (Bq/kg) in the secondary liquid waste (laundry, hot showers, drains, etc.) = 9.8×10^{4} Bq/kg.

$MP_{100,20}$: manpower need to carry out Task 100, i.e. the in-line decontamination of the MCC left loop (calculated by another algorithms). For this example $MP_{100,20}$ = 540 Mandays.

$X_{100,40}$: Fraction of time spent in the controlled area for Task 100. In this example, $X_{100,40}$ = 1.0 (code input parameter).

$KK_{10}{}^{0}$, $KK_{11}{}^{0}$ and $KK_{12}{}^{0}$: miscellaneous water consumption resulting into secondary liquid waste production (common parameters of the code).
$KK_{11}{}^{0}$ = hot laundry water consumption = 18 kg/manday;
$KK_{12}{}^{0}$ = hot shower water consumption = 68 kg/manday;
$KK_{10}{}^{0}$ = other water use (laboratory drains) = 5 kg/manday.

In (4), term $MP_{100,20}*X_{100,40}*[KK_{10}{}^{0} + KK_{11}{}^{0} + KK_{12}{}^{0}]$ corresponds to the production of secondary liquid waste (kg) resulting from Task 100 and due to the presence of manpower in the controlled area.

β^0 = coefficient ($\geq$1.00) taking into account the increase of radionuclide inventory in the liquid waste due to other sources not quantified in (4), such as liquid waste processing building drains, bitumenisation facility drains, etc. β^0 is a common parameter of the code. Currently, $\beta^0 = 1.05$.

Similarly, $I_{100,47}$ is assessed by:

$$I_{100,47} = \{Cs^{137}{}_{100,47} + Cs^{137}{}_{90,47} \times MP_{100,20} \times X_{100,40} \times [KK_{10}{}^{0} + KK_{11}{}^{0} + KK_{12}{}^{0}]\} \times \beta^0 \qquad (5)$$

$Cs^{137}{}_{100,47}$ = Cs^{137} activity inventory in the MCC left loop spent decontamination and rinsing solutions (i.e. input parameter of the code for this activity).
Ex: $Cs^{137}{}_{100,47} = 7.35\times10^{10}$ Bq (see U1DP0 chapter 4 and FDP chapter 6).

$Cs^{137}{}_{90,47}$ = Cs^{137} specific activity (Bq/kg) in the secondary liquid waste (laundry, hot showers, drains, etc.) = 5.4×10^4 Bq/kg.

The other parameters of (5) are defined hereabove.

$I_{090,46}$ and $I_{090,47}$ are assessed by:

$$I_{090,46} = Co^{60}{}_{90,46} \times X_{090,40} \times MP_{90,20} \times [KK_{10}{}^{0} + KK_{11}{}^{0} + KK_{12}{}^{0}] \qquad (6)$$

$$I_{090,47} = Cs^{137}{}_{90,47} \times X_{090,40} \times MP_{90,20} \times [KK_{10}{}^{0} + KK_{11}{}^{0} + KK_{12}{}^{0}] \qquad (7)$$

$MP_{90,,20}$: manpower need to carry out Task 090 (preparatory works, personnel training), calculated by another algorithm of the code. For this example $MP_{90,20}$ = 360 Mandays.

$X_{90,40}$: Fraction of training period spent in the controlled area. In this example, $X_{90,40}$ = 0.5 (code input parameter).

The other parameters are hereabove defined.

<u>Numerical Examples:</u>

On the basis of the above relationships and parameters values, the following results are derived:

$I_{090,46} = 9.8\times10^4\times0.5\times360\times91 = 1.61\times10^9$ Bq
$I_{100,46} = (1.34\times10^{13}+9.8\times10^4\times1\times540\times91)\times1.05 = 1.41\times10^{13}$ Bq
$I_{090,47} = 5.4\times10^4\times0.5\times360\times91 = 8.85\times10^8$ Bq
$I_{100,47} = (7.35\times10^{10}+5.4\times10^4\times1\times540\times91)\times1.05 = 8.0\times10^{10}$ Bq
(1) gives:

$R_{111,075} = 5.48\times10^8$ Bq (result displayed in cell 075 of Task 111 of Unit 1 in-line decontamination left loop DBS PSA/1/DEC/Y0.00/01 – see U1DP0 chapter 5 and Appendix 3.23.

<u>Nuclide j Releases (Examples)</u>

Co^{60}

(2) gives:

$$R^{Co60}{}_{111,75} = \frac{1}{10^5}[1.61\times10^9 + 1.41\times10^{13}]\times1 = 1.41\times10^8 \text{ Bq.}$$

Note: For Co^{60}, $SF^0{}_{Co}{}^{60}$ (dty) = 1.

Nb^{94}

$SF^0{}_{Nb}{}^{94}(4) = 2.1\times10^{-3}\times e^{0.131\times4} = 3.55\times10^{-3}$ and (2) gives:

$$R^{Nb94}{}_{111,75} = 1.41\times10^8 \times 3.55\times10^{-3} = 5.0\times10^5 \text{ Bq.}$$

Cs^{137}

(3) gives:

$$R^{Cs137}{}_{111,75} = \frac{1}{10^5}[8.85\times10^8 + 8.00\times10^{10}]\times1 = 8.1\times10^5 \text{ Bq.}$$

Note: For Cs^{137}, $SF^0{}_{Cs}{}^{137}$ (dty) = 1.

Pu^{239}

$SF^0{}_{Pu}{}^{239}(4) = 2.7\times10^{-2}\times e^{2.299\times10^{-2}\times4} = 2.96\times10^{-2}$ and (3) gives:

$$R^{Pu239}{}_{111,75} = 8.1\times10^5 \times 2.96\times10^{-2} = 2.40\times10^4 \text{ Bq.}$$

Example No 2 Aerosols Releases to the Atmosphere during the Evaporation/Bitumenisation Processes of the MCC Left Loop In-line Decontamination Spent Solutions

Aerosols global releases to the atmosphere during the evaporation / bituminization processes [Bq]:

$$R111{,}077 = \frac{1}{ENTR^\circ111\_77 * DF^\circ111\_77} * \{(I090{,}046 + I100{,}046) * \sum_{j=1}^{j=8}(SF^\circ j(dty)) + (I090{,}047 + I100{,}047) * \sum_{j=9}^{j=21}(SF^\circ j(dty))\} \quad (1)$$

$ENTR^0111$: ratio of the activity transferred to the evaporators and bitumenisation units to thatreleased as ambient airborne contamination (common parameter of the DBS software).

$ENTR^0111 = 1\times10^4$, i.e. 0.01 % of the activity inventory processed by the evaporators/bitumenisation units is released as airborne contamination, due to leakage, drains, sampling, etc. This value is likely conservative on the basis of the available measurements.

$DF^0111,77$: aerosols decontamination factor of the liquid waste processing building extraction ventilation (common parameter of the code).

$DF^0111,77 = 1\times10^2$ (typical requested value for this type of application).

All the other parameters of relationship (1) are defined in hereabove example No 1.

Numerical Examples

On the basis of the numerical results already obtained in Example No 1 ($I_{090,46}$, $I_{100,4}$, $I_{090,47}$, $I_{100,47}$) above relationship (1) gives:

$R111,077 = 5.48\times10^7$ Bq (result displayed in cell 075 of Task 111 of Unit 1 in-line decontamination left loop DBS PSA/1/DEC/Y0.00/01 – see U1DP0, chapter 5 and Appendix 3.23).

NuclideReleases (Examples)

Co^{60}

$SF^0{}_{Co}{}^{60}$ (dty)= 1 and (1) gives:

$$R^{Co60}{}_{111,077} = \frac{1}{10^4\times10^2}[1.61\times10^9+1.41\times10^{13}]\times1 = 1.41\times10^7 \text{ Bq.}$$

Nb^{94}

$SF^0{}_{Nb}{}^{94}$ (4) = 3.55×10^{-3} (see Example No 1) and (1) gives:

$$R^{Nb94}{}_{111,077} = 1.41\times10^7\times3.55\times10^{-3} = 5.0\times10^4 \text{ Bq.}$$

Cs^{137}

$SF^0{}_{Sc}{}^{137}$ (4) = 1 and (1) gives:

$$R^{Cs137}{}_{111,077} = \frac{1}{10^4\times10^2}[8.85\times10^8+8.00\times10^{10}]\times1 = 8.1\times10^4 \text{ Bq.}$$

Pu^{239}

$SF^{0}{}_{Pu}{}^{239}$ (4) = 2.96×10^{-2} (see Example No 2) and (1) gives:

$R^{Pu239}{}_{111,077} = 8.1\times10^{4}\times2.96\times10^{-2} = 2.40\times10^{3}$ Bq.

Remark:

The above examples pertain to the liquid and atmospheric releases of the decontamination of one loop (left loop) of the MCC. For the complete decontamination of both MCC (left and right) loops, the above discharges are to be multiplied by a factor 2 (see also U1DP0 Issue 05, chapter 5 and Appendix 3.23).

6.13 References

76. Об утверждении нормативного документа LAND 42-2001 «Ограничение выброса радионуклидов в окружающую среду с объектов ядерной энергетики и порядок выдачи разрешений на выбросы, а также порядок радиологического мониторинга». Приказ министра окружающей среды литовской республики, № 60 от 23 января 2001 г., Вильнюс.
77. Environmental dose conversion factors for the Ignalina Nuclear Power Plant, Lithuania. D.M. Hamby, T. Nedveckaite, S. Motiejunas, V. Filistovic, J. Mazeika, and E. Maceika. Nuclear Engineering and Radiation Health Physics, Oregon State University, Corvallis, OR 97331-5902; Radiation Protection Department, Institute of Physics, A. Gostauto 12, 2600, Vilnius, Lithuania; Lithuanian Ministry of Environment, A. Jaksto 4/9, 2694, Vilnius, Lithuania; Institute of Geology, T. Sevcenkos 13, 26000, Vilnius, Lithuania.
78. International Commission for Radiation Protection Publication №72, (ICRP №72) – IAEA – Vienna.
79. Addendum to the IAE project chapter “Uranium-erbium fuel handling at the power units”, VNIPIET Report, Inv.Nr. 97-00826, St. Petersburg, 1997 (in Russian).
80. Arrangement of additional baskets in the storage pools of the Ignalina NPP Unit 1, VNIPIET Report, Inv.Nr. 98-01545, St. Petersburg, 1998 (in Russian).
81. Strength analysis of the basket filled with SFA and structural constructions under accident conditions during SF transportation from the INNP power units, VNIPIET Report, Inv.Nr. 92-01707, St. Petersburg, 1992 (in Russian).
82. Analysis of initial events in the cooling, makeup and cleaning system of storage pools in the Ignalina NPP, VNIPIET Report, Inv.Nr. 92-09325, St. Petersburg, 1992 (in Russian).
83. Calculation of static loads and maximum designed earthquake of 6.5 magnitude and selection of calculated combination of forces and valves, VNIPIET Report, Inv.Nr. 91-07797-P, St. Petersburg, 1991 (in Russian).
84. Seismic stability analysis of structures of Units A1 and A2 in the building 101 of the Ignalina NPP, VNIPIET Report, Inv. No. 91-13775-P, St. Petersburg, 1991 (in Russian).
85. Permit for Release of Radioactive Materials into the Atmosphere No 1, issued by the Ministry of Environment of the Republic of Lithuanina, 2005-12-16.
86. Establishment of Scaling Factors for the Characterisation of the INPP Operational and Decommissioning RAW – INPP DPMU Technical Note; A1.4/TN/B2/0041, Issue 01.

87. Report on Radionuclide Determination in INPP Reactor Water, Fuel Pool Water and Evaporator Concentrates – Institute of Physics; Vilnius 1997.

88. Clearance Levels of Radionuclides, Conditions of Reuse of Materials and Disposal of Waste – LAND 34-2000, AM Order No 194 of 3 May, 2000.

89. INPP Landfill – STUDSVIK RADWASTE AB STUDSVIK/RW – 04/17, 2004-02-26.

90. Dėl bendrųjų radioaktyviųjų atliekų priimtinumo laidoti paviršiniame kapinyne kriterijų, Valstybės žinios, 2003, Nr.19-850.

91. Assessment of the Long Term Safety of the Existing Sorage Facility for Bituminised Waste of INPP; SKB – Stockholm, 1998 – Archive No 66263.

92. INPP Letter to DPMU: Upgrading of the Bituminised Waste Storage Vaults – No 80S-164-15.15-19 January 2004.

93. INPP Unit 1 Decommissioning Safety Analysis Report (DSAR) for Defuelling Stages 1 and 2; A1.4/ED/B4/005, Issue 05.

94. «Прочностные, тепловые, радиационные расчёты и расчёты ядерной безопасности в аварийных ситуациях», 2004, ЛЭИ, ТАСпд-1245-71128.

95. Report about the Results of INPP Region Radiological Monitoring during Year 2003. Radiation Protection Department - ПТОот-0545-11 (in the Russian language).

96. Report on Development of Nuclide Vector for Industrial waste of INPP. Vilnius, Institute of Physics, 2004 – TASpd-0545-71652.

97. Environmental Dose Conversion Factors for the Ignalina Nuclear Power Plant, Lithuania – D.M. Hamby, T. Nedveckaite, S. Matejunas, V. Filistovic, J. Mazeika, E. Maceika.

98. PMU Ignalina NPP Decommissioning Support Project Decommissioning Data Base Sheet Computer Tool Design Manual, Belgatom – TIERSOI/4NT/47790/000/00.

99. Regulatory Guide 1.109: Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, App. I U.S. Nuclear Regulatory Commission – Revision 03, October 1977.

7 Non Radiological Environmental Impacts

Hereafter we base the description of potential environmental impacts on the identification matrix established in section 4.3.3. These impacts are further assessed hereafter.

7.1 Introduction

The assessment of impacts is based on:

- The Environmental Impact Assessment Programme;
- Bibliography available on the Environmental Baseline and impacts resulting from the construction and start-up of INPP, and possible impacts of the Decommissioning of INPP;
- The EU funded study [9] and EIAR Manual [1];
- Methodologies used in traditional Environmental Impact Assessment for non radioactive issues and radioactive issues;
- The studies made on the Unit 1 Decommissioning Project Nr. 0 (Reactor Final Shutdown, Post-Shutdown activities and Defuelling) which include:
  - Systems Analysis,
  - the Analysis of Activities to be carried out during this project and calculation of costs, manpower, doses and waste per activity,
  - Safety Analysis.

  These studies will be published under the form of:

  - Decommissioning Project documents;
  - Decommissioning Safety Analysis Report;
- Results of meetings with the INPP, the Ministry of Environment and scientific Institutes, that gave some orientations on essential issues to be investigated as a result of the INPP Decommissioning

7.2 Social and Economic Issues

7.2.1 Impacts of the INPP Decommissioning Plan on Employment within INPP

In order to assess the impacts of the project on employment for the INPP personnel, we have to combine production shutdown of Unit 1 (then Unit 2), retirement schedule of personnel in subsequent years, continuation of post-shutdown activities by INPP personnel, internal changes in work functions and redundancies made available for pure decommissioning activities.

The INPP personnel that will be released from INPP operation and maintenance (including post-shutdown activities) will be used, to the largest reasonable extent, to perform new tasks associated to the D&D operations, for Health Physics Protection, for radioactive waste management, etc. The philosophy followed regarding manpower is to use, as much as possible, the competence and knowledge of the INPP personnel to perform decommissioning activities. It is a matter of fact that during decommissioning, the personal knowledge of the staff will be even more valuable than during normal operations.

In particular, the new Facilities under the INPP Decommissioning Investment support Packages will require skilled personnel for their operation and maintenance; however, one shall keep in mind that the designated contractors will also use their own personnel.

At the date of November 2003, there was 3,614 staff at the INPP[68]. The role of the Technical Directorate, the most concerned during the first years, will remain unaltered from that required in normal operation until Unit 1 is completely defuelled.

The majority of the staff will:

- Have similar activities, for post-shutdown activities and new activities oriented towards decommissioning, that do not need new qualification (the necessary training foreseen being sufficient);

- Have different activities than previously and for which training and qualification are necessary (see the Training Programme described in the FDP).

Input data on personnel made available for pure decommissioning works can be found in the Final Decommissioning Plan [103]. For the period 2005 – 2011, which corresponds roughly to the period of U1DP0, estimates are given inTable 7-1. For these people, training programmes are very important.

Table 7-1 Amount of Personnel (Cumulated) Made Available for Pure Decommissioning Needs

Year	2005	2006	2007	2008	2009	2010	2011
Amount	34	372	546	713	791	1204	1518

With the combination of the retirement schedule and the tasks evolution of INPP personnel into pure decommissioning activities, the amount of people losing their job at the INPP will increase more slowly than with other closure policies.

Staff necessary for the Investment Support Packages will be taken on by the contractors of these packages, so that external staff should be involved in the overall project as well. These works will also involve local manpower.

Therefore, the overall picture will not be as severe as presented in some references (e.g. ref. [10]).

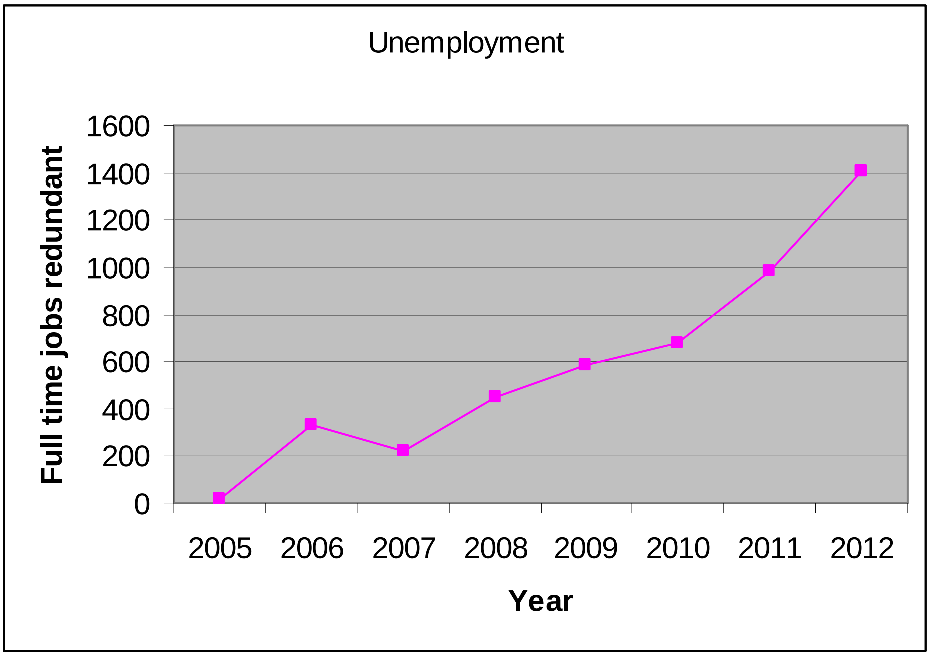
This philosophy will influence positively the social impacts of the decommissioning of INPP, by smoothing the evolution of the yearly redundancy rate. It is also important for maintaining as long as possible the social cohesion of INPP families and Visaginas in general, in order to allow a possible, positive evolution in the local economy (named “Regeneration”, according to ref. [10]).

[68] Some publications indicate personnel numbers around 5,000. This great difference with the number announced here comes from the separation by INPP of its non core activities (for example canteen, vehicle fleet, printing house, construction and repair shop).

It is impossible at this stage to accurately determine the amount of INPP manpower that will be effectively involved in the decommissioning activities. Taking into account the estimated manpower needs and also the possibilities offered by new facilities (provided a significant amount of INPP personnel being involved in these activities, say the half of it), one could estimate the unemployment of INPP personnel as shown on Figure 7-1.

We can see that a significant effect will happen in 2006, with some stabilisation in 2007 then a continual increase up to 1,000 in 2011. The figure in 2012 is a rough estimate.

Figure 7-1 Estimation of Unemployment of INPP Personnel



7.2.2 Impacts on the Socio-economic Evolution of Visaginas

The closure of the INPP is taking place in a unique socio-cultural environment. The impacts may come from the decrease of financial yield and the potentially resulting recession of local and regional economy but also from other particularities, such as relative cultural isolation, closed society and economical reforms [41].

The direct effects of unemployment at the INPP create indirect effects on the socio-economic evolution of Visaginas.

These indirect effects, in terms of job losses, are related to:

- The decrease of orders to subcontractors and suppliers;
- The decrease of the average income of the Visaginas residents, due to unemployment, migration to other areas of the country or abroad, the lack of substitution jobs for ex-INPP persons on the local place in sufficient amount, substitution jobs with lower salaries, etc.

Estimates were made in the EU funded Study on Social Costs of Decommissioning of Ignalina Nuclear Power Plant published in 2001 [10]. In this study, 1,700 job cuts among INPP suppliers were expected at the 2010 horizon, and through the multiplication effect[69], additional 1,600 job cuts were estimated.

These estimates were made on assumptions of more INPP job losses than presented here (about 4,000 at the end of the U1DP0 period (2012) in the Study, whereas we estimate the figure at about 1,400).

Therefore these estimates should be revised accordingly. It goes somewhat out of the scope of the present EIA Report, but only by applying a proportional rule[70], these indirect job losses could be rather 1155 in 2010[71].

Hence, the addition of direct and indirect effects gives a global job loss of about 1,830 units[72] in 2010. This figure will increase in the following years, especially once the Unit 2 is in the course of dismantling.

A more detailed, scientific assessment would certainly be useful for determining more accurate figures. Moreover, the socio-economic monitoring implemented will provide for factual data that will improve the economical model established.

There are other indirect effects to be considered. For example, the closure of INPP, with its highly skilled workers, specialists and managers, could decrease the general level of education in case there is an emigration toward other areas of the country or abroad. Together with the decrease of income in the INPP region, this effect would lead to a social recession as well (the so-called “Town-zombie” scenario[73] mentioned in the EU funded Study on Social Costs of INPP Decommissioning).

Though of a good economical level, Visaginas is currently isolated from other attractive areas and its area of influence is quite limited. The majority of activities are oriented toward the INPP (goods or services) and to services to workers from the INPP. If no active programme is implemented, aimed at redeploying the social and economic activities, it is quite sure that Visaginas does not possess significant advantages for avoiding a local, severe recession.
Some ideas for mitigation measures are presented in section 8.2.

A positive impact could happen in the recreation and tourism sector, if it is stimulated. The presence of INPP may frighten some western tourism candidates, though the region’s attractiveness was higher than the fear of the INPP to the tourists from Russia. Up to now, the flow of the tourists from the Western countries in the region of Visaginas is in its initial phase [42].

---

69 The multiplication effect is due to the decrease of the local market.

70 Though we are dealing with large numbers (in favor of proportionality), the difference between 4,000 and 1,400 is large enough to expect a non-proportional relationship for indirect effects.

71 The EU study does not provide results for the year 2012 (end of U1DP0 period).

72 The rationale is to consider :

- For direct effects: the addition of job needs for U1 and U2 Decommissioning, job needs for Support Investment Projects and job cuts from the Decommissioning Process.
- For indirect effects: calculated from the EU funded study numbers, multiplied by a coefficient (total unemployment estimated by the INPP DPMU divided by the number in the EU funded study).

73 Though this scenario is based on more severe job cuts than in the present estimation, based on more recent data, it remains however a possibility, as, all things remaining equal, the final closure of the site will create a high rate of unemployment in the INPP region.

However, it is clear that, without positive and important financial and social support, the current social and economic level of Visaginas is at stake. In itself Visaginas does not possess enough attraction elements for other activities to come.

The public does not really understand the reasons that were considered to decide the Decommissioning of INPP and express some discontent. Russian speaking people are faced with difficulties to find other jobs in the country, because of the language barrier.

7.2.3 Wider Socio-economic Impacts

As explained above, socio-economic impacts will probably arise beyond the municipality of Visaginas, as the town is an economic centre in the region.

As a major company in Lithuania, INPP contributes to a significant part of national income.

In the EU funded Study on Social Costs of INPP Decommissioning, it is stated that:

"In analysing the impact of decommissioning of Ignalina NPP on the total Gross Domestic Product, we can maintain that this impact is negative. Taking into consideration the fact that in the year 2000 the GDP totalled about Litas 44.8 billion and taking into account the calculated losses, which in 2000 - 2019 will amount to Litas 18.9 billion (in case Unit 1 is closed down in 2005, and Unit 2 - in the year 2010). This accounts for approximately 2.2 per cent of the GDP annually during the period of 2000 – 2019 (calculations have been made without taking into consideration possible changes in the GDP or inflation).

The data have been provided on the basis of the Report of the Institute of Economics of Lithuania "General Economic Balance Model to Assess Consequences of Decommissioning of Ignalina NPP" ([104]) (…) Taking into account a complicated economic situation in the country and difficulties in the execution of the budget, we can claim that the 2.2 per cent annual loss of the GDP will reduce the number of the employed in the country at least by 1-2 per cent every year (see Employment in Europe 2000, ECSC – EC – EAEC, Brussels, Luxembourg, 2000). Taking into consideration this tendency, one can maintain that the turnover of trade, retail trade, in particular, as well as the number of work places at the same time, will decrease" [10].

What can also be taken into account is the possible increase in the price of electricity and perhaps some impact on the average competitiveness of goods produced [42].

7.3 Air

7.3.1 Main air Pollutant Sources

In November-December 2004, the UAB "Ekomodelis" laboratory executed the inventory of stationary air pollution sources for the INPP [100], including existing HOB and steam generating facilities. Having analysed 63 sources, the operational efficiency of 13 air purifying facilities was established.

The total air emission of INPP in 2004 amounts to 89,702 t/y of polluting substances (see Table 7-2). The main pollutants are carbon monoxide (31,537 t/y), nitrogen oxides (7,913 t/y), dust (4,189 t/y), volatile organic compounds (0,997 t/y) and sulphur dioxide (43,543 t/y). The operational efficiency of air purifying facilities fluctuates from 78,6 to 99,3% [100].

In 2004, INPP used 90 cars, 23 self-propelled tractors and machines, 50 stationary machines, 2 cutters and 5 diesel locomotives. 118,566 t of petrol and 198,337 t of diesel are used in a year (2004). Carbon monoxide emissions amount 107,709 t/y, carbohydrates 23,485 t/y, nitrogen oxides 9,031 t/y, sulphur dioxide 0,295 t/y and dust 0,928 t/y [100].

In 2005, the "Permission for Pollution Integral Prevention and Control, TV(1)-7" [101], covering the operation of new Heat Only Boiler Station (HOBS), and the "Permission for Pollution Integral Prevention and Control, TV(2)-3" [102], covering the operation of new Steam Boiler Station (SBS) and INPP itself, were issued.

The major contribution to atmosphere pollution is provided by Steam and Heat Only Boiler Stations. The data on permissible and actual releases are presented in Tables 7-3 and 7-4.

A **new HOB** has been erected between the INPP and Visaginas. It is a Natural Gas-fired Boiler (Light Fuel Oil being used as back-up). The new HOB complies with the EU norms set up in the Directive 2001/80 on the limitation of emissions of certain pollutants into the air from large combustion plants and Lithuanian pollution emission limits for stationary combustion sources. . More details can be found in the technical design documents of this project [105].

Moreover, a **new SBS** has been erected and operates on INPP territory. It is gas fired as well. . More details can be found in the technical design documents of this project [106].

Table 7-2 Pollutants Released into the Air from INPP in 2004 (A = from boilers; B = from other combustion sources; C = due to chemical reactions)

Name of pollutant	Code of pollutant	Pollutant amount emitted from stationary source, t/y	From this amount		Pollutant amount captured in purifying facilities, t/y	Pollutant amounts emitted to the air from purifying facilities, t/y	Total amount of pollutants released to the air	
			Untreated pollutant amount emitted, t/y	Pollutant amount treated in purifying facilities, t/y			t/y	max g/s
1	2	3	4	5	6	7	8	9
acetone	65	0,001	0,001	-	-	-	0,001	0,00005
tin and its compounds	118	0,00002	0,00002	-	-	-	0,00002	0,00007
carbon monoxide (A)	177	29,001	29,001	-	-	-	29,001	400 mg/m^3;
carbon monoxide (B)	5917	2,394	2,394	-	-	-	2,394	52,94259
carbon monoxide (C)	6069	0,142	0,142	-	-	-	0,142	0,19296
nitrogen oxide (A)	250	7,174	7,174	-	-	-	7,174	450 mg/m^3 [a.p.s.049]; 650 mg/m^3 [a.p.s.050]
nitrogen oxide (B)	5872	0,693	0,693	-	-	-	0,693	15,22670
nitrogen oxide (C)	6044	0,046	0,046	-	-	-	0,046	0,02917
butyl acetate	367	0,038	0,038	-	-	-	0,038	0,02837
emulsol	712	0,183	0,108	0,075	0,074	0,001	0,109	0,05490
ethylcellulosic solvent	771	0,026	0,026	-	-	-	0,026	0,01850
fluorides	3015	0,003	0,0016	0,0014	0,0012	0,0002	0,001	0,00185
fluoride hydrogen	862	0,004	0,004	-	-	-	0,004	0,00330
difluorochloromethane (CFC-22)	961	1,000	1,000	-	-	-	1,000	0,03171
iron and its compounds	3113	0,053	0,029	0,024	0,0237	0,0003	0,029	0,06190
potassium hydroxide	3327	0,014	0,014	-	-	-	0,014	0,00431

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
dust (A)	6493	2,212	2,212	-	-	-	2,212	100 mg/m^3 [a.p.s.049]; 250 mg/m^3 [a.p.s.050]
dust (B)	6486	0,260	0,260	-	-	-	0,260	0,53617
dust (C)	4281	50,444	0,378	50,066	48,727	1,339	1,717	0,74014
volatile organic compounds	308	0,997	0,997	-	-	-	0,997	7,39687
manganate oxides	3516	0,005	0,003	0,002	0,002	0,00003	0,003	0,00580
sodium alkali	1501	0,007	0,007	-	-	-	0,007	0,00084
sulphur dioxide (A)	1753	43,370	43,370	-	-	-	43,370	1700 mg/m^3
sulphur dioxide (B)	5897	0,173	0,173	-	-	-	0,173	0,59379
sulphuric acid	1761	0,021	-	0,021	0,0208	0,0002	0,0002	0,00230
Non-organic lead compounds	2094	0,000004	0,000004	-	-	-	0,000004	0,00001
toluene	1950	0,150	0,150	-	-	-	0,150	0,10680
vanadium pentoxyne (A)	2023	0,141	0,141	-	-	-	0,141	0,00151
TOTAL:	*9991*	**138,552**	**88,363**	**50,189**	**48,849**	**1,341**	**89,702**	
among them								
solid	*9984*	**53,343**	**3,154**	**50,189**	**48,849**	**1,341**	**4,493**	
liquid and gas	*9977*	**85,209**	**85,209**	**-**	**-**	**-**	**85,209**	

Table 7-3 Number of Pollutants Released into the Air from SBS and INPP itself [102] (A = from boilers; B = from other combustion sources; C = due to chemical reactions)

Pollutants released into the environment air from pollution stationary sources			
Name of pollutant	**Code of pollutant**	**Releases in 2005, tons/year**	**Allowed to be released in 2006-2009, tons/year**
1	**2**	**3**	**4**
carbon monoxide (A)	177	104.773	104.773
carbon monoxide (B)	5917	0.031	-
carbon monoxide (C)	6069	0.139	0.0502
nitrogen oxide (A)	250	37.733	37.733
nitrogen oxide (B)	5872	0.010	-
nitrogen oxide (C)	6044	0.046	0.040
dust (A)	6486	0.243	-
dust (B)	6493	1.702	0.012
dust (C)	4281	1.702	1.298
sulphur dioxide (A)	1753	26.467	0.017
sulphur dioxide (B)	5897	0.161	-
acetone	65	0.001	-
tin and its compounds	118	0.00002	-
butanol	359	следы	-
butyl acetate	367	0.038	0.038
emulsol	712	0.109	0.001
ethanol	739	следы	0
ethylcellulosic solvent	771	0.026	0.026
fluorides	3015	0.00257	0.001
fluoride hydrogen	862	0.00342	0.003
freon-141b	-	1.000	1.000
freon-22	961	1.000	1.000
iron and its compounds	3113	0.0231	0.014
potassium hydroxide	3327	0.014	0.014

1	2	3	8
volatile organic compounds	308	6.705	0.596
manganate oxide	3516	0.00209	0.001
sodium alkali	1501	0.007	0.007
sulphuric acid	1761	0.00022	0.000
Non-organic lead compounds	2094	0.000004	-
toluene	1950	0.1503	0.150
TOTAL:		**182.089**	**146.780**

Table 7-4 Number of Pollutants Released into the Air from INPP HOBS [100]

Pollutants released into the environment air from pollution stationary sources			
Name of pollutant	**Code of pollutant**	**Releases in 2005, tons/year**	**Allowed to be released in 2006-2009, tons/year**
carbon monoxide	177	28.960	289.760
carbon monoxide	6069	0.003	0.003
nitrogen oxide	250	6.172	112.320
nitrogen oxide	6044	0.0003	0.000
dust	6493	2.212	1.930
dust	4281	0.015	0.015
sulphur dioxide	1753	43.350	36.280
fluorides	3015	0.0001	0.000
fluoride hydrogen	862	0.0002	0.000
iron and its compounds	3113	0.006	0.006
manganate oxide	3516	0.0007	0.001
volatile organic compounds	308	0.234	20.674
vanadium pentoxyne (A)	2023	0.141	0.100
TOTAL:		**81.0943**	**461.089**

A radwaste incinerator will be erected close to the INPP, at the south of the INPP fences. It is part of the Support Investment Packages, for which a dedicated EIA procedure will be made.

It will work for 2400 hours per year and will:

- use 25 kg of light fuel oil per hour for pre-heating and sustaining combustion;
- process maximum 100 kg of combustible solid waste per hour;
- process maximum 40 kg of waste oil per hour.

Although above quantities are neglectible and although plants treating only radwaste are excluded (Article 2 (2) (a) (vi)) from the scope of the European Union Directive 2000/76/EC on the incineration of waste, this incinerator will be designed for respecting the air emissions limits given in Annex V as well as with the measurement requirements given in Article 11 of this Directive.

After Unit 1 and Unit 2 final shutdown, HOB and SBP will thus constitute the main contributors to atmospheric pollution.

Under the **U1DP0 Project**, the works to be done does not cause significant non-radiological atmospheric emissions. The shutdown will decrease operational emissions but this is insignificant in comparison with HOB and SBP. It is therefore not necessary to make calculations for the atmospheric impact of the **U1DP0 Project.**

Indirectly however, the shutdown of Unit 1 will necessitate alternate furniture of heat for Visaginas and the INPP, and steam for INPP. Even gas-fired (in comparison with other fossil fuels), these plants will increase the global emission of air pollutants.

There are a few circumstances to be considered for determining the environmental impact of these changes:

- As long as natural gas cannot be used in the new plants, light fuel oil appears the most interesting in terms of availability and air pollution.

- After Unit 1 shutdown, the Unit 2 will still provide heat and steam necessary for operations and urban heating; then the new HOB and SBP will be used as back-up installations.

Finally, the following schedule can be established:

- After Unit 1 shutdown, the HOB and SBP facilities will be used as back-up (e.g. when Unit 2 is not at base load), with light fuel oil as combustible; air pollution is made each time these new installations have to be operated.

- The new facilities, using natural gas, are in back-up operations until the Unit 2 shutdown; light fuel oil is only used when natural gas is not available; air pollution is made each time these new installations have to be operated, but with less pollutant emissions than with the use of light fuel oil.

- When Unit 2 is shut down (end 2009), the new HOB and SBP operate on base load with natural gas; the existing HOB will be used in particular circumstances (e.g. when air temperatures are very low = during severe winter conditions). Air pollution becomes significant.

Mobile sources, such as personnel transport (private cars, public busses), will evolve according to the evolution of the INPP personnel (see section 7.2.1). Along with fuel improvement and old cars replacement, there will be a reduction of pollutant emissions from mobile sources. Moreover, EU norms for fuels (among which sulphur content) and vehicle exhausts will help in the relative reduction of pollutant emissions from each individual vehicle.

7.3.2 Influence of the Local Microclimate

Alterations to the regional climate would not be expected since the dismantling activities will not lead to the release of significant quantities of material or energy that might result in such impacts. However, as thermal releases will decrease, there could be some influence on the local climate because of decreasing heat releases in the Lake Drūkšiai, in the direction of the restoration of the original microclimate (coming back to the pre-Unit 2 conditions).

The influence should be small, until Unit 2 is also shut down. Then, the microclimate around the lake could come back to its natural situation. Calculations made under the INPP Environmental Monitoring Programme showed that the heat released to the atmosphere is very small compared to the heat added to the lake [109].

The most important potential source of atmospheric emissions would be a fire. The INPP Fire Protection Plan will be adapted to the U1DP0 Project, based on the prevention of risks including the means required for both the rapid detection and extinguishing of fires.

7.4 Soil

In itself, the U1DP0 Project does not include activities that can have a physical influence on the soil. Therefore, this subject does not need impact assessment.

We can however mention that current activities on the site, in particular the storage and distribution of hazardous or potentially polluting substances, can affect the soil in case of accidental spillage. There will be also some consumption of hazardous substances that will become waste during the implementation of U1DP0 (see Table 7-5).

Table 7-5 Use of Hydrogen and Hydrocarbons for U1DP0

<table>
<tr><th>Hazardous decommissioning waste</th><th>Statistical code</th><th>Code of list</th><th>Use or Production due to Decommissioning</th><th>Remarks</th></tr>
<tr><td>Hydrogen</td><td>02 14</td><td>16 05 05</td><td>640 m^3 of compressed gas</td><td>For generators cooling, stored in 8 “Receiver tanks”, each 80 m^3, 5 bara</td></tr>
<tr><td>Spent lubrication oil</td><td rowspan="2">01 32</td><td>12 01 07</td><td>600 t</td><td>Including 500 t of lubrication oil from the 4 turbo – generators</td></tr>
<tr><td>Spent transformer oil</td><td>13 03 10</td><td>1000 t</td><td>250 t / transformer,
4 transformers</td></tr>
</table>

Diesel fuel	03 12	13 07 01	1200 m^3	100 m^3 / Diesel generator, 12 Diesel generators. Annual consumption: 150 t/y (periodic testing)

The list of hazardous waste produced at INPP during normal operation, the approximate volumes of waste generated annually and the waste management routes are given in Table 7-7.

In order to be complete, we can mention the storage of chemical reagents in Building 131 that are used for the conditioning of the heating plant and the regeneration of the resins of the water makeup system:

- H_2SO_4 (100%) = according to design values, the use can reach 365 tons/y, but due to internal policy aimed at decreasing the use of demineralized water, the current use is about 80 tons/y
- NaOH (100%) = originally 14 tons/y, actually 3 tons/y.

The impact of accidental spillages in places where there is no protection of the soil (as concrete or ground layer in buildings, etc.) can be significant if no rapid intervention is made. We saw in 3.6.2 that the upper level of the water table is at near-surface level position and that the soil is permeable.

7.5 Underground

In itself, the U1DP0 Project does not include activities that can have a physical influence on the underground. Therefore, this subject does not need impact assessment.

In case of accidental spillage of polluting substances, there could be a contamination of groundwater if no rapid intervention is made. Risk for the aquifer mainly results from its near-surface level position. This implies that particular precautions should be taken during the handling operations to avoid any large scale contamination: use of appropriate equipment and handling procedures, together with appropriate surveillance.

7.6 Water

One of the main effects of the Units shutdown is the decrease of thermal releases into the Lake Drūkšiai with Unit 1 then Unit 2 shutdowns.

7.6.1 Water Consumption

The INPP uses lake water and artesian water.

The evolution of the water needs is further developed in the following paragraphs. The evolution can be summarized as a reduction of the total water use following the Reactor Final Shutdown of Unit 1 (RFS U1). Indeed:

- the cooling needs of the plant will decrease;
- the needs for demineralised water will progressively decrease;

- the needs for water for maintenance operations and lab's activities will globally remain unchanged;
- the water consumption for sanitary purposes will progressively decrease.

It has to be reminded that, resulting from the implementation of the INPP decommissioning, a new Heat Only Boiler (HOB) and Steam Boilers (SB) are erected on the INPP site, in order to reliably supply steam and hot water for both INPP decommissioning and Visaginas town. The process will use artesian water and discharge the blowdown water into the lake. This project is detailed in the technical design documents referenced in [105, 106].

7.6.2 The Thermal Releases from the Plant

The lake Drūkšiai is used for cooling purposes of INPP Units and ancillary facilities. Discharge of NPP heated-up water causes lake temperature increase and associated intensification of water evaporation, which in turn, result in increased eutrophication and salinification of the water body.

With the RFS U1, the thermal releases from that unit will cease. This will lead to the restoration of the thermal situation that prevailed between the years 1984 and 1987, when only the first reactor was operating. The heat load to the lake will be reduced from 120 W/m³, resulting from the operation of the two units, to 60 W/m³ (i.e. $8.7x10^{15}$ J/month).

The water temperature regime of the mid-eighties will be restored. The episodes of excessive temperatures (keeping in mind that the lake thermal state can be determined by the combination of unfavourable conditions and that the wind conditions are determinant for the surface water temperature) will decrease significantly. The Lithuanian norm temperature admissible for fish life set up for the lake (water temperature cannot exceed 28°C in the minimum 80% of the total lake area) could not be exceeded any more.

The evaporation process will also be globally reduced to its 1987's level, which was about $50.8x10^6$ m³/an or about 30% higher than in pre-INPP operations. The implementation of the U1DP0 Project will reduce the effects of INPP on the natural evaporation process of the lake. The pre-INPP thermal conditions will only be restored when the Unit 2 RFS will be implemented. In the meantime, these conditions can only be partially restored (period of evaporation in the year, local microclimate). The water level could increase but let us remind that the lake water level is also regulated by the Byelorussian hydraulic power station on the Prorva River.

However the evolution is different for eutrophication (see hereafter), so that the water condition of the lake will not come back as it was before the Commissioning of Unit 2.

7.6.3 Liquid Releases including Toxic and Harmful Substances

The lake Drūkšiai is the receiver of cooling water and water discharged through the rain and drainage sewerage (see Appendix 8) systems.

Service water

As the service water used for cooling purposes does not receive treatment on the site, there is no pollution in the lake to be awaited from it (apart thermal outputs).

Regeneration effluents

The RFS U1 will reduce the cooling requirements of the INPP. The need in demineralised water will progressively decrease as the water circuits will progressively be shut. Accordingly, the discharge of regeneration effluents should also decrease. Thus, the RFS U1 will result in a reduction of discharged salts (Cl^-, SO_4^{--}, Na^+, Ca^{++}, Mg^{++}, etc) and corrosion particles, which are released through the regeneration process of the perlite filter beds and resins. To be noted that the rain sewerage system (RSS) channel collecting water from the different INPP buildings including drainage water and rainwater is equipped with oil removers.

Rain and drainage water

The U1DP0 Project will have no influence on the amount of rain and drainage water collected in the rain and drainage sewerage systems. The amount of collected rainwater will only decrease with the restoration of infiltration capacity on the site. This implies demolition of buildings or removal of impermeable areas, which are not covered by the present U1DP0 project and EIA.

Maintenance and household wastewater

The amount of wastewater produced by maintenance activities on the INPP site will probably remain unchanged. The water consumption related to the specific maintenance of Unit 1 can be mentally shifted towards the water consumption related to the specific dismantling operations. This concerns mainly maintenance of instruments and equipments at the workplaces, and should not represent large amounts of water. The maintenance wastewater quality will also remain unchanged.

For what concerns the releases of sanitary waste waters during the U1DP0 Project, the evolution of the number of employees on the INPP site has to be considered. This cannot be done by considering the U1DP0 Project on its own but has to integrate the employment provided by all the activities on the site and the evolution of this with time. The evolution comprises:

- the pure decommissioning of Unit 1 (defuelling, dismantling, decontamination and removal) while Unit 2 is still operating;
- the construction and operation of new installations such as the new steam boiler plant or the new waste treatment and storage facilities;
- the pure decommissioning of Unit 2;
- the B packages supporting the Decommissioning Project (Interim Spent Fuel Storage Facility, Solid Radioactive Waste Storage Facility).

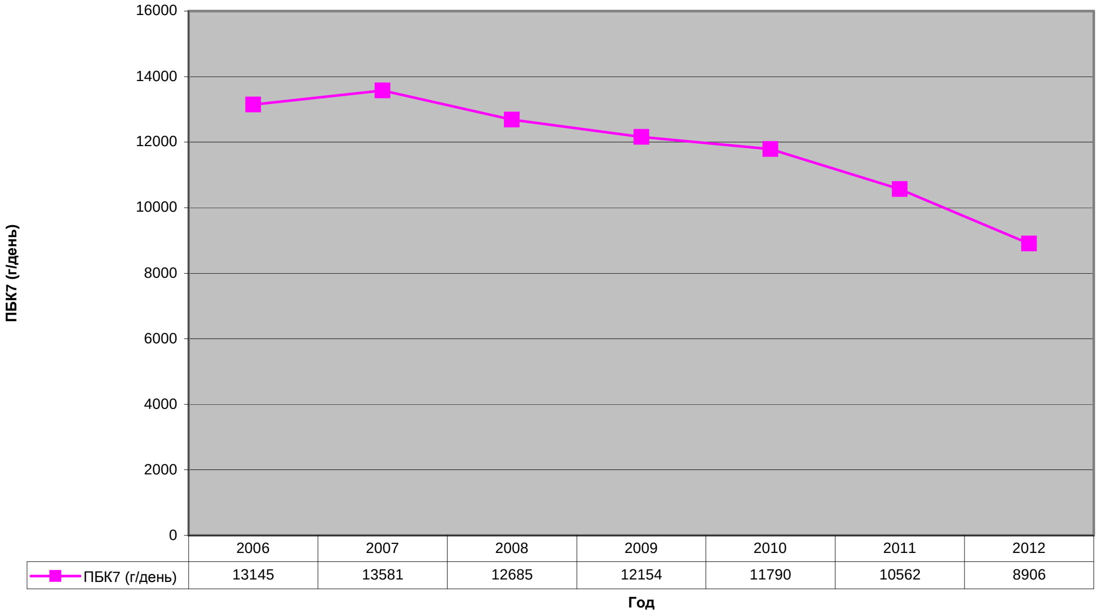
In January 2006, the INPP occupied 3,349 persons. The estimated evolution of the total population at the INPP is presented in Table 7-1.

According to the data of BOD7 measurements from January 2005 to February 2006 (average BOD7 was 24.65 mgO_2/l, average drain flow in January-February 2006 was 16000 m^3/month), it is possible to evaluate BOD7 evolution of INPP drains to be treated at cleaning facilities of Visagino Eneregija – see Table 7-6.

Table 7-6 Estimated BOD7 Evolution of INPP Site Drains to be Treated at Cleaning Facilities

Year	2006	2007	2008	2009	2010	2011	2012
BOD7 (g/day)	13145	13581	12685	12154	11790	10562	8906

	2004	2005	2006	2007	2008	2009	2010	2011	2012
P.E.	1,825	1,818	1,659	1,714	1,601	1,534	1,488	1,333	1,124



This table shows that the discharge of wastewater from the INPP will progressively decrease with the implementation of the U1DP0 Project. This trend is influenced by the manpower needed for the decommissioning works and support investments made on the site.

The unemployment at INPP could also be considered has having an influence on the urban wastewater sent to the Visaginas Municipal Sewage Wastewater Treatment Plant. Nevertheless, this related evolution is highly difficult to predict as it depends of many other social and economic parameters.

Part of the personnel of the INPP comes from the ex Soviet Union. When losing their job, some of those people and their families could decide to return in their country. Some Lithuanian employees could also decide to quit Visaginas. Those departures will notably depend of the possibilities for them to find another job in the proximity of Visaginas and of the ties they have with the region. The evolution of the local economical context and the possible departures linked to it would induce a reduction of the volume of urban wastewater produced by Visaginas. However, it is not possible to assess accurately that potential tendency.

It can be reminded here that the renovation of the design of the Visaginas Municipal Sewage Wastewater Treatment Plant is foreseen to include further nitrogen and phosphorus removal (eutrophicating nutrients). The improvement of the treatment efficiency of the plant is expected to progressively improve the water quality of the lake Drūkšiai, and possibly reduce the eutrophication rate.

Groundwater

The handling of hazardous substances during the implementation of the U1DP0 Project could lead to potential chemical pollution of the soil and/or the groundwater if an accidental overflow or spill occurs. Risk for the groundwater body mainly results from its near-surface level position. This implies that particular precautions should be taken during the handling operations to avoid any large scale contamination.

7.7 Fauna and Flora

The U1DP0 Project will not affect terrestrial habitats and species in the area as no construction or demolishing activities are included. Lake Drūkšiai will be affected mainly by the evolution of cooling water releases and, in a smaller way, by the evolution of releases of industrial and sewage water.

Lake Drūkšiai and surroundings are important habitats; there has been an official application for classifying the major part of the lake and some terrestrial zones as a Natura 2000 territory.

The construction and the commissioning of INPP created changes in the hydrobiology of the lake (see 3 The Environmental Baseline). This was due mainly to the settling of solid particles, thermal releases and organic releases (sewages from INPP and Visaginas).

Because of the complex (thermal and chemical) anthropogenic impacts, different ecological zones formed in Lake Drūkšiai [19]:

- Type A: The most eutrophicated south-eastern part of the lake, where the main eutrophicating factor is the municipal wastewaters with a large amount of biogenic substances (N, P). An increased amount of all groups of planktonic organisms as well as an increased activity of production-destruction processes was determined in this area.

- Type B: The heated water outflow zone is the area of greatest thermal impact, where water temperature often exceeds 28°C. There is the lowest abundance and variety of the most planktonic organisms (phytoplankton and protozooplankton) as well as a decreased production process and increased transformation and destruction processes of organic matter.

- Type C: In the pelagic part of the lake, including the deep and mediate deep zones, various impact factors reveal themselves not periodically, depending on the working regime of INPP, wind directions, waves, etc.

The implementation of the U1DP0 Project will result in the stop of thermal releases from Unit 1. The situation in terms of thermal releases will be similar to what it was after the Commissioning of the first Unit of INPP.

It is supposed, at least during the first years after Unit 1 Reactor Final Shutdown that sewage water releases from the Visaginas Municipal Wastewater Treatment Plant will not evolve in an important way. It will be the case in several years, where a possible decrease of the population in Visaginas may happen and with a further removal of P and N nutrients at the Municipal Wastewater Treatment Plant (efficiency upgrade of the plant according to EU requirements).

Hence, there will be:

- A decrease (by half) of thermal releases and a modification of the average and extreme thermal conditions of the different lake water masses;

- Little or almost no evolution of organic releases in a first stage and, after several years, a decrease of eutrophicating releases.

Therefore, the future condition of the lake water will be less directed by temperature than previously (with 2 Units in operation) and still directed by eutrophication as it is before Unit 1 Reactor Final Shutdown, at least during the first years following the Unit 1 Shutdown.

The difference with the years before the Commissioning of Unit 2 is that the eutrophication of the lake is more important now. Then, the evolution of the biocenosis cannot come back to pre-Unit 2 compositions.

In order to make some prognosis, if possible, we have to take into account the results of different researches on the subject [55].

Regarding relationships between thermal and/or eutrophicating releases and fish growth:

Eutrophication

- There was found a **positive correlation** between the total biomass of fish and some parameters determining the trophic state of the lake, i.e. concentrations of total phosphates in water and the original annual intra-production of phytoplankton.

- There was **no** reliable correlation between the total biomass of fish and the average biomass of phytoplankton during the season of vegetation and the amount of the dissolved organic material in water.

- There is **no** correlation between the total biomass of stenothermic fish and various limnological parameters determining the trophic state of a water body.

- There is **no** correlation between the biomass of eurybiontic fish and the parameters determining the trophic state of a water body, *except the concentration of phosphates in water*.

Thermal influence

- The biomass of stenothermic fish species is ***negatively correlated*** with the average temperatures of the water surface during the warm period of the year, whereas the same parameter of eurybiontic fish **correlated positively** with the average temperatures of the water surface during the same period of the year.

- There is a **positive correlation** between the water temperature and the growth rate of 0+ fish, their ability to survive and the number of 1-year-old individuals in fish populations.

- However, higher temperatures may cause different damages of gameto- and gonadogenesis and spawning disorder, one or several misses of spawning periods, increased mortality of fertilised eggs, reduced rate of growth of mature fish, especially individuals or younger age groups, increased mortality of grown individuals and reduced life-spans.

- The total higher temperature of water than the natural season temperatures adds to the effect of higher average temperature.

- For stenothermic fish species, their habitat (low temperature water volumes) is limited by temperature but also by their formation in the lower strata of water which lack oxygen. These oxygen free areas form in the second half of summer and they greatly decrease the size of habitats for stenothermic species. Because of this, their growth rate slowed down, their life-span has become shorter, and their abundance has decreased.

It was shown that thermal influence accelerates biological metabolism in a water body which, as well as chemical eutrophication, stimulates an increase in its trophic level [55].

According to these data, the possible evolutions could be:

- In type A areas, the shutdown of Unit 1 should not exert significant influence, as the major influence are the sewage wastewaters coming from Visaginas; perhaps stenothermic fish species could be less influenced by temperature changes than with the influence of two units in operation, as colder water volumes could be less influenced by the thermal releases of Unit 2 only.

- In type B areas, it is clear that the influence will be significant. On the average[74], it will decrease the area of warm waters and narrow the range of (min-max) temperatures. There could be less damage to physiological parameters of fish populations. The increase of trophic level of the lake could be slowed down and possibly halted.

- In type C areas, the influence of the U1DP0 Project could be a decrease of the variation in the impact factors. Only monitoring can give better understanding of this evolution.

For other biota, the influence of the U1DP0 Project does not appear to be evident, as the organic releases remain. It seems that there should not be significant changes but environmental monitoring is necessary to allow the follow-up of the evolution of the lake's biocenosis.

Terrestrial species will not be affected by the Project.

7.8 Landscape: the Visual Impact of INPP Decommissioning due to the Buildings to be Maintained, to be Demolished and to be Erected – Land Use

The description of landscape is to be found in section 3.8.1.

It is a matter of fact that the construction of INPP and related equipment such as electricity transformers and transmission lines affected significantly the landscape. From a natural lake and forests landscape, the situation evolved to a technological landscape at INPP site and urban landscape in and around Visaginas.

[74] The temperature of the lake water is influenced also by wind regime and air temperature.

Negative landscape elements are:

- The INPP with its huge buildings and stacks;
- Auxiliary buildings and roads;
- Transmission lines;
- Urban heat and hot water distribution systems.

Positive elements are:

- The natural areas such as the lakes in the region and areas of particular ecological interest;
- The forests covering an important part of the region;
- Elements of cultural interest mentioned in the section related to environmental baseline.

An overview of the local landscape is shown in Appendix 4. The visibility can be defined as follows:

- The visibility of the main buildings of INPP is mainly limited to the closest roads and areas.

- Once the observer has forest between INPP and himself, stacks can still remain visible at a certain distance (max. 2-3 km or on some parts of the lake shores, where no natural or vegetal obstacle hide the INPP).

As the INPP cooling system is an open loop with the lake, there is no cooling tower nor vapour cloud formation that are characteristic of closed-loop cooling systems.

The U1DP0 Project does not contain any dismantling or demolition works. It will not change the ratios in natural and semi-natural territories (forests, wetlands, waters, etc.) to urbanized territories (built-up territories, roads) and will not influence the mosaics of the landscape, biotope fragmentation, ecotones, aesthetical value of the landscape.

The implementation of the U1DP0 Project will not influence protected territories. The ecological impacts that will result from the implementation of the U1DP0 Project will not be visible in a way they affect landscape.

Similarly, the Project will not influence natural-recreational territories (recreational forests, greenery of common usage, forest parks, water bodies, and camping places) in another way than today.

We can remind that the implementation of Support Investment Packages will exert an influence on the current INPP landscape.
The land use pattern should not be affected, though it depends also on alternative social and economic developments that should accompany the implementation of the Decommissioning (see section 8.2).

7.9 Non-Radioactive Waste Management

INPP’s non-radioactive waste management activities are performed in accordance with “Non-radioactive waste management manual”, code PTOed-0412-1, developed in line with the requirements of “Waste management rules”. The objective of work performance is the protection of environment, the decrease of the quantity of waste to be disposed off and the safe waste storage.

INPP‘s non-radioactive waste management activities are ruled by the “Permission for Pollution Integral Prevention and Control, TV(2)-3“. This document specifies the list and permitted volumes of the waste generated at INPP. Utena Regional Environmental Protection Department of the Environment Ministry is the control administration.

INPP may carry out the following activities in accordance with the “Permission for Pollution Integral Prevention and Control”:

- sorting of waste at the places of their origin, accumulation of waste at the INPP site in order to transfer them later to other enterprise for utilisation;
- storage of hazardous waste not more than three months;
- storage of non hazardous waste not more than one year;
- disposal of non hazardous waste in industrial waste polygon (with some constraints).

Construction waste of INPP are handed over to state enterprise “Visagino statybininkai”, sanitary waste of INPP are handed over to state enterprise “Visagino būstas”. Other solid or liquid wastes of INPP are handed over by INPP to other companies dealing with this waste treatment and granted with permission for this activity and registered in the State Register of enterprises dealing with waste. Waste is transferred to them in accordance with contracts concluded annually. Enterprises are selected on a Tender basis in compliance with the Law of the Lithuanian Republic on open procurement and other legislative acts.

Upon financial year (calendar year) completion and according to reference [14], INPP submits annual reports to the Utena Regional Environmental Protection Department for the purpose of waste accounting.

INPP is registered in the Register of enterprises dealing with waste. This registration is related only to removal of non-hazardous waste in the polygons of Decontamination Department industrial waste.

Note:

In the event any change occurs in the waste management activity, the company is to submit an official request for a new Registration Certificate to Utena Regional Environmental Protection Department. Registration procedure is carried out in accordance with section III of “Waste management rules” (News N° 68-2381, 2004), code NTdoc-0051202-B2.

The list of hazardous waste produced at INPP, the approximate volumes of waste generated annually and the waste management routes are given in Table 7-7.

Most of the types of hazardous waste produced at INPP are delivered to other enterprises for appropriate processing or elimination.

Apart from that, a few types of hazardous waste are stored at INPP site (waste types numbered 15 to 17 in Table 7-6). It cannot be removed from the site since currently there are no companies capable of accepting such waste. Barium chloride and metal thallium belong to this category of waste. This waste is temporarily stored following safety precautions, which exclude waste contact with environment.

Note: Chemicals

In Building 131, the following reagents are used for the conditioning of the heating plant and the regeneration of the resins of the demineralised water plant:

- H_2SO_4 (100%);
- NaOH (100%).

The spent reagents are not contaminated. After neutralization, they are discharged into the lake.

Any non-radioactive solid waste to be produced during the U1DP0 project is not expected to lead to specific problems, as they are routinely managed at the plant. More information on the waste management for the U1DP0 project is given in reference [108].

Table 7-7 List of Hazardous Operational Waste at INPP

No.	Hazardous waste type	Statistical code[75]	Code of list[76]	Amount, t/year	Processing methods
1	Electrolyte of alkaline accumulators	01.21	16 06 06	2.0	Processed by chemical shop of INPP
2	Luminous tubes (lamps)	08.43	20 01 21	20 000 pieces	Accumulated waste is transferred for treatment to specialised enterprises having appropriate MoE permissions for such activity type.
3	Asbestos-containing insulation materials	12.21	17 06 01	1.5	
4	Sealing material hot water accumulation tanks	02.13	08 04 09	15.0	
5	Waste generated as a result of cleaning of tanks used for oil products storage	03.22	16 07 08	0.5	
6	Oiled filter materials	03.14	15 02 02	2.0	
7	Oiled cotton waste	03 14	15 02 02	2.5	
8	Sand contaminated with oil products	12 61	17 05 03	10.0	
9	Lead-acid accumulators	08.41	16 06 01	5.0	
10	Oil-in-water emulsion (total for various types of oil: machinery, transformer, turbine)	03.12	13 08 02	15	
11	Spent turbine oil	01 32	13 03 10	0.1	
12	Spent machine-tool oil	01 32	12 01 07	1.8	
13	Spent transformer oil	01 32	13 03 10	0.5	
14	Asbestos	12.21	17 06 01	-	Since 1992 residuary asbestos is on sale gradually. About 40.0 t of waste remains at the moment[77]. It is expected that this material will be evacuated before dismantling works start. If not, the remainder will be transferred as waste in items 1-13
15	Chemical agents with expired useful date	02 31	16 05 07	0.2	As in items 1-13

75 Statistic code – 4-digit code in accordance with Attachment 11 “Waste management rules”;
76 Code of list – 6-digit code in accordance with the list of waste in Attachment 2 “Waste management rules”
77 2003-11-01

7.10 The Emission of Noise Related to the Project

Noise as a physical harmful factor, is present mainly in the Ignalina NPP work environment.

According to the physics law of noise attenuation with the distance, and the fact that the closest neighbours are situated at more than 2 km, one can expect noise reduction levels of more than 65 dB(A).

As the U1DP0 Project does not include particular noise emitting works, no particular nuisance is to be awaited[78].

Therefore, no further assessment is necessary.

7.11 Possible Transboundary Aspects

The lake Drūkšiai is located at the frontier with Byelorussia, with a small part of it (6.7 km² i.e. 14% of the total area) belonging to that country. Hence, the thermal and qualitative aspects of the lake water concern Byelorussia directly.

The surface outflow of the lake occurs through the river Prorva and finally reaches the Gulf of Riga of the Baltic Sea through a long and complex pathway of approximately 550 km [63]. The discharge of treated and untreated waste water into the lake Drūkšiai participates to the global downstream water quality of the hydrological network. That global quality results from complex biological, chemical and physical interactions that occur all along the network.

Improvement of the water quality of the lake Drūkšiai could help to manage the downstream water quality. Nevertheless, such a management has to be considered on a much larger scale than the lake Drūkšiai on its own.

It was shown that the individual dose (already at 2% of the limit for the most exposed people) reduces significantly with the distance from the release point [63].
As Byelorussia is not a Party to the Espoo Convention[79], the Ministry of Environment is free to consult the Government of Byelorussia on this issue.

Reliable Heat and Steam Sources are built for INPP and Visaginas. The total Heat Only Boilers thermal power amount to 194 megawatts. Therefore, according the criteria set up in the Espoo Convention, Lithuania did not have to come to an agreement on it with other countries, therefore notification to neighbouring countries that might have negative environmental impacts, is applicable.
Other INPP non radiological decommissioning activities will have much less environmental impact.

[78] For example, if an ambient noise at the plant reaches 85 dB (A) (which is typical of an automobile passing at a few meters), than the resulting noise at 2 km distance will be 20 dB (A), which is a noise that cannot be distinguished from other ambient noises even in quiet places.
[79] Convention on Environmental Impact Assessment in a Transboundary Context, adopted at Espoo on 25th February 1991.

7.12 Occupational Hazards and Industrial Safety

The decommissioning project implies certain activities that give rise to a series of occupational risks. The Ignalina NPP Decommissioning Project and its associated documentation identify such risks and methods to prevent or minimise them.

The Chapter 8 of the U1DP0 Project documents describes measures foreseen for workers protection, such as:

- Physical Protection:
  - to make sure that all radioactive materials cannot leave INPP in an unauthorized way,
  - to prevent illegal intrusions;
- Safeguards:
  - to ensure absence of misuse of nuclear materials and keep accurate inventories of nuclear materials;
- Fire Protection:
  - in accordance with INPP Safety documentation, fire protection measures are established and implemented throughout the Site and, in the event of fire, personnel actions are defined,
  - specific attention shall be paid to flammable wastes retrieved during the implementation of the U1DP0 Project,
  - particular measures are taken for what concerns H_2 production;
- Industrial Safety and Health Protection:
  - the industrial safety and health protection rules to be followed during the Post-shutdown and Defuelling phases remain the same as in normal operation,
  - industrial safety data will be recorded, monitored and acted upon to prevent industrial accidents and opportunities taken to improve industrial safety and health protection,
  - special attention shall be paid for the workers protection against the potential harmfulness of the chemical reagents in the frame of the in-line decontamination operations, by:
    - respecting all legal requirements in the field (identification of pipes and systems according to the transported fluids, presence of eyebaths, showers, use of dedicated protections means, etc.),
    - preventing leakages and determining remedial actions in advance,
    - taking these aspects into account during adequate training sessions.

7.13 Environmental Risks Associated with the Use of Hazardous Non-radioactive Products

The hazardous products used during the Phase 1 of INPP Decommissioning are mainly:

- Sulphuric acid (H_2SO_4): sulfuric acid is harmful to aquatic life in very low concentrations, due to its effect on the pH. Ecotoxicological values towards different species of crustaceans and fish have been determined in the range from 42 to 82 mg/l.

- Sodium hydroxide (NaOH): highly soluble in water and dissociates to sodium and hydroxide ions, with the effect of increasing pH and alkalinity. The aquatic toxicity of sodium hydroxide has been investigated towards crustaceans and fish. Ecotoxicological values are in the range of 30-180 mg/l.

- Hydrogen (H_2): there are no known ecotoxicological effects for this substance.

- Lubrication and transformer oils: mainly soil and surface water pollution by hydrocarbons.

- Diesel fuel: the toxicity of diesel fuel is generally attributed to soluble aromatic compounds, but insoluble hydrocarbons should also be implicated. Alkyl derivatives of benzene and polycyclic aromatic hydrocarbons are considered as most harmful. New oxygen and nitrogen derivatives of hydrocarbons are formed as a result of oxidative and pyrolytic processes during their combustion. Possible interactions with other substances from soil and waters can also occur, contributing thus to further environmental damage.

The potential pollution could come from spills of these products during transport, storage and handling on site. Spills can produce vapors (diesel), liquid effluents and soil pollution if no prevention measures are taken. Recommendations are made in section 8.9.

7.14 References

100. Inventory Report on Environmental Air Pollution Sources, 2005, UAB “Ekomodelis”, TASpd-0445-72006.
101. Permission for Pollution Integral Prevention and Control No TV(1)-7.
102. Permission for Pollution Integral Prevention and Control No TV(2)-3.
103. Final Decommissioning Plan for Ignalina Units 1 & 2, Report Nr A1.1/ED/B4/0004, INPP-DPMU, 2004.
104. The General Economic Balance Model to Assess the Consequences of Decommissioning of Ignalina NPP, Institute of Economics of Lithuania, Vilnius 1999.
105. Technical Design of New Heat Only Boiler Station No P-1323/PDW/04, 13 volumes.
106. Technical Design of New Steam Boiler Station No 2003-20031209-1, 18 volumes.
107. Air pollution prognosis during reorganization of Visaginas heating structure after closing the INPP, V. Strimaityte, G. Denafas, Energetika, 1, pp. 55-61, 2003.
108. Decommissioning Project U1DP0 – Chapter 9 – Waste Management, document A1.4/ED/B4/0004, INPP DPMU (2004).
109. Отчет по анализу безопасности 2-го энергоблока ИАЭС. Задача 2 – История безопасности и воздействие на окружающую среду. Глава 2 - Воздействие на окружающую среду. Раздел 2.3 – Воздействие тепловых сбросов на окружающую среду; ПТОаб2-0345-223 В2.
110. Отчет по обучению персонала за 2004 год (код ООТОТ-0545-17).
111. Radiological Characterisationof INPP Main Fluids and Waste Streams – Analysis of Intitute of Physics Measurements Results – Validation of DPMU Predicted Scaling Factors, DPMU A1.4/TN/0006 – 01.
112. Determintation of Radioactivity in Operational Waste Phase 2 – Stage 1: Water from the Primary Circuit and from the SNF Pools. Stage 2: Water from Evaporator Concentrates, Ion Exchange Resins, Scrap Samples, Vilnius 15/01/02 – TASPD – 1345-70091, 2003-02-06.

8 Impact Minimisation and Mitigation Measures

8.1 Introduction

Adequate measures are identified hereafter to prevent, minimise or mitigate the negative environmental consequences of the project and to maximise possible positive aspects.

These measures may be preventive if they remove the impact by modifying the project activity causing it, or mitigating if they cancel, attenuate or modify the impact once it has been caused.

8.2 Social and Economic Issues

As seen in section 7.2, direct and indirect job losses could amount 1,830 units in 2010 and more in the next years. The first significant wave of job losses will arrive in 2006.

For the INPP personnel, there will be training programmes for new activities and new facilities. The philosophy and contents of the programmes are described in the FDP [8].

We discussed the position of Visaginas on social and economic points of view. Several initiatives have been taken to favour social and economic deployment in the region, such as:

- The INPP Regional Development Agency (RDA) which was established in November 2002 by the Lithuanian Government, of which the shareholders are:

  - The Lithuanian Ministry of Interior;
  - The Lithuanian Ministry of Economy;
  - Ignalina, Zarasai and Visaginas municipalities.

  The guiding principles are established by the INPP Regional Council (Governor of the Utena County and Mayors of the three municipalities). The main tasks of the RDA are:

  - To execute the INPP Unit 1 decommissioning programme;
  - To alleviate the negative social and economical impact of the INPP decommissioning on the inhabitants of the region;
  - To support the development of the market economy and to provide support to enterprises and entrepreneurs to access EU Structure Funds;
  - To make recommendations to those charged with the preparation of the National Development Plan.

  The RDA administers and implements:

  - A Business Development Programme in order to provide grant support to Small and Medium Enterprises (SMEs) in the Region;
  - Youth Programmes;
  - A Local Initiatives Programme.

The RDA also has the responsibility to prepare an INPP Regional Development Strategy and a SME Development Plan for the region.

At the municipality level, business information centres were established to provide business management services for start-up entrepreneurs and SMEs.

An INPP Region Business Incubator has been established by the Ministry of Economy and the Visaginas Municipality in October 2002. The willingness is to stimulate SME development, particularly in consideration of the decommissioning of INPP, through expansion and diversification of the local economy, by supporting sustainable business development opportunities with premises, equipment and logistics and with a wide range of business consulting and IT services.

In itself, in the current situation, the city appears to have only little advantages to be able to redeploy its social and economic activities to compensate the Decommissioning of INPP.

The measures aimed at monitoring the socio-economic evolution in the INPP region and at engaging the economical transformation of the Visaginas society are of course of prior importance.

The programme for the socio-economic monitoring of the INPP region was compiled and prepared by the scientists of the Division of Regional Geography of the Institute of Geography. The preparation of the programme was funded by the United Nations Development Programme (UNDP/Lithuania) and co-ordinated by the Ministry for Social Security and Labour [41]. This programme covers the territories of Ignalina, Zarasai and Visaginas municipalities.

Devoted to the transition of the region from one state to another, the programme intends to:

- Observe the social development of the region and the factors that influence it;
- Establish the effectiveness of the preventive measures of social policy and to enhance their flexibility;
- Prepare the measures for the improvement of the socio-economic state of the region.

A proposal was made in ref [41], which is to establish a special institution for the implementation of the monitoring, located in Visaginas and inviting the assistance of local experts and institutions providing the information.

This proposal could be incorporated in a larger one, aiming at setting up a research and development agency, for example on the basis of an existing institution, which would for example:

- Be “sustainable development” oriented: it would integrate environment (ecology, public health and well being), economy and social issues in its mission, with a vision of solidarity through successive generations;
- Carry out monitoring and provide help in the development of projects as well;
- Be composed of scientists of all necessary disciplines;

- Be a relay of information for any developer in the region (public or private) and be consulted for advice on development plans and projects;

- Become a centre of reference for the development of the INPP region;

- Be financed by the International Support Fund for Decommissioning of Ignalina NPP.

Regarding the necessary evolution of the socio-economic situation in Visaginas, some proposals were made in the EU funded Study [10], such as:

- Support of studying at universities in Lithuania for 30 – 50 young people from poor living families of Visaginas;

- Formation of business motivation: a very poor entrepreneurship level of population exists in INPP region and specifically among INPP employees. It requires special training for 150 – 200 people each year;

- Teach the Lithuanian language (500 – 600 people each year);

- Support to individual businesses;

- Support to employees for establishment of the new jobs and other measures;

- Public works: to create conditions in the Region to employ in average 2500 unemployed people each year to public works;

- Design a Regional Development Programme and implement development measures, e.g. through a development agency (see above);

- Develop and implement a Programme for Public Awareness on the evolution of the region, so that the population develop confidence in its means and a self development mentality.

Most of all, efforts should not be dissipated in too many initiatives because of the necessity to reach a critical level of investment efforts versus effective return.

Is it possible to attract investors in Visaginas?

Let us have a look on advantages and disadvantages of the city:

<u>Advantages:</u>

- young and highly qualified labour force;
- relatively cheap immovable property;
- prepared infrastructure;
- a great variety of industrial buildings;
- comparatively cheap energy resources;
- vicinity of the eastern market;
- privileges granted by the local government;
- planned assistance provided by international institutions to the region.

Disadvantages:

- geographical position of the town;
- specificity of the town;
- vicinity of the Nuclear Power Plant;
- insufficient preparation of local businessmen for work in the market conditions;
- lack of investment funds;
- undefined perspective of the region.

Because of the low attractiveness of the region, several support and development measures are necessary:

- Take advantage of the attractive advantages for tourism by developing tourism marketing and recreational infrastructures for servicing tourists;

- To develop the marketing of the region by :

  - educating the inhabitants of Ignalina NPP region, the main objective of which should be the increase of the level of associativeness of the inhabitants, encouragement of business relations among separate territories and enterprises of the region, as well as softening the disposition towards isolation of the inhabitants of the town of Visaginas,

  - propagating the region as the uniform social economic space in the country and abroad, underlying specific possibilities of the region for the development of businesses;

- To attract inward investment;

- To promote sales of the production of Local Enterprises and Farms, through an existing agency, in order to highlight the specific advantages of local productions (e.g. the quality of food products, produced in an environment of particularly good quality) and to find partnerships with other entities;

- To favour the development of Small and Medium-sized Enterprises, by :

  - encouraging the establishment of new enterprises, for example through local initiatives (call for projects and subsequent support : organisational, financial, managerial, etc.), sponsored by a special fund of Ignalina NPP local employment initiatives,

  - Supporting/Strengthening of the development of existing Small Enterprises,

  - Providing assistance to Small Enterprises to become Medium-size Enterprises, e.g. by taking an active part in the process of decommissioning of Ignalina NPP. The administration of Ignalina NPP could make a considerable contribution into that process,

- Ensuring the Transfer of Know-how once the strategy of the development of Ignalina NPP region has been adopted. The authors of the study [10] propose possible directions: virtual commodity exchange of products and services, the centre of scientific research and training, the enterprise of construction of new nuclear power plants, the enterprise providing services related to decommissioning of the Nuclear Power Plant, the enterprise receptive to scientific production.

In the study, a vision was proposed, together with long-term strategic objectives:

"The INPP Region in 2010/2015 will be an attractive business environment, with a diversified, varied and stable business structure, based on high technologies, a stable labour market, qualified and competitive sources of employment, and enjoying a high level of employment among the population able to work, balanced development of urban and rural communities, and continuous social and economic improvement of individuals, groups and communities".

"Analysing the present situation of the INPP Region and the negative consequences of the decommissioning of the INPP, the need arises to create permanent jobs, actively support the entrepreneurship among the youth as well as their other opportunities to find a job, enable farmers and the rural population to receive additional income, ensure the continuous development of Visaginas as a new town as well as encourage its socio-economic links with Ignalina and Zarasai districts, facilitate the integration of different nationalities of the Visaginas community into the society of Lithuania and Europe."

It was also proposed to create a Euro-region in the crossing of the three states [41]; this should be easy with Latvia (as a recent new EU Member State as Lithuania) and possibly give access to some Structural Funds, but less easy with Belarus (however the EU plans to initiate discussions with this country for cooperation on some economic issues).

A recent workshop was held in June 2004 in Visaginas on the social and economic issue.

8.3 Air

8.3.1 Radionuclide Content in the Discharged Gaseous Effluents

The Project in itself will decrease the radionuclide content in the discharged gaseous effluents, of which the impact on health and environment were shown insignificant.
The decrease will come from the following facts:

- After the RFS, there will be a drastic reduction of radionuclide content in the discharged gaseous effluents (absence of noble gases discharges soon after the RFS, absence of short lived iodine nuclides, drastic reduction of tritium and C^{14} releases after RFS, reduction of the contribution to the global effective dose by the short half-lide nuclides)
- The significant decrease of releases through the main stack

Though there will be increases in alpha activity and in the releases via the intermediate height stacks and at low elevation, these effects will not counterbalance the decreases described above.

Therefore, no particular recommendation is made on the release of such air contaminants. Of course, precaution shall be paid on the potential releases during the implementation of the U1DP0 Project.

8.3.2 Gaseous Non-radioactive Releases

The Project in itself has no particular consequence on the evolution of pollutant emissions from INPP Units.

However, the new HOB, SBP and the waste incinerator will globally bring additional pollution. Natural gas shall be used as principal combustible. Natural gas is the less polluting combustible, in comparison with other fossil fuels. Light fuel oil can be used as reserve fuel. Additional information is to be found in their related EIA Screening documents (see [99] and [100]).

These installations have to comply to applicable EU norms for emissions, as well as with Lithuanian requirements for air quality (which implies the definition of sufficient height for stacks so that allow the air quality norms are complied with).

8.4 Soil and Underground

8.4.1 Contamination by Radionuclides

The contamination of soils and groundwater by INPP operations was not shown significant and, as the release of radionuclides will decrease again along the implementation of the U1DP0 Project, this issue will remain definitely insignificant.

The U1DP0 inventory of systems and activities, the definition of the most appropriate techniques and interventions, safety analyses and the continual implementation of industrial security rules and high health protection standards will allow for controlling every potential release. Intervention means will also be adapted to the works to be carried out during the implementation of U1DP0.

8.4.2 Contamination by Other Pollutants

The Project involves the use of some chemical reagents that, in case of accidental releases, could contaminate the soil and groundwater.

Recommendations made in this case are:

- The training of workers on the properties, potential impacts and intervention means in case of accidental spill;

- A safe handling of chemicals or polluting substances during storage and use; if necessary, written instruction will be prepared and appropriate tools and individual protection equipment made available;

- Intervention kits will be prepared in function of the products to be handled and made available close to the handling places;

- A regular inspection of installations in which chemicals and polluting substances are present.

An organizational system for quick response will be established and awareness of workers will be increased on this subject. A clean site is an advantage for later – yet to be established - activities.

8.5 Water

8.5.1 Radionuclide Content in the Discharged Water

As mentioned in section 6.4, the releases of radionuclides via the discharged water, resulting from all[80] activities carried out during the defuelling of Unit 1, will be somewhat (by a factor 2-8) lower than those occurring during routine operation of Unit 1. Minimisation of the radionuclide content in the discharged water results mainly from:

- the absence of nuclide production in the MCC after the RFS (activated corrosion products, C^{14}, H^3, fission products release into the MCC from the failed fuel cladding assemblies) and, thus, from the reduction of the radioactive contamination levels in the auxiliary circuits functionally linked to the MCC;

- the progressive reduction of the number of large systems kept in operation (MCC+ PCS), CPS, turbine hall systems, etc.) and, therefore, from the reduction of liquid waste production resulting from the operation of those systems and requiring conditioning prior to the discharge of the non-recycled waters.

Further, the procedures currently implemented during routine operation of the Units, in order to minimise the release of nuclides into the lake, will still be implemented after the RFS (e.g. the recycling, to the largest possible extent, of the evaporator clean condensate in function of the plant needs).

Eventually, a particular effort has been dedicated to:

- the selection of decontamination processes minimising the production of liquid waste requiring conditioning. For example, the CORD process enables to carry out the oxidation and dissolution steps with the same solution, i.e. avoids the drain down and refill of the circuit between the 2 consecutive steps;

- the implementation of the new solid waste treatment facilities minimising the production of the secondary[81] liquid waste.

8.5.2 Liquid Non-radioactive Releases

8.5.2.1 Thermal Aspects

In first instance, the INPP thermal releases have to respect the applicable regulation in matter of water temperature which is established by the normative document LAND-7-95/M-02 "Lake Drūkšiai Water Limit Warming Values and Temperature Control Methodology", NTdoc-0052-318 imposing that water surface temperature cannot exceed 28°C in the minimum 80% of the total lake surface.

The norms set up for the lake water quality must also take into account the applicable EU norms, once the destination of this water body is defined. The Council Directive 78/659/EEC of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support cyprinid fish life (see **Error! Reference source not found.**), sets up the limit value of 28°C that

[80] All activities are: the operation of Unit 1 after the RFS, the modifications to be brought to installations, the processing of the operational waste, the in-line decontamination operations.

[81] Secondary waste is waste which is generated during handling, treatment and disposal of waste.

have to be respected during 98% of the time. The increase of temperature between the intake water and the Lake Drūkšiai water after mixing with the cooling water (downstream of the outlet canal) may not exceed 3°C.

The non respect of the 28°C value was exceptional, due partly to particular weather conditions (high temperatures, no or calm wind).

As it was seen, the RFS U1 will help to respect those obligations. However, during exceptionally hot summer, a conjunction of unfavourable conditions could lead to a non-respect of those obligations. Then, it could be required to reduce the power capacity of the Unit 2 in order to respect the legal context.

Therefore, it is important to pursue the survey of the Drūkšiai lake temperature until the final shutdown of Unit 2.

After the end of the operation of INPP, there could still be scientific interest to monitor the evolution of the lake temperature, together with the water quality.

8.5.2.2 Chemical Aspects

The assessment made in this study in order to identify the environmental impacts of the INPP has not highlighted serious problems related to liquid releases. The regeneration effluents of the demineralization process are neutralised before their release and the rain and drainage sewerage system is equipped with grease/oil separators.

However a particular attention will be paid by INPP to the use of regeneration reagents (sulphuric acid and sodium hydroxide) in order to decrease as much as reasonably possible their use and therefore the release of sulphur and other salts into the lake. For indicative purpose, the implementation in the 90s of a Plant Water Balance programme enabled to reduce the makeup of fresh demineralised water down to some 30,000 m^3/y, i.e. a small fraction of the Makeup Water Production Plant capacity (up to 100 m^3/h).

Particular precautions shall be taken to prevent accidental releases of chemicals and other polluting substances.

The upgrade of the Visaginas Municipal Wastewater Treatment Plant should improve the nitrogen and phosphorus abatement and hence the quality of the lakes Skripki and Drūkšiai. It was recommended to bypass the lake Skripki [35].

8.6 Biodiversity

8.6.1 Effects from Radionuclides

As the releases of radionuclides will decrease, by a factor 2-5, due to the implementation of the U1DP0 Project, the impacts will decrease as well. Therefore, no particular action should be engaged. Naturally, the good practices already implemented during the routine operation of Unit 1 (ALARA policy) will further be implemented during Unit 1 DP0 activities.

8.6.2 Other Effects

The main impact of the implementation of the U1DP0 Project is the decrease of thermal releases by about half. This should lead to positive impacts, as the thermal load discharged will affect stenothermal fish less than with two units in operation.

The evolution of INPP personnel should also decrease the sanitary wastewater effluents, but they will anyway arrive to the Municipal Sewage Wastewater Treatment Plant. This one should be upgraded in the coming years in order to comply with EU norms. In the future, the global eutrophicating releases should decrease.

However, the eutrophication status would not come back to pre-INPP situation. At least, the eutrophication process could be decreased and possibly halted.

Up to now, the impacts were a trophic evolution of the lake with changes in the fish population; the global biodiversity was affected (mainly on stenothermal fish and some vegetal species with, as a result, a decrease in biota diversity) but a new biodiversity pattern has formed. Active measures do not appear to be necessary or even possible.

Nevertheless, a scientific monitoring should be implemented to follow the new evolution of the lake biodiversity and appropriate actions taken if necessary (e.g. in case of biodiversity degradation) (see 9.3).

8.7 Landscape

As the U1DP0 Project does not include activities or works that may affect landscape, there is no particular measure to take for landscape protection.

8.8 Waste Management

Waste Management has been designed specifically for the U1DP0 Project and is the subject of one of the DP documents [**Error! Reference source not found.**]. It is also described in the present Report (Chapter 6, sections 6.4 and 6.5).

The criteria used to design an appropriate waste management programme, in order to reduce the environmental impacts of waste management are:

- on-line control and tracking of the production and location of waste, associated with methods promoting their recycling or re-use;

- control of landfills and the clearing of areas;

- the safe arrangement of the main areas used for the handling and storage of radioactive, toxic and other waste. Those areas, in which the quantities of materials and the risk are highest, will need to incorporate construction characteristics and equipment preventing flooding, leakage, spillage and uncontrolled or inadvertent releases, and to achieve confinement and control if such events were to occur. The design of such areas will include measures preventing uncontrolled access and the risk of fires;

- minimisation of the extent of land required for the storage of radioactive wastes and installations during the latency period. This will require the intensive use of waste production minimisation techniques such as the following:

    - Detailed identification and characterisation of materials prior to dismantling,
    - Classification at the point of origin, elimination of intermediate stages of decontamination prior to dismantling,
    - Minimum secondary waste treatment,
    - Prevention of cross-contamination and recontamination through the control of contaminated materials and of transport vehicles,
    - Reduction of potential sources of risk, preventing the dispersion of materials from storage facilities and intermediate collecting areas and reduction of transport operations;

- application of a flexible fire protection system; flexibility is an essential element, given the changing nature of the situation of the Ignalina NPP during dismantling;

- adequate personnel training, for all the levels and areas of the organisation;

- truck washing station to prevent problems of mud on the roads;

- periodic revision of obligatory safety elements, e.g. fire extinguishers and alarms.

Accordingly, the different issues of waste management for the U1DP0 activities are designed as follows:

- Waste inventories and classification, with:

    - Radiological Inventories,
    - Radioactive Waste Classification,
    - Spent resins, Perlite and Sediments (Group B + C),
    - Solid Waste;

- RAW management Strategy:

    - Decommissioning Waste Minimization,
    - Radioactive Waste Conditioning:

        - Treatment/conditioning techniques,
        - Waste concrete containers types;

- Liquid waste treatment and conditioning;
- Spent Ion Exchange Resins, Perlite and Sediments Treatment and Conditioning;

- Solid Waste Treatment/conditioning:

    - Operational waste stored in Buildings 155, 155/1, 157 and 157/1,
    - Operational, Post-shutdown & Defuelling Phase waste;

- Global Solid Waste Treatment/conditioning;

- Spent Fuel;

- Non-radioactive hazardous waste:

    - Legal framework,
    - Management of operational hazardous waste at INPP,
    - Decommissioning waste.

Additional information can be found in [**Error! Reference source not found.**].

8.9 Prevention of Accidental Releases of Non-radiological Products

The implementation of technical means and management measures aimed at preventing accidental releases, taken within INPP, participate in the prevention of accidental releases of non radiological products.

More specifically:

- Reagents (such as H_2SO_4 and NaOH) and diesel oil are stored in existing tanks, on concrete layer and within a retention system; loading operations are operated in the presence of a member of INPP personnel.

- Lubricating and transformer oils are stored in drums; transformers and drums are located above retention systems. Frequent inspections are made to check for leaks or spills. Adequate tools and sorbents are available in case.

- Hydrogen is kept in tight tanks, in specifically designated areas, with pictograms and alarm systems.

- The personnel who handles such products is trained to protection measures, safe handling and intervention in case of spills.

- Instructions exist on the proper storage of wastes produced during intervention (see waste management).

- In case liquid effluents go into the drainage system, it is still possible to shut valves or sections in order to keep these effluents from being released directly into the lake.

For what concerns fire, the INPP fire prevention and intervention procedures apply. The fire protection organisation and industrial safety during decommissioning is described in the Chapter 8 of the U1DP0 DP documents.
External risks are dealt with as well:

- Earthquakes: though the area is not located in a strong seisms area (level 7 on the MSK-64 scale), the conception of the INPP provides a good protection to sensitive installations; recently, new sensors were installed in a large area around INPP in order to detect the very first signs of a seism and allow for the INPP shutdown systems to operate as quickly as possible; the new buildings to be erected will present an even better seismic protection.
- Flooding: see §6.5.4 and 8.8.
- Sabotage: the physical protection of installations is described in the Chapter 8 of the U1DP0 DP documents.

9 Environment Monitoring Programme

9.1 Introduction

This Chapter of the EIA Report describes the Monitoring Programme that can be implemented in order to follow up the evolution of the environmental components and the impacts of the U1DP0 Project.

The Lithuanian Law on Environmental Monitoring provides the requirements for the country overall environmental monitoring system. Parts of this system, called "monitoring of the environment of economic entities" are performed by the physical and juridical entities that affect the environment and that use natural resources.

Monitoring is the collection of specific data about selected environmental variables (impact indicators) in space and time, with the objective of supplying information on the amplitude and rate of change in these variables (impact indicators) so that, in turn, it allows to assess related environmental impacts. The purpose of the environmental monitoring programme is to detect impacts as they occur, to estimate their magnitude and ensure that they are the consequence of a well identified project or activity. Monitoring includes the follow-up of impacts and their verification against predictions. Monitoring allows also the assessment of the effectiveness of mitigation and remedial measures. This information should be the basis for modifying either the activity or the mitigation measures.

Applied to the U1DP0 Project, these principles become:

- The determination of the real effects of the activities under the U1DP0 Project;
- The direct tracking of the works and possible feedback on work arrangements in order to decrease the environmental impacts;
- The estimation of residual impact to demonstrate compliance with mitigation measures implemented and, finally, with applicable environmental norms.

9.2 INPP Valid Environment Monitoring Programme

The INPP Environment Monitoring Programme includes:

a) monitoring of water quality in the lake and of groundwater (physical – chemical parameters);
b) monitoring of nuclides concentration in the air and atmospheric fallouts;
c) chemical composition monitoring of the discharge channel and storm sewage drainage from the INPP territory ;
d) monitoring of nuclides concentration in the lake, the outlet channel, the rain sewerage system channels and underground water;
e) dose and dose rate monitoring in the buffer (3 km) and supervised (30 km) areas;
f) monitoring of nuclides concentration in the fish, algae, soil, grass, sediments, mushrooms, leaves;
g) monitoring of nuclides concentration in food products (milk, potatoes, cabbage, meat, grain-crops).

The INPP Environment Monitoring Programme includes the monitoring of all the environmental exposure pathways that may exhibit long term concentration effects, such as the sediments, silts, algae, mussels and milk.

The locations of the sampling points, the periodicity of analyses and the sample analytical techniques are determined in the INPP Environment Monitoring Programme (ПТОэд-0410-3В2).

The INPP Environment Monitoring Programme should be regularly adapted along the decommissioning projects to cope with the changes in the nature or importance of performed activities and their related environmental impacts (e.g. changes in abiotic parameters such as lake water level and its natural change, temperature and concentration of pollutants, changes in the organisms communities). This statement will be reviewed in the forthcoming EIA Reports.

We can take into account that the yearly discharges of long lived aerosols are predicted to be comparable[82] to those of the plant during normal operation and that the yearly releases of long lived nuclides via the discharged waters are predicted to be somewhat lower (factor 2) than those prevailing during normal operation. Hence, the current environmental monitoring programme can remain as it is until the RFS of Unit 2 under the responsibility of INPP.

9.3 Scientific Environmental Monitoring Programme

Another thing is the scientific monitoring of the potential evolution in the biocenosis of Lake Drūkšiai. This kind of monitoring pursues other objectives than the current INPP monitoring. It is however of great interest on a scientific point of view. Proposals were made on this subject as a conclusion of the State Research [19]. It is the responsibility of the Authorities and concerned Research Institutes, to establish an appropriate monitoring and the Authorities to provide for funding (in cooperation with the funding institutions established).

9.4 Social and Economic Issues

A social and economic monitoring of Ignalina NPP region was proposed in 2002 [41].

9.5 Environment Monitoring Programme Data Reporting

The data concerning monthly monitoring of air and water effluents should be submitted to the Ministry of Environment and VATESI at the latest week after end of month.

Annual report on results of Environmental Monitoring should be submitted to the Ministry of Environment, VATESI, Radiological Protection Center and Local Authorities before first of April of next year. This report should include:

a) results of all measurements, anticipated in the Monitoring Programme;

b) activities of radionuclides by months;

c) general information concerning realized activities (fulfilled works, generated and treated waste);

d) comparison of radionuclides activities with limits;

[82] However, with a drastic reduction of C^{14} and H^3.

e) releases and contamination changing trends and their analysis, in particular related to the parameters influenced by the implementation of the U1DP0 Project;

f) evaluative doses of members of critical groups, caused by radionuclides; analysis of extraordinary releases of radionuclides into environment;

g) other important information.

Ecological Safety Service (Environment Protection Laboratory and Hazardous Chemical Materials Control Laboratory) of INPP Radiation Protection Department will carry out all activities concerned with environmental monitoring.

Part II Attached Documents

There are attached copies of these documents:

- EIA subjects approval letters;
- Announcements in the press about public meeting for EIA report presentation;
- List of the public proposals regarding the EIA.

The EIA Report approval letter of Visaginas municipal administration

SEKRETORIATAS
Gauta
2004-09-27 Nr. 2994
/

VISAGINO SAVIVALDYBĖS MERAS

VĮ Ignalinos AE generalinio direktoriaus
pavaduotojui – ENT vadovui
Sauliui Urbonavičiui

2004-09-23 Nr. (4.21)-1-2231
Į 2004-08-12 Nr. 10S-4673-(15.15)

DĖL ATASKAITOS DERINIMO

Visagino savivaldybė dėl pateiktos Ignalinos AE pirmojo bloko eksploatavimo nutraukimo projekto U1DPOPAV ataskaitos esminių pastabų neturi.

Savivaldybės mero pavaduotoja Dalia Štraupaitė

Robertas Juknevičius, 31 372
S. Š.

Kodas 188711925
Parko g. 14
31139 Visaginas
Tel. (8 ~ 3 8 6) 31 233
Faks. (8 ~ 3 8 6) 31 286
El. p. meras@visaginas.lt
Atsiskaitomoji sąskaita Nr. LT957300010042144361
AB banke „Hansabankas“
Banko kodas 73000

The EIA Report approval letter of Utena county administration

SEKRETORIATAS
Gauta
2004-09-03 Nr. 2795

UTENOS APSKRITIES VIRŠININKO ADMINISTRACIJA
Kodas 8862574. Aušros g. 22, 28142 Utena. Tel.(8~389) 5 75 00. Faks. (8~389) 5 95 36

Valstybinei įmonei
Ignalinos atominė elektrinė

2004-08-31 Nr. (1.15.)-6-1038
Į 2004-08-12 Nr. 105-4673-(15.15)

DĖL POVEIKIO APLINKAI VERTINIMO ATASKAITOS DERINIMO

Išnagrinėję Ignalinos AE I-ojo bloko eksploatavimo nutraukimo projekto kuro iškrovimo fazei poveikio aplinkai vertinimo ataskaitą (U1DPO PAVA), jai pritariame ir manome, kad I-ojo bloko kuro iškrovimo darbai gali būti vykdomi, kadangi šių darbų poveikis aplinkai minimalus.

Apskrities viršininkas Vilius Cibulskas

Jonas Spietinis (8~389) 6 40 71

The EIA Report approval letter of Utena Regional Environmental Protection Department

SEKRETORIATAS
Gauta
2004-09-13 Nr. 2868

LIETUVOS RESPUBLIKOS APLINKOS MINISTERIJOS
UTENOS REGIONO APLINKOS APSAUGOS DEPARTAMENTAS

Kodas 9074286 Metalo g. 11, 28217 Utena, Tel. 69106 Faks. 69662, El-paštas: utenos.aa@is.lt
Ats. sąsk. Nr. LT 857044060002546370, Vilniaus bankas, banko kodas 70440

Valstybės įmonei Ignalinos atominė elektrinė 2004-09-10 Nr. (5.1)-s-1111
Į 20047-08-12 Nr. 10S-4673-(15.15)

DĖL EKSPLOATAVIMO NUTRAUKIMO POVEIKIO APLINKAI VERTINIMO ATASKAITOS

Pateiktai IAE 1 bloko eksploatavimo nutraukimo projekto kuro iškrovimo fazei poveikio aplinkai vertinimo ataskaitai (U1DPO PAVA) pastabų neturime.

Direktorius Ričardas Vygantas

V. Margelytė, L. Jovaišienė, 69369

The EIA Report approval letter of VATESI

Gauta
2004-11 29 361

VALSTYBINĖ ATOMINĖS ENERGETIKOS SAUGOS INSPEKCIJA (VATESI)

Kodas 8863987 Goštauto g. 12, LT-01108 Vilnius Tel. 2624141, 2661584 Faks. 2614487 El.p. atom@vatesi.lt

IAE Generalinio direktoriaus pavaduotojui
ENT vadovui
✓ Sauliui Urbonavičiui

2004 11 26 Nr. (14.4.17)- 988
Į 2004-11-18 Nr. 10S-6249-(15.15)

DĖL EKSPLOATAVIMO NUTRAUKIMO POVEIKIO APLINKAI VERTINIMO ATASKAITOS DERINIMO

VATESI išnagrinėjusi „IAE 1 bloko Eksploatavimo nutraukimo projekto U1DPO poveikic aplinkai vertinimo ataskaitą", bei įvertinusi atliktas pataisas, derina ją be pastabų.

VATESI viršininkas Saulius Kutas

E.Vaitkus, 2661583, vaitkus@vatesi.lt

The EIA Report approval letter of Health Protection Ministry

LIETUVOS RESPUBLIKOS SVEIKATOS APSAUGOS MINISTERIJA

Kodas 188603472, Vilniaus g. 33, LT-01506 Vilnius, tel. (8~5) 266 14 00, faks. (8~5) 266 14 02, el. p. ministerija@sam.lt, www.sam.lt

Valstybės įmonės Ignalinos atominė elektrinė
Eksploatavimo nutraukimo tarnybai

2005-01-12 Nr. 10-237
Į 2004-12-21 Nr. 10S-6785-(15.15)

DĖL SVEIKATOS APSAUGOS MINISTERIJOS PASTABŲ IAE 1-OJO BLOKO EKSPLOATAVIMO NUTRAUKIMO PAV ATASKAITAI

Išnagrinėję papildomai pateiktus atsakymus ir paaiškinimus VĮ Ignalinos atominė elektrinė 1-ojo bloko eksploatavimo nutraukimo Poveikio aplinkai vertinimo ataskaitos (toliau – PAVA) 3-iajam leidimui, jį deriname.

Tačiau, atsižvelgdami į tai, kad eksploatavimo nutraukimo rėmimo investiciniai projektai: dalinai išdegusio branduolinio kuro perkėlimo operacijos iš Ignalinos AE pirmojo bloko į antrąjį bloką (Eksploatavimo nutraukimo projektas Nr. B8) bei panaudoto branduolinio kuro transportavimo operacijas iš pirmojo bloko į naujai planuojamą įrengti panaudoto branduolinio kuro sausojo tipo laikinąją saugojimo saugyklą (Eksploatavimo nutraukimo projektas Nr. B1), bus rengiami atskirai, anksčiau minėtus projektus derinsime, jeigu bus atsižvelgta į šioje PAVA pateiktas pastabas ir pasiūlymus, kurie tiesiogiai susiję su B1 ir B8 projektais.

Ministerijos sekretorius Romualdas Sabaliauskas

A. Mastauskas, 2644720, el.p. rsc@rsc.lt

The EIA Report approval letter of Lithuanian Fire and Rescue Service

SEKRETORIATAS
Gauta
2004-08-26 Nr. 2721

PRIEŠGAISRINĖS APSAUGOS IR GELBĖJIMO DEPARTAMENTAS
PRIE LIETUVOS RESPUBLIKOS VIDAUS REIKALŲ MINISTERIJOS

VĮ „Ignalinos atominė elektrinė"

2004-08-24 Nr. 9/4-9.4.- 1328
Į 2004-08-12 Nr.108-4673-(1515)

DĖL IGNALINOS ATOMINĖS ELEKTRINĖS 1 BLOKO EKSPLOATAVIMO NUTRAUKIMO POVEIKIO APLINKAI VERTINIMO ATASKAITOS

Priešgaisrinės apsaugos ir gelbėjimo departamentas, išnagrinėjęs Jūsų specialistų parengtą Ignalinos atominės elektrinės 1 bloko eksploatavimo nutraukimo projekto U1DPO poveikio aplinkai vertinimo ataskaitą, pagal savo kompetenciją pastabų ir pasiūlymų neturi.

Direktoriaus pavaduotojas
Vyriausiasis valstybinės priešgaisrinės
priežiūros inspektorius

Zenonas Praniauskas

Dalius Ūba, (8~5) 271 6818

Kodas 8860131. Švitrigailos g.18, LT-03223 Vilnius. Tel. (8 ~ 5) 271 6866. Faks. (8 ~ 5) 216 3494. El.p. pagd@vpgt.lt

The EIA Report approval letter of Heritage protection department

SEKRETORIATAS
Gauta
2004-08-25 Nr. 2707
/

KULTŪROS VERTYBIŲ APSAUGOS DEPARTAMENTAS
PRIE LIETUVOS RESPUBLIKOS KULTŪROS MINISTERIJOS

Valstybės įmonei Ignalinos atominė elektrinė

2004-08-23 Nr. (1.29)-2-840
Į 2004-08-12 Nr. 10S-4673-(15.15)

DĖL IGNALINOS ATOMINĖS ELEKTRINĖS 1 BLOKO EKSPLOATAVIMO NUTRAUKIMO POVEIKIO APLINKAI VERTINIMO ATASKAITOS DERINIMO

Išnagrinėję Jūsų parengtą „IAE 1 bloko Eksploatavimo nutraukimo projekto U1DP0 poveikio aplinkai vertinimo ataskaitą", informuojame, kad pastabų bei pasiūlymų šiai ataskaitai neturime.

Direktorė Diana Varnaitė

Rimantas Kraujalis, 272 40 10, rimas@heritage.lt

Kodas 8869268, Šnipiškių g. 3, LT-09309 Vilnius, tel. (8~5) 273 42 56, faks. (8~5) 272 40 58, el.paštas: centras@heritage.lt

Announcement in *Lietuvos Rytas*, 2004 08 13

siliepimo nepateiks, teismas
į priimti sprendimą už akių.

rajono apylinkės teisme (Auš-
, Varėna) iškelta civilinė byla
zūkijos nacionalinio parko di-
pareiškimą dėl pastatų: gyve-
namo, 90,54 m², unikalus
30-0034-01-7, pažymėtas pla-
(p); ūkinio pastato, 24 m², uni-
. 38/980-0034-02-8, pažymė-
2I1p; garažo 22 m², unikalus
30-0034-03-9, pažymėtas pla-
ūkinio pastato, 29 m², unika-
8/980-0034-04-6, pažymėtas
1p, ūkinio pastato, 37 m², uni-
. 38/980-0034-05-0, pažymė-
5I1; kiemo statinio (šulinio ir
alus Nr. 38/980-0034-06-0,
ų 1980 metais, esančių Mar-
kaime, Varėnos rajone, val-
kto patvirtinimo. Nuo 1995 04
ol pastatus valdo Dzūkijos na-
o parko direkcija. Suinteresuo-
menims siūlome per tris mė-
reiptis su pareiškimais į Varė-
no apylinkės teismą dėl savo
urodytus pastatus.

rugsėjo 7 d. 10.30 val. Kau-
ardos administraciniame teis-
.Čiurlionio g. 33, Kaunas) bus
ama administracinė byla pa-
iškėjų Editos Gintarės Tuni-
Ligijos Nijolės Tunikienės
atsakovui Kaino SĮ „Kapinių
", tretieji suinteresuoti asme-
uno miesto savivaldybė, Vik-
žimienė, Valdemaras Olšaus-
Kauno SĮ „Kapinių priežiūra"
gruodžio 31 d. leidimo pa-
o bei įpareigojimo pašalinti
į pažeidimą.

Pamestas Laimos Stankaitienės įmonės pažymėjimas (įm. kodas 4472807, reg. 1993 06 28 Šiaulių m., Draugystės pr. 12-65). Tel. (8-698) 7 45 42.

Vilniaus aukštesniosios transporto mokyklos diplomą B Nr. 135253, išduotą Rasai Rožaitienei, laikyti negaliojančiu.

Diplomą, priedą prie diplomo UK Nr.000014, išduotą Dainai Pavilonytei Utenos kolegijos, laikyti negaliojančiu.

Dingusį Daivos Bingelytės Kauno P.Mažylio medicinos mokyklos diplomo LT Nr.193601 priedą laikyti negaliojančiu.

Studijų knygelę Nr. 91-233, išduotą VPI 1991 m. Vidai Pivoriūtei, laikyti negaliojančia.

tis iki 2004 08 18 d.

Individuali įmonė LIUKARTAS perregistruojama į UAB „LIUKARTAS".

tacijos" (įm. kodas 2516483, Žalgirio g. 114, Vilnius) keičia savo pavadinimą. Naujas pavadinimas yra UAB „GELVORA".

AB banko „NORD/LB Lietuva"

INFORMACIJA VERSLO KLIENTAMS

Nuo 2004 m. rugpjūčio 20 d. įsigalioja nauji įkainiai.

Grynųjų pinigų perskaičiavimas, nepriklausomai nuo po to atliekamų operacijų:
Centų:
iki 10 Lt – nemokamai;
daugiau kaip 10 Lt – 3 proc. nuo sumos.
Litų monetų:
iki 100 Lt – nemokamai;
daugiau kaip 100 Lt – 1,5 proc. nuo sumos.
Banknotų:
iki 1000 Lt – nemokamai;
daugiau kaip 1000 Lt – 0,035 proc. nuo sumos.

NORD/LB

Dėl visuomenės informavimo ir dalyvavimo poveikio aplinkai vertinimo procese

Valstybės įmonė Ignalinos atominė elektrinė planuoja ūkinę veiklą „IAE eksploatavimo nutraukimas". Pagal š.m. gegužės 27 d. Aplinkos ministerijos patvirtintą poveikio aplinkai vertinimo (PAV) programą IAE parengė ataskaitą „IAE 1 bloko eksploatavimo nutraukimo projektas kuro iškrovimo fazei. Poveikio aplinkai vertinimo ataskaita".

Viešas supažindinimas su šia PAV ataskaita įvyks 2004 09 07 17 val. IAE Informacijos centro salėje (102 kabinetas, 31 pastatas).

Su PAV ataskaita darbo laiku galima susipažinti:

- IAE Eksploatacijos nutraukimo tarnyboje, 408 kabinetas, 31V pastatas;
- IAE Informacijos centre, 106 kabinetas, 31 pastatas.

Kontaktiniai duomenys teikti pasiūlymams (iki š.m. rugsėjo 7 d.) PAV klausimais bei pasiteirauti:

V.Kačka, tel. (8-386) 2 43 88, faksas (8-386) 24387, el.p: kachka@mail.iae.lt, IAE ENT, 408 kabinetas, 31V pastatas, LT-31500.

(Užs. 4AVIL-1385)

Announcement in *V Kazdyj Dom* (Visaginas), 2004 08 13

- gyvenamą plotą.

Prašome siųsti CV iki 2004-08-25 lietuvių kalba, nurodžius telefono numerį, faksu (8-386) 34186, el.paštu: vpm@ vpm.lt

32*11

Dėl visuomenės informavimo ir dalyvavimo poveikio aplinkai vertinimo procese

Valstybės įmonė Ignalinos atominė elektrinė planuoja ūkinę veiklą "IAE eksploatavimo nutraukimas".
Pagal š. m. gegužės 27 d. Aplinkos ministerijos patvirtintą poveikio aplinkai vertinimo (PAV) programą IAE parengė ataskaitą
"IAE 1 BLOKO EKSPLOATAVIMO NUTRAUKIMO PROJEKTAS KURO IŠKROVIMO FAZEI. POVEIKIO APLINKAI VERTINIMO ATASKAITA".

Viešas supažindinimas su šia PAV ataskaita įvyks 2004-09-07 17 val. **IAE Informacijos centro salėje (102 kabinetas, 31 pastatas).**

Su PAV ataskaita darbo laiku galima susipažinti:

- IAE Eksploatacijos nutraukimo tarnyboje, 408 kabinetas, 31V pastatas;
- IAE Informacijos centre, 106 kabinetas, 31 pastatas.

Kontaktiniai duomenys teikti pasiūlymams (iki š. m. rugsėjo 7 d.) PAV klausimais bei pasiteirauti:
V. Kačka, tel. nr.: (8-386) 24388, faksas: (8-386) 24387, el. paštas: kachka@mail.iae.lt, IAE ENT, 408 kabinetas, 31V pastatas, LT-31500.

Об информировании и участии общественности в процессе оценки влияния на окружающую среду

Государственное предприятие «Игналинская атомная электростанция» планирует хозяйственную деятельность
«СНЯТИЕ С ЭКСПЛУАТАЦИИ ИАЭС».
Согласно программе оценки влияния на окружающую среду (ОВОС), утвержденной 27 мая с. г. Министерством окружающей среды, ИАЭС подготовила отчет
«ПРОЕКТ СНЯТИЯ С ЭКСПЛУАТАЦИИ I БЛОКА ИАЭС НА ФАЗУ ВЫГРУЗКИ ТОПЛИВА. ОТЧЕТ ПО ОЦЕНКЕ ВЛИЯНИЯ НА ОКРУЖАЮЩУЮ СРЕДУ».

Публичное представление данного отчета по ОВОС состоится 2004-09-07 с 17.00 в зале информационного центра ИАЭС (102 кабинет, 31 здание).

С отчетом по ОВОС в рабочее время можно ознакомиться:

- в службе снятия с эксплуатации ИАЭС, помещение 408, здание 31В;
- в информационном центре ИАЭС, помещение 106, здание 31.

Контактные данные для предложений (до 7 сентября с. г.) по вопросам ОВОС и справок:
В.Качка, тел.: (8-386) 24388, факс: (8-386) 24387, эл. почта: kachka@mail.iae.lt, ССЭ ИАЭС, 408 кабинет, здание 31В, LT-31500.

32*07

Visagino miesto apylinkės teisme (Taikos pr. 80a, Visaginas) yra gauti ieškininiai pareiškimai dėl įsiskolinimų išieškojimo iš Leono CHUSAINOVO ir Valerijaus ANDREJEVO. Civilinės bylos dėl įsiskolinimų išieškojimo bus nagrinėjamos 2004-09-08 11 val.

32*09

Ina"
ты "Летувос ритас".
айдишкес, Соду, 83.
Заказ No

Редакция не несет ответственности за содержание рекламы и статей, публикующихся на правах рекламы.

Претензии по доставке не принимаются, если ваш почтовый ящик неисправен.

Announcement in *Nauja Vaga* (Ignalina), 2004 08 14

DĖL VISUOMENĖS INFORMAVIMO IR DALYVAVIMO POVEIKIO APLINKAI VERTINIMO PROCESE

Valstybės įmonė Ignalinos atominė elektrinė planuoja ūkinę veiklą „IAE eksploatavimo nutraukimas". Pagal š. m. gegužės 27 d. Aplinkos ministerijos patvirtintą poveikio aplinkai vertinimo (PAV) programą IAE parengė ataskaitą „IAE 1 bloko eksploatavimo nutraukimo projektas kuro iškrovimo fazei. Poveikio aplinkai vertinimo ataskaita".

Viešas supažindinimas su šia PAV ataskaita įvyks 2004-09-07 17 val. IAE Informacijos centro salėje (102 kabinetas, 31 pastatas).

Su PAV ataskaita darbo laiku galima susipažinti:

IAE Eksploatacijos nutraukimo tarnyboje, 408 kabinetas, 31V pastatas;

IAE Informacijos centre, 106 kabinetas, 31 pastatas.

Kontaktiniai duomenys teikti pasiūlymams (iki š. m. rugsėjo 7 d.) PAV klausimais bei pasiteirauti:

V.Kačka, tel. (8-386) 24388, faksas (8-386) 24387, el. paštas kachka@mail.iae.lt, IAE ENT, 408 kabinetas, 31V pastatas, LT-31500

Steigėja ir leidėja UAB
Nauja vaga
Laikraštis įsteigtas 1951 05 07
REDAKTORĖ
LAIMA MILIUVIENĖ
TEL. 52474
El. paštas: **naujavaga@takas.lt**

Redaktorės pavaduotoja Vida **GASPARAVIČIENĖ**
Tel.: **54161, (8 -614) 16818,**
Mamertas **KRAPAUSKAS** (gamyba, socialiniai klausimai),
Leonas **MEILUS** (laiškai, žemės ūkis, teisėsauga) **- 52350,**
Danutė **SURVILIENĖ**, Laimonas **MILIUS** (kompiuteriai),
Milda **RIMŠELIENĖ** (korektūra) **- 52563.**

Laikraštis leidžiamas lietuvių kalba trečiadieniais ir šeštadieniais. Tiražas 1920
Apimtis - 2 spaudos lankai. Spausdino UAB Ignalinos spaustuvė.

Announcement in *ZarasuKrastas* (Zarasai), 2004 08 13

Nr. 64 (8436). 2004 m. rugpjūčio 13 d. ZARA

Dėl visuomenės informavimo ir dalyvavimo poveikio aplinkai vertinimo procese

Valstybės įmonė Ignalinos atominė elektrinė planuoja ūkinę veiklą "IAE eksploatavimo nutraukimas". Pagal šių metų gegužės 27 d. Aplinkos ministerijos patvirtintą poveikio aplinkai vertinimo (PAV) programą IAE parengė ataskaitą "IAE 1 bloko eksploatavimo nutraukimo projektas kuro iškrovimo fazei. Poveikio aplinkai vertinimo ataskaita".

Viešas supažindinimas su šia PAV ataskaita įvyks **2004-09-07, 17 val.**, IAE Informacijos centro salėje (kabinetas Nr. 102, 31 pastatas).

Su PAV ataskaita darbo laiku galima susipažinti:

*IAE Eksploatacijos nutraukimo tarnyboje, kabinetas Nr. 408, 31 V pastatas;

*IAE Informacijos centre, kabinetas Nr. 106, 31 pastatas.

Kontaktiniai duomenys teikti pasiūlymams (iki šių metų rugsėjo 7 d.) PAV klausimais bei pasiteirauti: V. Kačka, tel. (8*386) 24388, faksas (8*386) 24387, el. paštas: kachka@mail.iae.lt ; IAE ENT, kabinetas Nr. 408, 31 V pastatas, LT-31500 Visaginas.

Zarasų rajono savivaldybės Dusetų komunalinio ūkio įmonė skelbia viešą konkursą patalpų, skirtų šarvojimo salei įrengti, nuomai adresu: Vilniaus g. 8, Dusetos. Pradinė nuomos kaina 303 litai (su PVM). Nuomos trukmė 10 m.

Paraiškų pateikimo terminas 15 kalendorinių dienų.

Paraiškos pateikiamos adresu: V. Bukauskui, K. Būgos g. 31a, Dusetos, tel. 56858.

Bankas NORD/LB Lietuva 40100, sąsk. Nr. LT134010040300030072

Proposals of the public regarding the EIA

There was not received any proposals of the public regarding the INPP Decommissioning EIA until 2004-12-01.

Protocol of the EIA Report public presentation

Viešo supažindinimo
su Ignalinos AE 1 bloko eksploatavimo nutraukimo projekto kuro iškrovimo fazei
poveikio aplinkai vertinimo ataskaita (U1DP0 PAVA)
susirinkimo protokolas

2004 m. rugsėjo 7 d., IAE Informacinis centras

Susirinkimo pirmininkas: V.Ledzinskas.
Susirinkimo sekretorė: M. Lukomskaja.

Atvyko PAV ataskaitos rengėjai JP. Tack, V. Kačka, B. Centner. Taip pat stebėti susitikimą atvyko Europos rekonstrukcijos ir plėtros banko atstovas L. Blank.

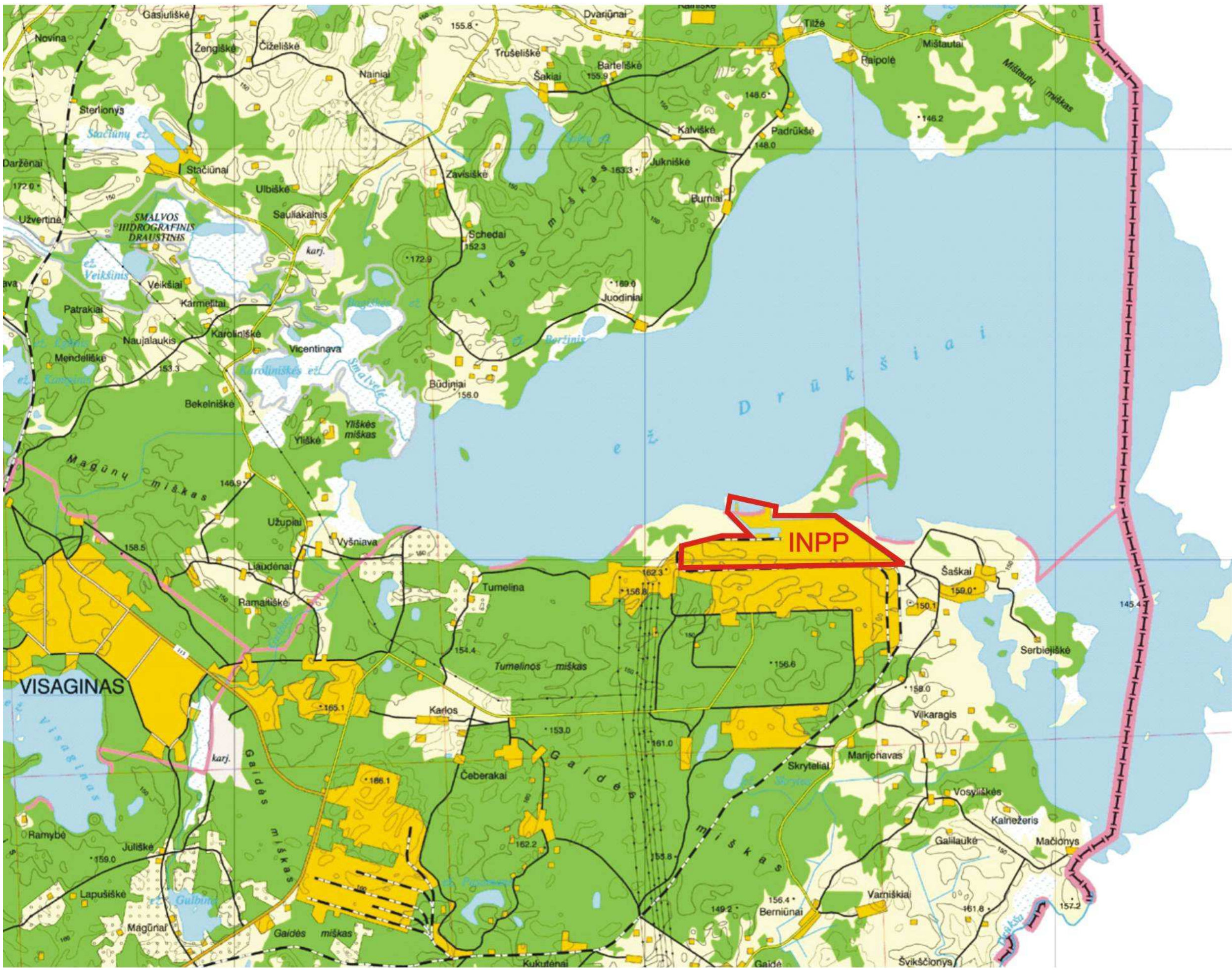
Viešo supažindinimo susirinkimo pradžia buvo paskelbta 17:00. Buvo laukiama nuo 16:30 iki 18:00, tačiau neatvyko nė vienas visuomenės atstovas. Konstatuojame, kad visuomenė nėra suinteresuota planuojama ūkine veikla.

Susirinkimo pirmininkas: — V.Ledzinskas

Susirinkimo sekretorė: M. Lukomskaja

Part III Graphic Materials

Appendix 1 Topographic Map of the INPP Environs



Appendix 2 Excerpt from the Territorial Planning Register

VALSTYBĖS ĮMONĖS REGISTRŲ CENTRO UTENOS FILIALAS
Utenio a. Nr. 7, 4910 Utena

PAŽYMĖJIMAS
APIE NEKILNOJAMOJO DAIKTO IR DAIKTINIŲ TEISIŲ Į JĮ
ĮREGISTRAVIMĄ NEKILNOJAMOJO TURTO REGISTRE
2003-07-04

1. Nekilnojamojo turto registre įregistruotas turtas: registro įrašo Nr. 44/22151
Adresas: **Visagino sav. Karlų k.**

---

2. Nekilnojamieji daiktai:

2.1. **Žemės sklypas**

Unikalus Nr.: **4400-0030-6969**
Kadastrinis adresas: **4535/0002:5 Karlų k.v.**
Paskirtis: **Kita (kitai specialiai paskirčiai)**
Bendras žemės sklypo plotas: **899.0794 ha**
Miško plotas: **245.7660 ha**
Matavimų tipas: **Žemės sklypas suformuotas atliekant kadastrinius matavimus**
Kadastro duomenų fiksavimo data: **2000-09-04**
Žemės sklypo vertė (indeksuota): **8362689 Lt**

3. Daikto priklausiniai iš kito registro: įrašų nėra

4. Nuosavybė:

4.1. **Nuosavybės teisė**

Savininkas: **LIETUVOS RESPUBLIKA , a.k. 4400**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**

5. Valdymas:

5.1. **Valdymas**

Valdytojas: **UTENOS APSKRITIES VIRŠININKO ADMINISTRACIJA , a.k. 8862574**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**

6. Kitos daiktinės teisės :

6.1. **Kelio servitutas - teisė naudotis pėsčiųjų taku (tarnaujantis daiktas)**
Leisti kitiems asmenims prieiti prie paviršinių vandens telkinių (sevituto plotas 10 m.) paž. indeksais "40.1", "40.2" (ež. Drūkšiai ir ež. Skrytas)

Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **6.6608 ha**

6.2. **Kelio servitutas (tarnaujantis daiktas)**
Leisti kiteims asmenims naudotis privažiavimo keliu paž. indeksu "20"

Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **2.3905 ha**

Lapas 2 iš 3

7. Juridiniai faktai:

7.1. **Sudaryta panaudos sutartis**
Panaudos gavėjas: **VALSTYBĖS ĮMONĖ "IGNALINOS ATOMINĖ ELEKTRINĖ" , a.k. 5545008**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Panaudos sutartis , 2003-07-02, Nr. PN45/03-0071**
Plotas: **899.0794 ha**
Terminas: **Nuo 2003-07-02 iki 2102-07-02**

8. Žymos: įrašų nėra

9. Specialios naudojimo sąlygos:

9.1. **Pelkės ir šaltinynai**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **64.796 ha**

9.2. **Valstybinio geodezinio pagrindo punktų apsaugos zonos**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **0.007 ha**

9.3. **Vandens telkinių apsaugos juostos ir zonos**
ež. Drūkšių ir Skryto
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **223.8132 ha**

9.4. **Miško naudojimo apribojimai**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **245.766 ha**

9.5. **Gamybinių ir komunalinių objektų sanitarinės apsaugos ir taršos poveikio zonos**
Ignalinos atominė elektrinė
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **899.0794 ha**

9.6. **Kelių apsaugos zonos**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **23.0777 ha**

9.7 **Geležinkelio ir jų įrenginių apsaugos zona**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **25.605 ha**

9.8. **Elektros linijų apsaugos zonos**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **8.1229 ha**

9.9 **Vandentiekio, lietaus ir fekalinės kanalizacijos tinklų ir įrenginių apsaugos zonos**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas. **55.103 ha**

9.10. **Šilumos ir karšto vandens tiekimo tinklų apsaugos zonos**
Daiktas. **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**

Lapas 3 iš 3

Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **24.842 ha**

9.11. **Ryšių linijų apsaugos zonos**
Daiktas: **žemės sklypas Nr.4400-0030-6969, aprašytas p. 2.1.**
Juridinis pagrindas: **Apskrities viršininko įsakymas, 2003-06-20, Nr. 14-293**
Plotas: **4.1388 ha**

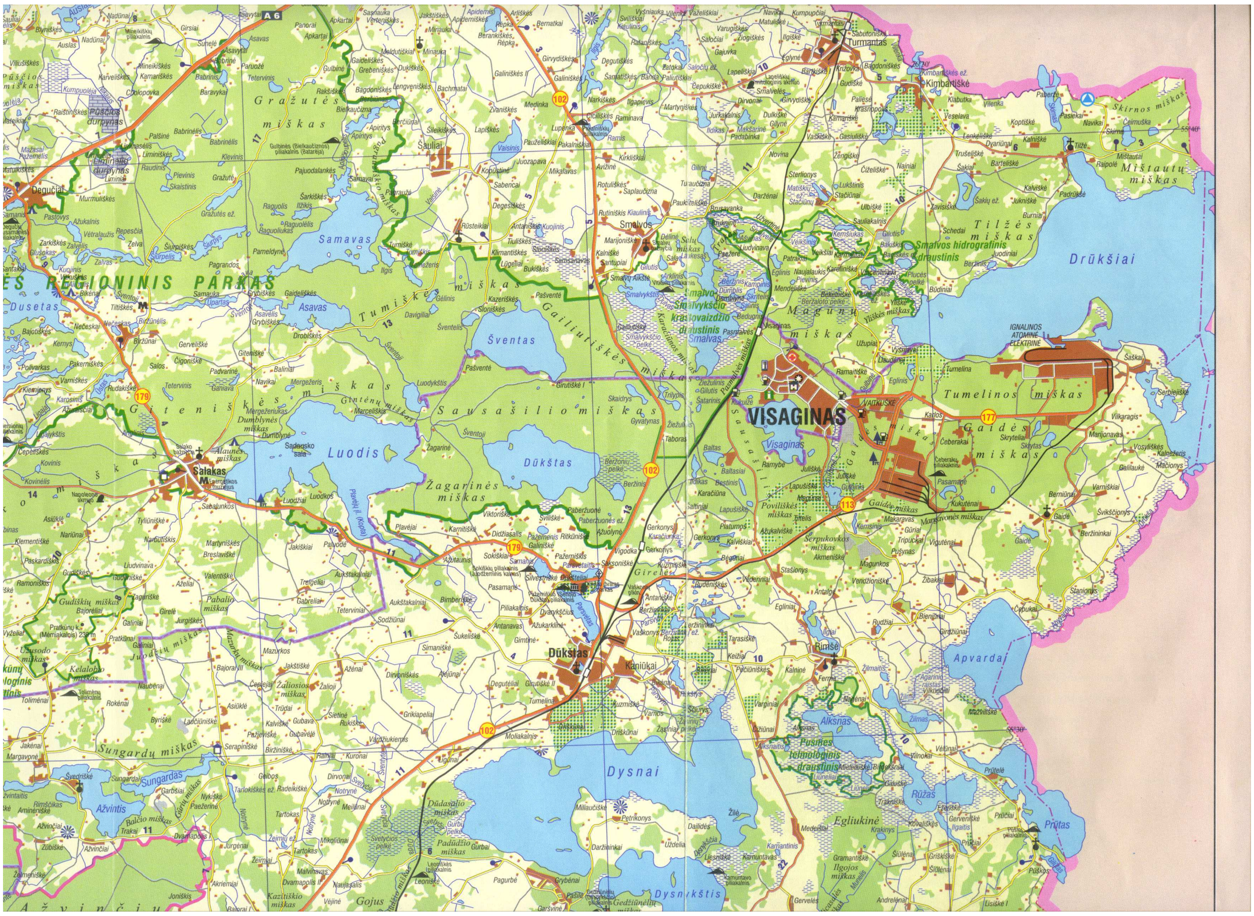
10. Daikto formavimas: įrašų nėra

11. Registro pastabos: įrašų nėra

12. Kita informacija:

Pažymėjimą išdavė Enrikas DOVJAKOVSKIS

Appendix 3 Land Use Map



Appendix 4 Landscape: Photographic Report

Figure 1. View from the east, on INPP Units 1 & 2, and partly built (abandoned) Unit 3.

Figure 2. View on the south-eastern part of Lake Drukshiai. Some islands can be seen.

Figure 3. View on the warmed cooling water release and outtake channel

Figure 4. View on the closest dwellings (few houses) to the INPP.

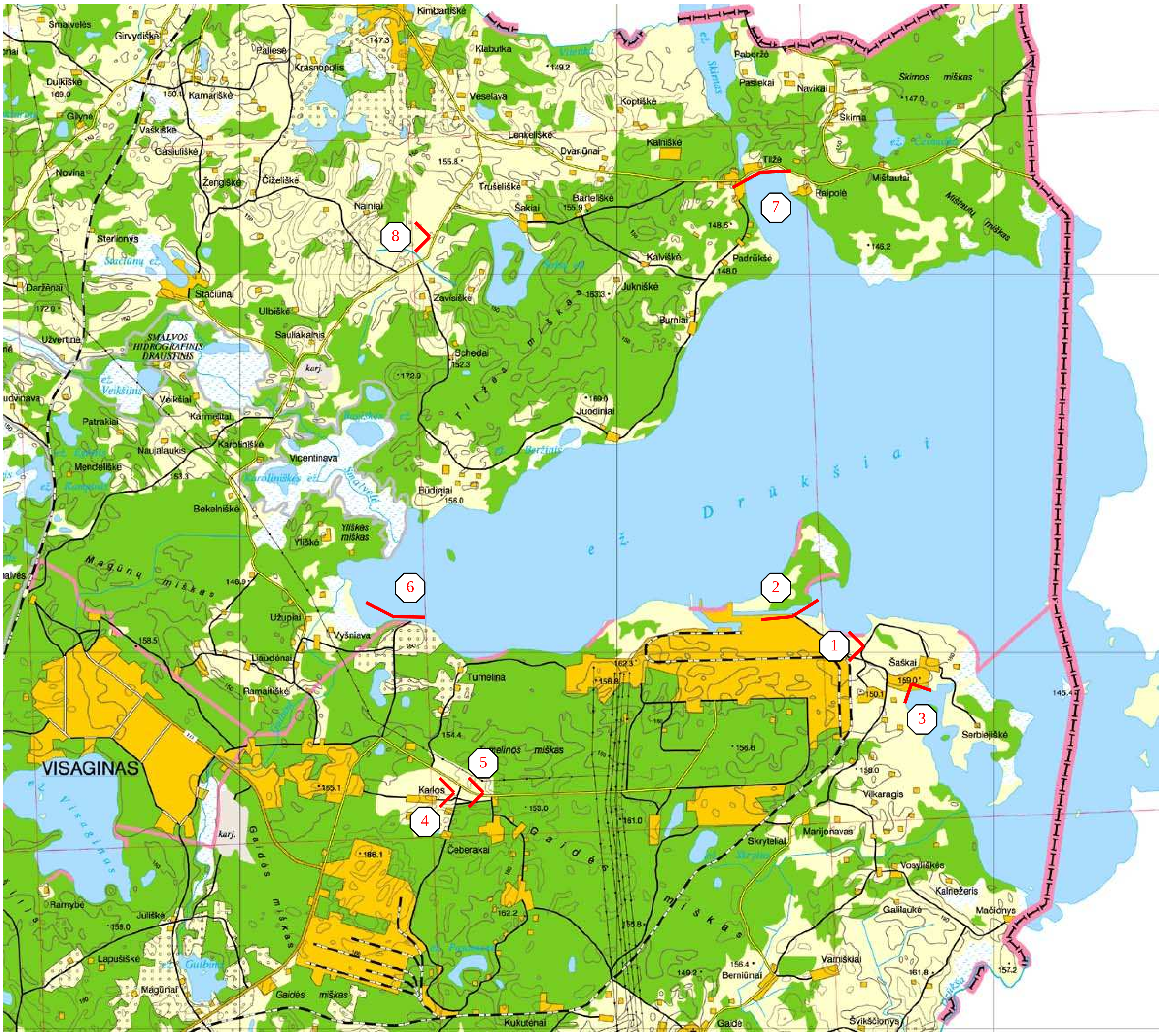
Figure 5. View on the road from INPP to Visaginas. The landscape is composed of pineyards, marshes and some agricultural parcels

Figure 6. View on the south western part of the Lake Drukshiai. The Vyšniava village is behind the photographer.

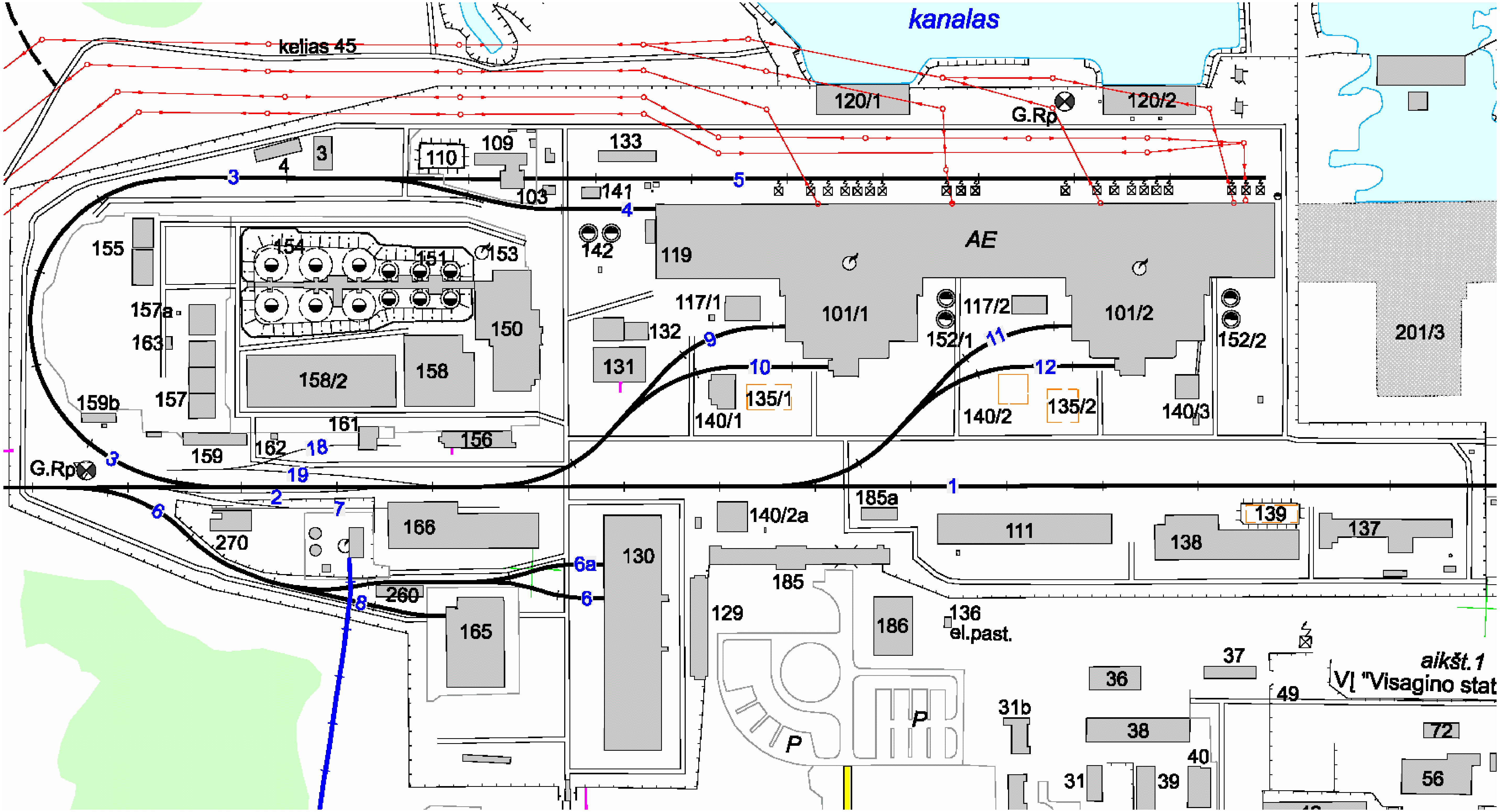
Figure 7. View of the lake from the northern bank. The INPP stacks are hidden by the peninsula on the right.

Figure 8. Typical marsh landscape.

Appendix 5 Location of the Picture Shots



Appendix 6 General Panorama of the Ignalina NPP



Legend of the main INPP buildings:

101/1 - Main plant Unit 1, 101/2 - Main plant Unit 2, 201/3 – structures of Unit 3, 117/1 and 2 - Pressurised tanks of the ECCS, 119 – Heat supply station, 120/1 and 2 - Service water pump station, 129 - Administrative building, 130 - Repair building, 135/1 and 2 - Gas holding chambers, 140/1 and 3 - Sanitary passageways, 140/2 - Industrial waste storage, 150 - Liquid waste treatment building, 151 - Waste water tanks, 152/1 and 2 - Low-salt water tanks, 154 - Operational water reservoirs, 155 - Solid low-level waste storage facility, 156 - Special laundry, 157 and 157a - Solid radwaste storage facilities, 158 - Bituminized radwaste storage facility, 159 - Vehicle washing facility, 159b - Free release facility for industrial waste, 165 - Fresh fuel storage, 185 - Administrative building.

Appendix 7 Locations of Existing and New Spent Fuel Interim Storage (B1) Facilities and New Solid Radioactive Waste Retrieval, Management and Interim Storage Facility (B2/3/4)