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DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D - Nuclear Safety and Fuel Cycle
Radiation protection

Technical Report of the Verification under the Terms of Article 35 of the Euratom Treaty

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Environmental radiological monitoring in the Slovak Republic

Monitoring of liquid and gaseous discharges at the Mochovce NPP

3 to 7 November 2014

Reference: SK 14-03

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES	Environmental radiological monitoring in the Slovak Republic Monitoring of liquid and gaseous discharges at the Mochovce NPP
LOCATION	Bratislava, Banska Bystrica, Mochovce
DATES	3-7 November 2014
REFERENCE	SK 14-03
TEAM MEMBERS	V. Tanner (team leader) C. Hanot A. Ryan T. Tollefsen
REPORT DATE	29 May 2015
SIGNATURES	

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TABLE OF CONTENTS

1 INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State shall establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the Basic Safety Standards[1] Article 35 also gives the European Commission (EC) the right of access to such facilities in order that it may verify their operation and efficiency. The Radiation Protection Unit (ENER D.3) of the EC's Directorate-General for Energy (DG ENER) is responsible for undertaking these verifications.

The main purpose of verifications performed under Article 35 of the EURATOM Treaty is to provide an independent assessment of the adequacy of monitoring facilities for:

- Liquid and airborne discharges of radioactivity into the environment by a site.
- Levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant pathways.
- Levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication[2] was published in the EU Official Journal on 4 July 2006 describing practical arrangements for the conduct of Article 35 verification visits in Member States.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The EC's decision to conduct an Article 35 verification was notified to the Slovak Government by a letter addressed to the Slovak Permanent Representation to the European Union. The Slovak Government subsequently designated the Public Health Authority of the Slovak Republic (PHA) to lead the preparations for this visit.

2.2 DOCUMENTS

In order to facilitate the work of the verification team, a package of information was supplied in advance by the national authorities. Additional documentation was provided during and after the visit. All documentation received is listed in Appendix 1 to this report. The information thus provided has been extensively used for drawing up the descriptive sections of the report.

2.3 PROGRAMME OF THE VISIT

The EC and the PHA discussed and agreed upon a programme of verification activities (Appendix 2), with due respect to the Commission Communication of 4 July 2006 setting out practical arrangements for the conduct of Article 35 verification visits. The verifications were carried out in accordance with the programme.

The following representatives of the national authorities and other parties involved were met:

[1] Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L-159 of 29/06/1996) which will be superseded by Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom (OJ L 13 of 17.1.2014, p. 1).

[2] Commission Communication Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty - Practical arrangements for the conduct of verification visits in Member States (OJ C 155, 4.7.2006, p. 2–5).

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3 MONITORING PROGRAMMES AND RESPONSIBLE ORGANISATIONS

3.1 INTRODUCTION

The regulatory authority responsible for monitoring radioactivity in the environment consists of the Public Health Authority of the Slovak Republic (PHA) and several regional Public Health Authorities. All these bodies operate under the Ministry of Health of the Slovak Republic.

Environmental radioactivity monitoring in the surroundings of the nuclear power plants of Mochovce and Jaslovske Bohunice is carried out by the operators (as approved by the Public Health Authority) and, independently from the operator, by the regulator.

3.2 PUBLIC HEALTH AUTHORITY OF THE SLOVAK REPUBLIC

The Public Health Authority of the Slovak Republic is the national authority in charge of all matters of public health, including radiation practices. Within the PHA the Section of Radiation Protection is responsible for radiation protection in general. It comprises a working group for Nuclear Installations, a group for Biological Effects, a group for Workplaces with Ionising Sources, a group for Environmental Monitoring, a group for Radiation Monitoring Network and a group dealing with the central register of sources and doses.

3.3 REGIONAL PUBLIC HEALTH AUTHORITIES

There are five regional public health authorities in Slovakia, working under the national health authority. Three of these carry out monitoring of environmental radioactivity, but particularly important in this regard are the two authorities with a nuclear power plant in their region (Regional PHA in Banska Bystrica and Public Health Authority of the Slovak Republic).

3.4 SLOVAK HYDROMETEOROLOGICAL INSTITUTE

The Slovak Hydrometeorological Institute (SHMI) is a specialised organisation providing hydrological and meteorological services at the national and international level. The scope of its activities is currently laid down in Act no. 201/2009 on state hydrological and meteorological services. It is a state-subsidised organisation operating under the Slovak Ministry of Environment.

The SHMI's activities include the following: monitoring of quantitative and qualitative parameters of the air and water within the Slovak territory; collecting, verifying, interpreting and archiving data and information on the condition of air and water; describing developments in the atmosphere and hydrosphere and issuing forecasts, warnings and other information regarding the atmosphere and hydrosphere.

The SHMI obtains most of its data on the quality of air and water from the various monitoring facilities of the state hydrological and meteorological network. A key aspect of the institute's activities is the international cooperation and the exchange of data with counterpart services abroad. SHMI is certified to ISO 9001.

4 LEGAL FRAMEWORK FOR RADIOACTIVITY MONITORING

4.1 LEGAL PROVISIONS FOR ENVIRONMENTAL RADIOACTIVITY MONITORING

The Act Nr. 355/2007 Coll. from 21 June 2007 on Protection, Support and Development of Public Health issued by the Ministry of Health of the Slovak Republic forms the legal basis for radiation protection in the Slovak Republic. The act requires that environmental radioactivity monitoring systems managed by the operators of nuclear power plants are established and operational.

Subsequent regulations issued by the Ministry of Health of the Slovak Republic define the general requirements for health protection including environmental monitoring, the state authorities responsible for health protection, obligations of persons regarding health protection and requirements for the execution of state regulations and sanctions. These regulations include:

- Governmental decree Nr. 545/2007 from August 16th, 2007 on the requirements related to activities involving radiation;
- Governmental decree Nr. 345/2006 from May 10th, 2006 (on the basic principles and requirements related to the protection of public and workers against ionising radiation;
- Regulation Nr. 524/2007 from August 16th, 2007 on the radiation monitoring network.

4.2 LEGISLATIVE ACTS REGULATING THE RADIOLOGICAL SURVEILLANCE OF FOODSTUFFS

The national food legislation of the Slovak Republic is regulated by the Food Law Act. 152/1995 Coll. on Foodstuffs and by the implementing regulation 'Food Code of the Slovak Republic'. The legislative acts regulating the radiological surveillance of foodstuffs in the Slovak Republic are fully harmonised with the legislation of the European Union.

In the Slovak Republic, there is a radio hygienic surveillance control program (RHK) which consists of long-term monitoring of selected commodities. The RHK program of agricultural commodities, semi agricultural products and products produced in the Slovak Republic observes the requirements of EU law. The program is in accordance with the following EU requirements:

- Council Regulation (EC) No 733/2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station;
- Commission Recommendation (EC) 2003/274/Euratom on the protection and information of the public with regard to exposure resulting from the continued radioactive cesium contamination of certain wild food products as a consequence of the accident at the Chernobyl nuclear power station;
- Commission Recommendation 473/2000/Euratom on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole.

The responsibilities of the various actors in this domain are established by the following legislative acts:

- Regulation (EC) No 882/2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules;
- Reference laboratory for radiometry and radiology (B3f according to Annex 2 of the Government Regulation. 320/2003 Coll.);
- Regulation No. 524/2007 Coll. on the radiation monitoring network.

4.3 GUIDANCE DOCUMENTS

Environmental radioactivity monitoring and the radiological surveillance of foodstuffs are based upon the following guidance documents:

- ICRP Publication 60. Recommendations of the International Commission on Radiological Protection 1990;
- IAEA International Basic Safety Standards for Protection against Ionising Radiation and for the Safety of Radiation Sources. Safety Series № 115, 1996;
- Council Directive 96/29/Euratom of 13 May 1996 laying down basic standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation;
- Commission Recommendation 2004/473/Euratom of 8 June 2000 on the application of Article 36 of the EURATOM Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the populations as a whole;
- Council Regulation737/90 of 22 March 1990, on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station;
- WHO Codex Alimentarius Commission Guideline 5-1989 Guideline levels for radionuclides in foods following accidental nuclear contamination for use in international trade.

4.4 LEGAL PROVISIONS FOR DISCHARGE RADIOACTIVITY MONITORING

The following legislative acts cover radiation protection and the discharge radioactivity monitoring:

- Law of the Slovak parliament No. 355/2007 Coll. on "Protection, support and development of public health";

- Governmental order of Slovak Republic No. 345/2006 Coll. on "Basic protection requirements for protection of employees and public against ionising radiation";
- Decree of the Slovak Ministry of Health No. 545/2007 Coll. on "Laying down details on requirements to assure the radiation protection at activities leading to radiation and activities important from radioprotection viewpoint".

More specific legislative acts concerning the radioactive discharges from nuclear power plants are the following:

- Governmental order of Slovak Republic No. 345/2006 Coll. provides that radioactive substances can be discharged from nuclear installations to the air and surface water if it is provided that effective doses in the relevant critical population group will not exceed 250 µSv/calendar year due to these discharges;
- The permission to release airborne substances into the environment through the ventilation stack and to release liquid radioactive substances through the pipeline into the river Hron under normal conditions is given by a permit of the Public Health Authority of the Slovak Republic No. OOZPŽ/6773/2011 of 20th October 2011;
- The decision of the Water Management Department of the regional environmental authority in Nitra, No. 2007/000029 of 25 January 2007 specifies values of indicators of the waste water discharged into the river Hron as well as No. 2010/00729 of 6 December 2010 and No. 1893/2013/1961 of 16 May 2013.

5 NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING IN THE SLOVAK REPUBLIC

5.1 INTRODUCTION

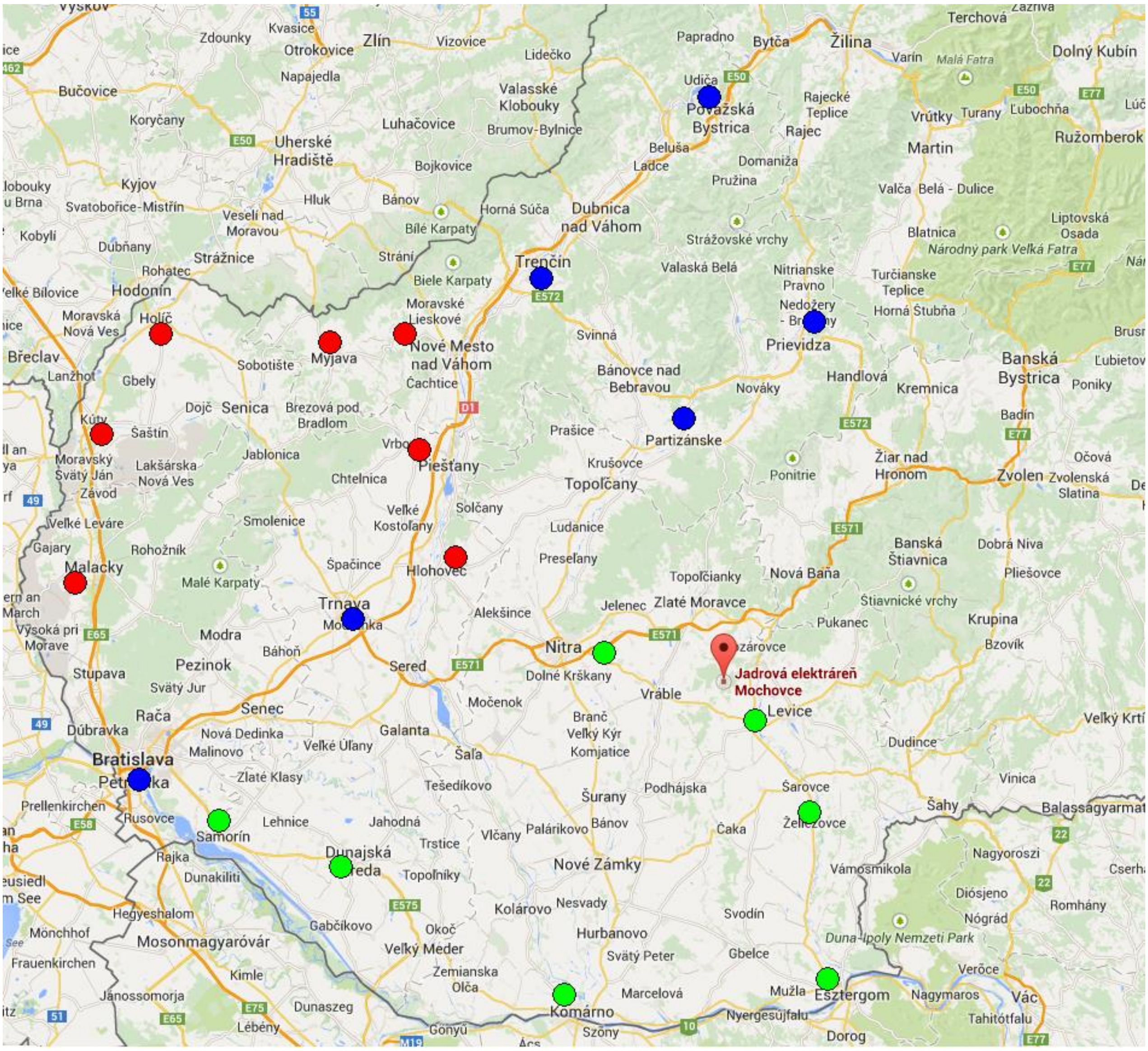
Monitoring of environmental radioactivity in the Slovak Republic is carried out by the PHA and the regional public health authorities. Laboratories taking part in this programme include PHA, RPHA Banská Bystrica, RPHA Košice, RPHA Bratislava and the Slovak Hydrometeorological Institute (SHMI).

5.2 GAMMA DOSE AND DOSE RATE

The Radiation Protection Department of the PHA carries out regular integral gamma dose measurements using thermoluminiscent dosimetry (TLD) in the region of western Slovakia. Lithium fluoride dosimeters are exchanged and evaluated at three-month intervals. A Harshaw 3500 TLD reader is used for the evaluation. Integral doses are monitored at 20 sites, shown on Figure 1.

Calibration of the TLD system involves exposing a group of TLD dosimeters to a known level of radiation. It is important that the time between preparation (ignition) and radiation exposure as well as between exposure and reading is the same for all dosimeters.

For measurement of gamma dose rate the SHMI operates 14 GammaTracer detectors produced by Genitron, 5 RPSG-05 detectors produced by Microstep-MIS and one GammaTracer mobile detector. Five new Eco-Gamma G detectors produced by Canberra-Packard will be installed to replace some old GammaTracer detectors. The table below gives the coordinates of the 19 stations which comprise the network and Figure 2 shows their locations.



Nitra, Kalná n./Hronom, Želiezovce, Štúrovo, Komárno, Dunajská Streda, Šamorín

Hlohovec, Piešťany, Nové mesto n./Váhom, Myjava, Holíč, Kúty, Malacky

Bratislava, Trvnava, Trenčín, Považská Bystrica, Prievidza, Partizánske

Figure 1. TLD monitoring network for integral gamma dose rate in western Slovakia

GammaTracer network coordinates

No.	Ident.	Station	Long.	Lat.	Metres above sea level
1	11812	Malý Javorník	48 15	17 09	584
2	11813	Bratislava-Koliba	48 10	17 06	340
3	11819	Jaslovské Bohunice	48 29	17 40	176
4	11826	Piešťany	48 32	17 50	163
5	11855	Nitra	48 17	18 08	135
6	11856	Mochovce	48 17	18 27	261
7	11867	Prievidza	48 46	18 36	259
8	11918	Liesek	49 22	19 41	692
9	11930	Lomnický štít	49 12	20 13	2635
10	11933	Štrbské Pleso	49 07	20 05	1355
11	11938	Telgárt	48 51	20 11	901
12	11952	Poprad-Gánovce	49 02	20 19	695
13	11958	Kojšovská Hoľa	48 47	20 59	1242
14	11968	Košice	48 40	21 13	231
15	11976	Stropkov	49 13	21 39	216
16	11993	Kamenica nadCirochou	48 56	22 00	117
17	12366	Banská Bystrica	48 44	19 08	362
18	12367	Liptovská Ondrášová	49 05	19 35	569
19	12238	Trenčín	48 52	18 02	303

The technical specifications of the 3 different systems are as follows:

Manufacturer & type	**Genitron, GammaTracer**	**Microstep, RPSG-05**	**Canberra-Packard, ECO-Gamma-G**
Detector	two H*(10) GM tubes (high and low range)	two H*(10)GM tubes with energy compensation filter	two H*(10)GM tubes (high and low range)
Measuring range	20 nSv/h – 10 Sv/h	10 nSv/h – 10 Sv/h	10 nSv/h – 10 Sv/h
Energy range	50 keV to 1.5 MeV (6.6. MeV)	50 keV to 1.5 MeV (6.6. MeV)	
Energy compensation filter range	40 keV to 1.25 MeV	50 keV to 1.5 MeV	30 keV to 5.0 MeV (H*10)
Temperature range	-40˚C to +60˚C	-40˚C to +60˚C	-40˚C to +60˚C

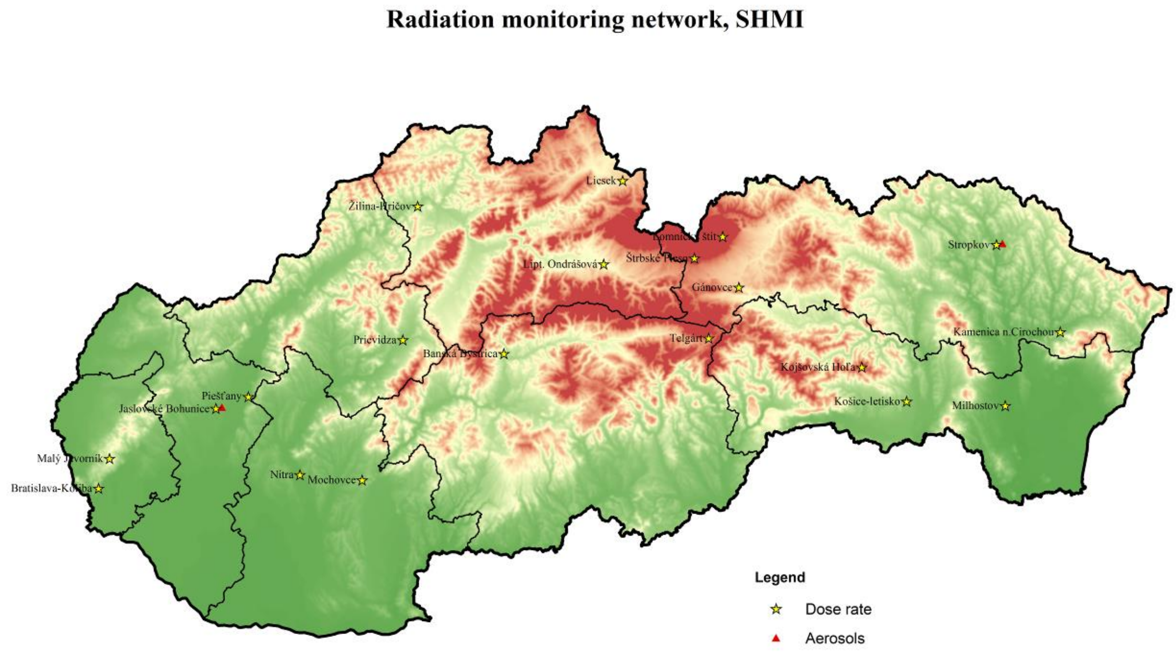


Figure 2. Radiation dose rate and air sampling stations (aerosols) in Slovakia

Data transmission

Radiation data (gamma dose rate in nSv/h) from all detectors in the automated meteorological stations are transmitted by data logger and private SHMI network to the National Telecommunication Centre in Bratislava. The service program runs on the RADMON server in SHMI and every 10 minutes the data (dose rate and precipitation) are inserted into the database. One hour and 24 hour averages are automatically computed on the server. The delay between the time of measurement and time of inserting data to the database is 10 min.

Calibration and maintenance procedures

The detectors are verified every 2 years by the Slovak Institute of Metrology in compliance with the calibration plan based on the Metrology Law 142/2000. Detectors are calibrated every 4 years. RPSG-05 and Eco-Gamma-G detectors have their own built-in calibration.

Data management and control centre of the telemetric network

The system of radiation monitoring runs on two backed up servers under the Windows 2003 Server operating system and MS SQL Server 7.0 database system. The database contains one table for radiation data and several tables for configurations, catalogues of stations and additional tables. The database works in a client-server environment. This extensive database provides a good opportunity to design reports in many formats based on SQL scripts. Time series from monitoring sites are analysed by the statistical software STATISTICA 8.0 and presented in reports and yearbooks. Precipitation values from meteorological stations are integrated to the information system of radiation monitoring for better interpretation of gamma dose rate values. All yearbooks (in Slovak with an English resume) are available on the SHMI web page (http://www.shmu.sk/sk/?page=265).

Data from the new RPSG-05 detectors are inserted to the new ORACLE database. This is expected to be the database environment for all radiation data of the SHMI network in the future.

The radiation files from the SHMI network are transmitted on-line to the information system of the Nuclear Regulatory Authority of the Slovak Republic. SHMI cooperates with other operators of radiation monitoring networks (Ministry of Interior, Ministry of Health, Slovak Army and the Slovak nuclear power plants).

Radiation data are exchanged between SHMI and neighbouring countries (Austria, Hungary and the Czech Republic) on the basis of bilateral agreements signed by the Ministry of Environment of the Slovak Republic. Data are transmitted every ten minutes to the centres in Vienna, Budapest and Prague. Each hour data files are made available on the ftp-server for the EURDEP system.

5.3 AIR RADIOACTIVITY CONCENTRATION

Public Health Authority of the Slovak Republic carries out continuous sampling of particulate matter in air with the following device:

- Sampling device manufacturer: F&J Specialty Products, Inc.;
- Type of device: Model DH-50810E, microprocessor controlled environmental air sampling system with flow control;
- Filter manufacturer and type: F&J Specialty Products, Inc., Glass Fibre, FP 8”x10”.

Filter change frequency is monthly. Flow measurement is automatic with total volume determination. Control of the device is usually done once a week.

The filter is dried, folded and analysed by gammaspectroscopy. Radionuclides assessed are Cs-137, Cs-134, I-131, Co-60, Co-57, Am-241 and any other radionuclide emitting gamma radiation beyond the Am-241 energy that can be identified and quantified.

At present SHMI operates one aerosol sampling station at Stropkov. Filters from this station are analysed in the Public Health Authority in Kosice (Cs-137, Be-7). However the measurement device is obsolete and near the end of its lifespan.

On the basis of the bilateral agreement between the Austrian Ministry of Agriculture, Forestry, Environment and Water Management and the Slovak Ministry of Environment, the Austrians have given Slovakia an AMS-02 automatic aerosol monitor including a container and weather station, with the following technical specifications:

- Manufacturer and type: BITT-Technology AMS-02;
- Type of filter:60 mm diameter glass fibre filter Schleicher & Schüll type 10 (DIN 24 184) and 60 mm diameter paper filter with active carbon impregnated (charcoal);
- Ag-activated silicagel filter column;
- Frequency of filter change: 24 hours in normal regime, 1 hour in emergency situations;
- Air flow 6 m^3/ hour.
- Type of detector: 2x2“ Na(Tl) (2 detectors);
- PIPS 1700 mm^2;
- Coaxial germanium detector (HPGe);
- Integration time: automatic measurement cycle 30 min in normal regime;
- Automatic measurement cycle 5 min in emergency mode with measurement of organic Iodine.

Radionuclides assessed are Rn-222, Rn-220, Cs-137, Cs-134, I-131, I-132, I-133 and artificial α/β. This monitor was installed at the Jaslovske Bohunice meteorological station on 4 October 2001. The national monitoring centre in Bratislava-Koliba is connected with the Austrian centre providing the data exchange.

Deposition

Sampling locations for radioactive material deposition are the meteorological stations in Bratislava, Koliba, Jaslovské Bohunice and Levice (RPHA). Sampling procedure is water surface deposition on two stainless cylinder vessels (diameter 20 cm, collection area 0,0314 m^2) with water volume of min. one litre (depends on season and rainfall). Distilled water is added in summer, ethanol in winter. Sampling is done monthly. Radionuclides assessed are Sr-90 and Cs-137 (quarterly), H-3 (monthly) and gross beta (monthly).

5.4 WATER SAMPLING

5.4.1 Surface water

There are 13 sampling locations for surface water: river Váh (Sereď), iver Dudváh (Trakovice), Žlkovce, Manivier waste water drain (Žlkovce), Socoman waste water pipeline (Madunice), river Hron (Kalná n/H-Hron), river Dunaj (Bratislava), river Morava (Vysoká pri Morave), Čifáre stream, Mochovce drain and Širočina stream (Horný Ohaj). Sampling procedure is single point spot sampling, manually taken monthly from the middle of the river stream. Sample volume is 5 litres. Radionuclides assessed are Sr-90, Cs-137, H-3, I-131, gross alpha, gross beta and residual beta (quarterly).

5.4.2 Drinking water

Sampling locations for tap water are Jaslovské Bohunice, Levice and Mochovce. Ground water is sampled at Bratislava (Sihoť), Jelka, Krásna n/Hornádom, Borša, Banská Bystrica and Žilina. Sampling procedure is monthly spot sampling. Sample volume is 5 litres. Radionuclides assessed are ^{90}Sr, ^{137}Cs, ^{3}H, ^{222}Rn, gross alpha, gross beta (monthly); if needed also ^{226}Ra and U_{nat} can be measured.

5.5 SEDIMENT SAMPLING

Sampling locations for sediments are Manivier waste water drain (Žlkovce), river Dudváh (Trakovice), Malá Mača, Žlkovce and river Morava (Vysoká pri Morave). Annual sample is taken manually in a two litre metal cylinder vessel. Radionuclides assessed are ^{90}Sr and^{137}Cs.

5.6 SOIL SAMPLING

Soil sampling locations are Jaslovské Bohunice, Žlkovce, Kátlovce, Bernolákovo, Mochovce, Kalná n/Hronom, Červený Hrádok and Čifáre. Sampling is done using a stainless steel shovel (20x10x4 cm) on a sampling area of 1 m^2 at a depth of 0-4 cm. Sample quantity is 5 litres annually. Radionuclides assessed are ^{90}Sr and ^{137}Cs.

5.7 BIOTA AND FLORA SAMPLING

Sampling of biota and flora is carried out as follows:

Mushrooms

Sampling locations	Lakšárska Nová Ves, Devičany, Studienka.
Sample quantity	3 kg fresh mass yearly
Radionuclides assessed	^{137}Cs

Moss

Sampling location	Lakšárska Nová Ves, Studienka
Sample quantity	1 kg fresh mass yearly
Radionuclides assessed	^{137}Cs

Grass

Sampling location	Devičany.
Sample quantity	3 kg fresh mass yearly
Radionuclides assessed	^{137}Cs

Water plants

Sampling locations	Bučany, Trakovice, Malá Mača, Žlkovce za kanálom, Žlkovce kanál. (Sample collection manually in the same places as sediments)

Sample quantity	5 kg fresh mass yearly
Radionuclides assessed	^{90}Sr, ^{137}Cs

Feed

Sampling locations	Jaslovské Bohunice, Žlkovce, Kátlovce, Bernolákovo, Kalná n/Hronom, Kozárovce. (Sample collection directly from fields in the season manually with scissors)
Sample quantity	5 kg yearly
Radionuclides assessed	^{90}Sr, ^{137}Cs

5.8 FOOD SAMPLING

5.8.1 Milk

Sampling locations	Farms: Malženice, Žlkovce, Kátlovce, Bernolákovo, Starý Tekov, Tekovský Hrádok, Kozárovce Diaries: Bratislava, Levice, Kežmarok, Zvolen
Sample quantity	3 litres of fresh cow milk from farms and diaries. Sample is collected monthly by farm employees, preservative (formaldehyde) is added.
Radionuclides assessed	^{90}Sr, ^{137}Cs

5.8.2 Mixed diet

Sampling locations	Bratislava, Košice, Banská Bystrica
Sampling procedure	Complete day's meals from a hospital canteen
Sample quantity	2 – 4 kg quarterly
Radionuclides assessed	^{90}Sr, ^{137}Cs, ^{40}K

5.8.3 Foodstuffs

Vegetables

Sampling locations	Čakany, Topoľníky, Orechová Potôň, Gajary, Šaľa, Nový Tekov, Tekovské Lužany, Kolárovo
Sampling procedure	Spot sampling from marketplaces or farms
Sample quantity	3 kg fresh mass (potatoes, cabbage, onion, kale, carrot, etc...) yearly
Radionuclides assessed	^{90}Sr, ^{137}Cs

Cereals (barley, wheat)

Sampling locations	Jaslovské Bohunice, Žlkovce, Kátlovce, Bernolákovo, Kalná n/Hronom, Červený Hrádok, Telince, Starý Tekov.
Sampling procedure	Spot sampling from farms
Sample quantity	5 kg yearly
Radionuclides assessed	^{90}Sr, ^{137}Cs

Meat, flour, rice, poppy, tea, fish

Sampling locations	Bratislava, Vlčkovce, Madunice, Devičany
Sampling procedure	Samples are bought in the shops and markets
Sample quantity	4 kg (meat, flour, rice, paste, oil, nuts, pulses, sugar, ...), 1 kg river fish, 1 kg herbal tea (garden herbs) yearly
Radionuclides assessed	^{137}Cs, ^{40}K

6 DISCHARGE RADIOACTIVITY MONITORING AT THE MOCHOVCE NPP

6.1 INTRODUCTION

Slovak legislation requires that facilities which may discharge liquid and airborne effluents into the environment need an administrative license for this. Pursuant to legal provisions on public health protection operators are obliged to qualify and quantify harmful factors produced or used during their operation and to ensure that their effect on health is as low as reasonably achievable. Therefore, operators of nuclear facilities are obliged to assure monitoring of radiation parameters at the site of nuclear facilities and their surroundings, and to evaluate corresponding public exposure. The operator can carry out these measurements himself or by means of authorised organisations on a contractual basis. At the Mochovce site and in the surroundings of the nuclear facility the monitoring is performed by the operator Slovenské elektrárne a.s.

The range of measurements at the site and the surroundings is specified in a monitoring plan, where measured components, locations, measurement frequency, measurement methods, devices, quality requirements and other details are defined. The monitoring plan is a part of the documentation submitted to the public health authorities by an operator together with an application for an operation licence.

The operator is obliged to submit regular quarterly and annual reports on discharges and their effects on the environment. Moreover, the operator has to immediately report any excess of the regulatory thresholds (examination level, intervention level or the limit value).

The supervisory authority reviews the discharge monitoring plan during the process of nuclear facility authorisation, specifies the limits for radioactive discharges and lays down other specifications for the nuclear facility operation. The licence for operation of a nuclear facility is issued by the Public Health Authority of the Slovak Republic only if the monitoring plan enables to evaluate the effect of the operation on the environment. Compliance with the monitoring plan and results of the monitoring are controlled by the Public Health Authority during the process of state health surveillance in nuclear facilities. During inspections results of measurements, condition of measurement devices, metrological verification, calibration, compliance with methodology and sample and measurement result records are controlled. The supervisory authority carries out control measurements on discharge water by sampling water from collection tanks before discharge.

Regarding the monitoring in the surroundings of the nuclear facilities, the Public Health Authority carries out sample collection, measurements and evaluations. Especially surface and drinking water, sediments, water plants, fallout, soil, agricultural products and feed contamination and milk are controlled. The range of these measurements is significantly less than the range of measurements carried out by the operator.

The license issued for the Slovenské elektrárne a.s. by the PHA in Bratislava, under the Nr. OOZPŽ/6773/2011 on 20.10.2011, states the basic radiological limit for liquid and airborne discharges, i.e. the annual effective dose, received by a representative person from the population caused by radioactive discharges to surface waters and air during the operation of the NPP will not exceed 50 µSv.

The NPP operator provides the PHA with data on liquid and gaseous discharges and the estimated doses resulting from these releases. These data are included in the quarterly and annual operating reports. PHA evaluates these data, verifies compliance with the established limits and conditions, and tracks discharge trends in order to detect operational occurrences and to verify that treatment systems are operative. Any increases above normal values lead to investigations. Information is requested from the NPP on the possible activities that could have caused the increased effluent radioactivity levels. The regulatory control of reported discharges is supplemented by the effluent inspections that PHA periodically performs at the NPP.

6.2 MONITORING OF LIQUID DISCHARGES

6.2.1 Liquid effluent control

At the Mochovce NPP the wastewater containing radioactive substances from the plant controlled areas is accumulated in seventeen collection tanks before discharge. This wastewater may have several origins:

- Water from the operational building (changing rooms, laundry facility, laboratories);
- Cleaning water from regeneration of filters of the secondary circuit;
- Water from flushing filters of the water purification systems;
- Tritiated water from the reactor and auxiliary building systems.

Samples taken from the collection tanks are analysed for tritium and total gamma. If the total gamma is below 40 Bq/l, the tank content can be released. If not, the water is recirculated back to the plant waste water cleaning system.

Samples collected from the tanks are combined monthly and analysed by gamma spectroscopy. A quarterly representative sample is combined for alpha spectrometry analyses of Pu-238, Pu-239/240 and Am-241 and radiochemical analyses of Sr-89 and Sr-90. These samples are analysed by an external laboratory.

6.2.2 Dilution of tritium discharges

When releasing water containing tritium, the radiation protection supervisor determines the required dilution of the water during the release. Based on the flow rate of the river Hron and on the tritium concentration in the discharge, the dilution factor is calculated, as well as the release rate in order to keep the tritium concentration below investigation level at the release point and also below the maximum allowed level in the river (1000 Bq/l).

6.2.3 Site release water control

Monitoring of the site wastewater is carried out on the outflow from the NPP site collecting pool at the release water control station. All wastewater from the NPP is discharged through this control station and then through a pipeline into the river Hron below the Malé Kozmálovce dam.

Two identical systems based on ultrasound measuring instruments are used for online wastewater flow measurement. Total gamma radioactivity is measured by two online Berthold BAI 9125 monitors with NaI(TI) detectors and Gracon digital electronics. Measurement results are sent to the Central Radiological Computer System (CRCS). When an alarm is triggered, visible and audible signals are produced. These alarms are also archived in the radiological data archive.

An automatic online sampler located in the release monitoring building is used as an off-line control mechanism. The wastewater is sampled by a pump system located in the discharge channel. In case the running pump should stop for any reason, the system has an automatic switch to a back-up pump. Water sampling is proportional to the channel flow rate. The weekly water sample is analysed with gamma spectroscopy and liquid scintillation (tritium). In case of an alarm, the sampler automatically pumps water into a separate bottle for analysis. A signal is also generated causing the electric valve located on the release pipe in the auxiliary building to close thus stopping the release.

All monitors in the release water control station are calibrated every two years by the Slovak Metrological Institute.

6.3 MONITORING OF GASEOUS DISCHARGES

6.3.1 Introduction

The two Mochovce reactor units have a common ventilation stack. The gaseous effluents are released into the surrounding environment through this stack during the reactor unit's normal operation and during the refuelling outages. In the case of an accident situation, the ventilation systems are switched off with the aim of preventing the dispersion of radioactive substances into the environment.

The gaseous discharge monitoring system consists of several on-line and off-line (samplers) systems, most of which have been installed in a double configuration for redundancy. The common part of the subsystem for monitoring of the gaseous effluents (for both on-line and sampling systems) is an autonomous sampling system (bypass flow from the stack). This system provides the representative isokinetic sampling of the stack air flow. The flow rate in the primary part of the sampling line is about 400 – 800 m^3/hour, i.e. 1/1000 of the total flow rate through the ventilation stack. The bypass tube is heated by 2 independent heaters. A schematic diagram of the monitoring and sampling systems in the ventilation stack is presented in Annex 4.

6.3.2 On-line monitoring of the gaseous discharges

The on-line gaseous discharge monitoring system provides measurements of:

- Volume activity of the basic components of the gaseous effluents: radioactive noble gases; airborne particulates and iodine in the air;
- Climatic parameters of the air masses released through the ventilation stack: temperature and relative humidity in the bypass and stack;
- Flow-rate of the air masses through the bypass and ventilation stack.

The following on-line monitors are available:

Particulate monitor

This monitor (Berthold Technologies BAI 9100D) ensures the continuous monitoring of the gross activity of alpha and beta emitting particulates. The sample of particulates is collected on a filter tape. Two identical monitors are installed in the monitoring assembly. The flow-rate in the secondary sampling circuit is regulated on the basis of the signal of the flow rate in the ventilation stack to maintain the conditions of isokinetic sampling. The monitor samples and measures on-line the volume activity of aerosols. The basic measurement period is 5 minutes (short-time values), though also long-time values can be measured for 60 minutes. The monitor automatically checks exceeding of reference values as well as itself for malfunctions. These data are sent every two minutes to the CRCS. For operation control the system has two internal test sources (^{241}Am and ^{36}Cl).

Iodine monitor

The iodine monitor (Berthold Technologies BAI 9103-21) is dedicated to the continuous monitoring of the volume activity of iodine in the gaseous effluents. Both organic and inorganic forms of iodine (mainly I-131) are measured by spectroscopy as cumulated on the absorbent. Two identical monitors are installed in the monitoring assembly.

The monitoring equipment is equipped with a control source (Ba-133), sample heating system and background compensation. The flow rate of the sample in the secondary sampling line is constant (3 m^3/hour). The basic measurement period is 5 minutes (short-time values), though also long-time values can be measured for 60 minutes. The monitor automatically checks exceeding of reference values as well as itself for malfunctions. These data are sent to the CRCS every two minutes.

Noble gas monitors

The volume activity of the radioactive noble gases is monitored on-line on the basis of the beta activity of the radioactive noble gases – mainly Kr-85, Xe-133 and Ar-41. The continuous monitoring of the radioactive noble gases is ensured by two radioactive noble gas monitors (MAB SB-150).These are installed in the sampling circuits behind the sampling assembly for particulates and Iodine. These sampling assemblies (JAP-SR) ensure the necessary treatment of the air sample for the selective measurement of radioactive noble gases. The measuring chambers of the detection units are equipped with control sources and shielded by lead shielding. The monitor automatically checks exceeding of reference values as well as itself for malfunctions. These data are sent every 2 minutes to the CRCS.

Air flow rate monitors

There are flow rate monitors for measuring the air flow in the sampling system bypass line using Venturi-tubes. The total flow in the stack is monitored using Airflow Pitot-tubes on 70 m height in the middle of the stack.

Emergency monitor

The emergency monitor is an ionisation chamber located directly at the airflow on the bottom of the stack. The purpose of the monitor is to provide an estimate of the discharged gaseous activity in an emergency situation when the routine monitoring systems are saturated due to high radioactivity concentration in the stack.

Other on-line monitoring equipment

The monitoring systems Kalina and SEJVAL from the original Russian plant design for monitoring aerosols, iodine and noble gases are still available, but due to technical limitations their use in discharged monitoring is limited.

6.3.3 Off-line monitoring of the gaseous discharges

The sampling arrangement of the stack air flow includes the following:

Particulates and iodine in normal operation

This sample is taken by the high-volume sampler MAB JAP/S 180. Flow rate through sampler is 60 - 120 m^3/hour. Sampling period is one week. The aerosol filter has a diameter of 20 cm and is measured in the laboratory by gamma spectroscopy. A composite sample is prepared quarterly for alpha spectrometry analyses of Pu-238, Pu-239/240, Am-241 and radiochemical analyses of Sr-89, Sr-90 by an external laboratory. Iodine sample is 1 litre of charcoal and is measured in the laboratory by gamma spectroscopy.

Particulates and iodine in emergency situation

The particulate and iodine filters are located in the secondary sampling system before the continuous monitors of radioactive noble gases. These samplers ensure the cleaning of the sample (the capture of the particulates and Iodine). The sampler is MAB JAP-SR. The samples from this sampler are not measured during normal operation.

Air humidity and tritium volume activity

The sampling is done by capturing the air humidity using silicagel. The samples taken are processed and evaluated in the laboratory and measured by a liquid scintillation. Sampling period is usually 10 days.

Carbon-14

Sampler V14C samples inorganic and organic carbon in two separate lines using bottles with NaOH. The sampling period is usually 10 days. The samples are combined into one quarterly sample and analysed by an external laboratory.

Radioactive noble gases

A sample is taken in pressurised bottles by means of a high-pressure compressor. This sample is evaluated in the laboratory by gamma spectroscopy. Sampling is carried out once per week.

6.3.4 Equipment control procedures

All continuous monitors of the gaseous effluents in the ventilation stack are verified for correct calibration of the detectors every 2 years by the Slovak Metrological Institute. The same is valid for all laboratory measurement systems.

All on-line monitors and laboratory detectors are QA-controlled once per month. Internal or external radioactive sources are used for this purpose. The results data are put into Excel spreadsheets and checked for trend and 2 sigma test. The gamma spectroscopy systems use the Quality Assurance tool included in the Genie2k spectrometry software. The liquid scintillation counter has an internal control for calibration; other measurement devices are metrologically verified once per year by the NPP internal metrological department.

6.4 LABORATORY ANALYSIS

6.4.1 Spectrometry laboratory, radiochemical laboratory & chemical laboratory

The Spectrometry Laboratory is part of the Off-site Radiation Monitoring and Laboratory measurements group of the Radiation Protection Department. It is situated on the NPP site in the operational building. It participates in the monitoring of NPP radioactive effluents into the environment.

The laboratory carries out the measurements on samples received from the NPP gaseous discharge monitoring system (paper filters, carbon-14 (organic and inorganic), silica gel, high pressure bottles, charcoal sample (iodine)).

Sample reception

The laboratories use the sample database system SAP Nuclear. Each sample coming into the laboratory is registered in this system and given a unique identification number “M-yy-xxxx” where M stands for NPP Mochovce spectrometry laboratory; yy for the year and xxxx is the consecutive sample number.

Sample preparation

Preparation methods of the different sample types are the following:

- Aerosol filters from the ventilation stack are twice replicated and rotated around the HPGe detector.
- Iodine charcoal from the ventilation stack monitor is homogenised and put into a Marinelli beaker and measured on the HPGe detector.
- Air samples are filled into high-pressure bottles by a high-pressure compressor. Four bottles are measured together on the HPGe detector.
- Radiocarbon from the stack is trapped in bottles with sodium hydroxide. Afterwards the samples are combined into quarterly samples and sent for external analysis.
- Tritium from the stack is trapped in silica gel in Dreschler bottles. The silica gel is weighted before and after sampling. After weighting a part of silica gel is dried; water is evaporated and condensed. 3 ml of this water sample plus 10 ml of scintillator are put into 20 ml vials and measured in a liquid scintillation counter.
- Tritium measurement of a water sample is prepared by combining 3 ml of the water sample plus 10 ml of scintillator cocktail in a 20 ml vial.
- Water samples are put into a 1 litre or 0.5 litre Marinelli beaker or a 1 litre plastic bottle and measured on an HPGe detector. The samples from the control tanks are representatively poured together in one monthly composite sample and put into a 1 litter Marinelli beaker, which is measured on an HPGe detector. After measurement of the monthly samples they are combined in one quarterly sample and sent for external analysis.

Measurement devices in the laboratories

The Spectrometry Laboratory is equipped with four HPGe detectors (3 Canberra, 1 Princeton Gamma-Tech), calibrated for measuring aerosol filters, Marinelli beakers and pressurised bottles. There are also two NaI scintillation detectors (Canberra and Tesla) for the 1 litre Marinelli beaker geometry and a liquid scintillation counter (Perkin Elmer) for tritium measurements. The Radiochemical Laboratory equipment includes two gamma spectroscopy systems.

Sample storage

The aerosol filters from the stack are archived for one year and iodine cartridges for four months. The silica gel samples for tritium, sodium hydrate for radiocarbon and the air in pressurised bottles are kept until the results of the measurements are available. Composite monthly water samples are archived for one year and weekly water samples for one month.

Laboratory accreditation and intercomparison exercises

Mochovce NPP Laboratories are not accredited. The laboratories participate every year in international laboratory comparison tests organised by IAEA, ASLAB (Czech Republic) or the National Physical Laboratory (UK). These usually compare results in gamma spectroscopic analyses and liquid scintillation counting for tritium analysis.

6.4.2 Third party analytical assessments

The Faculty of Natural Sciences of Comenius University in Bratislava, Department of Nuclear Chemistry, has an accredited laboratory which has a contract with the Slovenské elektrárne for analyses of Pu-238, Pu-239+240, Am-241 and radiochemical analyses of Sr-89, Sr-90 and radiocarbon C-14 in release samples.

7 ENVIRONMENTAL MONITORING AROUND THE MOCHOVCE NPP

7.1 INTRODUCTION

Monitoring of radiation in the environment is carried out according to the approved monitoring plan prepared in accordance with the law No 355/2007 on the protection, support and development of public health, and government decree No 345/2006 on basic safety requirements for health protection of workers and the population from ionising radiation.

The monitoring plan is based on the predominant wind directions i.e. covering those sectors where it could be expected to measure the highest values resulting from the NPP's gaseous discharges to the atmosphere. Monitoring of the hydrosphere surrounding the NPP is focused on the river Hron and its surroundings as well as the waste water discharge.

The monitoring plan aims to:

- Monitor the dose, dose rate and activities of the radionuclides around the Mochovce NPP;
- Obtain long-term trends of dose, dose rate and distribution of radionuclides in the environment for the early detection of deviations from long-term averages;
- Build a database of results, which serves as a basis for assessing the impact of discharges from nuclear power plants.

The monitoring plan describes:

- Sampling locations,
- Sample types,
- Sampling frequency,
- Reference levels,
- Archiving of samples and measurement results,
- Quality assurance,

- The method of results presentation,
- Data flow and information,
- Considered exposure pathways from liquid and airborne discharges.

The monitoring plan of the radiation situation around the NPP Mochovce includes measurements of dose rate and monitoring of radioactivity in various environmental matrices:

- water (surface, drinking, ground),
- soil,
- air,
- fallout,
- water plants,
- sediments,
- food chain products.

For the purpose of monitoring the radiation situation around the Mochovce NPP, the following analyses (measurements) are performed by the Environmental Radiation Monitoring Laboratory**:**

- Measurements performed in the laboratory:
  - Gamma spectroscopy,
  - Total beta activity,
  - Total alpha activity,
  - Tritium activity,
  - Integral dose and average dose rate by means of TLD.
- Measurements performed in the field:
  - In situ measurements,
  - Dose rate measurements by means of ionising chambers or other portable devices, by means of the detectors situated in the TDS stations or by means of the detectors and portable devices situated in the mobile laboratories,
  - Measurements of volume activity of aerosols and iodine (TDS).
- Measurements carried out by contractors:
  - Alpha spectroscopy,
  - ^{14}C in the environmental samples,
  - ^{90}Sr measurements.

The elements of the monitoring plan are summarised in the following tables.

Sample type	**Dose rate**		
	Total number of measurements per year: 769		
	Number of sampling points	Number of measurements per year	Total per year
Dose rate - IK	5	1	5
Dose rate - TDS	39	12	468
Dose rate - TLD	74	4	296

Sample type	**Gamma spectrometry**		
	Total number of measurements per year: 216		
	Number of sampling points	Number of measurements per year	Total per year
Aerosols	5	26	130
Fruit, vegetables, grain	6	1	6
In situ measurements	5	1	5
Milk	1	12	12
Ground water boreholes RK	5	2	8
Surface water	4	4	16
Soil	15	4	15
Fish	2	4	2
Sediments	3	4	3
Fallout	3	4	12
Grass	5	1	5
Water plants	2	1	2

Sample type	**Gross alpha and beta**		
	Total number of measurements per year: 16 (8 * 2)		
	Number of sampling points	Number of measurements per year	Total per year
Surface water	2	4	8

Sample type	Tritium (^{3}H)		
	Total number of measurements per year: 552		
	Number of sampling points	Number of measurements per year	Total per year
Drinking water	3 3	4 26	12 78
Ground water (discharge water pipeline)	17	2	34
Ground water (boreholes around the N. Tekov small hydro power plant)	19 6	4 26	79 156
Ground water (Boreholes RK)	6	2	12
Ground water (Shafts OTKS01 and OTKS02)	2	4	8
Surface water	6 4	26 4	156 16
Rainfall	1	4	4

Sample type	^{90}Sr		
	Total number of measurements per year: 38		
	Number of sampling points	Number of measurements per year	Total per year
Aerosols	2	4	8
Fruit, vegetables, grain	6	1	6
Milk	1	4	4
Surface water	4	4	16
Soil	1	1	1
Sediments	3	1	3

Sample type	**Alpha spectrometry**		
	Total number of measurements per year: 5		
	Number of sampling points	Number of measurements per year	Total per year
Surface water	2	1	2
Soil	2	1	2
Sediments	1	1	1

Sample type	**^{14}C**		
	Total number of measurements per year: 10		
	Number of sampling points	Number of measurements per year	Total per year
Fruit, vegetables, grain	6	1	6
Milk	1	2	2
Surface water	1	1	1
Water plants	1	1	1

7.2 ENVIRONMENTAL SAMPLING

Sections 7.2.1 to 7.2.12 describe the Mochovce NPP environmental sampling programme in detail.

7.2.1 Aerosols

Regular sampling points	SDS LRKO Levice SDS Nový Tekov SDS Tajná SDS Č. Hrádok SDS EMO	
Sampling frequency	Bi-weekly	
Performed analyses	Gamma spectrometry, ^{90}Sr	
Number of analyses carried out per year	Gamma spectrometry ^{90}Sr	130 minimum 8

The following 10 dosimetry stations are in "hot stand-by mode" and would allow additional aerosol filters to be analysed in case of necessity or during a radiation accident: Levice, Nemčiňany, Kalná n. Hronom, Zl. Moravce, M. Kozmálovce, Kozárovce, V. Ďur, Rybník, Čifáre and Vráble.

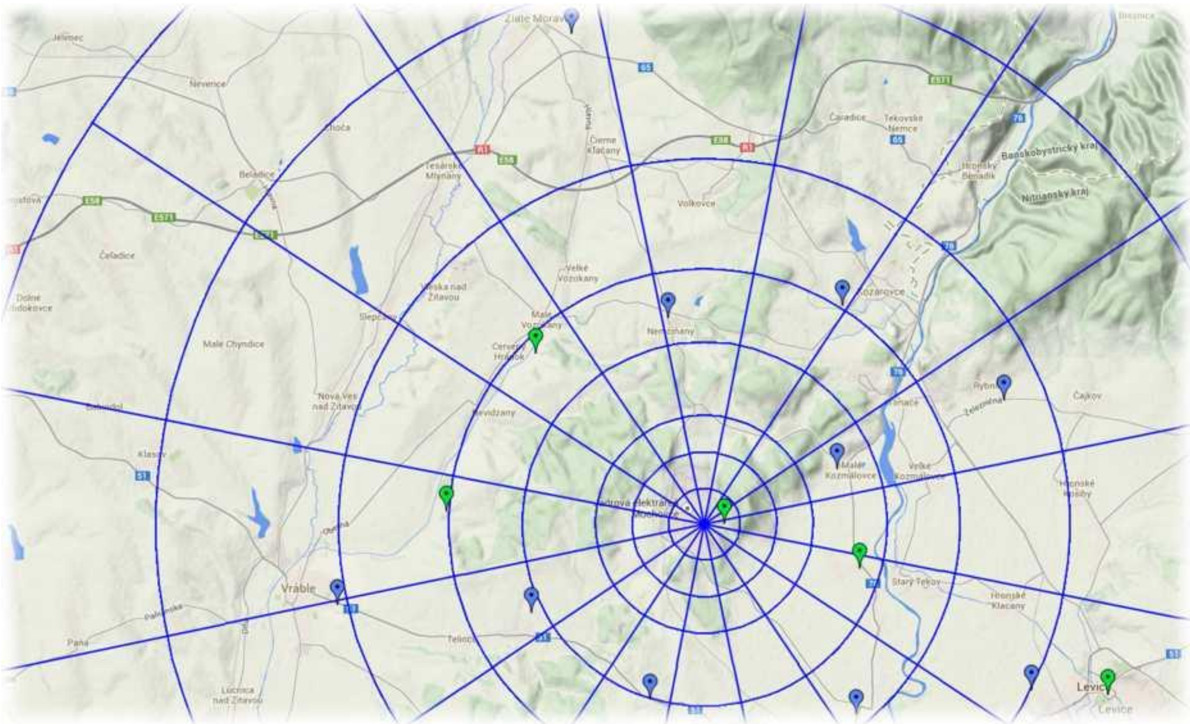


Figure 3. Locations of all aerosols sampling points (green = continuously sampling, blue= sampling in case of necessity)

7.2.2 Fallout

Sampling points	SDS Nový Tekov SDS EMO SDS Č. Hrádok
Sampling frequency	Quarterly
Performed analyses	Gamma spectrometry
Number of analyses carried out per year	12 (4*3)

It is also possible to sample fallout at the following 12 dosimetry stations in case of necessity or during a radiation accident: Levice, Nemčiňany, Kalná n. Hronom, Zl. Moravce, M. Kozmálovce, Kozárovce, V. Ďur, Rybník, Čifáre, Vráble, LRKO Levice, Tajná,

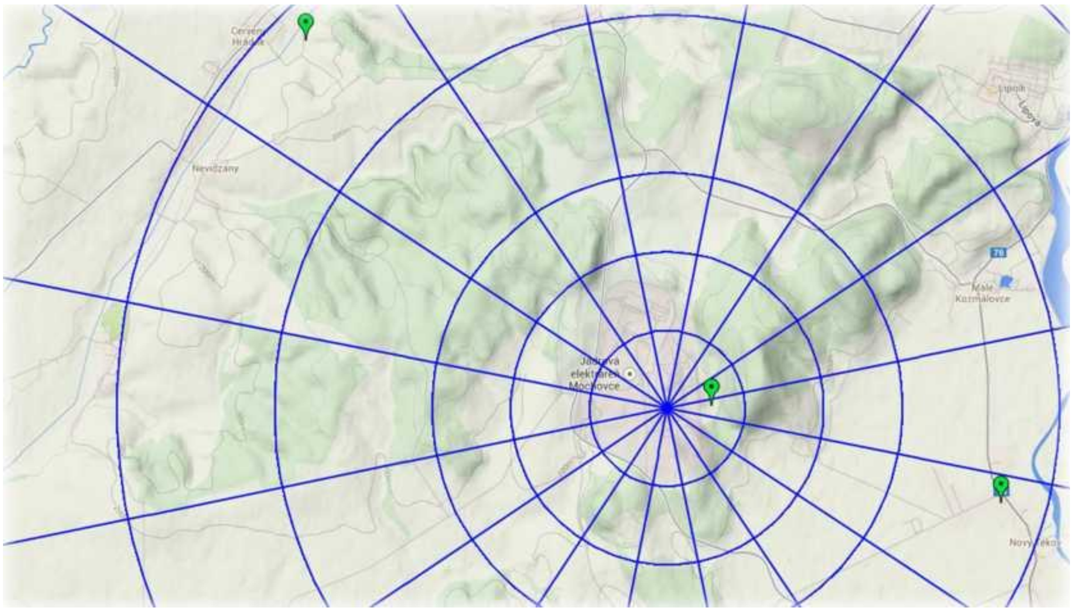


Figure 4. **Fallout sampling locations**

7.2.3 Soil

Sampling points	Červený Hrádok Nevidzany EMO - Z157 Nový Tekov Starý Tekov
Sampling frequency	Annually
Performed analyses	Gamma spectrometry, ^{90}Sr, Alpha spectrometry
Number of analyses carried out per year	Gamma spectrometry 15 (1*5*3) ^{90}Sr (1 sampling point EMO Z157) Alpha spectrometry 2 sampling points EMO Z157 and Nový Tekov

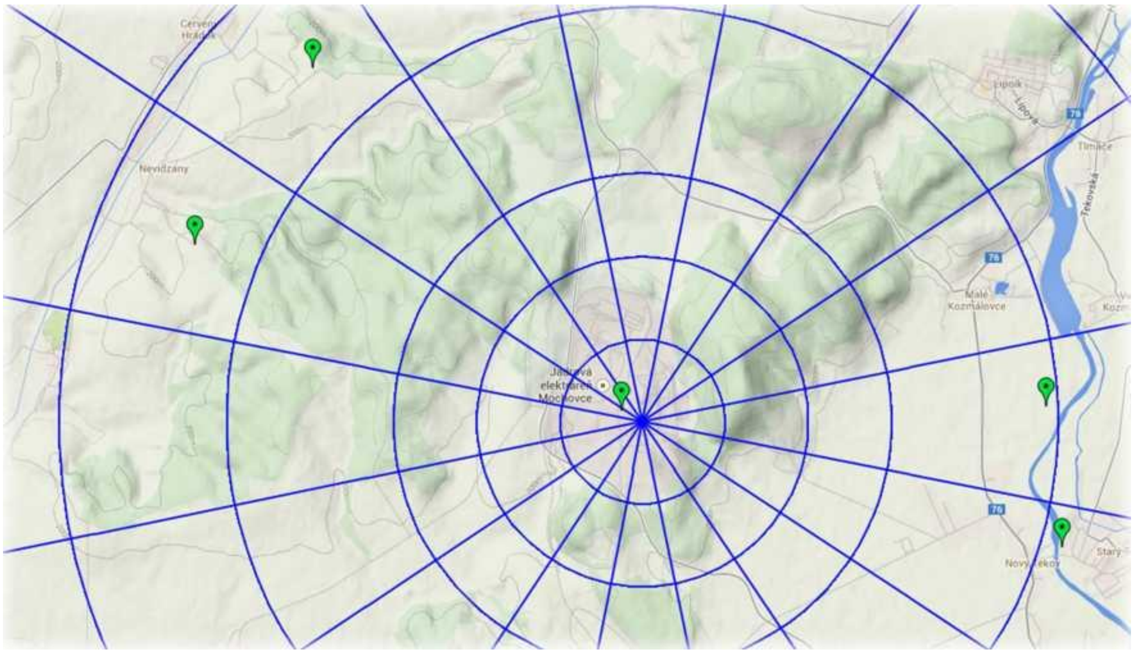


Figure 5. **Soil sampling locations**

7.2.4 Milk

Sampling point	Starý Tekov
Sampling frequency	Weekly
Performed analyses	Gamma spectrometry, ^{90}Sr, ^{14}C
Number of analyses carried out per year	Gamma spectrometry – 12, a combined monthly sample is prepared from the weekly samples ^{90}Sr- 4, a combined quarterly sample is prepared from the weekly samples ^{14}C - 2

7.2.5 Sediment

Sampling points	Tlmače - reference (background) sampling point Nový Tekov (MVE) Kalná n/Hronom (elektráreň)
Sampling frequency	Annually
Performed analyses	Gamma spectrometry, ^{90}Sr, Alpha spectrometry
Number of analyses carried out per year	Gamma spectrometry 3 ^{90}Sr 3 Alpha spectrometry 1, sampling point Nový Tekov (MVE)

Figure 6. Sediment sampling locations

7.2.6 Foodstuffs

Fruit, vegetables, grain

Sampling points	Sampling is concentrated in the sectors with the most common frequency of wind directions
Sampling frequency	Monitoring of the activity concentration in the fruits, vegetables and grain is ensured with variable frequency depending on the type of sample, vegetation period, locality and other factors
Performed analyses	Gamma spectrometry, ^{90}Sr, ^{14}C
Number of analyses carried out per year	Gamma spectrometry - 6 -(2x fruit, 2x vegetables a 2x grain) ^{90}Sr- 6 -(2x fruit, 2x vegetables a 2x grain) ^{14}C - 6 -(2x fruit, 2x vegetables, 2x grain)

Fish

Sampling point	River Hron - under the discharge outlet
Sampling frequency	Annually
Performed analyses	Gamma spectrometry
Number of analyses carried out per year	2

7.2.7 Water plants

Sampling points	River Hron - Tlmače - reference (background) sampling point River Hron -under the discharge outlet
Sampling frequency	Annually from the first location and semi-annually from the second location
Performed analyses	Gamma spectrometry, ^{14}C
Number of analyses carried out per year	Gamma spectrometry - 2 ^{14}C - 1 , River Hron - under the discharge outlet

7.2.8 Grass

Sampling points	Červený Hrádok Nevidzany EMO - Z157 Nový Tekov Starý Tekov
Sampling frequency	Annually
Performed analyses	Gamma spectrometry
Number of analyses carried out per year	5

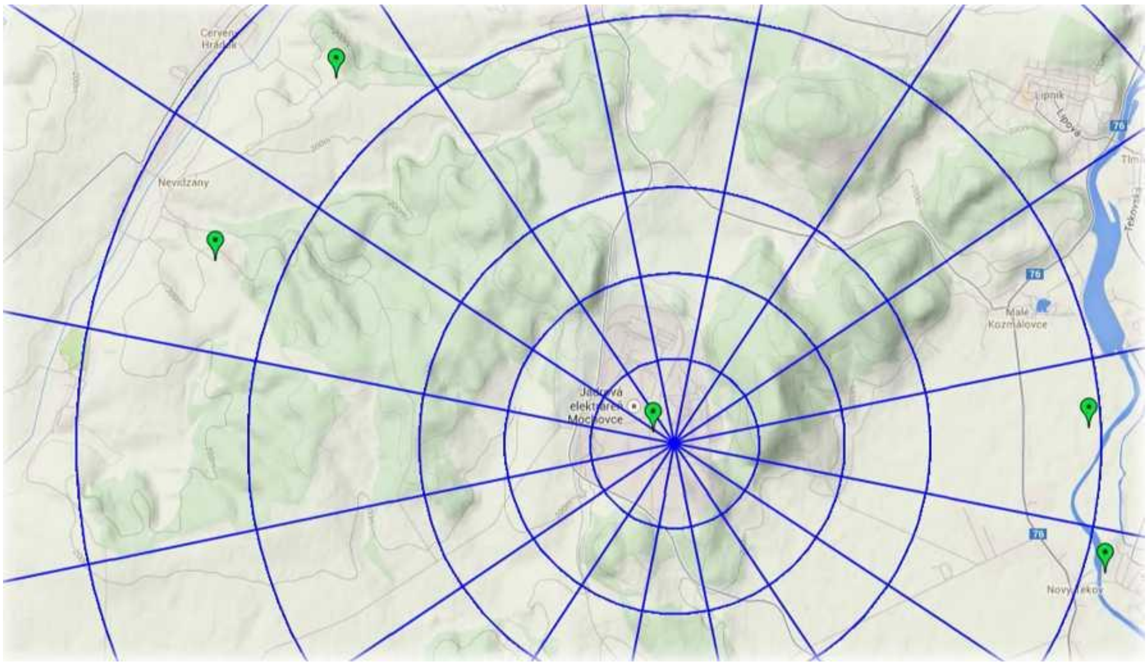


Figure 7. Grass sampling locations

7.2.9 Surface water

Sampling points	Mochovce (Telinský potok) Tlmače (Hron) - reference (background) sampling point Kalná n/Hronom - reference point for sampling according to the decision of the Regional environmental authority in Nitra, No. 2007/000029 of 25 January 2007Nevidzany *OK-LČ. 1* *OK-LČ. 2* *OK-LČ. 3*
Sampling frequency	Quarterly - Mochovce /Telinský potok/, Tlmače, Kalná n/Hronom and Nevidzany For the remaining sampling points: Biweekly during the first year of operation of the N. Tekov hydro power plant (till 31.3.2015) Monthly during the second year of operation of the Small hydro power plant N. Tekov (from1.4.2015 to 31.3.2016)
Performed analyses	Gamma spectrometry, gross Alpha activity, gross Beta activity, ^{90}Sr, ^{3}H, Alpha spectrometry, ^{14}C
Number of analyses carried out per year	Gamma spectrometry - 16 Gross Alpha – 8 (4 x 2) (Tlmače, Kalná n/Hronom) Gross Beta – 8 (4 x 2) (Tlmače, Kalná n/Hronom) ^{90}Sr - 16 ^{3}H – 172 (156(26x6)+ 16(4x4)) Alpha spectrometry – 2 (1 x 2) (Tlmače, Kalná n/Hronom) ^{14}C –1 (Kalná n/Hronom)

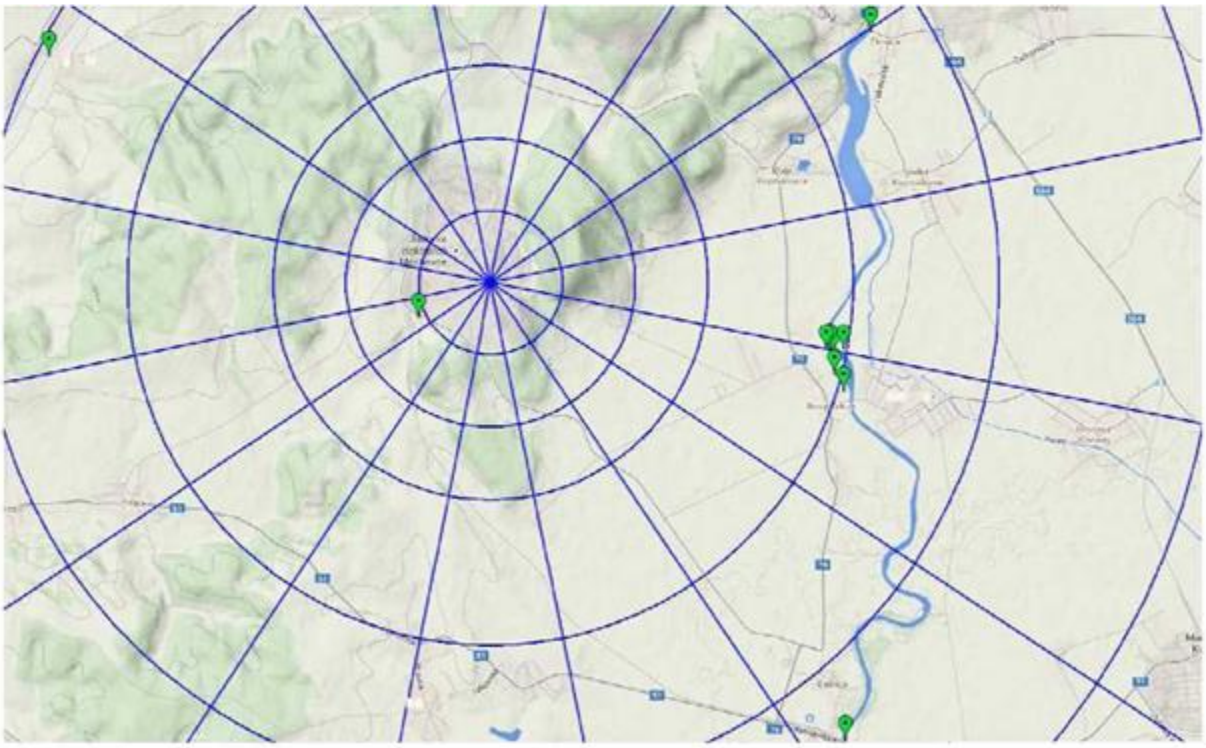


Figure 8. Surface water sampling locations

7.2.10 Drinking water

Sampling points	Malé Kozmálovce Starý Tekov Kalná nad Hronom *Nový Tekov č. d. 96* *Nový Tekov č. d. 116* *Nový Tekov č. d. 132*
Sampling frequency	Quarterly - Malé Kozmálovce, Starý Tekov and Kalná nad Hronom For the remaining sampling points: Biweekly during the first year of operation of the N. Tekov hydro power plant (till 31.3.2015) Monthly during the second year of operation of the N. Tekov hydro power plant(from1.4.2015 to 31.3.2016) Weekly in case of increasing of tritium activity above agreed intervention levels
Performed analyses	^{3}H (Gamma spectrometry and ^{90}Sr - only in case of exceeding the investigation level for ^{3}H)
Number of analyses carried out per year	minimum 90 (78 (3x26) +12 (3 x 4))

Figure 9. Drinking water sampling locations

7.2.11 Groundwater

Groundwater wells (boreholes along the waste pipeline Mochovce – Hron)

Sampling points	HG-3 HG-5 HG-7 EM1 to EM13 EMH1
Sampling frequency	Semi-annually
Performed analyses	^{3}H (in case that investigation level for tritium is exceeded, gamma spectroscopy and Sr-90 analyses are performed)
Number of analyses carried out per year	34 - (2 x 17)

Groundwater wells (boreholes around the N. Tekov hydro power plant)

Sampling points	EM-14 to EM-34 PS-1 to PS-4
Sampling frequency	Quarterly from boreholes EM-14 to EM-34 For the boreholes *PS-1 to PS-4, EM-31 and EM-34* Biweekly during the first year of operation of the N. Tekov small hydro power plant (till 31.3.2015) Monthly during the second year of operation of the N. Tekov small hydro power plant (from1.4.2015 till 31.3.2016) Weekly in case of increasing of tritium activity above agreed intervention levels (boreholes PS-1 to PS-4 and EM-34)
Performed analyses	^{3}H (in case that investigation level for tritium is exceeded, gamma spectroscopy and Sr-90 analyses are performed)
Number of analyses carried out per year	Minimum 232 -(156 (26x6) + 76 (4 x 19))

Groundwater (on-site radiation monitoring boreholes)

Sampling points	RK 1 to RK 4 RK 7 to RK 13 RK 30 RK 31 RK 32 RK 40 HMB1 HMB2 Note: Water is regularly found only in boreholes RK11, RK 13, RK 30, RK 31, RK 32 and RK 40, remaining boreholes are checked for the presence of water and, if there is, samples are taken off also from them.
Sampling frequency	Semi-annually
Performed analyses	Gamma spectrometry and ^{3}H
Number of analyses carried out per year	Gamma spectrometry - 8 - (2 x 4) (RK 11, RK 13, RK 30 and RK 40) ^{3}H - 12 - (2 x 6)

Groundwater

Sampling points	Shaft 0TKS01 Shaft 0TKS02
Sampling frequency	Quarterly
Performed analyses	^{3}H
Number of analyses carried out per year	8 - (4 x 2)

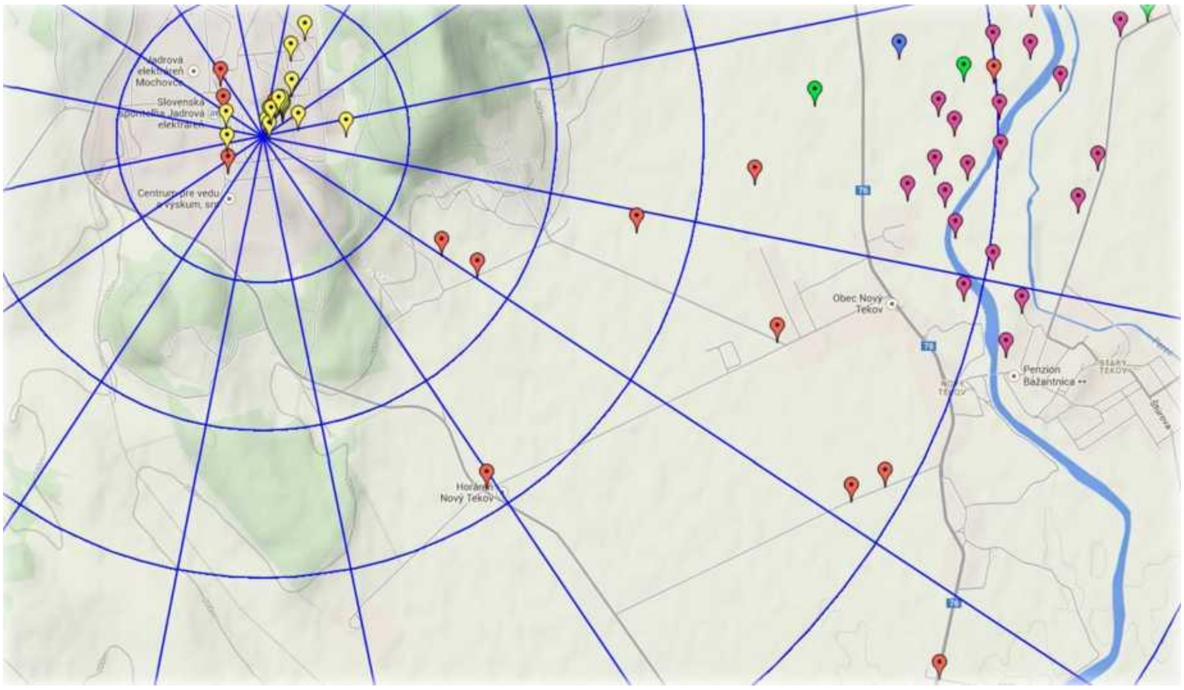


Figure 10. Groundwater sampling locations

7.2.12 Precipitation

Sampling point	SDS C. Hrádok
Sampling frequency	Quarterly
Performed analyses	^{3}H
Number of analyses carried out per year	4 - (4 x 1)

7.3 FIELD MEASUREMENTS

In situ gamma spectrometry

Sampling points	Červený Hrádok Nevidzany EMO - Z157 Nový Tekov Starý Tekov
Sampling frequency	Annually
Number of analyses carried out per year	5

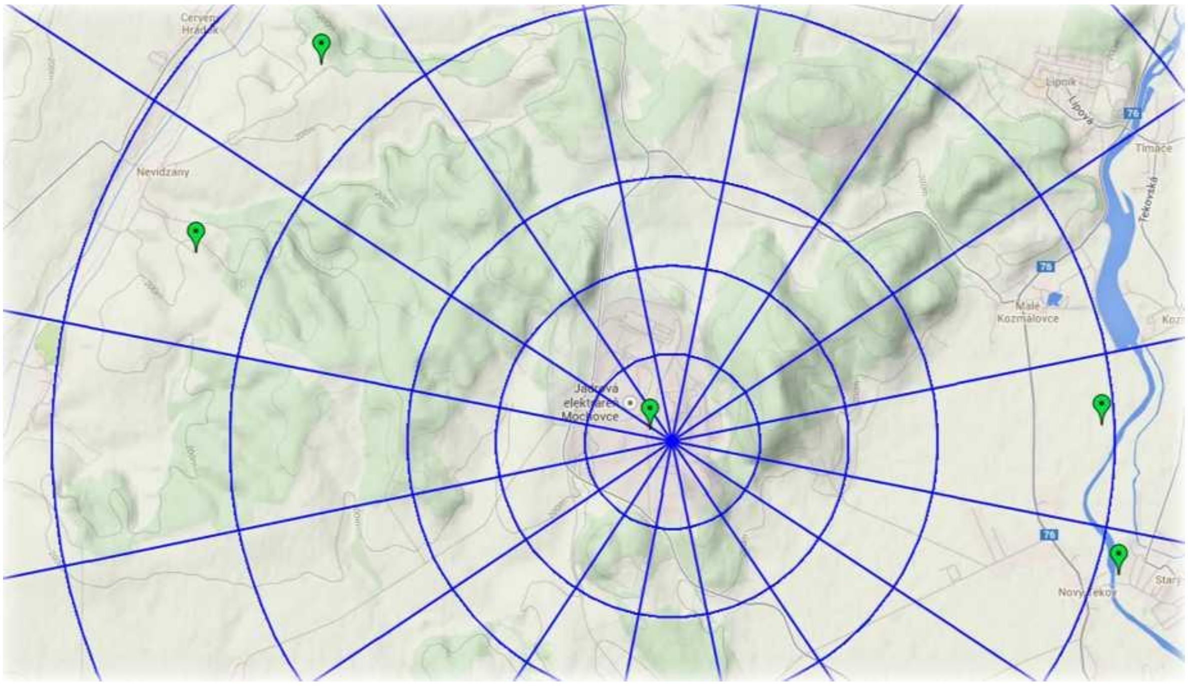


Figure 11. In situ gamma spectrometry locations

Dose rate (measured by means of ionisation chamber RSS 121)

Sampling points	Červený Hrádok Nevidzany EMO - Z157 Nový Tekov Starý Tekov
Sampling frequency	Annually
Number of analyses carried out per year	5

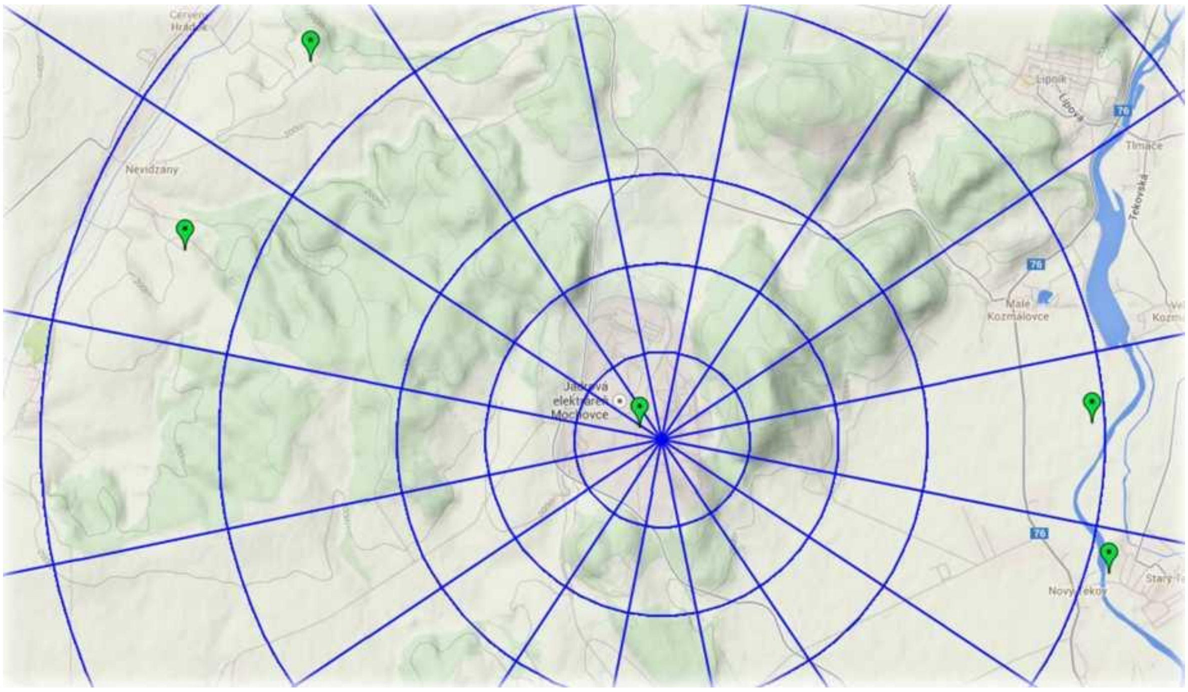


Figure 12. Dose rate monitoring locations

7.4 TOTAL DOSE MONITORING

Sampling points	SDS LRKO Levice	Bardoňovo	Orovnica
	SDS Levice	Beša	Podháj ska
	SDS Kalná n/Hronom	Caradice	Slažany
	SDS Nový Lekov	Čierne Kľačany	Slepčany
	SDS M. Kozmálovce	Dolná Seč	Starý Lekov
	SDS Veľký Ďur	Dolné Obdokovce	Lehla
	SDS Ċ if áre	Golianovo	Lekovská Breznica
	SDS Vráble	Horná Seč	Lekovské Lužany
	SDS Lajná	Horný Pial	L ekovské Nemce
	SDS Č. Hrádok	Hr. Beňadik	L elince
	SDS Nemčiňany	Hronské Kľačany	Lesárske Mlyňany
	SDS Zlaté Moravce	Jur n/ Hronom	Llmače - Lipník
	SDS Kozárovce	Kmeťovo	Lopoľčianky
	SDS Rybník	Krškany	V. Chrasť any -
	EMO SDS	Lok	Beladice
	EMO chlad, veže	Machulince	V. Kozmálovce
	EMO metrológia	Malé Vozokany	Velčice
	EMO dekarbo	Maňa	Veľké Chyndice
	EMO údržba	Melek	Veľké Vozokany
	EMO ZS	Mýtne Ludany	Veľký Cetín
	EMO vrátnica	Neverice	Veľký Lapáš
	EMO FS KRaO 1	Nevidzany	Vinodol
	EMO FS KRaO 2	Nová Dedina	Volkovce
	EMO FS KRaO 3	Obyce	Vyšné n/ Hronom
		Ondrej ovce	Zemliare
			Zitavce
Sampling frequency	Quarterly		
Number of analyses carried out per year	296 (4 x 74) per year		

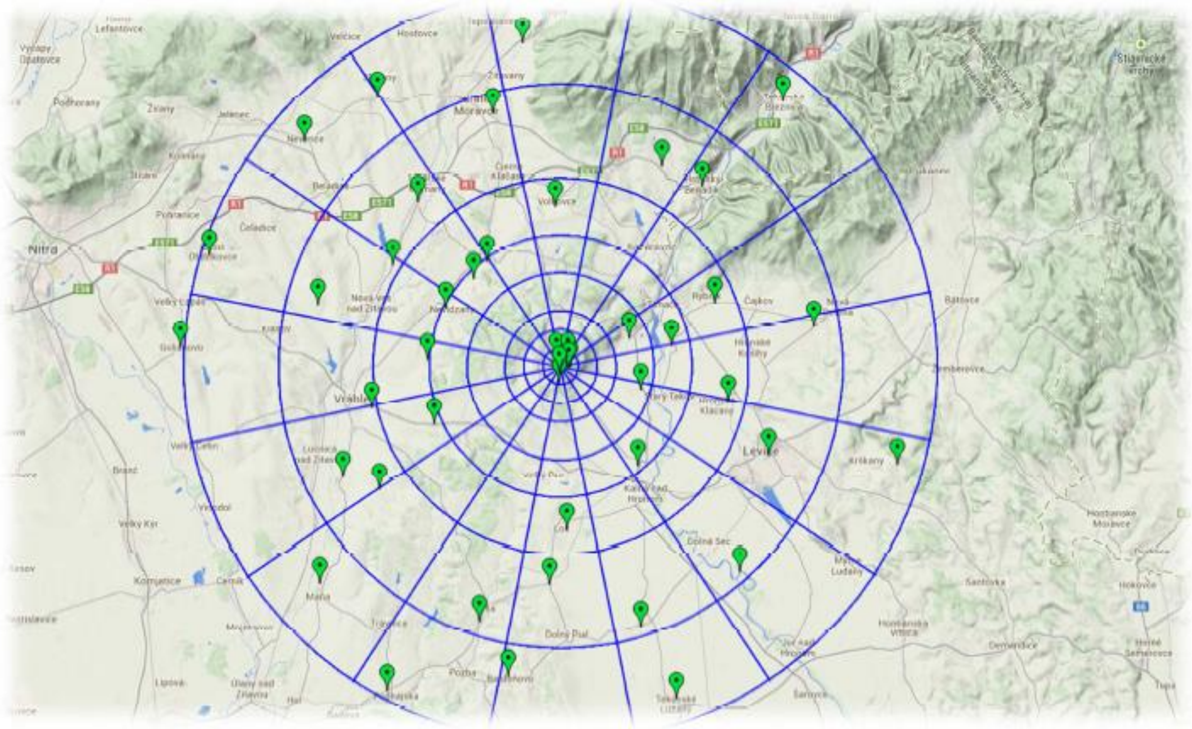


Figure 13. Total dose monitoring locations

7.5 TELEDOSIMETRIC SYSTEM

In accordance with the document "0-PLN/0006 Radiation monitoring plan in the vicinity of the Mochovce NPP", the ERML carries out monitoring by means of the teledosimetric system (TDS). The system is used for continuous monitoring of the radiation situation on the site and around the Mochovce NPP during normal operation, as well as in case of events defined in the internal emergency plan. The system consists of monitoring stations which are deployed in two circuits. The first circuit consists of 19 TDS monitoring stations, which are located on site. Transfer of data from these stations to the centralised radiation control system (CRCS) is by means of a bilaterally closed cable loop at two minute intervals. The second circuit is located outside the Mochovce NPP and consists of 20 monitoring stations, which are located near major towns up to about 15 km distance. The teledosimetric system operates continuously. Data from the stations are sent to the CRCS at two-minute intervals by means of a radio modem network.

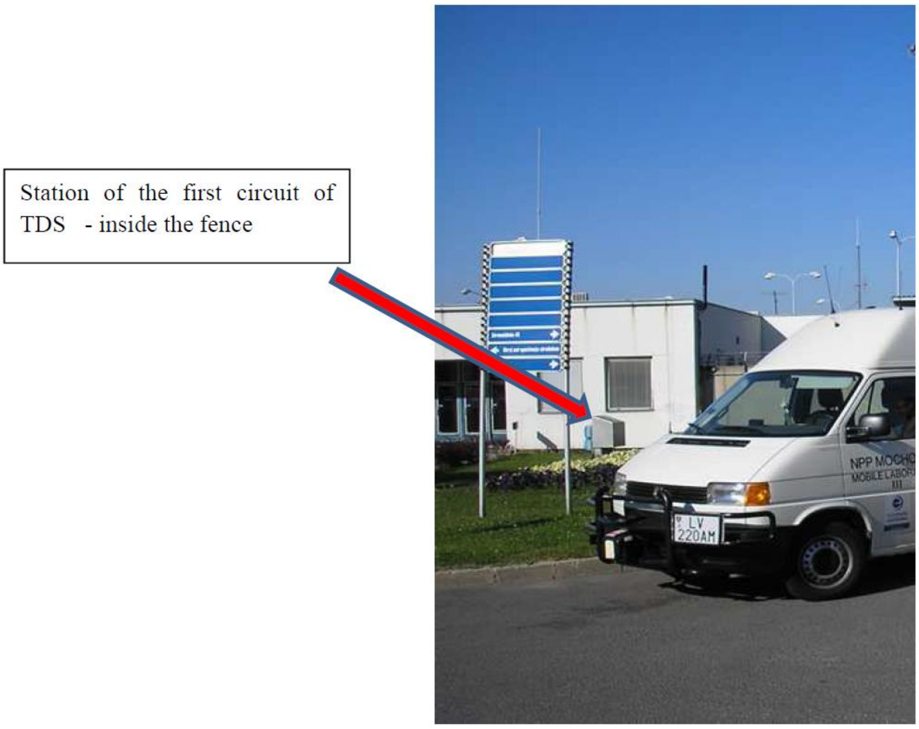


Figure 14. Teledosimetric station TDS inside the fence

The TDS consists of three types of stations:

STATION type 1 - (16 stations, all situated in the first TDS circuit on the NPP site). The most important data transmitted from the radiation monitoring point of view are:

- dose rate,
- exceeding of set thresholds for dose rate.

STATION type 2 - (16 TDS stations, all situated in the second TDS circuit). The most important data transmitted from the radiation monitoring point of view are:

- dose rate,
- exceeding of set thresholds for dose rate,
- iodine and aerosol sampler's status information.

STATION type 3 - (7 stations, three of them situated in the first TDS circuit and four in the second one). The most important data transmitted from the radiation monitoring point of view are:

- dose rate,
- exceeding of set thresholds for dose rate,
- artificial beta activity concentration in aerosols,
- exceeding of set thresholds for artificial beta activity concentration,
- iodine activity concentration,
- exceeding of set thresholds for iodine activity concentration.

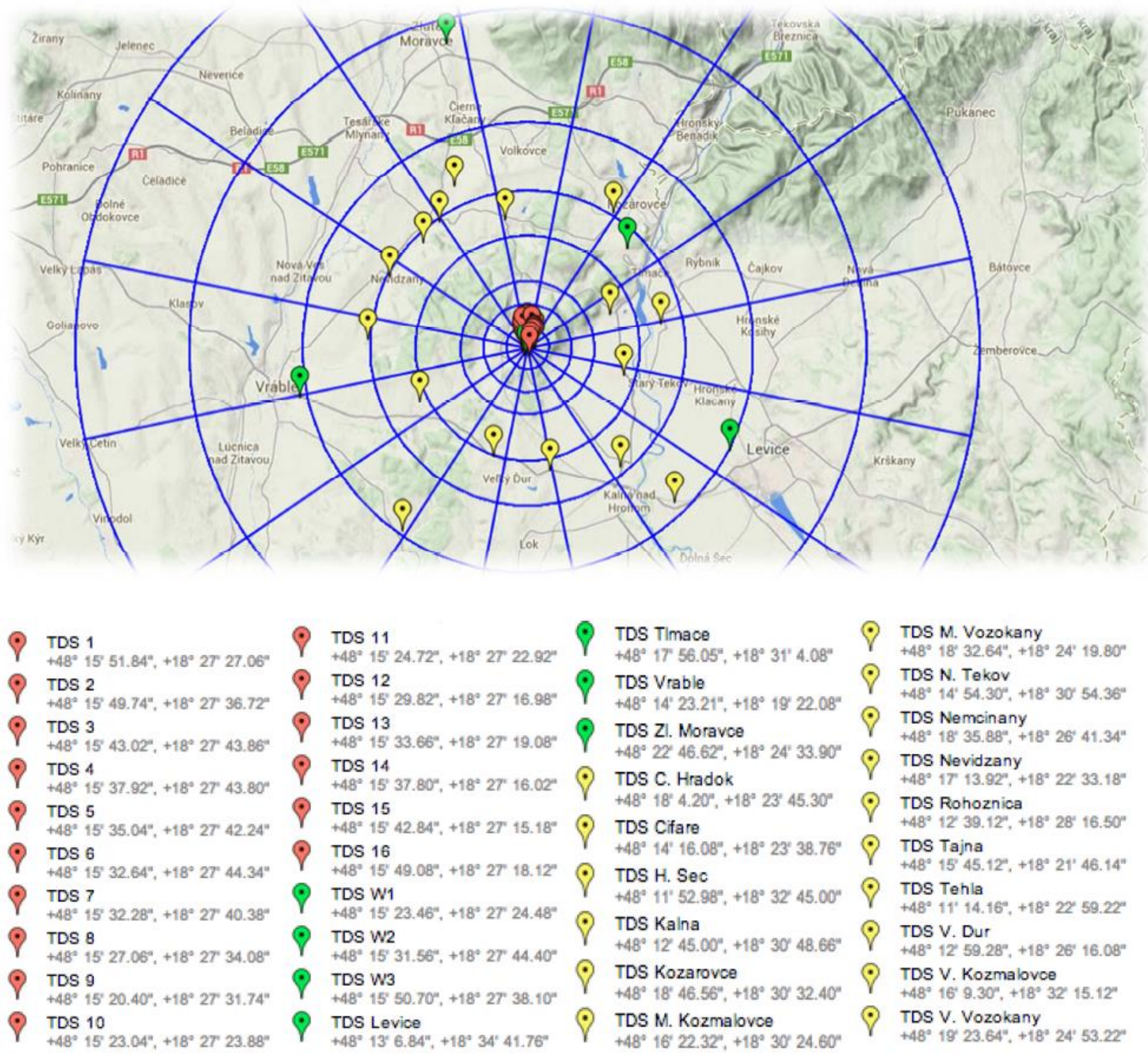


Figure 15. Locations of the TDS stations

7.6 FIXED DOSIMETRIC STATION NETWORK

There are fifteen fixed dosimetric stations (SDS) around the Mochovce NPP. These are equipped with devices for collecting aerosols and fallout. In normal operation, the aerosols are collected from five SDS and fallout from three SDS. If necessary, samples may be taken from all stations.

Each SDS contains the following equipment:

- VOPV-12 high-volume air sampler,
- Fallout device (fallout is captured through a chimney with a diameter of 196 mm on water, which is in a polyethylene container with a capacity of 10 litres),
- Temperature regulating device.

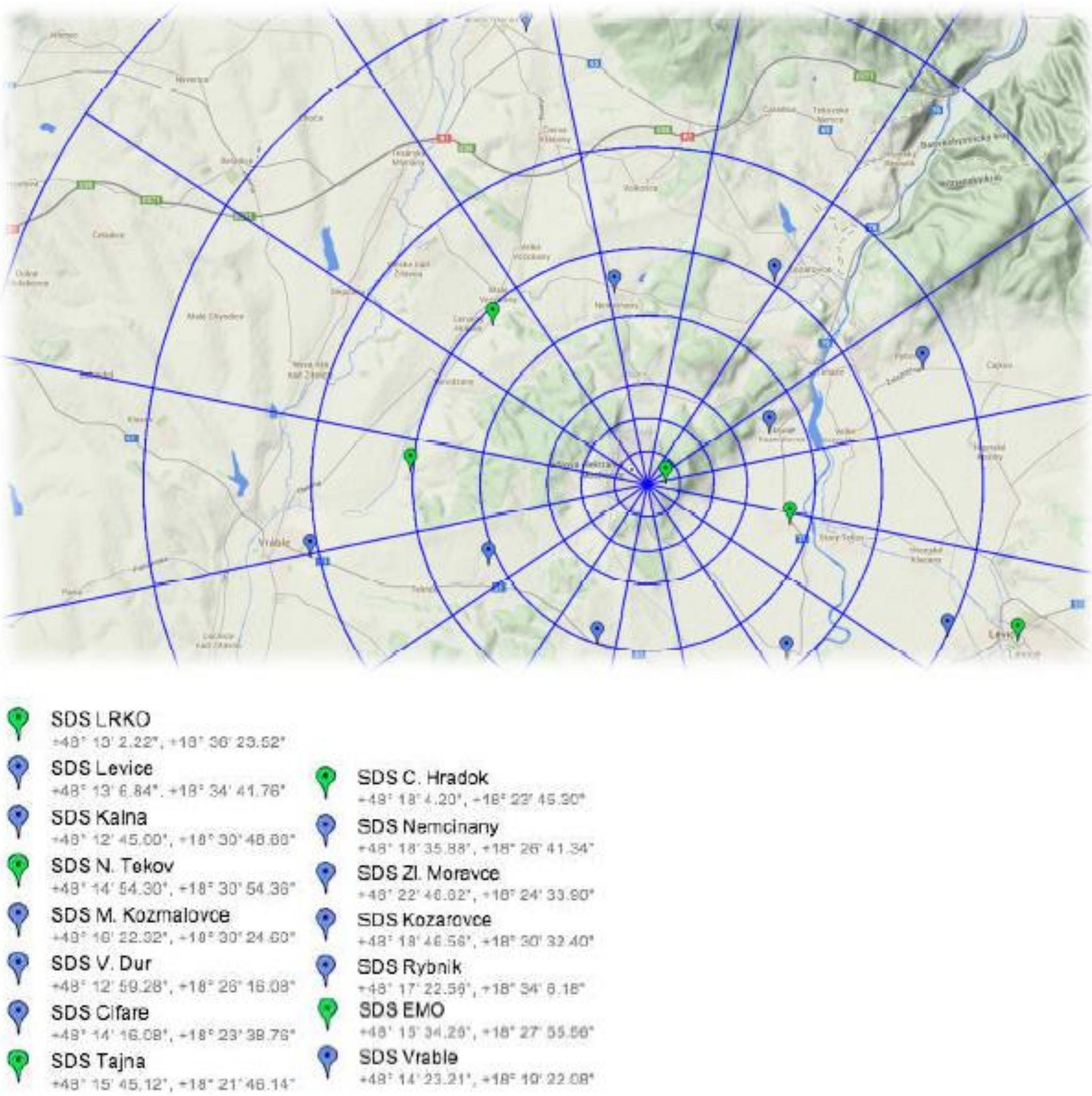


Figure 16. Locations of the fixed dosimetric stations

7.7 MOBILE MONITORING SYSTEMS

Mochovce NPP has three environment monitoring vehicles. One vehicle is located on site at the NPP and the others are located in the environmental radiological monitoring laboratory (ERML) in Levice.

The technical specifications of the three vehicles are identical. A decontamination unit is installed with tanks for clean hot and cold water and a waste water tank. The measuring and sampling systems are almost identical, with the exception of the vehicle, which is located on site at the NPP where no gamma spectroscopy system is installed. However, this vehicle is equipped with an aerosol sampling unit to collect samples while driving. The vehicles are equipped with battery systems which provide a power supply for approximately ten hours without recharging. The monitoring vehicles are designed to support the fixed radiological and sampling monitoring systems and can be used as a continuous or as a spot check monitoring system. Some of the sampling units in the vehicles can be used while driving.

The sampling system in the vehicles can be used to collect samples of aerosols and iodine in ambient air and also to collect environmental samples (e.g. water, grass, soil, etc.). Special tools are used for packing and storing the samples.

Measurement results and some additional information are transmitted to the NPP and ERML via radio modems. Special software has been designed for tracking the vehicles and viewing the measurement results in real time. The software also displays the dose rate measured by the teledosimetric system. A set of colours is used to visually distinguish the predefined dose rate intervals.

Figure 17 presents an example of the real time tracking software GISMON showing TDS stations and the vehicle trajectory. Measured data can also be shown in graph form, printed or exported for further processing.

The mobile monitoring laboratories contain:

Communication equipment – for communication between the vehicle crew members or with the headquarters.

Dose rate monitor – a FH 40G is mounted on the dashboard, but can also be used as a portable monitor outside the vehicle. The monitor sends data to the online tracking system GISMON installed on the vehicle PC. There are also other portable dose rate devices which can be used while driving and also outside of the vehicle.

Aerosol and iodine sampling unit – there are two types of aerosol and iodine sampling units installed in the vehicles. One vehicle has a fixed unit whilst the other two have portable units, which are stored in the vehicles.

Gamma spectroscopy system including PC and printer - this system performs analysis of gamma-isotopes and can be used as a fixed unit in the vehicle and also as a mobile system outside the vehicle.

Contamination monitors - the contamination of objects in the environment is monitored with a large area portable monitor equipped with a Xenon gas filled detector and also with a portable dose rate monitor with an external GM detector.

Figure 17. Real time radiation dose rate tracking example

Tools for collecting the samples – various tools can be found in the vehicle e.g. soil sampling tool, spade, bags and bottles for collecting the samples, foil sealer, telescopic container for water sampling etc.

Decontamination unit - for cleaning purposes a decontamination system is installed, containing a fresh water tank, a water heating unit, a sink, a liquid soap tank, a waste water tank and a container for paper towels.

Power supply system - independence of the vehicle is ensured by 230 V AC and 12 V DC electric networks powered by the vehicle alternator, the vehicle battery, additional special batteries, and an external electric network or by an emergency generator.

Global positioning system (GPS) - guarantees correct information about the geographical position of the moving vehicle. The GPS receiver sends data to the on-board computer by serial link.

Data transmission and computer system – the systems are used for indicating, storing, printing and transmitting all measured values to the data transmission units. The systems are designed to operate while driving.

7.8 METEOROLOGY SYSTEMS

The meteorological situation at the Mochovce NPP is obtained from the on-site meteorological station. All measurements have redundancy. Wind direction, wind velocity and category of stability are taken from the SODAR system at levels from 50 m to 275 m every 25 m and the wind measurement mast. Category of stability is determined from solar radiation balance and SODAR.

Rainfall is taken from a precipitation gauge. The above-mentioned measuring instruments are subject to regular metrology calibration and verification.

8 MOCHOVCHE NPP ENVIRONMENTAL RADIATION MONITORING LABORATORY

8.1 INTRODUCTION

The environmental radiation monitoring laboratory (ERML) is part of the off-site radiation monitoring and laboratory measurements group of the radiation protection department. It is located outside of the NPP in Levice town and is responsible for monitoring radioactivity in the surroundings of the Mochovce NPP. The laboratory is part of the radiation monitoring network of the Slovak Republic.

The environmental laboratory is not an accredited laboratory. Every year the laboratory participates in international laboratory comparison tests organised by the IAEA, ALMERA (Analytical Laboratories for the Measurement of Environmental Radioactivity), ASLAB or NPL. The laboratory also takes part in ISIGAMMA in-situ intercomparison measurements.

Slovenské elektrárne has an agreement with the accredited laboratory of the Faculty of Natural Sciences of Comenius University in Bratislava, Department of Nuclear Chemistry, for analyses of transuranium elements and radiochemical analyses of Sr-90 and radiocarbon C-14 in environmental samples.

8.2 SAMPLE RECEPTION

The laboratory has a schedule for the whole year, establishing what samples have to be taken and when (sampling and measuring logbook No DDZ/8210).

On arrival at the laboratory all samples are logged into the laboratory information system (SAP laboratory measurements and discharges module). The data recorded for each sample includes evidence number, sampling location, GPS co-ordinates, type, date, analysis type etc. The laboratory information system allows also viewing historical data according to selected criteria.

Each sample recorded in the SAP has its own unique registration number, consisting of letter "L", the last two digits of the current year and a sequential number for recorded samples in that year, e.g. "L-14- 1236". Every measurement also has its own unique registration number, which is made of the unique sample number plus the appropriate analysis code, e.g. "L14-1236-H3_LS -1".

An accompanying form (see example below) is printed out for those samples which require further preparation before measurement. During the sample preparation process some information is written on the accompanying sheet, e.g. who prepared the sample and when, who carried out the measurement and when, etc.

SLOVENSKÉ ELEKTRÁRNE Enel

Slovenské Elektrárne, a.s.
závod Atómové elektrárne Mochovce

L-14-1236

Accompanying letter of sample

SAMPLE

Evidence no.:	**L-14-1236**		
Sample type-subtype:	**WATER_SURFACE**		
Sample description:	**Demi voda**		
Sampling location:	**LRKO - Levice**	*Closer location:*	**Laboratory**
Volume:	**0,5**	*UoM:*	**l**
Exp.start date and time:		*Samp. date and time:*	**12.09.2014 10:00:00**
Sample taken by:	**Eliašová Erika**	*Signature:*	
GPS N:	**48°13,024'**	*GPS E:*	**18°36,380'**
Remark:	**Kontrola kvality**		

MEASUREMENTS

Measurement no.:	**L14-1236-H3_LS-1**		
Analysis:	**Tritium - liquid scintillation**		
Device:			
Remark:			
Sample processed by:		Date of sample treatment:	
Sample measured by:		Date of measurement:	
Checked by:		Date of control:	
Used scintillator:		Data stored in the file:	

Figure 18. Example of a sampling sheet

8.3 Sample Preparation

Aerosol samples

Aerosols are captured on a filter by the VOPV-12 high-volume air sampler, installed in the SDS (Stable Dosimetric Station). The system is equipped with many functions such as the automatic regulation of the desired airflow, automatic restart after power supply failure, etc. The flow rate is adjustable from 20 m^3/h up to 160 m^3/h, but is maintained at 60 m^3/h. Sampling is continuous and filter replacement is done once every two weeks. After that the filter is dried, folded, wrapped with thin paper and compressed to a cylindrical shape with a diameter of 60 mm by means of a hydraulic press.

Fallout samples

Fallout is captured on a water surface through a hole with a diameter of 196 mm. Sampling is continuous; replacement of the water in the bucket is done quarterly. Sample preparation consists of:

- Filtering,
- Evaporating to dryness,
- Transferring to a ceramic bowl,
- Ashing the fallout sample,
- Weighing the fallout sample,
- Homogenising,

- Fixation with dispersion glue onto a measurement plate,
- Drying.

Soil samples

Samples are taken by a special small shovel (100x200 mm) enabling layer-by-layer sampling. Samples are taken from three sampling layers (0-2 cm, 2-5 cm and 5-10 cm) from the vertices of an equilateral triangle, inscribed within a circle with a 3m radius. Soil samples from the same spot are combined and represent one sample from the site. Sample preparation consists of:

- Drying at room temperature,
- Crushing,
- Sieving,
- Homogenising,
- Drying in a furnace,
- Weighing,
- Filling into a Marinelli beaker.

Milk samples

Milk samples are taken from the cooperative farm in Starý Tekov. For gamma spectrometry analysis a monthly composite sample is prepared from the weekly samples. For analysis of ^{90}Sr a quarterly composite sample is prepared from the monthly samples. Sample preparation for gamma spectrometry measurements consists of:

- Combining samples,
- Dehydration by lyophilisation,
- Weighing,
- Filling into a Marinelli beaker.

Sediment samples

Monitoring is aimed at obtaining information on the contamination trends of the river bed by discharge water sedimentation. Bottom sediments are taken manually using a suitable tool down to a depth of 10 cm. Samples are taken at 3 points from the so called mud bed (if possible from the vertices of an equilateral triangle, inscribed in a 1m radius circle). Sample preparation for gamma spectrometry measurements consists of:

- Drying at room temperature,
- Crushing,
- Sieving,
- Homogenising,
- Drying in the furnace,
- Weighing,
- Filling into a Marinelli beaker.

Food chain samples

Food chain sampling is concentrated in the sectors with the most common frequency of wind directions. The monitoring plan focuses mainly on examining activity in vegetables, fruit and cereals. Preparation of cereal and fruit samples for gamma spectrometry measurements consists of:

- Drying at room temperature,
- Drying in the furnace,

- Milling,
- Sieving,
- Homogenising,
- Weighing,
- Filling into a Marinelli beaker.

Preparation of vegetable and fruit samples for gamma spectrometry measurements consists of:

- Washing the sample,
- Homogenising,
- Weighing,
- Filling into a Marinelli beaker.

Grass samples

Sample preparation consists of:

- Drying at room temperature,
- Milling,
- Sieving,
- Homogenising,
- Drying in the furnace,
- Weighing,
- Filling into a Marinelli beaker.

Water samples

The sampling bucket is carefully rinsed with water prior to the collection of surface water. After that the bucket is immersed in the water to a maximum depth of 0.5m. The sample is then transferred to the transport containers. After sampling the sampling bucket is thoroughly washed with distilled water. A similar method is also used for sampling of drinking water from home wells.

Monitoring of ground water aims to determine any contamination caused by direct leakage of radioactive substances at various depths and distances. Samples are taken from the test boreholes situated around Mochovce NPP. There is a pneumatic sampler device, permanently placed in some of the boreholes. Where such a device is not installed, a portable one is used for sampling.

Preparation of water samples for gamma spectrometry measurement consists of:

- Preservation of the samples by pH acidification,
- Filtering,
- Concentrating,
- Filling into a Marinelli beaker.

Preparation of water samples for tritium measurements consists of:

- Distillation twice,
- Pipetting the sample – 10 ml into a 20 ml PE vial,
- Pipetting the scintillator – 10 ml into a 20 ml PE vial,
- Mixing.

Preparation of water samples for total alpha and total beta measurements consists of:

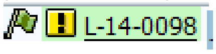
- Preservation of the samples by pH acidification,
- Filtering,

- Concentrating,
- Evaporating to dryness,
- Heating residue to redness,
- Weighing,
- Homogenising,
- Transferring to a stainless steel planchette.

8.4 SAMPLE MEASUREMENTS AND DEVICES

Appendix 3 provides in table form an overview of the analyses carried out and the laboratory equipment.

8.5 MEASUREMENT RESULTS

The results of the measurements are entered into the SAP laboratory measurements module. Some results are imported from a text file and some are entered manually. Depending on whether or not the investigation level is exceeded, SAP graphically shows the status. In case of exceeding the investigation level of a monitored parameter a yellow square with a black exclamation mark in it is shown before the project number 

If the activity is lower than the minimum detectable activity (MDA) the result box is left empty and the MDA value is written into the corresponding box. Half the MDA is used for statistical processing of the data.

Reports with the measurement results are archived on a CD. Accompanying sample sheets are archived in paper form. 10 minute average values from the TDS system are archived in CRCS and calculated monthly averages are archived in the reports.

8.6 DATA HANDLING AND REPORTING

In addition to the information given above concerning data handling it is worthwhile to mention that SAP also allows export of data to ASCII or Excel files.

The SAP system is controlled by access rights, assigned to individual functions or workers, for each transaction, according to assigned roles and statuses. Data handling is performed mainly in SAP, Excel and in the STATGRAPHICS software. Data for processing in Excel and STATGRAPHICS are transferred from the SAP database. It is possible to print protocols and accompanying letters directly from SAP. There are some statistical functions built into SAP, but for more complex processing Excel or STATGRAPHICS are used.

Law 355/2007 Z.z. covering the protection, support and development of public health provides the operator details of the measurements and analyses to be specified in the monitoring plan. According to the Decision OOZPŽ/7042/2012 for authorisation to carry out activities leading to irradiation, measurement results shall be given to authorities (PHA) quarterly as follows:

- Report for the first quarter of current year by the end of May,
- Report for the second quarter of current year by the end of August,
- Report for the third quarter of current year by the end of November,
- Report for the fourth quarter by the end of February of the following year (note: results for the fourth quarter are not published separately but included in the annual report).

The results of dose rate measurements are published regularly in the monthly newspaper Atom.Sk.

Reports on radioactivity monitoring around the Mochovce NPP are sent to the following organisations:

- The Nuclear Regulatory Authority,
- Public Health Authority of the Slovak Republic,
- Regional Public Health Authority (Levice),
- CEZ (NPP Temelín),
- Slovak Health University,
- Regional Office Banská Bystrica, Environmental Department,
- Regional Office Nitra, Environmental Department,
- District Office Levice, Environmental Department,
- District Office Nové Zámky, Environmental Department,
- District Office Zlaté Moravce, Environmental Department,
- Municipal offices of the villages around Mochovce NPP (Tlmace, Vráble, Nemcinany, Malé Vozokany, Velké Vozokany, Cervený Hrádok, Nevidzany, Tajná, Cifáre, Telince, Velký Dur, Kalná nad Hronom, Starý Tekov, Nový Tekov, Malé Kozmálovce, and Velké Kozmálovce).

8.7 SAMPLE STORAGE

Samples are archived for 5 years and stored in the ERML building in Levice. Samples archived in Marinelli beakers or in measurement vials are marked with a registration label that contains the following information:

- Registration number,
- Sample type,
- Sampling point,
- Date of collection,
- Information note.

Aerosol filters are archived in compressed form. The name of the spectrum, air volume and the weight of the filter are written on it. Fallout is fixed with dispersion glue and archived on planchettes, with the name of the spectrum and sampling point. The set is wrapped in paper, labelled and deposited in the samples archive. Processed soils and sediments are archived in the amount of about 600 g in Marinelli beakers, which are marked with a registration label. Grass, grain and water plants are archived in the amount of about 200 g, prepared in the form of dried and homogenised samples, stored in Marinelli beakers, which are marked with a registration label. Milk is kept in the amount of about 250 g in the form of milk powder in Marinelli beakers, which are marked with a registration label. Fruit and vegetable samples are not archived.

8.8 QUALITY ASSURANCE AND CONTROL

Quality processes in the environmental laboratory are ensured through the following:

- Qualified personnel,
- Sampling schedule,
- Established system of quality control and quality assurance,
- Only written and approved analytical procedures are used,
- Only certified standards and calibrated measuring devices are used,
- Quality control of samples,
- Quality control of measuring devices,
- Participation in international laboratory comparison measurements,
- Audits (internal and external).

Quality control of samples is provided by the following types of samples:

- Blind samples,
- Blank samples,
- Spiked samples,
- Duplicated samples.

Quality control of measuring devices includes:

- Background measurements,
- Measurements performed with working standards,
- Periodic calibration of devices,
- QA/QC testing of individual devices.

9 VERIFICATIONS

9.1 PUBLIC HEALTH AUTHORITY LABORATORY

The PHA laboratory in Bratislava is in charge of the analysis of the environmental samples of the national monitoring programme. The laboratory is not involved in commercial activities. It is ISO 9001 certified, but does not have specific laboratory accreditation. In order to maintain the quality the laboratory regularly participates in intercomparison exercises organised by the IAEA, ASLAB (Czech Republic), Water Research Institute (Slovakia) and the EC.

Sample receipt

The PHA laboratory receives some 800 samples each year. Each sample is numbered and registered in a sample data base and in a paper logbook.

Verification does not give rise to remarks.

Sample preparation

The sample preparation room is equipped with scales and furnaces for drying/ashing samples. The calibration certificates of the scales were presented to the verification team.

Verification does not give rise to remarks.

Counting

The PHA laboratory counting room houses a Perkin-Elmer TriCarb 200TR scintillation counter for H-3 and Radon analysis and a Slovak Metrological Institute alpha-beta counter.

For gamma spectroscopy there is an Ortec HPGe detector (35% relative efficiency) and an Ortec DSpec digital signal processing system. During the verification the system electronics unit was overheating and cooled by an improvised external fan.

Energy and efficiency calibration of the gamma spectroscopy system is based on commercial multinuclide standards; calibration of the resolution (FWHM) is not carried out. Efficiency calibration of the air filters is based on a point source standard, with experimental verification through ^{137}Cs paper filter.

For strontium, iodine and alpha/beta analysis the laboratory has a Thermo Scientific FHT 770T Multi Low Level Counter.

The PHA laboratory equipment includes only one unit of each equipment type. This fulfils the minimum criteria, but raises serious concerns on the reliability of the laboratory operation, since malfunction of crucial equipment could seriously affect the laboratory throughput. Additionally, with the current analysis capacity in the event of an emergency the number of samples would quickly overwhelm the laboratory.

The verification team recommends that PHA improves the laboratory equipment situation by acquiring additional counting equipment or by agreeing on back-up counting arrangements with other laboratories in the event of a malfunction.

The verification team recommends that the PHA laboratory takes action to resolve the overheating problem of the DSPEC unit.

In order to detect technical problems as early as possible, the verification team recommends including control of HPGe detector resolution (FWHM of the Co-60 peak at 1332 keV) in the regular equipment control programme.

Particulate air sampling and ambient gamma dose rate monitoring

The PHA laboratory has a particulate air sampling system and a gamma dose rate detector installed on the roof of the building. The air sampler has a factory-calibrated integrated flow meter. Flow measurement recalibration has not been undertaken. The air sampler does not include sampling of gaseous iodine.

The ambient gamma dose rate monitor is old, but still functional. There is a local display at the laboratory. The dose rate values are recorded locally on 10-minute intervals, but not distributed outside the laboratory.

The verification team suggests considering the possibility of installing activated charcoal cartridges for measurement of gaseous iodine during emergency situations.

TLD

PHA has TLD monitoring capability (TLD reader Harshaw QS 3500). The TLDs are used as a part of the environmental monitoring programme.

Verification does not give rise to remarks.

Mobile measurement systems

The PHA laboratory has no mobile monitoring capability. It has one gamma spectroscopy system for mobile use (Canberra HPGe + Inspector 2000), but there are no established procedures for using it and the system has no calibration for in-situ measurements in the environment.

The verification team suggests the PHA considers the need to establish procedures for carrying out mobile radioactivity monitoring during an emergency situation and to institute the necessary technical arrangements.

9.2 SHMI LABORATORY

The verification team visited the SHMI laboratory located in Bratislava. The laboratory operates an on-line system consisting of 20 ambient dose rate detectors: 14 Genitron GammaTracer detectors, 5 Microstep-MIS RPSG-05 detectors and one GammaTracer mobile detector.

The team was informed that by the end of 2014, 5 new Canberra-Packard Eco-Gamma G detectors would be installed to replace ageing GammaTracer instruments. The SHMI is preparing public tendering to continue this modernisation. For budget reasons, there is a tendency towards decreasing allocations for renewal so that only a few detectors may be purchased per lot. Not only does this increase the administrative burden on the technical personnel, but also increases the risk of evolving towards different systems, depending on which supplier wins the current bid.

The verification team suggests that allocations for renewing monitoring detectors be increased to meet demands for several years to come. Reducing the number of invitations to tender procedures would better allow staff to focus on their operational tasks and to avoid a possible profusion of different systems to maintain.

In the meteorological garden belonging to the institute, the verification team inspected a gamma dose rate measurement station. It was well positioned in an open grass field and carried clearly visible detector specifications. The accompanying Vaisala Milos 500 automatic weather station was equally well situated.

The data centre for the on-line monitoring system is placed in the main computer room of the institute. From there, the SHMI transmits radiation files online to the Slovak Nuclear Regulatory Authority, several other operators of radiation monitoring networks in Slovakia, as well as to neighbouring countries Austria, Hungary and the Czech Republic. Detailed knowledge of the computer programs resides mainly with the Head of the Radiation Monitoring Network at SHMI, who is supported half-time by a technician.

> *The verification team points out that relying mainly on one person, with only half-time support from a colleague, may, in case of prolonged absences, cause problems with guaranteeing continuity of operational tasks. The team recommends that staff allocations for these tasks be reinforced.*

9.3 RPHA LABORATORY BANSKÁ BYSTRICA

The RPHA laboratory carries out a large variety of environmental measurements. The verification team restricted their attention to the analyses carried out in the context of the independent monitoring carried out in relation to the Mochovce NPP.

The following sampling programme is implemented:

Sample type	Sampling points	Sampling frequency	Measurements
Drinking water	4	monthly	Gross alpha, gross beta, H-3
Surface water	3	monthly	Gross alpha, gross beta, H-3
Sediment	1	yearly	Cs-137

ISO 17025 accreditation is held for drinking water sampling and analysis. Water samples are prepared in accordance with the procedure STN EN ISO 5667-3 (Water quality sampling part 3, preservation and handling of water samples). Participation in intercomparison exercises regarding the gross alpha and gross beta measurements is limited to water samples and involves cooperation with the Slovak and Czech water authorities. The RPHA takes part in the intercomparison exercises organized by the IAEA as well.

Additionally dose rate is measured at Nová Baňa, Hronský Beňadik, Tlmače, Nový Tekov (ferry) and Bátovce using a Canberra FieldSpec mobile device.

Sample receipt

Upon arrival at the laboratory all samples are recorded in a central register and receive a unique identification code. Several rooms are available for sample preparation and there is an effective separation between areas where different sample types are treated. The sample receipt area can be separated in such a way as to enable potentially higher activity samples to be segregated from more routine samples.

Gross alpha and gross beta measurements

Gross alpha and gross beta measurements are performed using a Thermo Scientific FHT 770 T6 gas flow proportional counter. Quality is ensured through the use of certified standards, participation in intercomparison exercises and calibration (at least twice a year).

The RPHA laboratory has accredited procedures for the determination of ^{226}Ra and ^{234,235,238}U by alpha spectrometry in water samples. The RPHA laboratory has a procedure for the determination of other specific nuclides, such as ^{210}Po, ^{228}Ra, ^{137}Cs and ^{90}Sr as foreseen by the Euratom Drinking Water Directive.

During the verification the liquid scintillation counter was out of order, therefore samples for tritium analysis were being sent to the PHA in Bratislava for analysis.

Gamma spectrometry

Two HPGe detectors, manufactured by Princeton Gamma Tech (model IGC30), with 32.4% and 25% relative efficiencies are operated. The former has a 20cm thick steel shield manufactured by Vitkovice, whilst the latter has a 10cm lead/copper shield. Both systems use Canberra Genie 2000 software and have been calibrated for 3 different geometries (0.5l Marinelli beaker, 7cm diameter cylinder and LSC vial). Background spectra are collected at least once per year for each measurement geometry. Every 2 years calibration is performed using mixed nuclide standard water solutions from the Slovak Metrological Institute. In addition the laboratory can obtain, on loan, certified standards from the PHA when necessary.

Sample storage and reporting

Samples are stored until the relevant measurement documentation has been generated, then destroyed. After calculation of the results in Excel the result is printed and signed off by the laboratory manager. A locally developed Microsoft Access database is used for storage of measurement data. All data is backed-up every Friday on CD which is stored on-site. Each RPHA has its own database of measurement results without any common methodology or centralised backup.

> *The verification team recommends, as was previously the case following the 2009 verification, putting in place a system covering all the RPHAs (and possibly other entities) for the back-up of raw measurement data and final results in electronic format. As a minimum, the verification team recommends finding an off-site storage location for the backup CDs.*

9.4 LIQUID DISCHARGE MONITORING AT THE MOCHOVCE NPP

The verification team verified the liquid effluent discharge monitoring systems at the Mochovce NPP. The team visited the control tank room and the release water station as described in section 6.2. All the systems were operational and together form a comprehensive monitoring arrangement for liquid discharges from the whole site (not only from the controlled areas).

The release water station is equipped with two identical systems backing up each other in case of breakdown. Measurements are taken by two online Berthold gamma monitors with scintillator detector. Sample water is collected by pumps in the collecting pool. In case of an alarm, more samples are collected. All written procedures and operator instructions are available on site.

The team visited also the dilution room (see section 6.2) where tritiated water is diluted with water received from the Hron River before release. It was confirmed that the release control arrangements between the plant laboratory and the plant control room are in place and the valve allowing the discharge into the canal is secured with a key, as the room itself.

> *Verification does not give rise to remarks.*

9.5 GASEOUS DISCHARGE MONITORING AT THE MOCHOVCE NPP

The verification team verified the on-line monitoring and air sampling systems at the NPP common air exhaust stack. Gaseous discharge monitoring at the Mochovce NPP consists of several on-line and off-line sampling systems, as presented in section 6.3. All the systems were operational and together form a very comprehensive monitoring arrangement for gaseous discharges. The reliability of the system is ensured by regular testing and inspections and by doubling each on-line system with an identical back-up system.

Verification does not give rise to remarks.

9.6 DISCHARGE LABORATORIES AT THE MOCHOVCE NPP

The verification team verified the radiochemical laboratory and the spectroscopy laboratory of the Mochovce NPP. The laboratories are not accredited, but both of them have an internal quality management system in place. This system requires written procedures and approved calibration procedures for all measurement techniques. All sample information is recorded in the laboratory database and on paper log sheets. Both laboratories participate regularly in IAEA proficiency tests and comparison exercises with the Bohunice NPP laboratory.

Radiochemical laboratory

The radiochemical laboratory carries out measurements of the water discharge samples. Sampling is done by the laboratory personnel. Analysis methods are gross-β counting, gross-γ counting and liquid scintillation counting. Calibration of the equipment is carried out by an external calibration service (Slovak Metrological Institute).

All measurement equipment at the laboratory was operational, calibrated and supported with regular maintenance and control programmes.

Verification does not give rise to remarks.

Spectroscopy laboratory

The spectroscopy laboratory carries out measurements on samples received from the NPP gaseous discharge monitoring system, as described in section 6.3. Measurements of Am-241, Pu-238, Pu-239/240 and Sr-89/90 from paper filters are carried out by an external laboratory.

All measurement equipment at the laboratory was operational, calibrated and supported with regular maintenance and control programmes.

The verification team noted that the method of measuring the paper filters by wrapping the filter paper around the HPGe-detector is rather unique and the efficiency calibration of this measurement geometry is challenging. However, having received an explanation how the filter wrapping and the calibration are performed, the team does not see any particular problem with this solution, as long as the wrapping is done the same way each time.

The practise of collecting discharge air from the stack in small pressurised bottles and performing direct gamma spectroscopy on these bottles is also rather unique – typically discharge air flow is monitored either using on-line monitors or filter sampling (both also present at Mochovce). Taking into account the rather small collection volume, low radioactivity concentration in the sampled air (in normal situations) and the attenuation of the steel bottle the measurement sensitivity of this method is rather low. However, this type of measurement can be very valuable in the event of an abnormal gaseous release of radioactivity and the verification team acknowledges the Mochovce NPP for adding this unusual monitoring system in its already excellent collection of gaseous discharge monitoring systems.

Verification does not give rise to remarks.

9.7 ENVIRONMENTAL MONITORING AROUND THE MOCHOVCE NPP

The verification team inspected a TDS station located at the Mochovce NPP, just inside the fence next to the main entrance. This sensor, of type Rados RD-02, forms part of a network of 16 Type I TDS sensors in the first circuit around the NPP. Every 2 minutes, the sensor sends data to the central control room. Once a month, these sensors are controlled using an external standard source.

The verification team inspected TDS and SDS monitoring stations in the village of Nový Tekov, close to the Hron River. The SDS station is equipped with VOPV-12 high-volume air sampler, installed next to a fallout sampler. The high-volume air sampler filter is changed every 2 weeks. A field technician demonstrated the replacement of the exposed air filter.

North of this village upstream on the Hron river is a small hydroelectric power plant (MVE Tekov). Close to the banks, in an area which is occasionally flooded by the river, are situated the boreholes for groundwater sampling. The verification team witnessed how a water sample was hauled from the borehole (about 15 m deep). Samples are regularly collected every 2 weeks; in case of elevated tritium levels samples are taken every week.

A reference point for sampling surface water is located a few kilometres downstream, close to a provincial road bridge crossing the Hron River in the village of Kalná. Even if a small recreational area lies next to the banks, the verification team found the sampling point to be at safe distance from casual interference. Sampling is regularly performed every 3 months.

The verification team inspected a wastewater sampling station located only a couple of kilometres from the Mochovce NPP. Samples are regularly taken and analysed for gross alpha and gross beta.

Verification does not give rise to remarks.

9.8 MOCHOVCE NPP ENVIRONMENT LABORATORY

The operator's environmental samples are analysed in the company laboratory in Levice, about 20km from the NPP. The laboratory is well situated to implement the sampling programme in the vicinity. Current staffing dedicated to radiation protection consists of 5 people in Levice and 3 in the NPP. In 2013 approximately 2960 analyses were carried out and around 1700 were foreseen for 2014.

Sample receipt and preparation

The operators who have collected samples in the vicinity can drive their vehicle into the garage, where there is a door leading to a dedicated area for sample receipt. Procedures are in place to deal with potentially contaminated samples that could be expected in an emergency situation. The procedures even foresee a route for the driver to take a decontaminating shower. The sample preparation area is comprehensively equipped to carry out operations such as crushing, freeze drying etc.

Equipment in the laboratory

A full list of the equipment available is given in Annex 3. The laboratory has sufficient reserve capacity to deal with a greater number of analyses if necessary. Operational devices have a white label attached with technical details and calibration validity information. All gamma detectors have a motorised system to slide the top cover of the shielding. The Dewar's bottles containing the liquid nitrogen are mounted on balances which allow to gauge the amount remaining and to top up if necessary to maintain cooling of the HPGe-detector crystals.

It was noted that the Harshaw TLD reader runs under DOS. A Windows software version is available but has proved to be prone to errors.

The laboratory has a comprehensive set of calibration sources and reference samples for calibration.

Verification does not give rise to remarks.

10 CONCLUSIONS

All verification activities that had been planned were completed successfully. In this regard, the information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, was useful.

The information provided and the verification findings lead to the following observations:

(1) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil around the site of Mochovce NPP as well as on the territory of the Slovak Republic in the vicinity of the site are adequate. The Commission could verify the operation and efficacy of a representative part of these facilities.

(2) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of radioactive discharges to air and water at the Mochovce NPP site are adequate. The Commission could verify the operation and efficacy of these facilities.

(3) A few technical recommendations and suggestions are formulated. These aim at improving some aspects of the national monitoring system. They do not discredit the fact that environmental monitoring around the NPP site as well as the verified parts of the national monitoring system for environmental radioactivity are in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(4) The recommendations are summarised in the 'Main Conclusions document that is addressed to the Slovak Republic competent authority through the Slovak Republic Permanent Representative to the European Union.

(5) The Commission services request a report on the implementation of the recommendations by the Slovak authorities and about any significant changes in the set-up of the monitoring systems before the end of 2016. Based on this report the Commission will consider the need for a follow-up verification in the Slovak Republic.

(6) The verification team acknowledges the excellent co-operation it received from all persons involved in the activities it performed.

APPENDIX 1

REFERENCES & DOCUMENTATION

- Article 35 preliminary information questionnaire - Mochovce NPP discharge and environmental monitoring and the national environmental radioactivity monitoring network in the vicinity
- Article 35 preliminary information questionnaire – Slovak Hydrometeorological Institute
- Article 35 preliminary information questionnaire – Public Health Authority

APPENDIX 2

THE VERIFICATION PROGRAMME

Date	Time	Team 1	Team 2
Monday 3 November	15.30 – 17.00	Opening meeting with National authorities in Bratislava **Public Health Authority** **Trnavska cesta** 52	
Tuesday 4 November	9.00 – 15.00	Public Health Authority laboratories	
	9.00 – 11.00		SHMI laboratories
	11.00 – 14.00		Travel to Banska Bystrica
	14.00 – 16.00		RPHA laboratories Banska Bystrica
Wednesday 5 November	9.00 – 9.30	Opening meeting with Mochovce NPP representatives	
	9.30 – 12.30	Verification of liquid discharge monitoring	Verification of operator's and regulator's on-site and off-site environmental monitoring and stations of national monitoring programme in the vicinity
	13.00 – 17.00	Verification of gaseous discharge monitoring	
Thursday 6 November	9.00 – 15.00	Visit to laboratories dealing with analysis of discharge samples	Visit to laboratories dealing with analysis of environmental samples
	14.00 – 15.00	Closing meeting/debriefing with NPP representatives	
	15.00	Departure for Bratislava	
Friday 7 November	9.00 – 10.00	Closing meeting/debriefing with National authorities	

APPENDIX 3

SAMPLE MEASUREMENTS AND DEVICES

Analyses/ Measurements	Nuclide	Measurement Device Used	Geometry	Type of Sample	Counting Time [s]
Gamma spectrometry	γ nuclides	Detector GC 3018, ser. No b97095, Canberra spectrometric modules, GENIE 2000 software	Marinelli beaker - 11	Surface Water	300000
			Marinelli beaker - 11	Ground Water	300000
			Marinelli beaker - 0,5 1	Soil	160000
		Detector IGC 25, ser No DI 679, Canberra spectrometric modules, GENIE 2000 software	Marinelli beaker - 0,5 1	Fish	180000
			Marinelli beaker - 0,5 1	Fruits, vegetables	180000
			Marinelli beaker - 0,5 1	Milk	300000
			Marinelli beaker - 0,5 1	Grass	300000
			Marinelli beaker - 0,5 1	Grain	300000
			Marinelli beaker - 0,5 1	Sediments	200000
		Detector GC 3518, ser. No b08063, Canberra spectrometric	60 mm planchette	Fallouts	200000
			Cylindrical shape - 60 mm	Aerosols	220000
		Detector GC 4018, ser. No bl2123, Canberra spectrometric	Cylindrical shape - 60 mm	Aerosols	200000
		Detector GC 3018, ser. No b98091, Canberra spectrometric	IN SITU	IN SITU measurements	4000
Tritium	^{3}H	Liquid scintillation detector TRICARB 3170	Vials - 20 ml	Surface Water	43200
			Vials - 20 ml	Drinking Water	43200
			Vials - 20 ml	Ground Water	43200
Gross Alpha	α	Low background proportional	60 mm planchette	Surface Water	50000
Gross Beta	ß	Low background proportional	60 mm planchette	Surface Water	50000

Measurement devices available in the environmental radiation monitoring laboratory

Measuring device	Type	Quantity	Measured parameter	Radiation detected	Measuring range	Calibration period	Manufacturer
Gamma spectrometry system	AIM 556+GC 3018	1	γ-activity		(1.10"^{3}- 1.10^{5}) Bq	2 years	Canberra Packard
Gamma spectrometry system	AIM 556+IGC 25	1	γ-activity	'1	(1.10"^{3}- 1.10^{5}) Bq	2 years	Canberra Packard
Gamma spectrometry system	AIM 556+IGC 25	1	γ-activity	'1	(1.10"^{3}- 1.10^{5}) Bq	2 years	Canberra Packard
Gamma spectrometry system	AIM 556+IGC 25	1	γ-activity	'1	(1.10"^{3}- 1.10^{5}) Bq	2 years	Canberra Packard
Gamma spectrometry system	Lynx DSA+GC 3518	1	γ-activity	'1	(1.10"^{3}- 1.10^{5}) Bq	2 years	Canberra Packard
Gamma spectrometry system	Lynx DSA+GC 4018	1	γ-activity	'1	(1.10"^{3}- 1.10^{5}) Bq	2 years	Canberra Packard
Portable Multichannel Analyser	Inspector 2000r+GC 3018	1	γ-activity	'1	(1.10"^{3}- 1.10^{5}) Bq	2 years	Canberra Packard
Portable Multichannel Analyser	Inspector 2000+GC 3519	1	γ-activity	'1	(1.10"3 - 1.105) Bq	2 years	Canberra Packard
High pressurised Ion Chamber	RSS 112	2	γ-dose rate	'1	(1.10"8-1.10"3) Gy/h	2 years	Reuter - Stokes
High pressurised Ion Chamber	RSS 131	2	γ-dose rate	'1	(1.10"8- 1.10"2) Sv/h	2 years	Reuter - Stokes

Measuring device	Type	Quantity	Measured parameter	Radiation detected	Measuring range	Calibration period	Manufacturer
TLD Reader	TLD HARSHAW 4500	1	Dose	ǐ	TLD 100 - (1.10"5 - 10) Sv TLD 200 - (1.10-7 - 10) Sv	2 years	HARSHAW, BICRON
Low Level Alpha, Beta counter	FHT 770 T	1	Activity	α, β	(1.10-2 - 99 999) imp/s	2 years	Thermo Scientific
Low Level Alpha, Beta counter	MINI 20	1	Activity	α, β	(1.10-2 - 99 999) imp/s	2 years	Canberra Packard
Liquid Scintillation Analyser	TriCarb 3170 TR/SL	1	Activity	β	(1.10-2 - 99 999) imp/s	2 years	Perkin Elmer
Digital Hand-Held Multichannel Analyser	INSPECTOR 1000	2	Activity, Dose Rate	γ	(1.10^{-8}- 1.10^{-2}) Sv/h	1 year - Dose Rate 2 years - Activity	Canberra Packard
Universal radiation survey meter	RDS 120	2	Dose Rate	γ	(5.10^{-8}- 10) Sv/h	1 year	RADOS

Measuring device	Type	Quantity	Measured parameter	Radiation detected	Measuring range	Calibration period	Manufacturer
Digital Survey Meter	FH 40 G	1	Dose Rate	γ	(1.10^{-5}- 10) Sv/h	2 years	Thermo Scientific
Digital Survey Meter	FH 40 G	1	Dose Rate	γ	(1.10^{-5}- 10) Sv/h	1 year	Thermo Scientific
Digital Hand-Held Radiometer	RP 2000+ DJ2000B	2	Dose Rate	γ	(1.10^{-4}- 1) Gy/h	1 year	VF, a.s.
Digital Hand-Held Radiometer	RP 2000+ DJ2000A	2	Surface Activity, Count Rate, Dose Rate, Dose	γ, β	(1.10^{-7}- 1.10^{-1}) Sv/h, (3.10^{-1}- 3.10^{4}) Bq/cm^2	1 year	VF, a.s.
Universal radiation survey meter	RDS 120 + GMP 11	3	Surface Activity, Count Rate	β	(0 - 99 999) imp/s	1 year	RADOS
Digital Survey Meter	FH 40G + FHZ 732	1	Surface Activity, Count Rate	α, β	(1.10^{-2}- 99 999) imp/s	1 year	Thermo Scientific
Digital Survey Meter	FH 40G + FHZ 742	1	Surface Activity, Count Rate	α,β,γ	(1.10-2 - 99 999) imp/s	1 year	Thermo Scientific
MicroCont nuclear contamination monitor	H 13422 + HGZ 190	1	Surface Activity, Count Rate	α,α+β	(0.01 - 9 999) imp/s	2 years	RADOS
MicroCont nuclear contamination monitor	H 13422 + HXE 260	1	Surface Activity, Count Rate	β +	(0.01 - 9 999) imp/s	2 years	RADOS
Multi-purpose evaluation unit	UVJ 01+MK 30	1	Surface Activity, Count Rate	β	(0 - 9 999) imp/s	1 year	VF, a.s.

Measuring device	Type	Quantity	Measured parameter	Radiation detected	Measuring range	Calibration period	Manufacturer
Hand-foot contamination monitor	HFM 2102	2	Surface Activity, Count Rate	*α, β*	(0 - 9 999) imp/s	1 year	Thermo Scientific
Intelligent probe RD-02	RD 02	51	Dose Rate	*γ*	(1.10-9 - 10) Sv/h	2 years	RADOS
Aerosols Monitor	FHT 8000 + FHT 59S	7	Activity Concentration, Count Rate	*α, β*	(0 - 1.108) imp/s	1 year	Thermo Scientific
Iodine Monitor	FHT 8000 + FHT 1700	7	Activity Concentration, Count Rate	*γ*	(0 - 1.108) imp/s	1 year	Thermo Scientific

Remark: Measuring devices with 2 years calibration period are metrologically tested by the Slovak Metrological Institute in Bratislava. Measuring devices with 1 year calibration period are metrologically tested by the NPP's internal metrological department.

APPENDIX 4

Mochovce NPP gaseous discharge monitoring systems at the main stack