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TECHNICAL REPORT

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

National Environmental Radioactivity Monitoring

HUNGARY

18 to 20 May 2010

Reference: HU-10/03

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35
OF THE EURATOM TREATY

FACILITIES:	- Provisions for monitoring and controlling levels of radioactivity on the national territory - Provisions for monitoring and controlling radioactive discharges at the State Health Centre and Pozitron Diagnosztika Ltd. - The national radiological early warning network
DATE:	18-20 May 2010
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1. ABBREVIATIONS

ALMERA	Analytical Laboratories for the Measurement of Environmental Radioactivity (Network of IAEA)
CAO FFSD	Central Agricultural Office, Food and Feed Safety Directorate
CRL	Central Radiohygiene Laboratory (part of NRIRR)
EC	European Commission
ENER	Directorate General ENERGY of the European Commission
HAEA	Hungarian Atomic Energy Authority (OAH in Hungarian)
IAEA	International Atomic Energy Agency
INT BUTE	Institute of Nuclear Techniques of the Budapest University of Technology and Economics
ISFS	Interim Spent Fuel Store at Paks under PURAM
JERMS	Joint Environmental Radiation Monitoring System (HAKSER in Hungarian)
KFKI	Hungarian Academy of Sciences KFKI Atomic Energy Research Institute (AEKI in Hungarian)
MARD	Ministry of Agriculture and Rural Development (FVM in Hungarian)
MD	Ministry of Defence
MEC	Ministry of Education and Culture
MEC-REWMS	Radiation Early Warning, Monitoring and Surveillance System of MEC
MEW	Ministry of Environment and Water (KvVM in Hungarian)
MH	Ministry of Heath (EüM in Hungarian)
MLG	Ministry of Local Government
MNDE	Ministry for National Development and Economy
MTTE	Ministry of Transport, Telecommunications and Energy
NDGDM	National Directorate General for Disaster Management
NEIAC	Nuclear Emergency Information and Analysis Center
NERMS	National Environmental Radiation Monitoring System (OKSER in Hungarian)
NPHMOS	National Public Health and Medical Officer Service
NREWMS	National Radiation Early Warning, Monitoring and Surveillance System

NRIRR	"Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene (OSSKI in Hungarian)
NRWR	National Radioactive Waste Repository under PURAM
PERMS	Paks NPP Plant Environmental Radiation Monitoring System (üKSER in Hungarian)
PET-CT	Positron Emission Tomography- Computed Tomography
PURAM	Public Limited Company for Radioactive Waste Management
RAMDAN	Radiological Monitoring and Data Acquisition Network
RMN	Radioanalytical Monitoring Network of the Ministry of Agriculture and Rural Development
RWTDF	Radioactive Waste Treatment and Disposal Facility in Püspökszilágy under PURAM
STIENW	South Transdanubian Inspectorate for Environment, Nature and Water
TREN	Directorate General TRANSPORT and ENERGY of the European Commission

2. INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State 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.

For the EC, the Directorate-General for Energy (DG ENER), and in particular its Radiation Protection Unit (ENER D4), 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 (and control thereof).
- 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.

From 18 to 20 May 2010, a verification team from DG ENER visited Hungary, and in particular the area around Budapest to check the operation and efficiency of the facilities and associated analytical laboratories for continuous monitoring of the level of radioactivity in air, water and soil on the territory of Hungary. In addition, two medical installations were included in the programme to verify the measures in place for the monitoring of gaseous and liquid radioactive discharges from their departments handling radioactivity. The verification team selected two hospitals in Budapest which were visited during the verification mission: the nuclear medicine department of the State Health Centre and the Pozitron-Diagnosztika Ltd diagnostic centre, running a PET/CT and its own cyclotron with a radiopharmaceutical production facility.

The present report contains the results of the verification team's review of relevant aspects of the national radiological surveillance put in place by the competent Hungarian authorities and the control of gaseous and liquid radioactive discharges from the chosen hospitals.

[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 ionizing radiation (OJ L-159 of 29/06/1996)

3. PREPARATION AND EXECUTION OF THE VERIFICATION

3.1. Preamble

The Commission’s decision to request the execution of an Article 35 verification was notified to the Hungarian Permanent Representation to the European Union by letter TREN.H4 CG/rm D(2010) 53781dated 17 February 2010.

Subsequently, practical arrangements for the implementation of the verification were made through contacts with the Hungarian Atomic Energy Authority (HAEA).

3.2. Programme of the visit

A preliminary programme of verification activities under the terms of Article 35 of the Euratom Treaty was discussed and agreed upon with the Hungarian competent authorities.

The programme encompassed verifications of selected parts of the Hungarian national environmental radioactivity monitoring programme and the radioactive discharges from the nuclear medicine department of the State Health Centre and from the Pozitron-Diagnosztika Ltd diagnostic centre, running a PET/CT and an own cyclotron with a radiopharmaceutical production facility.

The verifications were carried out in accordance with the programme, a summary overview of which is attached as Appendix 1 to this report.

3.3. Documentation

In order to facilitate the work of the verification team, a package of information was supplied in advance by the Hungarian authorities in response to a questionnaire from the Commission. Additional documentation was provided during and after the visit. All documentation received is listed in Appendix 2. The verification team notes the comprehensiveness of the documentation provided. The information thus provided has been extensively used for drawing up the descriptive sections of this report.

3.4. Representatives of the competent authorities and other bodies

During the verification visit, the following representatives were met:

Hungarian Atomic Energy Authority

Dr. Árpád VINCZE	Deputy Head of Dept. of Nuclear and Radiological Materials Euratom Art. 35-36 coordinator

State Health Centre

Dr. István SZILVÁSI	Head of Department of Nuclear Medicine

Pozitron Diagnosztika Ltd.

Dr. Gyula TÓTH	Radiochemist

National Research Institute for Radiobiology and Radiohygiene

Dr. István TURAI	Head Chief Physician , Division of Radiation Medicine
Mr. Gábor KOCSY	Head of Division of Public and Environmental Radiohygiene
Mr. Nándor FÜLÖP	Head of Department of Radiohygiene
Dr. László BALLAY	Head of Division of Occupational Radiohygiene

Ministry of Agriculture and Rural Development - Central Agricultural Office, Food and Feed Safety Directorate

Dr. Sándor TARJÁN	Head of the Radioanalytical Reference Laboratory – Central Agricultural Office Food and Feed Safety Directorate
Dr. Ákos: JÓŽWIAK	Deputy Director of Food and Feed Safety Directorate – Central Agricultural Office
Dr. Beáta VARGA	Deputy Head of Radioanalytical Reference Laboratory – Central Agricultural Office Food and Feed Safety Directorate

National Early Warning Monitoring and Surveillance System

Ms. Anita SZEITZ	Analyst, Department of Crisis Management, National Directorate General for Disaster Management

Ministry of Environment and Water

Dr. Bálint DOBI	Head of Department of Environmental Preservation

4. LEGISLATION AND COMPETENT AUTHORITIES

4.1. Primary legislation and derived regulations

Nuclear legislation in Hungary is based on the Act on Atomic Energy (Act CXVI 1996) that came into force on 1 June 1997. The Act on Atomic Energy (hereafter referred to as the Act) establishes the basis for the development of a legislative and regulatory system for the safe application of nuclear energy. The Act specifies that the tasks of control and surveillance of the safe application of nuclear energy are the responsibility of the Government.

The Act stipulates that atomic energy can only be used in ways identified by (derived) legal instruments (government and ministerial decrees) and shall be subject to regular supervision by the designated competent authorities. The Act can be downloaded from the HAEA web site (www.haea.gov.hu).

The Act names the following ministers as having major responsibilities:

- The Minister of Health (MH) - through his/her National Public Health and Medical Officer Service (NPHMOS) - is the national Radiation Protection Authority. The latter is inter alia responsible for defining dose constraints.

- The Minister of Environment and Water (MEW) is inter alia responsible for defining the maximum quantity of radioactive materials that may be released to the atmosphere and into water bodies (discharge limits).

- The Minister of Agriculture and Rural Development (MARD) is responsible for the inspection of radioactivity in soil, flora, fauna and products of both vegetable and animal origin.

Other ministers and organisations that participate in radiological protection are: the Minister of the Local Government (particularly with respect to matters of early warning and emergency preparedness in case of radiological incidents), the Ministry for National Development and Economy, the Ministry of Transport, Telecommunications and Energy, the Minister of Defence, the Minister of Education and Culture, and the Hungarian Mining Office.

The Decree of the Minister of Health 16/2000 (VI.8) - on the implementation of the provisions of the Act CXVI of 1996 on Atomic Energy introduces basic standards in accordance with international references such as the publication ICRP 60 (International Commission on Radiological Protection) and the IAEA SS-115 (safety standards) and transposes Council Directive 96/29/Euratom into national law. This Decree lays down the basis for radiation protection in Hungary. The competent authority is the National Public Health and Medical Officer Service (NPHMOS)

4.2. Environmental radioactivity monitoring

The Government Decree 275/2002 (XII.21) - on the monitoring of the national environmental radiation situation and levels of radioactivity describes the legal background and principles of operation of the National Environmental Radiation Monitoring System (NERMS). It defines the structure of the monitoring systems and networks as well as the monitoring and reporting requirements. The decree also stipulates that the radiological surveillance of the food chain for human consumption be within the scope of the monitoring. The national environmental monitoring shall be organised by a steering committee comprising members of all ministries and/or organisations involved and shall be chaired by the HAEA. The decree requires the NRIRR to operate the Information Centre for data collection and evaluation of the system.

This Decree also requires to establish monitoring systems around special installations (e.g. nuclear power plants, training and research reactors, nuclear waste management facilities, etc.); according to this requirement, a separate Joint Environmental Radiation Monitoring System JERMS; (in Hungarian: HAKSER) is operated within a 30 km radius around the Paks NPP.

The Decree of the Minister of Environment and Water 15/2001 (VI.6) - on discharges of airborne and liquid radioactivity and their monitoring when using atomic energy requires the Regional Environmental Inspectorates of the Ministry of Environment and Water to establish environmental monitoring programmes for special facilities (nuclear power reactors, research reactors, training reactors, uranium mines, radioactive waste depositories, A-level isotope laboratories, interim spent-fuel storage and other areas).

Nuclide specific measuring methods have to be applied to determine activity concentrations in environmental samples. Gross-beta measurement results may only be used for trending purposes. Detection limits shall correspond to international and national quality levels. Only accredited laboratories can be used for regulatory inspection purposes.

The Decree of the Minister of Health 8/2002 (III.12) – on the operation and structure of the Radiological Monitoring and Data Acquisition Network of the health sector describes the legal background and principles of operation of its own radiological monitoring network (ERMAH – Hungarian acronym; RAMDAN – English acronym). The sampling/monitoring programme focuses on air, surface waters, soil, drinking water, essential components of the food chain for human consumption and the most representative foodstuffs (either from domestic production or imported) consumed by the population. Analytical procedures performed are mainly of gross beta and gamma spectrometric nature. The results are published annually in the "Egészségtudomány" (Health Science) journal.

4.3. Radiological surveillance of foodstuffs

The following legal texts cover the statutory requirements for foodstuffs' radioactivity monitoring:

Article 23 of the 1996 Act CXVI on Atomic Energy requires the Minister for Agriculture to be responsible for assessing the radioactivity of soil, the Minister responsible for the food-chain to be responsible for monitoring the radioactivity of animals, plants, foodstuffs of animal and non-animal origin, for expertise, for the inspection activity regarding the international trade of these products and for issuing certificates.
The 2. July 2008 Act XLVI on Food-chain and its Official Control Act names the Ministry of Agriculture and Rural Development responsible for the control of the whole food chain.

Government Decree 274/2006 (XII.23) establishing the Agricultural Office sets out, in compliance with EU legislation, 882/2004/EC, Article 12 that any kind of analysis regarding foodstuffs should only be carried out in dedicated, accredited laboratories.

4.4. Discharge monitoring

The following legal texts cover the statutory requirements for discharge monitoring:

Government Decree 275/2002 (XII.21) on the monitoring of the national environmental radiation situation and levels of radioactivity requires establishing a monitoring system around special installations (e.g. nuclear power plants, training and educational nuclear reactors, nuclear waste management facilities, etc.), it charges the Minister of Environment and Water, the Minister of Health and the Minister of Agriculture and Rural Development to establish a common monitoring system, the National Environmental Radiation Monitoring System (NERMS).

Decree of the Minister of Environment and Water 15/2001 (VI.6) on discharges of airborne and liquid radioactivity and their monitoring when using atomic energy specifies that the producer of atomic energy (i.e. Paks NPP) shall derive its annual discharge limits for radioactive effluent in accordance with the methodology (based on dose constraint) as specified by the National Public Health and Medical Officer Service (NPHMOS) of the Ministry of Health.

4.5. Competent authorities

Environmental radioactivity monitoring in Hungary is complex due to the involvement of many ministries with their specific responsibilities and scopes of monitoring programmes.

The National Environmental Radiation Monitoring System (NERMS) consists of the following members representing different ministries, authorities and special installations as regulated by the Government Decree 275/2002 (XII.21):

- Ministry of Health (MH)
- Ministry of Agriculture and Rural Development (MARD)
- Ministry for National Development and Economy (MNDE) and Ministry of Transport, Telecommunications and Energy (MTTE)

- Ministry of Defence (MD)
- Ministry of Environment and Water (MEW)
- Hungarian Academy of Sciences
- Ministry of Education and Culture (MEC)
- Hungarian Atomic Energy Authority (HAEA)
- Ministry of Local Government (MLG)
- Nuclear Power Plant Paks (NPP Paks)
- Public Limited Company for Radioactive Waste Management (PURAM)

The activity of NERMS is governed by the NERMS Steering Committee and chaired by the Hungarian Atomic Energy Authority (HAEA). The NERMS Steering Committee approves the annual environmental sampling and measuring programme to be performed by the radiological monitoring networks belonging to the NERMS Members. NERMS Information Centre collects and processes the radiological data measured by the individual monitoring networks, and prepares the annual reports from the results.

The National Public Health and Medical Officer Service (NPHMOS) works under the Ministry of Health and is responsible for carrying out the central collection, processing, recording and evaluation of data related to the national radiation situation (centralisation of the data of the various Hungarian environmental monitoring programmes). Its expert institute is the “Frédéric Joliot-Curie” National Research Institute for Radiobiology and Radiohygiene (NRIRR). NPHMOS operates its own monitoring network RAMDAN.

The Radioanalytical Monitoring Network under the responsibility of Ministry of Agriculture and Rural Development (RMN of MARD) works under the umbrella of the Central Agricultural Office and the Agricultural Offices of eight counties. The responsibility of the network covers the whole food-chain, including radiological surveillance of food and feed stuffs and surveys connected to the safety of agricultural production. Radioanalytical Reference Laboratory (RRL) of CAO FFSD is responsible for the harmonised methods and database, the quality assurance in the network level and the training of the staff. The nuclideselective methods have priority in the network, alpha-, beta- and gamma-spectrometries often combined with different chemical separations. RRL operates a mobile laboratory capable for route monitoring, in-situ and sample measurement by gamma-spectrometry.

The environmental inspectorates under the Ministry of Environment and Water perform measurements as part of NERMS. Data collected by the inspectorates are integrated and processed to NERMS by the information centre of a designated regional inspectorate, the South Transdanubian Inspectorate for Environment, Nature and Water (STIENW). The inspectorates perform gross-beta measurements of surface waters and sediments. In addition STIENW measures activity concentration of ^{3}H, ^{90}Sr and gamma-emitting nuclides in surface waters, sediments, fish and algae (except ^{90}Sr for the latter).

At the Hungarian Academy of Sciences KFKI Atomic Energy Research Institute (KFKI AEKI) campus, the Budapest Research reactor and the Institute of Isotopes Co. Ltd. producing a wide variety of radioactive isotopes are in operation. An environmental monitoring station has been installed to monitor the ambient dose rate and the air contamination. The station is run by the Environmental Protection Service. The measured data is submitted to NERMS. For emergency situations a mobile laboratory is also in service.

For training purposes the Ministry of Education and Culture Institute of Nuclear Techniques (INT) of the Budapest University of Technology and Economics (BUTE) operates a small pool-type nuclear training reactor since 1971. An environmental monitoring system is operated using both continuous and discrete measuring and data collection devices. INT also serves as the data centre for 13 ambient gamma-dose rate measuring stations belonging to the Radiation Early Warning, Monitoring and Surveillance System of the Ministry of Education and Culture (MEC- REWMS). The measured data is submitted to NERMS. These stations are also part of the National Radiation Early Warning, Monitoring and Surveillance System (NREWMS).

The National Directorate General for Disaster Management (NDGDM) works under the Ministry of Local Government. It is the centre of the National Radiation Early Warning, Monitoring and Surveillance System (NREWMS).

The HAEA Emergency Response Organization (ERO) is responsible for analyzing the situation and predicting the possible consequences of a nuclear and radiological emergency. In case of a nuclear or radiological accident it is the responsibility of the HAEA ERO to give advice to the decision makers on both technology and radiation related issues. As part of the National Nuclear Emergency Response System, NERMS is used to gather information on radiation appearing on the territory of Hungary. HAEA is the international contact point for receiving and sending notifications in any nuclear or radiological emergency at both national and international levels.

The Ministries of Health, of Agriculture and of the Environment JERMS, with their independent site-related monitoring systems around the Paks NPP established the Joint Environmental Radiation Monitoring System (JERMS). The Paks NPP also participates in JERMS by providing its own environmental data. The Plant Environmental Radiation Monitoring System PERMS is the statutory monitoring programme that is implemented by the Paks NPP.

The Public Limited Company for Radioactive Waste Management (PURAM) has three facilities for the short term and long-term storage of radioactive wastes and nuclear fuels, the Radioactive Waste Processing and Disposal Facility (RWTDF) at Püspökszilágy for the disposal of radioactive waste from hospitals etc, the National Radioactive Waste Repository (NRWR) at Bátaapáti for the final disposal of low- and intermediate-level wastes of nuclear power plant origin, and the Interim Spent Fuel Store (ISFS) at Paks for the safe interim storage of the spent fuel assemblies from the nuclear power plant, for a period of 50 years, which is required for technical reasons before disposal. The environmental monitoring data (aerosol, fall-out, soil and plants) of the Radioactive Waste Treatment and Disposal Facility (RWTDF) in Püspökszilágy, and that of the National Radioactive Waste Repository (NRWR) in Bátaapáti is integrated into NERMS. The ISFS and the Paks Nuclear Power Plant are located directly next to each other, therefore the environment monitoring system of the ISFS has been integrated to the system of the nuclear power plant.

All of the Ministries and organisations which constitute the NERMS have some responsibilities in their own field regarding the radiological emergency preparedness according to the National Nuclear Emergency Preparedness Plan as regulated by the Government Decree 248/1997 (XII.20) on the National Nuclear Emergency Response System.

5. THE NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

5.1. General description

In summary the following monitoring programmes/networks exist that are relevant in the context of Article 35 of the Euratom Treaty:

- The Ministry of Health with its Radiological Monitoring and Data Acquisition Network (RAMDAN).
- Radioanalytical Monitoring Network (RMN) of the Ministry of Agriculture and Rural Development.
- Environmental monitoring program of the Environmental Inspectorates of the Ministry of Environment and Water
- Regional environmental monitoring program of the South Transdanubian Inspectorate for Environment, Nature and Water (STIENW)
- The National Radiation Early Warning, Monitoring and Surveillance System (NREWMS) under the National Directorate General for Disaster Management of the Ministry of the Local Government.

- The Ministries of Health, the Ministry of Agriculture and Rural Development and the Ministry of Environment and Water with their independent site-related check monitoring around the Paks NPP, called Joint Environmental Radiation Monitoring System (JERMS). Paks NPP participates in JERMS by providing own environmental data.
- The Paks NPP with its statutory Plant Environmental Radiation Monitoring System (PERMS).

The data from the above mentioned radiological environmental monitoring programmes is centralised in the National Environmental Radiation Monitoring System (NERMS) database.

The Radiological Monitoring and Data Acquisition Network (RAMDAN) covers almost the entire territory of Hungary and monitors air, surface waters, soils, drinking waters, vegetation and the major foodstuffs for human consumption.

The sampling and measuring programme of RAMDAN comprises the following components:
- the main programme, which is obligatory for all the RAMDAN laboratories
- four sub programmes, which are performed only by the NRIRR CRL, namely Danube, Mohi, Paks and National TLD networks and Püspökszilágy.

The main programme of RAMDAN must be submitted for approval to the Chief Medical Officer on a year to year basis and is performed by the whole RAMDAN network. The RAMDAN network is structured around a central institute, the NRIRR and more in particular its Central Radiohygiene Laboratory (CRL), which is accredited under Nr. NAT-1-0969/2010 according to standard MSZ EN ISO/IEC 17025:2001. Apart from this laboratory, the network contains 7 regional centres.

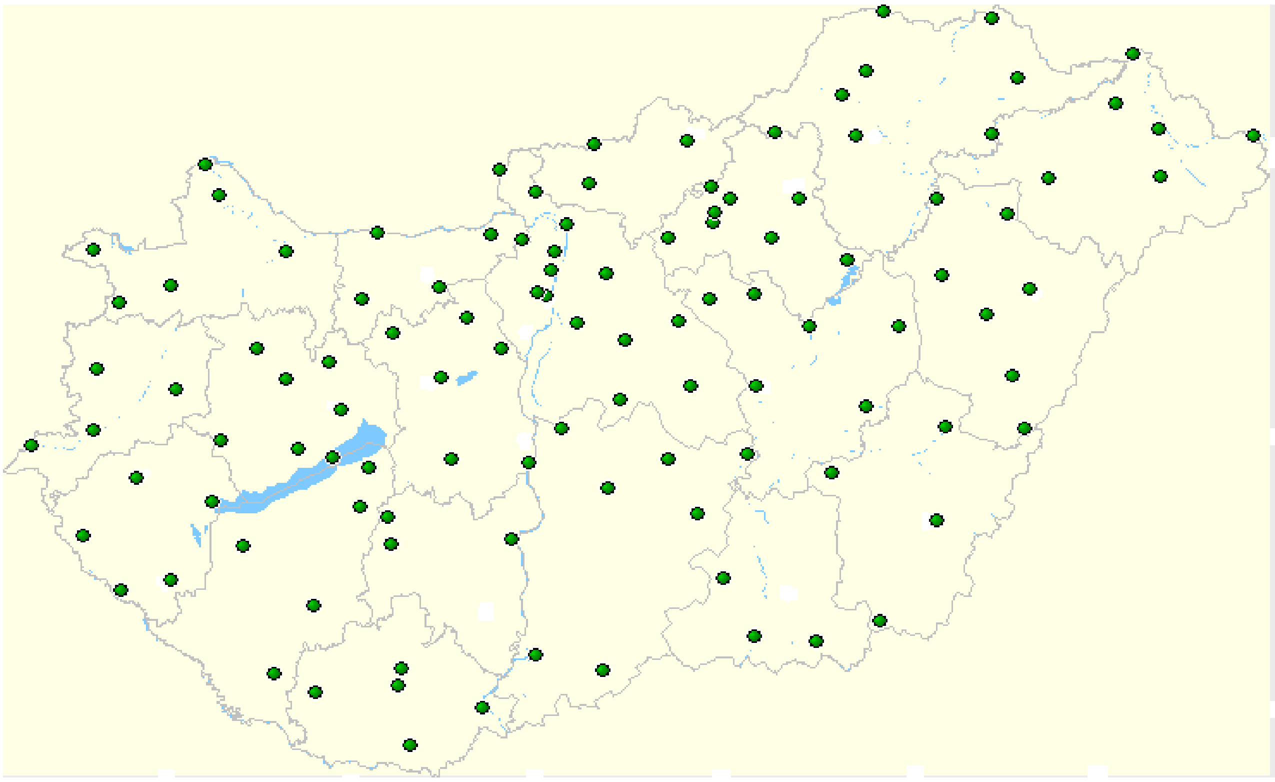
The network collects approximately 2400 environmental and food samples a year. These entail about 4000 measurements (mainly gross beta and gamma-spectrometry). On average the environmental samples (air, soil, water and vegetation) represent 65% of the total taken. Foodstuff categories that are covered by the network include cereals, bread, meats, milk, milk products, eggs, mixed diet, vegetables and fruit. The 2010 main monitoring programme of RAMDAN is given in Appendix 3.

In the Danube sub programme the NRIRR monitors the whole Hungarian section of the Danube on a monthly basis. The sampling locations are: Gönyű, North-Pest, South-Pest, Paks, Mohács, and samples are also taken from the Szelidi lake. On the samples gross beta activity, ^{40}K and ^{3}H concentration measurements are taken monthly, and ^{90}Sr activity concentration and gamma-spectrometric measurements are performed quarterly. The number of samples is approximately 80; the number of measurements is approximately 300 per year.

The Slovakian Nuclear Power Plant Mochovce (Mohi in Hungarian) lies about 40 km from the Slovak-Hungarian border, to the northwest of Levice. In order to monitor the effects of its operation, samples (tap water, river water, sediment, soil, grass, fallout, vegetables and fruits) are taken and in-situ gamma spectrometric and dose rate measurements are done in the vicinity of 14 Hungarian towns and villages along the border (Komárom, Esztergom, Balassagyarmat, Dobogókő, Királyrét, Vámosmikola, Romhány, Salgótarján, Vác, Letkés, Bernecebaráti, Nagybörzsöny, Ipolytölgyes, Ipolyvece). Samples are analysed by the same type of measurements as for the Danube sub programme. The number of samples is approximately 100, the number of measurements is approximately 170 per year.

In the framework of RAMDAN, one river and one lake in each county are monitored by the laboratories monthly and quarterly, respectively. Gross beta activity of the samples is measured, as well as gamma spectrometry analyses are carried out on the aggregated 6-month sample. The lower level of detection is 2.3 mBq/l for ^{137}Cs and 20 mBq/l for ^{90}Sr respectively.

The NRIRR maintains a TLD network consisting of 115 measuring locations shown on the map below to monitor the ambient gamma dose rate with thermoluminescent detectors. Volunteers from the public contribute to the operation of this network, to whom the NRIRR sends TL detectors quarterly. The volunteers place the detectors in their garden and they post the previously sent detectors back to the NRIRR. Thus, the NRIRR gets an image quarterly of the ambient dose rates all over the country.



The TLDs consist of $CaSO_4$:Tm powder in own-design capsules (teflon + copper), with a measurement range of 30 µSv – 5 mSv (calibrated), LLD: 10 µSv, frequency: quarterly integration. Data are stored electronically. The powder is irradiated with different doses of a ^{137}Cs source by the Hungarian Trade Licensing Office every two years. The doses are 30 µSv, 200 µSv, 500 µSv, 1000 µSv, 5000 µSv.

In order to monitor the ambient gamma dose rate around the Paks Nuclear Power Plant, the NRIRR maintains a separate TLD network, consisting of 40 measuring locations within a radius of 30 km around the power plant. The thermoluminescent detectors (TLDs) are exchanged quarterly, thus the NRIRR gets an image every quarter of the ambient dose rate around the Paks NPP.

The NRIRR monitors the vicinity of the site of the Public Limited Company for Radioactive Waste Management at Püspökszilágy every half year. It measures the gross beta activity and ^{3}H concentration of surface waters, the gross beta activity of the soil and performs a gamma spectrometric analysis of soil and sediment samples.

The NRIRR performs regular environmental monitoring on its own site, too. It measures the ambient dose rate three times a day (on working days), the gross beta activity of aerosol daily, the gross beta activity of fallout monthly and it performs in-situ gamma spectrometric measurements every half year.

The Radioanalytical Monitoring Network under the responsibility of Ministry of Agriculture and Rural Development works under the umbrella of the Central Agricultural Office and Agricultural Offices of eight counties. The responsibility of the network covers the whole food-chain. The network currently consists of nine laboratories including the Radioanalytical Reference Laboratory of Food and Feed Safety Directorate of the Central Agricultural Office. All of the laboratories are accredited according to the MSZ EN ISO/IEC 17025:2005 (RRL is accredited since 1996).

The monitoring programme covers the control of radioactivity in food (meat, milk and dairy products, vegetables, fruits and cereals) and feed produced in the country, monitoring the import of these products, controlling the agricultural area (moss, mushrooms, game, soil, pasture, and fodder) and in particular food production in the vicinity of nuclear facilities within the country. For the sake of getting reliable long-term data of food-chain sample pairs are taken, for example milk and fodder sampled in the same time 12 times in a year from the same farm in every county; the grass, alfalfa, spinach samples are taken with soil samples together. Several integral and differential bioindicators are also monitored for getting information for the agricultural production. There are sampling points around the Paks NPP, around RWTDF, NRWR and inside the 80km circle of Slovakian nuclear power plants – the goal of the monitoring here as well as the whole territory of the country is to control the radioactivity of food-chain. The frequency of sampling and measuring the samples was defined to obtain the best representative information about the specific situation taking into account the Euratom regulation. The programme is regularly reviewed and, when deemed necessary, adapted to evolving consumption habits and modifications in the country's agricultural structure. Data are stored on the common server of the Agricultural Offices, the countrywide sample administration system is used since 2007. Laboratories perform about 30000 measurements yearly, the conclusion from these analysis is that there is no need for any kind of restriction concerning the food-chain taking into account natural and artificial radioactive isotope-content of the media.

Since 2005 the Radioanalytical Reference Laboratory works as IAEA Collaborating Centre for the production and characterization of matrix reference materials of terrestrial origin.

The Inspectorates for Environment, Nature and Water perform regular environmental measurements on radiological protection in the framework of the Monitoring Program for Radiological Protection established in the 1980s-1990s in Hungary. The program has not been significantly modified since its launch.

Based on the Hungarian national legislation, the environmental sector is in charge of the radiological control of the aquatic environment, 95% of which is surface water. In addition some samples of sediment, fish and aquatic plants are analysed. The analysis mainly consists of gross beta measurements. Radioactive pollution of surface water is insignificant not only in normal conditions but also in the case of accidents. The continuous monitoring of these surface waters is important however, since most of drinking water is of surface water origin.

In the framework of the National Surface Water Quality Programme, laboratories of the regional inspectorates of the Ministry of Environment and Water continuously perform measurements for gross beta activity concentration. As part of the environmental monitoring programme of the Paks Nuclear Power Plant, the Radiological Laboratory at Pécs regularly measures ^{137}Cs and ^{90}Sr activity concentrations in the water taken down stream from the Danube.

The South Transdanubian Inspectorate for Environment, Nature and Water is the authority in charge of monitoring radioactive fallout and environmental effects of the nuclear facilities situated in its jurisdiction (NPP Paks and Interim Spent Fuel Storage Facility). In addition, monitoring the long term environmental effects of the re-cultivated areas of the closed uranium mine handled by Mecsek-Öko Environmental Ltd have been carried out. In the last two years, the tracing and analysing of radioactive emissions from the health institutions of Pécs has also been started.

In the framework of the analyses of the environmental effects of NPP Paks and the Interim Spent Fuel Storage Facility, measurements of water, sediment, aquatic plants, fall out and aerosol samples are regularly performed

In order to analyse radioactivity in the aquatic environment of the Danube in the vicinity of the Paks NPP and Interim Spent Fuel Storage Facility, sampling of water, sediment, aquatic plants (algae) and fish are regularly conducted in several river profiles (municipalities of Dunaföldvár, below sampling spot V3, Gerjen, Baja and the state border) once a month or quarterly. Fish samples are taken only in the river profile between Baja and the state border. Tritium and gross beta activity are measured in the monthly samples, while gamma spectrometry and ^{90}Sr activity concentration are determined in the samples taken three times per year.

Gross beta activity, gamma spectrometry, ^{90}Sr and tritium analyses are carried out on 114 water, 68 sediment and 24 fish samples, while gross beta activity and gamma spectrometry tests are done on 5 algae samples

There are well defined Hungarian-Croatian and Hungarian-Serbian joint sampling processes performed in the border profile of the Danube in the framework of Hungarian-Croatian and Hungarian-Serbian Water Quality Subcommittees. Gross beta activity and gamma spectrometry analyses are conducted on all types of samples (water, algae, sediment and fish); ^{90}Sr measurements are carried out on water, sediment and fish samples. Tritium concentration is measured only on water samples.

Gamma spectrometric analyses are carried out for 24 large volume aerosol and 24 fall out samples derived from two randomly selected monitoring stations around the NPP Paks and Interim Spent Fuel Storage Facility.

Gross beta activity and gamma spectrometry analyses are performed once a year on 5 samples from running water with low importance and low discharge in the plain region South East of the nuclear power plant collected during high water periods.

To monitor the environmental effects on the re-cultivated areas, which were previously affected by uranium mining 25 surface and well water samples, as well as 2 sediment samples are collected to perform gamma spectrometry analyses each year.

Two large volume aerosol (flying dust) and two fall out (settled dust) samples are collected every year to perform gamma spectrometry tests in two municipalities near the re-cultivated areas.

The South Transdanubian Inspectorate for Environment, Nature and Water monitors the radioactive contamination (^{131}I radionuclide) released by health institutions in the town of Pécs with 4 gamma spectrometry analyses per year on surface water samples from the Pécsi-víz stream, which receives treated sewage water from the town of Pécs.

The Joint Environmental Radiation Monitoring System (JERMS) was established in 1981, based on a decision of the Hungarian Atomic Energy Commission, to perform a regular and independent radiological monitoring of the environment of the Paks Nuclear Power Plant. Recently, the operation of JERMS is regulated by the Government Decree 275/2002 (XII.21).

The following ministries (via their organizations and institutions listed) and the nuclear installation itself are involved in the activities of JERMS:

- Ministry of Health:
    - National Public Health and Medical Officer Service (NPHMOS)
        - "Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene (NRIRR)
        - South Transdanubian Regional Institute of NPHMOS
- Ministry of Agriculture and Rural Development (MARD):
    - Central Agricultural Office Food and Feed Safety Directorate (CAO FFSD)
    - Radioanalytical Monitoring Network of MARD
- Ministry of Environment and Water:
    - South Transdanubian Inspectorate for Environment, Nature and Water
- Hungarian Atomic Energy Authority
- Nuclear Power Plant at Paks

The laboratories of the institutions above collect different environmental samples within a 30 km radius of the NPP. The results of the radiological analyses of the samples collected are sent to the Data Processing and Analyzing Centre of JERMS (operated by NRIRR), in order to process the data and determine the radiation burden of the population living around the NPP.

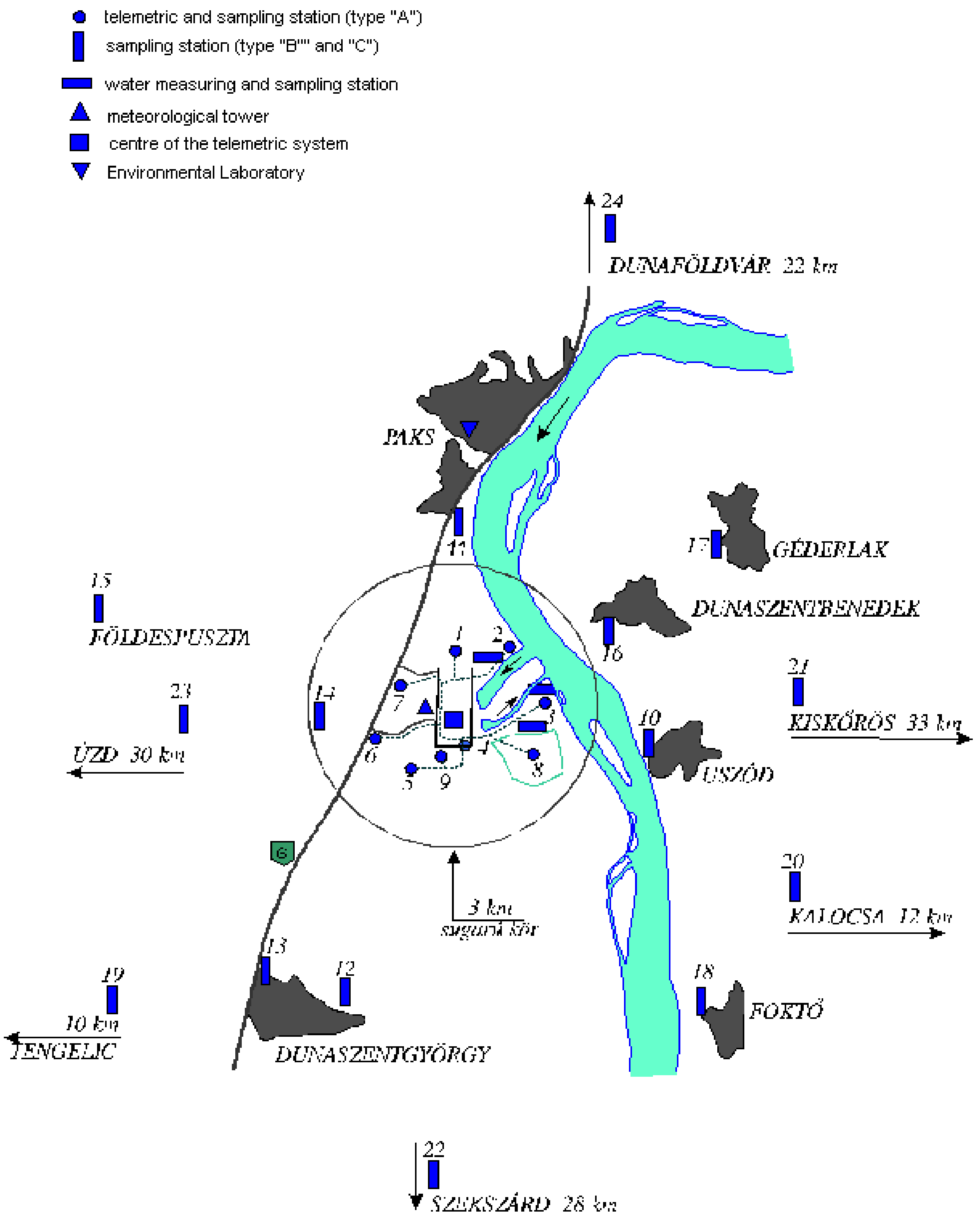
The contribution of the South Transdanubian Regional Institute of NPHMOS to the annual monitoring programme of JERMS can be found in Appendix 4.

The institutions taking part in the JERMS prepare and publish the results of the environmental monitoring of the vicinity of NPP via annual reports, which are available via World Wide Web without any restrictions (www.hakser.hu/eredmenyek/eredmenyek_en.html).

The Plant Environmental Radiation Monitoring System PERMS is the statutory monitoring programme implemented by the Paks NPP. The legal basis of this programme is provided by the Decree of the Minister of Environment and Water 15/2001 (VI.6). Details of the programme are given in Appendix 5.

The programme addresses liquid and airborne discharges of radioactivity into the environment (source term) as well as levels of radioactivity in the environment around the Paks site (impact).

PERMS consists of on-line systems and off-line systems that are located on-site as well as within a 1.5 km zone around the NPP as shown on the map below:



On-line: telemetric systems the units of which are situated:

- At the stacks, monitoring discharges.
- At the water monitoring and sampling stations V1, V2 and V3.
- At the meteorological tower (Data from the tower is continuously fed to the Budapest headquarters of the National Meteorological Service.).
- On-site, 18 dose rate probes (It must be noted that these gamma dose rate probes do not feed into the Nuclear Emergency Information and Analysis Centre of the National Disaster Prevention Authority).

- Off-site, 11 dose rate probes station G 1 to 11.
- At the off-site environmental monitoring stations A1 to A9, and B24.

Large volume aerosol, fall-out and Por TLD data from environmental monitoring stations A1-A9 and B24 and monthly average gross beta from water monitoring stations V1 and V2 are sent to the National Environmental Radiation Monitoring System (NEMS).

The water monitoring stations V1 to V3 are post-discharge reassurance monitors and are considered as environmental monitors. Total activity to be released into the environment is established at the various tanks prior to discharge through sample taking and analysis.

All environmental monitoring stations type A are situated within a fenced-off area and house on-line systems as well as sampling systems. Instrumentation is sheltered inside a locked aluminium container. This container is heated in winter and cooled in summer. Power supply is delivered by direct line from the Paks NPP, back-up power supply is ensured by local battery packs that allow approximately 24 hours of operation. The on-line systems communicate the data they have acquired to the DCR every 10 minutes. The systems also transmit their operating status to the DCR.

Stations A1 to A9 are equipped with a continuously operating on-line aerosol monitor equipped with a plastic scintillation detector for gross beta measurements and a continuously operating on-line iodine (elemental and organic) measurement system with a NaI(Tl) scintillation detector (temperature stabilised) which has a 6x1cm tube geometry (after the aerosol monitor). A multichannel analyser allows for the assessment of the activity concentration of four iodine isotopes: ^{131}I, ^{132}I, ^{133}I and ^{135}I. The measurement ranges for aerosol and elemental iodine gross beta are 6E+02 to 5E+07 Bq/m³, and for iodine isotopes (organic and elemental) 6E+03 to 5E+07 Bq/m³.

The sampling line is temperature controlled and has a nominal flow of 0.2-0.4 m³/h.

Sample filters are exchanged weekly and are stored only when their activity exceeds detection thresholds (aerosols). The iodine filters may be further assessed with gamma spectroscopy if deemed necessary

An on-line proportional gamma dose rate probe (type BITT RS03/X) with a detection range between 30 nSv/h and 10 Sv/h and an integration time of 10 minutes is located within the fenced area around the instrument container.

A high-volume air sampler (40 to 50 m³/h) taking aerosol and iodine samples for laboratory analysis (weekly exchange of the aerosol filter, monthly exchange of iodine filters, (elemental and organic). The measured throughput is corrected for air pressure and temperature. The pumps can be remotely controlled from the DCR.

An Al_2O_3 thermoluminescent dose meter (monthly integration and reading at the laboratory).

A wet/dry deposition collector (monthly laboratory analysis of the sample).
Additionally, stations A1, 3, 4, 6, 8 and 9 are equipped with tritium and carbon samplers. Tritium (HT and HTO) is sampled using an adsorption column containing a molecular sieve (monthly replacement of sampler). Carbon-14 (CO_2 and C_nH_m) is sampled with a NaOH bubbler (monthly replacement of the sampler).

Furthermore, positioned between the A type stations are 11 additional proportional gamma dose rate probes (type BITT RS03/X) operating in continuous mode. The probes are powered by solar panels and have battery back-up, integrate over 10 minutes, and send the acquired data via radio link to the DCR for display.

The type B environmental monitoring station is identical to an A type station with ^{3}H and ^{14}C sampling, except that it communicates with the DCR via a radio link. It is located further away from the Paks NPP (at approximately 22 km) and acts as a control station under the prevailing wind direction.

The Paks NPP Environmental Laboratory is situated in the town of Paks, approximately 5 km north of the NPP. The laboratory is accredited by the Hungarian Accreditation Board, the current accreditation is in accordance with standard MSZ EN ISO/IEC 17025:2005, accreditation number NAT-1-1195/2006, valid until 11 December 2010. The procedure to renew accreditation was launched in August 2010.

The laboratory's activities, equipment, staff, testing capacity and methods, links with authorities, data provision and reporting responsibilities, and arrangements for coordination of duties in emergency situations are set out in detail in the Paks NPP environmental radiation protection monitoring regulations (June 2003) and the Paks NPP written Quality Manual and its related compilation of written operating instructions. The Manual also lists the equipment the laboratory must possess in order to be able to discharge the Paks NPP from its regulatory obligations with regard to the statutory sampling and analysis programmes .

5.2. The National Radiation Early Warning Monitoring and Surveillance System (NREWMS)

In Hungary the National Directorate General for Disaster Management is the centre of the National Radiation Early Warning, Monitoring and Surveillance System (NREWMS).

The NREWMS consists of three subsystems:

- Early Warning Telemetric Network (automatic radiological monitoring stations)
- Fixed Radiological Laboratories
- Mobile Laboratories

5.2.1. Early Warning Telemetric Network

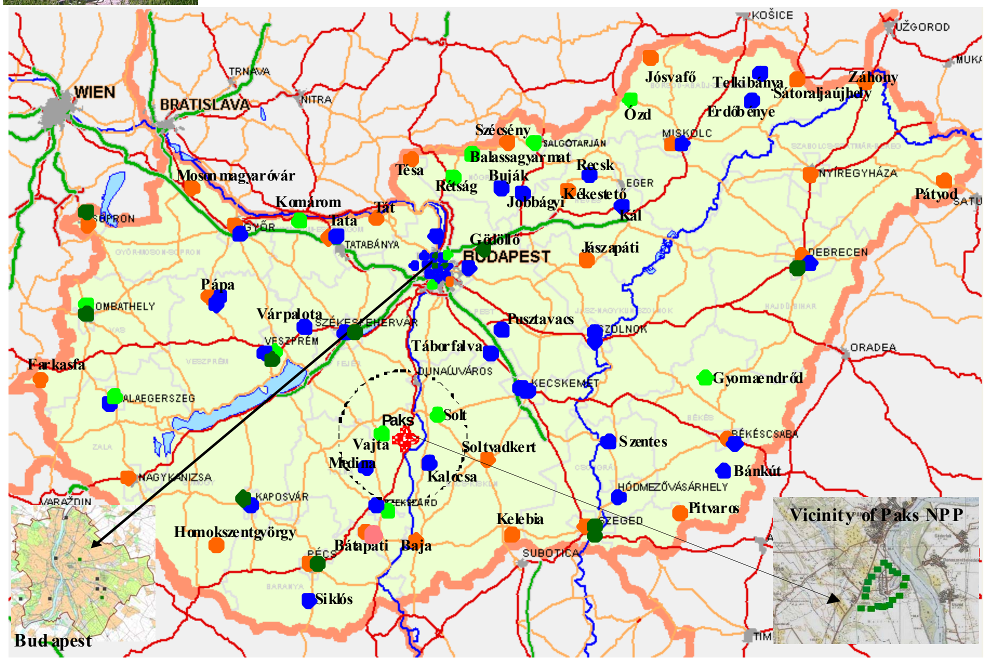
The telemetric gamma dose rate monitoring network consists of 121 automatic measuring stations. Six principal bodies provide data for the Telemetric Network of the NREWMS:

- Hungarian Army (41 monitoring stations) – Ministry of Defence
- National Meteorological Service (29 monitoring stations) – Ministry of Environment and Water
- Paks Nuclear Power Plant (20 monitoring stations)
- National Directorate General for Disaster Management (14 monitoring stations)
- Ministry of Education and Culture (13 monitoring stations)
- Public Limited Company for Radioactive Waste Management (4 monitoring stations)

The locations of these stations are shown on the map below:

Telemetric Network

121 Measuring Stations in the Telemetric Network of the National Radiation Early Warning, Monitoring and Surveillance System



National Meteorological Service: 29

National Directorate General for Disaster Management: 14

Hungarian Army: 41

Paks Nuclear Power Plant: 20

Ministry of Education and Culture: 13

Public Limited Company for Radioactive Waste Management: 4

The monitoring devices consist of proportional counting tube, model NPGD 02, with power compensation filter made by BITT Technology. The detection range is between 10 nSv/h and 10 Sv/h. The detector operates on 12V DC with current of about 200 mA. For the evaluation of the measured data a personal computer (PC) and interface is required. Data transfer protocol RS-232 is used in the case of a single detector.

The alarm threshold is set at 500 nSv/h; every subsystem sends the data to the national centre (National Directorate General for Disaster Management), where a 24/7 duty service monitors the data. Every subsystem of the NREWMS does the calibration, checking and maintenance according to its own procedures.

During normal conditions the subsystems send the measured data (10 minutes averages) to the centre of the telemetric network. The National Directorate General for Disaster Management receives the data measured by the subsystems (10 minutes averages) with different frequencies:

- Hungarian Army - every 6 hours
- National Meteorological Service - hourly
- Paks Nuclear Power Plant - every 10 minutes
- National Directorate General for Disaster Management - every 10 minutes
- Ministry of Education and Culture - every 10 minutes
- Public Limited Company for Radioactive Waste Management - every 10 minutes

In the National Directorate General for Disaster Management the data are visualized in two redundant places: the Nuclear Emergency Information and Analysis Centre (NEIAC) and at the 24 hour duty service. The data is available for public consultation online: http://www.katasztrofavedelem.hu/index2.php?pageid=monitor_nbiek_index.

At the NEIAC the work is 40 hours/week (but there is an assigned duty officer who can be reached by telephone any time of the day). After the workday is finished the 24 hour duty service pays increased attention to the system. If they see any malfunction (unexpected increase in measurement data, or outage in the data transmission) they call the officer on duty of the NEIAC who takes the necessary steps.

If any of the subsystems tests their measuring stations with isotopes or have any information about any planned and controlled activity that may lead to the increase of the measurement data, they notify the national centre, which forwards the information to the concerned organizations.

The verification team visited the Hungarian centre for disaster management at the National Directorate General for Disaster Management in Budapest. The staff of the Nuclear Emergency Information and Analysis Centre (NEIAC) presented the arrangements under the national nuclear emergency management action plan, the data collection and presentation system for the telemetric gamma dose rate monitoring network, and the systems in place for informing and alarming the population in case of an emergency. The verification team noted also the arrangements in place for the automatic exchange of gamma dose rate data with the neighbouring countries Austria, Slovakia and Slovenia. The verification team was also invited to visit the 24/7 duty service for disaster management where all types of disasters are monitored.

The verification team could see one of the BITT detectors installed at the National Directorate General for Disaster Management in Budapest. All probes of the network are of the same type and are calibrated by the National Metrological Institute which is certified according to ISO 9001.

Finally, the verification team visited the training reactor of the Technical University of Budapest where the 13 measuring stations of the Ministry of Education and Culture are coordinated as part of the early warning telemetric network. The data is available for public consultation online, http://omosjer.reak.bme.hu. Data from 13 BITT detectors are collected, controlled and transferred to the national system. One BITT detector is operated at the site of the training reactor together with an aerosol sampler in stand-by.

The system in place for continuous monitoring of ambient gamma dose rates on the territory of Hungary as part of the national nuclear emergency action plan and early warning system seems adequate. The verification did not give rise to comments or recommendations.

5.2.2. Fixed Radiological Laboratories

The following bodies have fixed Radiological Laboratories:

- Ministry of Agriculture and Rural Development
- Ministry of Environment and Water
- Ministry of Health ("Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene)
- Paks Nuclear Power Plant
- Hungarian Academy of Sciences
- National Meteorological Service

5.2.3. Mobile Laboratories

The following bodies operate Mobile Laboratories:

- Civil Protection Branch Office of the Capital
- Ministry of Health ("Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene)
- Ministry of Defence (Hungarian Army)
- Ministry of Agriculture and Rural Development
- Paks Nuclear Power Plant
- Hungarian Academy of Sciences (KFKI Atomic Energy Research Institute)

with the following characteristics:

	AEKI	MARD	NRIRR	PAKS	CP	MD
Response time [Hours] (WH/NWH)	1/6	0/6	1/6	1/1	0/2	1/3
vehicle type	WV Transporter Syncro T2	Land Rover Defender	Ford Transit	Renault Traffic 4x4	VW Transporter	VW LT-40
Power supply	1 pc 600 W inverter+75 Ah	1 pc 600 W inverter+75 Ah, 1 pc 300 W inverter 18 Ah	1 pc 300 W inverter, 1 pc aggregator	1 pc 900 W aggregator, 1 pc 1600 W aggregator, 1 pc 100 Ah accumulator	2 pcs 80 Ah Accumulator, 1kW inverter	1 pc 1000 W aggregator (220 V) +1pc inverter
Number of personel	3	2	2 + driver	3	2-3	3
In-situ gamma spec instruments	Canberra HpGe, Inspector, NaI detektor (nanospec)	Canberra HpGe, Inspector	Canberra HpGe, Inspector	Canberra HpGe, Inspector	ORTEC HPGe Nomád	Canberra HpGe GC2020, Inspector 2000 MCA
Dose rate meters	BNS 98, Nanospec, Umo, RSS 111	BITT RS 02/232/H Automess 6150 AD-b	AUTOMESS AD 6/H with scintillation det.	Automess, FH 40 F1, FHZ 621 G	BITT RS 02/232/H, Umo LB123 Gamma	SSM-1, IH-95
Gps	Garmin V	Garmin III	GARMIN GPSmap 176C	Evermore	ScoutMaster WGS-72	Garmin GPS320
Sampling	soil, air	soil, food, feed, plants	-	soil, air, water, sediment	soil, air	soil, air (VSMF)
Analysis software	Geni 2k, Wintcma, spc. Excel and Origin	Genie 2k	Genie2k, Excel	Genie 2000 v 3.0	GammaVision Wintmca In-Situ.xls TOI cd.	Geni 2k, MS. Excel
Surface contamination measurement	UMO	Automess 6150 AD-k	Contamat FHT 111M	LB 122	UMo LB123 Béta-Gamma	IH-95

5.3. RAMDAN sampling

5.3.1. Air related programme

There are five air samplers of medium flow rate (150 m^3/h, manufacturer: SENYA OY, type: SENYA JL-150, "HUNTER medium volume air sampler", glass fiber filter, change weekly, LLD: ~ μBq/m^3) and five air samplers with low flow rate (appr. 2 m^3/h, KFKI design, ∅ 5cm Millipore membrane filter, change daily, LLD (after 72 hours):.1.5 mBq/m^3)

The NRIRR has a continuous alpha (natural and artificial) and beta aerosol monitor: Thermo Electron FHT59Si. Flow rate about 8 m^3/h, detector type: PIPS semiconductor, LAN coupling. Measurement range: 0.1 Bq/m^3 – 1 MBq/m^3, LLD: 50 mBq/m^3 (alpha), 300 mBq/m^3 (beta). Alarm thresholds: 80 Bq/m^3 (artificial alpha and beta), 150 Bq/m^3 (natural alpha).

The filters of the medium flow rate air samplers are analyzed by gamma spectrometry (HPGe), those of the low flow rate air samplers are measured for gross beta activity.

RAMDAN has six fallout sampling devices. Their collection areas range from 0.16 to 3 m^2. The NRIRR has one steel collector (+heater) of 0.2 m^2, one steel collector (+heater) of 1 m^2, location: 1m above ground.

There is monthly exchange of collector canisters. The quantity depends upon the quantity of monthly precipitation. Cleaning is performed with distilled water and a brush.

Gross beta activity and gamma emitting isotopes are assessed, LLD: 1.3 - 6.7 Bq/m^2 (gross beta), 0.1 - 0.3 Bq/m^2 (gamma emitters).

5.3.2. Water sampling programme

The sampling frequency for surface waters is monthly in case of rivers and quarterly in case of lakes (see the main monitoring programme of RAMDAN in Appendix 3). The quantities fall in the range of 10-20 litres. Samples are taken from each county.

No continuous or autonomous sampling device is installed in RAMDAN.

Gross beta, ^{40}K and gamma emitting isotopes (mainly ^{137}Cs) are assessed.

For ground and drinking water, samples are taken quarterly from each county. The sample quantity is 5 litres. For ^{3}H measurements 1-1.5 litre of water is used.

No continuous or autonomous sampling device is installed in RAMDAN.

Gross beta, ^{40}K, ^{90}Sr and ^{3}H and gamma emitting isotopes (mainly ^{137}Cs) are assessed.

5.3.3. Soil related sampling programme

In RAMDAN the upper 10 cm thick layer of the soil is taken in every quarter of a year from each county (see the main monitoring programme of RAMDAN in Appendix 3). The sample quantity is 2-3 kg. and gamma emitting isotopes are assessed.

Grass and cereals are assessed in every quarter of a year from each county (see the main monitoring programme of RAMDAN in Appendix 3). The sample quantity is 1-2 kg. Gross beta, ^{40}K and other gamma emitting isotopes are assessed.

5.3.4. Foodstuffs sampling programme

Milk and milk product samples are bought in the shops. It is not necessary that the sample be from local production. Milk samples are taken monthly and milk product (cheese, cottage cheese and milk powder) samples quarterly from each territory of competence (see the main monitoring programme of RAMDAN in Appendix 3). The quantity of milk is 3 litres, that of the milk products is 0.5 kg.

Gross beta, ^{40}K, ^{90}Sr and gamma emitting isotopes are assessed.

Mixed diet samples are taken in every half year from the territories of competence of the laboratories. The samples are lunches of a catering company from 5 consecutive days. Their total mass is about 4 kg.

^{90}Sr and gamma emitting isotopes are assessed.

Vegetables, fruits, meat, egg and bread are assessed quarterly from each territory of competence (see the main monitoring programme of RAMDAN in Appendix 3).

Samples are bought in a shop in the following quantities:

Sample	Quantity
vegetables, fruits	1-1.5 kg
meats	1 kg
eggs	20 pieces
bread	2 kg

Gross beta, ^{40}K and gamma emitting isotopes are assessed.

5.4. Radioanalytical Monitoring Network under the responsibility of Ministry of Agriculture and Rural Development (RMN of MARD)

5.4.1. Air sampling

A "home-designed" device and produced by a Hungarian entrepreneur (András BERKÓ) is installed in Budapest, on the roof of the laboratory (installation in 1999, changes in construction in 2006). Type of filter: HEPA 5300, A=0.24m^2. Weekly changed, volume approx 40000 m^3/week

After 3 days delay gamma-emitting radionuclides are measured (HPGe), then gross-alpha activity is determined.

Two dry/wet deposition collectors with a collection area of 1m^2 are installed in Budapest, on the roof of the laboratory and at Szekszárd, in the laboratory of Tolna county. Samples are collected and treated monthly.

5.4.2. Water sampling

For surface waters 36 samples are taken monthly from the Danube within a 30 km radius of Paks NPP for tritium measurement.

Water for the food industry is sampled 3 times a year for all of the 19 counties. Sample with volume of 50 litre is collected then evaporated by infrared lamps.

Gamma-emitters (HPGe), gross-alpha, gross-beta are assessed.

5.4.3. Soil sampling

Soil (sediment is not included in the monitoring programme) is sampled with a corer, d=8.5cm l=22.5cm.The upper 5cm gives one sample and the bottom part another. For cultivated land only the upper 5cm is sampled.

Type of sample	Radionuclides	Number of samples	Comment
Soil from forest	Gamma-emitters, gross-beta, Sr-90	2 sample/year	Sampling in each county
Soil grassland with grass sampling	Gamma-emitters, gross-beta, Sr-90	3 sample/year	Sampling in each county
Agricultural: soil with Lucerne sampling	Gamma-emitters, gross-beta, Sr-90	3 sample/year	Sampling in each county
Agricultural: soil with spinach/sorrel sampling	Gamma-emitters, gross-beta, Sr-90	3 sample/year	Sampling in each county

Pu-isotopes are determined in some samples (different aspects year by year, for example in forest soils).

For terrestrial and aquatic biota and flora (including mushrooms) the following sampling plan is operated:

Type of sample	Radionuclides	Number of samples	Comment
Grass*	Gamma-emitters, gross-alpha, gross-beta Sr-90	6 samples/year	Sampling in each county
Nettles*	Gamma-emitters, gross-alpha, gross-beta Sr-90	3 samples/year	Sampling in each county
Moss*	Gamma-emitters, gross-alpha, gross-beta Sr-90	3 samples/year	Sampling in each county
Mushrooms	Gamma-emitters, gross-alpha, gross-beta Sr-90	3 samples/year	Sampling in each county
Feed for domestic animals	Gamma-emitters, gross-alpha, gross-beta	25 samples/year	Sampling in each county

* H-3 and C-14 are determined in green plants coming from the 30km circle of Paks NPP.

5.4.4. Food programme

Milk is sampled from one farm in each county (20 farms including Budapest – information from local production) Sample size is 5 litres of milk monthly with current fodder.

Gamma-emitters, Sr-90, gross-alpha, gross-beta are assessed.

Mixed diet is not applied in the network (ingestion dose is calculated from food consumption statistics and the individual food results).

The national monitoring program for food and feed is as follows:

Type of samples	Radionuclides	Number of samples	Comment
Cereals	Gamma-emitters, gross-alpha, gross-beta Sr-90	3 samples/year	Sampling in each county
Meat (beef, pork, poultry and small domestic animals)	Gamma emitters	420 samples/year	Slaughter houses
Vegetables	Gamma-emitters, gross-alpha, gross-beta	19 samples/year	Sampling in each county
Fruit	Gamma-emitters, gross-alpha, gross-beta	7 samples/year	Sampling in each county
Milk	Gamma-emitters, gross-alpha, gross-beta Sr-90	monthly	Sampling in each county
Milk products (cheese and milk powder)	Gamma-emitters, gross-alpha, gross-beta Sr-90	240 samples/year	Sampling in producer or in markets
Water used in food industry	Gamma-emitters, gross-alpha	3 samples/year	Sampling in each county
Baby food	Gamma-emitters, gross-alpha, gross-beta Sr-90	8 samples/year	Sampling in producer
Imported baby food	Gamma-emitters	7 samples/year	Sampling in each county

Type of samples	Radionuclides	Number of samples	Comment
Imported mushrooms	Cs-137	78 samples/year	From market
Imported vegetables	Cs-137	12 samples/year	Sampling in each county
Imported fruit	Cs-137	20 samples/year	Sampling in each county
Imported fish and other products of see	Cs-137, Po-210	6 samples/year	Sampling in each county from market
Wild animals	Gamma emitters	60 samples/year	Slaughter houses, collecting places
Mushroom (edible)	Gamma-emitters, gross-alpha, gross-beta Sr-90	3 samples/year	Sampling in each county
Dried fruits, nuts	Cs-137	4 samples/year	Sampling in each county

5.5. Laboratories participating in the National Environmental Radioactive Monitoring Programme

Both RAMDAN and the RMN of MARD operate separate laboratories

5.5.1. The laboratories of the Radiological Monitoring and Data Acquisition Network (RAMDAN)

The laboratories of the Radiological Monitoring and Data Acquisition Network operate under the National Public Health and Medical Officer Service and under the professional coordination of the NRIRR. They send the measurement results to the RAMDAN Information Centre, which is also maintained by the NRIRR. They are responsible to perform the main monitoring programme of RAMDAN (see Appendix 3).

Records on the samples are kept both in paper format and electronically.

Sample preparations for gamma spectrometry and gross beta measurements:

Sample	Sample preparation
aerosol	–
plants, milk, milk products, foodstuffs, mixed diet	drying and ashing
soil	drying if necessary
deposition, water samples	evaporation and ashing

For ^{90}Sr measurements chemical separation is performed on the samples prior to gross beta counting. For ^{3}H measurements electrolytic enrichment in performed on the water samples prior to liquid scintillation measurement.

The activity of ^{40}K is determined (apart from gamma spectrometry) by atomic absorption. The sample preparation is usually ashing but in case of water and milk samples it can be followed by chemical separation.

For gamma spectrometry HPGe detectors are used, the measuring time ranges from 50 000 s to 400 000 s. Measured radionuclides are ^{137}Cs, ^{7}Be, ^{40}K, ^{131}I, ^{210}Pb, ^{134}Cs.

For beta measurements plastic scintillation detectors or proportional chambers are used. The measurement time is about 3000-5000 s.

In addition to the central laboratory of NRIRR there are 6 regional laboratories with the following equipment:

NPHMOS NRIRR – Central Radiohygiene Laboratory (CRL)

Low background α, β detector (BERTHOLD)
Atomic absorption spectrophotometer (AA-20)
Low background α, β detector (TESLA)
Tri-Carb liquid scintillation analyzer (2550TR/AB)
Spectrometer / Scintillation detector (aerosol)
Spectrometer NK350 (spare)
Spectrometer NK350 / Scintillation detector (fall-out)
Electrolytic enrichment device
HPGe semiconductor detector
HPGe semiconductor detector (GC1520)
HPGe semiconductor detector (GR20195)
Alpha-spectrometric system (CANBERRA)
HPGe semiconductor detector (GX3020)
HPGe semiconductor detector (GX3020)
Radon monitor (Durridge RAD7)
TLD system (Harshaw)
Tri-Carb liquid scintillation spectrometer (2900TR)
Dose rate meter (AUTOMESS)
HPGe semiconductor detector
HPGe semiconductor detector (GR3519)

North Hungarian Regional Institute of NPHMOS (Miskolc)

DSA-1000 multichannel gamma spectrometry analyzer with GX3018 HpGe detector
AAS 1N atomic absorption spectrophotometer
UMO LB 1230 dose rate meter, with ß, γ and neutron radiation sensitive detectors
HUNTER JL-150 medium volume air sampler
NanoSpec-3k portable gamma spectrometer
Durridge Rad7 radon level meter
MPC-9300 (PIC) low level alpha and beta detector

Regional Institute of the South Plains of NPHMOS (Szeged)

CANBERRA1510 HPGe gamma spectrometer
BERTHOLD 5310 alpha and beta detector
Spektromom 190 A atomic absorption spectrophotometer

Central Hungarian Regional Institute of NPHMOS (Budapest)

NK 350 analyzer with ND 131 scintillation detector and ND 302 anticoincidence GM detector
Thermo Scientific FHT 770 S beta detector with FHT1100 analyzer
Canberra gamma-spectrometer with HPGe gamma detector
UMo LB 123 environmental dose and dose rate meter

West Transdanubian Regional Institute of NPHMOS (Győr)

HUNTER medium volume air sampler JL-150

Canberra GC 2520- 7500 SL HPGe semiconductor detector
Canberra GX3020 HPGe semiconductor detector
Eberline FHT 770 T6 low background α-β detector
BERTHOLD UMO LB 1230 dose rate meter

Regional Institute of the North Plains of NPHMOS (Debrencen)

NK 350 counter
NK 370 multichannel spectrometer
NK-401 spectrometer with beta and gamma detector
NK-401 NaI (Tl) gamma detector
OXFORD HPGe semiconductor gamma detector
Canberra HPGe detector
Berthold LB – 1230 dose rate meter
NS 118 Contameter
RUST-3 Radiometer

South Transdanubian Regional Institute of NPHMOS (Szekszárd)

Pegase low background α-β detector
Eberline FHT 770T α-β detector
ORTEC HPGe gamma spectrometer
NK-350 spectrometer
Canberra HPGe gamma spectrometer
Perals liquid scintillation alpha spectrometer
HUNTER medium volume air sampler

Furthermore the environmental Radiohygiene Laboratory of the Central Transdanubian Regional Institute of NPHMOS has not been established yet.

Only the Central Radiohygiene Laboratory of NRIRR is accredited under accreditation number: NAT-1-0969/2010. according to MSZ EN ISO/IEC 17025:2001. Furthermore they regularly take part in inter-comparison exercises, both at national and international level.

5.5.1.2 NRIRR laboratory

The verification team performed an in depth verification at the NPHMOS NRIRR – Central Radiohygiene Laboratory (CRL), also known as the Fréderic Joliot-Curie Institute. Founded in 1957 the Institute employs 80 staff, mainly scientists.

The laboratory has ISO 17025/2000 accreditation for over 70 methods, valid until 23 March 2014.

Samples arriving at the laboratory are registered in a ledger with the following information recorded:
- Central number (consecutive)
- Division number (each division starts with 10, 20, 30 etc followed by a consecutive number, e.g. 10491)
- Type of sample
- Date of order
- Date of sampling
- Sampling location
- Name of sampler
- Name of sample receiver
- Person responsible for measurement

A further column shows the date when the results were prepared and is completed after measurement.

The laboratories are fully equipped to undertake drying, ashing and milling as appropriate when preparing samples for analysis.

Records have been kept since 2001 when accreditation started and were readily accessible. A number of samples were selected and staffs were quickly able to retrieve all documents relating to sample receipt, measurement and results.

In addition to the paper records all data relating to sampling and results is input to the NERMS database which uses Microsoft Access. Each individual laboratory can see all data but only modify their own records. NRIRR can modify all records.

Radon measurements are taken on site. In addition one assistant has taken the initiative to establish a small weather station with a view to relating the radon measurements to the prevailing weather conditions.

Regular gamma dose rate measurements are taken at the same point in the garden since the 1970's.

The verification team visited the individual laboratories within the Institute and received valuable explanations from the staff regarding the instruments and methods used. The principal areas visited were the following:

Tritium and caesium measurement

A background measurement is undertaken before each sample measurement. H3 concentration is increased by electrolysis with the possibility to handle 12 samples per 5 day week. Around 500-600 analyses are carried out yearly. Typical concentrations are of the order of < 2Bq/litre for water from the river Danube and <0.2 MBq/litre for well water.

A Julabo evaporator is used for the concentration of surface water, 100 litres at the outset are reduced to 1 litre for the measurement of Cs 137, the activity of which is generally very low in water taken from the river Danube.

Gamma spectrometry

In addition to the some 250 analyses undertaken as part of the environmental monitoring programme the laboratory undertakes about 200 additional measurements for the construction industry and other interested parties.

The bulk of the accredited methods are undertaken in this lab with a wide range of calibrations from 0.8ml to 1 litre sizes covering trays, bottles and Marinelli beakers.

Though the laboratory has a number of detectors at it's disposal generally only 1 detector is used on a regular basis due to cooling costs.

Multi detector measurement was not possible at the time of the visit due to problems with the Procount 2000 software, though a repair was due to be undertaken.

In the past the laboratory took part in PROCORAD inter-comparisons but this has been discontinued due to the high cost. Very good results were obtained and delivery of overall results was quite quick. The laboratory continues to take part in other inter-comparison exercises, particularly where participation is free of charge.

Alpha spectrometry

A Canberra Alpha analyst system is used for measurements of Am, Pu, U and Th, with accreditation held for the Am methods. This machine has been found to give good results for Polonium-210 and radium but methods are not accredited. However it is envisaged to try and obtain accreditation. Around 150 samples are analysed annually.

TLD measurements

The TLD system which dates from 1976 uses $CaSO_4$: Tm powder, heated to 220 ^oC in a nitrogen atmosphere to avoid oxygen "burning". The laboratory has the necessary equipment to manufacture the TLD capsules, in addition to being able to read the results. The national network consists of 115 volunteers spread throughout the country.

Radon measurements

In addition to a Durridge RAD 7 radon monitor the laboratory operates a RADOSYS system which incorporates CR-39 particle registration material, an etching unit using a sodium hydroxide solution and an automatic track counting microscope using RADOSYS 2000 application software.

Overall

Owing to the prevailing weather conditions at the time of the visit it was not feasible to visit sampling points and gamma measurement stations in the countryside. The team were shown the measurements taken in the grounds of the Institute. Gamma dose rate has been measured since the 1970's on a regular basis at the same point in the garden using a portable gamma spectrometer. Nearby radon measurements are made inside a small "house". There is a small weather station which allows to relate radon content to the weather conditions.

Two fallout samplers are located near the main building, both of which are heated in winter. The larger for dry measurements is 1m * 1m, whilst the wet sampler is 0.2m^2. Both are emptied monthly, or more frequently, particularly in the case of the larger sampler.

Three aerosol samplers are also installed. A homemade device with a capacity of +/- 100 m^3 per day, the volume being measured by a gas meter has the filter placed in the top of the intake tube. The filter is changed every morning, 7 days a week and the gross beta activity measured without any preparation. A JL 150 Hunter air sampler is used for gross gamma measurements on the filter which is changed weekly. The device incorporates an auto stop if the filter is "full", i.e. there is a drop in pressure. The third device, a Thermo Eberline FHT 59 was out of order due to a software problem at the time of the visit. This allows the automatic measurement of alpha and beta separately with the results being sent directly to the main building. The flow rate is 7-8 m^3 per hour.

The verifications do not give rise to specific remarks.

5.5.1.3 West Transdanubian Regional Institute of NPHMOS (Győr).

The verification team performed an in depth verification at the laboratories of the West Transdanubian Regional Institute of NPHMOS (Győr). The Institute carries out all the analysis of environmental samples collected in the areas of Győr-Moson-Sopron, Vas and Zala. The institute operates under the National Public Health and Medical Officer Service under the professional coordination of the NRIRR. It sends the measurement results to the RAMDAN Information Centre, which is also maintained by the NRIRR.

Though the laboratory does not have official accreditation it uses the same methods as the central laboratory in Budapest.

The verification team visited the individual laboratories within the Institute and received valuable explanations from the staff regarding the instruments and methods used. The principal areas visited were the following:

Sample receipt and Results archive

Samples arriving at the laboratory are registered in a ledger with the following information recorded:
- Central number (consecutive)

- Division number (each division starts with 10, 20, 30 etc followed by a consecutive number, e.g. 10491)
- Type of sample
- Date of order
- Date of sampling
- Sampling location
- Name of sampler
- Name of sample receiver
- Person responsible for measurement

An additional column showing the date when the analysis is started and when it is completed (after measurement) is also present.

A number of samples were selected and staffs were quickly to retrieve all documents relating to sample receipt, measurement and results.

In addition to the paper records all data relating to sampling and results is input to the NERMS database which uses Microsoft Access. Each individual laboratory can see all data but only modify their own records. NRIRR can modify all records.

Verification does not give rise to particular recommendations

Ashing and drying

The laboratories are fully equipped to undertake drying, ashing and milling as appropriate when preparing samples for analysis.

Verification does not give rise to particular recommendations

Weighing *scales*

The laboratory uses an electronic scale, which are calibrated annually by an external calibration service. Calibration files and monthly control files were available.

Verification does not give rise to particular remarks.

Gamma spectrometry

Two gamma detectors are used for gamma measurements.
- gamma 1 is a Canberra GC 2520- 7500 SL HPGe semiconductor detector.
- gamma 2 is a Canberra GX3020 HPGe semiconductor detector.

The verification team also noted that to reduce measurement background the gamma detectors are surrounded by lead. The measurement chambers are furthermore protected by a thin copper liner to reduce the effects of Pb-210 gamma rays (46.5 keV). There is the possibility to use different geometry (from 25 to 1000 ml) at different heights.

The calibration of the efficiency is performed one or two times per year (the energy calibration is done much more frequently).

For gamma spectroscopy, the laboratory uses Genie 2000 software which includes a measurement QC package.

The laboratory undertakes about 500 measurements per year and two persons are trained to use the gamma spectrometry equipment.

Verification does not give rise to particular recommendations

Alpha spectrometry

For alpha/beta measurements the laboratory uses a multi low level alpha/beta counter Eberline FHT 770 T which offers complete software for automatically calculated measuring time for set limit values. This instrument has three double trays and the gas used is argon-methane (90/10). The calibration of the device is very often checked and a new calibration is carried out if necessary. The instrument has a high sensitivity and a low background. A physical separation is realised between Strontium 90 and Yttrium 90. This last one is then measured.

Verification does not give rise to particular recommendations

Inside the laboratories the verification team witnessed the presence of a hot plate from Infratherm and an automatic sample changer from Tema Sinergie (model IGS4 S/N 862). The presence of a dose rate meter from Berthold (model UMO LB 1230) was noted.
Outside, in the garden, a modern air filter station JL-150 Hunter (Senya Ltd., Finland) is installed and also a tub to collect rain water (once per month). This equipment is protected by a fence.

Verification does not give rise to particular recommendations

5.5.2. Radioanalytical Monitoring Network under the responsibility of Ministry of Agriculture and Rural Development (RMN of MARD)

Since 2007 a general data-management system was implemented in the Food-chain Laboratories of the network of Agricultural Offices. This laboratory data-management system is a countrywide uniform information network for handling the sample data including registration and measurement results. The system gives the possibility of the registration of the sample by the veterinary officers who are responsible for food and feed sampling.

Methodologies used to prepare samples before gamma-spectrometry:

Sample	Sample amount, kg or L	State of the sample	Acquisition time, s
Soil	1 – 2	air dried	80 000
Pasture	2 – 3	ash	80 000
Lucerne	2 – 3	ash	80 000
Fodder	2 – 3	ash	80 000
Sorrel, spinach	3	ash	80 000
Milk	5	ash	80 000
Milk products	1	ash	80 000
Meat	2	ash	80 000
Mushrooms	2 – 3	dry, ash	80 000 – 200 000
Potatoes	2 - 3	ash	80 000
Vegetables	3 - 4	ash	80 000

Sample	Sample amount, kg or L	State of the sample	Acquisition time, s
Fruit	3 – 4	ash	80 000
Cereals	2 – 3	ash	80 000

Only individual samples are treated and measured, there is no combination of different samples.

Methods routinely used:
- Gamma spectrometry: HPGe and scintillation
- Determination of Sr-90 (classical method, measurement of $SrSO_4$ by low background α-β counter,
- alpha-spectrometry: U isotopes, Po-210, Pu isotopes
- Liquid scintillation spectrometry: H-3, C-14
- Gross-alpha, gross-beta measurement

Methods available in the laboratories:

Code of the county	Methods					
	Scintillation gamma-spectrometry	Gamma-spectrometry with HPGe detectors	Low background beta-counter (with pulse shape analyser)	Low background alpha-beta counter	Alpha-spectrometry	Liquid scintillation system
BAC	+	+	+			
BOR	+	+	+			
BUD	+	+	+	+	+	+
FEJ	+	+	+			
HAJ	+	+	+	+		
SOM	+	+	+			
TOL	+	+	+	+	+	
VAS	+	+	+	+	+	
VES	+	+	+			

For gamma-spectrometry InterWinner software is used (except BOR, where Genie 2000 is applied)

Code of the Laboratory	Type of detector	Producer	Efficiency	Resolution*	Energy range	Analisator	Lead Shielding
BAC 1	p-type, coax.	Canberra	30%	2.2 keV	45 - 3000 keV	Accuspec-B	Canberra-747, 10 cm
BAC 2	p-type, coax.	Canberra	25%	2.0 keV	45 - 3000 keV	Accuspec-B	Canberra-747, 10 cm

Code of the Laboratory	Type of detector	Producer	Efficiency	Resolution*	Energy range	Analisator	Lead Shielding
FEJ	n-type, coax	Intertechnique	15%	1.9 keV	15 - 3000 keV	Accuspec-B	von Gahlen, 10 cm
VES	p-type, coax.	Canberra	30%	2.2 keV	45 - 3000 keV	EAGLE	Canberra-747, 10 cm
HAJ	n-type, coax**	Canberra	27%	1.9 keV	10 - 3000 keV	Accuspec-B	CLOR , 10 cm
TOL	n-type, coax**	Canberra	30%	1.9 keV	20 – 2700 keV	DSA1000	Canberra-747E, 10 cm
SOM	n-type, coax**	Canberra	26%	1.9 kev	10 - 3000 keV	Accuspec-B	CLOR, 10 cm
BOR	n-type, coax	Intertechnique	15%	1.8 keV	15 - 3000 keV	S-100	von Gahlen, 10 cm
VAS	p-type, coax.***	Canberra	26%	1.9 kev	10 - 3000 keV	NIM-MCA	Canberra-747, 10 cm
BUD (5 detektor)	3 n-type, coax**	Canberra	30%	1.9 keV	10 - 3000 keV	NIM-MCA	von Gahlen, 10 cm

* for the 1332.5 keV of the Co-60

** EPOXI-CARBON end window - low background version

*** detector with extended range and EPOXI-CARBON endwindow, low background version

Low background alpha-beta counters

Code of the Laboratory	Type of instrument	Producer
BUD	LB-5	Oxford
HAJ	Pegase	Eurisys
TOL	Pegase	Eurisys
VAS	LB-5100	Canberra

Alpha spectrometers

Code of the Laboratory	Type of instrument	Producer
BUD	Individual chambers	Oxford, Canberra, Eurysis
TOL	Individual chamber, 7000M	Silena
VAS	Alpha Quattro	Ortec

A Quantulus 1220 (Perkin-Elmer, without cooling system) Liquid Scintillation Counter is installed in the Budapest laboratory. In case of any problem with the equipment there is no replacement possibility in the network.

For Gamma-spectrometry calibration volume calibration sources (in different geometries and densities) are prepared from the certified reference solution (QCY48, QCYB40, QCY56, QCYB41…)
Sr-90: calibration source is prepared from certified calibrant (from metrological institute)
Alpha-spectrometry: tracer technique is applied (isotope dilution).
LSC: certified solution.

For result calculation the following methods are used:
Gamma-spectrometry: built-in procedure by InterWinner, report of the instrument
$\alpha-\beta$ counting: report of the instrument and spreadsheet is applied
α-spectrometry: report of the instrument and spreadsheet is applied
LSC: report of the instrument and spreadsheet is applied

Measurement results are introduced into the laboratory data-management system, archiving procedure is the same as in the whole system (not the responsibility of the radioanalytical laboratory). Results are also archived in paper form in the laboratory.

The Central Laboratory Data-management System is used for the individual sample reports; there are possibilities to make some queries from this system. Afterwards Excel is used for summarising and making more comprehensible the measurement results for the yearly written report.

Individual data reporting after the collection of the data are transmitted once a year to National Environmental Radioactivity Monitoring System (NERMS).

Ashed samples are stored for 5 years.

All of the laboratories are accredited according to the MSZ EN ISO/IEC 17025:2005**.** RRL takes part in the inter-comparisons are organised by JRC IRMM according to Euratom Article 35 and participate in IAEA: ALMERA and open proficiency tests at least yearly. The other laboratories participates in IAEA open proficiency tests and inter-comparisons are organised for the internal network regularly (at least once a year).

Since 2005 the Radioanalytical Reference Laboratory works as an IAEA Collaborating Centre for the production and characterization of matrix reference materials of terrestrial origin. In this field, the primary objective is the production and characterisation of reference materials for the organisation of inter-laboratory comparison and proficiency test exercises, and the development and validation of radioanalytical procedures. These activities are closely linked with the IAEA's Sub-programmes to enhance the reliability and comparability of measurement results obtained by nuclear and nuclear related analytical techniques in Member State laboratories through the provision of reference materials, organization of proficiency tests and intercomparison exercises, and training. The Radioanalytical Reference Laboratory is an active member of the IAEA Advisory Group for the production and characterization of reference materials. In the last ALMERA coordination meeting in November 2010 the laboratory was accepted as the Coordinating Centre for the European region for the period of 2010-2014.

The verification team visited two laboratories of the Radioanalytical Monitoring Network under the responsibility of the Ministry of Agriculture and Rural Development: the Radioanalytical Reference Laboratory in Budapest and the county laboratory in Kecskemet. The Article 35 team could verify the available methods for food and feed sampling and analysis. The verification team noted in particular the countrywide uniform data-management system for handling the sample data including sampling, registration, identification and measurement results. All laboratories are accredited according to the MSZ EN ISO/IEC 17025:2005

The laboratory in Kecskemet is currently developing an interesting system to determine the ^{3}H and ^{14}C activity concentration in environmental and food samples; sample preparation means a programmed heating and ashing of the fresh sample in a combustion system equipped with 4 traps after the furnace, 2 for trapping ^{3}H and 2 for trapping ^{14}C. The new system is replacing the old one which was used only for sample preparation of ^{3}H from fresh plants. Samples are delivered to RRL for liquidscintillation measurement by Quantulus.

> *The system in place to monitor nationwide the radioactivity content in food, feeding stuff and other environmental samples seems adequate. The verification did not give rise to comments or recommendations.*

6. MEDICAL FACILITIES USING RADIOISOTOPES

6.1. General

In Hungary, the establishment of a nuclear medicine facility as a medical isotope laboratory requires an authorisation issued by the State Public Health and Medical Officer's Service. The licence covers import, purchase, processing, and application of radioactive substances.

Nuclear medicine departments are designed and constructed as specific radionuclide laboratories with one controlled personal entrance and controlled active rooms: the hot laboratory in which radionuclide sources are stored, handled and prepared for use, the administration room, the radioactive waste storage room, and the examination rooms. Waiting areas for active and inactive patients are separated. Separate toilet facilities are available for active patients.

The following medical radioisotopes and applications are being used in Hungary: For in vivo diagnostics Tc-99m is with ≥ 80% by far the most applied radionuclide, but there is also Ga-67, Tl-201, In-111, I-131, I-123, F-18, etc. For in vitro diagnostics, I-125 is used (helicobacter pylori: C-14). I-131 is used for isotope therapy of the thyroid, in case of hyperthyroidism the applied I-131 activity stays below 550 MBq per patient, and the patient can leave the hospital after application. In case of cancer metastases treatment, 550 MBq – 5 GBq are applied to a patient which requires hospitalization of the patient in a specially designed, controlled „isotope" ward. For bone palliation therapy, the radionuclides Sr-89, Sm-153, Re-186, etc are use. The patient can leave the hospital after treatment. Immobilization in „normal" hospital bedrooms is required after application of Y-90, Re-186, Er-169, and Dy-165.

Radioactive releases from nuclear medicine facilities are regulated by the relevant Decree of the Minister of Environment (No 15/2001.(VI.6). Solid and liquid radioactive wastes have to be collected and handled, separated by waste types, and transported to the waste storage room.

In general, the disposal of liquid wastes from active areas of nuclear medicine departments directly into the municipal sewage system is permitted. The only requirement is that the sink traps should be accessible for periodic monitoring. A separate drainage system with delay tanks is only required in case of thyroid cancer metastases treatment with applied I-131 activities of more than 550 MBq per patient. Discharges from decay tanks are released after 3 months storage and monitoring. Liquid radioactive wastes e.g. from unused radiopharmaceuticals are not released but stored until decay.

The annual discharge limits for I-131 vary from 30 GBq/year (<10 m^3/s) and 150 GBq/year (10 m^3/s-100 m^3/s) to 900 GBq/year (>100 m^3/s) depending on the minimal water flow rate of the sewage system. An individual discharge authorization for a single nuclear medicine facility is not required.

Gaseous radioactive effluents arise in cyclotron facilities and radiochemistry laboratories. Most of the nuclear medicine departments, except during lung inhalation examinations, do not produce gaseous radioactive effluents.

Active areas, objects, persons, etc. need to be monitored for radioactive contamination. For nuclear medicine facilities, no on site or off site environmental monitoring programme is required.

6.2. Hospitals in Budapest visited during the verification mission

According to data from the latest yearbook of the Hungarian College of Nuclear Medicine (2007), there are 48 nuclear medicine departments in Hungarian hospitals employing 104 medical doctors specialised in nuclear medicine, 56 other graduates (physicists, chemists, etc.), and 291 assistants, most of them specialised in nuclear medicine. Furthermore, there are 4 PET/CT centres, two of which have a medical cyclotron to produce isotopes, 43 planar cameras, 36 SPECT (single or dual head), and 17 thyroid cameras.

The verification team selected two hospitals in Budapest which were visited during the verification mission: the nuclear medicine department of the State Health Centre and the Pozitron-Diagnosztika Ltd diagnostic centre, running a PET/CT and it's own cyclotron with a radiopharmaceutical production facility.

6.2.1 State Health Centre (in Hungarian: Állami Egészségügyi Központ)

Address: 1134 Budapest, Róbert Károly krt. 44 (www.aek.gov.hu)

The verification team visited the nuclear medicine department of the State Health Centre, one of the biggest hospitals in Budapest. The nuclear medicine department performs approximately 6000 examinations per year. The applied radionuclides include Tc-99m: 2 x 20 GBq/week (generator activity), Tl-201, Ga-67 and In-111 for in vivo diagnostic, and Sr-89, Y-90, Sm-153, and Re-186 for palliative therapy. Iodine diagnostic examinations and therapy treatments are also performed in the State Health Centre. 8 – 10 hyperthyroidism patients undergo I-131 uptake tests every second week. On average about 80% of these patients are later treated with I-131 therapy with applied iodine activities of a maximum of 550 MBq/patient. According to Hungarian regulations these patients can leave the hospital soon after treatment.

As there are no cancer treatments with I-131 activities above 550 MBq/patient in the State Health Centre, the use of decay tanks is not required and liquid discharges from the nuclear medicine department are directly released to the municipal sewage system. Monitoring of liquid radioactive discharges is not required. Similarly, no on site or off site environmental monitoring programme is required (except regular - daily - radiation monitoring of a diagnostic nuclear medicine department with gamma dose-rate meter, and personal dosimetry systems for staff members).

The verification team noted the arrangements for the management of liquid radioactive discharges which is in accordance with Hungarian regulation. The verification did not give rise to additional comments.

6.2.2 PET/CT Diagnostic Centre with Cyclotron – Pozitron-Diagnosztika Ltd.

Address: 1117 Budapest, XI. Hunyadi János út 9. (www.pet.hu)

The verification team visited Pozitron-Diagnosztika Ltd., a privately owned diagnostic centre performing two types of medical examinations: Positron Emission Tomography combined with Computed Tomography (PET/CT) and CT-coronary angiography (CARDIO-CT). Pozitron-Diagnosztika Ltd runs it's own radio-pharmaceutical production facility with a cyclotron for radioisotope production. Pozitron-Diagnosztika Ltd. comprises three main activities:

- A radio-pharmaceutical production including a cyclotron, licensed as an isotope laboratory level B.
- A PET/CT for in vivo diagnostics, licensed as an isotope laboratory level C, and
- A cardio CT licensed as a CT laboratory level C.

Cyclotron and production of radiopharmaceuticals:

The installed cyclotron accelerates protons in two beam lines with 11 MeV, 120 µA, onto two times four target positions. The cyclotron is licensed to produce the radionuclides F-18, C-11, N-13, and O-15, but in practice produces mainly F-18 and C-11 (58 TBq of F-18 was produced between 2005 and 2009). With these radionuclides the laboratory is licensed to routinely produce the radiopharmaceuticals F-18 FDG, and C-11 acetate, and for research purposes F-18 NaF, F-18 FET, F-18 SFB, F-18 FBA, and F-18 labelled peptides.

The isotope inventory of Pozitron-Diagnosztika Ltd is regularly reported to the Hungarian Atomic Energy Authority (HAEA) using software called *radiumprogram*. Inspections take place biannually.

A system of depression is installed in the cyclotron room, in the radiochemistry laboratory and in the hot cells to ensure full capture of the air in the ventilation system.

The entrance to the cyclotron is secured by an integrated interlock system. At the exit of the radiochemistry and cyclotron controlled zone, a Leonardo hand-foot monitor is installed. For contamination surveillance, at least one hand-held contamination monitor is installed in each isotope laboratory, and a GM gamma dose-rate meter is available if needed.

Staff members entering the controlled zone are individually monitored by a personal dosimetry system.

Gaseous radioactive effluent:

Gaseous radioactive effluents containing the short-lived radionuclides C-11, N-13, O-15 and F-18 are produced in the cyclotron room and in the radiochemistry laboratories, in particular in the hot cells in which the radiopharmaceuticals, i.e. C-11 acetate, are produced.

The hot cells in the radiochemistry laboratory are connected to an automated airborne radioactive effluents compressing system allowing storing exhausted air until decay of the short-lived radionuclides C-11, N-13, O-15 and F-18.

Exhaust air from the cyclotron room and the radiochemistry laboratories are released through a chimney equipped with a special plastic coincidence detector system measuring positron emitters in absolute units MBq/m^3. These continuous monitoring data are transferred to a data logging station where they are displayed, recorded and stored.

Liquid radioactive effluent:

Drainage water collected in the cyclotron room and the radiochemistry laboratories are transferred to a liquid waste storage system that stores the potentially radioactive liquid effluent in two tanks with 500 L each before discharging it to the municipal sewage system. Water containing organic solvent waste is collected separately. Before release of waste water to the municipal sewage system a sample (0.1L) from the storage container is taken and analysed with gamma spectrometry for its radionuclide content.

Solid radioactive waste:

Solid radioactive waste from the cyclotron consists mainly of the activated parts of the targets containing long lived isotopes. The wastes produced are of very small volume, less than 1L per five years. They are temporally stored in a shielded floor pit with 50 L capacity and finally transported to the final storage site in Püspökszilágy.

All other solid wastes, F-18, C-11, and other open sources, have less than 2 hours half life. In the radiochemistry laboratory, the majority of solid radioactive waste is left in the hot cell until the next day to allow for a decay factor of at least 1/100. After a further storage of more than 48 h in the basement, these wastes are handled as biological (non-radioactive) waste.

PET/CT diagnostic activity

The diagnostic activity with PET/CT does not produce any ***gaseous radioactive effluents***.

Liquid radioactive effluents arise exclusively from patient's excreta. These wastes do not require any special treatment and are discharged directly to the municipal sewage system, as authorised by the authority. Patients are released from the *after study waiting room* if the dose rate measured at a distance of 1 meter from the patient is below 25 μSv/h.

The majority of ***solid wastes*** containing F-18, or C-11 is left in the hot cell until the next day to allow for a decay factor of at least 1/100. After a further storage of more than 48 h in the basement, these wastes are handled as biological (non-radioactive) waste. The long lived sealed radioactive sources (Ge-68 calibration sources) are, after they become disused, transported to the final storage site in Püspökszilágy.

Environmental monitoring:

A gamma dose rate meter is installed in the garden of the site to monitor ambient dose rate.

Radiation surveillance system at Pozitron-Diagnosztika Ltd.

A radiation surveillance system, called NETVIEW, provides a centralised overview on the radiation situation at the site of Pozitron-Diagnosztika Ltd., including the dose rate inside and outside the cyclotron room, and in the radiochemistry laboratory, the activity of the air released through the chimney, and the dose rate in the garden of the site. The system provides also the history of these measurements.

The verification team visited the cyclotron, the radiochemistry laboratory for production of radiopharmaceuticals, the automated airborne radioactive effluents compressing system, the detector system in the chimney for on-line monitoring of gaseous radioactive effluents, the liquid waste storage system, the gamma spectrometry laboratory, the solid waste storage area, and the dose rate meter installed in the garden.

> *The system in place to monitor gaseous and liquid radioactive effluents as well as solid radioactive waste seems adequate. The verification did not give rise to comments or recommendations.*

The verification team was invited to participate in the patient preparation for a PET/CT procedure, including the preparation of the syringe with its filling with radiopharmaceuticals and the application of the radiopharmaceutical to the patient.

> *The system in place to ensure safe handling of the radiopharmaceuticals seems adequate. The verification did not give rise to comments or recommendations.*

7. CONCLUSIONS

All verifications that had been planned by the verification team were completed successfully. The team wishes to indicate its appreciation of the quality and the comprehensiveness of the information supplied to them before the visit.

At a number of points in the report reference is made to the sampling programme and specific measures in place at the Paks NPP. This information is provided to ensure an overall view of the situation in Hungary and was not the object of verification. An earlier report, reference HU/04/4 deals with this aspect in greater detail.

A summary overview of the verification findings and related recommendations will be compiled in the 'Main Findings' document that is addressed to the Hungarian competent authorities through the Hungarian Permanent Representative to the European Union.

The present Technical Report is to be enclosed with the Main Findings.

The information provided and the verification findings led 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 with regard to the surveillance of the Hungarian territory are adequate. The Commission could verify the operation and efficiency of these facilities.

The verification team noted the comprehensiveness of the systems currently in place and supports all efforts, budgetary or otherwise, to ensure that the current high standard is maintained.

<u>With respect to the national radiological early warning network</u>

(2) The verification activities demonstrated that the facilities necessary to carry out continuous monitoring of ambient gamma dose rates in Hungary are adequate. The Commission could verify the operation and efficiency of these facilities.

<u>With respect to the radiological surveillance programmes related to the nuclear medicine department of the State Health Centre in Budapest</u>

(3) The Commission noted the arrangements in place for the management of liquid radioactive discharges from the nuclear medicine department. Current Hungarian regulations require the monitoring of liquid radioactive discharges and the installation of a separate drainage system with adequate delay tanks only in case of thyroid cancer metastases treatment with applied I-131 activities of more than 550 MBq per patient.

(4) The verification activities have shown that there are no cancer treatments with I-131 activities above 550 MBq/patient in the nuclear medicine department of the State Health Centre, therefore neither a discharge monitoring programme nor on-site or off-site environmental monitoring programmes are required.

<u>With respect to the radiological surveillance programmes related to the PET/CT Diagnostic Centre with Cyclotron – Pozitron-Diagnosztika Ltd.:</u>

(5) The verification activities demonstrated that the facilities necessary to carry out continuous monitoring of gaseous and liquid radioactive discharges from Pozitron-Diagnosztika Ltd. are adequate. The Commission could verify the operation and efficiency of the facilities visited.

(6) The verification activities demonstrated that the installation to continuously monitor ambient dose rate in the vicinity of Pozitron-Diagnosztika Ltd is adequate. The Commission could verify the operation and efficiency of the facility.

Final remarks:

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

APPENDIX 1

THE VERIFICATION PROGRAMME – SUMMARY OVERVIEW

Monday 17/05

Verification team travel Luxembourg-Budapest

Tuesday 18/05

9.00 Opening meeting at Hungarian Atomic Energy Authority,: introduction and presentation.

13.00 Team 1 starts verification of the national monitoring network (Central Hungarian Regional Institute of NPHMOS).

12.00 Team 2 visit State Health Centre in Budapest to verify discharge monitoring. Presentation of verification activities to hospital authorities.

Wednesday 19/05

9.00 Team 1 continues verification of the national monitoring network (Mohi sub-programme).

9.00 Team 2 NREWMS

12.00 Team 2 visit PET/CT Centre in Budapest to verify discharge monitoring. Presentation of verification activities to hospital authorities.

Thursday 20/05

9.00 Team 1 NRIRR laboratories.

Team 2 RMN of MARD laboratories.

Both teams will look at samples handling, archiving and procedures and the actual analysis of samples

16.30 Closing meeting at Hungarian Atomic Energy Authority with all actors involved to present activities performed during the verification and a first analysis of the findings.

Friday 21/05

Verification team travel Budapest-Luxembourg-

Team 1: **P. VALLET**
A. RYAN

Team 2: **S. MUNDIGL (Team leader)**
R. BARANCZYK (trainee)

APPENDIX 2

DOCUMENTATION RECEIVED

Note: The list does not include various other documents that were asked for (and received) during the verification activities such as calibration certificates, standard operation procedures, quality assurance procedures, source records and measurement results, technical drawings, legislative texts, reports.

1. Decree of the Minister of Environment No. 15/2001.(VI.6.) on Radioactive Releases to the Atmosphere and into Waters in the Course of Using Atomic Energy and their Monitoring.

APPENDIX 3

The main monitoring programme of RAMDAN

SAMPLES		Sampling		Annual number of measurements					
		site	time	gross beta	^{40}K	^{3}H	^{90}Sr	gamma spectrometry	gamma dose rate
Aerosol		ME	(1,2)	(1,2)	-	-	-	(1,2)	-
Dose rate (3)		ME	Monday 09:00	-	-	-	-	-	52
Fallout		ME	monthly	12	-	-	-	12	-
Soil		CC	quarterly	-	-	-	-	4(a)	-
Grass	Hay	CC	1st, 4th quarter	2(a)	2(a,b)	-	-	2(a,c)	-
	Raw grass	CC	2nd, 3rd quarter	2(a)	2(a,b)	-	-	2(a,c)	-
Surface water	Lake	CC	quarterly	4(a)	4(a,b)	-	-	2(a,d)	-
	River	CC	monthly	12(a)	12(a,b)	-	-	2(a,d)	-
Cereals	Maize	ME	1st quarter	1	1(b)	-	-	1	-
	Rice	ME	2nd quarter	1	1(b)	-	-	1	-
	Wheat	ME	3rd quarter	1	1(b)	-	-	1	-
	Barley	ME	4th quarter	1	1(b)	-	-	1	-
Vegetables	Potato	ME	1st quarter	1	1(b)	-	-	1	-
	Onion	ME	1st quarter	1	1(b)	-	-	1	-
	Lettuce	ME	2nd quarter	1	1(b)	-	-	1	-
	Spinach (sorrel)	ME	2nd quarter	1	1(b)	-	-	1	-
	Cucumber	ME	3rd quarter	1	1(b)	-	-	1	-
	Green pepper	ME	3rd quarter	1	1(b)	-	-	1	-
	Tomato	ME	3rd quarter	1	1(b)	-	-	1	-
	Cabbage	ME	4th quarter	1	1(b)	-	-	1	-
	Carrot	ME	4th quarter	1	1(b)	-	-	1	-
	Pumpkin	ME	4th quarter	1	1(b)	-	-	1	-
Fruit	Apple	ME	1st quarter	1	1(b)	-	-	1	-
	Pear	ME	1st quarter	1	1(b)	-	-	1	-
	Banana	ME	2nd quarter	1	1(b)	-	-	1	-
	(Sour) cherry	ME	2nd quarter	1	1(b)	-	-	1	-
	Strawberry	ME	2nd quarter	1	1(b)	-	-	1	-
	Peach	ME	3rd quarter	1	1(b)	-	-	1	-
	Orange	ME	4th quarter	1	1(b)	-	-	1	-
	Grapes	ME	4th quarter	1	1(b)	-	-	1	-
Milk		ME	monthly	12	12(b)	-	4(c)	4(c)	-
Milk products	Cheese	ME	1st, 4th, 7th, 10th month	4	4(b)	-	-	2(d)	-
	Cottage cheese	ME	2nd, 5th, 8th, 11th month	4	4(b)	-	-	2(d)	-
	Milk powder	ME	3rd, 6th, 9th, 12th month	4	4(b)	-	-	2(d)	-

SAMPLES		Sampling site	Sampling time	Annual number of measurements: gross beta	^{40}K	^{90}Sr	gamma spectrometry	gamma dose rate
Meat	Beef	ME	1st, 7th month	2	2(b)	-	-	2
	Pork	ME	2nd, 5th, 8th, 11th month	4	4(b)	-	-	2(d)
	Chicken	ME	3rd, 6th, 9th, 12th month	4	4(b)	-	-	2(d)
	Fish (4)	ME	4th, 10th month	2	2(b)	-	-	2
Egg		ME	quarterly	4	4(b)	-	-	2(d)
Bread		ME	monthly	12	12(b)	-	-	4(c)
Mineral water		ME	quarterly	4	4(b)	-	-	-
Drinking water		CC	quarterly	4(a)	4(a,b)	-	-	1(a,e)
		CC	3rd, 9th month	-	-	2(a,NRIRR)	2(a)	-
Mixed diet		ME	3rd, 9th month	-	-	-	2	2

List of symbols

ME = Medium level laboratory
CC = Counties of competence
(a) = multiplied by the number of counties of competence (number of sampling locations)
(b) = according to the guide issued in 2005
(c) = on the ash of samples accumulated quarterly
(d) = on the ash of samples accumulated over half a year
(e) = on the ash of samples accumulated yearly
(1) = for laboratories equipped with an air sampler of medium air volume flow (HUNTER medium volume air samplers):

- Sampling frequency:
  - October 1st - April 30th: 1 per week
  - May 1st - September 30th: 1 or 2 per two weeks
- Sampling duration:
  - October 1st - April 30th: 2-7 days
  - May 1st - September 30th: 5-14 days
- Activity measurement by gamma spectrometry with a semiconductor detector. Due to the long sampling duration it is not reasonable to measure the beta activity of such samples as the natural isotopes decay away during sampling. Therefore, it could not be compared to the beta activity of samples collected over one day.
- Annual number of samples: min. 40

(2) = for laboratories equipped with an installed or portable air sampler of small air volume flow:

- Sampling frequency: at least 1 per week

- Sampling duration: maximum 24 hours
- Activity measurement: gross beta activity
- Annual number of samples: 52-365

(3) = dose rate measurements at one location for each laboratory equipped with a Berthold UMO dose rate meter:

- height: 1 m
- measurement duration: 30 min

(4) = frozen fish in April, Hungarian common carp or bighead carp fillet in October

APPENDIX 4

The monitoring programme performed by the South Transdanubian Regional Institute of NPHMOS for JERMS

Samples	Sampling location	Sampling frequency	Annual number of samples	Type of measurements	Annual number of investigations
Aerosol (low volume air sampler)	Szekszárd	daily	Working days	gross β	cca. 150
Aerosol (low volume air sampler)	Csámpa	weekly	52	gross β	52
Aerosol (low volume air sampler)	Dunaföldvár	weekly	52	gross β	52
Aerosol (low volume air sampler)	Kalocsa	weekly	52	gross β	52
Aerosol (medium volume air sampler)	Szekszárd	weekly	52		52
Fall-out	Szekszárd	monthly	12	gross β, Gamma spectrometry	12 12
Fall-out	Csámpa	monthly	12	gross β, Gamma spectrometry	12 12
Fall-out	Dunaföldvár	monthly	12	gross β, Gamma spectrometry	12 12
Fall-out	Kalocsa	monthly	12	gross β, Gamma spectrometry	12 12
Drinking water	Szekszárd	monthly	12	gross β, H-3	12 12
Drinking water	NPP Paks	monthly	12	gross β, H-3	12 12
Drinking water	Paks Kápolna út	monthly	12	gross β	12
Drinking water	Dunaföldvár	monthly	12	gross β	12
Drinking water	Kalocsa	monthly	12	gross β	12
Drinking water	Szekszárd	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Drinking water	NPP Paks	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Drinking water	Paks Kápolna út	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4

Samples	Sampling location	Sampling frequency	Annual number of samples	Type of measurements	Annual number of investigations
Drinking water	Dunaföldvár	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 ,4
Drinking water	Kalocsa	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Surface water (river Danube)	Gerjen	monthly	12	gross β, H-3	12 12
Surface water (river Danube)	Paks	monthly	12	gross β	12
Surface water (river Danube)	Dunaföldvár	monthly	12	gross β, H-3	12 12
Surface water (river Danube)	Kalocsa	monthly	12	gross β	12
Surface water (lake)	Lake Paks-Kondor	monthly	12	gross β	12
Surface water (lake)	Dombori (holt Duna-ág)	monthly	12	gross β	12
Surface water (lake)	Lake Szelidi	monthly	12	gross β	12
Surface water (river Danube)	Gerjen	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Surface water (river Danube)	Paks	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Surface water (river Danube)	Dunaföldvár	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Surface water (river Danube)	Kalocsa	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Surface water (lake)	Lake Paks-Kondor	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4

Samples	Sampling location	Sampling frequency	Annual number of samples	Type of measurements	Annual number of investigations
Surface water (lake)	Dombori (holt Duna-ág)	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Surface water (lake)	Lake Szelidi	quarterly	4	Gamma spectrometry, Sr-90 (radiochemical separation)	4 4
Soil	Csámpa	monthly	12	Gamma spectrometry	12
Soil	Paks	monthly	12	Gamma spectrometry	12
Soil	Dunaföldvár	monthly	12	Gamma spectrometry	12
Soil	Dombori	monthly	12	Gamma spectrometry	12
Soil	Kalocsa	monthly	12	Gamma spectrometry	12
Soil	Csámpa	quarterly	4	Sr-90 (radiochemical separation)	4
Soil	Paks	quarterly	4	Sr-90 (radiochemical separation)	4
Soil	Dunaföldvár	quarterly	4	Sr-90 (radiochemical separation)	4
Soil	Dombori	quarterly	4	Sr-90 (radiochemical separation)	4
Soil	Kalocsa	quarterly	4	Sr-90 (radiochemical separation)	4
Sediment	Gerjen-Duna	monthly	12	Gamma spectrometry	12
Sediment	Paks-Duna	monthly	12	Gamma spectrometry	12
Sediment	Dunaföldvár-Duna	monthly	12	Gamma spektr	12
Sediment	Kalocsa-Duna	monthly	12	Gamma spectrometry	12
Sediment	Dombori holt Duna ág	monthly	12	Gamma spectrometry	12
Sediment	Lake Szelidi	monthly	12	Gamma spectrometry	12
Sediment	Gerjen-Duna	quarterly	4	Sr-90 (radiochemical separation)	4

Samples	Sampling location	Sampling frequency	Annual number of samples	Type of measurements	Annual number of investigations
Sediment	Paks Duna	quarterly	4	Sr-90 (radiochemical separation)	4
Sediment	Dunaföldvár-Duna	quarterly	4	Sr-90 (radiochemical separation)	4
Sediment	Kalocsa-Duna	quarterly	4	Sr-90 (radiochemical separation)	4
Sediment	Dombori holt Duna ág	quarterly	4	Sr-90 (radiochemical separation)	4
Sediment	Lake Szelidi	quarterly	4	Sr-90 (radiochemical separation)	4
Cow milk (raw)	Szekszárd	monthly	12	gross β Gamma spektr	12 12
Cow milk (raw)	Duna-szentgyörgy	monthly	12	gross β Gamma spektr	12 12
Cow milk (raw)	Fajsz	monthly	12	gross β Gamma spektr	12 12
Cow milk (raw)	Szekszárd	quarterly	4	Sr-90 (radiochemical separation), Gamma spectrometry	4 4
Cow milk (raw)	Duna-szentgyörgy	quarterly	4	Sr-90 (radiochemical separation), Gamma spectrometry	4 4
Cow milk (raw)	Fajsz	quarterly	4	Sr-90 (radiochemical separation), Gamma spectrometry	4 4

APPENDIX 5

Paks statutory environmental sampling programme

Samples	Location Sampling frequency	Preparation	Geometry	Method	Measuring time (second)	Detection limit
Aerosol (small volume samplesr)	A1-A9 and B24 weekly	-	∅ 25 mm	Gross-beta	6 000	0.3 mBq/m^3
Iodine filter cartridge	A1-A9 and B24 monthly	-	∅ 60 x 25 mm	Gamma-spectroscopy	20 000	1 mBq/m^3
Aerosol (high volume samplesr)	A1-A9 and B24 weekly	-	∅ 40 x 4 mm	Gamma-spectroscopy	50 000	1 µBq/m^3
Iodine filter (PACI filter)	A1-A9 and B24 monthly	-	∅ 50 x 50 x30 mm	Gamma-spectroscopy	20 000	0.01 mBq/m^3
Dry and wet deposition	A1-A9 and B24 monthly	evaporation	35 x 35 x 5 mm	Gamma-spectroscopy	50 000	0.1 Bq/(m^2month)
Air: HT and HTO	A1, 3, 4, 6, 8, 9, and B24 monthly	desorption	20 cm^3 vial	liquid scintillation	60 000	1 mBq/m^3
air: CO_2 and C_nH_m	A1, 3, 4, 6, 8, 9, and B24 monthly	chemical separation	proportional chamber	beta-counting	50 000	0.1 mBq/m^3
Soil	A1-A9 and B24 0-5 and 5-10 cm annually	drying, griding, homogenisation, radiochemistry (^{90}Sr)	Marinelli (~1-2 kg) 50 mm tray	Gamma-spectroscopy beta-counting	20 000 10 000	0.5 Bq/kg 0.5 Bq/kg
Grass	A1-A9 and B24 2nd and 4th quarter	drying, griding, homogenisation, radiochemistry (^{90}Sr)	Marinelli (~1-2 kg) 50 mm tray	Gamma-spectroscopy beta-counting	80 000 10 000	0.5 Bq/kg 0.5 Bq/kg

Samples	**Location Sampling frequency**	**Preparation**	**Geometry**	**Method**	**Measuring time (second)**	**Detection limit**
Milk	monthly	-	Marinelli ($1,5\ dm^3$)	Gamma-spectroscopy	50 000	$0.5\ mBq/dm^3$
Fish	quarterly	raw fish measurement	Marinelli (~1 kg)	Gamma-spectroscopy	50 000	0.5 Bq/kg
TLD dose	A, B, C, SFISF monthly	-	Al_2O_3 chip	TL reading	60	10 µSv/month
Surface contamination	A1-A9 and B24 annually	-	in-situ	Gamma-spectroscopy	5 000	$30\ Bq/m^2$
Ground level dose rate	A1-A9 and B24 annually	-	in-situ	scint. detector GM tube	5 000	5 nGy/h
Water (inlet and outlet channels)	V1, V2 and V3 daily	evaporation ($300\ cm^3$) monthly average radiochemistry (^{90}Sr) distillation (^3H)	∅ 60 mm tray ∅ 30 x 30 x 5 mm ∅ 60 mm tray $20\ cm^3$ vial	Gross-beta Gamma-spectroscopy Beta-counting Liquid scintillation	10 000 50 000 50 000 18 000	$0.05\ Bq/dm^3$ $0,005\ Bq/dm^3$ $0.001\ Bq/dm^3$ $1\ Bq/dm^3$
Ground water	40 wells monthly	distillation (^3H) evaporation ($300\ cm^3$)	$20\ cm^3$ vial ∅ 60 x 30 mm ∅ 60 mm tray	Liquid scintillation Gamma-spectroscopy Beta-counting	18 000 50 000 50 000	$1\ Bq/dm^3$ $0.005\ Bq/dm^3$ $0.001\ Bq/dm^3$
Fishing ponds water	4 ponds quarterly	evaporation ($500\ cm^3$) distillation (^3H) yearly average ($4\ dm^3$)	∅ 60 mm tray $20\ cm^3$ vial ∅ 30 x 30 x 5 mm	Gross-beta Liquid scintillation Gamma-spectroscopy	10 000 18 000 50 000	$0.05\ Bq/dm^3$ $1\ Bq/dm^3$ $0.01\ Bq/dm^3$

Samples	**Location Sampling frequency**	**Preparation**	**Geometry**	**Method**	**Measuring time (second)**	**Detection limit**
Water	ditch ring (4 loc) quarterly at Fadd monthly	evaporation ($500cm^3$) distillation (^3H) yearly average ($4\ dm^3$)	∅ 60 mm tray $20\ cm^3$ vial ∅ 30 x 30 x 5 mm	Gross-beta Liquid scintillation Gamma-spectroscopy	10 000 18 000 50 000	$0.05\ Bq/dm^3$ $1\ Bq/dm^3$ $0.01\ Bq/dm^3$
Water	lime mud ponds 2 locations quarterly	evaporation ($500cm^3$) distillation (^3H) yearly average ($4\ dm^3$)	∅ 60 mm tray $20\ cm^3$ vial ∅ 30 x 30 x 5 mm	Gross-beta Liquid scintillation Gamma-spectroscopy	10 000 18 000 50 000	$0.05\ Bq/dm^3$ $1\ Bq/dm^3$ $0.01\ Bq/dm^3$
Danube sediment	3 locations semmi-annually	drying, griding, homogenisation, radiochemistry (^{90}Sr)	Marinelli (~2 kg) ∅ 50 mm tray	Gross-beta Beta-counting	20 000 10 000	0.5 Bq/kg 0.5 Bq/kg
Fishing and sediment	4 ponds annually	wet homogenisation	Marinelli (~2 kg)	Gamma-spectroscopy	20 000	0.5 Bq/kg
Sediment	ditch ring, Fadd drain (4 loc) semi-annually	wet homogenisation	Marinelli (~2 kg)	Gamma-spectroscopy	20 000	0.5 Bq/kg
Lime mud ponds	2 ponds semi-annually	wet homogenisation	Marinelli (~2 kg)	Gamma-spectroscopy	20 000	0.5 Bq/kg
Defecation mud	10 dehumidifiers before removal	homogenisation	Marinelli (~2 kg)	Gamma-spectroscopy	5 000	2 Bq/kg