EUROPEAN COMMISSION
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DIRECTORATE H - Nuclear Energy
Radiation Protection

TECHNICAL REPORT

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

PORTUGAL

20 to 24 November 2006

Reference: PT-06/7

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

FACILITIES:	- Installations for monitoring and controlling radioactive discharges and for surveillance of the environment in Portugal during normal operations of the Reactor Português de Investigação (RPI – the Portuguese Research Reactor), located on the Sacavém campus of the Instituto Tecnológico e Nuclear (ITN - Nuclear and Technology Institute). - Installations for radiological early warning as operated by the Instituto do Ambiente (IA – the Environment Institute). - Installations for monitoring and controlling levels of radioactivity around former Uranium mines in Portugal.
SITES:	- RPI: Sacavém, outskirts of Lisbon. - Uranium mines: Urgeiriça, near Viseu.
DATE:	20 to 24 November 2006
REFERENCE:	PT-06/7
VERIFICATION TEAM:	Mr A. JANSSENS (Head of team) Ms B. ANDRES ORDAX Mr S. VAN DER STRICHT Mr P. VALLET
DATE OF REPORT:	5 July 2007

SIGNATURES:

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1 ABBREVIATIONS

IAEA	International Atomic Energy Agency
CIPRSN	"Comissão Independente para a Protecção Radiológica e Segurança Nuclear" – Independent Radiation Protection and Nuclear Safety Commission
CNPR	"Comissão Nacional de Protecção contra Radiações" – National Radiation Protection Commission (of the DGS)
DGAE	"Direcção-Geral dos Assuntos Europeus" – Directorate-general for European Affairs (of the MNE)
DGGE	"Direcção-Geral de Geologia e Energia" – Directorate-general for Geology and Energy (of the MEI)
DGS	"Direcção-Geral da Saúde" – Directorate-general for Health (of the MS)
DG TREN	Directorate general Transport and Energy (of the EC)
DPRSN	"Departamento de Protecção Radiológica e Segurança Nuclear" – Radiation Protection and Nuclear Safety Department (of the ITN)
EC	European Commission
EMD	"Empresa de Desenvolvimento Mineiro SA" – the state enterprise for the restoration of mining sites
GRICES	"Gabinete de Relações Internacionais da Ciência e do Ensino Superior" – Office for International Relations in Science and Higher Education (of the MCTES)
HPGe	High Purity Germanium (detector)
IA	"Instituto do Ambiente" – Environment Institute (of the MAOTDR)
ITN	"Instituto Tecnológico e Nuclear" – Nuclear and Technology Institute (of the MCTES)
MAOTDR	"Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional" – Ministry of the Environment, Territorial Planning and Regional Development
MCTES	"Ministério da Ciência, Tecnologia e Ensino Superior" – Ministry of Science, Technology and Higher Education
MEI	"Ministério da Economia e da Inovação" – Ministry of Economy and Innovation
MNE	"Ministério dos Negócios Estrangeiros" – Ministry of Foreign Affairs
MS	"Ministério da Saúde" – Ministry of Health
RADNET	"Rede de Alerta de Radioactividade no Ar" – the national early warning network for airborne radioactivity (operated by the IA)
RPI	"Reactor Português de Investigação" – Portuguese Research Reactor (of the ITN)
TLD	Thermoluminescent dosimeter
TREN H4	The Radiation Protection Unit (of the EC)

2 INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State shall establish 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 Transport and Energy (DG TREN) and more in particular its Radiation Protection Unit (TREN H4) 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.

A verification team from DG TREN visited (20 to 22 November 2006) the site of the former uranium mine located at the township of Urgeiriça, near the city of Viseu, in the north-east of Portugal. The site is operated by the Empresa de Desenvolvimento Mineiro SA, the state enterprise for the restoration of former mining sites.

The team also visited (22 to 24 November 2006) the site of the Portuguese Research Reactor (RPI) located on the banks of the river Tagus near Lisbon. The site is operated by ITN, the Nuclear and Technology Institute of the Ministry of Science & Technology. The ITN site also houses the Radiation Protection and Nuclear Safety Department (DPRSN) that is in charge of implementing the national radiological surveillance programme. At Lisbon the visit also included the RADNET early warning network operated by the Environment Institute.

The visit included meetings with representatives of various national authorities having competence in the field of radiation protection. An opening and a closing meeting were held, with all parties involved during the visit, on the premises of Ministry of Foreign Affairs at Lisbon.

The scope of the mission addressed two distinct topics: firstly and mainly the purely technical aspects related to Article 35 of the Treaty (radiological surveillance) and secondly, during a meeting with the competent authorities, legal aspects concerning the licensing and discharge authorisation of the RPI as well as the transposition of Community legislation into Portuguese law. In both cases the recommendations made during the 2002 verification visit ([2]) were given due follow-up by the verification team.

The present report contains the results of the verification team's review of relevant aspects of the radiological environmental surveillance on and around the site of the former Urgeiriça uranium mine and the site of the RPI, as well as parts of the national radiological surveillance in Portugal.

The present report is also based on information collected from documents received and from discussions with various persons met during the visit.

[1] Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the health protection of the general public and workers against the dangers of ionizing radiation. (OJ L-159 of 29/06/1996 page 1).

[2] The first verification under Article 35 of the Euratom Treaty that was conducted in Portugal took place in May 2002. The Main Findings and Technical Report can be consulted at: http://ec.europa.eu/energy/nuclear/radioprotection/verification_en.htm

3 PREPARATION AND CONDUCT OF THE VERIFICATION

3.1 Preamble

The Commission's decision to request the conduct of an Article 35 verification was notified to the Portuguese Permanent Representation to the European Union by letter TREN.H4 SVdS/ab D(2006) 219281 dated 20 September 2006.

Subsequently the Portuguese Ministry of Foreign Affairs, more in particular its Directorate-general for Community Affairs, together with the Portuguese Permanent Representation to the Union, efficiently acted as co-ordinators and thus ensured not only that the verification programme could be implemented to its full extent but also that all ministries involved in matters of radiation protection relevant to the mission were present and available during the week.

3.2 Programme of the visit

During the opening meeting held on 20 November the programme of verification activities was discussed and finalised.

The agreed programme comprised:

- A visit to the former Urgeiriça uranium mine to verify the local radiological sampling and monitoring devices. At the location the verification team would be extensively briefed on the national plan for the rehabilitation of former uranium mining sites.
- The verification of liquid and gaseous radioactive discharges from the RPI (sampling and monitoring systems, analytical methods, quality assurance and control aspects, reporting). The activities also encompassed a follow-up of the recommendations made by the 2002 verification team.
- The verification of the RPI site-related environmental radiological monitoring programme as implemented by the operator (sampling and monitoring systems, analytical methods, quality assurance and control aspects, reporting). The activities also encompassed a follow-up of the recommendations made by the 2002 verification team.
- Verification activities at the DPRSN environmental laboratories, also addressing the follow-up given to the 2002 recommendations.
- Verification of the RADNET national surveillance network station located at Lisbon airport, system operated by the IA (the Environment Institute), as well as a visit to the central RADNET control room and data centre on the premises of the IA.
- A meeting to review and discuss the following legal issues with the Portuguese authorities ([3]):
  i. The licensing of the RPI and related discharge authorisation.
  ii. Compliance with the Basic Safety Standards.

A summary overview of the programme of verification activities is provided in Appendix 1.

The verifications were carried out in accordance with the programme.

[3] In 2002 the verification team observed that, contrary to the provisions of the Basic Safety Standards: (a) no operating licence with discharge authorisation had been granted to the RPI; (b) the operator had not put in place a statutory discharge monitoring programme nor a statutory site-related environmental monitoring programme; (c) no independent regulatory control was carried out in order to enforce the operator's statutory obligations. Concerning the implementation of Article 35 of the Euratom Treaty it was observed that no regulatory framework for a national environmental monitoring programme existed.

3.3 Documentation

In order to facilitate the work of the verification team, a package of information was supplied in advance by the Portuguese authorities. 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 the report.

3.4 Representatives of the competent authorities and the operator

During the verification visit, the following representatives of the national authorities and the operator were met:

The Ministry of Foreign Affairs:

Ms. Maria JOÃO BOTELHO	Deputy Director-general DGAE
Ms. Lénia REAL	Director Internal Market DGAE
Ms. Adelaide CARDOSO	Department for the Internal Market DGAE
Mr. Bernardo RIBEIRO DE CUNHA	Department for Legal Affairs DGAE
Ms. Joana BORGES CAPELA	Department for Legal Affairs DGAE

The Ministry of Economy:

Mr. Carlos A. CAXARIA	Deputy Director-general DGGE
Mr. Avelino RODRIGUES	
Mr. Luís MARTINS	
Ms. Donzília SANTO	

The Ministry of Health:

Mr. José ROBALO	Deputy Director-general DGS
Mr. Pedro ROSÁRIO	

The Ministry of Environment, Territorial Planning and Regional Development:

Ms. Fernanada SANTIAGO	Vice-president of the Environment Institute
Mr. João OLIVEIRA MARTINS	
Ms. Maria DO CARMO PALMA	
Ms. Ana Cristina CARREIRAS	

The Ministry of Science, Technology and Higher Education:

Ms. Maria DE FÁTIMA BRAVO	Deputy Director - Office for International Relations in Science and Higher Education (GRICES)

The Nuclear and Technology Institute:

Mr. Júlio M. MONTALVÃO E SILVA	ITN President
Mr. Manuel LEITE DE ALMEIDA	ITN Vice-president
Mr. José MARQUES	RPI
Mr. Andres KLING	RPI
Ms. Rita RAMOS	RPI
Mr. Carlos OLIVEIRA	DPRSN
Mr. Romão TRINDADE	DPRSN
Ms. Maria José MADRUGA	DPRSN
Mr. Fernando DA PIEDADE CARVALHO	DPRSN
Mr. Mário REIS	DPRSN
Mr. Nuno PINHÃO	DPRSN
Mr. João ALVES	DPRSN

Staff of the Empresa de Desenvolvimento Mineiro SA:

Mr. J.M. GASPAR NERO	Administrator
Ms. Sofía BARBOSA	Geological engineer
Ms. Helena GOMES	Environmental engineer
Mr. Armando CORREIA	Environmental engineer
Mr. Duarte BARROS	Civil engineer
Mr. Rui PINTO	Environmental engineer
Mr. José MATOS DIAS	Coimbra University – Department of Earth Sciences
Mr. A. PEREIRA	Coimbra University – Department of Earth Sciences
Mr. J. GUIMAS	Geologist
Mr. J. BALTAZAR	Geotechnical engineer

4 LEGISLATION AND COMPETENT AUTHORITIES

The following legal instruments currently provide the basis for radiation protection in Portugal, relevant in the framework of the verification activities performed:

- Decreto-Lei Nr 165/2002 of 17 July 2002: decree transposing Council Directive 96/29/Euratom (Basic Safety Standards) into Portuguese law.

  This act covers the Radiation Protection principles, identifies the practices subject to authorisation/declaration and defines the regulatory competencies of the administrations. With respect to the latter (summarised):

  i. The Directorate-general for Geology and Energy (DGGE) is the licensing authority for practices within the nuclear fuel cycle.

  ii. The Directorate-general for Health is the licensing authority for practices outside the nuclear fuel cycle.

  iii. The Ministries of Economy and Environment, in conjunction, are responsible for the remediation of former Uranium mining activities.

  iv. The ITN (the Nuclear and Technology Institute) for the implementation of the national radiological surveillance programme of the environment (including the food chain).

  v. The IA (the Environment Institute) for the implementation of the national radiological early warning network.

  vi. The CNPR (the National Radiation Protection Commission) acting as a high-level consultative body empowered to issue opinions or formulate recommendations on all matters, legal and practical, having a bearing on radiation protection.

- Decreto-Lei Nr 138/2005 of 17 August 2005: transposition of Commission Recommendation 2000/473/Euratom on the application of Article 36 of the Euratom Treaty.

- Decreto-Lei Nr 139/2005 of 17 August 2005 creating the CIPRSN (Independent Radiation Protection and Nuclear Safety Commission) as replacement of the CNPR and re-defining its competencies. The five members of this new Commission are appointed directly by the Prime Minister, following advice by the Ministers of Environment, Health and Science. The objective of the Commission is to evaluate the regulatory system, propose legislation and issue recommendations to the regulatory authorities concerning the national policies for radiation protection and nuclear safety.

5 CONTROL OF RADIOACTIVE DISCHARGES

5.1 Introduction

- The reactor

The RPI is a pool type research reactor with a nominal thermal power of 1 MW moderated with water. The reactor is fuelled with 93 % U-235 enriched U-Al elements and produces a maximal neutron flux of 2 E+13 n/cm²/s. Be blocks, H_2O and graphite are used as reflectors and the shielding consists of H_2O, Pb, barites and regular concrete.

- Regulatory control

The General Directorate for Energy (currently Directorate-general for Geology and Energy, abbreviated DGGE) was designated licensing authority for activities within the nuclear fuel cycle by Decree-Law 165/2002, of July 17, 2002. The RPI received an operating license from the DGGE on December 27, 2005. This license does however not formally limit the quantities of airborne radioactivity the RPI is entitled to discharge into the environment (absence of an explicit discharge authorisation). In what concerns liquid discharge limits, the licence now accepts the limits proposed by the operator of the RPI.

The first-level body currently controlling the operations of the RPI is the ITN Safety Commission. This Commission, nominated by the Minister of Science, is fully separated and "independent" from RPI operations and reports to the President of the ITN who, in turn, reports to the DGGE. The highest level of control rests with the Independent Radiation Protection and Nuclear Safety Commission, created in 2005 by Decree-Law 139/2005, reporting to the Prime Minister.

The DGGE, as licensing authority, does however not have in place provisions for an independent regulatory control and enforcement of the operator's statutory obligations; more in particular where it concerns airborne and liquid discharges of activity into the environment.

In the framework of the planned RPI core conversion from high to low enriched uranium fuel the ITN is in the process of applying for an operating license revision. It is noted that this application will submit, for formal approval, and for the first time, discharge limits for liquid as well as gaseous effluents. The licensing procedure for the operation of the converted reactor is expected to be completed by June 2007.

5.2 Provisions for monitoring/sampling of airborne discharges

5.2.1 Discharge limits

Currently there are no regulatory and enforceable limits for airborne discharges from the RPI. The application (in 2007) for an amended operating license will, however, propose appropriately justified airborne discharge limits for validation by the licensing authority. It is understood that this application will address yearly discharge limits for noble gases, particulate matter, Iodine-131 and Tritium.

5.2.2 Monitoring and sampling provisions

- Monitoring

Gaseous discharges from the RPI are released through a stack of 20 m height with a nominal stack flow rate of 3700 m³/h. Prior to release into the stack the air extracted from the RPI is passed through absolute filters.

The RPI stack is equipped with an IAEA AIRMON-91 continuous monitoring system for beta/gamma particulates, iodine (elemental fraction) and noble gases (mainly Ar-41 - scintillation detector mounted inside the stack). The system integrates and registers volumic activities in one-hour cycles. This system was installed in 1991.

An additional I-131 Monitor, model IM 201S (MGP Instruments), was commissioned in 2005, in order to continuously measure total iodine (both in elemental and particulate form). The spectral analysis provided by the system allows the subtraction of background contribution and therefore, in comparison to the AIRMON-91, improves the assessment of I-131 releases. This monitor was supplied with calibration sources and a written calibration procedure.

Characteristics:	detector	NaI (TI) scintillator
	cartridge type	activated charcoal
	measurement cycle	one minute
	measurement range	3.7 to 3.7 E+06 Bq/m^3

An additional aerosol monitor, model ABPM 201L (MGP Instruments), has been delivered and the factory acceptance test was made in early October 2006. The system is planned to become operational during December 2006. The monitor was supplied with calibration sources and a written calibration procedure.

Characteristics:	detector	Silicon	
	filter type	FSLW	(ribbon filter - up to 6 months of autonomy)
	measurement range	alpha	1 E-02 to 1 E+04 Bq/m^3
		beta	1 to 1 E+07 Bq/m^3

- <u>Alarm levels</u>

The data obtained from the continuous monitoring of discharged activity concentrations are displayed in the reactor's operations control room. Visual and auditive alarm systems are present. The early warning and alarm thresholds are set as follows:

	Threshold values		
	I-131 (Bq/m^3)	Particulates (Bq/m^3)	Noble gases (Bq/min)
Warning 1	1.0E+06	1.0E+06	2.0E+07
Warning 2	5.0E+06	5.0E+06	4.0E+07
Alarm	1.0E+07	1.0E+07	5.0E+07

- <u>Sampling</u>

The charcoal cartridges (the latter exchanged monthly for the AIRMON-91 and weekly exchange for the IM 201S) are not submitted to laboratory analysis for discharge accountancy purposes. Only the data acquired and stored by the monitoring systems themselves are used to quantify and report the discharge of activity into the environment.

- <u>Tritium releases</u>

The release of Tritium is estimated by calculation. To that effect a quarterly sample of reactor pool water is taken and measured. The resulting activity concentration (the yearly average over the four samples) is then multiplied by the quantity of evaporated pool water. The latter quantity is assumed to be equal to the amount of fresh demineralised water needed to refill the pool over the same period.

- <u>Carbon-14 releases</u>

The release of C-14 is estimated by calculation. Tritium and C-14 are both produced by reactions of thermal neutrons with pool water constituents. Therefore a constant ratio for their production rates can be derived. Taking into account the decay and loss by evaporation a quasi-equilibrium value for the activity concentration ratio of Tritium and C-14 is obtained. The C-14 release is calculated by multiplying this ratio with the Tritium release.

5.3 Provisions for monitoring/sampling of liquid discharges

5.3.1 Discharge limits and sampling provisions

- At RPI level – operational control

The discharge limit that is currently applicable to liquid effluents from the RPI is set at 740 Bq/dm³. Liquid effluents from the RPI are collected in 4 tanks, 2 of which (2.5 m³) are reserved for radioactive effluents, the others (7.5 m³) for potentially radioactive arisings.

The contents of the liquid effluent tanks of the RPI are systematically sampled. These samples (0.25 dm³ taken after a one-hour homogenisation of the tank contents) are transferred to the Radiological Protection and Radioactive Waste Management Unit (RWU) of the DPRSN for measurement with a 3"x3" NaI(Tl) detector. The activity concentration results are returned to the RPI supervisor. The co-operation between RPI and RWU in these matters is a formalised client vs. service provider relationship. The analytical results obtained are compared by the RPI supervisor against the release limits (740 Bq/dm³) and if compliant, the effluent tanks are emptied towards the discharge tanks that are operated by the RWU. If above the release limit, the collected effluent must be retained for further decay or diluted until the appropriate level of activity concentration is reached.

- At DPRSN level – discharge control

The RWU operates 4 liquid effluent tanks of 50 m³: 3 as spare capacities, 1 as continuously monitored discharge tank. Only the latter tank can discharge into the environment (a pipeline towards the municipal water treatment plant), given that the activity concentration of its contents abides by the 740 Bq/dm³ limit.

The continuous monitoring system on the discharge tank (commissioned in 2005 – replacing the former manual sampling and analysis control procedure) consists of a submerged NaI(Tl) detector and associated electronics. The system cycles through one-hour acquisitions. Acquired data and calculated results as well as system parameters are stored in a database.

Prior to a discharge RWU personnel activates the tank recirculation system in order to homogenise its contents. After one hour of homogenisation a new acquisition cycle of the monitoring system is manually initiated. Recirculation is maintained throughout the one-hour acquisition period.

If the spectral analysis indicates that the activity concentration in the discharge tank is superior to 740 Bq/dm³ the contents of the tank are not discharged but transferred to the spare capacities for dilution or prolonged retention (further decay of activity levels).

- Future discharge limits

The application (in 2007) for an amended operating license will propose an appropriately justified liquid discharge limits for validation by the licensing authority. It is understood that this application will propose, in addition to the current activity concentration limit of 740 Bq/dm³, a yearly total beta/gamma activity discharge limit.

5.4 Independent monitoring of discharges

Independent monitoring of discharges is not implemented: Portugal has no regulatory authority inspectorate in place. The operator of the RPI does however produce a yearly report containing discharge information; this report is formally submitted to the Safety Commission. When approved by the latter the report is communicated to the licensing authority.

6 VERIFICATION ACTIVITIES - RADIOACTIVE DISCHARGES

6.1 Introduction

The verification team visited:

- The monitoring/sampling devices for airborne discharges.
- The discharge sentencing tanks and related monitoring/sampling devices for liquid discharges.
- The RPI operations control room.
- The analytical laboratory for discharge samples.

At these locations the team verified the degree of follow-up given to the recommendations made in the 2002 Main Findings.

6.2 Verification findings - airborne discharges

The verification team confirmed the existence and functionality of the monitoring and sampling provisions as described in section 5.2 above.

6.2.1 Recommendations 2002

- Recommendation 2002

The verification team observed that the hardware and software underlying the on-line stack control systems is somewhat out of date. In view of a possible breakdown of the hardware and the probable difficulties in obtaining spare parts should such a breakdown occur, it is recommended that the upgrade of the systems be addressed as a matter of priority. With respect to the software the operator mentioned that its replacement with more robust applications is intended for the year 2003. The verification team endorses this remedial action.

Findings 2006

(1) The hardware and software supporting the function of the AIRMON-91 has been upgraded.

(2) Additional monitoring systems were installed: an Iodine-131 monitor (IM 201 S) and an aerosol monitor (ABPM 201 L), the former being operational at the time of the verification, the latter being commissioned. Both state-of-the-art monitors are designed to be on-line with the RPI operations control room. Continuous sampling is ensured via single-nozzle isokinetic intakes, one for each system.

Conclusion The recommendation has been satisfactorily implemented.

- Recommendation 2002

The verification team noted that the calibration of the airborne discharge monitoring system has, since commissioning in 1992, never been submitted to verification. Hence, the reliability of the measurement results is questionable. Written quality assurance and quality control procedures are not available. It is recommended that adequate quality assurance and control procedures for the airborne discharge monitoring system be put in place.

Findings 2006

(3) Calibration setup and procedure for the AIRMON-91 noble gas monitor were locally developed and audited by the Safety Commission of the RPI. The procedure is in force and applicable once a year.

(4) The newly installed state-of-the-art I-131 monitor (in operation) and alpha/beta aerosol monitor (being commissioned) significantly enhance the monitoring capabilities on the airborne effluents from the RPI.

(5) A comprehensive system of written procedures for the use, maintenance and calibration of the various monitoring devices has been put in place.

Conclusion The recommendation has been satisfactorily implemented.

- Recommendation 2002

The verification team noted that particulate Iodine-131 and Tritium are not measured. Furthermore, Carbon-14, which is a significant contributor to dose is not measured nor calculated. It is recommended that nuclide-specific measurements be performed, and that consideration be given to the routine assessment of Carbon-14 and Tritium, at least by calculation.

Findings 2006

(6) The installation of the IM 201S iodine monitor remedies the lack of particulate iodine assessment capability.

(7) Tritium and C-14 releases are now calculated. Quarterly samples are taken from the RPI pool for Tritium assessment. The analytical results obtained, combined with the known evaporation rate of pool water, are used to estimate the gaseous release of Tritium. C-14 release is connected by calculation to the Tritium release.

(8) Both the new iodine (for particulate as well as elemental forms of iodine) and aerosol monitors (alpha/beta emitters), in case of triggered activity alarms, will automatically start up their spectrometers so as to assess individual radionuclides present on the sampling media (charcoal cartridge and ribbon filter respectively).

Conclusion The recommendation has been satisfactorily implemented.

- Recommendation 2002

The verification team noted the elevated alarm thresholds for airborne releases. It is recommended that alarm thresholds be set at levels that ensure adequate early warning capability.

Findings 2006

(9) The alarm levels were revised to ensure early warning capability and were approved by the Safety Commission of the RPI. All monitoring systems present are (or will be) relaying auditive and visual alarms into the operations control: functionality alarms as well as activity threshold transgressions.

Conclusion The recommendation has been satisfactorily implemented.

6.2.2 Further findings 2006

(10) The ITN is planning the commissioning of a diesel generator to provide back-up power supply in case of failure of the mains. The team was informed that this device may become operational during the year 2007.

Observation:

The verification team fully endorses the project of commissioning a guaranteed power supply system and it is suggested that the operational status of the device be achieved during the year 2007.

Final observation:

The verification team notes with satisfaction that the recommendations made in 2002 have encouraged ITN/RPI staff to make significant efforts in improving the airborne discharge monitoring capabilities and related quality assurance aspects.

6.3 Verification findings - liquid discharges

The verification team confirmed the existence and functionality of the monitoring and sampling provisions as described in section 5.3 above.

6.3.1 Recommendations 2002

- Recommendation 2002

The verification team noted with respect to the discharge tanks that written work instructions (procedures) are not available for sampling and discharge operations. It is recommended, for quality assurance and control purposes that written operating instructions and procedures are put in place.

Findings 2006

(1) The sampling + analysis procedure that existed in 2002 has been discontinued.

(2) The old methodology has been replaced with a continuous monitoring device.

(3) The implementation of quality controlled written operating instructions for the discharge procedure as well as for the use, maintenance and calibration of the monitoring device is not yet fully completed. The team was told that this work should be completed before the end of 2007.

(4) The verification team was informed that the continuous monitoring system, since its commissioning never had been calibrated again.

Conclusion The recommendation has to be maintained but needs to be complemented by the observation made under section 6.3.2 below.

The verification team recommends that, for quality assurance and control purposes, written procedures are established for the operation, maintenance and calibration of the sampling and monitoring systems for liquid discharges.

- Recommendation 2002

The verification team observed that the level indicators on the discharge tanks are not operational and that the volume discharged is systematically recorded as being at nominal tank capacity. The verification team also noted that if the analysis of a discharge tank sample returns an activity concentration below the detection limit of the measurement device, then the detection limit multiplied with the nominal tank capacity is recorded as activity discharged. This approach generates over-estimation of the amount of activity discharged. It is recommended that the functionality of the level indicators be restored in order to correctly record the volumes discharged and, in order the achieve more realistic assessments, that sample measurement values below detection limit be substituted with an appropriate fraction of the detection limit actually achieved.

Findings 2006

(5) The functionality of the level indicators has not been restored. The discharged volume continues to be systematically recorded as being at nominal capacity.

(6) The verification team was informed about plans to further improve the existing discharge control facility (see appendix 2, reference 23). The document proposes, *inter alia*, to equip the discharge tank with low and high level indicators as well as input and output flow meters.

Conclusion The recommendation has to be maintained but shall be reworded to take into account and endorse the planned improvements:

The verification team recommends that the discharge tank, as a matter of priority, be equipped with level indicators and flow meters. Such devices, in conjunction with the already installed activity monitoring system, will allow a more accurate and less conservative assessment of the activity discharged into the environment.

- Recommendation 2002

The verification team noted that discharge tank emptying into the public sewers is not alarmed and that transient contamination is likely to go unnoticed. It is recommended that the discharge tanks be fitted with a continuous monitoring device alarming the operator in case an activity limit transgression occurs during discharge operations

Findings 2006

(7) The sampling + analysis procedure that existed in 2002 has been discontinued.

(8) The old methodology has been replaced with a continuous monitoring device.

Conclusion The commissioning of a continuously operating monitoring system is a satisfactory response to the recommendation.

6.3.2 Further findings 2006

(9) Monitoring results vs. analytical results. Basing itself on the findings as described under section 6.3.1 (3) and (4), the verification team believes that it would be beneficial from a QA/QC perspective, should the operator launch a (restricted) analytical programme on discharge samples. Such a parallel programme would seek at obtaining reassurance on the quality of the data delivered by the new monitoring system.

Observation:

The verification team suggests, in the framework of general QA/QC, that he operator puts in place a reassurance sampling and laboratory analysis programme on liquid discharges. It is also suggested that when assurance is obtained about the reliability of the new monitoring system, a quarterly laboratory control measurement be implemented.

Final observation:

The verification team notes with satisfaction that the recommendations made in 2002 have encouraged ITN/RPI staff to make significant efforts in improving the liquid discharge monitoring capabilities and related quality assurance aspects. The ongoing and/or planned improvement works are fully endorsed by the verification team. It is suggested that ITN management provide all the means necessary to ensure that the current and planned improvement works on the principal discharge tank can be carried out without undue delays.

6.4 Verification findings - analytical laboratory

The verification team visited the laboratory where it verified the adequacy of the analytical systems in place, including various aspects of quality assurance and control (working instructions, methodologies, calibration, maintenance, bookkeeping of results, reporting etc.).

6.4.1 Recommendations 2002

- Recommendation 2002

The verification team noted that there is room for improving quality assurance and quality control with respect to the measurement systems used for liquid discharge samples. For instance, measurement results obtained from a gamma spectrometry device showed the K-40 detection limits departing from standards, indicating that staff had not noticed a detector or analysis software problem. It is recommended that adequate quality assurance and control procedures for the measurement systems be put in place.

Findings 2006

(1) Four new Bicron NaI(Tl) detectors and associated electronic components + software have been installed and are operational. The systems have been installed in a new laboratory that is now physically separated from the environmental samples laboratory.

(2) Written procedures for the use, maintenance and calibration of the measurement systems has been put in place

Conclusion The recommendation has been satisfactorily implemented (see also section 8.2.3 on QA/QC below).

- Recommendation 2002

The verification team noted that the Tritium content of the liquid discharge samples is not measured. It is recommended that consideration be given to the routine assessment of Tritium, at least by calculation.

Findings 2006

(3) Tritium is now calculated at RPI level. The discharge values are published in the yearly ITN report titled 'Radiological Control at the Portuguese Research Reactor'.

Conclusion The recommendation has been satisfactorily implemented.

- Recommendation

The verification team noted that the measurement results for liquid discharge samples are not systematically validated. These data are transmitted to international organisations in the framework of conventions and may be used for publication. It is recommended that adequate data quality validation procedures are put in place, for instance by systematic peer-review of results obtained.

Findings 2006

(4) The general findings described in section 8.2.3 on QA/QC also apply to the analytical laboratory for discharge samples.

Conclusion The recommendation has been satisfactorily implemented.

- Recommendation 2002

The verification team noted the absence of structured record keeping and archiving procedures for discharge data. It is recommended that a comprehensive system of record keeping and archiving be put in place, preferably as an integrated database application.

Findings 2006

(5) A satisfactory system for sample identification has been implemented. The methodology ensures that samples are unequivocally identified (a well defined code is applied that registers the type, the origin and the date of sampling, as well as the analysis technique and measurement device to be used). Traceability of samples is now fully achieved.

(6) An appropriate database has been developed and is in use. Sample identifiers are linked to the analytical methods used and results obtained.

(7) In parallel to the database an operational procedure has come into effect that implements an effective and systematic storage of all related paper records.

Conclusion The recommendation has been satisfactorily implemented (see also section 8.2.3 on QA/QC below).

6.4.2 Further findings 2006

(8) The verification team took note of the formal separation between the operator of the RPI and the Radioactive Waste Management Unit (a department of the DPRSN). A more or less defined client vs. service provider relationship has been established where the RWU collects and measures the liquid discharge tank samples for the RPI. After measurement of the samples an analysis report is formally notified to the RPI operations manager on shift. The latter, based upon the data presented in the report is the only person entitled to initiate a discharge.

However, it is also noted that the RWU is left to decide about the type of detector and counting time to be used. This is perceived by the team as a weakness in this relationship: the service to be provided is not fully detailed with respect to the measurement technique to be used and precision to be achieved.

Observation:

The verification team suggests that RPI management revises the current client vs. service provider relationship modalities with DPRSN, to the effect of clearly specifying the object and deliverables of the service required, including aspects of quality assurance and control.

6.5 Verification findings - independent monitoring by the regulator

The site-related environmental monitoring as operated by the DPRSN (see section 7 below) addressing the surveillance of airborne discharges from the RPI cannot be considered as independent monitoring of the source term by a regulatory authority.

The continuous monitoring of the RPI liquid effluent tanks as well as the site's discharge tank is of operational nature and cannot be considered as independent monitoring of the source term by a regulatory authority.

In this context: see also the remarks made under bullet point 'regulatory control' in section 5.1 above.

Observation:

The verification team suggests, as a matter of generally accepted good practice, that the licensing authority brings into effect a system that allows independent and formal validation of the quality *assurance and control that underlies the operator's reporting on the amounts of radioactivity discharged into the environment.*

7 THE ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMMES

This section provides a summary description of the radiological monitoring programmes that are implemented in Portugal:

- RPI: the site-related monitoring programme by the DPRSN.
- The national radiological monitoring programme implemented by the DPRSN.
- The national radiological early warning network: RADNET for dose rate monitoring as well as airborne particulate monitoring, managed by the IA.
- The radiological surveillance of the former Uranium mines as put in place by EDM.
- The radiological surveillance of the mining region by the DPRSN.

7.1 The RPI site-related environmental monitoring programme by the DPRSN

The DPRSN is in charge of the implementation of the RPI site-related environmental monitoring programme.

7.1.1 Dose monitoring

- Active detectors

Three continuously operating on-line dose rate probes (Genitron GammaTRACER XL consisting of 2 Geiger-Müller tubes – low+high sensitivity) are installed on the Sacavém campus site. The positioning of the probes takes into account the prevailing wind direction from the RPI. The systems' measurement capability ranges from 10 nSv/h 10 Sv/h. Signals are relayed into a dedicated room (control station) within the DPRSN laboratory by a Shortlink communication system (backed-up by an internal data logger). The monitoring system was commissioned in October 2004.

- Passive detectors

Three arrays of 12 TL dose meters (LiF:Mg,Ti – TLD100) are installed on-site, on the same locations as the active dose rate probes. For each array of 12, four are used for measurement, four are pre-irradiated and four post-irradiated. The results obtained from the latter eight are used to compute correction factors to be applied to the measurement TLDs so as to take into account fading and sensitivity changes over the acquisition period. The dose meters are exchanged monthly.

7.1.2 Environmental sampling

- Air sampling

One continuously operating high-volume air sampler (Ecotech HiVol 3000 with an electronically maintained flow rate of app. 70 m^3/hour) is present on the Sacavém campus; under the prevailing wind direction from the RPI. An internal data logger records ambient temperature, barometric pressure, sampled volume, etc. The particulate filter (250x200 mm Pallflex filter type EMFAB TX40H120-WW) is exchanged weekly for laboratory analysis using gamma spectrometry.

- Dry/wet deposition sampling

One wet/dry deposition collectors (1 m^2 each) is situated on the premises of the Sacavém campus. The sample collected is sent to the laboratory once a month for analysis (total beta counting and gamma spectrometry).

- Soil

Soil sampling is carried out at two locations: one inside the Sacavém campus, the other beyond the site perimeter. Both locations have been chosen to take account of the prevailing wind direction from the RPI. Sampling is carried out on a monthly basis.

7.2 The national radiological monitoring programme by the DPRSN

7.2.1 Introduction

In 2005, the Environmental Monitoring Programme became mandatory and legally enforced through the Decree-Law N^{o} 138/2005 of 17 August. As a consequence the scope of the already existing Environmental Monitoring Programme was amended to achieve enhanced compliance with Recommendation 2000/473/EURATOM by increasing the number of sampling sites and by including new assessment techniques. It was noted during the verification activities conducted in 2002 that the DPRSN had already voluntarily (and in the absence of a regulatory authority) put in place an Environmental Monitoring Programme aiming at discharging Portugal's responsibilities in relation to the said Recommendation.

The current sampling programme is presented in Appendix 3 (sparse network) and Appendix 4 (dense network). A map with an indication of all sampling locations and sample types, extracted from the report for 2005 (July 2006) is given in Appendix 5.

7.2.2 Radiological surveillance of the environment

Air and fallout are assessed in one single location: the premises of the Sacavém campus.

- Airborne particulate matter

Airborne particulate matter is collected by a continuously operating high-volume aerosol sampler type ASS-500 (mean flow rate set at 800 m^3/h). The sampling filters (G-3 type polypropylene filters, 44x44cm) are replaced weekly; the filters are incinerated at 450°C for 24 hours, the resulting sample being analysed for Cs-137 by gamma spectrometry (Canberra GCW2522). For a typical measurement time of 3 hours, the detection limit for Cs-137 is ≈ 3 $\mu Bq/m^3$. Activity concentrations of the natural radionuclides Be-7 and Pb-210 are also determined.

- Dry/wet deposition

Samples are taken over a period of 30 days using a total atmospheric deposition collector having a truncated inverted pyramid shape with a 1m^2 in cross-section and a 50-litre receptor flask. Thirty litres of sample collected is concentrated to a 1-litre volume by evaporation. The concentrated sample is assessed using gamma spectrometry, followed by a determination of Cs-137 and Sr-90 by beta counting. For a typical gamma spectrometry measurement time 15 hours, the limit of detection for Cs-137 is 0.2 Bq/l or 0.1 Bq/l depending on the detector used. Also measured are Tritium concentration as well as total beta and total alpha counts. Finally, the activity concentration of the natural radionuclide Be-7 is determined.

7.2.3 Radiological surveillance of environmental indicators

See Appendix 3, 4 and 5.

7.2.4 Radiological surveillance of the food chain

See Appendix 3, 4 and 5.

7.3 The national radiological early warning network RADNET by the IA

Portugal runs a national network, RADNET, for the continuous monitoring of gamma dose rates in the air. This network was established in 1989, in application of the international convention on early notification of nuclear accidents, as well as Council Decision 87/600 EURATOM.

RADNET comprises a central station at the Environment Institute in Lisbon and 14 remote stations, distributed among major cities, the borders with Spain, two insular regions (Azores and Madeira) and one in Spain, near Badajoz (as part of an exchange with the Spanish REVIRA network). RADNET also comprises three mobile stations.

The dose rate probes consist of two Geiger-Müller detectors: one having a detection range between 10E-05 and 10 mGy/h, the other between 0.5 and 5E+03 mGy/h. The integration time is set at 1 minute, average results are computed every ten minutes, the latter are used for calculating two-hour average dose rate values. Average values are transmitted to the central control station in Lisbon. All results are additionally stored on a local data logger (max. 48 h capacity); logger data are downloaded remotely on a daily basis. A battery back-up power supply is present that allows an autonomy of app. 60 hours; the system sends an alert to the central control room after 15 hours of battery operation. Functionality checks are automatically performed from the central control room through on-line interrogation of various parameters of the stations.

The monitoring data are registered directly at the central station, equipped for raising alarms in the event of the alarm level being exceeded by one of the stations. Generally the alarm level is set at three times the local average background rate. Breaching the alarm level automatically increases the frequency of average dose rate calculations.

Six of the stations are also equipped with a continuous aerosol sampling device (9000 dm^3/h) combined with binary NaI detectors for on-line α-β monitoring. Integration times are set at 24 hours. The cabins housing the equipment are temperature controlled (air conditioning).

7.4 The radiological surveillance of former Uranium mines by EDM

7.4.1 Introduction

The exploitation of uranium ore in Portugal began in 1913 and ended by the year 2000. The total production of U_3O_8 reached about 4370 tons, in addition to radium salts that were the object of mining activities prior to 1944. Mining activities took place at 61 mostly small open pit exploitations although the larger ones were underground mines (or a combination of both). The great majority of the mining sites are located in the districts of Guarda and Viseu (central-east Portugal).

The most important mines were:

- Urgeiriça (underground mine + milling + chemical extraction; in-situ leaching at a later stage).
- Cunha Baixa (underground mine that evolved to open pit; in-situ and heap leaching extraction techniques).
- Quinta do Bispo (open pit; heap leaching).
- Bica (underground mine; in-situ and heap leaching).
- Castelejo (open pit; heap leaching).
- Vale da Abrutiga (open pit; ore not locally processed).
- Senhora das Fontes (underground + open pit mines; heap leaching).

For the smaller mines the extracted ore was mostly transported to the Urgeiriça milling and chemical extraction plants for further processing into uranium oxide.

All activities together generated approximately 13 million tons of waste deposited in several tailings close to the major mining sites. This waste consists of geological material that contains hazardous chemical and radioactive substances and, if left as such, is exposed to external geodynamic processes that are liable to transfer these substances into various environmental compartments (acid drainage following the percolation of rain and/or groundwater; dispersal of dust; emanation of Radon and progeny).

The dose equivalent rates measured on the tailings vary with the location and in some spots reach up to 25 µSv/h while the radiological background of the region typically varies between 0.2 and 0.7 µSv/h (Urgeiriça, Quinta do Bispo, Bica and Senhora das Fontes).

7.4.2 Legal acts

Legal instruments consulted during the verification visit were:

- Decreto-Lei Nr 198-A/2001 (legal provisions for the remediation of former [uranium] mines).
- Despacho Nr 242/2002 (the former uranium mining sites listed for remediation).
- Despacho Nr 267/2005 (addendum to the list of former uranium mines to be remedied).

7.4.3 The Urgeiriça mine

The Urgeiriça mine is located in central Portugal and was the country's most important uranium exploitation. Exploitation began in 1913 and until 1944 the ore was mined for radium extraction. After World War II the aim shifted to only recover uranium as radioactive substance. Until 1973 the ore was mined by conventional underground mining, through six shafts, to a maximum depth of about 500 metres. After 1973 in-situ leaching techniques were used, with the injection of sulphuric acid, to recover the low-grade ore still present in the abandoned mine galleries; this extraction continued until 1991.

The ores from the Urgeiriça mine, as well as from all the other 62 mines exploited in Portugal, were processed in a uranium mill facility build in 1951 nearby Urgeiriça. Sludge from this facility includes chemical elements and most of the radioisotopes contained in the extracted ores (those of the uranium decay chain), as well as several other substances used in the selective uranium extraction procedure (e.g. sulphuric acid, manganese oxides, ammonia, sodium chloride etc.).

The Urgeiriça mining activities left a large amount of waste deposited on three locations. The most voluminous tailing (an estimated 1.39 million m³ on 13.3 ha) consists of the sludge produced in the milling facility. A deposit of waste rock containing some low-grade ore that was extracted from the Urgeiriça mine is located near the main shaft (about 91 thousand m³ on 1.5 ha). Finally, a few tons of high-grade uranium ore, not milled, is still deposited near the plant.

Groundwater percolates the interior of the old mine and the nearby mill tailings where it can interact with the geological materials present, inducing a transfer of chemical and radioactive elements from solid into liquid phase. The resulting waters are acidic and are liable to transfer significant amounts of dissolved metals and radionuclides into the environment (acid drainage).

In order to prevent such a transfer into the environment a drainage system is in place that collects the contaminated waters from the mine and the mill tailings and diverts them to a water treatment plant. This latter plant neutralises the pH of the water by adding quicklime and precipitates radium compounds and heavy metals by adding barium chloride. The treated waters are sent to two sequential impervious settling basins (app. 19.6 ha) for the depuration of the chemical compounds (gradual accumulation at the bottom). Before discharge into the environment (into the "Ribeira da Pantanha" brook, a tributary to the Mondego river) the water that naturally overflows from the last basin is subjected to continuous hydrochemical monitoring as well as continuous sampling for the purpose of radiological assessments.

7.4.4 Remediation and rehabilitation of the Urgeiriça tailings

Environmental remediation of the tailings at the Urgeiriça mine is one of the top priorities ([4]) of the national plan for the rehabilitation of former uranium mining sites. This project also includes environmental remediation of the mine's industrial area where the remains of the former milling and processing plants are located (+ the two deposits of ore and waste rock respectively). All the waste arising from the industrial area will be transferred to the tailings.

The tailings area itself will have to be geotechnicaly stabilised (field works started in 2005), confined in-situ by a peripheral concrete support structure, equipped with surface and deep drainage systems, and sealed off with a multi-layer cover consisting of geological and synthetic materials over the surface of the tailing deposit.

The cover of the tailing deposit will consist of the following layers (bottom to top):

- a compacted layer of geological materials from other mine tailings (2 to 5 m),
- clay (60 cm),
- HDPE liner in conjunction with a geo-textile membrane,
- gravel (30cm),
- sand (25 cm),
- soil (50 cm) + vegetation.

After remediation the tailings will be fenced off to prohibit public access.

The above works are planned for completion before the end of 2007.

7.4.5 Environmental surveillance at Urgeiriça

- <u>Current situation</u>

Currently the surveillance put in place by the operator consists of:

- A water treatment plant where contaminated waters from the mine and the mill tailings are collected to neutralise the pH of the water by adding quicklime and to precipitate radium compounds and heavy metals by adding barium chloride. Both treatments are automated.

- Continuous hydrochemical monitoring of the liquid discharges into the environment (after the second settling basin). The monitoring devices (flow, pH, REDOX potential, conductivity, temperature, and total suspended solids) are connected to controllers and a data logger. From the controllers the normalised signals are sent to a local computer equipped with a GSM modem that transfers the acquired data (hourly average values) into the EDM main office server located at the company's headquarters in Lisbon.

- Continuous sampling of the environmental discharge for analytical assessments (20 dm^3/day). The radiological parameters that are measured are the concentration of both Ra-226 and total Uranium: these measurements are performed weekly on a 7-day composite sample.

- Surface water sampling of the "Ribeira da Pantanha" brook receiving the liquid discharge. Four sampling locations are defined where monthly spot samples are taken. These samples are assessed for the presence of Ra-226 and total Uranium (besides other hydrochemical parameters).

[4] The other top priorities are the mines of Cunha Baixa, Quinta do Bispo and Bica.

- Ground water sampling at 14 locations with a semi-annual frequency. These samples are assessed for the presence of Ra-226 and total Uranium (besides other hydrochemical parameters).

- Radiological air monitoring: 6 low volume air samplers (ALGADE type PSVOL2 with a flow rate of app. 60 m³ per month) distributed around the tailings (3 devices) and around the industrial area (3 devices), as well as 6 dry/wet deposition collectors similarly distributed. The filters ([5]) of the air samplers are exchanged monthly and sent to the ALGADE laboratories for total alpha counting on the particulate filter and assessment of the solid-state nuclear track detector. The dry/wet deposition sampling bottles (5 dm³) are exchanged whenever full but with a minimum frequency of once a month. The deposition sample collected is measured monthly, after filtering (0.45µm mesh), in order to assess the presence of Ra-226 and total Uranium.

- <u>Future situation</u>

After the remediation works will be finished the radiological surveillance will consist of the assessment of Ra-226 and total Uranium (as well as the other relevant parameters) on a 7-day composite sample of the discharge into the environment, in a similar fashion as currently practised.

- Surface water sampling of the "Ribeira da Pantanha" brook receiving the liquid discharge in the locations currently monitored. Spot samples will be taken with a frequency that will be established on the results of the current monitoring plan that will end in September 2007. These samples will be assessed for the presence of Ra-226 and total Uranium (and also other hydrochemical parameters).

- Ground water sampling at 11 new locations specially designed and implemented in the tailings dam to assess the cover efficiency. Spot samples will be collected with a semi-annual frequency, to measure Ra-226 and total Uranium (and other relevant hydrochemical parameters). Samples will also be collected semi-annually in 10 spots in the proximity of the Urgeiriça mine to assess the same parameters.

- Radiological air monitoring using low volume air samplers (ALGADE type PSVOL2), in the locations presently monitored, during two months – one month in the dry season and another in the rainy season. The current practice of determining the total suspended particulate deposition rate will be continued.

- In the first dry period after the remediation works a gamma radiation survey will be conducted at the tailings dam, similar to the one conducted before the remediation activities (base line assessment).

- Monitoring of radon fluxes at 6 new locations in the remediated tailings dam, measuring at three different soil depths in order to verify the cover efficiency.

7.5 The radiological surveillance of the mining region by the DPRSN

As part of its environmental radioactivity responsibilities (Art.14 of Decree-Law nr 165/2002) the DPRSN will put in place a periodical surveillance programme in the region of the former uranium mines.

This programme is planned to start in the year 2007 and will focus on the main five mining areas in the region where most of the mining and milling waste is deposited (Urgeiriça, Cunha Baixa + Quinta do Bispo, Bica, Castelejo and Prado Velho). The monitoring programme will address the possible transfer of radionuclides via the food chain to man and the potential transport of radionuclides into ground water and rivers crossing the region.

[5] The filtering head combines a particulate filter with a solid-state nuclear track detector. The latter is mounted in front of the particulate filter and records alpha emissions of the short-lived daughter products of Rn-220 and Rn-222 (Po-218, Po-214, Po-212, Bi-212).

For each mining area the following annual spot samples will be taken for subsequent analysis with alpha spectrometry:

- 4 soil samples
- 6 agricultural produce samples
- 2 surface water samples
- 2 sediment samples
- 5 well water samples
- 1 airborne particulates sample + radon (radon determinations will be performed occasionally during short periods with continuous radon monitors using silicium-based detectors).

8 VERIFICATION ACTIVITIES - ENVIRONMENTAL PROGRAMMES

8.1 The RPI site-related monitoring programme by the DPRSN

The verification team confirmed the existence and functionality of the monitoring and sampling provisions as described in section 7.1 above.

8.1.1 Recommendations 2002

- Recommendation 2002

  The verification team observed that the ASS-500 high volume sampler and the thermo-luminescent dose meters, in their function as site-related monitoring devices, are not optimally located with respect to the position of the reactor stack and the locally prevailing wind directions. It is recommended that the ASS-500 and the dose meters be relocated to positions where the dispersion of the airborne releases from the reactor may contribute to inhalation exposure and external exposure respectively.

  Findings 2006

(1) The Ecotech HiVol 3000 high volume sampler replaces the ASS-500 as a RPI discharge-related surveillance device (the ASS-500 continues to operate within the National Monitoring Programme). The position of the new sampler, relative to the RPI discharge stack, is now satisfactory.

(2) The position of the TL dosimeters has been modified: three locations in a semi-circle around the RPI stack (under the prevailing wind direction) are now equipped with arrays of twelve TL dosimeters.

Conclusion The recommendation has been satisfactorily implemented.

8.1.2 Further findings 2006

(3) The verification team noted with satisfaction that the site-related surveillance has been extended to include an on-line network of three gamma dose rate probes. The team verified the functionality of the system: data acquisition and storage, on-line real-time data display, functionality alarms, increased dose rate warning and alarm levels were demonstrated to satisfaction.

(4) The team noted that the TL dosemeter array that is located on the roof of the 'library' building is partially shielded by a concrete wall. The position of the TL dosimeters should be optimised.

Observation:

The verification team suggests that the positioning of the TL dosimeters situated on the roof of the library be optimised so as to remedy to the current partial shielding of the devices.

8.2 The national radiological monitoring programme by the DPRSN

8.2.1 The monitoring programme

As a follow-up to the Article 35 verification in 2002 milk samples are now collected from the main milk producers and delivery enterprises located in the north, centre, east (close to the border with Spain and to the Almaraz nuclear power plant) and south of Portugal. These locations were chosen as representative of the country and according to the geographic distribution of the dairies. The 2002 recommendation to the effect that *milk sampling procedures are not providing sufficiently representative samples* has been implemented to satisfaction.

In 2002, with respect to river water sampling, the verification team recommended the recording of river flow rates so as to enhance the representativeness of the results obtained. The DPRSN informed the team that, in spite of continued efforts to gather this information from the competent public entities, it was not possible to obtain these records. Hence the recommendation formulated in 2002 must be maintained:

It is recommended, in order to achieve representativeness, that river water samples be taken over defined periods of time and that river flow rates be recorded during this period.

8.2.2 Infrastructure of the environmental laboratory

The verification team noted the improvements in the overall set-up of the laboratory since the visit in 2002:

- The power supply of the measurement laboratories is presently maintained by two UPS units backed by a power generator for emergency operation in the rare eventuality of a power cut of a long duration.
- A new laboratory area with low background has been built for gamma spectrometry.
- All the measurement laboratories have controlled environmental conditions.
- An internal communication network has been installed to allow centralised data back-up, increased security and efficiency.

The verification team noted the existence and functioning of the equipment listed below:

- <u>Gamma spectrometry laboratory</u>

The gamma spectrometry laboratory is equipped with six HPGe detectors (two broad energy, one well-type and three coaxial), each with appropriate shielding. The NIM modules have been updated and data acquisition is presently done through two Canberra multiport II modules. Spectra analysis and reporting is performed with Canberra Genie2000 and custom-made software.

- <u>Total alpha and beta counting laboratory</u>

The total beta and alpha counting laboratory is equipped with two gas flow proportional detector systems, two liquid scintillation systems and two ZnS solid scintillators.

New analytical methods have been developed, validated and implemented with regard to the liquid scintillation technique mainly for the determinations of total alpha and total beta activities in drinking water and strontium-90 in milk. The application of this technique to the measurements of strontium-90 in foodstuffs is currently being studied.

- <u>Alpha spectrometry laboratory</u>

The alpha spectrometry laboratory is equipped with 40 surface barrier detectors.

8.2.3 Quality control programme

The team discussed the ongoing efforts with regard to accreditation and quality assurance. QA efforts started about three years ago, and procedures have been established for most parts of the sample preparation and measurement tasks (including calibration and functional tests).

Procedures for quality control of the analytical procedures include the use of internal standards and reference materials, repeatability assays and participation in inter-comparison exercises.

Procedures for quality control of equipments in the gamma spectrometry laboratory have been defined and data records are kept. The documentation of quality control procedures in the other two laboratories (total alpha and beta counting and alpha spectrometry) is underway.

For the gamma spectrometry laboratory, energy and efficiency calibration is performed using certified calibration sources in different geometries and matrix. The correction of the efficiency curves for matrix effects between the calibration source material and the sample material is underway.

Efficiency calibration in total alpha and beta counting is performed using diluted solutions obtained from certified solutions of the appropriate radionuclide or, in the particular case of ^{40}K, from KCI *pro analysis*.

In alpha spectrometry, quality control is performed using an internal source obtained from commercially certified sources and through periodic analysis of certified samples.

Background measurements are periodically performed. For gamma spectrometry, they are obtained every weekend and during the working days whenever possible. For total alpha and beta counting, the background is acquired between sample measurements, representing about 30% of the measurements. For alpha spectrometry they are acquired three times per year.

External quality control is obtained through involvement in inter-comparison exercises and proficiency tests. In the last years DPRSN took part in several exercises.

Since the last EC visit, an automatic data back-up routine for the spectral data was implemented in all three laboratories. Presently the traceability of data is obtained from a combination of the records kept in the database; documentation kept in paper form, including internal analysis reports, and the back-up archives of the spectra obtained by the measurement equipments.

Since 2004 the Environmental Radioactivity and Measurement Units have made an effort to implement a Quality Assurance System, in compliance with ISO/IEC 17025. Procedures have been established for sampling, sample preparation, analytical methods and operation and maintenance of all the equipment, for quality control of measurement and for data analysis. The improvement of the present Laboratory Information Management System is underway.

The verification team also noted the efforts undertaken with regard to achieving state-of-the-art analytical methods and data processing, in particular with regard to:

- Algorithm for improving the data analysis of gamma spectrometry supplementing the Geni2000 software with standard libraries for each sample type, so as to provide more meaningful results (not yet written down in a new procedure).
- Sr-analysis in foodstuffs and milk (extraction chromatography and liquid scintillation techniques are being introduced for milk, later also for foodstuffs); gamma spectrometry on foodstuffs is carried out on the basis of fresh (mashed) samples in Marinelli beakers.
- Preparation of aerosol samples by compressing the folded filter papers rather than by incineration, thus improving the efficiency of the method and resulting in lower limits of detection (the team checked the original procedure and its amendment for the new preparation mode).
- Correction for density variations in samples (in particular soil samples) on the basis of PIXE analysis of the composition of the sample.

- Correction for coincidence counting.

8.2.4 Traceability and data reporting

In January 2005 a database was installed to keep a record of environmental samples. The team examined the operation of the new database.

This database includes samples from the national environmental radiological survey and samples from services requested from the Environment Radioactivity Unit. The database includes the sample identifier, the analytical techniques and the results of the analysis. These records are also kept on paper.

Each data provider (technical staff) has restricted access to the database for his own area. The head of the laboratory has access to all data. Traceability of samples and results is ensured through a well-established procedure on the basis of barcode stickers printed at the time of sample receipt and codification of locations, sample categories and measurement types.

The results of the Environmental Monitoring Programme are published in annual reports submitted to two peer-reviewers and made available on the ITN internet site.

8.2.5 Vertical audit of reported data

The verification team proceeded with a full examination of the overall chain of data processing for randomly selected reported values:

- Surface water from station V.Velha de Ródão (Tejo river), for dissolved and suspended matter, (August 2005).
- Milk (February 2005): cow's milk from Douro e Minho & sheep's milk from V.Velha de Ródão.
- Aerosol sample, Sacavém (August 2005).

The examination of records in the database and paper documents enabled a check of record-keeping and data processing, both for the period before and after the introduction of the database.

With regard to the selected aerosol sample, the team noted that the significant value (Cs-137, 1.2 $\mu Bq/m^3 \pm 0.3\ \mu Bq/m^3$) was in fact the outcome of the measurement for the last of four weekly samples. While the results for the first three weeks showed values below the lower limit of detection, the assumption was made that a true positive value would not have been observed because of the higher limit of detection. Hence, the weekly value was extrapolated to the whole month. While this seems a valid approach, the team noted that there was neither a procedure for making this decision, nor an explicit recording of the assumption as such.

Observations:

The verification team notes with satisfaction that the recommendations made in 2002 have encouraged the laboratory to make significant efforts in improving the set-up of the laboratory, quality assurance and data processing. The verification team suggests maintaining these efforts and completing all procedures to achieve full certification of the laboratory. The team also endorses the prospect for extending Sr-90 analysis to foodstuffs.

The team concludes that the establishment of a legal framework for environmental monitoring largely reflecting Commission Recommendation 2000/473/EURATOM has contributed to putting in place a comprehensive environmental monitoring programme, both for the dense and the sparse network.

8.3 The national radiological early warning network RADNET by the IA

The verification team checked the operation of the central station, displaying the monitoring data and the status of the stations. Three stations displayed a malfunctioning alert. Arrangements are in place for the prompt repair of the stations as part of a maintenance contract. The average availability is of the order of 90%.

The availability of the aerosol stations is much lower (65%). The stations need regular intervention (e.g., failure of the filter ribbon). Maintenance is problematic as a result of the fact that the company that produced the equipment is no longer in business. The IA plans the gradual replacement of the gamma dose rate stations over the next three years.

The team also went to visit the stations (gamma and aerosol) near Lisbon airport (on a site run by the Meteorological Institute). The testing of the gamma station with a check source was witnessed. The aerosol station was in operation but the other verification team had to return the next day to examine it in more detail (the housekeeper of the Meteorological Institute could not find the key!). The second visit allowed a thorough inspection of the device whereby the team noted that:

- The system's integration time is set at 12 hours (normally 24 hours) before moving the filter ribbon: high levels of local air pollution are liable to clog up the filter.
- The maintenance of the systems is outsourced: the company exchanges the filter ribbon and overhauls the suction pump on a half-yearly basis. This maintenance is purely mechanical and does not address aspects of quality assurance and control.
- Calibration verifications are not part of the maintenance contract but the IA will provide a check source when "believed necessary". A formal quality assurance and control programme is not in place.
- The systems are not fed by a guaranteed power supply. Power supply failures as well as system failures are centrally recorded and the intervention procedures require the maintenance contractor to intervene within 24 to 48 hours after being notified by IA staff.

Observations:

The verification team welcomes the initiative of the IA to gradually replace the stations in order to ensure enhanced availability; the team underlines the importance of continuous aerosol stations in identifying the nature of the radioactive cloud and in distinguishing between airborne and deposited activity.

The verification team suggests the IA to put in place a comprehensive data quality assurance and control programme for the RADNET monitoring systems. Such a QA programme, including regular calibration controls, may become integral part of an outsourced maintenance contract on condition that the deliverables are well defined and supported by documented procedures.

8.4 The radiological surveillance of former Uranium mines by EDM

8.4.1 Briefing

Before visiting the monitoring systems in place around the Urgeiriça mine, the verification team was extensively and comprehensively briefed on the national plan for the remediation of former uranium mines and associated aspects of radiological protection. The information received (and other sources consulted) have been used to draft section 7.4 of this report. See also Appendix 1, section 4, reference 28 to 37 for the documentation received or consulted.

The verification team fully endorses the national plan for the remediation of former uranium mines.

8.4.2 Verification activities

The verification team visited the site of the Urgeiriça mine where it confirmed the existence and functionality of the monitoring and sampling provisions as described in section 7.4.5 above. The operator also voluntarily submitted its working files containing all the results from its monitoring/sampling programme: the team took this opportunity to verify (at random) the quality of the bookkeeping of these results.

The verification activities did not give rise to any particular remarks.

Observations:

See section 8.5 below.

8.5 The radiological surveillance of the mining region by the DPRSN

The DPRSN made a comprehensive presentation on the mine-specific radiological surveillance programme that will be conducted from 2007 onwards (a summary of which is given under section 7.4.6 above).

Observations:

The verification team welcomes and fully endorses the initiative of the DPRSN to conduct a specific and systematic radiological surveillance programme in the uranium mining region of Portugal.

The team suggests that this surveillance be integrated in the national monitoring programme and that such means are foreseen by the competent ministry as to ensure the continuity of the radiological surveillance of the uranium mining region.

The verification team should like to suggest that both the DPRSN and EDM consider the potential benefit in terms of radiological protection that would arise from a systematic and formal exchange of acquired surveillance data. The verification team believes that in the framework of the future surveillance programme by the DPRSN such collaboration would provide valuable complementary information for both actors.

Finally the verification team should also like to suggest that the competent Portuguese authorities keep the Commission abreast of the progress made with the national remediation plan.

9 CONCLUSIONS

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

With respect to the radiological surveillance programmes by the RPI:

(1) The verification activities demonstrated that the facilities necessary to carry out continuous monitoring of radioactive discharges from the RPI are adequate. The Commission could verify the operation and efficiency of these facilities. The recommendations made after the 2002 verification visit were given appropriate response.

(2) The verification activities demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil around the RPI are adequate. The Commission could verify the operation and efficiency of these facilities. The recommendations made after the 2002 verification visit were given appropriate response.

(3) However, some topical recommendations of purely technical nature will be formulated in the Main Findings. These recommendations do not discredit the fact that the radiological surveillance of the RPI is in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(4) The absence of a well defined programme of independent regulatory control on discharge monitoring as well as RPI site-related environmental surveillance is noted (cf. section 6.5 above).

With respect to the national radiological surveillance programme implemented by the DPRSN:

(5) Since the 2002 verification visit and ensuing recommendations, significant improvements have been achieved. These efforts have been translated into a new organizational structure to optimize the existing competencies; into the implementation of databases and quality control programmes; the acquisition of new equipment and acquisition or development of software; the development of new techniques and measuring methodologies and expansion of the environmental monitoring programmes.

(6) Continued effort has been made in order to achieve the accreditation of the DPRSN environmental analysis laboratories. Several improvements have been introduced, mainly the development of the environmental database, the writing of the administrative, laboratory and quality control procedures. In May 2006 the DPRSN submitted to the Portuguese Accreditation Institute (IPAC) an application for accreditation of the analytical and measurement techniques implemented in different units of the Department. The approval of this proposal is expected in the near future.

(7) The establishment in 2005 of a legal framework for environmental monitoring (Decreto-Lei N°138/2005), largely reflecting Commission Recommendation 2000/437/EURATOM, has contributed to putting in place a comprehensive national environmental monitoring programme, both for the dense and sparse networks.

(8) The verification activities demonstrated that the facilities necessary to carry out continuous monitoring of the level of radioactivity in the air, water and soil on the territory of Portugal are adequate. The Commission could verify the operation and efficiency of these facilities. The recommendations made after the 2002 verification visit were given appropriate response.

(9) However, one of these recommendations needs to be maintained (on river water sampling). It should be noted that the nature of this recommendation does not jeopardise the fact that the national environmental monitoring programme is in line with the provisions laid down under Article 35 of the Euratom Treaty.

With respect to the national radiological early warning network RADNET operated by the IA.

(10) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of gamma dose rates in air in Portugal are generally adequate. The Commission could verify the operation and efficiency of these facilities.

(11) However, a recommendation has to be formulated to the effect that the radiological surveillance through aerosol monitoring can be enhanced by putting in place a data quality assurance and control programme. The implementation of such a programme should not be postponed until the replacement of these devices, planned to be finalised within the next three years.

With respect to radiological surveillance around the former uranium mines.

(12) The verification team welcomed the extensive briefing it received on the national plan for the remediation of former uranium mines and associated aspects of radiological protection.

(13) The verification activities demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil around the Urgeiriça mine are adequate. The Commission could verify the operation and efficiency of these facilities.

Final remarks:

(14) The verification findings and ensuing recommendations are compiled in the 'Main Findings' document that is addressed to the Portuguese competent authorities through the Portuguese Permanent Representative to the European Union.

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

(16) The Commission should be grateful if the competent Portuguese authorities would keep it abreast of the progress made with respect to the national plan for the remediation of the former uranium mines.

(17) The discussions on legal matters that were conducted in the margin of the verification visit will be given separate consideration.

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

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APPENDIX 1

DOCUMENTATION RECEIVED AND CONSULTED

1. Legislation

1. Decreto-Lei Nr 198-A/2001 (legal provisions for the remediation of former [uranium] mines)
2. Despacho Nr 242/2002 (the former uranium mining sites listed for remediation)
3. Decreto-Lei Nr 165/2002 (transposition of Council Directive 96/29/Euratom)
4. Decreto-Lei Nr 138/2005 (transposition of Commission Recommendation 2000/473/Euratom)
5. Decreto-Lei Nr 139/2005 (creation of the CIPRSN)
6. Despacho Nr 15 172/2005 (creating a working group within the DGGE that shall tackle matters related to the licensing of the RPI)
7. Despacho Nr 267/2005 (addendum to the list of former uranium mines to be remedied)

2. Ministry of Economy and Innovation

8. Letter from the DGGE addressed to the ITN (ref. 113/GJ/2005) forwarding the draft proposal for RPI licensing conditions as formulated by the working group established under Despacho Nr 15 172/2005

3. Environment Institute

9. Presentation (slides) titled "The Portuguese Monitoring Network – RADNET"
10. RADNET – Annual Report 2004
11. RADNET – Annual Report 2005
12. A set of filled-in maintenance forms for the RADNET stations – by the maintenance contractor

3. Nuclear and Technology Institute

3.1 RPI

13. Radiological Control at the RPI – Annual Report 2005 (ref ITN/RPI-R-06/90).
14. Layout drawing of the monitoring/sampling systems at the RPI stack.

3.1 DPRSN

15. Presentation (slides) titled "Department of Radiological Protection and Nuclear Safety"
16. Annual National Radiological Surveillance Report – 2002 (ref. DPRSN-A Nr 26/2003)
17. Annual National Radiological Surveillance Report – 2003 (ref. DPRSN-A Nr 28/2004)
18. Annual National Radiological Surveillance Report – 2004 (ref. DPRSN-A Nr 29/2005)
19. Annual National Radiological Surveillance Report – 2005 (ref. DPRSN-A Nr 30/2006)
20. Environmental gamma radiation monitoring at ITN, October 2004 – August 2006
21. Communication to the verification team: "Actions undertaken and levels of implementation achieved as a result of the 2002 EC recommendations in the framework of the Euratom Treaty – Article 35" – October 2006
22. Internal document: "Estação de Controlo das Descargas dos Effluentes Líquidos Radioactivos (ECoDELiR)" – 2006. [Radioactive Liquid Effluents Discharges Control Facility]
23. Internal document: "Proposta de melhorias a effectuar na estação de controlo das descargas dos effluentes líquidos radioactivos. [Proposal involving revision and updating of the existing radioactive liquid effluents discharges control facility – central tanks]
24. Procedure for the manual sampling, handling and measurement of samples taken from the various discharge tanks
25. Procedure "Verificação das sondas GammaTracer-xl" [dose rate monitor checks using a source]

26. Procedure "Folha de registo para configuração das sondas GammaTracer-xl através do DataGate" [dose rate monitor configuration]
27. Analysis reports numbers 054/06, 055/06 and 056/06 for RPI discharge tank samples

4. Empresa de Desenvolvimento Mineiro

28. Presentation (slides) titled "Master plan for abandoned radioactive mine areas"
29. Presentation (slides) titled "Environmental evaluation and remediation methodologies of abandoned radioactive mines in Portugal"
30. Presentation (slides) titled "Environmental remediation of uranium mines – current status"
31. Presentation (slides) titled "Environmental monitoring of uranium mines"
32. Scientific paper titled "Modelling of the long term efficiency of a rehabilitation plan for a uranium mill tailing deposit (Urgeiriça – Central Portugal)" by A.J.S.C. Pereira, J.M.M. Dias, L.J.P.F. Neves & J.M.G. Nero; published at the XI International Congress of the International Radiation Protection Association (IRPA) 2004
33. Scientific paper titled "Evaluation of the radiological hazards from uranium mining and miling wastes (Urgeiriça – Central Portugal)" by A.J.S.C. Pereira, L.J.P.F. Neves, J.M.M. Dias, A.B.A. Campos & S.V.T. Barbosa published at the XI International Congress of the International Radiation Protection Association (IRPA) 2004
34. Scientific paper titled " Evaluation of radionuclide contamination in the vicinity of the Cunha Baixa and Quinta do Bispo old uranium mines (Central Portugal)" by A.J.S.C. Pereira, L.J.P.F. Neves, J.M.M. Dias & S.V.T. Barbosa – Radioprotecção, vol.2, n° 4/5, 2004
35. Scientific paper titled "Using geophysical methods to identify alteration zones in an abandoned mining site" by L. Carvalho, E. Ramalho and S. Barbosa – Journal of the Balkan Geophysical Society, Vol.8, 2005, Suppl.1
36. Internal document: "Plano de monitorização hidroquímica relativo ao tratamento e descarga de effluentes – Urgeiriça, Canha Baixa, Quinta do Bispo, Bica e Castelejo" [hydrochemical monitoring of the treatment and discharge of effluents - mines]
37. MinUrar Reports "Minas de urânio e seus resíduos: efeitos na saúde da população" [Uranium mines and their residues: health effects on the population] http://www.itn.pt/docum/relat/minurar/2005-MinUrar-relatorio1.pdf

5. IAEA

38. "Environmental contamination from uranium production facilities and their remediation" – Proceedings of an international workshop, Lisbon, 11-13 February 2004. ISBN 92-0-104305-8.

Web sites

39. ITN www.itn.pt
40. EDM www.edm.pt
41. IAEA www.iaea.org
42. European Commission (radiation protection) http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

APPENDIX 2

THE VERIFICATION PROGRAMME

Sunday 19/11

1. EC team-1 (Mr Van der Stricht & Mr Vallet) travels from Luxembourg to Lisbon.

Monday 20/11

2. Opening meeting at the DGAC: introductions / presentations / programme of the visit. Representatives of the Ministries of Economy, Science, Environment and Health will attend the meeting.
3. EC team-1 + PT representatives travel to the Urgeiriça uranium mines where a first information meeting is held (presentations by the EDM).

Tuesday 21/11

4. Information meeting (part 2 – also including a presentation by the DPRSN).
5. EC team-1: verification of a representative selection of the site-related provisions for environmental monitoring/sampling put in place by the operator and/or by the regulator. Return travel to Lisbon.
6. EC team-2 (Mr Janssens & Ms Andres-Ordax) travels from Luxembourg to Lisbon.

Wednesday 22/11

7. Both teams arrive at ITN Sacavém (RPI) site.
8. Meeting with all representatives to discuss legal issues (meet representatives of the Ministries of Foreign Affairs, Economy, Science, Environment and Health).
9. Team-1: verification of the follow-up given to the 2002 recommendations + other changes implemented since:
   - Discharge monitoring/sampling of discharges from the RPI.
   - Analytical laboratory for discharge samples.
   - Environmental monitoring/sampling devices on the Sacavém site.
   - National environmental monitoring programme as performed by the DPRSN.
   - Environmental samples laboratory.
10. Team-2: verification of a RADNET national monitoring network station operated by the IA.

Thursday 23/11

11. Team-1 and team-2: completion of verification activities.
12. Closing meeting with all parties involved – preliminary conclusions and discussions.

Friday 24/11

13. Return travel to Luxembourg.

APPENDIX 3

DPRSN – NATIONAL RADIOLOGICAL SURVEILLANCE - SPARSE NETWORK

Type of samples	Sampling locations	Sampling frequency	Type of analysis
Aerosols	Sacavém (ITN campus)	Weekly	Cs-137, Be-7, Pb-210
Air	Sacavém (ITN campus)	Monthly	Ambient dose equivalent rate (active detectors)
Surface water	Rio Tejo (V. Velha Ródão)	Monthly	Cs-137, Sr-90, Tritium, total beta, residual beta
Drinking water	Rio Zêzere (Barragem de Castelo de Bode) Lisbon	Monthly	Cs-137, Sr-90, Tritium natural radionuclides according to Directive 98/83/EC (transposed by Decree-Law nr. 243/2001)
Milk	North Portugal (Vila do Conde) East Portugal (Portalegre)	Monthly	Cs-137, Sr-90, K-40
Mixed diet (complete meals)	Lisbon	Monthly	Cs-137, Sr-90*, K-40

* Implementation in 2007.

APPENDIX 4

DPRSN – NATIONAL RADIOLOGICAL SURVEILLANCE - DENSE NETWORK

Type of samples	Sampling locations	Sampling frequency	Type of analysis
Rain water	- Sacavém (ITN campus) - Castelo Branco	Monthly	Cs-137, Sr-90, Be-7, Tritium, total alpha, total beta
Air	- Sacavém (ITN campus) - Bragança, Penhas Douradas, Castelo Branco, Portalegre, Beja, V. Nova de Gaia, Faro, Funchal (Madeira)	Quarterly	TLD
Surface water	- Rio Tejo (V. Velha Ródão, Valada) - Rio Zêzere (Bar. de Castelo de Bode) - Rio Tejo (Bar. de Fratel, Bar. de Belver) - Rio Guadiana (Bar. Alqueva) - Rio Mondego (Bar. Alguieira) - Rio Douro (Barca d'Alva)	Monthly Monthly Quarterly Annual Annual Annual	Cs-137, Sr-90, Tritium, total beta, residual beta
Sediments, fish and aquatic plants	- Rio Tejo (V. Velha Ródão, Valada) - Rio Zêzere (Bar. de Castelo de Bode) - Rio Tejo (Bar. de Fratel, Bar. de Belver) - Rio Guadiana (Bar. Alqueva) - Rio Mondego (Bar. Alguieira) - Rio Douro (Barca d'Alva)	Monthly Monthly Quarterly Annual Annual Annual	Gamma spectrometry (natural and anthropogenic radionuclides)
Drinking water	Randomly chosen sampling locations covering the national territory (10 locations)	Annual	Natural radionuclides according to Directive 98/83/EC (transposed by Decree-Law nr. 243/2001)
Milk	- Central Portugal (Tocha) - South Portugal (Aguas de Moura)	Quarterly	Cs-137, Sr-90, K-40

Cont'd

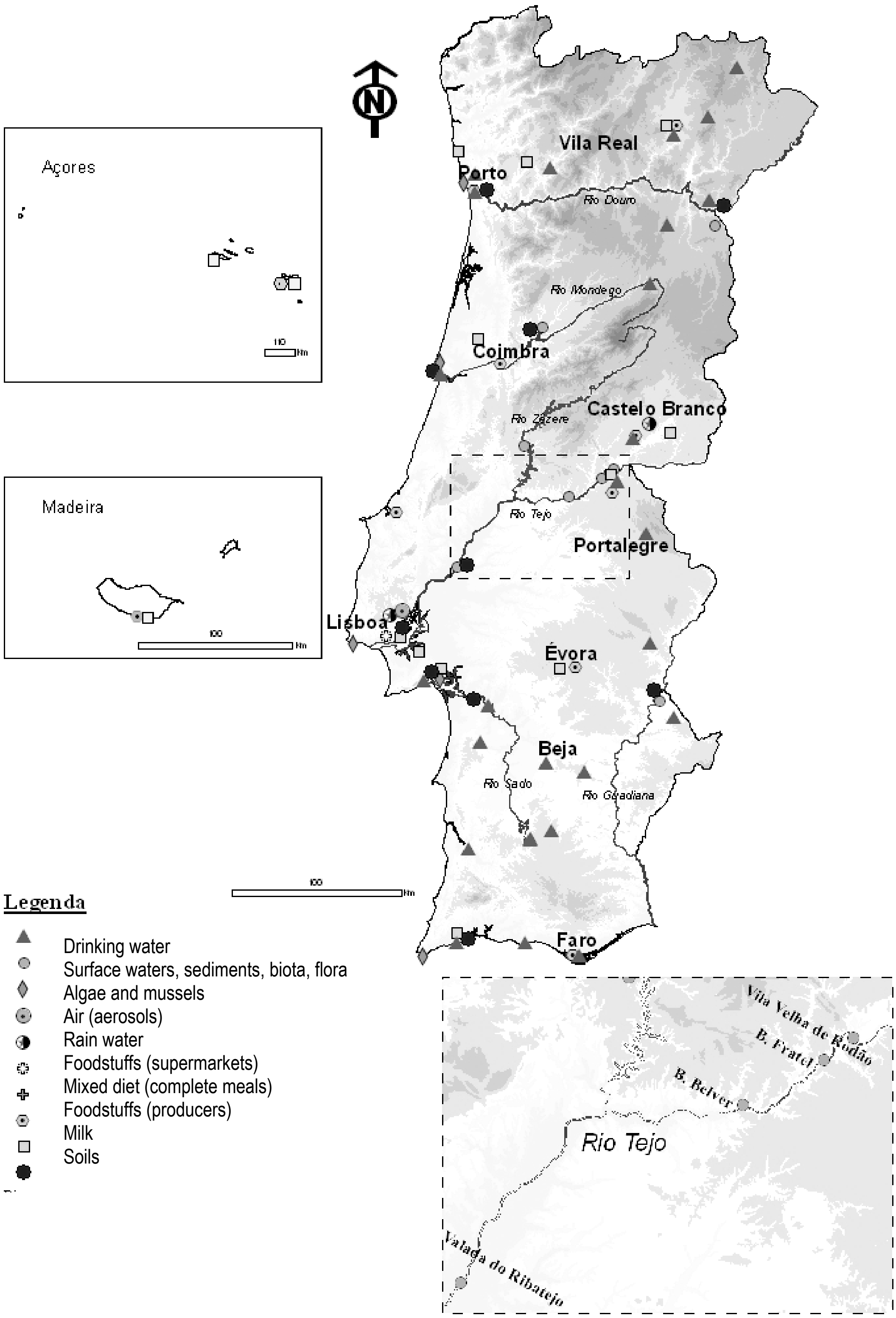
Type of samples	Sampling locations	Sampling frequency	Type of analysis
Mixed diet (individual components)	- 7 locations sampled by the Direcções Regionais de Agricultura do Continente* - Lisbon (supermarket) - Nisa - Madeira - The Açores	Semestrial	Cs-137, Sr-90**, K-40
Marine samples (algae and mussels)	- Matosinhos - Figueira da Foz - Rio Tejo (estuary) - River Sado (estuary) - Cabo de S. Vicente	Annual	Gamma spectrometry (natural and anthropogenic radionuclides) and plutonium
Soils	- Sacavém campus (2 locations) - Randomly chosen sampling locations covering the national territory (5 locations)	Monthly Annual	Gamma spectrometry (natural and anthropogenic radionuclides)

* Regional directorates for agriculture (continental Portugal).

** Implementation in 2007.

APPENDIX 5

DPRSN – NATIONAL RADIOLOGICAL SURVEILLANCE – SAMPLING LOCATIONS



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