EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D - Nuclear Energy
Radiation Protection

TECHNICAL REPORT

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

URANIUM SITES

Environmental Radioactivity and Discharge Monitoring and part of National Monitoring System for Environmental Radioactivity

Portugal

10 to 15 April 2011

Reference: PT-11/01

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

FACILITIES:	Uranium mining and milling sites: Provisions for monitoring and controlling of radioactive discharges and for the surveillance of the environmental radioactivity in the vicinity of the sites. (Part of the) National Monitoring System for Environmental Radioactivity.
DATE:	10 to 15 April 2011
REFERENCE:	PT-11/01
VERIFICATION TEAM:	Mr C. GITZINGER (Head of team) Mr E. HENRICH Mr. A. RYAN Mr. E. HRNECEK
DATE OF REPORT:	26/04/2012

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1. ABREVIATIONS

APA	*Agência Portuguesa do Ambiente* (Portuguese Environment Agency, of the *MAOT*)
ARH	*Administração da Região Higrografica do Centro* (Hydrographic Region Administration - Center, of the *MAOT*)
CCDR	*Comissão de Coordenação e Desenvolvimento Regional* (Regional Development and Coordinating Commission)
BSS	Basic Safety Standards
CIPRSN	*Comissão Independente de Protecção Radiológica e Segurança Nuclear* (Independent Commission on Radiation Protection and Nuclear Safety)
CPR	*Companhia Portuguesa de Radio*
DGAE	*Direcção –Geral dos Assuntos Europeus* (Directorate-General for European Affairs of the *MNE*)
DGAE	*Direcção –Geral das Atividades Económicas* (Directorate-General for Economic Activities of the former *MEID*)
DGEG	*Direcção -Geral de Energia e Geologia* (Directorate-General for Energy and Geology, of the former *MEID*)
DG ENER	Directorate General for Energy (of EC)
DG JRC – IES	Directorate General Joint Research Centre – Institute for Environment and Sustainability (of EC)
DGS	*Direcção -Geral da Saúde* (Directorate-General of Health of the Ministry of Health)
DG TREN	(former) Directorate General for Energy and Transport (of EC)
DPP	*Departamento de Prospectiva e Planeamento e Relações Internacionais* (Planning and Prospective Department of the former *MAOT*)
EC	European Commission
EDM	*Empresa de Desenvolvimento Mineiro, S.A.* (state enterprise for the restoration of mining sites)
ENU	*Empresa Nacional de Uranio*
EURDEP	EUropean Radiological Data Exchange Platform
EXMIN	*Companhia de Indústria e Serviços Mineiros e Ambientais, SA* (Limited Liability Company by Shares under Portuguese law)
GM	Geiger Müller (radiation detector)
GPS	Global Positioning System
GSM	Global System for Mobile communications
HDPE	High Density PolyEthylene
HPGe	High Purity Germanium (gamma radiation detector device)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ILO	International Labour Organization
ISL	In Situ Leaching
ISO	International Organization for Standardization
ITN	*Instituto Tecnológico e Nuclear* (Nuclear and Technological Institute)

JEN	*Junta de Energia Nuclear*
LIMS	Laboratory Information Management System
LSC	Liquid Scintillation Counter (radiation detector device)
MAOT (now *MAMAOT)*	*Ministério do Ambiente e do Ordenamento do Território,* now *Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território* (Ministry of the Environment and Spatial Planning, now Ministry of Agriculture, Sea, Environment and Spatial Planning)
MCTES (now MEC)	*Ministério da Ciência, Tecnologia e Ensino Superior* (Ministry of Science, Technology and Higher Education)
MEID, (now *MEE)*	*Ministério da Economia, da Inovação e do Desenvolvimento*, now *Ministério da Economia e do Emprego* (Ministry of Economy, Innovation and Development, now Ministry of Economy and Employment)
MNE	*Ministério dos Negócios Estrangeiros* (Ministry of Foreign Affairs)
NIM	Nuclear Instrumentation Module
NORM	Naturally Occurring Radioactive Material
OJ	Official Journal
PC	Personal Computer
PM10	Particulate Matter < 10 µm
RADNET	Portuguese RADiological monitoring NETwork (for ambient gamma dose rate)
REVIRA	*REd de VIgilancia Radiologica Ambiental* (Environmental Radiological Monitoring Network in Spain)
SMI	*Direcção de Serviços do Mercado Interno* (Internal Market Department of the *DGAE* of the *MNE*)
SUR	*Sociedade Uranio-Radio*
TLD	ThermoLuminescence Dosimeter
TSS	Total Suspended Solids
UPS	Uninterruptible Power Supply
UPSR	*Unidade de Protecção e Segurança Radiológica* (Radiological Protection and Safety Unit of *ITN*)

1. INTRODUCTION

Article 35 of the Euratom Treaty requires that each Member State establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the Basic Safety Standards ([1]).

Article 35 also gives the European Commission (EC) the right of access to such facilities in order that it may verify their operation and efficiency.

For the EC, the Directorate-General for Energy (DG ENER), and in particular its Radiation Protection Unit (ENER D4), is responsible for undertaking these verifications.

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

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

From 10 to 15 April 2011, two verification teams from DG ENER (former DG TREN) visited different uranium mining and milling sites around Urgeiriça (northern/central Portugal). The aim of the verification was to check the operation and efficiency of the facilities and associated analytical laboratories for continuous monitoring of the level of radioactivity in air, water and soil in the vicinity of these sites on the territory of Portugal. The verification scope also covered on-site facilities monitoring liquid and aerial discharges of radioactivity into the environment. Stations of the national network for ambient gamma dose rate monitoring in the area were visited as well.

During the verification activities the EC teams were accompanied by representatives of the relevant Portuguese authorities and other actors.

The visit included meetings with representatives of various national authorities having competence in the field of radiation protection. An opening meeting and a closing meeting were held, with all parties involved during the visit, in the premises of the Directorate-General for European Affairs (Ministry of Foreign Affairs).

The present report contains the results of the verification team's review of relevant aspects of discharge control, radiological environmental surveillance and remediation activities put in place by the competent Portuguese authorities on and around the verified uranium mining and milling sites as well as of the national monitoring network stations in the area.

2. PREPARATION AND EXECUTION OF THE VERIFICATION

2.1 PREAMBLE

The Commission's request to perform of an Article 35 verification was notified to the Permanent Representation to the European Union of Portugal by letter ENER/D4/CG/cn ARES(2011)79630, dated 31 January 2011.

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

Subsequently, practical arrangements for the implementation of the verification were made with the competent authority, which provided preliminary information on the Portuguese legislation and its implementation with respect to radiation protection for uranium mining and milling sites.

The competent Portuguese authority, the Ministry of Foreign Affairs, with its Directorate-General for European Affairs efficiently acted as co-ordinator and thus ensured not only that the verification programme could be fully implemented, but also that all other actors involved in matters of radiation protection relevant to the mission were present and available during the week of the visit.

2.2 PROGRAMME OF THE VISIT

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

The programme encompassed:

- The verification of liquid and gaseous radioactive discharge control and of the environmental radioactivity monitoring programmes as carried out for the visited uranium mining and milling sites (sampling and monitoring systems, analytical methods, quality assurance, bookkeeping, reporting).
- The verification of laboratories associated with the monitoring of former uranium sites.
- The verification of stations of the national monitoring system for environmental radioactivity in the area.

At the locations visited the verification addressed technical aspects of monitoring and sampling activities, analytical methods used, quality assurance, data handling, archiving and reporting.

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

2.2.1 Documentation

In order to facilitate the work of the verification team, a package of information was supplied in advance by the Portuguese authorities in response to questions from the Commission. Additional documentation was provided during and after the visit. All documentation received is listed in Appendix 2 as well as the web sites used. 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.

2.3 REPRESENTATIVES OF THE COMPETENT AUTHORITIES AND THE SITE-OPERATORS

During the verification visit, the following representatives of the national authorities and the site-operators were met:

Ministry of Foreign Affairs (MNE)

DGAE – Directorate-General for European Affairs, ***SMI*** (Internal Market Department)

Ms. Lénia Real	Head of Department
Ms. Adelaide Cardoso	Head of Unit 'Energy and Atomic Questions'

Ministry of Science, Technology and Higher Education (*MCTES*)

ITN - Nuclear and Technology Institute

Mr. Julio Montalvão e Silva	President of the Directive Board
Mr. Pedro Vaz	Coordinator, Radiological Protection and Safety Unit (*UPSR*)/*ITN* researcher
Mr. Romão Trindade	Deputy-Coordinator, Radiological Protection and Safety Unit (*UPSR*)/ *ITN* researcher
Ms. Maria José Madruga	responsible for the National Environmental Monitoring Programme / *ITN* researcher and Portuguese representative to the Group of Experts under the Article 35/36 of the EURATOM Treaty
Mr. Fernando Carvalho	responsible for the Environmental Monitoring Programme around the former uranium mines/*ITN* researcher
Mr. Mário Capucho Reis	responsible for the Environmental Monitoring Programme of the *ITN* campus/ *ITN* researcher

Ministry of Economy, Innovation and Development (*MEID*)

DGAE - Directorate-General for Economic Affairs

Ms. Donzilia Santo	Head of Unit

DGEG - Directorate-General for Energy and Geology

Mr. Luis Martins	Head of Department / Geologist
Mr. Luis Morais	Head of Unit/Mining engineer

EDM (the state enterprise for the restoration of mining sites)

Mr. José Manuel Gaspar Nero	CEO
Ms. Sofia Barbosa	Geological engineer
Mr. Pedro Tavares	Civil engineer
Mr. Rui Pinto	Environmental engineer
Ms. Helena Gomes	Environmental engineer
Mr. José Martins	Mining engineer
Mr. José Baltazar	Geotechnical engineer

Ministry of the Environment and Spatial Planning (*MAOT*)

DPP - Planning and Prospective Department

Ms. Patricia Lopes	Legal adviser

APA - Portuguese Environment Agency

Mr. Mário Grácio	Director-General
Ms. Maria do Carmo Palma	Head of Unit
Mr. João Oliveira Martins	Adviser

Ministry of Health

DGS - Directorate-General of Health

Mr. José Robalo	Deputy Director-General of Health
Mr. Paulo Diegues	Head of Environmental and Occupational Health Division
Mr. Pedro Rosário	Engineer -Environmental and Occupational Health Division

Independent Commission on Radiation Protection and Nuclear Safety (*CIPRSN*)

Mr. José Carvalho Soares	President
Ms. Ana Lino	Technical Team
Ms. Maria Manuel Meruje	Technical Team

3. LEGAL PROVISIONS

3.1 LIST OF LEGISLATIVE ACTS REGULATING ENVIRONMENTAL RADIOACTIVITY MONITORING

- Decree-Law nº 165/2002, of 17 July 2002

Establishes the general principles of protection against ionising radiation arising from the pacific use of nuclear energy and defines the competences and attributions of the relevant institutions, partially transposing Council Directive 96/29/Euratom, of 13 May 1996.

(http://dre.pt/pdf1sdip/2002/07/163A00/53645370.pdf)

- Decree-Law nº 138/2005, of 17 August 2005

Establishes a national environmental monitoring system to measure the level of radioactivity in the air, water and soil, in compliance with the monitoring and reporting requirements (under Articles 35 and 36 of the Euratom Treaty, and in accordance with the Recommendation of the European Commission, of 8 June 2000 (COM/473/EURATOM)). The monitoring system is managed by the Nuclear and Technological Institute that must also prepare an annual report ("Relatório de Vigilância Radiológica a Nível Nacional").

(http://dre.pt/pdf1sdip/2005/08/157A00/47734777.pdf)

3.2 LIST OF LEGISLATIVE ACTS ESTABLISHING THE RESPONSIBILITIES OF THE VARIOUS ACTORS IN THIS DOMAIN

- Decree-Law nº 426/83, of 7 December 1983

Approves the Rules of Radiological Protection and Safety in Mines and the Annexes of Ore Treatment and Uranium Recovery.

(http://dre.pt/pdf1sdip/1983/12/28100/39893989.pdf)

- Executory Decision 34/92, of 4 December 1992

Establishes standards for safety and radiological protection in the mining and processing of radioactive ores.

(http://dre.pt/pdf1sdip/1992/12/280B00/55705585.pdf)

- Decree-Law nº 198-A/2001, of 6 July 2001

Establishes the legal regime of the concession to exercise the activity of environmental recovery of degraded mining areas, which will be awarded to *EXMIN*[2] *- Companhia de Indústria e Serviços Mineiros e Ambientais, SA* (Limited Liability Company by Shares under the Portuguese law), according to the bases of the concession contract.

(http://dre.pt/pdf1sdip/2001/07/155A01/00020007.pdf)

- Decree-Law nº 165/2002, of 17 July 2002

Establishes the general principles of protection against ionising radiation arising from the pacific use of nuclear energy and defines the competences and attributions of the relevant institutions, partially transposing Council Directive 96/29/Euratom, of 13 May 1996.

[2] *EXMIN* ceased its activities (September 2005) which are now under the responsibility of *EDM*.

(http://dre.pt/pdf1sdip/2002/07/163A00/53645370.pdf)

- Decree Law nº 174/2002, of 25 July 2002

Regulates the procedures to be adopted in case of radiological emergency, transposing Title IX of Directive 96/29/EURATOM.

(http://dre.pt/pdf1sdip/2002/07/170A00/54735479.pdf)

- Decree-Law nº 138/2005, of 17 August 2005

Establishes a national environmental monitoring system to measure the level of radioactivity in the air, water and soil, in compliance with the monitoring and reporting requirements (under Articles 35 and 36 of the Euratom Treaty, and in accordance with the Recommendation of the European Commission, of 8 June 2000 (COM/473/EURATOM)). The monitoring system is managed by the Nuclear and Technological Institute that must also prepare an annual report ("*Relatório de Vigilância Radiológica a Nível Nacional*").

(http://dre.pt/pdf1sdip/2005/08/157A00/47734777.pdf)

- Decree-Law nº 75/007, of 29 March 2007

Approves the organisation of the National Authority for Civil Protection.

(http://dre.pt/pdf1sdip/2007/03/06300/18341839.pdf)

- Decree-Law nº 139/2007, of 27 April 2007

Approves the organisation of the Directorate General for Energy and Geology.

(http://dre.pt/pdf1sdip/2007/04/08200/26842686.pdf)

- Decree-Law nº 156/2007, of 27 April 2007

Approves the organisation of the Nuclear and Technological Institute.

(http://dre.pt/pdf1sdip/2007/04/08200/27592763.pdf)

- Decree Order 535/2007, of 30 April 2007

Establishes the main structure of the Directorate General for Energy and Geology and the competences of its units.

(http://dre.pt/pdf1sdip/2007/04/08300/28692873.pdf)

- Decree Order 573-C/2007, of 30 April 2007

Establishes the main structure of the Portuguese Environment Agency and the competences of its units.

(http://dre.pt/pdf1sdip/2007/04/08301/00030009.pdf)

3.3 LEGISLATIVE ACTS GOVERNING NORM

- Decree-Law nº 222/2008, of 17 November 2008

Partially transposes the Council Directive 96/29/Euratom, of 13 May 1996, on the BSS for the protection of the health of workers and the public against dangers arising from ionizing radiation.

(http://dre.pt/pdf1sdip/2008/11/22300/0800008076.pdf)

3.4 LIST OF LEGISLATIVE ACTS REGULATING THE RADIOLOGICAL SURVEILLANCE OF FOODSTUFFS AND FEEDING-STUFFS

- Decree-Law nº 138/2005, of 17 August 2005

This Decree-Law establishes a national environmental monitoring system to measure the level of radioactivity in the air, water and soil, in compliance with the monitoring and reporting requirements (under Articles 35 and 36 of the Euratom Treaty, and in accordance with the Recommendation of the European Commission, of 8 June 2000 (COM/473/EURATOM)). The monitoring system is managed by the Nuclear and Technological Institute that must also prepare an annual report ("*Relatório de Vigilância Radiológica a Nível Nacional*").

(http://dre.pt/pdf1sdip/2005/08/157A00/47734777.pdf)

3.5 INTERNATIONAL (GUIDANCE) DOCUMENTS (IAEA, ICRP, EU) UPON WHICH THE ENVIRONMENTAL RADIOACTIVITY MONITORING AND THE RADIOLOGICAL SURVEILLANCE OF FOODSTUFFS ARE BASED

IAEA Documents:

- Safety and Health in Mines Convention, ILO (Entry into force: 2002/03/25);
- Radiation Protection Convention - Convention concerning the Protection of Workers against Ionising Radiations, ILO (Entry into force: 1994/03/17);
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, IAEA (Entry into force: 2009/08/13).

EU Documents:

- Council Directive nº. 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation;
- Directive nº. 1999/2/EC of the European Parliament and of the Council of 22 February, on the approximation of the laws of the Member States concerning foods and food ingredients treated with ionizing radiation;
- Directive nº. 1999/3/EC of the European Parliament and of the Council of 22 February on the establishment of a Community list of foods and food ingredients treated with ionizing radiation;
- Regulation (EC) nº. 854/2004 of the European Parliament and of the Council of 29 April 2004, laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption.
- Commission Recommendation 2000/473/EURATOM.

4. URANIUM MINING AND MILLING IN PORTUGAL

4.1 HISTORICAL OVERVIEW

The mining of uranium and radium in Portugal started in 1909 in the Rosmaneira mine. Initially, the extraction of radium was the main objective of this mining activity and the associated uranium was not exploited. The Portuguese mines may have produced about 100 mg of purified radium in the radium salts factory in Barracão near the city of Guarda. After 1945, when the nuclear fission chain reaction was controlled, the price of uranium rose in the international market and the production of uranium became the target of the mining activity in Portugal, whereas the production of radium was discontinued.

From 1907 to 2001, five different entities were responsible for the exploitation of uranium and radium minerals in Portugal: *Sociedade Uranio-Radio, SUR* (1912–1945), *Companhia Portuguesa de Radio, CPR* (1945–1962), *Junta de Energia Nuclear, JEN* (1962–1977), *Empresa Nacional de Uranio, E.P., ENU* (1977–1990), and *Empresa Nacional de Uranio, S.A.* (1990–2001) (see Fig. 1). Until 2001, when the production ceased, about 4370 tonnes of U_3O_8 had been produced and an estimated 13 million tons of different kinds of wastes were generated.

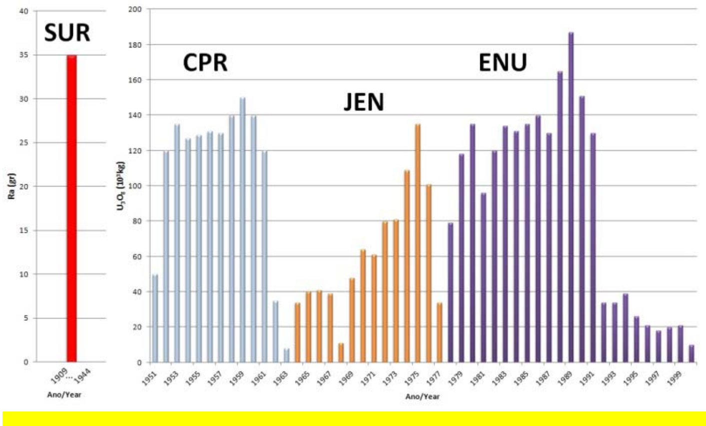

Figure 1: Production of radium and U_3O_8 in Portugal (©*EDM*)

At the time of the verification in 2006 the team was informed that this waste consisted of geological material containing hazardous chemical and radioactive substances and, if left as such, would be exposed to external geodynamic processes that would be 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).

In 2006 the dose equivalent rates measured on the tailings varied with the location and in some spots reached 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).

Sixty mines were exploited for uranium and radium ore, most of them located in the counties of Guarda, Viseu and Coimbra (Figs. 2 and 3). The exploited ore bodies had different characteristics, particularly in terms of typology and structure (depth and regularity of the mineralization distribution), or host rock characteristics. These characteristics determined the different mining methods: underground, open pit, combined underground/open pit, sometimes using heap or in situ acid leaching (ISL). A great number of mines were of small size and exploited as open pits, although some of the larger ones were exploited as underground galleries or in a combination of both methods (see Appendix 3.

Figure 2: Location of uranium and radium mines in Portugal (overview)

In most cases, the uranium ore was extracted and then transported to Urgeirica (Canas de Senhorim, Guarda) or another major mining facility for milling and extraction of the uranium, in the form of uranium oxide U_3O_8. Other chemical treatment facilities were operated at Bica (Sabugal, Guarda), Quinta do Bispo and Cunha Baixa (Mangualde, Guarda), Senhora das Fontes (Pinhel, Guarda) and Castelejo (Gouveia, Guarda).

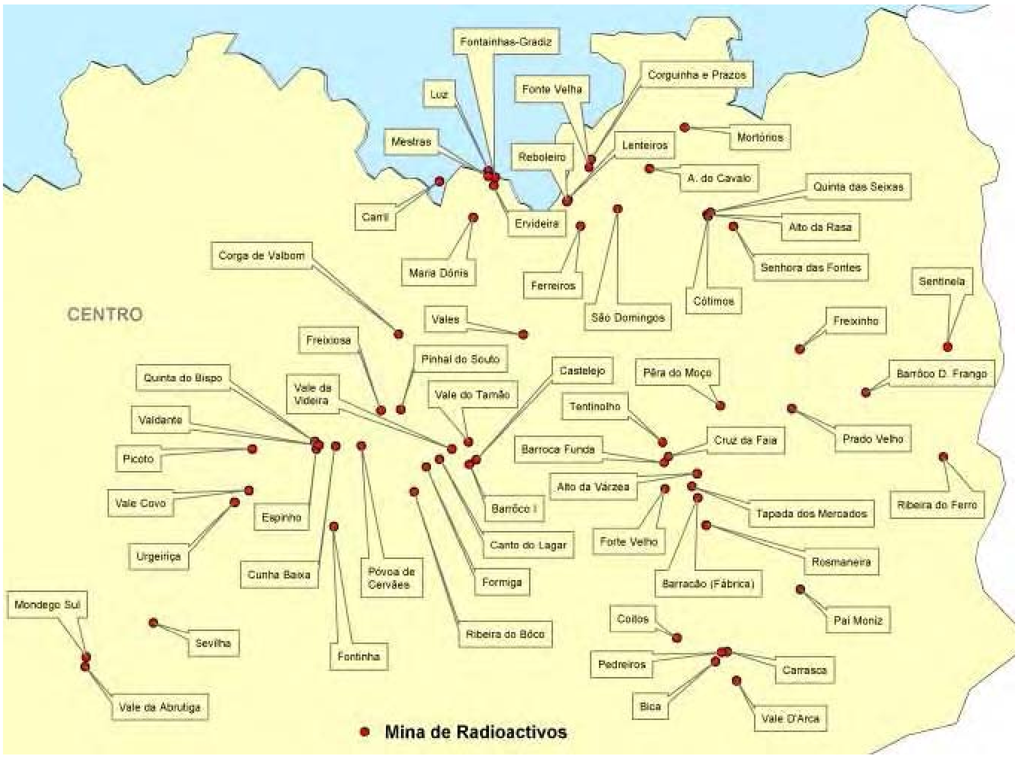

Figure 3: Location of uranium and radium mines in Portugal (details)

4.2 ENVIRONMENTAL REHABILITATION OF URANIUM MINING AND MILLING SITES IN PORTUGAL

The need to find appropriate means for re-establishing an environmental equilibrium in the areas affected by the mining industry led the Portuguese Government to assume, as its fundamental duty, the insurance of adequate remediation of those areas in Portugal mainland.

This policy has led to the publication of *Decree Law Nr 198-A/2001*, which establishes the main principles and objectives of the remediation and monitoring of abandoned mining areas. This legislation established the public service nature of remediation and granted the exclusivity of such activity to the *EXMIN* company - *Companhia de Industria e Servicos Mineiros e Ambientais, S.A.*

Nowadays, it is the responsibility of *EDM - Empresa de Desenvolvimento Mineiro, S.A.*. According to the concession contract, the remediation of abandoned mines aims at an improvement in environmental, cultural, economic and regional conditions, assuring the public interest and the preservation of environmental and patrimonial heritage, through a set of interventions based on adequate levels of efficiency and quality and guided by entrepreneurial management criteria.

Following *Despacho Conjunto Nr 242/2002*, dated 14 March 2002, that recognized the "undeniable public interest of an immediate state intervention on the area of uranium mining exploitation", an initial set of 30 uranium mines were considered under the scope of *Decree-Law 198-A/2001*. Afterwards, *Despacho Nr 267/2005* was published (addendum to the list of former uranium mines to be remedied).

EDM's rehabilitation activity was broken down into different phases. A first phase comprised the inventory of the situation and local surveys, followed by an analytical hierarchy process to identify priorities and an initial planning period. Having defined the main characteristic types, according to the environmental impacts and particular features of the mines, in a second phase, master or action plans were produced, as well as engineering designs and environmental impact studies, along with the implementation of effluent treatment systems. Currently and simultaneously, rehabilitation and monitoring works are at different levels of progress. Phase four combines the maintenance and long term monitoring of the rehabilitated areas.

Presently, for the vast majority of former uranium mines in Portugal, phase two is completed.

All these activities developed by *EDM*, have to be approved by *DGEG* (*Direcção Geral de Geologia e Energia*) prior to their implementation. Two of the environmental impact studies (Urgeiriça and Vale da Abrutiga) have undergone a complete environmental impact assessment in the Portuguese Environmental Agency, while for all the others the regional *CCDR* (*Comissão de Coordenação e Desenvolvimento Regional*) has been consulted.

4.3 APPLIED REGULATIONS

As criteria for water quality monitoring, *EDM* considers the national standards of water intended for irrigation and the environmental objectives of minimum quality standards for surface waters defined in *Decree-Law No. 236/98*, of 1 August 1998.

For mine water treatment plants (Urgeirica, Cunha Baixa, Quinta do Bispo, Bica Castelejo and Vale da Abrutiga mines), the limits considered are those defined in *Decree Law No. 236/98* on the discharge of sewage.

Since the national legislation of Portugal does not address the radiological parameters analyzed, *EDM* uses the USA standard *USEPA 40 CFR Parts 9, 141*, and *142* of the *National Primary Drinking Water Regulations, Final Rule* for drinking water, whose limits are 0.185 Bq/l (for 226-Ra + 228-Ra) and 30 µg/l for uranium. In the U.S., the limits set for the discharge of effluents from mining of uranium (*USEPA* Standard *CFR440.32 "Effluent limitations for mine drainage from open pit and underground uranium mines"*) for total uranium and 226-Ra are 4000 µg/l and 1.11 Bq/l, respectively, for daily values, and 2000 µg/l and 0.37 Bq/l for the monthly average values.

4.4 MONITORING PROGRAMME

4.4.1 Liquid Discharges

Six of the former uranium mines currently have an active mine water treatment, and the discharged effluent is controlled. Presently, in four of those treatment plants (Urgeiriça, Cunha Baixa, Castelejo and Bica), *EDM* implemented a continuous monitoring system that measures pH, conductivity, temperature, Eh, flow and TSS (Total Suspended Solids). The sensors measuring the different parameters are connected to controllers and to a data logger. From those controllers data are sent (as normalised signals) to a computer equipped with a GSM modem.

The computer acquires, stores and does a first level treatment of the data and manages the transmission to the *EDM* main office server in Lisbon. In this server, the data are treated, properly stored and prepared for user access, using Internet.

In addition to the continuous monitoring, *EDM* does a weekly composite sample (two samples per month) in the Urgeiriça, Cunha Baixa, Quinta do Bispo, Castelejo, Bica and Vale da Abrutiga mines, in which pH, temperature, conductivity, chlorides, manganese, calcium, sodium, Ra-226, total uranium and sulphates are analysed. The same parameters are determined every three months in the raw effluent. Table 1 summarizes the discharged effluent control.

Table 1: Summary of liquid discharge control at various sites (©*EDM*)

Mines	Number of Samples	Sampling frequency	Parameters
Urgeiriça, Cunha Baixa, Quinta do Bispo and Bica	-	Continuous	Flow, pH, conductivity, ORP, temperature, TSS
Urgeiriça, Cunha Baixa, Quinta do Bispo, Castelejo, Bica and Vale da Abrutiga	2 per month (treated effluent)	Weekly (composite sample)	pH, Temperature, Conductivity, Cl^-, Mn^{2+}, Ca^{2+}, Na^+, ^{226}Ra, U_{total}, SO_4^{2-}
	1 (raw effluent)	Quarterly	pH, Temperature, Conductivity, Cl^-, Mn^{2+}, Ca^{2+}, Na^+, ^{226}Ra, U_{total}, SO_4^{2-}

4.4.2 Water Sampling Programme

The programme executed by *EDM* comprises mine waters, as well as surface and ground waters. This programme has been optimised taking into account the results obtained in previous and more comprehensive programmes and characterisation work done from 2006 to 2009.

4.4.2.1 Mine Waters

In the Urgeiriça, Cunha Baixa, Quinta do Bispo, Castelejo, Bica and Vale da Abrutiga mines, mine waters are sampled quarterly to measure pH, temperature, conductivity, Eh, Cl^-, Mn^{2+} , Ca, Na, Ra-226, total U and SO_4^{2-}, defined in previous work as indicator parameters.

In other mines, e.g. Senhora das Fontes, Mortorios and Prado Velho, the mine waters are sampled semi-annually, to measure pH, temperature, conductivity, Eh, Cl^-, Mn^{2+}, Ca, Na, Ra-226, total U and SO_4^{2-}.

Historic results of the monitoring have not shown significant contamination in other areas of former uranium mines. In these cases, *EDM* ensures the monitoring of pH, conductivity, Eh, temperature, sulphate, manganese, iron, uranium and radium-226, on an annual basis. This is the case for the Alto do Cavalo, Alto da Varzea, Barração, Barroco Dom Frango, Barroco I, Canto do Lagar, Carrasca, Coitos, Corga de Valbom, Cruz da Faia, Espinho, Ferreiros, Fonte Velha, Fontainhas-Gradiz, Fontinha, Forte Velho, Freixinho, Freixiosa, Lenteiros, Luz, Maria Donis, Mestras, Mondego Sul, Pera do Moco, Picoto, Pinhal do Souto, Póvoa de Cervães, Ribeira do Boco, Rosmaneira, S. Domingos, Sentinela, Tintinolho, Valdante, Vale do Tamão, Vale da Videira and Vale de Arca mines.

4.4.2.2 **Surface Waters**

Surface waters are monitored upstream and downstream of the former uranium mines with different frequencies: upstream waters are monitored biannually and downstream waters quarterly to assess pH, temperature, conductivity, Eh, Cl^-, Mn^{2+}, Ca, Na, Ra-226, total U and SO_4^{2-}. This is done for the Urgeiriça, Cunha Baixa, Quinta do Bispo, Castelejo, Bica and Vale da Abrutiga mines. In the Senhora das Fontes, Prado Velho and Mortorios mines, the sampling is done biannually upstream and downstream.

4.4.2.3 **Ground Waters**

Groundwater monitoring is carried out in the same mines where surface water monitoring is performed. The samples are collected twice a year and the same parameters are analysed.

4.4.3 Air Sampling Programme

EDM also carries out radiological air quality monitoring, determining the alpha emissions of the decay products of Rn-222 and Rn-220, the gross α activity of suspended particles in the air and also the deposition rate of suspended particles using dosimeters and site deposition meters. Samples are taken continuously for a month, at the end of this period the heads of the dosimeters and the sampling bottle of the deposition meters are replaced.

4.4.4 Soil Radon Monitoring System

To check the effectiveness of the technical remediation solution used at the Urgeiriça Old Tailings Dam (*Barragem Velha*), *EDM* implemented a continuous monitoring system that measures the volume activity of radon in the soil at six sites at different depths; thus the effectiveness of the sealing materials used to prevent radon diffusion into the atmosphere can be assessed.

The probes installed count the pulses produced by α particles in the detector chamber, with a sensitivity of 50 Bq/m^3 per impulse/hr, by taking measurements at two or three levels over a vertical profile:

- Point A: the deepest point, located below the applied geotextile membrane (depth 1.10 to 1.20 m);
- Point B: intermediate point, situated above the applied geotextile membrane (depth 0.70 m);
- Point C: the top spot, situated in the surface soil.

Points A, B and C at each station were deployed at the vertices of an equilateral triangle with 10 to 12 m distance (see Fig. 4) in order to avoid interference between them. Three stations have three (A, B, C) and three stations have two measuring probes (B, C).

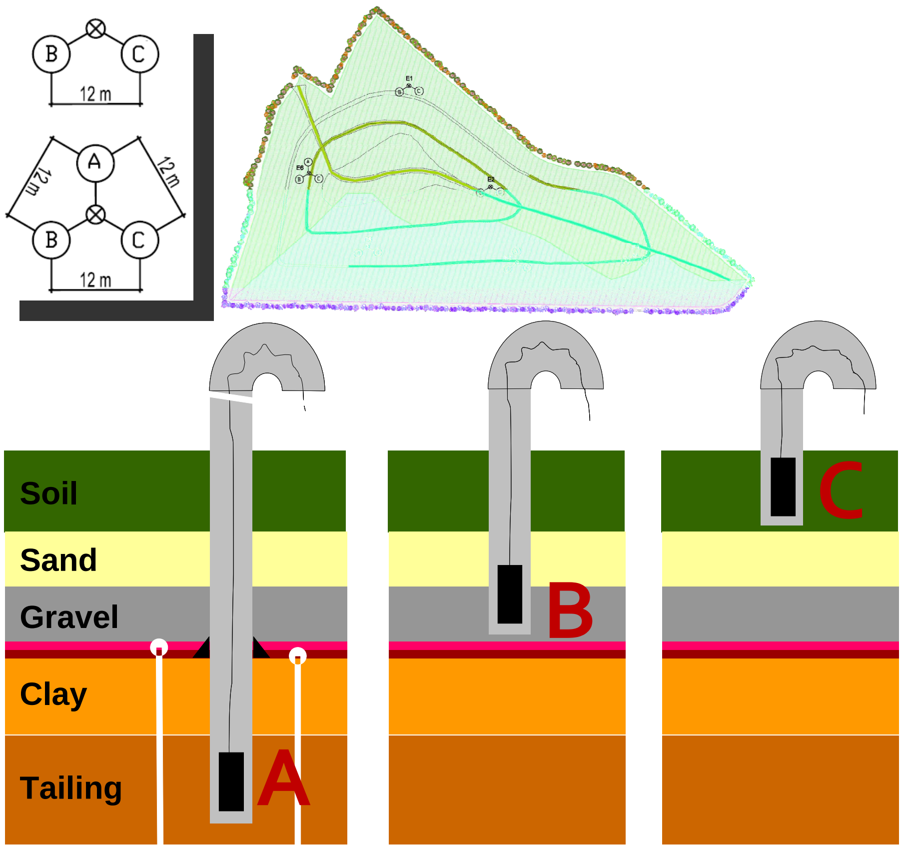

Figure 4: Soil radon measuring stations at Urgeiriça *Barragem Velha* (©*EDM*)

4.4.5 Environmental monitoring of sites released for public access

All the results of the monitoring programme carried out by *EDM* are sent to *DGEG – Direcção Geral de Geologia e Energia*. The data regarding the liquid discharge control are also sent to the regional *ARH – Administração de Região Higrografica do Centro.*

4.4.6 Meteorological Stations Involved

EDM has a meteorological station at the Cunha Baixa Mine, near Mangualde. This station has the following devices:

- *Campbell Scientific CR800* measurement and control system;
- *ARG100* aerodynamic rain gauge manufactured by *EML*;
- *Gill Instruments WindSonic™* - sensor for wind speed and direction;
- *SP1110* pyranometer;
- *Vaisala HMP45A* relative humidity and temperature probe.

EDM also acquires data (temperature, precipitation, average wind speed and evapotranspiration) from the Guarda meteorological station that forms part of the Meteorological Institute's (*Instituto de Meteorologia*) national network.

4.5 Laboratories involved in the Monitoring – Description and Verification

All the chemical and radiological analyses done under the monitoring programme implemented by EDM are outsourced to third parties, duly formalised by contract.

All processes associated with water sampling and monitoring are properly controlled by *EDM*, which coordinates the activities, checks the results, and – for this purpose – has developed and implemented a manual of procedures for: collecting samples (according to its type), preservation of the sample and expenditure to the laboratory, reception, verification, testing and validation of laboratory results.

4.5.1 *Instituto Tecnológico e Nuclear* (*ITN*) Sacavém

4.5.1.1 General

The team visited the *Instituto Tecnológico e Nuclear* (*ITN*) at Sacavém. The institute is subordinated to the *Ministério da educação e ciência* (Ministry of Science, Technology and Higher Education) and employs about 170. *ITN* was integrated in that ministry which has as it's objective "pursuing the national science and technology policies, namely in the area of peaceful applications of nuclear energy, as well as assuring the State duties in radiological protection, environmental radioactivity, and nuclear safety".

The team received several presentations and was informed that the province of Beiras Portugal has some 400 uranium ore deposits. Between 1998 and 2001 up to 60 mines were operational, in which first radium was extracted and afterwards uranium. All uranium ore was sent to one of the five mills in Portugal (mostly to Urgeiriça). The rio Mondego which flows through the main uranium mining area, is the drinking water supply for central Portugal (including the city of Coimbra).Though the risk of surface water contamination exists it is considered very low considering the quality of the remediation work undertaken and the regular monitoring activities performed as part of the National Monitoring Programme for Environmental activity.

In some of the former mining areas (e.g. the former Bica uranium mine), there is still a need to treat mine waters (which are still acidic and have high concentrations of U and Ra), since there might be water overflow into agricultural areas. In such areas, the water is currently collected and treated.

Under the terms of Article 14 of decree Law 165/2002 *ITN* is responsible for the environmental monitoring in the regions around uranium mines. The former Minister for Science, Technology and Higher Education has formally approved the comprehensive and detailed monitoring programme proposed by ITN. Currently monitoring activities concentrate on the main former uranium mining and milling areas, other areas are included in a rotational mode.

4.5.1.2 *ITN* radiological laboratories [

A ASS500 high volume air sampler operated by ITN as a member of the Portuguese environmental radioactivity monitoring system is located on the grass in front of the laboratory building .

The verification team noted that the set-up of the buildings housing the laboratory is far from ideal and is rather 'provisional' with staff having to go outside when moving from one lab room to another. This may be a problem when it rains, e.g. with regards to the integrity of samples transported.

> *The verification team recommends finding a solution that leads to fewer problems with regard to physical transfers between the laboratory rooms.*

Sample registration and sample preparation room

For this purpose, the laboratory uses a LIMS data base system (*SIAC 2000*). This commercial product, originally foreseen for medical applications, was adapted "in-house" to the needs of the laboratory.

All samples are taken by ITN's own staff. Upon their arrival at the laboratory they are accompanied by a sample sheet including data such as GPS coordinates of the sampling location, a description of the sampling place etc.. All samples are registered in a log book and receive a unique sample number (bar-code; additional information on the type of sample; code for the relevant monitoring programme).

The team noted several furnaces, (a large *Termolab* device, several from *Heraeus*) and several dryers (*Memmert*) used for sample preparation.

Separation of Th (using Th-229 as tracer), U (U-232 as tracer), Ra, and Po (Po-209 as tracer) is performed using an appropriate ion exchange resin (*UTEVA* from *Eichrom), whilst* the tracers are from *Oak Ridge* and *Amersham*. Electroplating is performed on stainless steel disks.

Altogether five staff members work in radiochemistry, two of them are specialised in alpha spectrometry.

Alpha spectrometry room

The team were shown three *Ortec Octète plus* counters (8 chambers each), eight *Ortec 576* devices (2 chambers each) in NIM frames, four *Ortec* vacuum pumps and three PCs using *Ortec Maestro* software for spectrum management and analysis. An external hard disk is used for back-ups.

Gamma spectrometry laboratory

The building housing the gamma spectrometry systems is constructed from low activity limestone. Air is circulated to reduce radon and to maintain a stable gamma background.

The laboratory has nine HPGe detectors from *Ortec*, *Canberra* and *PGT*, among them some low energy versions. At the time of the verification, only four devices were in operation. NIM electronics is from *Canberra* and *Ortec*.

For the lead shields various designs are used: cubic, cylindrical, side slide, top slide and some are constructed with swallow tail lead bricks. At the time of the visit one shield was being re-installed.

Spectrum analysis calculations are performed using the *Canberra Genie 2000* software. For summing and matrix corrections *GeSpeCor* software (*CID GmbH*, Freigericht, Germany) is used. The lab hopes to move to a Monte Carlo based spectrum analysis system.

Calibration sources (water equivalent resin) are from *Eckert & Ziegler*; they are replaced every two years; five geometries are calibrated.

Electrical power back-up is provided by UPS and a diesel generator which covers all measurement devices.

Quality and Data management

Accreditation of the laboratory is ongoing. Some operations are already accredited. The laboratory participates in two to three inter-comparisons per year. They have already been invited by IAEA to certify for reference material, which is a sign of quality. Accreditation also covers areas beyond technical (administration etc.) that currently are a weak point. The laboratory is waiting for the accreditation of eleven further techniques (including gamma spectrometry.

> *The verification team encourages all efforts aimed at receiving formal accreditation for U mine related work.*[3]

Tracing

[3] According to information by the Portuguese authorities successful audits were undertaken in December 2011 and January 2012 for ten techniques.

The team asked to trace a "historical" sample of 10 August 2009, water from well no U5 *'poço Loureiro Pinto'*, of the Urgeiriça site, with the sample number 990in the LIMS.The alpha spectrum was measured in September 2009 (serial number 2314) and immediately found in the LIMS. A second measurement was performed on 5 May 2010. All values could easily be traced back.

4.5.2 University of Coimbra

The verification team visited the laboratory of Natural Radioactivity which is part of the Earth Sciences faculty of the University of Coimbra. The lab performs a large part of the analysis for *EDM* following a public tender award. From 2006 to 2008 there was a peak in the number of analyses performed, the number has reduced somewhat since then. Over 6000 individual analyses have been performed up to the date of the visit. The sampling is done by *EDM*, or their subcontractors. Analyses relate to the determination of uranium and Ra-226 in waters.

Each batch of samples is accompanied by an *Excel* spreadsheet with data concerning the sample (date of sampling, location etc,) which is uploaded to *FULCRUM*, an internally developed system for sample management. This generates an internal reference which is printed in the form of a bar code and will accompany the sample throughout the laboratory.

A LIMS system, tailored to the needs of the laboratory was developed in house using *Visual Basic* and an *Access* database

Correction factors are calculated in accordance with international standards. At the outset 40-60 of the initial samples were analysed by both the University and *Algade* and the results compared.

Protocols for Ra-226 and total U analyses were available in the lab. All procedures are in line with what one would expect of a certified lab, however the University is precluded from obtaining ISO certification as the lab is also used by students.

Background radiation is measured daily in the labs.

For both U and Ra-226 a *Quantulus* LSC is used.

For the determination of Ra-226 in water a ~ 500 g sample is weighed in a beaker and the volume reduced on a hotplate in two steps to ~ 30 g, weighed and a 10 g aliquot taken by weight into an LSC vial, *Betaplate Scint* cocktail is added and stored for 21 days before counting. Each beaker is numbered and its tare weight is registered in the system. Results are reported in Bq/litre.

For uranium a 500 g sample is degassed for 10 minutes to remove the radon. Uranium is extracted with 20 ml *Betaplate Scint* cocktail plus 1 ml (2-ethylhexyl)phosphate and put into an LSC vial. An extraction efficiency of 100% is assumed (there were comparison measurements with *Algade* (France) in the beginning to check this). U-238 is determined from the LSC spectrum (50% of the alpha portion is taken for this purpose); from this U-238 is calculated as Bq/L and then converted to ppb uranium for reporting.

White caps are used on vials to indicate samples for radon analysis whilst red caps denote samples for U analysis. After every 50 passages through the system the vials are cleaned with *Count-off* ™.

A set of reference weights was available for calibration of the balances used.

All original samples and prepared vials are held until *EDM* validates and accepts the results.

Recently a contract was signed with '*ECODEAL'* for the safe elimination of all waste.

The verification does not give rise to any remarks.

4.6 FORMER URANIUM MINING AND MILLING SITES - VERIFICATION

With regards to former mining activity in Portugal there were altogether some 174 mines, of which some 60 extracted uranium. All former uranium mines are the property of the Portuguese State. Thus, responsibility for any measures including long-term stewardship lies with the government. The technical control of the measures/action implemented by *EDM* is by *ITN*.

Altogether more than 20 Mt of material have been moved during remediation until recently. The total project costs total more than 116 M€.

Water treatment systems are in place in five areas; *EDM* wants to develop solutions with minimal water flow and minimum monitoring and energy consumption with a view to facilitate long-term stewardship. During project realisation the influence on the waters (composition etc.) has to be registered and the methods have to be adapted during the work. Currently active and passive systems are used; in the long term only passive systems should remain.

The automatic equipment used is essentially the same everywhere, thus allowing efficient handling, maintenance and repairs.

Data reporting by *EDM* is every 3 months to the responsible authority (e.g. local water authority).

For drinking water a limit of 30 ppb is set for U; which is the limit for well water for the general population. Mine waters currently show values of ca. 200 µg/l. For Ra-226 a 'limit' of 0.28 Bq/l is in place (the old US "*ANS*" value of 0.74 Bq/l is no longer used); there are no limits for drinking water foreseen in Portuguese law (only for surface water). Measured values are some 0.01 Bq/l. Using these values is seen as a conservative approach, since even treated waters are not used as drinking water, only for irrigation; the limits have never been reached .

4.6.1 Urgeiriça former uranium mining and milling area

The Urgeiriça mine is located in central Portugal and was the country's most important uranium exploitation site. Exploitation began in 1913 and until 1944 the ore was mined for radium extraction. After World War II the aim shifted to solely recovering uranium as a 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 uranium mines exploited in Portugal, were processed in a uranium mill facility built in 1951 near Urgeiriça. Sludge from this facility included 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).

Figure 5 gives an overview over the Urgeiriça site and shows the remediation steps.

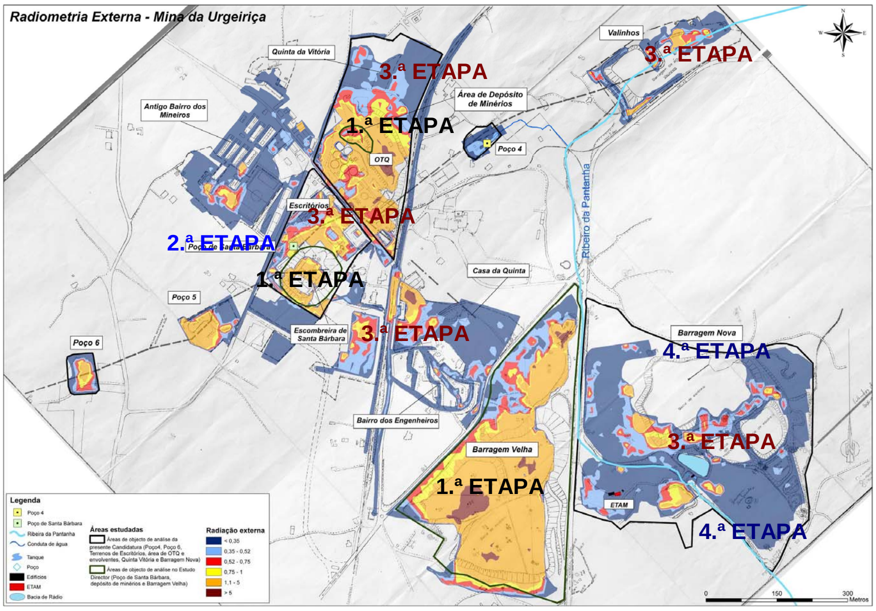

Figure 5: Urgeiriça uranium mining and milling area; remediation steps 1 to 3 were completed at the time of the verification visit (©*EDM*)

At the 2006 Art. 35 verification, the Commission experts learned that the Urgeiriça mining activities left a large amount of waste deposited at three locations. The largest tailings (an estimated 1.39 million m³ on 13.3 ha) consisted 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 was located near the main shaft (about 91 000 m³ on 1.5 ha) at the time of the 2006 visit. Finally, a few tons of high-grade uranium ore (not milled) were still deposited near the plant.

At that time, groundwater percolated the interior of the old mine and the nearby mill tailings where it could interact with the geological materials present, inducing a transfer of chemical and radioactive elements from solid into liquid phase. The resulting waters were acidic and 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 had been put in place in order to collect contaminated waters from the mine and the mill tailings and to divert them to a water treatment plant.

This latter plant neutralised the pH of the water by adding quicklime and precipitated radium compounds and heavy metals by adding barium chloride. In 2006, the treated waters were sent to two sequential impervious basins (approximately 19.6 ha) for the settling of the chemical compounds (gradual accumulation at the bottom). Before discharge into the environment (into the "Ribeira da Pantanha" stream, a tributary of the Mondego River) the water that naturally overflows from the last basin was subjected to continuous hydro chemical monitoring as well as continuous sampling for the purpose of radiological assessments. This purification plant was still operating during the 2011 visit.

4.6.1.1 Remediation and rehabilitation of the Urgeiriça tailings, *Barragem Velha*

"*Barragem Velha*" is located a few hundred metres southeast of the former Urgeiriça mine and the mill (see figure 5).

Already at the 2006 verification visit, the old dam "*Barragem Velha*" and its tailings ponds, were considered to be one of the most important tasks for remediation. The environmental remediation of the tailings at the Urgeiriça mine was declared to be of top priority([4]) within the national plan for the rehabilitation of former uranium mining sites. This project also included environmental remediation of

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

the mine's industrial area where the remains of the former milling and processing plants are located (plus the two deposits of ore and waste rock respectively). Furthermore all the waste arising from the industrial area would be transferred to the tailings.

A master plan for the remediation of the Urgeiriça site was developed at that time. The plan was that the tailings area itself would have to be geo-technically stabilised (field works had started already 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.

It was projected that the cover of the tailings deposit should 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 (30 cm),
- sand (25 cm),
- soil (50 cm) + vegetation.

After remediation the tailings would be fenced off to prohibit public access. The above works were planned for completion before the end of 2007.

Optimisation processes with regard to different projects took place, the necessity of various cover layers (e.g. clay) was investigated and their effect versus costs discussed. Local tests and experience gained from former projects were considered. It was noted that in general, problems occurred at the joints of the various materials.

For each material, the 'waste' treatment strategy adopted was depending on the type of waste to be treated (natural rock, treated rock, leaching waste) and its quantity, etc.

The plan foresaw also that larger open pits would be filled with material from neighbouring areas (and then covered).

The old tailings pond of about 13 ha had a drainage system. It was covered by various layers of clay, covered by a polyethylene foil, followed by a layer of ground cultivated with vegetation (grass). At the 2011 verification the team was informed that about 1.6 Mm^3 have been handled during the 25 months of remediation, at a cost of more than ca 7.89 M€.

At the 2006 verification, the radiological environmental surveillance put in place by the operator consisted of:

- A water treatment plant where contaminated waters from the mine and the mill tailings were 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 were automated.

- Continuous hydro-chemical monitoring of the liquid discharges into the environment (after the second settling basin). The monitoring devices (flow, pH, redox potential eH, conductivity, temperature, and total suspended solids) were connected to controllers and a data logger. From the controllers the normalised signals were 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 dm³/day). The radiological parameters that were measured were the concentration of both Ra-226 and total Uranium: these measurements were performed weekly on a 7-day composite sample.

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

- Ground water sampling at 14 locations with a semi-annual frequency. These samples were assessed for the presence of Ra-226 and total Uranium (besides other hydro chemical 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 were 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) were exchanged whenever full but with a minimum frequency of once a month. The deposition sample collected was measured monthly, after filtering (0.45 µm mesh), in order to assess the presence of Ra-226 and total Uranium.

In 2006, the team was informed that the future monitoring and radiological surveillance after remediation work finished would 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 practised in 2006.

- Surface water sampling of the *"Ribeira da Pantanha"* stream receiving the liquid discharge. Spot samples will be taken with a frequency to be established based on the results of the 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 hydro chemical 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 hydro chemical parameters). Samples will also be collected semi-annually in 10 spots in the vicinity 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 practice of determining the total suspended particulate deposition rate will be continued.

[5] The filter 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).

- 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.

During the present verification, the team visited the fully remediated site (*Barragem Velha*; tailings pond with dam), which is fenced; the entrance gate was locked.

To prevent the growth of trees and to keep the grass cover low, the surface is grazed by sheep from time to time (this use is permitted by the responsible authorities). The stabilising wall (dam) around the site is partly made of gabions, the deterioration of which (naturally or by human influence) could severely jeopardise the stability of the construction. It is also feared that in the very long run it will not be possible to prevent trees from growing on the area, in particular deep rooting trees which could destroy the surface construction in place. The site has three drainage levels and that the drained water is treated in the effluent treatment plant nearby (see below).

> *The verification team recommends considering the construction of a wall of suitable stone masonry to protect the cover construction. It also suggests considering the deliberate planting of trees with flat growing roots with a view to avoid natural growth of deep rooting trees.*

The team visited the soil radon monitoring stations (*ALGADE* devices) no 3 (two sensors for the depth profile) and no 4 (three sensors for the depth profile) situated on-site (see also chapter 4.4.4). Originally, ten stations with three sensors each (serving different soil-depths) were planned to be installed on the site. Due to budgetary restrictions the number of sensors was reduced and only six stations were installed, however all with automatic data transfer. Data from these devices are logged and automatically transferred to Lisbon. Each device is powered by a solar panel. Check labels on the *ALGADE* devices read ('*verifié*' July '09; '*à revoir en*' July '11).

The team observed that at the time of the verification, one of these sensors was disconnected; upon this observation it was re-connected during the visit. The fact that data transmission is with several hours delay of could explain why there was no immediate reaction from the *EDM* data centre when this sensor did not supply any more data (a reaction is foreseen using an automatic GSM based call system). The team was told that the connecting cable fell off 'due to wind' just before the visit'. No operation manual was available at the verified monitoring stations; such manuals are kept in the service car.

Several air control stations (code "A") are set up in the area.

The team verified station A3 at the southern tip of the *Barragem Velha* site which was fenced and locked though there was a hole in this fence caused by vandalism (apparently people tried to steal the reserve batteries of the measurement device). The measurement device from *ALGADE* is powered by a large solar panel (60x60 cm) and connected to reserve batteries. Control labels on the device indicated "*verifié en novembre 2007; à revoir en novembre 2009*".

Generally, for the *ALGADE* air samplers, the sampling heads are sent monthly to the *ALGADE* laboratory in Bessines, France, for analysis of the Rn, Tn and long lived total alpha activity in aerosols. There are no TLDs at the stations.

With regard to technical control of the air samplers the team was informed that maintenance is local (marked on the devices); some spare devices are available if needed; if necessary devices are sent to *ALGADE* for repair. *ALGADE* staff comes to Portugal every two years also for calibration of the equipment. Locally, two persons are trained for changing sampling heads; the procedure was available.

The team also visited station A2 situated outside the main fence of the *Barragem Velha* site, near its southwest tip, close to a house alongside the road, and station A4 situated in a residential area some 100 metres west of the site also passing station A1 situated near a kindergarten, south of the former, now flooded, mine shaft. When the mine was still working radionuclide determinations were performed at these stations using air samplers with a PM10 head. At the time of the verification only total particle deposition was measured.

The team noted also several locked piezometers distributed across the *Barragem Velha* site. At the beginning of remediation of the site, monthly samples were taken, now one sample is taken manually every six months.

4.6.1.2 Remediation and rehabilitation of the Urgeiriça tailings, *Barragem Nova*

The team was informed that remediation of the 'new dam' (*Barragem Nova*), located east of the *Barragem Velha* site has not yet been terminated (see figure 5). This is performed in several steps as the fifth (and last) remediation item for the Urgeiriça site, within the second budgetary phase, and includes the re-naturalisation of the Pantanha River. The location also contains several waste rock piles. Due to lack of time the site itself could not be visited.

4.6.1.3 Industrial zone (chemical plant of the Urgeiriça mine)

The verification team visited the former 'chemical plant', i.e. the installations to extract the uranium from the ore through an acid leaching process. The site is almost fully remediated, some work still needs to be completed. Formerly, for uranium production, the extracted ore bearing rocks were milled/ground and then leached with acid in basins located in the adjacent building (under mechanical agitation). After this, "cleaning" (separation of leachate from residues) took place in outdoor basins. (In some mines, during the last ten years of exploitation in-situ leaching was also used; from those mines the leachate was transported to the chemical plant at Urgeiriça.)

Altogether five tanks had been in operation for the 'cleaning' process. Remediation of three of them is finished, work on the remaining two will probably take another two years.

Currently the remediated site is preserved as a museum, however, there seems to be very little public interest for this action.

Though not part of the verification visit the team were shown the uranium storage building located nearby which is verified by EURATOM safeguards inspectors once a year. The building seems well protected with the gate in the fence as well as the door to the building locked.

The verification does not give rise to specific remarks.

4.6.1.4 Urgeiriça water treatment plant (*Estação de neutralização de efluentes*)

The plant, located east of the *Barragem Velha* site, treats all effluents from the underground drainage system from *Barragem Velha* and from the lowest point of the whole Urgeiriça site, which is located near the treatment building, next to the second sedimentation pond for treated water. All effluent waters that are not directly piped to the treatment plant, are collected here in a "sump"; at the time of the visit, the water level was very low. From there, water is pumped to the treatment plant. The entire site is fenced and locked.

The water treatment plant is an automatic plant with the pH signal for the inflowing water being passed to the main controller (*Lange* device) which adjusts the speed of feeding lime. The verification team was told that the inflow flow rate (*Eastech Badger* flow rate meter) decreased continually due to remediation work. Lime milk from a 40-50 m³ storage recipient and $BaCl_2$ in solution are added to the waters to be purified. The mixed solution is stirred in three tanks arranged in line. After this treatment, the liquid is transferred to two settling ponds, arranged in line. An operator performs the control of the process if needed. The plant uses some 20 t lime per month and some 25 kg $BaCl_2$ per day.

From the treatment plant, a mixture of water and sludge (30% solid, 70 % liquid) is pumped to the first settling pond for sedimentation. Two pumps are available for this operation. At the time of the visit only one was needed to perform this pumping. When necessary – i.e. the pond capacity is near its limit – the sediments are moved to a lower part of the area (surface ca 1 ha) where they dry in the sun. The supernatant waters are piped to the second settling pond which is sealed by a polyethylene foil. In summer, there are nearly no effluents from this second settling pond, due to evaporation and recirculation (see below) of water.

At the time of the visit, the first settling pond was already quite 'full' and ready for discharge of sediments. There was some outflow of the second pool.

The outflow from settling pond two is measured and samples are taken. Before release to the river, purified waters pass the effluent control station (*Estação de controlo de efluentes*). Schematics of the process and an electric wiring diagram were visible on a panel on the site. Since two years, water recirculation (by pumping water up to the treatment plant) is used to feed the lime adding process.

At the effluent control station, pH, temperature, conductivity, the Redox potential Eh, and total suspended solids (TSS) are measured (*Lange SC100* device). Automatic flow control and measurement is in place using an *Eastech Badger* device.

Locally, there is no access to the measured data (formerly there was local access to these data; however, since a conflict of data was noticed, this was stopped). Now, data are only sent directly to the EDM headquarters in Lisbon.

For water sampling a hose leads from the outflow pipe of the second settling pond to a 25 litre canister. From this, a sample/day is taken and stored in a refrigerator. A weekly composite sample is taken from these samples and analysed in the University of Coimbra laboratory.

The verification team was informed that since twenty years, this water purification process works perfectly. Regular maintenance of the station is in place. Being an active method, plant operation is planned only for a transition period after remediation, estimated to last probably 5, minimum 2-3 years. Then a move to a passive method is foreseen (some treatment plants are used as pilots for such a project).

The verification team noted that the waters of the stream before receiving the effluents were deeply coloured. As an explanation the influence of an industry upstream (car textile) was given, the colour depending on the chemicals used there. The flow rate in the small stream was estimated at a few litres per second.

The verification team was told that as an impact of flooding the mine uranium concentrations (that before were ca. 300 µg/l) decreased to ca 50 µg/l in the waters released to the river. Sealing of the old tailings pond led to a decrease for Ra-226 from ca 10 to 2 Bq/l.

> *The verification strongly encourages finding passive methods for water purification with a view to be able to decrease the amount of monitoring in the long run.*

4.6.2 Valinhos former uranium mine

The team visited the Valinhos former underground mine; 130 m deep, which has been closed and is now completely flooded situated in the Urgeiriça area, a few hundred metres northeast of the former mine (see figure 5). The closed access to the mine is situated on a small island accessible by a wooden bridge from the shore of a small lake through which the river Ribeiro da Pantanha flows. The old mine shaft entrance construction has been kept.

The whole site has been transformed into a recreational area, with a wooden fence with signs '*proibido entrar; zona não vigiada*'. This protection of the site seems to be mainly due to the fact that waters of the river are heavily polluted by the upstream car textile industry which effectively forbids the use of the area as a recreational public site.

The verification does not give rise to specific remarks.

4.6.3 Espinho former uranium mine

The team visited the remediated former uranium mine Espinho. The locked site (with signs ('*Perímetro de segurança; entrada proibida*') now has the character of a recreational area. The former open pit mine has been completely flooded and forms a lake. The surroundings have been reshaped with granite rocks etc. The signs were erected to avoid legal problems in case of (swimming) accidents or such. There was no chemical treatment on site. The only residues on site were some waste rocks (granite). During remediation of the site, some problems with waste dump slope stability were encountered and the dam had to be re-shaped.

Drainage water goes directly to a nearby river. Measurement of these waters indicated that there was no contamination. The water had drinking water quality and therefore monitoring was stopped. Fish in the lake were never monitored. Such monitoring would only be done in case suspected contamination. This could be the case if the surroundings consisted of alkaline rocks; however, this site consists mainly of granite. Waters have almost neutral pH values, thus U is not leached by them.

There are plans to use the remediated site for the public (e.g. as boy-scout camp).

The verification does not give rise to specific remarks.

4.6.4 Cunha Baixa former uranium mine

The area of the former uranium mine Cunha Baixa is fenced but at the time of the visit, the gate was not locked. Signs with the indication '*Perímetro de segurança; entrada proibida*' were attached at the fence.

This uranium mining site (one of the biggest in Portugal) comprised a large open pit and an underground mine. In addition in-situ leaching took place. For this, rocks to be treated were put in the open pit and sprinkled with acid; the leachate was pumped out from the lowest gallery of the underground mine and transported by tankers to Urgeiriça for further treatment.

Because of the former leaching activity, studies on the behaviour of the acid in the soil of this area were conducted. There are no final conclusions yet. A risk of drinking water contamination persists.

There are many piezometers on the site for monitoring of groundwater. Also all superficial (surface) waters in the neighbourhood of the mining area are monitored. The inflow of water from outside into the mining area has been investigated.

A thin aquifer exists some 10 m below ground (alluvial system). Permeability tests of the bed rock have been performed and indicated that inflow only occurs through fractures in the rocks. Currently, the pH of this aquifer is rising quickly (now it is at ph 4.5). Based on these findings it is assumed that leaching will stop soon.

This water is used only for irrigation, not for drinking water purposes. Studies performed on vegetables demonstrated that this practice did not lead to any ingestion risks.

The intention is to fill up the mining site with waste rock and then reshape the whole area. Waste with higher contamination levels will be deposited in a small open pit close to the site.

For treatment, water is pumped out of the mine at the lowest point (4 days/week, in summer less) and transferred to the treatment station situated uphill in the woods nearby. It is planned to prevent rainwater entering the mine by means of a barrier and thus to reduce the water volume to be treated. The team was informed that for the future, setting up of a passive system is planned.

Bed rock in this region is very strong, thus there are no risks of galleries caving in which explains why there are houses on top of the former mine. No cracks or other damages have been noted till now.

The Cunha Baixa effluent treatment plant is located some one hundred metres uphill of the former mine.

At the time of the verification the entrance to the treatment building was locked. The treatment procedure of the effluents is different to the one applied at Urgeiriça. Instead of lime milk, hydrated lime is used (ca 20 t per year), together with about 25 kg of $BaCl_2$ per week. The plant has three concrete tanks for stirring of the mixture with the effluent waters.

Two probes for pH and temperature measurement of the incoming mine waters are installed. They are cleaned weekly. The automatic measuring system (*Lange SC1000*) is calibrated once a week.

At the time of the verification a fenced sedimentation lagoon (sealed with a polyethylene layer) was in operation. The overflow from that lagoon was continuously monitored before being discharged to a small river.

Once per year, the sediments are pumped to a nearby 'drying lagoon' (another former open pit mine).

The effluent control station is situated directly below the sedimentation lagoon and is set up in a similar way as the one at Urgeiriça.

Sampling takes place directly before a small concrete basin where the monitoring probes are installed. The flow measurement device is located in a locked cage because of vandalism. Sampling follows the same procedure as in Urgeiriça (daily 25 l samples converted to 5 l weekly samples).

Measurement data are directly transmitted to Lisbon (no local display is available due to graphics conflicts).

The site also contains a small meteorological station, separately fenced and solar powered.

The team was informed that plans have been accepted to create a 5 ha 'intervention' area for irrigation tests with treated water, in an area with agricultural use, an agreement has been reached with regard to in situ soil treatment with phosphorus rich fertilizer for this project.

The team also noted the former main shaft entrance which has been fully closed , a small ca. 3 m high metal construction.

> *The verification team encourages termination of the studies with regard to the effects on irrigation water in the area.*

4.6.5 Quinta do Bispo former uranium mine

The Quinta do Bispo former mining site is fenced and the gate locked with signs saying '*perímetro de segurança; entrada proibida*'; '*águas, areias e escombros eventualmente contaminadas; não utilizáveis*'; and '*proibida entrada cratera* ' mineira. Quinta do Bispo was the biggest open pit mine of Portugal with a depth of about 80 metres. Low grade ore was leached in the open pit and the leachate transported to Urgeiriça for further treatment.

The verification team was told that the Quinta do Bispo mining site will be the last place to be remediated. It is planned to deposit all remaining mining and milling waste from other areas in the open pit before the final remediation of the area.

The effluent treatment plant uses the same process and equipment as the one in Urgeiriça. A *ROTA* flow meter measures the water inflow (at the time of the visit: 0 m^3/h). A *Lange SC1000* is used for measuring pH and conductivity of the inflow water. The treatment plant operates three days per week, in summer less. A diagram of the process was attached to the wall of the building.

The inflowing waters are mixed with lime milk (ca 50 t/year) and $BaCl_2$ and stirred in three consecutive concrete tanks. From there the liquid is transferred to a first lagoon for settling with the overflow going to a second settling pond. The sediment is transferred periodically to a nearby mud drying area in the open pit.

Some piezometers that were used for in situ studies of the ground water flow are still in place.

Monitoring of treated waters before release to a nearby river is performed in the same way as described for Urgeiriça. The probes are mounted in a locked cage to protect them from vandalism. The flow rate measurement is installed in a cage screwed onto the concrete outflow duct. The team was told that annual control and calibration is performed when the device gives a message. A *Lange SC100* device is used as a multi-display; the data transfer controller is a *Foxboro Communication Series* device.

Sampling is performed in a similar way as in the other treatment plants, using a hose mounted on the ca. 30 cm diameter outflow pipe that leads from the 2nd lagoon to the concrete basin housing the measuring probes.

Until 1980 the use of waste rock from the mine was permitted for the construction of house foundations. Signs on the fence indicate that this practice is now forbidden.

The verification does not give rise to specific remarks.

4.6.6 Freixiosa former uranium mine

This site, situated just outside the village of Freixiosa, included both, an underground and an open pit mine. The underground mine had three shafts which have already been closed and covered. The former mine is situated on private property. An agreement for the planned remediation exists with the owner. The area is not fenced. Financing of the planned remediation seems secured.

The verification team was informed that it is planned to start remediation work of the mining area in summer 2011. It is projected to collect drainage water from the area for precipitation of radium in tanks. The purified waters will be discharged to the river in a cascade system and the entire process monitored. No reagents for treatment are planned to be used because additives could increase the iron content of the water.

The old waste dump material will be removed from the mining area, transported to the Quinta do Bispo site and filled into the open pit there. The trucks themselves will be monitored and the water used for washing the trucks will be transferred to a pond and tested before release.

At present the area is used for agriculture. There are 'hot spots' due to uncontrolled water discharge during the former mining activity. There is more contamination near the road because of the (former) use of water from the mine for irrigation; this practice has now been stopped. Particular attention will be paid to these areas during remediation.

The verification team encourages timely remediation of the area.

4.6.7 Mangualde 'event'

The team received explanations concerning the Mangualde – Quinta do Bispo 'event' in 2004.

Apparently, material from the Quinta do Bispo site was used by a firm for work in the City of Mangualde without asking. However, obviously this became 'public'. Consequently, *EDM* was involved and asked about potential consequences. Finally, the contractor had to remove (most of) the material to the uranium site, lost the contract and was fined.

The verification does not give rise to any remarks.

4.6.8 Mondego Sul former uranium mine

Mondego Sul is a small opencast mine where about 75 t of uranium oxide was produced between 1987 and 1991. The site, which is fenced off, is not considered a priority site for rehabilitation and is thus unlikely to be completed before 2016. Tailings and rejected materials (400 000 t) were deposited on the ground and form three dumps. There has not been any significant development in the area. A lake was formed in the open pit. The abandoned mine is about 10 m away from the reservoir of the Aguieira dam. The acid water from the pit lake and dumps flows directly to this reservoir. It is currently envisaged that rock from the adjacent hill will be used to fill the open pit. Ultimately a caravan park may be built on the remodelled hill which would be an asset to the local community.

The verification does not give rise to any remarks.

4.6.9 Vale da Abrutiga former uranium mine

At the former Vale da Abrutiga mine a water treatment plant has been installed. As there is no mains electricity a large diesel pump has been installed in a shed to drive excess water from the mine to a reservoir when levels reach a certain height. At periodic intervals water is brought up to the treatment plant where barium sulphate and lime are added in 3 agitator tanks. After a period of settling the water flows by gravity to the lower reservoir from where there is a natural overflow which takes the water to a small stream. Periodic measurements are carried out on the water in this reservoir. Across the rehabilitated mine there are a number of marked points where through regular checks on the height of the land some evidence of settling has been noticed though this is not dramatic.

Sampling of the piezometers is carried out by *EDM*'s subcontractor twice a year with a total of 13 samples taken whilst 6 surface water samples are taken.

The verification team witnessed a demonstration of water sampling at the sampling point *Fura 2*, however the sampling point was not labelled. The well was locked but not properly and could be opened without a key. The sampling bottle was labelled with black marker by hand on the site. The pH meter was not calibrated before measurement and overall no written procedure was available.

EDM stated that subcontractor has written procedure for sampling, there seems to be some problem connected with outsourcing and defining and also controlling the work of subcontractor.

The verification team suggests reviewing the procedures and the work of their subcontractor.

4.6.10 Senhora das Fontes former uranium mine

Initially Senhora das Fontes was an underground mine but open pit mining was carried out in the 1980s. For a period of +/- 5 years processing of uranium was carried out at this site during the closure of Urgeiriça for maintenance and 4 tailings ponds were in operation.

Rehabilitation finished in December 2010 so at the time of the visit the vegetation was still quite sparse. During the rehabilitation phase 73641 m^3 of sludge and waste rock was placed on site. Earth moving equipment was still on site as some further levelling etc may be necessary following settling after the winter. All material deposited on site is contained by a geomembrane which ensures that no water escapes to the surroundings.

The verification team witnessed the monthly exchange of the 5 litre bottle under the precipitation sampler, the contents of which will be analysed for airborne particles.

Monitoring of surface water, mine water in main shaft and piezometers in surroundings is carried out regularly. Twelve surface water samples (semi-annual frequency) and 6 surface water samples are taken.

An *ALGADE LR115* detector equipped with a solar panel is used to measure radon in the surroundings. The visit coincided with the exchange of the measuring head, which has a barcode for easy identification. A further two of these devices are installed, together with precipitation samplers at separate locations in the nearest village situated a short distance away downhill. *EDM* has a contract with *ALGADE* for maintenance and calibration of the detectors. Nevertheless it was noted that the detector at the remediated mine site had been verified in July 2008 and that the verification foreseen in July 2010 had not been performed.

The verification team suggests reviewing the verification of the ALGADE detectors.

4.6.11 Vale de Arca former uranium mine

The verification team stopped briefly at the Vale de Arca site where at the beginning of the 19th century some chemical processing was done on site leaving some 26000 m³ material. All will be removed and deposited at the Bica site. A sample of mine water is taken annually for analysis.

The verification does not give rise to any remarks.

4.6.12 Carrasca former uranium mine

The verification team also visited the Carrasca underground mine which has not yet been remediated. At present water flowing from the mine is used by the nearby landowner for irrigation despite warnings concerning its uranium and iron content. It is envisaged that partial removal of the top soil in the surrounding area will also be required with a total of 4775 m^3 on both sides of the road being removed. A sample of mine water is taken annually for analysis.

The verification does not give rise to any remarks.

4.6.13 Bica former uranium mine

The Bica underground mine operated from 1912-44 and from 1951-1999 and involved in situ acid leaching, Mud from treatment and tailings will also have to be treated in the remediation process.

Site suffered forest fire quite recently which has actually been of benefit as it exposed the various elements of the site.

There is a water treatment plant on the site where data is collected every 15 minutes for pH, redox, temperature, conductivty, and turbidence, together with the flow rate and sent once per day by modem to *EDM* Lisbon headquarters. The pH can be adjusted via the pH sensor by the addition of NaOH.

The river Valverdinho is monitored upstream and downstream of the discharge point though the locations were not seen.

The verification does not give rise to any remarks.

5. NATIONAL MONITORING SYSTEM (RADNET) IN THE REGION VISITED – DESCRIPTION AND VERIFICATION

5.1 GENERAL

Portugal runs a national network, RADNET, for the continuous monitoring of ambient gamma dose rates. This network was established in 1989 as an early radiological warning system.It comprises a central station at the Portuguese Environment Agency (*APA*) in Lisbon and 14 remote stations, in the major cities, on the borders with Spain, on the two islands (Azores and Madeira) and one in Spain, at Talavera La Real near Badajoz (as part of an exchange with the Spanish *REVIRA* network). RADNET also comprises three mobile stations.

The dose rate probes have been upgraded in 2008 and now consist of two Geiger-Müller detectors: one having a detection range between 10 nSv/h and 2 mSv/h (low dose rate), the other between 0.1 mSv/h and 10 Sv/h (high dose rate). 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) and downloaded remotely on a daily basis. A battery back-up power supply is present that allows autonomy of approximately 60 hours; after 15 hr of battery operation a message is sent to the data centre in Lisbon.

Some of the stations are also equipped with a continuous aerosol monitor.

The data centre which is located at *APA* in Lisbon and stations with air monitors were not part of this verification; they were included in the 2006 visit.

Under 'normal' conditions, for data transmission all stations are called once per day from the data centre in Lisbon. In 'emergency situations', i.e. when a predefined value is exceeded, data transmission automatically switches to 'intensive mode' and stations are called every hour; data are also sent to the 24/7 duty officer at *APA*. Data transmission is performed using fixed land lines. All data are also sent to EURDEP and to a public web site. At the time of the visit due to the Fukushima accident and the subsequent general 'alert' for the EURDEP system, 'intensive mode' had been set.

The stations and the central equipment are from *TechniData* (Markdorf, Germany). They are serviced by *Quincomer - Importações e Exportações, Lda.*, Lisbon, on behalf of *TechniData*. A 24 hour repair contract exists.

5.2 COIMBRA METEOROLOGICAL OBSERVATORY

The verification team visited the ambient gamma dose rate station at the Meteorological Observatory at Coimbra located on the premises of the Geophysical Institute. The overall site is not fenced, access is free, however not easy.

The general placing of the station is excellent, on a hill, still within the Coimbra city limits, overlooking the town. The probe is located on a lawn in the local meteorological garden. The nearest building is at a distance of 10 m (low, only ground floor), there are no large trees in the neighbourhood. A low hedge that is obviously frequently cut is some 50 cm away.

The probe (serial number 1058) is of the type *TechniData AG IGS421B-H*, with two GM tubes (high/low dose rate).

The data logger (*Hörmann/TechniDATA*) is mounted in a cabinet in the nearby office building in a closed but not locked room. The electronics cabinet was locked; no log book (with installation and repair logs) was available locally, all such logs are stored centrally. For backup a battery (*powerfit S312/18 G5*) provides electrical power for up to 65 hours. Opening of the cabinet door leads to a warning (which is also transferred to the data centre in Lisbon).

The possibility is foreseen to receive meteorological data and samples for laboratory analysis from this station (e.g. there is a wet-and-dry precipitation sampler on site for deposition samples) when deemed useful.

The verification team suggests having (repair) log books also available locally.

5.3 PENHAS DOURADAS METEOROLOGICAL OBSERVATORY

The verification team visited the RADNET station at Penhas Douradas (Serra da Estrela mountain range) which is situated within the grounds of the meteorological station (*Instituto de Meteorologia I.P.*) at 1380 m.

The gate to the site is generally locked, additionally two dogs guard the site when no meteorological staff is present.

Overall the site has been well selected, on the soft top of a wide mountain range. The probe is very well placed, in the meteorological garden with no buildings or trees in the immediate vicinity.

In addition to the *TechniData* high and low dose rate gamma detectors there is also a device belonging to the Spanish ambient dose-rate monitoring network *REVIRA*, the border being some 60 km in a direct line. Similarly Portugal has installed a detector on Spanish soil.

The station is polled daily using a land line, should an anomaly occur the station sends a signal to Lisbon directly. Owing to the insecurity of the electric power supply there is a device installed to stabilise the power. In the event of a total power failure batteries can maintain the equipment operational for 65 hours.

The verification does not give rise to any remarks.

5.4 CASTELO BRANCO METEOROLOGICAL OBSERVATORY

The team verified the gamma dose rate monitoring station situated on the premises of the Meteorological Observatory at Castelo Branco.

The cabinet (*Hörmann/TechniData*) with the data logger (*DLM 1450 Version 5.01*) and a *Logem LGM 28.8D1* data transmission device is mounted in one of the meteorological offices.

At the time of the verification, no manuals and log books were on site, these are stored at the data centre in Lisbon.

The location of the station is very good, in a wide plain, on granite bed rock. The probe is located on a lawn, near the meteorological garden. The nearest house is at some 20 m and the nearest trees are at some 15 m.

However, the team noted that the probe is mounted slightly more than one metre above ground level on a concrete foundation of some 25x25x25 cm sitting on granite bedrock.

The verification team suggests having (repair) log books also available locally. It also suggests exploring the possibility of mounting the dose rate probe in such a way that the effective measuring height is 1 m above ground.

6. CONCLUSIONS

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

(1) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil around the remediated former uranium mining and processing sites at Urgeiriça, Valinhos, Espinho, Cunha Baixa, Quinta do Bispo, Freixiosa, Mondego Sul, Vale de Abrutiga, Senhora das Fontes, Vale de Arca, Carrasca and Bica as well as the verified parts of the national monitoring system for environmental radioactivity are adequate. The Commission could verify the operation and efficiency of these facilities.

(2) A few topical suggestions and recommendations are formulated. These aim at improving some aspects of the remediation and the environmental surveillance of former uranium sites and do not discredit the fact that environmental monitoring around former uranium sites is in conformity with the provisions laid down under Article 35 of the Euratom Treaty if the measures are maintained in the long term and the recommendations implemented.

(3) The verification team recommends for all remediated sites maintaining an appropriate radiological monitoring (e.g. with regard to radon emanation at the site and potential groundwater contamination). Such monitoring would have to be in place for long term surveillance; adequate administrative and financial support would be necessary.

(4) The Commission services ask the Portuguese competent authority to inform them of any progress or significant changes with regard to the situation at the time of the verification.

(5) The present Technical Report is enclosed with the Main Conclusions document and is addressed to the Portuguese competent authorities through the Portuguese Permanent Representative to the European Union.

(6) Finally, 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

THE VERIFICATION PROGRAMME – SUMMARY

Art. 35 verification PT – 11 to 15 April 2011

Former uranium mining and milling areas

National monitoring network

Date	Team 1	Team 2
Mon 11.4.	Lisbon DGAE/MNE, opening meeting	
	ITN lab at Sacavém	
	Coimbra RADNET station	Coimbra University lab
Tue 12.4.	Barragem Velha da Urgeiriça	
	Urgeiriça, former milling and processing area	
	Valinhos mine	
	Urgeiriça treatment station	Vale de Abrutiga, Mondego Sul mines
Wed 13.4.	Espinho, Cunha Baixa, Quinta do Bispo, Freixiosa mines	Senhora das Fontes, Vale de Arca, Carrasca, Bica mines
	Mangualde issue	
Thu 14.4.	Castelo Branco RADNET station	Penhas Douradas RADNET station
Fri 15.4.	Lisbon DGAE/MNE, closing meeting	

Team 1: Constant Gitzinger, Eberhardt Henrich

Team 2: Alan Ryan, Erich Hrnecek

APPENDIX 2

REFERENCES AND DOCUMENTATION

	PT answer to the preliminary information questionnaire, 30th of March 2011
EDM	Preliminary information questionnaire: Mining activities – description of activities and monitoring programme
APA	*Relatório da RADNET – Rede de Alerta de Radioactividade do Ar 2009*
APA	*Relatório da RADNET – Rede de Alerta de Radioactividade do Ar 2010*
MCTES	*Relatório UPSR-A, nº32/08 –Programas de Monitorização Radiológica Ambiental (Ano 2007)*
MCTES	*Relatório UPSR-A, nº37/10 –Programas de Monitorização Radiológica Ambiental (Ano 2009)*

PowerPoint Presentations

EDM	Rehabilitation Plan of abandoned radium and uranium mines in Portugal
J.M. Gaspar Nero, EDM	Master Plan for Old Uranium & Radium Mines in Portugal
Sofia Barbosa, EDM	Detailed Project Development – Master Plan for Environmental Remediation of Old Uranium & Radium Mines in Portugal
Helena Gomes, EDM	Environmental Monitoring of Abandoned Uranium Mines in Portugal

Web sites

Decree-Law nº 165/2002, of 17 July 2002	http://dre.pt/pdf1sdip/2002/07/163A00/53645370.pdf
Decree-Law nº 138/2005, of 17 August 2005	http://dre.pt/pdf1sdip/2005/08/157A00/47734777.pdf
Decree-Law nº 426/83, of 7 December 1983	http://dre.pt/pdf1sdip/1983/12/28100/39893989.pdf
Executory Decision 34/92, of 4 December 1992	http://dre.pt/pdf1sdip/1992/12/280B00/55705585.pdf
Decree-Law nº 198-A/2001, of 6 July 2001	http://dre.pt/pdf1sdip/2001/07/155A01/00020007.pdf
Decree-Law nº 165/2002, of 17 July 2002	http://dre.pt/pdf1sdip/2002/07/163A00/53645370.pdf
Decree Law nº 174/2002, of 25 July 2002	http://dre.pt/pdf1sdip/2002/07/170A00/54735479.pdf
Decree-Law nº 138/2005, of 17 August 2005	http://dre.pt/pdf1sdip/2005/08/157A00/47734777.pdf
Decree-Law nº 75/007, of 29 March 2007	http://dre.pt/pdf1sdip/2007/03/06300/18341839.pdf

Decree-Law nº 139/2007, of 27 April 2007	http://dre.pt/pdf1sdip/2007/04/08200/26842686.pdf
Decree-Law nº 156/2007, of 27 April 2007	http://dre.pt/pdf1sdip/2007/04/08200/27592763.pdf
Decree Order 535/2007, of 30 April 2007	http://dre.pt/pdf1sdip/2007/04/08300/28692873.pdf
Decree Order 573-C/2007, of 30 April 2007	http://dre.pt/pdf1sdip/2007/04/08301/00030009.pdf
Decree-Law nº 222/2008, of 17 November 2008	http://dre.pt/pdf1sdip/2008/11/22300/0800008076.pdf
Decree-Law nº 138/2005, of 17 August 2005	http://dre.pt/pdf1sdip/2005/08/157A00/47734777.pdf
EDM	http://www.edm.pt/
EDM (Barragem Velha)	http://www.edm.pt/html/proj_urgbarvelha.htm
EDM (Barragem Nova)	http://www.edm.pt/html/proj_urgbarnova.htm

APPENDIX 3

Former uranium and radium mines in Portugal

MINA / MINE	POPULAÇÃO MAIS PRÓXIMA / NEAREST POPULATION km)	VOLUME TOTAL DE RESÍDUOS / WASTES TOTAL VOLUMES (m3)	TIPO DE EXPLORAÇÃO/ EXPLOITATION WORKS	LIXIVIAÇÃO E TRATAMENTO QUÍMICO LEACHING METHODS/ PROCESSING PLANT	PERÍODO DE EXPLORAÇÃO EXPLOITATION PERIOD
URGEIRIÇA	0,0	3.150.000	UNDR	LEACH + PP	1913-1950/1951-1991
CUNHA BAIXA	0,0	288.500	UNDR+OPIT	LEACH	1968-1993
QUINTA DO BISPO	0,8	1.075.100	OPIT	LEACH	1979-1999
BICA	0,8	49.300	UNDR	LEACH	1912-1944/1951-1999
CASTELEJO	2,0	781.900	OPIT	LEACH	1977-1990
VALE DA ABRUTIGA	2,0	462.000	OPIT	–	1982-1989
SENHORA DAS FONTES	1,0	38.380	UNDR+OPIT	LEACH (+ PP)	1967-1982
Vales	1,5	13.810	UNDR	LEACH (+ PP)	1922-1944/1957-1960
Forte Velho	2,0	11.680	UNDR	LEACH	1960-1965
Rosmaneira	0,5	15.200	UNDR	LEACH	1909-1914/1941-1961
Vale d'Arca	1,0	23.200	UNDR	LEACH	1917-1923/1957-1962
São Domingos	1,7	7.130	UNDR+OPIT	LEACH (+ PP)	1945-1953
Barracã	0,0	13.000	–	PP	1909-1944
Barrôco	2,0	80.000	OPIT	–	1988-1989
Canto do Lagar	2,5	46.000	OPIT	–	1987-1988
Ribeira do Bôco	2,0	52.000	OPIT	–	1986-1988
Espinho	0,5	76.360	OPIT	–	1989-1990
Mondego Sul	1,0	596.520	OPIT	–	1987-1991
Corga de Valbom	2,0	26.660	OPIT	–	1990-1991
Valdant	0,8	33.000	OPIT	–	1986-1987
Prado Velho	0,9	178.306	OPIT	–	1976-1982
Barrôco D. Frango	0,6	40.020	OPIT	–	1988-1989
Freixinho	1,0	37.500	OPIT	–	1975-1977
Pêra do Moço	0,0	12.830	OPIT	–	1982-1982
Maria Dónis	1,0	67.690	OPIT	–	1988-1989
A-do-Cavalo	0,7	55.770	OPIT	–	1982-1988
Mortórios	2,5	155.000	OPIT	–	1982-1988
Fontinha	1,5	168.460	OPIT	–	1990-1991
Freixios	0,0	1.760	UNDR+OPIT	–	1971-1984
Picoto	1,1	11.320	UNDR+OPIT	–	1917-1921/1950-1958
Tentinolho	1,5	21.880	UNDR+OPIT	–	1977-1982
Pinhal do Souto	0,0	42.000	UNDR	–	1975-1989
Formiga	0,8	1.980	UNDR	–	1915-1920
Vale Covo	2,0	1.650	UNDR	–	1922-1949
Alto da Várzea	1,0	25.310	UNDR	–	1913-1962
Barroca Funda	2,0	6.140	UNDR	–	1964-1965
Carrasca	0,5	11.260	UNDR	–	1923-1924/1953-1959
Coitos	0,7	3.900	UNDR	–	1912/1939-1942
Cruz da Faia	2,0	7.630	UNDR	–	1975-1978
Pedreiros	1,5	3.320	UNDR	–	1912-1944/1951-1999
Corguinha e Prazos	0,8	220	UNDR	–	1920-1925/1950-1962
Ervideira	1,2	1.075	UNDR	–	1919-1920/1962
Ferreiros	1,0	3.740	UNDR	–	1923-1944/1954-1962
Fonte Velha	0,8	13.850	UNDR	–	1920-1925/1944-1956
Lenteiros	0,4	5.570	UNDR	–	1943-1947/1955-1957
Mestras	0,0	4.520	UNDR	–	1919-1924/1954-1962
Reboleiro	0,0	23.160	UNDR	–	1947-1955
Póvoa de Cervães	1,0	37.650	OPIT	–	1978-1979
Sevilha	0,7	–	OPIT	–	1998-1999
Tapada dos Mercados	0,3	–	OPIT	–	1982
Ribeira do Ferro	2,5	2.000	OPIT	–	1985-1986
Quinta das Seixas	2,0	880	OPIT	–	1971-1972
Vale do Tamão	1,8	1.800	OPIT	–	1989-1990
Vale da Videira	0,3	7.100	OPIT	–	1989-1990
Cótimos	1,8	330	UNDR+OPIT	–	1971-1974
Alto da Rasa	1,8	430	UNDR	–	1971-1972
Luz	0,3	–	UNDR	–	1919-1944/1954-1962
Carril	0,5	2.420	UNDR	–	1954-1958
Pai Moniz	1,0	–	INC EXP	–	1923, 1945/1961-62
Sentinela	0,9	700	INC EXP	–	1958-1961
Fontaínhas-Gradiz	1,2	–	INC EXP	–	1919-1944/1962

Abbreviations:

UNDR … Underground Works	OPIT … Open Pit	INCP EXP … Preliminary Exploration and/or Exploitation Works
LEACH … Leaching Methods	PP … Deactivated Processing Plant	(PP) … Processing Plant Ruins