STATE ENTERPRISE
IGNALINA NUCLEAR POWER PLANT

REPORT ON THE IMPLEMENTATION OF THE POST-PROJECT ANALYSIS PROGRAMME FOR THE NEW INPP NUCLEAR INSTALLATIONS

REPORT ON EVALUATION OF THE ENVIRONMENTAL MONITORING RESULTS DURING THE OPERATION OF THE INTERIM SPENT FUEL STORAGE FACILITY (B1 PROJECT) AND THE SOLID RADIOACTIVE WASTE RETRIEVAL FACILITY (B2-1 AND B2-2 PROJECT)

2022

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1 INTRODUCTION

The purpose of the present document is to provide the information on the implementation of the post-project analysis for the new Ignalina NPP nuclear installations for which transboundary environmental impact assessment has been carried out pursuant to the Convention on Environmental Impact Assessment in a Transboundary Context of the United Nations Economic Commission for Europe (Espoo, 1991), in order to ascertain that operation of nuclear installations newly constructed on the Ignalina NPP site and the overall decommissioning activities carried out on the INPP site do not have and will not have significant adverse transboundary impact and is in line with the assessments and safety substantiations made during the environmental impact assessment and safety analysis stage. The following newly constructed on the INPP site spent nuclear fuel and radioactive waste management facilities include:

- Dry Type Interim Spent Nuclear Fuel Storage Facility (ISFSF, B1 Project);
- Solid Waste Management and Storage Facilities (SWMSF, B2/3/4 Project) consisting of Solid Waste Retrieval Facility (SWRF, B2 Project) and Solid Waste Treatment and Storage Facility (SWTSF, B3/4 Project);
- Landfill Disposal Facility for Short-Lived Very Low-Level Waste (Landfill Repository, B19 Project).

Therefore, for the transparent implementation of the Post-Project Analysis Programme for the New Ignalina NPP Nuclear Installations the Ignalina NPP [1] made a compilation of the annually conducted monitoring results with the purpose to demonstrate that the objectives of the post-project analysis as set in the Espoo Convention:

- Monitoring of the compliance with the safe operation conditions and limits as set out in the design of the installation approved in the established manner and assessment of the effectiveness of the impact mitigation measures;
- Review of a potential impact for proper implementation of appropriate measures and to prepare to take actions for coping with uncertainties;
- Verification of previously made predictions in order to transfer the gained experience to implement the future activities of the same type,

are fully fulfilled and the obtained monitoring results have not indicated any negative impact to the health of the population and the environment of the neighbouring countries.

By continuously and systematically carrying out the environmental radiological monitoring both during the normal operation conditions and in case of potential emergency situations, the INPP seeks:

- to limit radionuclide pathways into the environmental components, thus protecting the INPP personnel, the population and the environment against hazardous radionuclide impact, as well as to forecast contamination effects;
- to prove conformity with the discharge limits set for airborne and waterborne discharges and that determined exposure doses of the personnel and the population do not exceed the limit dose values;
- to analyse and assess efficiency of the implemented environmental protection measures;
- to accumulate, analyse and submit to the state institutions and the population the information on the environment condition on the INPP territory and the sanitary protection zone, including the interested neighbouring countries in implementing the provisions of the Espoo Convention.

The present report contains a brief overview of the operation of the three newly commissioned nuclear installations, i.e. the Interim Spent Fuel Storage Facility (B1 Project), the Solid Radioactive Waste Retrieval Facility, RU-1 (B2-1 Project) and the Solid Radioactive Waste Retrieval Facility, RU-2, RU-3 (B2-2 Project) that have started their commercial operation and the potential impact related to their operation to the population and the environment, including also assessment of the results of the cumulative impact produced by all the INPP nuclear installation located on the INPP site to the population and the environment. The impact of the other two already constructed and commissioned nuclear facilities referred to above: Solid Radioactive Waste Treatment and Storage Facility (B3/4 Project), the permit for commercial operation of this facility was obtained on 28 March 2022, and Landfill Disposal Facility for Short-Lived Very Low-Level Waste (B19 Project), the permit for transportation of nuclear fuel cycle materials on the disposal facility site and to start tests with the nuclear fuel cycle materials was obtained on 31 March 2022, will be analysed in the post-project report for year 2022.

1.1. Interim Spent Nuclear Fuel Storage Facility

The ISFSF is located within approximately 0.5 km to the south of the INPP Units. The territory of the ISFSF occupies 5.93 ha. The ISFSF site is connected to the INPP via railway as well as the road connection. The transfer of the casks to the ISFSF is performed by the rail transport. The ISFSF main storage building is licensed for the interim storage of 201 CONSTOR® RBMK1500/M2 casks loaded with spent fuel assemblies. However, the volume of leaktight, damaged and experimental nuclear fuel temporary stored within the INPP units corresponds to the loading of 190 casks. 22 casks out of the total number of casks are dedicated for storage of damaged and experimental fuel bundles. Therefore, the design of the ISFSF main storage building provides sufficient storage capacity to house all the nuclear fuel (including untight and heavily damaged).

Three basic areas are distinguished at the main ISFSF storage building: Reception Hall, Storage Hall, and Fuel Inspection Hot Cell. The building and all the structures were designed taking into consideration the seismic loads and explosion impact. The building stability calculations were performed in compliance with the requirements of valid normative documents considering the initial impact data of the seismic loads and explosion wave.

CONSTOR® RBMK1500/M2 casks are designed as dual-purpose casks for storage and transport after expiration of the storage period. They meet the ISFSF requirements for storage period of not less than 50 years from the scheduled completion of transfer of all SNF into the ISFSF without any need for scheduled intervention during the entire storage period plus an allowance of 5 years for the subsequent transport of the fuel to the final storage site. The storage configuration of the cask CONSTOR®RBMK1500/M2 loaded with 91 Spent Fuel Assembles or 182 Fuel Bundles is 102 FB in the 32M Basket and 80 FB in the Ring Basket.

Construction of the ISFSF was completed in October 2014. Nuclear Safety Requirements BSR-3.1.1-2016 "General Requirements for Dry Type Storage for Spent Nuclear Fuel" [2] and Nuclear Safety Requirements BSR-1.8.5-2018 "Commissioning of Nuclear Facility" [3] establish requirements for development of the commissioning programmes of the storage facility (General, "Cold" and "Hot" trial programmes), performance of the "Cold" and "Hot" trials and development of reports following the completion of these trial programmes. Nuclear Safety Requirements BSR-3.1.1-2016 "General Requirements for Dry Type Storage for Spent Nuclear Fuel" [2] were developed taking into consideration the IAEA recommendations provided in the Safety Guide SSG-15 "Storage of Spent Nuclear Fuel" [4]. During the period of 2016-2017 the "Cold" and later "Hot" Trial (using the radioactive materials) programmes were successfully performed and the appropriate performance report were developed and approved by VATESI. Based on the conclusion of the State Commission on the Construction

Completion that the constructed Storage Facility meets the design requirements and approved "Cold" trial performance report, on 20 September 2016 VATESI issued the ISFSF operational licence. The permit for commercial operation of the ISFSF was issued by VATESI on 5 May 2017 after approval of the „Hot" trial performance report.

Start-up of the commercial operation of the ISFSF led to completion of defueling of Unit 2 Reactor on 28 February 2018, thus enabling to start defueling of the INPP spent fuel storage pools. By 13 August 2020 only leaktight fuel assemblies were loaded into storage casks and transported for storage to the ISFSF. In September 2020 handling and transportation for storage of the damaged fuel was started at Unit 1.

The Special Damage Fuel Handling System was designed for damaged and experimental nuclear fuel removal from the cooling pools, their processing in pools and insertion of the individual fuel bundles into cartridges for subsequent loading into the CONSTOR® RBMK1500/M2 casks. The safety justification and design documents of the equipment for handling of the damaged and experimental fuel assemblies including all aspects related to the risk assessment during the handling process were performed within the scope of the safety case development and were approved by the regulatory body, including performance of the "Hot" trial in accordance with the Commissioning Programme and approval of the Report and the Final Safety Analysis Report.

During 2021, in total 15 casks filled with the spent nuclear fuel were transferred to the ISFSF: 5 casks loaded with the damaged fuel were transported from Unit 1 and 10 casks were transported from Unit 2, whereas 9 of these casks were loaded with the damaged fuel.

On 11 May 2021 the last cask filled with the damaged fuel was transported to the ISFSF from Unit 1. On 5 May 2021 handling of the damaged fuel at Unit 2 started by using the same damaged fuel handling equipment that was used for handling operations at Unit 1. After removal of damaged fuel from Unit 1, the damaged fuel handling equipment was dismantled, transported to Unit 2 and assembled for the similar work performance. In total, 182 damaged fuel assemblies were stored at Unit 1, and 189 – at Unit 2. It should be noted that the total number of damaged fuel assemblies stored in both units is relatively small and constitutes only 1.7% of the total number of spent fuel assemblies stored in the reactors. All damaged fuel was placed in 22 containers out of the total number of 190 storage casks transported to the ISFSF. The last cask with the spent nuclear fuel from the storage pool of Unit 2 was removed on 21 April 2022. The total number of casks transported from Unit 1 is 88 casks, including 11 casks with the damaged fuel and from Unit 2 – 102 casks, including 11 casks with the damaged fuel. The works related to collection of the fuel debris from the bottom of the storage pools are scheduled to be finished by IVQ 2022.

The SNF storage norms and conditions are established in the INPP Instruction on Safety Assurance during Nuclear Fuel Storage and Transportation [5]. All operations with SNF storage casks at the Units are performed following the requirements of the Instruction on CONSTOR®RBMK1500/M2 Cask Handling at the Units A-1,2 [6], and the Instruction on Nuclear Fuel Accounting at the ISFSF [7]. All nuclear fuel handling, hoisting, transportation and storage equipment located at the Units and the ISFSF is operated, maintained, periodically inspected and tested in compliance with the operational procedures and the requirements of the normative technical documentation by the qualified and appropriately trained and certified staff undergoing training in accordance with annual training programs. Prior to start of activities with cask handling all hoisting and process equipment is checked for their safe and secure operability. During the SNF handling nuclear safety and radiological protection of workers, the public and the environment is always maintained following the ALARA principle.

The ISFSF is operated strictly following the requirements of the Interim Spent Nuclear Fuel Storage Facility Operation Technical Specification [8]. Mandatory monitoring of the surface temperature of each cask with the spent nuclear fuel is performed. The measured temperature of all the casks was below the established limit. During the storage period the cask body (internal side) temperature is monitored once per month. Radiological monitoring of the casks is performed in compliance with the INPP Instruction on Performance of Radiological Monitoring during Handling of the Cask CONSTOR®RBMK1500/M2 [9] providing the detailed description of the composition and volumes of to be performed radiological measurements while handling casks at different stages of its handling, including measurement of the gamma and neutron radiation dose rate from the cask surface (after its loading with SNF and transfer to the ISFSF) and radiological monitoring of the working places at different stages of the cask handling.

The cask storage safety at the ISFSF is ensured by consistent realisation of the "defence in depth" principle based on the system of barriers preventing or hindering migration of radionuclides or other substances at the ISFSF and to the environment and by using of the system of technical and organisational measures protecting those barriers and maintaining their efficiency during the ISFSF operation, thus directly protecting employees and the public from harmful impact of ionising radiation.

The containment system of the cask CONSTOR® RBMK1500/M2 consists of two independent sealing barriers: the inner containment and the outer containment, steel is used for the outer containment of the cask, heavy concrete as additional shielding, and a triple closure system with one bolted lid and two welded lids. The double-barrier welded lid system, together with the double-barrier design of the cask body ensure confinement of radionuclides during the long-term storage. The outer containment of a loaded cask can be fully inspected at the ISFSF. The Fuel Inspection Hot Cell is a high integrity enclosure constructed from reinforced concrete and providing the primary containment barrier.

ALARA principle is considered at the ISFSF by implementing four major ways to reduce radiation exposure of the personnel and population:

- Shielding: proper barriers and shielding walls ensure reduction of ionizing radiation;
- Time: well-planned operations ensure less time spent in radiation fields;
- Distance: increased distance between radioactive sources and the personnel or population, remote control is applied to decrease personnel exposure;
- Amount: reduction of the quantity of radioactive material for a practice.

Continuous monitoring of the following parameters is conducted during operation of the storage facility:

- Gamma radiation dose rate and neutron radiation dose rate in the cask Storage Hall and along the perimeter of the ISFSF site;
- Monitoring of radionuclide discharges to the atmosphere via the ventilation stack and from the Cask Storage Hall;
- Individual dose of external exposure of the personnel attending the ISFSF.

More detailed information on the description of the ISFSF and the operations performed therein is provided in the Post-Project Analysis Programme for the New INPP Nuclear Installations [1].

The possibility of airborne discharges during container preparation and storage at the ISFSF under normal operational conditions is excluded as it is ensured by:

- Tightness of the primary lid during cask preparation for the storage (tightness is tested directly before transfer of the cask);
- Tightness of a cask body, and also tightness of the welded seal plate and welded secondary lid.

Airborne discharges are possible only during SNF inspection and repackaging. The Fuel Inspection Hot Cell (FIHC) is intended for servicing of maximally one cask a year. However, there is no defined throughput target for the FIHC. It is likely that FIHC during 50 years of the storage period will never be used as a cask by itself ensures long-term containment integrity.

The radioactive substances are released via the ventilation stack in the form of aerosols and gases. Isokinetic air sampling is performed in the stack which allows the determination of the total gas volume flow. In order to determine the activity release rate and the released activity, monitoring equipment is installed to determine the aerosol alpha/beta/gamma activity and the activity of tritium and noble gases in the samples. The information on radiological monitoring of airborne discharges from the ISFSF is presented in Table 5.2 of the Post-Project Analysis Programme for the New INPP Nuclear Installations [1].

No breach of the normal operation conditions and operational limits were identified during the ISFSF operation in 2021. All systems and components of the storage facility are operated without failures. No changes to the safety features of the ISFSF site have been identified. No initiating events of either natural or man induced origin as provided for in the ISFSF Safety Analysis Report have been identified.

Technical maintenance, monitoring, testing and inspections of the ISFSF process equipment is carried out at the established periodicity and in accordance with the established procedures and schedules developed in compliance with the requirements of the Nuclear Safety Requirements BSR-3.1.1-2016 “Spent Nuclear Fuel Handling at the Dry Type Spent Nuclear Fuel Storage Facility” [1].

1.2. Solid Radioactive Waste Retrieval Facility (Retrieval Unit 1, RU1, B2-1 Project and Retrieval Units 2,3, RU2, RU3, B2-2 Project)

The Solid Radioactive Waste Management and Storage Facility (SWMSF, B2/3/4 Project) consists of several facilities located on two separate sites:

- the Solid Waste Retrieval Facility (SWRF, B2 Project) constructed within the boundary of the INPP site close to the existing solid waste storage buildings 155, 155/1, 157 and 157/1;
- the Solid Waste Treatment and Storage Facility (SWTSF, B3/4 Project) constructed on a separate site located approximately 0.6 km to the south from the Ignalina NPP adjacent to the Interim Spent Fuel Storage Facility.

The purpose of the SWRF is to retrieve waste from its present storage location, i.e. buildings 155, 155/1, 157 and 157/1, pre-sort and package this waste. The SWRF consists of three Retrieval Units (RU), the Landfill Separation Facility and the Control Building. The INPP operational solid radioactive waste accumulated in building155, 155/1, 157 and 157/1 was classified on the basis of the old waste classification system that was valid during the INPP operation according to:

- Radiological properties – into three groups: G1 (low activity waste), G2 (intermediate activity waste) and G3 (high activity waste);
- Combustibility properties – into two groups: combustible and non-combustible waste.

More detailed information on the waste retrieved from these facilities is provided in the Post-Project Analysis Programme for the New INPP Nuclear Installations [1].

The Retrieval Unit 1 (RU1) is used to retrieve radioactive waste from buildings 155 and 155/1, to receive Group 1 waste retrieved from buildings 157 and 157/1 (RU2), to receive class A operational RW, to perform pre-sorting, processing and radiological characterization of the waste; to transfer pre-sorted RW either to the LSF sorting area or to SWTF for further treatment.

Waste is retrieved by using remotely operated vehicles which enter the waste storage compartments of buildings 155 and 155/1 via access apertures cut in the side of the waste buildings. The remote control of all operations is carried out from the control room arranged in the control building.

The Retrieval Unit 2 (RU2) is used to retrieve, pre-sort and pack Group 1 and Group 2 radioactive waste from buildings 157 and 157/1. RU2 is a mobile unit located on the top of the waste storage building. The unit can move in two directions due to rail system mounted on the top of the waste storage building. The Unit can move to the required position above the waste storage compartment opening by means of the rail system. Waste retrieval is performed from the top of the waste storage compartments, after removal of closure panels. Waste is retrieved remotely with a girder crane equipped with specific grabs, which is lowered through an existing aperture of the roof slab of the waste compartment. Then the waste is loaded into appropriate waste transport containers for transfer to corresponding waste sorting and processing sites. When no retrieval operations are run, the sliding hatch that completely close the compartment aperture and the sealing skirt in rubber, fixed on frames due to rubber moulding, together with the sliding hatch ensure radiological protection to the personnel in order to permit maintenance operations inside the unit.

The Retrieval Unit 3 (RU3) is used to retrieve Group 3 radioactive waste from compartments 1 and 4 of building 157. Like the RU2, the RU3 is a mobile framed metal structure located on the top of the storage building. The waste retrieval is performed from the top of the compartments of building 157 after removing plugs from waste compartment roofs. All waste retrieval and packaging operations are performed inside the Unit with a remote tool carrier arm (manipulator). Operations are remotely controlled from the Control Building.

The confinement of the radioactive waste during the solid radioactive waste retrieval from the existing INPP solid waste storage buildings is ensured by the Retrieval Units construction and the safety systems. The RU1 is designed as a concrete structure with separate monolithic structural elements providing appropriate sealing between the RU1 and the INPP solid waste storage buildings. The RU2 and RU3 are sealed to the solid waste storage building roofs. The exhaust ventilation of the radioactive waste treatment areas (retrieval, sorting, treatment, etc.) is maintained at a depression in comparison to the outside environment. Fine cleaning and high efficiency particulate air (HEPA) filtering systems are installed for cleaning of the exhaust air. The design of SWRF is based on the principle of multi-barrier protection. The principle of double confinement of radioactive contamination sources envisages the following measures implemented at the SWRF:

- Zoning of rooms with the application of access restriction to those with potential risk of contamination;
- Establishing of a dynamical confinement constituting the creation of an air depression cascade from rooms with the lowest risk of contamination towards those of the higher risk of contamination.

Radiation safety and environmental impact minimizing measures are implemented during the entire lifetime of the SWRF:

- “defence in depth” principle is implemented encompassing a comprehensive barrier system limiting ingress of radioactive substances into the rooms and the environment;
- application of ALARA principle (well planning of activity, personnel training, experience assessment, operations improvement, etc.);
- continuous monitoring of discharges into the environment;
- monitoring of the radiological situation in premises during the work performance;
- monitoring of radiological contamination of the ambient air, soil, underground and ground water, monitoring of ionizing radiation dose rate on the INPP site.

The SWRF construction was completed in October 2015. The “Cold“ trial were conducted in early 2017. Upon completion of the “Cold“ trial stage and having developed the trial performance reports and having agreed them with the regulatory body the State Commission on the Construction Completion signed the Statement on the SWRF Construction Completion on 07 June, 2017. Based on the conclusion made by the Commission that the facility meets the design requirements, the SWRF operation licence was issued by the VATESI on 08 June, 2017 and the “Hot“ trial started. After successful completion of the „Hot“ trial programme, on 30 April 2019 VATESI issued the permit for the industrial operation of the B2-1 Project. More detailed information on the description of RU-1 and the operations performed therein is provided in the Post-Project Analysis Programme for the New INPP Nuclear Installations [1].

During 2021 439 m^3 of class A radioactive waste (very low-level waste) was retrieved from RU1. The waste originating as a consequence of the equipment dismantling and transported from Bld. 101/1,2; 130/2, 159B, as well as industrial waste retrieved from Bld. 155/1 was treated at the Landfill Separation Facility of RU1. The SWRF is operated strictly following the requirements of the Solid Radioactive Waste Management and Storage Facility, B2-1 Project, Operation Specification, [10] establishing the safe operation limits and conditions, requirements for operation, monitoring of the functioning of the systems important to safety, as well as other general requirements for safe organising of works related to radioactive waste retrieval and management till their transfer for further processing or storage, including other operational instructions and procedures dedicated for assurance of the safe radioactive waste retrieval, processing and transportation to other INPP on-site radioactive waste management facilities for further processing or storage.

In case of emergency situations, the operating personnel will act in compliance with the Instruction on Elimination of Emergency Consequences during Radioactive Waste Treatment [11]. The systems important to the SWRF safety are included into the List of Systems Important to Safety of Unit 2 and General Power Plant Facilities [12]. Periodicity of inspections and testing of systems important to safety, their maintenance is carried out incompliance with the Regulations of Inspections and Tests of SWRF Systems Important to Safety [13]. Technical supervision of building structures is carried out at the periodicity and following the requirements and the procedure established in the Instruction on the Technical Supervision of the INPP Buildings and the Territory [14]. All the procedures related to the SWRF operation, radioactive waste retrieval and initial processing is carried out in compliance with the requirements stated in the Nuclear Safety Requirements BSR-3.1.2-2017 “Pre-disposal Management of Radioactive Waste at Nuclear Installations” [15].

The B2-2 Project (Retrieval Units 2,3, RU2, RU3) was implemented following the modification procedure of the existing radioactive waste storage facility in Bld. 157, 157/1. The “Cold“ trial were conducted in early 2017. Upon completion of the “Cold“ trial stage and having developed the trial performance reports and having agreed them with the regulatory body the „Hot“ trial programme was developed in July 2017 and agreed with the regulatory body to test technical characteristics of the B2-2 facilities process systems and equipment. After completion of the „Hot“ trial programme in October 2019 and December 2019 (handling of Group 3 solid radioactive waste) and agreement of the „Hot“ trial report, the final safety analysis report and the report on implementation of the modification with the regulatory body, the RU2, RU3 were authorised to start the operation on 5 May 2020. More detailed information on the description of RU2, RU3 and the operations performed therein is provided in the Post-Project Analysis Programme for the New INPP Nuclear Installations [1].

During 2021 108 m^3 and 45.3 m^3, respectively, of class B and C radioactive waste (low and intermediate level waste) was retrieved from Bld. 157 and 157/1. The SWRF (RU2, RU3) is operated strictly following the requirements of the Solid Radioactive Waste Management and Storage Facility, B2-2 Project, Operation Specification [16] establishing the safe operation limits and conditions, requirements for operation, monitoring of the functioning of the systems important to safety, as well as other general requirements for safe organising of works related to radioactive waste retrieval and handling till their transfer for further processing, including other operational instructions and procedures dedicated for assurance of the safe radioactive waste retrieval, processing and transportation to other INPP on-site radioactive waste management facilities for further processing.

1.3. Abbreviations

DL	detection limit;
FIHC	Fuel Inspection Hot Cell;
ISFSF	Interim Spent Fuel Storage Facility;
MPC	maximum permissible concentrations;
NI	Nuclear Installation;
RU	Retrieval Unit;
SPH	Spent Fuel Pools Hall;
SPZ	Sanitary Protection Zone;
SWRF	Solid Radioactive Waste Retrieval Facility;
SWTSF	Solid Radioactive Waste Treatment and Storage Facility.

1.4. Definition of the Representative Person

Representative person is assumed as a representative person, a member of a representative public group who is subject to the significant exposure due to airborne and waterborne discharges. The exposure dose of a representative person is evaluated taking into consideration all exposure pathways from the radiation source.

The following public groups that potentially may be close to the sanitary protection zone, such as farmers, gardeners, fishermen, hunters, mushroom pickers, berry, herbs pickers, tourists, holidaymakers have been analysed for screening of the representative persons characteristic for the INPP region by evaluating all exposure pathways and exposure duration.
In calculating the exposure doses of a representative person the radionuclide dispersion models into the environment as provided in the IAEA Safety Reports Series No. 19 “Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment” [17] and the International Commission on Radiological Protection [18] and recommended by the national regulatory requirements Nuclear Safety Requirements BSR-1.9.1-2017 “Standards of Release of Radionuclide from Nuclear Installations and Requirements for the Plan on Release

of Radionuclides” [19] were applied, considering the radiation protection optimisation results, realistic life-style and food chains of the representative person, as well as the realistic airborne discharges into the atmosphere and waterborne discharges into lake Drūkšiai.

The performed analysis of all the external and internal exposure pathways considering the life-style and food chains of all the public groups that potentially may be close to the INPP sanitary protection zone due to residing or performing their daily activity on the boarder of the INPP sanitary protection zone and the surveillance zone and the estimation of the contribution of airborne and waterborne discharges into the exposure dose, it was identified that the farmers, gardeners and fishermen may experience the highest exposure due to airborne and waterborne discharges:

- In case of fishermen the exposure dose will consist of the following exposure doses: to all the body, to the skin, due to aerosol inhalation from immersion in the plume, from ground depositions and shore sediments, due to consumption of fish;
- In the case of farmers the exposure dose will consist of the following exposure doses: to all the body, to the skin, due to aerosol inhalation from immersion in the plume, from ground depositions, due to consumption of milk, meat, drinking water;
- In the case of gardeners the exposure dose will consist of the following exposure doses: to all the body, to the skin, due to aerosol inhalation from immersion in the plume, from ground depositions, due to consumption of terrestrial foodstuffs.

The Lithuanian Hygiene Standard HN 73:2018 “Basic Standards of Radiation Protection” [20] establishes the dose constraint of annual effective dose -0.2 mSv for the general public due to exposure resulting from airborne and waterborne discharges from the nuclear installation and the exposure resulting directly from the NI.

This dose constraint is applied for design, operation and decommissioning of nuclear installations during the normal operation conditions and anticipated operational occurrences. If radionuclides are released from several NI and in different ways (into the air and water), the dose constraint is distributed for each NI and each radionuclide pathway insomuch that the dose constraint would not be exceeded for the representative persons exposed by several NI situated in the same territory, irrespective if the impact is incurred by the same or different representative person.

In limiting release of radionuclides, internal and external exposure determining the annual effective dose of the representative person is taken into account. The cumulative annual effective dose (due to released radionuclides and direct external exposure) of the representative person shall not exceed the dose constraint of annual effective dose - 0.2 mSv.

Based on the analysis performed in the INPP Report on Establishment of Data Required for Assessment of Exposure Doses due to Airborne and Waterborne Discharges, At-2371(3.166) [21], it was determined that the contribution of the airborne and waterborne discharges to the exposure dose of the representative person is of the same order of magnitude, thus, the annual effective dose due to each radionuclide discharge pathway (airborne and waterborne discharges) constitutes 0.1 mSv per year, i.e. half of the dose constraint of the annual effective dose - 0.2 mSv.

2 SUMMARY OF THE EARLIER PERFORMED CONSERVATIVE ENVIRONMENTAL IMPACT ASSESSMENT RESULTS OF THE ISFSF AND THE SWRF

The summary of the estimated activity values of airborne radionuclide discharges from the ISFSF and the SWRF and the resultant exposure dose of the representative person is presented in Tables 2.1-1- 2.1-5 based on the estimation results obtained during the ISFSF and the SWTSF environmental impact assessment process and presented in the ISFSF and the SWTSF Environmental Impact Assessment Reports data [22, 23].

Table 2.1-1 Radionuclide composition in airborne discharges from the ISFSF via the ventilation stack as based on the ISFSF Environmental Impact Assessment Report [22]

Radionuclide	Activity, Bq/year	Dose, Sv/year
H-3	1.04E+11	3.56E-09
Kr-85	2.44E+12	2.09E-09
I-129	6.04E+06	1.38E-07
Cs-134	6.63E+05	l.05E-09
Cs-137	2.87E+06	6.54E-09
Total:	**2.54E+12**	**1.5E-07**

Table 2.1-2 Radionuclide composition in airborne discharges from the RU1 via the ventilation stack as based on the SWTSF Environmental Impact Assessment Report [23]

Radionuclide	Activity, Bq/year	Dose, Sv/year
C-14	5.00E+03	5.50E-14
Mn-54	1.81E+06	1.45E-10
Fe-55	5.00E+06	6.89E-09
Co-58	1.49E+06	4.10E-ll
Co-60	1.06E+06	1.51E-09
Ni-59	1.06E+03	3.71E-13
Ni-63	2.55E+05	1.59E-11
Nb-94	2.02E+03	1.46E-12
Sr-90	9.89E+03	1.73E-11
Tc-99	6.58E+02	1.81E-13
1-129	5.92E+00	1.78E-13
Cs-134	2.30E+06	4.77E-09
Cs-137	1.64E+06	4.92E-09
U-235	4.44E-04	7.89E-19
U-238	1.32E-02	2.25E-17
Pu-238	2.79E+01	2.45E-13
Pu-239	7.23E+00	6.87E-14
Pu-240	1.81E+01	1.72E-13
Pu-241	2.63E+03	4.80E-13
Am-241	3.95E+01	2.96E-13
Cm-244	7.73E+00	3.42E-14
Total:	**l.36E+07**	**l.83E-08**
Total alpha *)	100.5	

*) Radionuclides U-235, U-238, Pu-238, Pu-239, Pu-240, Am-241 and Cm-244

Table 2.1-3 Radionuclide composition in airborne discharges from the RU2 via the ventilation stack as based on the SWTSF Environmental Impact Assessment Report [23]

Radionuclide	Activity, Bq/year	Dose, Sv/year
C-14	6.63E+03	l.02E-13
Mn-54	2.40E+06	2.69E-10
Fe-55	6.63E+06	l.28E-08
Co-58	l.98E+06	7.62E-11
Co-60	l.41E+06	2.81E-09
Ni-59	1.41E+03	6.91E-13
Ni-63	3.39E+05	2.97E-11
Nb-94	2.68E+03	2.71E-12
Sr-90	2.87E+02	7.03E-13
Tc-99	1.92E+01	7.39E-15
I-129	1.72E-01	7.22E-15
Cs-134	6.71E+04	1.95E-10
Cs-137	4.79E+04	2.01E-10
U-235	l.29E-05	3.21E-20
U-238	3.83E-04	9.13E-19
Pu-238	8.14E-01	1.00E-14
Pu-239	2.11E-01	2.81E-15
Pu-240	5.27E-01	7.01E-15
Pu-241	7.66E+01	1.96E-14
Am-241	1.15E+00	1.21E-14
Cm-244	2.25E-01	1.39E-15
Total:	**l.29E+07**	**l.64E-08**
Total alpha *)	2.93	

*) Radionuclides U-235, U-238, Pu-238, Pu-239, Pu-240, Am-241 and Cm-244

Table 2.1-4 Radionuclide composition in airborne discharges from the RU3 via the ventilation stack as based on the SWTSF Environmental Impact Assessment Report [23]

Radionuclide	Activity, Bq/year	Dose, Sv/year
C-14	5.55E+06	8.55E-11
Fe-55	8.69E+08	1.68E-06
Co-60	1.42E+08	2.83E-07
Ni-59	5.98E+05	2.93E-10
Ni-63	6.83E+07	5.98E-09
Nb-94	1.14E+06	1.15E-09
Sr-90	6.13E+01	1.50E-13
Tc-99	4.09E+00	1.57E-15
I-129	3.68E-03	1.55E-16
Cs-134	1.23E+03	3.57E-12
Cs-137	1.02E+03	4.28E-12
U-235	1.63E-03	4.06E-18
U-238	5.00E-02	1.19E-16
Pu-238	1.02E+02	1.25E-12

Radionuclide	Activity, Bq/year	Dose, Sv/year
Pu-239	2.76E+01	3.67E-13
Pu-240	6.54E+01	8.70E-13
Pu-241	9.70E+03	2.48E-12
Am-241	1.53E+02	1.61E-12
Cm-244	2.86E+01	1.77E-13
Total:	**1.09+09**	**1.97E-06**
Total alpha *)	376.9	

*) Radionuclides U-235, U-238, Pu-238, Pu-239, Pu-240, Am-241 and Cm-244

Table 2.1-5 Total radionuclide activity in airborne discharges from the B2 Facility and the determined exposure dose as based on the SWTSF Environmental Impact Assessment Report [23]

Retrieval Unit	Activity, Bq/year	Dose, Sv/year
RU-1	1.36E+07	1.83E-08
RU-2	1.29E+07	1.64E-08
RU3	1.09E-+09	1.97E-06
Total:	1.11E+09	2.00E-06

3 DISCHARGE LIMIT VALUES OF AIRBORNE RADIONUCLIDE DISCHARGES FROM ALL THE INPP NUCLEAR INSTALLATIONS

A summary of the discharge limit values of airborne radionuclide discharges and the planned to be released activity values as set in the Plan on Release of Radionuclides into the Environment[1] [24] from all nuclear installations (NI) located within the INPP site is presented in Table 3.1-1, including the resultant exposure dose of the representative person. The total activity of all planned discharges into the air constitutes 8.3 % of the limit annual activity based on the Plan on Release of Radionuclides into the Environment [24].

Table 3.1-1 Estimated limit and planned activity of airborne discharges from all NI Located within the INPP site [24]

Nuclide	Discharge limit values set in the Plan [24], Bq/ year	Dose, Sv/year	Planned to be released activity values set in the Plan [24]
Noble gases	2.78E+13	5.00E-09	2.31E+12
Long-lived radionuclides	2.90E+09	9.80E-05	2.41E+08
H-3	1.01E+13	9.95E-07	8.42E+11
C-14	1.42E+11	1.00E-06	1.18E+10
Total:	**3.81E+13**	**1.000E-04**	**3.16E+12**

No uncontrolled waterborne discharges into the environmental waters during the normal operation of the ISFSF and the SWRF are expected. But to demonstrate compliance with the

[1] In compliance with the Nuclear Safety Requirements BSR-1.9.1-2017 “Standards of Release of Radionuclide from Nuclear Installations and Requirements for the Plan on Release of Radionuclides” the Plan on Release of Radionuclides into the Environment was updated in 2020 and the radionuclide discharge limit values were revised.

established criteria monitoring results of discharges into Lake Drūkšiai and its aquatic environment is provided hereafter bellow.

4 ENVIRONMENTAL MONITORING RESULTS

4.1. Radiological Monitoring Results

Radiological condition of the environmental components and the radiological situation within the Ignalina NPP sanitary protection zone (including the ISFSF site) and the surveillance zone is evaluated based on radionuclide activity concentrations measurement results in taken samples of the environmental components. The environmental components, their sampling periodicity and sequence are established in the Radiological Environmental Monitoring Programme [25].

Find below the radiological monitoring results on the basis of the Report of the INPP Region and Maišiagala Radioactive Waste Storage Facility Radiological Monitoring Results for Year 2021 [26].

4.1.1. Release of Radionuclides and Radionuclide Activity Concentration in the Atmospheric Air

Table 4.1-1 Activity of airborne discharges from all NI located on the INPP site [26]

Radionuclides	**2020**		**2021**	
	Bq/year	% of discharge limit*, Bq/year	Bq/ year	% of discharge limit*, Bq/year
Long-lived radionuclides	4.826E+07	1.66	5.428E+07	1.87
H-3	6.098E+09	0.06	4.846E+09	0.05
C-14**	1.05E+11	73.93	2.242E+10	15.79

*The estimated airborne discharge limit values as set in the Plan on Release of Radionuclides into the Environment [24] are provided in Table 3.1-1.

**Increase of C-14 activity in airborne discharges in 2020 is related to unloading of the control and protection system rods from the reactor core, as these rods contain boron carbide and graphite.

Co-60, Sr-90, Cs-137, H-3, C-14 mostly contribute to the release activity (Table 4.1-2). Discharges (Table 4.1-1) from the following on-site facilities (Bld. 101/1, 101/2, 150, 156, 158/2, 159, 117/1, 117/2, Landfill buffer storage facility, ISFSF, SWRF, SWTSF*, Bld. 130 (controlled area)) are included into the overall airborne discharges.

*) It should be noted that the Solid Radioactive Waste Treatment and Storage Facilities (B3/4 Project) were operated not in their full capacity for the last year, i.e. only testing of the radioactive waste incineration facility of the SWTSF were conducted. The permits for commercial operation of the SWTSF were issued by the regulatory body on 28 March 2022, therefore the impact of these facilities will be analysed in the post-project report for year 2022.

Table 4.1-2 Radionuclide composition and activity and the resultant dose of the representative person during 2021

Radionuclide	**Released activity, Bq/year**	**Dose, Sv**	**Input to dose, %**
Co-60	2.521E+07	2.473E-07	18.00
Sr-90	5.859E+05	5.279E-09	0.38
Cs-137	2.849E+07	9.630E-07	70.08
H-3	4.846E+09	4.754E-10	0.03
C-14	2.242E+10	1.581E-07	11.50
Total	**2.732E+10**	**1.374E-06**	**100.00**

Table 4.1-3 Doses of the representative person during 2021 due to radionuclide discharges from on-site INPP facilities

Bld.	Activity released per year, Bq/year	Dose, Sv
150	3.951E+09	5.602E-08
130	1.441E+06	2.386E-08
156	9.558E+02	3.231E-11
159	2.382E+03	8.050E-11
158/2	0.000E+00	0.000E+00
117/1	0.000E+00	0.000E+00
117/2	0.000E+00	0.000E+00
Landfill buffer storage facility	4.118E+03	1.392E-10
101/1	2.029E+07	6.655E-07
101/2	2.306E+10	4.067E-07
B1 (ISFSF)	2.730E+08	1.002E-09
B2 (SWRF)	2.198E+07	2.204E-07
B34 (SWTSF)	3.519E+04	3.171E-10
Total	**2.732E+10**	**1.374E-06**

Based on the exposure dose calculations, the total exposure dose of the representative person resulting from the radionuclide discharges into the atmosphere from the INPP in 2021 constituted 1.374E-03 mSv, what makes up 1.374 % of the half (0.1 mSv) of the dose constraint - 0.2 mSv. For the demonstration purposes find below the comparison of annual radionuclide activities released into the environment during the period of 2019-2021 from the ISFSF, SWRF and in total from all the INPP on-site nuclear installations indicating the insignificant change in values of released radionuclide activity and the resultant doses to the representative person.

Table 4.1-4 Comparison of annual radionuclide activities released into the environment for the period of 2019-2021 and the resultant doses to the representative person

Facility	Released activity, Bq/year			Dose, Sv		
	2019	**2020**	**2021**	**2019**	**2020**	**2021**
B1 (ISFSF)	2.35E+07	8.478E+07	2.730E+08	2.79E-10	2.049E-10	1.002E-09
B2 (SWRF)	1.18E+07	1.717E+07	2.198E+07	1.69E-07	1.684E-07	2.204E-07
Total INPP*	5.53E+09	1.111E+11	2.732E+10	3.48E-06	1.792E-06**	1.374E-06

*Bld. 101/1, 101/2, 150, 156, 158/2, 159, 117/1, 117/2, Landfill buffer storage facility, ISFSF, SWRF, SWTSF, Bld. 130 (controlled area) are included into the overall airborne discharges from the INPP.

** The total exposure dose due to radionuclide activity in the INPP airborne discharges includes exposure doses from all radionuclides measured during the radiological monitoring process. The radiation exposure dose of a radionuclide is defined as the product of its activity and its dose factor. Therefore, decrease in the exposure dose in half in year 2020 compared to year 2019 is due to decrease in the exposure dose from Cs-137 and decrease in the exposure dose in 2021 compared to 2020 is due to decrease in the exposure dose from tritium and C-14.

If to compare the radionuclide discharges and the resultant doses to the representative person (see Table 4.1-3) with the planned radionuclide discharges from the ISFSF, SWRF and the resultant exposure doses as envisaged in the corresponding Environmental Impact Assessment Reports [22, 23] (see Tables 2.1-1 - 2.1-5), it could be stated that neither the released activity values, nor resulting exposure doses were exceeded.

Table 4.1-5 Radionuclide activity concentration in the atmospheric air in year 2021

Month	Concentration, 10^{-6} Bq/m^3												
	Cs-137	**Cs-134**	**Mn-54**	**Co-58**	**Co-60**	**Zr-95**	**Cr-51**	**Nb-95**	**Fe-59**	**I-131**	**Sr-90**	**Be-7**	**Total, Be-7 excluded**
Surveillance Zone													
January	0,56	0	0	0	0	0	0	0	0	0	0.04	1037	0.60
February	1,40	0	0	0	0	0	0	0	0	2,26		2815	3.70
March	0,69	0	0	0	0	0	0	0	0	0		2634	0.73
April	0,23	0	0	0	0	0	0	0	0	0		3923	0.27
May	0,24	0	0	0	0	0	0	0	0	0		3663	0.28
June	0,44	0	0	0	0	0	0	0	0	0		4506	0.48
July	0,45	0	0	0	0	0	0	0	0	0	0.04	4810	0.49
August	0	0	0	0	0	0	0	0	0	0		2196	0.04
September	0,19	0	0	0	0	0	0	0	0	0		2629	0.23
October	0,70	0	0	0	0	0	0	0	0	0		2692	0.74
November	0,26	0	0	0	0	0	0	0	0	0		1441	0.30
December	0	0	0	0	0	0	0	0	0	0		1508	0.04
Average in 2021	**0.43**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0,19**	**0,04**	**2821**	**0.66**
Average in 2020:	**0.22**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.01**	**1862**	**0.23**
Sanitary Protection Zone													
January	0.19	0	0	0	0	0	0	0	0	0	0.07	633	0.25
February	0.47	0	0	0	0	0	0	0	0	0.90		1308	1.43
March	0.26	0	0	0	0	0	0	0	0	0		1601	0.32
April	0	0	0	0	0	0	0	0	0	0		2597	0.06
May	0	0	0	0	0	0	0	0	0	0		2371	0.06
June	0.70	0	0	0	0	0	0	0	0	0		4184	0.76
July	1.40	0	0	0	0	0	0	0	0	0	0.05	4583	1.46
August	0.62	0	0	0	0	0	0	0	0	0		3083	0.68
September	1.49	0	0	0	0	0	0	0	0	0		2842	1.55
October	0.84	0	0	0	0	0	0	0	0	0		2712	0.90
November	0.25	0	0	0	0	0	0	0	0	0		2006	0.31
December	0.29	0	0	0	0	0	0	0	0	0		1882	0.35
Average in 2021:	**0.54**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.08**	**0.06**	**2484**	**0.68**
Average in 2020:	0.12	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.02**	**1131**	**0.14**

During 2021 the annual dose due to induced radionuclides and cosmogenic radionuclide Be-7 was 10.74E-10 Sv, including:

- cosmogenic radionuclide Be-7- 10.1E-10 Sv;
- Cs-137- 4.24E-11 Sv;
- I-131 – 1.55E-12 Sv;
- Sr-90 - 1.75E-11 Sv.

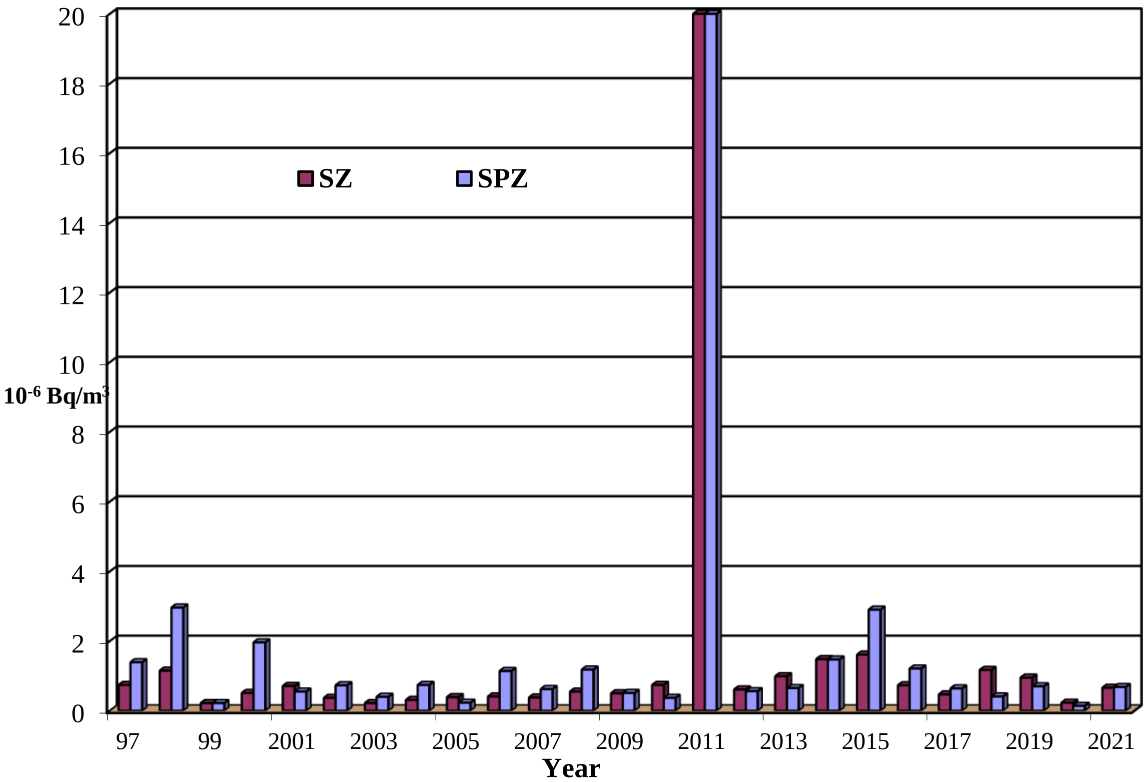

Fig. 4.1-1 Total radionuclide activity concentration in the air in the surveillance and the sanitary protection zone during the year 1997-2021 (Effects of the Fukushima accident in 2011 are clearly expressed)

4.1.2. Radionuclide Activity Concentration in the Atmospheric Precipitation

Table 4.1-6 Radionuclide activity concentration in the atmospheric precipitation during 2021

Month	Concentration, 10^4 Bq/(km^2 day)													
	Cr-51	**Cs-137**	**Cs-134**	**Mn-54**	**Co-58**	**Co-60**	**Zr-95**	**Nb-94**	**Fe-59**	**Zn-65**	**I-131**	**Be-7**	**K-40**	**Total, K, Be excluded**
Surveillance Zone														
January	0	0	0	0	0	0	0	0	0	0	0	34.9	0	0
February	0	0	0	0	0	0	0	0	0	0	0	19.3	0	0
March	0	0	0	0	0	0	0	0	0	0	0	14.7	0	0
April	0	0	0	0	0	0	0	0	0	0	0	81.4	0	0
May	0	0	0	0	0	0	0	0	0	0	0	26.0	3.03	0
June	0	0	0	0	0	0	0	0	0	0	0	54.5	3.63	0
July	0	0	0	0	0	0	0	0	0	0	0	168	0	0
August	0	0	0	0	0	0	0	0	0	0	0	465	0	0
September	0	0	0	0	0	0	0	0	0	0	0	16.8	0	0
October	0	0	0	0	0	0	0	0	0	0	0	18.6	0	0
November	0	0	0	0	0	0	0	0	0	0	0	97.6	0	0
December	0	0	0	0	0	0	0	0	0	0	0	74.5	0	0
Average in 2021	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**89.3**	**0.56**	**0**
Average in 2020:	**0**	**0.24**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**71.7**	**2.34**	**0.24**
Sanitary Protection Zone														
January	0	0.44	0	0	0	0	0	0	0	0	0	73.7	0	0.44
February	0	0.21	0	0	0	0	0	0	0	0	0	36.7	0	0.21
March	0	0.23	0	0	0	0	0	0	0	0	0	102	0	0.23

Month	Concentration, 10^4 Bq/(km^2 day)													
	Cr-51	**Cs-137**	**Cs-134**	**Mn-54**	**Co-58**	**Co-60**	**Zr-95**	**Nb-94**	**Fe-59**	**Zn-65**	**I-131**	**Be-7**	**K-40**	**Total, K, Be excluded**
April	0	0	0	0	0	0	0	0	0	0	0	157	0	0
May	0	0	0	0	0	0	0	0	0	0	0	209	0	0
June	0	0.31	0	0	0	0	0	0	0	0	0	115	0	0.31
July	0	0	0	0	0	0	0	0	0	0	0	111	0	0
August	0	0.76	0	0	0	0	0	0	0	0	0	83.0	0	0.76
September	0	0	0	0	0	0	0	0	0	0	0	67.7	0	0
October	0	0.13	0	0	0	0	0	0	0	0	0	95.6	10.1	0.13
November	0	0.26	0	0	0	0	0	0	0	0	0	201	0	0.26
December	0	0	0	0	0	0	0	0	0	0	0	115	7.34	0
Average in 2021	**0**	**0.20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**114**	**1.45**	**0.20**
Average in 2020:	**0**	**0.08**	**0**	**0**	**0**	**0.04**	**0**	**0**	**0**	**0**	**0**	**119**	**0.55**	**0.12**

Based on the atmospheric precipitation measurement results from 15 sampling points installed within the INPP territory and the surveillance zone, the natural radionuclides Be-7, K-40 and globally distributed in the atmosphere Cs-137[2] mostly determined the radionuclide composition in precipitation in 2021.

4.1.3. Radionuclide Activity Concentration in the Aquatic Environment

Table 4.1-7 Annual radionuclide discharges into Lake Drūkšiai (including debalanced water*) in year 2021

Sampling point	**Activity, MBq**							
	Cs-137	**Cs-134**	**Mn-54**	**Co-60**	**Fe-59**	**Nb-94**	**H-3**	**Total γ nuclides**
IK	0.144	0	0	0	0	0	0	0.144
GPNN-1,2	12.70	0	0	12.35	0	0	$3.04 \cdot 10^4$	25.05
GPNN-3	0.916	0	0	0.009	0	0	579.7	0.926
GPNN PBKS	0.001	0	0	0.006	0	0	0.861	0.007
Total:	**13.76**	**0**	**0**	**12.36**	**0**	**0**	**$3.10 \cdot 10^4$**	**26.12**
% of discharge limit**	**0.46**	**0**	**0**	**2.66**	**0**	**0**	**0.21**	**0.73**

* Debalansed water is the wastewater originating due to processing of the liquid radioactive waste and cleaned following the normative requirements which is discharged (directed) to the water body since it is not possible to reuse it for INPP technological needs.

** Discharge limit is set in the Plan on Radionuclide Releases into the Environment from the Ignalina NPP, No. MtDPl-5(3.254) [24].

[2] Globally distributed in the atmosphere radionuclide Cs-137 is one of the major radioactive contamination components of the biosphere, mostly originating due to nuclear weapon tests and nuclear accidents. Cs-137 is the main fission product of the nuclear fission of uranium-235 (reactor fuel). Since Cs-137 concentrations measured in the environmental components in the INPP surroundings are at the background values level, separation of globally distributed in the atmosphere Cs-137 from the INPP activity induced Cs-137 is not possible. Therefore, the INPP controls radionuclide composition and activities in all airborne and waterborne discharges into the environment from all the NI located in the INPP SPZ, including also Cs-137, as well as possesses authorisations for discharge of respective amounts of radionuclides that are agreed in the procedure established by the legal acts of the Republic of Lithuania. Each year INPP performs environmental impact assessment of the activities conducted by the INPP NI, also encompassing assessment of Cs-137 impact.

No Pu isotopes were detected in water of the inlet and discharge channels. Detection limit of Pu-239+240 does not exceed 0.0002 Bq/kg.

As it could be seen from Table 4.1-7 the main source of Tritium discharge into Lake Drukšai is discharge through the Industrial and Surface Wastewater Drainage collector (GPNN-1,2) collecting water from the surface runoff (precipitation) and debalance water from building 150 (primarily purified off the radioactive contamination). Such significant activity of Tritium in GPNN-1,2 is due to the large volume of water diverted through this discharge route. The total annual Tritium activity discharged into Lake Drukšiai through all organized waterborne discharge sources in 2021 amounted only to 0.21% of the annual Tritium discharge limit specified in the Plan on Radionuclide Discharges into the Environment from the Ignalina NPP [24].

Fig. 4.1-2 Layout of water sampling points

IK, GPNN-1,2, GPNN-3, GPNN-SPBKS (Lithuanian abbreviation) denoting the channels as presented in the order below):

- (IK) Discharge channel – service water discharge from Bld. 101/1,2;
- (GPNN-1,2) Industrial and Surface Wastewater Drainage channels 1,2 – discharge of rainwater and melted snow from the entire INPP site, discharge of service and debalanced water from Bld. 150 (INPP Liquid Radioactive Waste Treatment and Bituminising Facility);
- (GPNN-3) Industrial and Surface Wastewater Drainage channel 3 – discharges of process equipment located in Bld. 120/1,2 (pumping stations) and drainage water from Bld. 101/1,2;
- (GPNN-PBKS) Dry Type Spent Fuel Storage Facility (the old storage facility) site channel – discharge of rainwater from this site and household wastewater.

Radionuclide activity concentration in baseline sampling points (see Fig. 4.1-3) in Lake Drūkšiai in 2021 is presented in Table 4.1-8.

The estimation of the dose of the representative person due to radionuclide discharges into Lake Drūkšiai is provided Table 4.1-9.

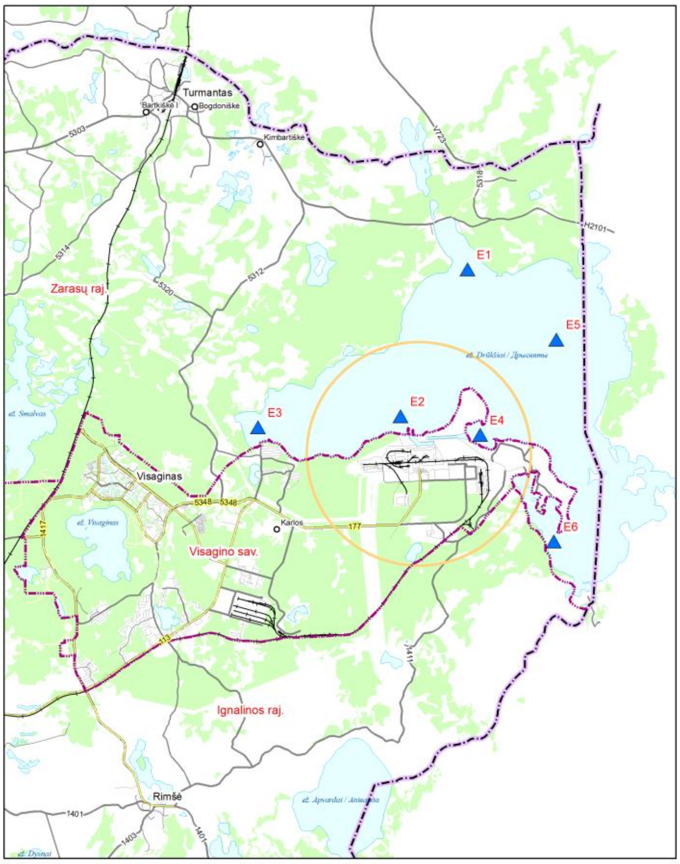

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Fig. 4.1-3 Baseline sampling locations in Lake Drūkšiai (▲ Sampling locations)

Table 4.1-8 Radionuclide activity concentration in baseline sampling points in Lake Drūkšiai in 2021

Sampling point	Concentration, Bq/kg								
	Cs-137	**Cs-134**	**Mn-54**	**Co-60**	**Fe-59**	**Nb-94**	**Sr-90**	**H-3**	**Total, H-3 excluded**
Point E1 in Lake Drūkšiai	$<7.5\cdot10^{-3}$	$<6.6\cdot10^{-3}$	$<8.1\cdot10^{-3}$	$<9.4\cdot10^{-3}$	$<3.6\cdot10^{-2}$	$<6.8\cdot10^{-3}$	$1.65\cdot10^{-3}$	<7.3	$\mathbf{1.65\cdot10^{-3}}$
Point E2 in Lake Drūkšiai	$<1.3\cdot10^{-2}$	$<1.1\cdot10^{-2}$	$<1.4\cdot10^{-2}$	$<1.7\cdot10^{-2}$	$<6.1\cdot10^{-2}$	$<1.1\cdot10^{-2}$	$1.81\cdot10^{-3}$	<7.3	$\mathbf{1.81\cdot10^{-3}}$
Point E3 in Lake Drūkšiai	$<5.8\cdot10^{-3}$	$<5.4\cdot10^{-3}$	$<6.7\cdot10^{-3}$	$<7.7\cdot10^{-3}$	$<3.0\cdot10^{-2}$	$<5.3\cdot10^{-3}$	$2.02\cdot10^{-3}$	<7.3	$\mathbf{2.02\cdot10^{-3}}$
Point E4 in Lake Drūkšiai	$<1.6\cdot10^{-2}$	$<1.5\cdot10^{-2}$	$<1.9\cdot10^{-2}$	$<2.1\cdot10^{-2}$	$<9.3\cdot10^{-2}$	$<1.4\cdot10^{-2}$	$2.27\cdot10^{-3}$	<7.3	$\mathbf{2.27\cdot10^{-3}}$
Point E5 in Lake Drūkšiai	$<1.2\cdot10^{-2}$	$<1.2\cdot10^{-2}$	$<1.4\cdot10^{-2}$	$<1.4\cdot10^{-2}$	$<6.3\cdot10^{-2}$	$<1.1\cdot10^{-2}$	$1.15\cdot10^{-3}$	<7.3	$\mathbf{1.15\cdot10^{-3}}$
Point E6 in Lake Drūkšiai	$<6.4\cdot10^{-3}$	$<6.1\cdot10^{-3}$	$<7.5\cdot10^{-3}$	$<8.2\cdot10^{-3}$	$<3.6\cdot10^{-2}$	$<5.6\cdot10^{-3}$	$1.31\cdot10^{-3}$	<7.3	$\mathbf{1.31\cdot10^{-3}}$
Total:	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 4.1-9 Dose of the representative person due to radionuclide discharges into Lake Drūkšiai in 2021

Radionuclide	**Activity discharged, Bq/year**	**Dose, Sv**
H-3	3.100E+10	2.52E-08
Co-60	1.236E+07	7.99E-08
Cs-137	1.376E+07	3.88E-07
Total	**3.10E+10**	**4.93E-07**

The estimated dose of the representative person due to radionuclide discharges into Lake Drūkšiai (including debalanced waters) is equal to 4.93E-04mSv and it makes up 0.5 % of the half (0.1 mSv) of the dose constraint – 0.2 mSv).

The total estimated dose to the representative person during 2021 due to airborne and waterborne discharges from the INPP is equal to 1.87E-03 mSv, which is 107.1 times less than the dose constraint of the representative person - 0.2 mSv/year.

4.1.4. Radionuclide Activity Concentration in the Water of the Monitoring Wells

Within the framework of the Radiological Environmental Monitoring Programme [25] monitoring of the condition of the ground water, its chemical and radiological composition is performed. Periodicity and monitoring scope of the ground water parameters is established in the Radiological Environmental Monitoring Programme [25]. Twice a year, in spring and autumn, the ground water level, gamma nuclide composition, Sr-90 and H-3 are measured.

Find below the data on the radionuclide activity concentration in the water of monitoring wells in the vicinity of the ISFSF/SWTSF. The layout of monitoring wells within the territory of the ISFSF/SWTSF is provided in Fig. 4.1-4.

Table 4.1-10 Radionuclide activity concentration in the water of the ISFSF/SWTSF Monitoring Wells during 2021

Monitoring well	Radionuclide activity concentration, Bq/kg			
	Cs-137	**Co-60**	**Sr-90**	**H-3**
43988	0	0	$5.84 \cdot 10^{-4}$	0
43989	0	0	$1.03 \cdot 10^{-3}$	0
43990	0	0	$2.93 \cdot 10^{-4}$	0
43991	0	0	$1.92 \cdot 10^{-4}$	0
43992	0	0	$4.61 \cdot 10^{-4}$	0
43993	0	0	$6.38 \cdot 10^{-4}$	0
43994	0	0	$2.10 \cdot 10^{-4}$	0
43995	0	0	$3.43 \cdot 10^{-4}$	3.47
43996	0	0	$2.28 \cdot 10^{-4}$	0
43997	0	0	$6.83 \cdot 10^{-4}$	0
43998	0	0	$9.13 \cdot 10^{-4}$	0
43999	0	0	$9.35 \cdot 10^{-4}$	0
44000	0	0	$3.76 \cdot 10^{-4}$	0
54311	0	0	$8.86 \cdot 10^{-4}$	0
54312	0	0	$6.94 \cdot 10^{-4}$	0
54313	0	0	$3.13 \cdot 10^{-3}$	0
54314	0	0	$6.00 \cdot 10^{-4}$	6.25
54315	0	0	$1.05 \cdot 10^{-3}$	0
54316	0	0	$1.14 \cdot 10^{-3}$	0
54317	0	0	$2.40 \cdot 10^{-3}$	0
54318	0	0	$6.54 \cdot 10^{-4}$	0
54319	0	0	$4.54 \cdot 10^{-4}$	0
54320	0	0	$1.33 \cdot 10^{-3}$	0
54321	0	0	$3.10 \cdot 10^{-4}$	0
54322	0	0	$6.97 \cdot 10^{-4}$	0
54323	0	0	$2.93 \cdot 10^{-4}$	0
54324	0	0	$3.34 \cdot 10^{-4}$	0
54325	0	0	$5.82 \cdot 10^{-4}$	0

Monitoring well	**Radionuclide activity concentration, Bq/kg**			
	Cs-137	**Co-60**	**Sr-90**	**H-3**
54326	0	0	$7.55 \cdot 10^{-4}$	0

As it could be seen from the table above, H-3 concentration in the water of most of the monitoring wells on the ISFSF/SWTSF territory is 0 Bq/kg and only in a few monitoring wells H-3 concentration reaches 3.47 and 6.25 Bq/kg as measured during 2021 and could be compared to tritium concentration values in natural environment (1÷4 Bq/kg, in non-contaminated surface waters and rainwater [27], but they are significantly lower than the value of tritium activity concentration of unconditional clearance level, equal to 100 kBq/kg [28]. Radiochemical analysis of Sr-90 and gamma spectrometric radionuclide measurements show that radionuclide activity concentrations during 2021 remains at the same level as during the previous years and could be compared with the background concentrations.

Find below the data on the radionuclide activity concentration in the water of monitoring wells in the vicinity of the SWRF. The layout of monitoring wells within the territory of the B2 facility is provided in Fig. 4.1-5.

Table 4.1-11 Radionuclide activity concentration in the water of the monitoring wells, located close to B2 facility during 2021 (see Fig. 4.1-5)

Monitoring well	**Radionuclide activity concentration, Bq/kg**			
	Cs-137	**Co-60**	**Sr-90**	**H-3**
29201	0	0	$1.05 \cdot 10^{-3}$	6.20
29202	0	0	$6.58 \cdot 10^{-4}$	1951
29541	0	0	$6.67 \cdot 10^{-4}$	395
29542	0	0	$6.04 \cdot 10^{-4}$	32.6
29219	0	0	$6.21 \cdot 10^{-4}$	20.1
29535	0	0.93	$6.47 \cdot 10^{-4}$	2134
29536	0	2.29	$8.62 \cdot 10^{-3}$	187
29537	0	0.03	$4.64 \cdot 10^{-4}$	72.2
29538	0	0	$5.76 \cdot 10^{-4}$	69.6

If to compare the data of both tables above, H-3 concentration in the water of most of the monitoring wells close to the SWRF is significantly higher. Regarding H-3 concentration in the water of monitoring wells close to the SWRF, it should be stated that the highest H-3 values of 2134 Bq/kg and 1951 Bq/kg was measured in the water of monitoring wells 29535 and 29202 located in the vicinity of Bld. 157/1 and Bld. 155/1 (see Fig. 4.1-5 the layout of the monitoring wells in this area), but which is still lower than the value of tritium activity concentration of unconditional clearance level, equal to 100 kBq/kg [27]. H-3 concentrations measured in other monitoring wells close to the SWRF are significantly lower and vary between 6.20 and 395 Bq/kg. The increased tritium concentration in the water of the monitoring wells located close to the interim radioactive waste storage facilities (Bld. 155, 155/1, 157, 157/1) was already detected in 1995 in the water of the monitoring wells located around the Bld. 155 and the industrial waste storage site. As the underground transfer of most of radionuclides is a very slow process, the potential cause of origination of higher Tritium concentrations in these monitoring wells is due to broken flashing warning sign "Exit" containing Tritium of the activity more than 1 Curie. This sign could be broken somewhere in 1989 in the radioactive waste storage facility, Bld. 155. Besides, it should be noted that though the high tritium concentration is measured in several monitoring wells, but Cs-137 and Co-60 isotopes characteristic for the nuclear industry radioactive waste are not detected and it indicates that this contamination is not related to the INPP operation. It should also be said that retrieval and further processing of the stored operational radioactive waste from the existing interim radioactive waste storage facilities (Bld. 155, 155/1, 157, 157/1) within the scope of the Project B2 will enable to eliminate further potential radionuclide contamination of the ground water.

Find below the Table 4.1.-12. and Fig. 4.1-6 indicating fluctuation of Tritium concentration in the water of monitoring wells located in the vicinity of Bld. 155, 155/1, 157, 157/1.

Table 4.1-12 Concentration of H-3 in the water of monitoring wells at the ISFSF/SWTSF territory and close to the SWRF

Monitoring well No.	H-3 concentration, Bq/kg			
	2018	2019	2020	2021
Monitoring wells at the ISFSF/SWTSF territory				
43988	2.62	0	0	0
43989	0.64	0.41	0	0
43990	1.04	0	0	0
43991	0.85	1.97	0	0
43992	0.43	2.89	0	0
43993	0.78	1.13	0	0
43994	0.49	0.34	0	0
43995	1.94	1.33	0	3.47
43996	0.24	0.89	0	0
43997	2.95	1.13	0	0
43998	0.21	4.64	3.47	0
43999	0.49	0.54	0	0
44000	0.45	0.64	10.1	0
54311	1.23	2.55	0	0
54312	0.68	1.11	3.49	0
54313	0.81	1.25	0	0
54314	1.31	0.55	0	6.25
54315	0.37	0.81	0	0
54316	0.44	3.41	0	0
54317	0.24	1.39	0	0
54318	0.83	2.45	0	0
54319	0.43	1.02	0	0
54320	0.43	1.41	0	0
54321	0.48	3.12	3.30	0
54322	0.39	0.47	0	0
54323	0.68	0.98	0	0
54324	1.40	0.69	3.65	0
54325	0.49	0.88	0	0
54326	0.61	1.34	4.08	0
Monitoring wells close to SWRF				
29201	7,59	2.85	0	6.20
29202	2677	1715	2493	1951
29541	570	537	515	395
29542	36.4	998	22.2	32.6
29219	7.68	12.5	15.0	20.1
29535	1821	1729	1906	2134
29536	175	223	244	187
29537	79.8	96.8	70.8	72.2
29538	54.9	59.5	64.2	69.6

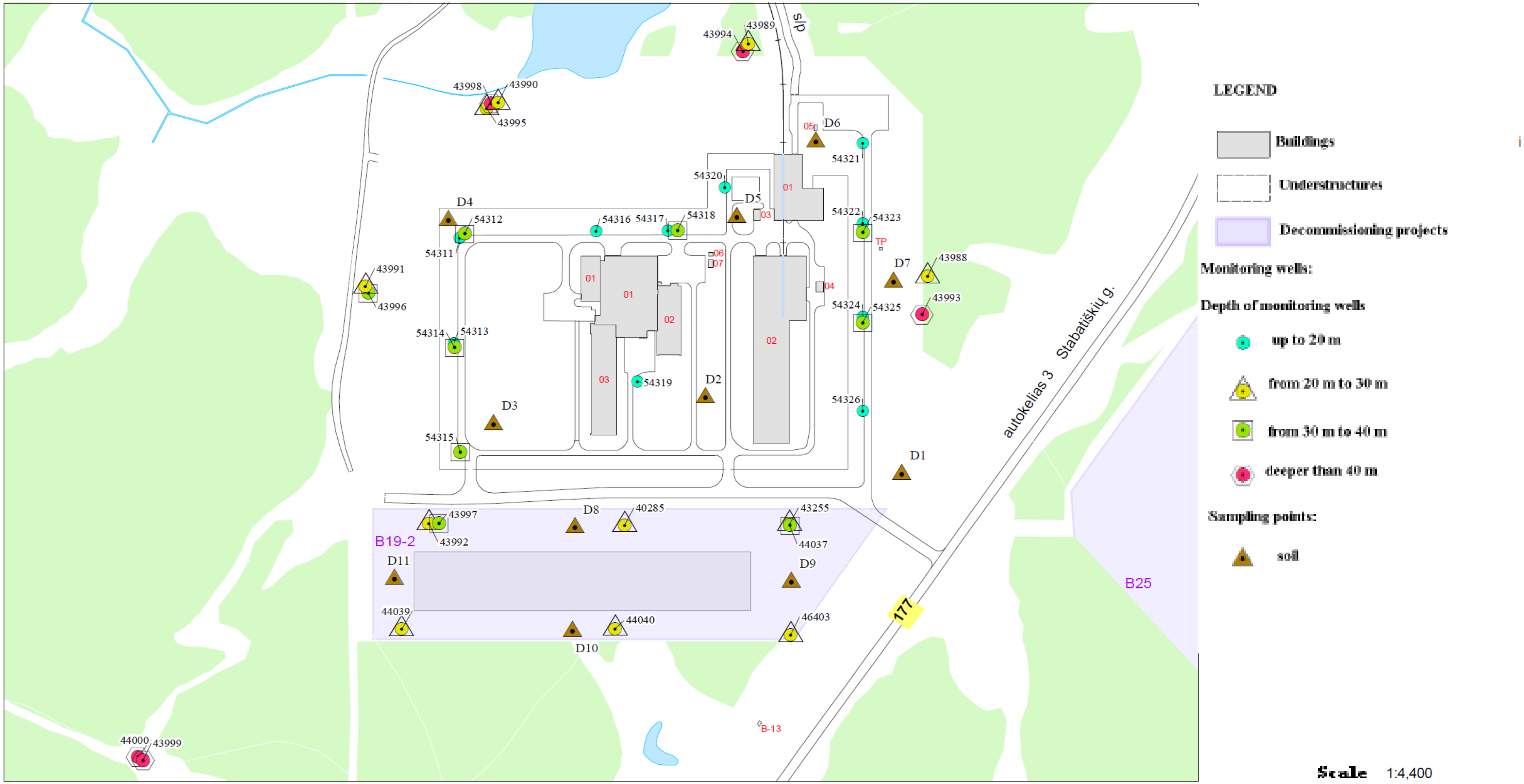


Fig. 4.1-4 Layout of monitoring wells within the territory of ISFSF/SWTSF and newly constructed, but not yet commissioned Landfill facility (B19-2)

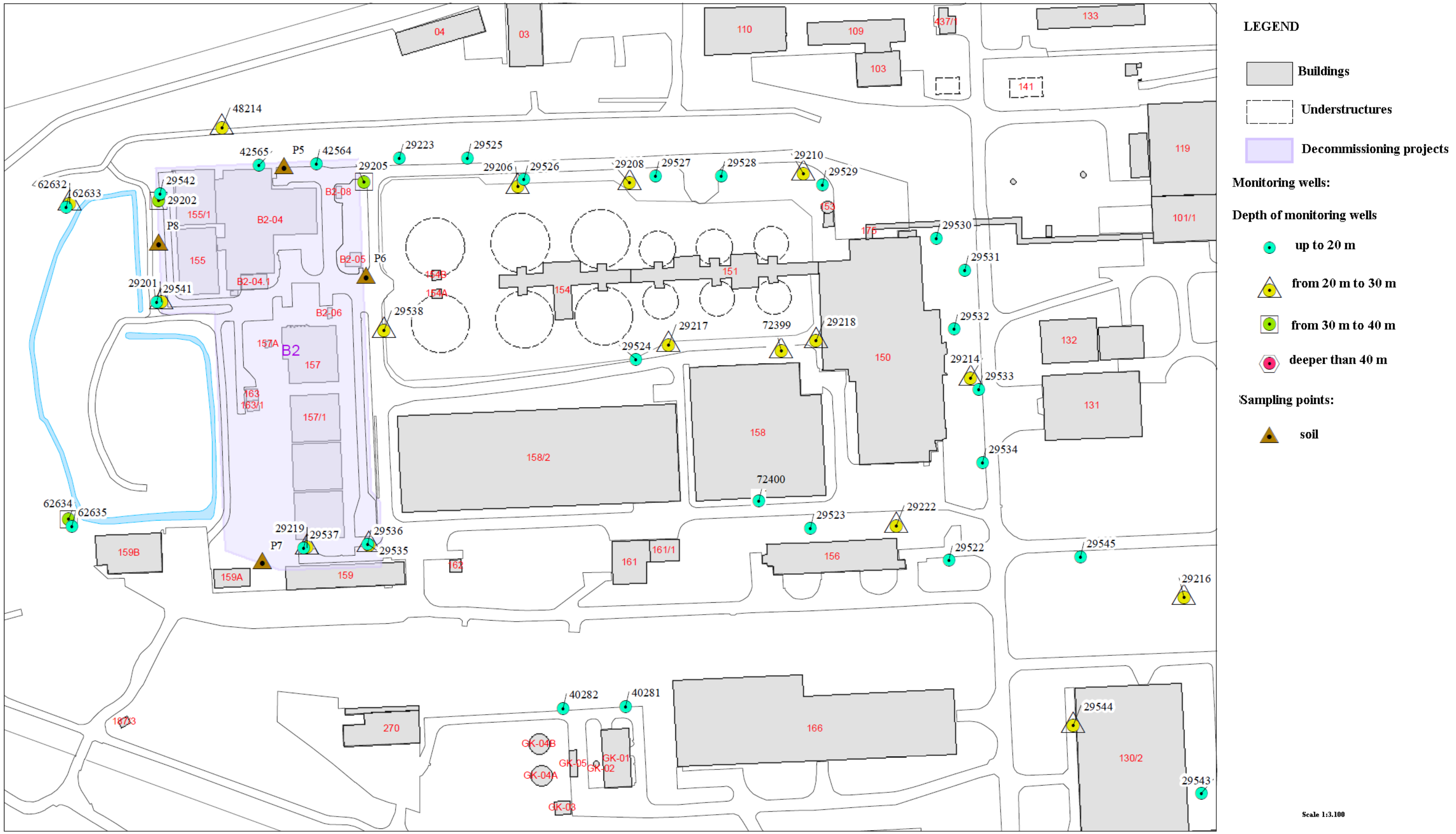


Fig. 4.1-5 Layout of monitoring wells within the territory of radioactive waste storage facilities

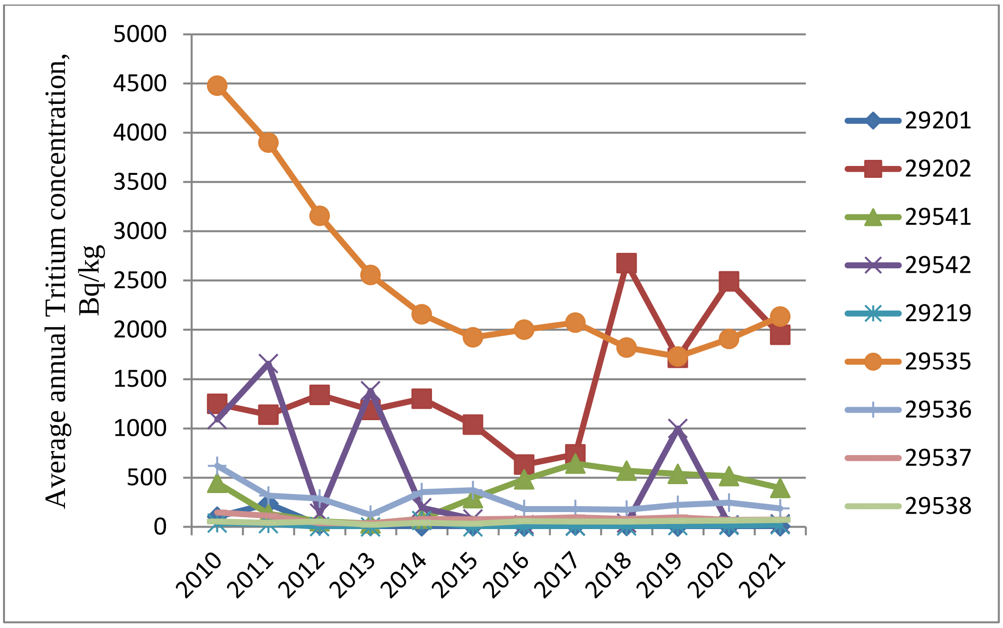


Fig. 4.1-6.Tritium concentration in the water of monitoring wells located in the vicinity of the interim radioactive waste storage facilities

As it could be seen from the table and the figure above, based on the multiyear monitoring data, the radionuclide activity concentration in water of monitoring wells do not indicate the clearly expressed tendency for growth and even the decrease or slight fluctuation of radionuclide activity concentration is observed in some wells, therefore it could be stated that this indicates sufficiently good state of the physical barriers providing radionuclide confinement. Continuous functioning and control of the INPP buildings drainage systems also serve as preventive measure against contamination of the ground water. Migration of H-3 towards Lake Drūkšiai is not observed since the increased values of H-3 are not detected in the water of the sampling point GPNN-1 (see Fig. 4.1-2) located in the close vicinity to the above indicated monitoring well.

To increase H-3 counting efficiency in samples, the correction procedure (quench correction curve) for liquid scintillation analyser TRI-CARB was performed in 2019. The obtained results after correction demonstrate that the measured H-3 values remain unchanged as during the previous years (see Table 4.1-12).

To assess the potential consequences due to the increased Tritium concentration in the groundwater, the conservative assessment of the cumulative effective dose due to Tritium impact on the human body after its consumption was performed. Based on the European Commission publication „Methodology for Assessing the Radiological Consequences of Routine Releases of Radionuclides to the Environment“ on average 600 litres intake rate is assumed in assessment for the tritium model. If the tritium concentration is 2134 Bq/kg (one of the highest Tritium concentrations in year 2021 close to SWRF), then $1.28 \cdot 10^6$ Bq would get into the human body. The annual effective dose of the general public due to tritium impact as a consequence of water consumption as the only source of potable water is equal to 0.02 mSv and is lower than the dose constraint of the annual effective dose - 0.2 mSv set for the general public in the Lithuanian Hygiene Standard HN 73:2018 “Basic Standards of Radiation Protection” [20]. It should be noted that the water from the monitoring wells located on the INPP site is not intended for human consumption or any other human needs.

4.1.5. Radionuclide Activity Concentration in the Soil

Table 4.1-13 Radionuclide activity concentration in the soil of the ISFSF/SWTSF territory during 2021

	Activity concentration, Bq/kg								**Total, Ra, Th, K excluded**	
Sampling point	**Cs-137**	**Mn-54**	**Co-58**	**Co-60**	**Sr-90**	**K-40**	**Th-228**	**Ra-226**	**Bq/kg**	**Bq/m^2**
Sampling points at the ISFSF/SWTSF area										
D1	0.92	<0.23	<0.44	<0.41	2.78	490	13.4	12.3	**3.7**	**146**
D2	1.74	<0.28	<0.67	<0.45	0.87	517	14.8	14.3	**2.61**	**65.5**
D3	0.77	<0.42	<0.45	<0.43	2.51	498	13.9	13.5	**3.28**	**111**
D4	1.26	<0.49	<0.58	<0.49	1.43	546	17.6	15.2	**2.69**	**79.2**
D5	1.15	<0.48	<0.49	<0.48	2.03	475	13.8	12.2	**3.18**	**99**
D6	1.28	<0.24	<0.49	<0.39	1.87	546	15.7	14.9	**3.15**	**114**
D7	1.22	<0.27	<0.58	<0.37	1.68	492	13.8	12.9	**2.90**	**96.2**
Sampling points close to SWRF area*										
P5	2.47	<0.34	<0.57	<0.59	2.08	522	16.1	<0.85	**4.55**	**132**
P6	3.55	<0.40	<0.62	3.13	2.14	509	15.1	13.1	**8.82**	**294**
P7	4.58	<0.35	<0.66	4.91	3.08	552	18.4	15.1	**12.6**	**410**
P8	4.36	<0.27	<0.55	2.62	1.84	513	15.5	13.4	**8.8**	**275**
Total radionuclide activity concentration in the soil of the INPP region (Surveillance Zone)										
2020	0.53	0	0	0	0	461	9.58	8.23	0.53	17.3
2021	1.26	0	0	0	2.56	14.7	16.3	583	3.82	157

* Co-60 activity concentration in the soil of sampling points from the SWRF territory is due to presence of Co-60 in airborne discharges from the SWRF, see Tables 2.1-2 – 2.1-4.

The ISFSF and the SWRF operation did not have impact on the radionuclide activity concentration in the soil of the INPP region. Natural radionuclides K-40, Th-228 and Ra-226 are provided for comparison purposes only, as they are not released from the INPP. As it could be seen from the Table, K-40, Th-228 and Ra-226 and the globally distributed in the atmosphere radionuclide Cs-137 mostly contribute to the soil activity.

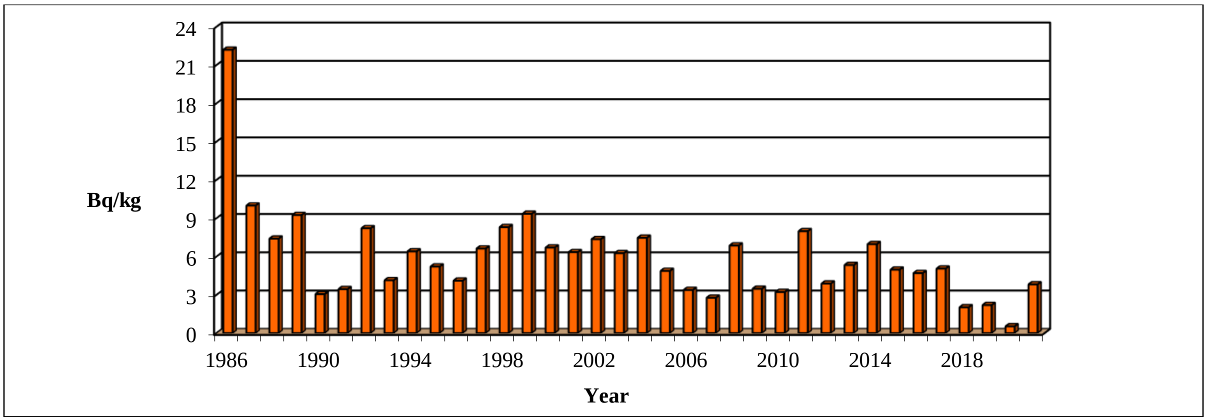


Fig. 4.1-7 Total radionuclide activity concentration in the soil of the INPP region during 1986-2021

4.1.6. Radionuclide Activity Concentration in the Bottom Sediments of Water Bodies (not related to the ISFSF and SWRF operation)

Radionuclide activity concentration in bottom sediments of water bodies in 2021 is provided in Table 4.1-14. The layout of sampling points is provided in Fig. 4.1-2 and Fig. 4.1-3.

Table 4.1-14 Radionuclide activity concentration in bottom sediments of water bodies in 2021

Sampling point	Sampling data	Dry weight concentration, Bq/kg												Total, Ra, Th, K excluded
		Cs-137	Cs-134	Mn-54	Co-58	Co-60	Zr-95	Nb-95	Fe-59	Sr-90*	Ra-226	Th-228	K-40	
Lake Drūkšiai E1 point	July	34.8	<5.36	<6.28	<3.35	<6.77	<2.24	<1.56	<36.1	1.63	<79.7	34.3	769	36.4
Lake Drūkšiai E2 point	July	6.12	<0.47	<0.29	<0.40	0.52	<2.55	<1.73	<1.76	2.41	<8.13	13.0	550	8.53
Lake Drūkšiai E3 point	July	1.15	<1.49	<1.80	<0.93	<1.69	<3.69	<2.53	<10.8	2.26	<22.0	12.8	478	3.41
Lake Drūkšiai E4 point.	July	8.25	<0.69	<0.66	<0.62	<0.59	<3.42	<2.40	<2.63	2.08	<13.8	7.85	442	10.3
Lake Drūkšiai E5 point	July	2.23	<0.95	<0.45	<0.81	<0.82	<3.11	<2.29	<1.99	2.43	<15.5	28.4	994	4.66
Lake Drūkšiai E6 point	July	12.5	<0.76	<0.69	<0.51	<0.66	<2.87	<1.89	<0.51	1.93	<12.3	13.4	508	14.4
In Lake Drūkšiai points. average:		**10.8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2.12**	**0**	**18.3**	**624**	**13.0**
GPPN-1.2	April	19.6	<2.02	<1.97	<1.15	13.5	<2.24	<1.79	<4.73	-	<32.3	16.7	552	36.0
-"-	July	18.3	<1.29	<1.19	<1.15	16.3	<1.68	<0.74	<4.27	-	<27.8	14.2	627	37.5
-"-	October	0.73	<0.38	<0.19	<0.24	0.36	<0.39	<0.29	<0.90	-	<6.06	8.86	408	4.00
GPPN-1. 2. average:		**12.9**	**0**	**0**	**0**	**10.1**	**0**	**0**	**0**	**2.86**	**0**	**13.3**	**529**	**25.8**
Drainage water after purification plant	April	2.42	<0.68	<0.58	<0.43	<0.62	<0.61	<0.49	<1.45	-	24.3	6.51	393	5.36
-"-	July	1.39	<0.59	<0.58	<0.38	<0.56	<0.78	<0.45	<2.19	-	<7.99	4.02	342	4.33
-"-	October	12.2	<0.51	<0.37	<0.58	<0.45	<1.09	<0.91	<1.62	-	<9.93	13.1	405	15.1
Drainage water after purification plant. average:		**5.34**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2.94**	**8.10**	**7.88**	**380**	**8.28**
GPNN PBKS	April	1.43	<0.53	<0.46	<0.48	<0.51	<0.51	<0.43	<1.24	-	<8.37	3.89	375	3.15
-"-	July	1.67	<0.59	<0.56	<0.57	<0.59	<0.77	<0.49	<2.09	-	<11.7	4.49	421	3.39
-"-	October	1.49	<0.32	<0.31	<0.34	<0.32	<0.59	<0.42	<0.89	-	<5.02	5.67	436	3.21
GPNN PBKS, average:		**1.53**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.72**	**0**	**4.68**	**411**	**3.25**

Since no bottom sediments in GPPN-3 is observed as the bottom of the channel is concrete, no sampling of the bottom sediments is performed, including the IK channel, as no bottom sediments were detected in this channel in 2021. Natural radionuclides K-40, Th-228 and Ra-226 are provided for comparison purposes only, as they are not released from the INPP.

* - Sr-90 measurement is performed once per year (integrated and homogenised sample).

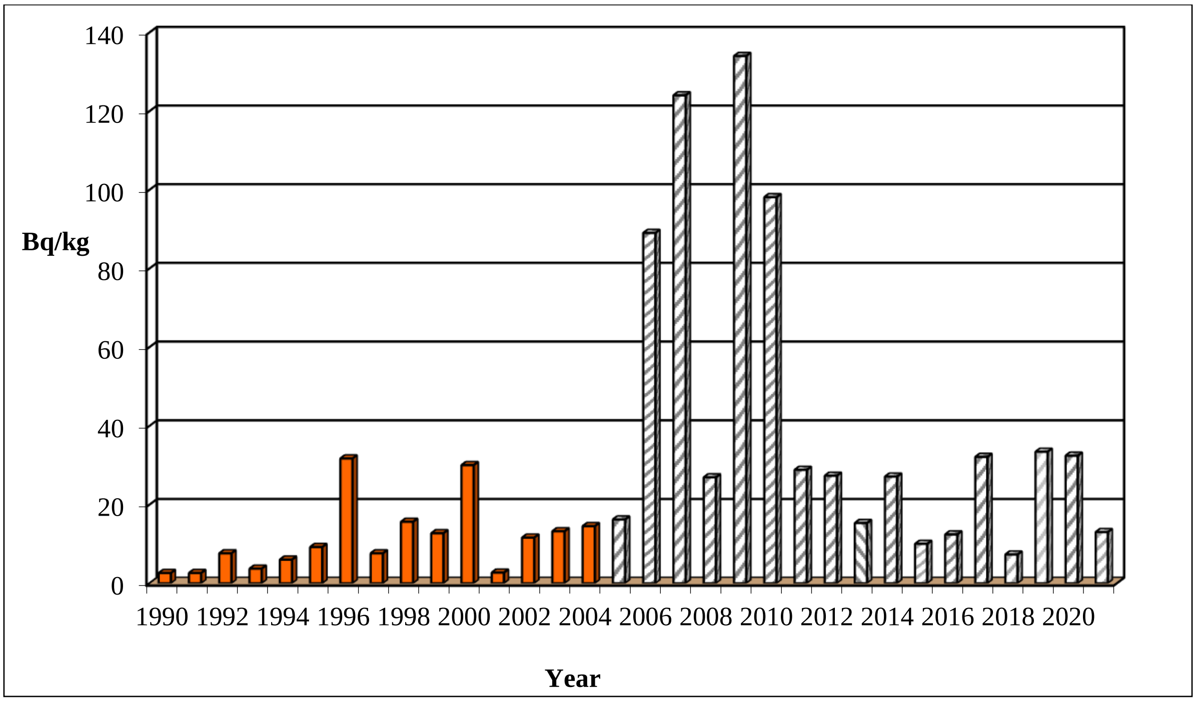


Fig. 4.1-8 Radionuclide content in samples of bottom sediments taken from lake Drūkšiai baseline measurement points (Fig. 4.1-3) (starting from 2005 concentrations are provided for dry mass)

Cs-137 and Sr-90 background concentrations in bottom sediments of Lake Drūkšiai during the start-up period varied between 44 and 170 Bq/kg (Cs-137) and from 0.9 to 1.3 Bq/kg (Sr-90) for dry mass. Specific radionuclide activity concentrations during 2021 are within the level of the background values.

4.1.7. Radionuclide Activity Concentration in Plants and Foodstuff

Table 4.1-15 Radionuclide activity concentration in algae of Lake Drūkšiai in 2021 (see Fig. 4.1-3)

Sampling point	Dry weight concentration Bq/kg													
	Cs-137	Cs-134	Mn-54	Co-58	Co-60	Cr-51	Fe-59	Sr-90	K-40	Be-7	Th-228	Ra-226	Total	Total, K, Be, Th, Ra exc.
E1	2.85	<2.75	<2.59	<1.90	<2.61	<5.91	<6.13	2.76	725	179	3.54	43.8	957	5.61
E2	2.27	<1.36	<1.32	<0.98	<1.36	<4.44	<3.39	1.14	1121	134	2.42	<20.2	1261	3.41
E3	1.14	<2.39	<2.44	<1.83	<2.55	<4.76	<6.51	4.14	786	173	<4.32	<43.8	964	5.28
E4	4.64	<0.84	<0.78	<0.63	<0.79	<2.81	<1.93	2.77	462	153	6.25	<14.6	629	7.41
E5	2.93	<2.49	<2.81	<2.0	<2.75	<3.39	<8.57	0.76	968	278	2.53	<54.1	1252	3.69
E6	22.3	<1.21	<1.15	<0.94	<1.13	<4.25	<2.65	5.18	347	308	4.75	<19.1	687	27.5
IK	2.84	<1.59	<1.49	<1.12	<1.57	<3.37	<3.52	5.42	258	157	0.99	21.6	446	8.26
GPNN-3	4.60	<1.07	<1.00	<1.02	0.59	<9.70	<2.27	1.68	299	193	1.56	35.5	536	6.87

Natural radionuclides K-40 and Be-7 make the biggest contribution to the total specific activity of algae.

Table 4.1-16 Radionuclide activity concentration in the fish caught in Lake Drūkšiai in 2021

Fish	**Fresh weight concentration, Bq/kg**			
	Cs-137	**Sr-90**	**K-40**	**Total, K-40 excluded**
Pike	1.08	0.02	122	1.10
Perch	3.29	0.03	130	3.32
Roach	0.73	0.05	129	0.78
Trench	0.69	0.13	138	0.82

Fish	Fresh weight concentration, Bq/kg			
	Cs-137	**Sr-90**	**K-40**	**Total, K-40 excluded**
Bream	0.69	0.05	130	0.74
Average:	**1.30**	**0.06**	**130**	**1.36**

The average annual radionuclide activity concentration in the fish caught in Lake Drūkšiai (1985 – 2021) is provided in Figure below.

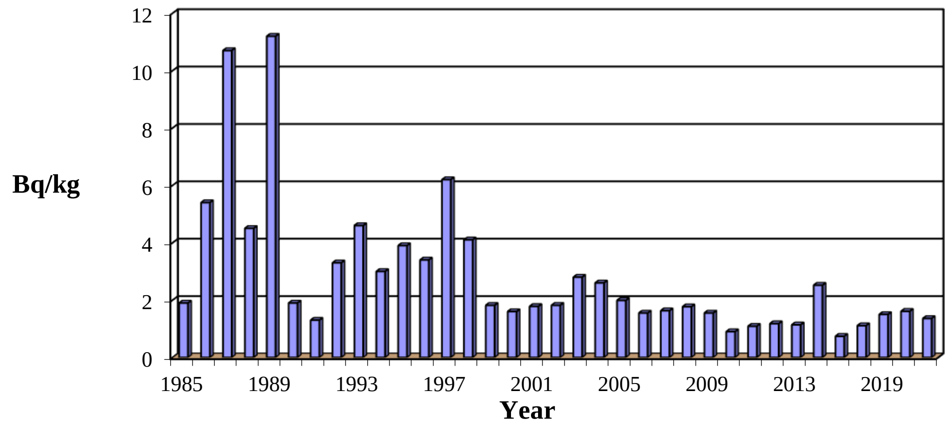


Fig. 4.1-9 Average annual radionuclide activity concentration in the fish caught in Lake Drūkšiai

Radionuclide activity concentration values in plants, vegetables and foodstuff are provided in Table 4.1-17.

Table 4.1-17 Radionuclide activity concentration in plants, vegetables, foodstuff in 2021

Sample	Consumption per year, kg	Dry weight concentration, Bq/kg					Exposure dose (K-40 excluded), 10^{-4} mSv	Exposure dose (K-40 included), 10^{-4} mSv
		Cs-137	**Mn-54**	**Co-60**	**Sr-90**	**K-40**		
Grass	-	0.08	0	0	0.51	705	-	-
Moss	-	13.1	0	0	-	175	-	-
Mushrooms	3	40.5	0	0	<0.003	97.2	15.8	33.9
Fish	18	1.30	0	0	0.06	130	3.34	145
Milk (Tilžė)	326	0	0	0	0.002	44.8	0.18	906
Grain (Tilžė)	103	<0.3	<0.4	<0.4	0.06	145	1.73	926
Potatoes (Tilžė)	81	<0.3	<0.3	<0.3	0.03	150	0.68	754
Cabbages (Tilžė)	102	<0.3	<0.4	<0.4	0.03	66.4	0.86	420
Total annual dose:							**22.6**	**3184**

No nuclear origin radionuclides were detected in vegetative and animal products.

The total annual exposure dose because of consumption of measured products due to induced radionuclide activity constitutes $22.6 \cdot 10^{-4}$ mSv and is practically in line with the previous year's results.

4.1.8. Dose Rate. Exposure Dose

The INPP environmental monitoring includes monitoring of the exposure dose and dose rate in different locations of the INPP region. Continuous dose rate monitoring is performed by the "Skylink" system stationary gamma detectors. 12 detectors are installed in the INPP SPZ (Fig. 4.1-10). 10 detectors are installed in the 30 km surveillance zone (Fig. 4.1-11). In addition to stationary detectors, dose rate is measured by portable devices 4 times per year in various locations of the surveillance zone.

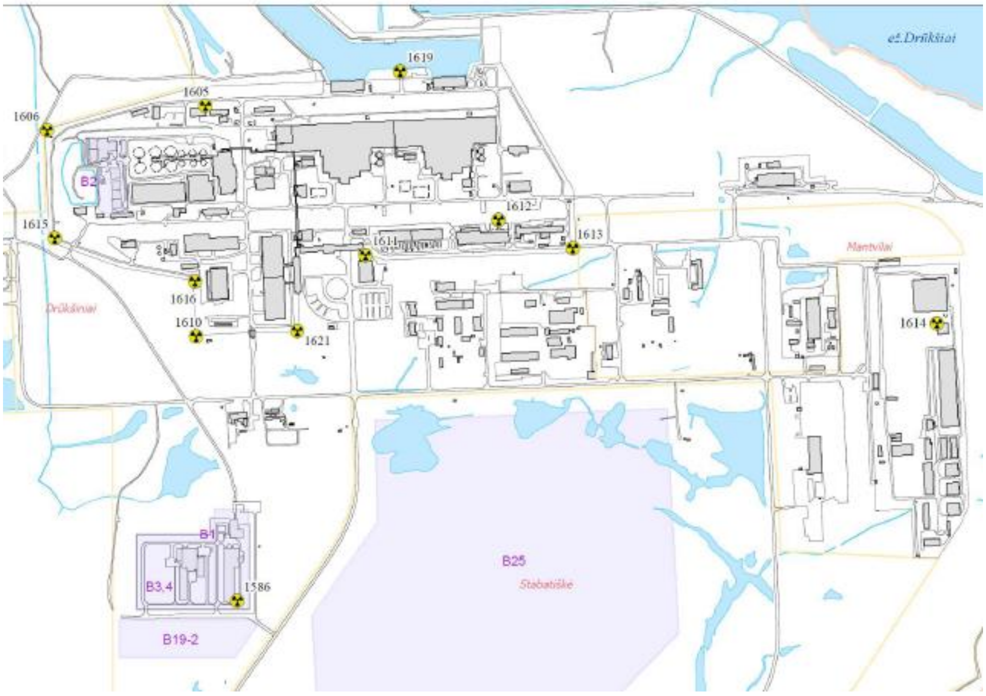


Fig. 4.1-10 Layout of the Skylink system gamma detectors within the INPP 3 km zone

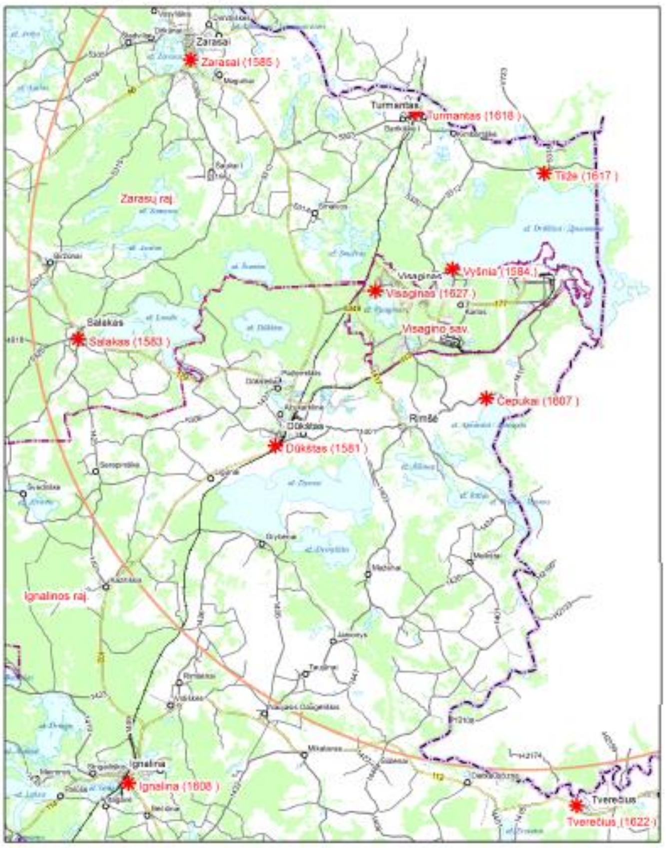


Fig. 4.1-11 Layout of the Skylink system gamma detectors within the INPP 30 km zone

The measured dose rate within the surveillance zone was between 0.067 and 0.196 μSv/h during 2021. During 2021 the average dose rate within the surveillance zone was 0.101 μSv/h. The maximum dose rate value (up to 0.196 μSv//h) was detected in case of intensive precipitation (15.7 mm, 28 August 2021). The measured dose rate within the sanitary protection zone was between 0.069 and 0.196 μSv/h during 2021. During 2021 the average dose rate within the sanitary protection zone was 0.105 μSv/h.

The average gamma radiation dose rate in the INPP region measured by the portable dosimeters was 79.3 nSv/h in 2021. The average dose rate of the population living in the surveillance zone due to external radiation background measured by the portable dosimeters was 0.70 mSv/year in 2021.

The radiological impact to the population and the environment due to nuclear origin radionuclides detected in the atmosphere and water media is far below than the impact due to cosmogenic radionuclides and the globally distributed in the atmosphere radionuclide Cs-137.

The annual ambient dose equivalent of the representative person due to all gamma radiation sources in the sanitary protection zone and surveillance zone continuously measured by 27 thermoluminescent dosimeters (Fig. 4.1-12) are provided in Table 4.1-18.

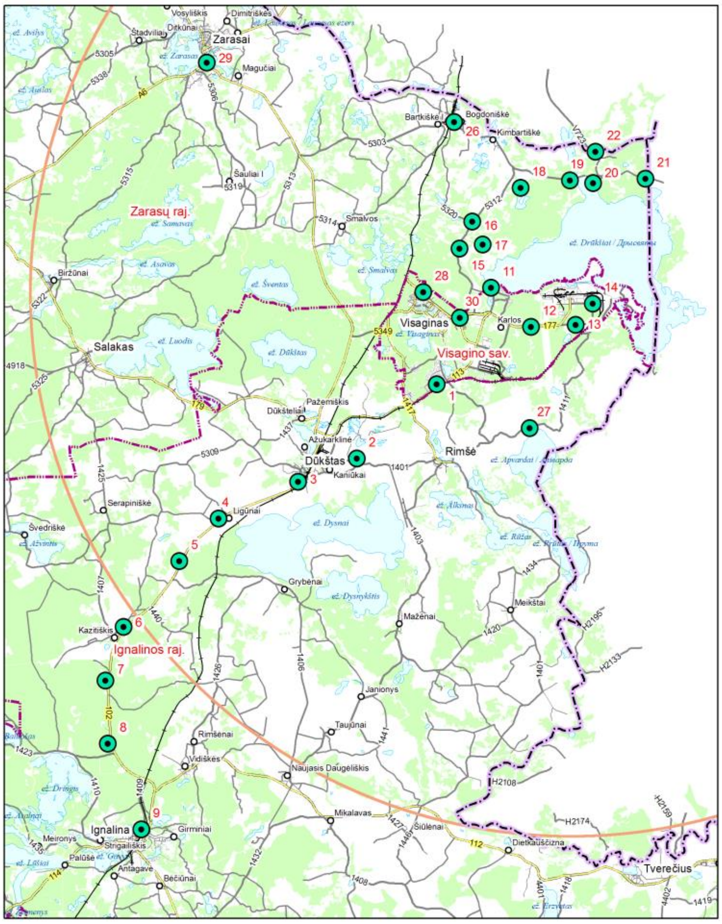
Table 4.1-18 Ambient dose equivalent during 2021 based on TLD measurement results

TLD	Name of the location where TLD are installed	Direction from the INPP, º	Distance from the INPP, km	Ambient dose equivalent, mSv
1	Magūnai	236	9.0	0.59
2	Rojus	236	9.7	0.69
3	Dūkštas	237	18	0.86
4	Ligūnai 1	239	23	0.66
5	Ligūnai 2	236	28	0.72
6	Kudiškėliai	234	32	0.60
7	Kazitiškės	233	33	0.68
8	Obza	225	36	0.54
9	Ignalina 1	220	38	0.51
10	Ignalina 2	219	38	0.72
11	Vyšnia	257	4.5	0.55
12	Watering place	238	3.6	0.62
13	Transportation unit	186	1.9	0.74
14	Equipment depot	106	1.6	0.48
15	Iliškiai	286	6.3	0.46
16	Stačiūnai	306	6.6	0.63
17	Schodai	323	6.0	0.78
18	Šakiai	351	6.3	0.64
19	Tilžė 1	6	6.2	0.64
20	Tilžė 2	29	7.3	0.76
21	Raipolė	15	6.2	0.59
22	Demenė	15	6.6	0.51
23	Turmantas	329	11	0.71
24	Čepukai	187	7.7	0.62
25	Visaginas hospital	269	7.9	0.52
26	Zarasai	302	24	0.60
27	Bld. 438	258	6.2	0.52
Average:				**0.63**

Annual ambient dose equivalent measurements on the ISFSF/SWTSF site are performed continuously by 17 thermoluminescent dosimeters (8 dosimeters around the ISFSF) (Fig. 4.1-13). Estimated annual ambient dose equivalent of the representative person is provided in Table 4.1-19.

Table 4.1-19 Ambient dose equivalent of the representative person on the ISFSF site during 2021 based on TLD measurement results

Name of the location where TLD are installed	Annual ambient dose equivalent, mSv/year					
	2016	**2017**	**2018**	**2019**	**2020**	**2021**
Point 1	0.72	0.82	0.65	0.66	0.54	0.61
Point 2	0.82	0.79	0.67	0.75	0.69	0.71
Point 3	0.77	0.78	0.66	0.75	0.69	0.71
Point 4	0.67	0.75	0.68	0.81	0.69	0.75
Point 5	0.78	0.83	0.72	0.67	0.71	0.65
Point 6	0.65	0.80	0.70	0.71	0.63	0.69
Point 16	0.65	0.80	0.71	0.71	0.65	0.65
Point 17	0.77	0.76	0.70	0.76	0.63	0.63
Average:	**0.73**	**0.79**	**0.69**	**0.72**	**0.65**	**0.67**



Termoliuminescencinių dozimetrų išdėstymo vietos

Fig. 4.1-12 Layout of TLD dosimeters in the area

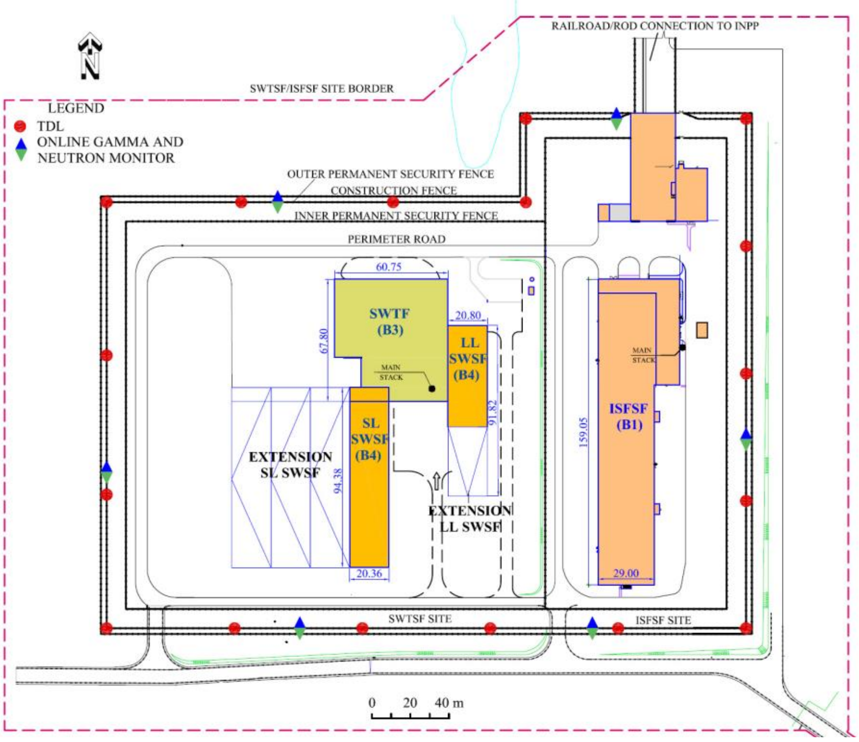


Fig. 4.1-13 Layout of TLD, gamma and neutron dosimeters on the ISFSF/SWTSF sites

4.1.9. Conclusions

The continued operation of the ISFSF and the SWRF did not have impact on the radiological situation within the INPP sanitary protection zone and the surveillance zone in 2021, as:

- No radionuclides that have not been identified in the ISFSF and the SWRF Environmental Impact Assessment Reports [22, 23] and included into the Plan on Radionuclide Release into the Environment from the Ignalina NPP [24] were identified in airborne discharges from the ISFSF and SWRF.
- Released radionuclide activities during the ISFSF and SWRF operation (2.730E+08 and 2.198E+07 Bq/year) are far below the permissible values set in the Plan [24], including that no other radionuclide release pathways have been identified.
- The contribution of radionuclides released from the ISFSF and the SWRF (only airborne discharges as no uncontrolled waterborne discharges could occur from the ISFSF and the SWRF) into the total exposure dose due to discharges from all the INPP nuclear installations is negligible and constitutes 1.002E-09 and 2.204E-07 Sv, correspondingly, and the total exposure dose of the representative person due to airborne discharges from all the NI on the INPP site is equal to 1.374E-06 Sv and constitutes 1.374 % of the dose constraint [20].
- The total estimated dose to the representative person during 2021 due to airborne and waterborne discharges from all the INPP nuclear installations is equal to 1.87E-03 mSv which is 107.1 times less than the dose constraint of the representative person - 0.2 mSv/year.
- No operational occurrences breaching the safe operating limits and conditions have occurred. All the required accident elimination instructions and plans related to the ISFSF and SWRF operation are developed and tested.
- No uncontrolled radionuclide airborne and waterborne discharges from the ISFSF and the SWRF to the environment have been detected.

- Operation of the SWRF facility. i. e. retrieval and further processing of the stored INPP operational radioactive waste from the existing interim radioactive waste storage facilities (Bld. 155. 155/1. 157. 157/1) will enable to eliminate further potential radionuclide contamination of the ground water in the vicinity of these facilities.
- The ISFSF and SWRF operation, including operation of all other INPP nuclear installations, did not have negative impact on the health of the population and the environment of the neighbouring countries.

Besides, based on the measurements conducted by the Radiation Protection Centre of the Republic of Lithuania during 2021 within the scope of the State Environmental Monitoring Programme for years 2018–2023 encompassing, among others, monitoring of airborne and waterborne discharges from the Ignalina NPP and radiological measurements of Lake Drūkšiai water, bottom sediments and biota and the summarised results provided in the State Radiological Environmental Monitoring Report for year 2021 [29], it is concluded that:

- The analysis of obtained radiological environmental monitoring survey and measurements results show that the radiological situation of the environment did not change due to the INPP activities, no higher-than-normal volumes of radioactive materials in the environment were detected.
- Contamination of foodstuffs (meat, fish, milk, grain, vegetables) and potable water by Cs-137 and Sr-90 was negligible. The analysed radionuclide activity concentrations in samples from the INPP region do not differ from the activity concentrations in samples taken from other regions of Lithuania. The activity concentration in most of the taken samples is less than 0.1 Bk/kg.
- Co-60 and Cs-137 activity concentration values in water samples of Lake Drūkšiai are below the minimum detection activity during the last 15 years. The average Sr-90 activity concentration in the water is 3.12 Bq/m^3.
- Co-60 and Cs-137 activity concentrations in bottom sediments and vegetation of Lake Drūkšiai show clear tendency for decrease for the last 10 years.

5 MONITORING RESULTS OF CHEMICAL POLLUTANTS IN THE ENVIRONMENTAL WATER COMPONENTS

The scope of monitoring of the chemical parameters is established in the INPP Environmental Monitoring Program [30] and the Summarising Report on Monitoring of the Impact of the Facilities located on the SE INPP Territory to the Groundwater for Years 20017-2021 and the Programme for Years 2022-2026 [31].

The results of Lake Drūkšiai water chemical monitoring performed by the accredited INPP Laboratories according to the INPP Environment Monitoring Program [30] are provided in Table 5.1-1. Sampling locations are provided in Fig. 5.1-1.

According to the data in Table 5.1-1. Lake Drūkšiai water quality indicators comply with the established norms. According to the Environmental Monitoring Report [32] results, Lake Drūkšiai water quality complies with the criteria established for lakes of very good ecological state [33] according to the physical and chemical quality parameters (N and P total content).

Table 5.1-1 Pollutants concentration in water of Lake Drūkšiai

Parameters	Limit values according to the established norms	2021	
		Min. values	Max. values
t. ^{0}C	28	7.1	28.8
pH.	6 – 9	7.0	8.8
Suspended solids. mg/l	≤25	<2.0	12.8
BOD_7. mgO_2/l	≤ 6	0.9	2.6
COC. mgO_2/l	More than 2000 GE	<8.43	55
NH_4-N content. mg/l	≤0.78	0.004	0.034
NO_3-N content. mg/l	-	0.027	0.1
NO_2-N content. mg/l	≤0.05	0.001	0.003
N total content. mg/l	0.9-1.20	0.59	0.60
PO_4-P content. mg/l	≤0.13	0.006	0.024
P total content. mg/l	0.030-0.050	0.017	0.022
Cl- content. mg/l	≤300	6.12	11.7
SO_4^{2-} content. mg/l	≤100	3.99	13.3
Petroleum products content	-	0.058	0.086

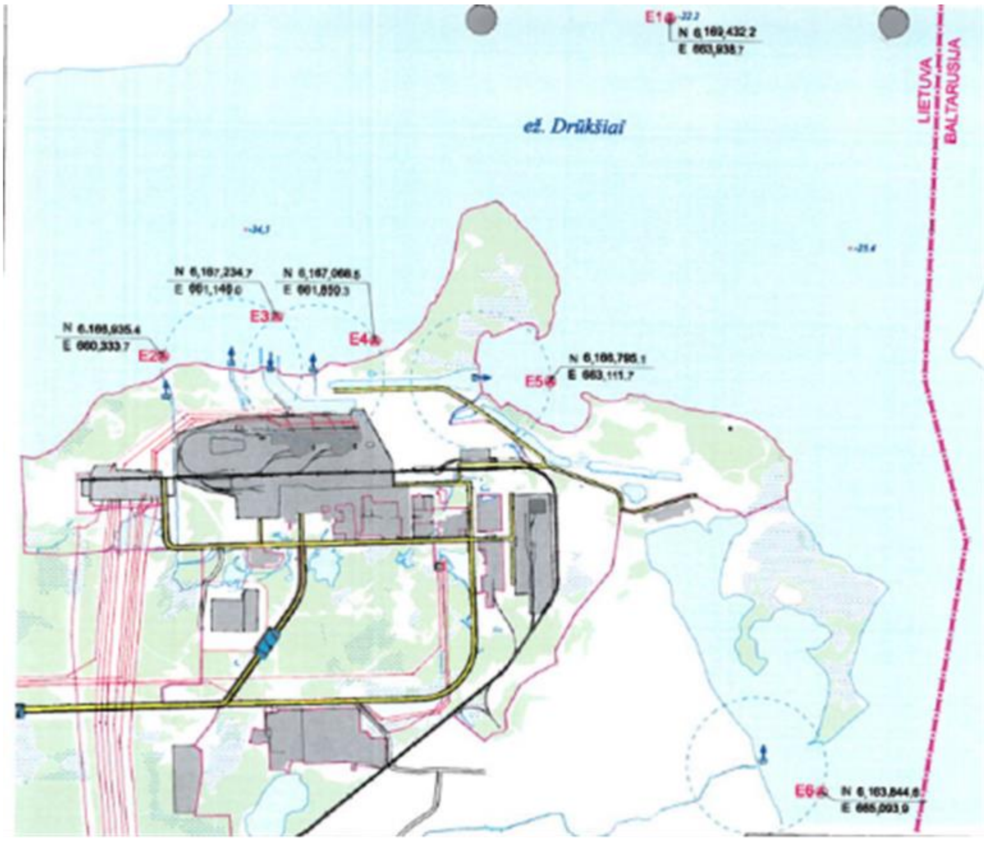


Fig. 5.1-1 Lake Drūkšiai Water Sampling Locations

If to mention about the atmospheric air pollution from the established air pollution source (the steam boiler station) during the monitoring period, it could be stated that the measured values do not exceed the limit values set in the Permit for Pollution No. TV(2)-3 /TL-U.5-13/2016 [34].

In compliance with the Summarising Report on Monitoring of the Impact of the Facilities located on the SE INPP Territory to the Groundwater for Years 2017-2021 and the Programme for Years 2022-2026 [31] developed on the basis of the requirements of the Regulation of Environmental Monitoring of Economic Entities [35] the following general chemical composition parameters, general pollution indicators and indicators specific to the INPP activity and produced waste are measured 2 times/year: groundwater level, temperature, pH, oxygen concentration, electric conductivity, total chemical analysis (dissolved solids total, hardness total, Permanganate, Bichromate index, Cl, SO_4, NO_2, NO_3, Na, K, Ca, Mg, NH_4), COD, petroleum products total content, heavy metals content, Nitrogen (N), Phosphate (P) total content, PO_4, BOD_7.

In summarising the annual groundwater monitoring results [31], it should be stated that the measured values of the following monitored microelements/heavy metals Cd, Cr, Cu, Hg, Zn did not exceed the maximum permissible concentrations (hereafter referred to as MPC), but the measured values of Pb, Ni in several monitoring wells increased in comparison with the previous years monitoring results. Such increase of heavy metals concentrations in the groundwater of the INPP territory stands out against the clean hydrochemical background of the groundwater of the INPP territory according to the other measured parameters and could be explained by the fact that a specific rarely found hydrogeological environment has formed in this area that is favourable for accumulation and migration of such metals. The episodic groundwater pollution by petroleum products was observed, but not exceeding the MPC (1 mg/l) and the tendency for reduction is observed. Results of measurement of such parameters as electric conductivity, water temperature, pH, dissolved oxygen show that neither increased salinity of the water, nor abnormal temperatures are observed. In most cases pH of monitoring wells water is within the range of 7-8. However increased acidity (pH<7) of the water is observed in the vicinity of solid radioactive waste retrieval facility and the area between the Units and lake Drūkšiai and is related to technological processes using acids. Increased alkalinity (pH>8, >10-12) of the water is observed in the area between the Units and lake Drūkšiai and buffer storage of the Landfill facility and are related to degradation of organic materials. Analysis of Cl, SO4, NO2, NO3, Na, K, Na, Ca, Mg, NH4-N in samples indicated that only NH4-N is of concern (MPC – 10 mg/l). The maximum values were observed in shallow monitoring wells in the vicinity of the recultivated wastewater sludge dumping site reaching 35.2 – 63.5 mg/l. However, in deeper monitoring wells the values were within the range of background level and did not exceed 0.5 mg/l, thus indicating that only shallow ground water is polluted by sludge. Permanganate index did not exceed the established value of <20 mg/l O2 in water of none of the monitoring wells, however BI/COD (MPC<30 mg/l O2) values within the range of 30 – 100 mg/l O2 (average pollution level) were detected. The maximum measured values of BOD7 (MPC 29 mg/l O2) in the water of monitoring wells close to the recultivated wastewater sludge dumping site (the only monitoring point) reached only 8.4 – 8.5 mg/l O2 and are considered as negligible. The total content of Nt (MPC - 30 mg/l) and Pt (MPC - 4 mg/l), as well as PO4-P (MPC - 3.3 mg/l) were also measured only in the water of monitoring wells close to the recultivated wastewater sludge dumping site and the maximum values of Nt reached 34.2- 58.3 mg/l. All this nitrogen is bonded into ammonium. The maximum values of Pt and PO4-P were far below the established MCP and are negligible.

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