EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

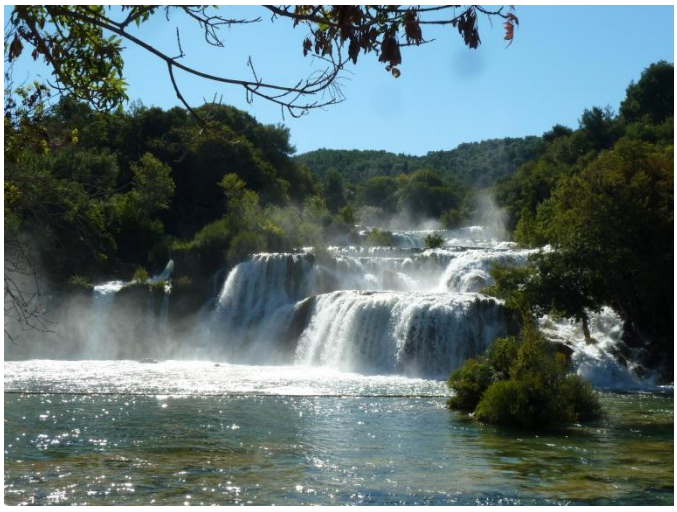
DIRECTORATE D - Nuclear Safety and Fuel Cycle
Radiation protection

TECHNICAL REPORT

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35 OF THE EURATOM TREATY

Environmental radiological monitoring in Croatia

16 to 20 September 2013



Reference: HR-13/03

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES:	Installations for monitoring and surveillance of environmental radioactivity in Croatia.
DATES:	16 to 20 September 2013
REFERENCE:	HR-13/03
VERIFICATION TEAM:	Mr C. Gitzinger (Team 1) Mr E. Henrich(Team 1) Mr S. Mundigl (Team 2) Mr A. Ryan (Team 2) Mr T. Tollefsen (Team 2)
DATE OF REPORT:	23 April 2014

TABLE OF CONTENTS

TECHNICAL REPORT

ABBREVIATIONS AND ACRONYMS

ADSL	Asymmetrical Digital Subscriber Line (telecommunication)
AED	Active Electronic Dosimeter
ALMERA	Analytical Laboratories for the Measurement of Environmental Radioactivity (IAEA network)
CEWS	Croatian Early Warning System
CRIS	Common RELEX Information System
CSV	Comma-Separated values (informatics)
DG ELARG	Directorate General for Enlargement (of the EC)
DG ENER	Directorate-General for Energy (of the EC)
DSL	Digital Subscriber Line (telecommunication)
DZRNS	*Državni Zavod za Radiološku i Nuklearnu Sigurnost* (State Office for Radiological and Nuclear Safety, SORNS)
EC	European Commission
EML	Environmental Measurements Laboratory
EU	European Union
EURDEP	European Radiological Data Exchange Platform
FTP	File Transfer Protocol
Ge(Li)	Germanium Lithium drifted (gamma detector material)
GPRS	General Packet Radio Service (telecommunication)
HASL	Health and Safety Laboratory (of EML)
HPGe	High Purity Germanium (gamma detector material)
IAEA	International Atomic Energy Agency
IEC	International Electrotechnical Commission
IMROH	Institute for Medical Research and Occupational Health (*Institut za medicinska istraživanja i medicinu rada*)
IPA	Instrument for Pre-accession Assistance (EU programme)
IRMM	Institute for Reference Materials and Measurements (of JRC)
ISO	International Organization for Standardization
ITU	Institute for Transuranium Elements (of JRC)
JRC	Joint Research Centre (EC Directorate-General)
MA	Ministry of Agriculture
MH	Ministry of Health
NPRD	National Protection and Rescue Directorate
NPRDC	National Protection and Rescue Directorate Centre
OG	Official Gazette (Croatia)
OJ	Official Journal (EU)
PCI	Peripheral Component Interconnect (informatics)
PDF	Portable Document Format
PIPS	Passivated Implanted Planar Silicon (alpha detector material)
REM	Radioactivity Environmental Monitoring
RBI	Ruđer Bošković Institute
SCADA	*Supervisory Control And Data Acquisition* (software system by *Bitt technology*)
SIM	Subscriber Identity Module (telecommunication)
SLES	*SUSE Linux Enterprise Server*
SMS	Short Message Service
SORNS	State Office for Radiological and Nuclear Safety (*DZRNS*)
SQL	Standard Query Language
UPS	Uninterruptible Power Supply
USDHEW	U.S. Department of Health, Education and Welfare
VPN	Virtual Private Network
WHO	World Health Organization

1. INTRODUCTION

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

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

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

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

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

Taking into account previous bilateral protocols, a Commission Communication has been published in the EU Official Journal on 4 July 2006 with a view to define some practical arrangements for the conduct of Article 35 verification visits in Member States.

Two verification teams from DG ENER.D.3 visited Croatia from 16 to 21 September 2013 in order to verify the monitoring of environmental radioactivity on its territory. The visit also included meetings with representatives of the national and regional authorities having competence in the field of radiation protection.

Representatives of Croatia provided full information of the environmental radiological monitoring in Croatia on paper and during the opening meeting. The present report is based on information collected from documents received and from discussions with various persons during the visit and contains the results of the verification teams reviews of relevant aspects of the radiological environmental surveillance on the territory of Croatia.

2. PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 PREAMBLE

The Commission's request to conduct an Article 35 verification was notified to the Croatian Permanent Representation to the European Union by letter Ares(2013)677212 - 11/04/2013. Subsequently, practical arrangements for the verifications were made with the Croatian competent authority State Office for Radiological and Nuclear Safety (SORNS).

2.2 PROGRAMME OF THE VISIT

On 16 September an opening meeting was held in Zagreb in the premises of the State Office for Radiological and Nuclear Safety (SORNS). The Croatian competent authority (SORNS) and a representative of the Ministry of Health (representatives of the ministries responsible for agriculture and for customs could not attend) participated in this meeting. The verification team received an oral presentation of the radiological monitoring programme already implemented in Croatia and the activities that are to be implemented in the near future. The programme of verification activities was

[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)

discussed and finalised, based on a Communication by the EC[2], setting out the framework and modalities within which Article 35 verifications may be conducted.

The verifications were carried out in accordance with the agreed verification programme in Appendix 1.

The verification was focused on the environmental radiological monitoring programme and activities as implemented in the visited regions of Croatia including sampling and monitoring systems, analytical methods, quality assurance and control aspects, reporting, etc..

Verification activities at the measuring laboratories addressed infrastructure, analytical methods, quality assurance and control aspects, as well as reporting. At the same time the monitoring and sampling provisions located on the laboratory premises were also subject to verification.

The main focus was on verifying the installation of ambient gamma dose rate probes as part of the national surveillance network.

2.3 DOCUMENTATION

In order to facilitate the work of the verification team, a package of information was supplied in advance by the Croatian authorities. Additional documentation was provided during and after the visit. All documentation received is listed in Appendix 2. The verification team notes the comprehensiveness of all presentations made and documentation provided.

The information thus provided has been extensively used for drawing up the descriptive sections of the report.

2.4 REPRESENTATIVES OF THE COMPETENT AUTHORITY AND OF OTHER BODIES MET DURING THE VERIFICATION

During the verification visit, the following representatives of ministries, the national authority dealing with the management of the verification and of other bodies involved in the monitoring of environmental radioactivity were met.

State Office for Radiological and Nuclear Safety (SORNS)

Ms Sanja Krca	Head of Environment And Radioactive Waste Department
Mr Ivo Valčić	retired; consultant for SORNS
Mr Nikša Sviličić	Head of the IT department

Ministry of Health

Ms Koraljka Knezic	Head of Border Sanitary Inspection Service (responsible for foodstuff of non-animal origin and non-primary foodstuffs)

Institute for Medical Research and Occupational Health (IMROH)

Mr Ivica Prlić PhD	Head of the Licensed IMROH Radiation Protection Technical Service and Head of the Unit for Radiation Dosimetry and Radiobiology

[2] Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty – Practical arrangements for the conduct of verification visits in Member States (OJ 2006/C 155/02).

Mr Zdenko Franic, PhD	Deputy director for the Quality Management at IMROH

Ruđer Bošković Institute, Laboratory for Radioecology

Mr Delko Barišić, PhD	Head of Laboratory
Mr Željko Grahek, PhD	Research associate

BITT technology

Mr Damir Pinezic	Service representative

Contacts at monitoring stations

Mr Zdenko Perušina	Hydro meteorological station Dubrovnik
Mr Zoran Lasić	Hydro meteorological station Karlovac
Ms Silvana Boško	Hydro meteorological station Rijeka
Mr Aleksandar Stipanović	Hydro meteorological station Split

3. COMPETENT AUTHORITIES AND RELEVANT LEGISLATION

3.1 BODIES HAVING COMPETENCE IN THE FIELD OF RADIATION PROTECTION AND MONITORING

3.1.1 Environmental radioactivity monitoring

State Office for Radiological and Nuclear Safety

The State Office for Radiological and Nuclear Safety (SORNS) is the competent state administration body for activities relating to protection against ionising radiation and nuclear safety.

SORNS

- issues licences for practices and sources; import / export /transport transit permissions;
- performs administrative, control and development tasks related to practices involving radiation and use of radiation sources;
- manages national registries of institutions (users), sources, workers and doses;
- prepares legal acts;
- co-operates with other organisations, institutions and associations relevant to radiation protection and nuclear safety;
- organizes environmental radiological monitoring;
- performs inspections.

3.1.2 Radiological surveillance of foodstuffs

Ministry of Agriculture (MA)
The Ministry of Agriculture (MA) and Ministry of Health (MH) are the competent authorities responsible for the policy in the food safety area. MA and MH have overall responsibility for food safety, while feed safety, animal health, animal welfare and plant health is the responsibility of MA.

3.1.3 Sanitary inspection - border sanitary control

Ministry of Health (MH)

The Ministry of Health - Directorate for Sanitary Inspection is responsible for border sanitary control. It performs inspections, administrative and other tasks concerning the implementation of acts, other regulations and general acts in the field of sanitary inspection. The Ministry also has tasks in foodstuff control.

3.1.4 Nuclear and radiological emergency preparedness

National Protection and Rescue Directorate (NPRD)

The National Protection and Rescue Directorate Centre (NPRDC) receives the information in case of an emergency event communicated to the national emergency phone number (112). The National Protection and Rescue Directorate (NPRD) orders the implementation of urgent protection and rescue measures in the threatened area or in the area affected by the consequences of an emergency at the proposal of the State Office for Radiological and Nuclear Safety. Special intervention units and technical services perform protection measures.

The emergency preparedness system will be upgraded through the on-going IPA 2011 project: "Upgrading of emergency preparedness system in the Republic of Croatia" which started in April 2013. The aim of the project is to harmonise radiological and nuclear emergency response procedures with neighbouring countries, in particular with Slovenia and Hungary, to upgrade national radiological and nuclear emergency response capabilities to face incidents and accidents of different levels and to upgrade the national emergency plan that will enable rapid implementation of protective measures within the first few hours and in the days after the radiological and nuclear emergency through coordinated response of the emergency services and other agencies.

3.1.5 Food import control

With regard to control of food imports from third countries see Chapter 5.

3.1.6 Analytical laboratories involved

3.1.6.1 Institute for Medical Research and Occupational Health – Radiation Protection Unit (IMROH)

The Radiation Protection Unit of the Institute for Medical research and Occupational Health (IMROH) carries out research in the field of radiation protection and radiation science, which is facilitated via scientific research projects and professional activities on public health related issues.

3.1.6.2 Ruđer Bošković Institute (RBI)

The Laboratory for Radioecology of the Ruđer Bošković Institute (RBI) provides contributions to the knowledge and to the better understanding of biogeochemical behaviour of natural and artificial radionuclides in the environment. Its work is based on development and advancement of methods and procedures for alpha, beta and gamma radioactivity measurements where nuclear instruments and methods are applied.

3.2 RELEVANT LEGISLATIVE ACTS

3.2.1 Environmental radioactivity monitoring

With regard to environmental radioactivity monitoring the following legal instruments apply:

- Law on radiological and nuclear safety (OG 28/10)
- Ordinance on the conditions, manner, places and deadlines for systematic testing and monitoring of the type and activity of radioactive substances in the air, soil, the sea, rivers, lakes, ground water, solid and liquid precipitation, drinking water, foodstuffs and general use products and dwelling and working spaces (OG 60/08) a new ordinance is in the acceptance procedure
- Regulation on the conditions and methods of disposal of radioactive waste, spent sealed radioactive sources which are not intended for further use (OG 44/08)

3.2.2 Radiological surveillance of foodstuffs

With regard to the radiological surveillance of foodstuffs the following legal instruments apply:

- The Food Act (OG 81/13)
- Act on official controls performed in accordance with food, feed, animal health and animal welfare legislation (OG 81/13).
- Act on water for human consumption (OG 56/13)
- Act on contaminants (OG 39/13)
- Act on imports of feed and food from third countries (OG 39/13)
- The Regulation on border-crossing points on which sanitary inspection control is performed (OG 33/13)
- A list of official laboratories for food and feed (OG 137/13

3.2.3 International legislation and guidance documents

The following international documents are taken into account:

- Council Directive 96/29/Euratom laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation
- Commission Recommendation 2000/473/Euratom of 8 June 2000 on the application of Article 36 of the Euratom treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole
- IAEA Nr. RS-G-1.8 – Environmental and. Source Monitoring for Purposes of Radiation. Protection
- Council Directive 98/83/EC on the quality of water intended for human consumption

4. ENVIRONMENTAL RADIOACTIVITY MONITORING IN CROATIA

4.1 ON-LINE NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME (EARLY WARNING SYSTEM)

The Croatian Early Warning System (CEWS) is operated by the State Office for Radiological and Nuclear Safety (SORNS). This on-line monitoring system consists of 25 measuring stations[3] and a central unit where the data are collected, analysed and stored. Each monitoring station continuously measures the ambient gamma dose rate. Radionuclide concentrations in the atmosphere and certain meteorological parameters are measured at two stations. After each measuring cycle data from measurement stations are fed back to the central unit. If elevated radiation levels are detected, an alarm system is automatically triggered and measurement data are examined by the SORNS duty officer.

[3] An additional eight ambient gamma dose rate monitoring stations are to be installed within the scope of the on-going IPA project financed by the EU.

The Croatian Early Warning System is an important component of the Croatian emergency response system related to nuclear accidents. The upgrading and modernisation of the Croatian Early Warning System in order to enhance its operability was supported by the EU under PHARE project EuropeAid/126553/D/SUP/HR. Within this project all former equipment has been replaced (both at the measuring stations and at the Central Unit) and the number of gamma dose rate measuring stations has been increased from 15 to 25.

At two locations aerosol measuring units as well as meteorological sensors have been installed in addition to the gamma dose rate sensors.

Within the Central Unit a new software application for remote management of the measuring stations as well as data analysis has been implemented.

All monitoring locations of the telemetric network(s) operated by SORNS (twenty five gamma dose rate stations and two stations measuring aerosol particles and meteorological parameters) are shown in figure 1.

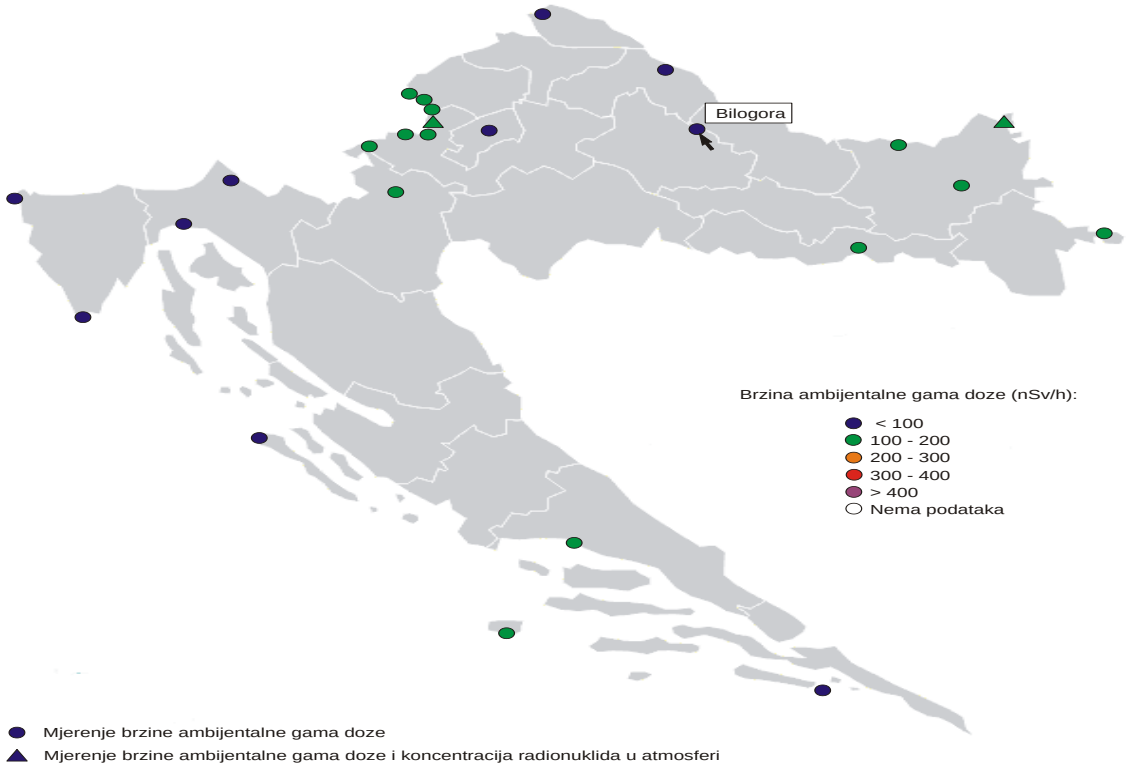


Figure 1: Locations of the stations of the Croatian Early Warning System (CEWS). Circles: ambient gamma dose rate monitors; triangles: air and dose rate monitors

4.1.1 Central Unit – description and verification

Hardware description

Because of its relation to public safety, the Croatian Early Warning System Central Unit has been designed as a system with full redundancy. The cluster configuration of the servers as well as the use of a high availability software enable automatic switching between the servers in case of a server malfunction. The Central Unit hardware consists of the components summarised in table 1.

Table 1: Central Unit hardware components

Type	Product	Quantity
Servers	*HP ProLiant DL360 G5*	2
Workstation	*HP Compaq DC7900CMT*	1
Backup devices	*HP Storageworks DAT72 USB*	2
LAN switches	*Linksys SRW2016*	2
DSL modem/router	Delivered by communication links provider	1
GPRS modem/router	*Funkwerk Bintec R1200wu*	1
UPS for Server	*Eaton PW9130i1500R-XL2U*	2
UPS for Workstation	*Powerware 5110 700VA*	1
UPS for routers/switches	*Powerware 5115RM 500VA*	1
Alarm module	*BITT SCADA AlarmHW*	2
Rack	*DIGITUS DN-19 SRV-26U-SW-N*	1

Both of the *HP ProLiant DL 360 G5* server machines are equipped identically (exception: additional serial line PCI extension card for Server 1). Each server has one UPS (*Eaton 9130*) and one *HP StorageWorks DAT72 Streamer* tape device attached.

The Croatian Early Warning System components and their interaction are shown in figure 2.

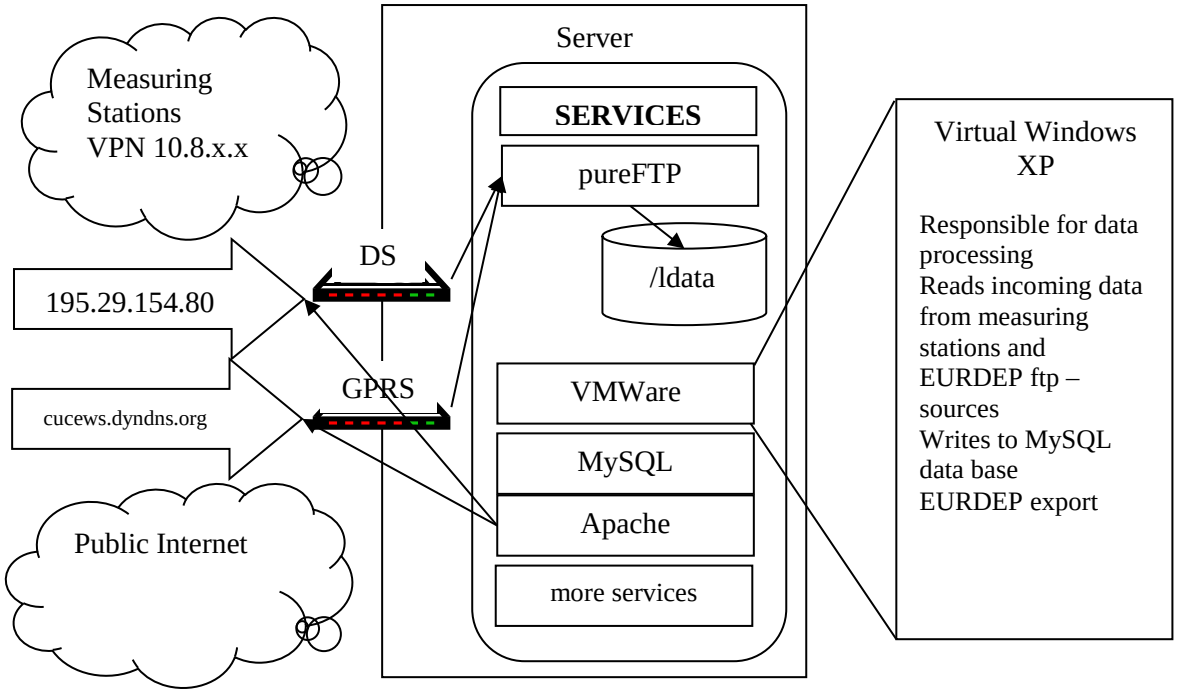


Figure 2: Croatian Early Warning System components and their interaction

Server Operating System

The *Novell SUSE Linux Enterprise Server* (*SLES*) operating system version 10 is installed on the Central Unit servers. Configuration of *SLES10* can be performed via the graphical configuration tool *YaST2*.

The automatic update feature of *SLES10* is disabled in the current configuration and updates have to be done manually using the "software updater" service. This configuration is advantageous in case of a possible kernel update where the server has to be rebooted and several services and drivers have to be recompiled for the new kernel.

Central Unit Software Application

The software application installed on the Croatian Early Warning System is "*BITT SCADA*", a software package for an early radiation monitoring control centre. *BITT SCADA* acquires data from the CEWS measuring stations and provides visualisation Additionally remote control of the measuring stations is possible.

The main general features of the *BITT SCADA* software are:

- Data can be queried from gamma probes and aerosol measuring stations;
- Data are stored in a SQL database;
- Collected data can be accessed through a FTP server and queries can be run directly from the database;
- Data export to CSV files is via predefined queries or user defined queries;
- Client based on simple browser supported;
- Modular structure, so the system is easily upgradeable and adaptable;
- User management that supports different user types and different users where the user types have different privileges;
- Confirmation of every triggered alarm;
- Configuration of various alarm triggers. The alarm notification can be carried out by email;
- Data is visualised through a web server;
- Visualisation of data via configurable maps, e.g. topology and population density maps;
- Charts and tables of every measurement type and comparison of different stations via predefined queries or user defined queries;
- Adding new stations. Adding and placement of static symbols on the map, e.g. nuclear power plants;
- Tables of status data via predefined queries or user defined queries;
- Control of the stations;
- Direct generation of *Adobe* PDF files;
- An electronic maintenance book is included. Each service worker can add service reports.

The software has been modified for the Croatian Early Warning System project to reflect the special demands made by SORNS as stated in the technical specifications for the project.

The *BITT SCADA* software package is a living project and therefore under continuous development. SORNS will receive software updates from *BITT Technology GmbH,* Spillern, Austria, as soon as they are available.

Description of *BITT SCADA* main features

The installed software application for the Central unit fulfils all requirements of the Technical specification for this project as devised by SORNS.

Measuring stations control

If the station is connected to the virtual private network (VPN) it may be controlled by remote shell, ftp and http.

Data acquisition, processing, analysis and storage

All stations send their data to an ftp server located on the central station (Linux OS) protected by a VPN. Two different program modules (*AMS02 Time control* and *RS03S Time control*) on the virtual *Microsoft™ XP* machine (*vXP*) check for new data every 10 seconds, process and analyse the input data sent in and store new data into the database (*MySQL*) back on the Linux host.

Alerting duty officers

The *BITT SCADA Alerting Tool* (on *vXP*) is responsible for notifying duty officers by e-mail, SMS and visual alarms.

Data visualisation and printing for internal users

Data visualisation and printing is done by the *SCADA* workstation, which is part of the VPN and has direct network access to the Central Server, using the *BITT SCADA Web application* with a browser

like *Firefox 3.5* or *Microsoft™ Internet Explorer 7*. Printout of data stored in the database is possible at any graphical printing equipment in the form of screenshots, tables (textual or *Adobe™* PDF files) or graphs.

Data visualisation for external users

Via the external IP interface of *BITT SCADA* any person with sufficient user rights has the same possibilities of viewing and printing data as internal users.

Data import and export

The EURDEP format is used for international data exchange. The EURDEP software module consists of 3 different types of programmes. The controlling software (*EURDEP Message Control Centre*), an export program (*EURDEP Writer*) and finally an import program (*EURDEP Import*). The export of hourly average data takes place between 20 minutes and 25 minutes past each hour. The import is triggered every 30 minutes (see table 3). If there is no data available at time, the generated file will be deleted.

Table 3: Timeframe for import/export of data

Data Type	Import/export every X minutes past the hour
TOTAL GAMMA AMS	20
TOTAL GAMMA GMS	20
RADON 222 EEC	21
IODINE 131 MAX	22
IODINE 131 MIN	24
CAESIUM 137 MAX	23
CAESIUM 137 MIN	25
TEMPERATURE	20
WIND SPEED	21
WIND DIRECTION	22
AIR PRESSURE	23
RELATIVE HUMIDITY	24
EXPORT OF VALIDATED DATA	21
EURDEP IMPORT	0, 30

The verification team visited the central data centre of SORNS in Zagreb where the hardware elements of the system were explained in detail. In addition it was possible to see at a glance the current measurement values at the various stations.

Verification does not give rise to specific remarks.

4.1.2 Measuring stations - description

Within the new Croatian Early Warning System five types of measuring stations have been installed (see table 4 for a description and Section 4.1.2.6 for the locations).

Table 4: Main characteristics of the different measuring station types

Station Type	Description
A	***BITT RS04H/232***: γ dose rate, wide range, redundant communication
B	***BITT RS04L/232***: γ dose rate, reduced range, redundant communication
C	***BITT RS04L/232Solar***: γ dose rate, reduced range, single communication, autonomous
D	***BITT AMS02A with RS04H/232***: γ dose rate, wide range; air monitoring; meteorology; redundant communication
E	***BITT AMS02A with RS04L/232***: γ dose rate, reduced range; air monitoring; meteorology; redundant communication

4.1.2.1 Type A stations – *BITT RS04H/232*

Type A stations are used for measuring gamma dose rate.

The *BITT RS04H/232* station consists of a dose rate measuring probe (sensor), a data logger, a communications terminal, a DC-UPS system, a cabinet and all necessary cable interconnections.

The gamma dose rate sensor is physically separated from the data logger. Measuring range of the sensor is 10 nSv/h – 10 Sv/h. Data logger, communication terminal and UPS system are located in a single wall mounted indoor cabinet. The cabinets are installed in existing buildings supplied with electric power and wired communication links.

The gamma dose rate sensor is installed outdoors on a tripod. Sensor and data logger are connected by an underground cable connection with adequate cable protection.

The stations support bidirectional communication with the Central Unit by using DSL as primary connection and GPRS as secondary (backup) connection. The secondary link will only be used if the communication cannot be established through the primary link. Switching between the communication links is done without human intervention. The communication terminal for the DSL connection (i.e. DSL modem/router) is located inside the measuring station cabinet. The communications terminal for the GPRS connection (i.e. GPRS modem/router with SIM cards) is an integral part of the measuring station.

The stations have adequate lightning and power surge protection. They require a low level of maintenance (one site visit per year).

4.1.2.2 Type B stations – *BITT RS04L/232*

For Type B stations the required gamma sensor measuring range is reduced to 10 nSv/h – 15 mSv/h. All other characteristics are identical to the characteristics of Type A stations.

4.1.2.3 Type C stations – BITT RS04L/232 Solar

Type C stations are outdoor located autonomous stations that are used for measuring gamma dose rate at locations where electric power and wired communication lines are not available.

The *BITT RS04 Solar* station consists of gamma dose rate measuring sensor, data logger, communications terminal, solar panel with battery, cabinet and all necessary cable interconnections. Measuring range of the sensor is 10 nSv/h – 15 mSv/h.

Stations 11, 15, 17, 18, 19 and 24 (locations see table 5) have their sensors mounted on the cabinet above the solar panel.

The gamma dose rate sensor and the data logger are connected by an underground cable connection with adequate cable protection.

Station 12 (location see table 5) due to its unique characteristics is a customized version with the cabinet separated from the solar panel. Solar panel and gamma dose rate sensor are installed on the roof of the Sveta Gera chapel tower. Solar panel and sensor are connected to the cabinet by cables with adequate cable protection.

All Type C stations support bidirectional communication with the Central Unit by using a GPRS link. The communications terminal for the GPRS connection (i.e. GPRS modem/router) is an integral part of the measuring station.

All stations have adequate lightning protection. They require low level of maintenance (one site visit per year). All components of the stations are suitable for long term installation at humid and saline environments.

4.1.2.4 Type D station – *BITT AMS02A* with *RS04H/232*

The Type D station is a station for measuring gamma dose rate, air radioactivity and meteorological parameters.

The *BITT AMS02A* air monitoring station consists of a gamma dose rate sensor, meteorological sensors, an air measuring unit, data logger, communications terminal, outdoor container, UPS system and all necessary cable interconnections. Measuring range of the gamma dose rate sensor is 10 nSv/h – 10 Sv/h.

For air monitoring air is pumped through the system with a maintenance free pump at a flow rate of ca. 6 m^3/h. Aerosols are collected on glass fibre filters (60 mm diameter) and immediately analysed by alpha and beta spectrometry (PIPS detector with an area of 1700 mm^2, resolution of ~55 keV for α and ~30 keV for β particles) and by gamma measurement (2"x2" NaI(Tl) detector with a resolution of 8.5% for the 661 keV Cs-137 peak). A subsequent special active carbon filter (60 mm diameter) allows analysis of elemental iodine with a 2"x2" NaI(Tl) detector. In case of elevated measuring results organic iodines are measured in a temperature controlled bypass system using a NaI(Tl) detector and activated carbon in Marinelli geometry. The *AMS-02* device contains racks with 400 aerosol filters and 100 iodine filters. Before each measurement series an energy calibration is performed using Cs-137 in filter geometry (positions 498 and 500 in the filter trays). The filters (including check filters for calibration) are moved within the device using a robotic manipulator system.

All the components except the sensors are located inside the container. The station supports bidirectional communication with the Central Unit by using DSL as the primary connection and GPRS as the secondary (backup) connection. The secondary link will be used only if the communication cannot be established through the primary link. Switching between the communication links is done without human intervention. The communication terminal for the DSL connection (i.e. DSL modem/router) has been delivered by the communication links provider. The communications terminal for the GPRS connection (i.e. GPRS modem/router) is an integral part of the measuring station.

The mast for the meteorological sensors and the gamma dose rate probe are mounted on top of the container.

The station has adequate lightning and power surge protection. It requires a low level of maintenance (3 site visits per year).

4.1.2.5 Type E station – *BITT AMS02A* with *RS04L/232*

For the Type E station the required gamma sensor measuring range is reduced to 10 nSv/h – 15 mSv/h. All other characteristics are identical to the characteristics of the Type D station.

4.1.2.6 Locations of the measuring stations

The locations of the measuring stations of the new CEWS are presented in table 5.

Table 5: List of CEWS measuring stations with locations

Nr.	*BITT* Nr.	Name	Address	Station type	Telecom. service	Coordinates (Deg, decimal Min)
1	GMS-006	Stojdraga	Perivoj kralja Tomislava 1 10432 Stojdraga Žumberak	A	DSL/GPRS	N 45°50.239' E 15°34.017'
2	GMS-007	Bregana	Žumberačka cesta 1 10432 Bregana	A	DSL/GPRS	N 45°50.436' E 15°41.157'
3	AMS-035	Sveti Križ	Sveti Križ Bregovita ulica 18 10299 Marija Gorica	D	DSL/GPRS	N 45°54.074' E 15°42.059'
4	GMS-008	Dubravica	Lukovečka 10 10293 Dubravica	A	DSL/GPRS	N 45°57.688' E 15°43.847'
5	GMS-009	Klanjec	Erdodiyeva 9 49290 Klanjec	A	DSL/GPRS	N 46°03.079' E 15°44.342'
6	GMS-010	Plavić	Plavić 20 49296 Zagorska sela	A	DSL/GPRS	N 46°06.687' E 15°36.860'
7	GMS-011	Gola	Stjepana Radića 136 48331 Gola	B	DSL/GPRS	N 46°12.110' E 17°02.396'
8	GMS-012	Bilogora	Meteostation Sedlarica 33405 Pitomača	B	DSL/GPRS	N 45°53.018' E 17°12.032'
9	GMS-013	Drava	Measuring station Hrvatske vode Dravska ulica bb 31530 Podravska Moslavina	B	DSL/GPRS	N 45°47.399' E 17°58.886'
10	AMS-036	Batina	Spomen-dom Batina 31306 Batina	E	DSL/GPRS	N 45°51.277' E 18°50.810'
11	GMS-014/S	Parg	Meteostation Parg 51306 Parg Čabar	C	GPRS	N 45°35.592' E 14°37.834'
12	GMS-015/S	Sveta Gera	Sveti Ilija Chapel Sveta Gera	C	GPRS	N 45°45.581' E 15°19.006'
13	GMS-016/S	Štrigova	Banfi 218 40312 Štrigova	C	GPRS	N 46°30.164' E 16°16.251'
14	GMS-017/S	Slavonski Brod	Meteostation Slavonski Brod Svetog Nikole Tavelića bb 35000 Slavonski Brod	C	GPRS	N 45°09.557' E 17°59.710'
15	GMS-018/S	Ilok	Radoš 448 32236 Ilok	C	GPRS	N 45°11.137' E 19°25.035'
16	GMS-019/S	Savudrija	Drain Water Station Bašanija, 52475 Savudrija	C	GPRS	N 45°29.307' E 13°29.844'
17	GMS-020/S	Premantura	Premantura Polje bb 52100 Pula	C	GPRS	N 44°47.230' E 13°54.601'
18	GMS-021/S	Verunić	Verunić, Put lučice bb 23287 Veli Rat	C	GPRS	N 44°08.572' E 14°51.695'
19	GMS-022/S	Stiniva	Marinje Zemlje bb 21480 Vis	C	GPRS	N 43°01.523' E 16°10.165'
20	GMS-023/S	Dubrovnik	Meteostation Dubrovnik Liechensteinov put 27 21000 Dubrovnik	C	GPRS	N 42°38.692' E 18°05.090'
21	GMS-024/S	Rijeka	Meteostation Rijeka Lukovići 7a, 51000 Rijeka	C	GPRS	N 45°20.232' E 14°26.561'

Nr.	*BITT* Nr.	Name	Address	Station type	Telecom. service	Coordinates (Deg, decimal Min)
22	GMS-025/S	Karlovac	Meteostation Karlovac Put Davorina Trstenjaka bb 47000 Karlovac	C	GPRS	N 45°29.615' E 15°33.884'
23	GMS-026/S	Zagreb-RBI	Laboratory for Radioecology Bijenička cesta 10000 Zagreb	C	GPRS	N 45°49.836' E 15°59.331'
24	GMS-027/S	Split	Meteostation Split Gljagoljaška 11 21000 Split	C	GPRS	N 43°30.505' E 16°25.574'
25	GMS-028/S	Osijek	Meteostation Osijek 31431 Čepin	C	GPRS	N 45°30.143' E 18°33.717'

4.1.3 Measuring stations - verification

The team received detailed information about the history of the Croatian Early Radiation Warning System. For siting, pieces of land were rented, usually looking for rather open sites without obstacles. Originally, the early warning feature was seen as more important than the exposure estimate, thus not all ambient gamma probes were mounted in the ideal way (1 m above ground). Site physical protection and the availability of local meteorological data were seen as important. The team was also told that Croatia intends to add 8 to 10 stations to the system and that the authorities want to determine corrective factors for measurement values at non-ideal sites (where usually the probe is mounted on the solar panel holder, ca 2.5 m above ground). A respective task is included in the 2011 IPA Horizontal Programme on Nuclear Safety and Radiation Protection – PF5 - Croatia (DG ELARG; project no. 5; CRIS decision number 2011/023-389).

For all devices servicing is outsourced to the *Bitt Technology* Croatia branch (annual contract).

With regard to automatic surface water monitoring, the team was informed that currently there are no such devices installed.

The verification teams visited the following monitoring stations:

Karlovac (nr. 22)

The measuring station nr. 22 is located at the Karlovac Hydro meteorological station, situated at Put Davorina Trstenjaka bb, 47000 Karlovac (N 45°29'36.90"; E 15°33'53.04").The area is fenced, with a locked gate and guarded. At the time of the visit the meteorologist on duty was present.

The ambient dose rate monitoring station (type C) was installed in 2009. The probe *Bitt RS042/232* had the serial number AG 56. The team noted the large solar panel (*PVT Solar Inc.*, 11x6 fields), *Bitt WEBDL-S* electronics and a *Steco PR 2020* solar charge controller (12 V). The solar device has a 'smart' energy consumption, i.e. it is programmed in a way that in case of no sunshine (less energy available) data transmission is suspended, whilst measurements keep going on. Data transfer starts again when enough energy is available.

Overall the station is situated on a wide plain in a large meteorological garden, meadow, building (single storey) ca. 20 m distance; trees ca. 50 m distance; tripod with measuring point mark at ca. 1 m above ground.

The measurement values at the time of the verification were 111 nSv/hr (1-min value) and 113 nSv/hr (10-min average).Specific local issues are frequent fog (which reduces solar power output) and a significant daily time trend due to radon emanation.

The flexible sleeve that is meant to protect the electronics cable linking the probe to the electronics rack was crumbling due to UV radiation. The responsible noted the issue and will ask for a replacement at the next opportunity.

Savudrija (nr. 16)

The measuring station nr. 16 (type C) is located at the Savudrija-Bašanija sewage purification plant, situated at 52475 Savudrija (N 45°29'18.42"; E 13°29'50.64"). The area is fenced, with a locked gate and normally guarded. At the time of the verification, staff had already left the premises, but the key for opening the gate was available.

The station covers a large area (ca. 100 x 100 m) with meadow and asphalt/concrete in a wide flat area ca. 250 m from the sea., few buildings (2 storey ca. 25 m distance, 1 storey ca. 10 m distance); trees ca. 20 m distance; tripod with measuring point mark at ca. 1 m above ground.

The probe had the serial number AF 52; at the time of the visit the solar charge controller was at 92%. At the time of the verification the measurement values were 99.4 nSv/hr (1-min value) and 104 nSv/hr (10-min average).

The sleeve of the electronics cable at the tripod was ok. However the display in the electronics rack had a low contrast.

Split (nr. 24)

The measuring station nr. 24 (type C) was reported to be located at the Split Hydro meteorological Station situated in Gljagoljaška 11, 21000 Split. Upon arrival the team found that the measuring devices are not installed there. The team was informed by phone that they are located at: Kolombatovićevo Šet. 1 (N 43°30'30.30"; E 16°25'34.44").

The general access to the Marjan hill park area is guarded by a barrier and a control post. The site (containing the installation) within the park boundaries is fenced, with a locked gate and belongs to RBI. At the time of the visit the meteorologist on duty was present.

The locality is on a wooded hill, ca. 125 m a.s.l., ca. 400 m from the sea. With the station sited in a small area (ca. 20 x 15 m) with lawn, some meteorological devices and an old gamma dose rate station (two probes of the Slovenian type, belonging to RBI, which are no longer in use). A two storey building is situated at ca. 20 m distance from the probe. Some trees are at a few metres distance, but below the level of the terrace housing the measuring device. The probe is mounted on a pole which maintains also the solar panel and the electronics cabinet. The measuring point mark of the probe is at ca. 2.5 m above ground.

At the time of the verification the serial number of the probe could not be read due to its elevated mounting. The ambient dose rate values at the time of the visit were 64.5 nSv/hr (1-min) and 63.2 nSv/hr (10-min average). The solar charge controller was at 90%.

The team was informed that no permit could be received to install the probe 1 m above the ground. The area being hilly and forested, there is no better location for installation of the monitor in the surroundings.

Dubrovnik (nr. 20)

The measuring station nr. 20 (type C) is located at the Dubrovnik Meteorological Station situated in Liechensteinov put 27, 21000 Dubrovnik (N 42°38'41.52", E 18°05'05.40"). The area is fenced, with a locked gate and guarded. At the time of the visit the meteorologist on duty was present.

The station is situated on a large terrace, ca. 30 m a.s.l., ca. 100 m from sea. And covers a large area (ca. 50 x 50 m) , including a meteorological garden with lawn; ca. 5 m near fence. A one storey building is at ca. 20 m and some trees are at a few metres distance, but they are rather small and on the other side of the fence. A tripod supports the probe with a measuring point mark at ca. 1 m above ground.

The probe had Ser. Nr. AF 51 and the solar charge controller was at 100%. Dose rate values at the time of the verification were 73.5 nSv/hr (1-min value) and 73.0 nSv/hr (10-min average).

The protective sleeve for the electronics cable showed little signs of deterioration.

Rijeka (nr. 21)

The measuring station nr. 21 (type C) is located at the Rijeka Meteorological Station situated in Lukovići 7a, 51000 Rijeka (N 45°20'13.92"; E 14°26' 33.66"). The area is fenced, with a locked gate and guarded. At the time of the visit the meteorologist on duty was present.

The station is on a slight hill, ca. 1000 m from sea. within a large meteorological garden (ca. 80 x 50 m), on a lawn with a small, 1 1/2 storey building at ca. 25 m distance and some trees at ca. 15 m distance; the tripod supporting the probe had a measuring point mark at ca. 1 m above ground.

The probe had Ser. Nr. AF 50 and the solar charge controller was at 96% :The ambient gamma dose rate values at the time of the verification were 111 nSv/hr (1-min value) and 118 nSv/hr (10-min average).

The team was informed that energy problems occur in winter (leading to frequent breaks in communication, not in measurement). The protective sleeve for the electronics cable was damaged by UV radiation. There were two wasp's nests underneath the solar panel; the representative made a note to have them removed at the next service, probably in October or November.

Zagreb (nr. 23)

The measuring station nr. 23 is located at the RBI Laboratory for Radioecology, situated in Bijenička cesta, 10000 Zagreb (N 45°49.836', E 15°59.331'). This device of the C type is located on a small patch of grass between two small roads which are on the extensive site of the RBI. Access to the institute is controlled by security guards at the entrance. Currently power is supplied by a solar panel though this is not always reliable and it is being investigated whether it would be feasible to have it supplied by mains electricity. In the surrounding area there are a number of low buildings and semi mature trees though neither affect the probe, nor are they likely to have an adverse effect in the foreseeable future.

Owing to the heavy rainfall at the time of the visit the verification team did not ask that the nearby box be opened, nevertheless it had been observed that morning during the visit to the data centre at SORNS that the station was operating correctly.

Osijek (nr. 25)

The measuring station nr. 25, of the C type is located in the village of Čepin (N 45°30.143', E 18°33.717')which lies about 11 km from the centre of Osijek. In common with much of Eastern Croatia the land is largely a flat plain with some soft hills in the distance. The station is located within a fenced area belonging to the Meteorological service where there is a 24hr presence of one or more staff members. There are no obstructions (buildings, trees etc.) within 10-15 m of the station which is situated on grass which is regularly cut.

The verification team witnessed the station's operation.

Slavonski Brod (nr. 14)

The measuring station nr. 14 of the C type is located within a fenced area belonging to the Meteorological service situated in Nikole Tavelića bb, 35000 Slavonski Brod (N 45°09.557', E 17°59.710') where there is a 24 hr. presence of one or more staff members. In addition to the gamma probe there are a number of instruments for the measurement of wind, precipitation etc. all of which are sited in the garden of the station. The area is very flat, with some low hills lying over 1km away. The station house is the highest object in the vicinity, but at ± 20 m form the probe does not interfere with the measurements.

An air quality monitoring station was installed also on the same site but this does not make measurements of any radioactivity, the principal concern being the emissions from an oil refinery situated in Bosnia Herzegovina, only 1-2 km from Slavonski Brod.

The station's operation was demonstrated to the verification team.

Batina (nr. 10)

The measuring station nr. 10 (type E, containing an AMS02 air monitor) is located in Spomen-dom Batina, 31306 Batina (N 45°51.277', E 18°50.810'). This station is the only one of type E in Croatia,

the sole other *AMS* station at Sveti Križ being of type D. Located on a piece of high ground overlooking the Danube River it is also very close to the Hungarian and Serbian borders. The Paks NPP is situated some 80 km to the north.

Following a detailed explanation of the station's operation the technician turned off the power to enable him to proceed with a number of maintenance tasks, which were foreseen to take a few hours. The following day, in advance of the closing meeting at SORNS it could be seen that the maintenance had been successfully carried out and after an outage of some hours the station returned to normal operation.

The verification team supports and encourages that on the occasion of the next service at all stations, where necessary, damaged protective sleeves be replaced by UV resistant material and low contrast displays be fixed. Any "foreign" objects such as wasp nests should be removed.

With regard to the station at Split the team suggests trying to receive permission for mounting the probe at 1 m above ground at the site or finding a reasonable correction factor for the measurement values.

The verification team supports installing automatic surface water monitors at some locations, in particular downstream from the Slovenian Nuclear Power Plant of Krško.

4.2 THE OFF-LINE NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

Environmental radiological sampling (off-line monitoring) is performed mainly by the Radiation Protection Unit of the Institute for Medical Research and Occupational Health (IMROH). The design of this system is based on ordinance OG 60/08 that describes conditions, methodology, monitoring and sampling techniques, taking into consideration all environmental compartments. IMROH delivers annually a technical report to SORNS.

The transfer of such data for the sparse and the dense network to the European REM data base at JRC-ITU in Ispra, Italy, has been agreed and is the responsibility of SORNS. First data sets should be sent for 2013 (i.e. in 2014). Transmission of data from previous years (10 years) is in preparation.

4.2.1 External gamma dose and dose rate monitoring

For external gamma dose and dose rate monitoring the following devices are used:

- Thermo-luminescent dosimeters for determination of ambient equivalent dose H*(10) for photons in the energy range between 30 keV and 3 MeV. These dosimeters are not exceeding –20% and +50% of the true value of the limit dose in the conditions of the external environment.
- Active electronic dosimeters (AED) for continuous measurements of dose rate. Sensitivity: 10 nSv/h; energy range 30 keV to 4.4 MeV.
- Digital survey meter with a dose range from 0.1 μSv/h to 0.99 Sv/h in the energy range from 36 keV to 1.3 MeV.

This system did not form part of the verification.

4.2.2 Air monitoring

4.2.2.1 Air samplers

Air sampling devices are located in Zagreb (IMROH) and Zadar (see figure 3; blue circles).

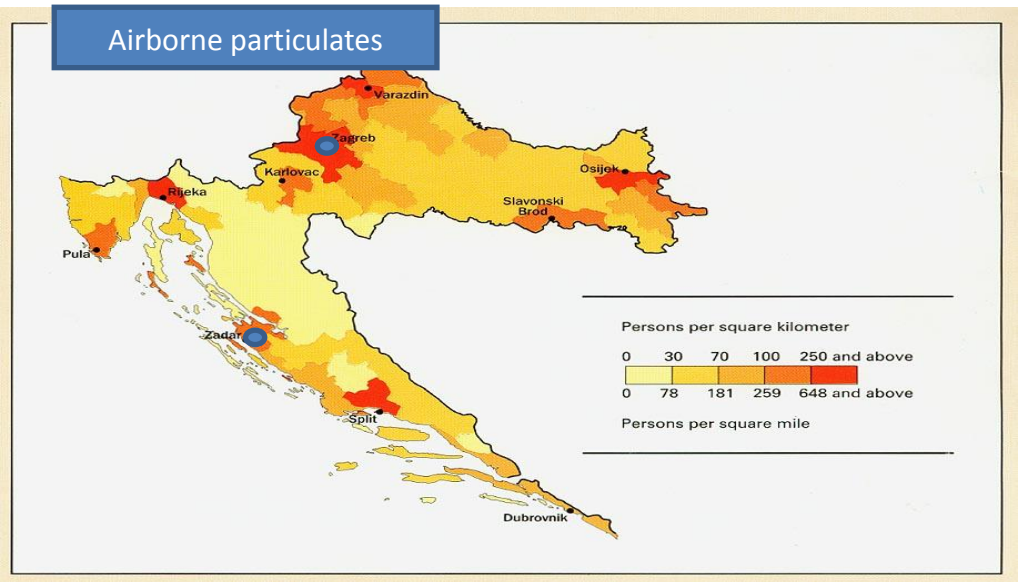


Figure 3:Locations of non-automatic air samplers (blue circles). In addition, population density information is presented.

In Zagreb at the Institute for Medical Research and Occupational Health – Radiation Protection Unit (IMROH) aerosol contamination in the air is sampled by continuously pumping air through cellulose filters (*Petrianov FPP-15-1.5*) using a high volume sampler (type *ASS-500*), mounted 1.5 m above the ground. The airflow is about 500 to 750 m^3/h. Sampled filters are measured by gamma spectrometry.

Monthly, during 14 days air is pumped through charcoal filters, used for gamma spectrometric determination of radioiodine (I-131, I-132, I-133, I-134, I-135).

Total beta activity in air is measured daily by sampling aerosols on filter paper by continuously pumping ~130 m^3/day (sampling height 1 m above the ground).

The verification team was shown the air sampler manufactured by *Polon Izot* and could confirm its correct operation. The institute also has its own gamma dose rate monitor on site which is used to decide whether the air sampling frequency should be increased, particularly in the case of an accident. An air quality monitoring station is also situated on the site, though this does not measure any radioactivity.

The verification does not give rise to any remarks.

In Zadar air is sampled daily on filter paper by continuously pumping ~100 m^3/day (1 m above ground). Total beta activity is measured daily from the same filter samples and the pooled filters are measured quarterly by gamma spectrometry.

Originally the team planned to visit the sampling station in Zadar (air and precipitation) at Puntamika (Institute for Medical Research). However on the day that the specialist for air sampling was not available. Moreover, weather conditions would have made outdoor work nearly impossible; thus this part of the verification had to be cancelled.

4.2.2.2 Dry/wet deposition collectors

Dry and wet deposition collectors are located at IMROH (Zagreb), Zadar, Osijek, Bjelovar, Pula, Rijeka and Dubrovnik (see figure 4, blue dots).

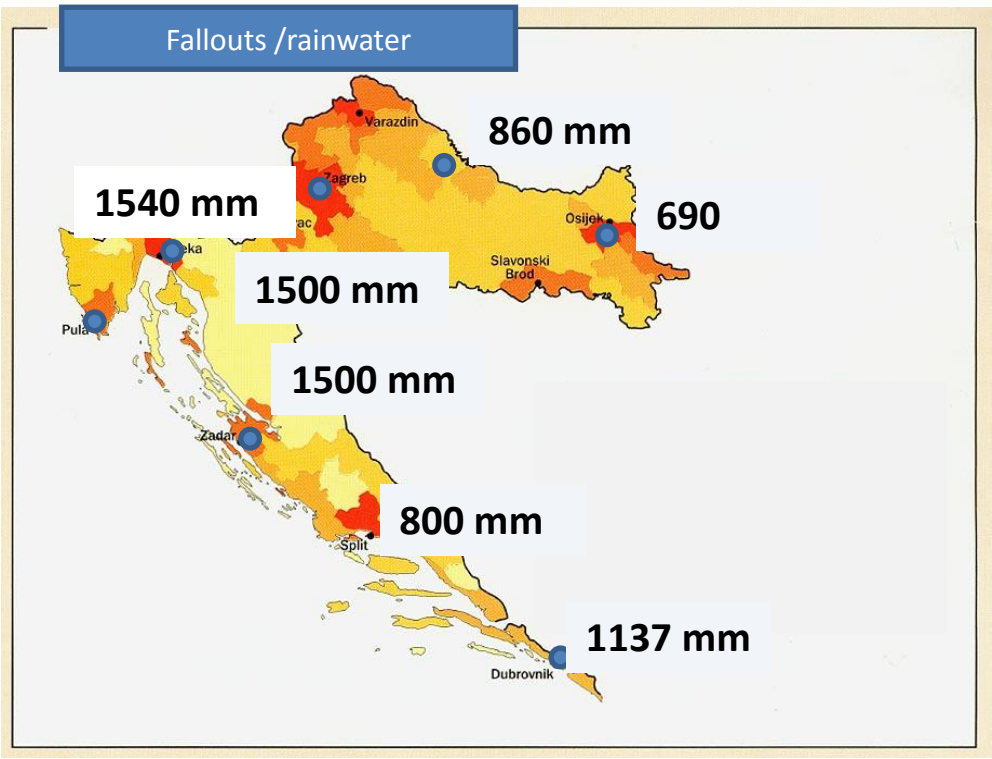


Figure 4: Locations of precipitation (wet and dry deposition; fall-out) collectors (blue dots)

Liquid precipitation samples are collected at a height of 1 m above ground using collectors with surface areas of 0.25 m^2, 0.5 m^2 and/or 1 m^2. Samples are collected quarterly in Zagreb, Zadar and Osijek, but only semi-annually in Bjelovar, Pula, Rijeka and Dubrovnik. These samples are measured by gamma spectrometry. For the determination of Sr-90 samples are collected monthly in Zagreb and semi-annually in Osijek and Zadar.

In Zagreb at the Institute for Medical Research and Occupational Health – Radiation Protection Unit (IMROH), a dry sample is collected quarterly on a *Vaseline*® covered plate with a surface of 0.0929 m^2, mounted 1 m above ground. These samples are measured by gamma spectrometry.

This system did not form part of the verification.

4.2.3 Water monitoring

With the exception of one surface water site the water monitoring programme did not form part of the verification.

4.2.3.1 Surface water – description and verification

Surface water is sampled at the locations given below.

River water:

- Sava River at Zagreb, Harmica, Sisak and Županja;
- Drava River at Varaždin and Osijek;
- Danube River at Batina and Vukovar;
- Neretva River at Opuzen;
- Krka River at Skradin.

Lake water:

- Plitvice Lakes at Kozjak;
- Vransko Lake.

Samples are collected once or twice per year. The samples undergo gamma spectrometry and determination of Sr-90 and determination of Ra-226. A map showing the locations is given in figure 5.

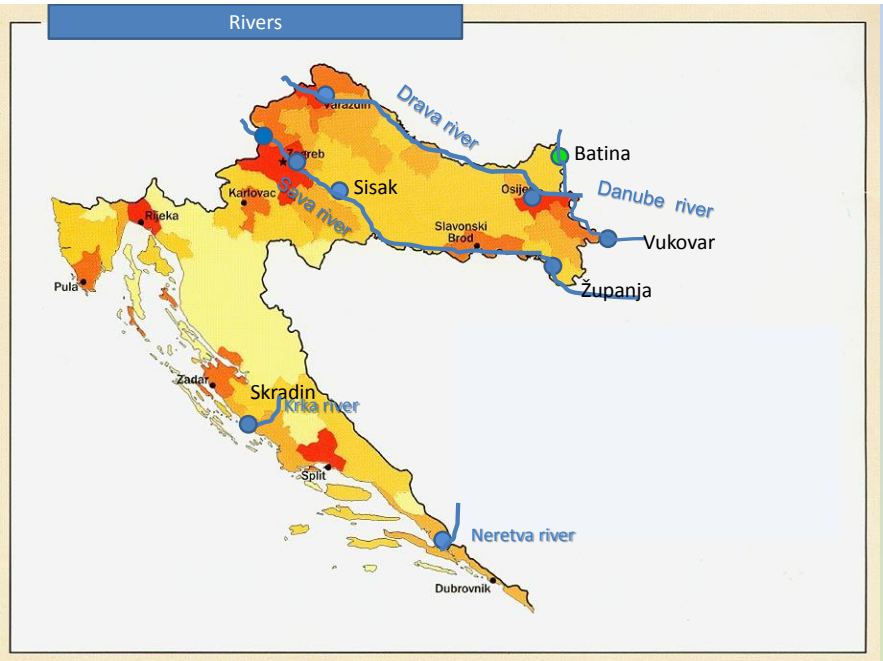


Figure 5: Locations of river water sampling (blue dots)

The team was informed that for Croatian waters continuous monitoring is not yet in place (due to technical problems), but the authorities intend to install such devices later on.

Surface water control (NPP Krško related) is also done by the Ruđer Bošković Institute (RBI); furthermore, RBI together with Hungarian bodies takes samples from the Danube River (with regard to any effects by the Hungarian NPP Paks).

For the Plitvice Lakes the team visited the sampling place at Kozjak Lake (near the boat station).

Verification does not give rise to specific remarks.

4.2.3.2 Ground water and drinking water

Ground and drinking water samples are taken at the following locations:

- Tap water is sampled in Zagreb, Rijeka, Istra, Međimurje, Zadar, Split, Dubrovnik and in Osijek;
- Cistern water is sampled in Bale, Marina, Pag and in Doli;
- Mineral waters are sampled in Jamnica and in Lipik;
- Thermal waters are sampled in Istarske toplice, Krapinske toplice, Tuheljske toplice, Stubičke toplice, Varaždinske toplice and in Bizovačke toplice.

Samples are collected once or twice a year (except in Zagreb where 1 l/day is collected and measured quarterly). The samples undergo gamma spectrometry, determination of Sr-90 and determination of Ra-226.

A map showing the locations is given in figure 6.

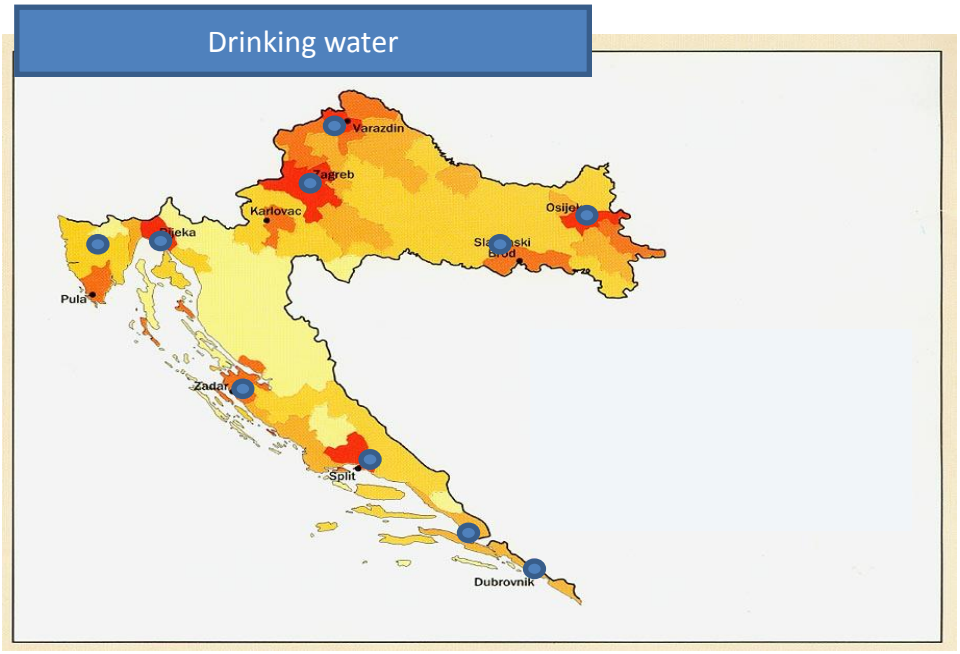


Figure 6: Locations of routine drinking water sampling (blue dots)

4.2.3.3 Sea water and marine biota

Sea water samples are taken at Rovinj, Plomin, Rijeka, Kaštela, Split and in Dubrovnik.Samples are collected once or twice per year. The samples undergo gamma spectrometry as well as determination of Sr-90 and determination of Ra-226.

The team was informed that with regard to marine biota the Ruđer Bošković Institute (RBI) operates a so-called 'mussel watch' programme, taking samples in different locations (for verification of RBI see Chapter 6.2).

4.2.4 Soil monitoring

Soil samples are collected at Zagreb, Osijek, Zadar and Gospić. They are taken once a year in layers 0-5 cm, 5-10 cm and 10-15 cm for uncultivated and 0-20 cm for cultivated soil. The samples undergo gamma spectrometry and determination of Sr-90.

Aquatic biota are sampled in Rovinj, Plomin, Rijeka, Grad Kaštela, Split and in Dubrovnik.Terrestrial flora, including mushrooms, berries, moss and Iceland moss is collected in NW Croatia, Slavonia, the coastal region, Istria and in central region Lika.

Samples are collected once or twice a year. The samples undergo gamma spectrometry, determination of Sr-90 and determination of Ra-226.

This programme did not form part of the verification.

4.2.5 Monitoring programme for foodstuffs and feeding stuff

The food and feed stuff sampling programme did not form part of the verification.

4.2.5.1 Milk

Milk samples are collected at markets in Zagreb and in Varaždin and at farms in Osijek, Zadar and Pušća.Samples are collected monthly in Zagreb, Osijek and in Zadar, or bi-monthly inVaražd̄in and in Pušća. Seven litres of milk are evaporated under UV lamps, followed by ashing at 450°C (for gamma spectrometry) or at 650°C (for determination of Sr-90).

4.2.5.2 Mixed diet

Mixed diet is sampled in Zagreb in kindergartens and student canteens. Samples are collected once a year. They are dried at 105°C followed by ashing at 450°C (for gamma spectrometry) or at 650°C (for determination of Sr-90).

4.2.5.3 Individual foodstuffs

Foodstuffs are sampled in open markets in three regions (Slavonia, NW Croatia, the coastal region).Foodstuffs collected are lettuce, beans, cabbage, potatoes, apples, eggs, chicken, beef, pork, lamb, fish, wheat and Swiss chard. Samples are collected twice a year (type of sample depends on the season). Samples are dried at 105°C followed by ashing at 450°C (for gamma spectrometry) or at 650°C (for determination of Sr-90).

4.2.5.4 Feedstuffs

Animal feedstuffs (grass, lucerne and silage) are collected at farms and fields in three regions (Slavonia, NW Croatia, the coastal region).Samples are collected twice a year. They are dried at 105°C followed by ashing at 450°C (for gamma spectrometry) or at 650°C (for determination of Sr-90).

5. BORDER CONTROL PROGRAMME

Imports of agricultural products originating from third countries after the Chernobyl Accident are regulated by the following acts:

- Council Regulation No 733/2008 of 15 July 2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station (codified version); Council Regulation (EC) No 1048/2009 extends its validity until 31 March 2020), (OJ L-201 of 30/07/2008, page 1);
- Council Regulation No 1048/2009 of 23 October 2009 amending Regulation (EC) No 733/2008 on the conditions covering imports of agricultural products originating in third countries following the accident of the Chernobyl nuclear power station, (OJ L-290 of 06/11/2009, page 4);
- Commission Regulation No 1635/2006 of 6 November 2006 laying down detailed rules for the application of Council Regulation (EEC) No 737/90 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power-station, (OJ L-306 of 07/11/2006 page 3);
- Commission Regulation No 1609/2000/EC of 24 July 2000 establishing a list of products excluded from the application of Council Regulation (EEC) No 737/90 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station, (OJ L-185 of 25/07/2000, page 27).

According to Council Regulation No 733/2008/EC, Member States shall check compliance with the maximum permitted levels for radioactivity of imported products, taking into account contamination levels in the country of origin.

Control may also include the presentation of export certificates.

The list of products to which the provisions of Council Regulation No 733/2008/EC apply is given in Commission Regulation No 1609/2000/EC.

Specific provisions established in Commission Regulation No 1635/2006 apply to imports of uncultivated mushrooms (quantities over 10 kg).

At the opening meeting the verification team discussed 'wild food product' import control issues with representatives from SORNS and the Ministry of Health, responsible for foodstuff of non-animal origin. The Ministry of Agriculture was invited to the meeting but could not send a participant.

The representatives of the authorities present at the meeting informed the verification team that Croatia is aware of the issue of the control of radioactivity levels in food imports from third countries to the EU and that such controls lie within the responsibilities of the Ministry of Agriculture (phytosanitary issues).

The Croatian authorities will organise a meeting with all concerned Croatian actors to discuss the issue and to decide on how to implement the relevant EU legislation for food imports (including mushrooms) from third countries in the near future. The Croatian authorities will also contact the

concerned Slovenian authorities to learn how Slovenia managed this issue before the Croatian accession to EU. The authorities agreed to implement food control measures at the concerned border stations within the near future.

In Croatia there are seven border inspection posts that may be concerned by food imports from third countries (Serbia: Bajakovo; Bosnia and Herzegovina: Metković, Nova Sela; Montenegro: Karasovići; the Ports of Rijeka and Ploče, Zagreb International airport).

Commission Regulation No 1635/2006 has been implemented by the border sanitary inspection since December 2013. Instructions were given to the inspectors and Regulation will be included into the next amendment of the Law on imports of feed and food from third countries (OG 39/13).

The verification team recommends Croatia to produce a detailed report of all implementation measures taken in this context and to forward it to Commission services before 1 October 2014.

6. LABORATORIES PARTICIPATING IN THE NATIONAL ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME – DESCRIPTION AND VERIFICATION

6.1 INSTITUTE FOR MEDICAL RESEARCH AND OCCUPATIONAL HEALTH (IMROH) - RADIATION PROTECTION UNIT

6.1.1 General information

The verification team visited the Institute for Medical Research and Occupational Health (IMROH) - Radiation Protection Unit and Unit for Radiation Dosimetry and Radiobiology (formally accredited by the Croatian Accreditation Agency) and licensed by SORNS Technical Radiation Protection Service – (according to EU BBS), located at Ksaverska cesta 2 in HR-10001 Zagreb

In addition to the analysis performed under contract for SORNS the institute is qualified as a reference laboratory recognised by WHO, IAEA amongst others in such fields as heavy metals and pesticides. As a scientific institute it was established 65 years ago and branched into radiation protection in 1959.

During the course of the visit the sample arrival station, sample preparation rooms and measurement devices were shown. Extensive explanations were given concerning all aspects of the handling and measurement of environmental samples for SORNS. The laboratory holds ISO 17025 accreditation,for all environmental sample measurement methods and therefore has all the necessary procedures in place to ensure that these are performed to the highest standard.

Vast archives of data are held within the institute but shrinking budgetary resources mean that much of the data is scattered throughout the institute. It could be advantageous to bring all data together in a central database so that time series could be created allowing trends to be observed over a long period.

The facilities within the laboratories, in particular the sample receipt station, were rather archaic. Recently an architectural design for a designated centre for environmental health and radiation protection was drawn up. The foreseen building would cover 5 floors and would offer many activities, including education, facilities for visiting professors and spin off activities, which would partially finance the operation.

The verification does not give rise to recommendations. Nevertheless the verification team expresses its support for the building project under consideration, which would offer a marked improvement in the working environment and which could also be of additional benefit concerning the overall management of the measuring techniques employed.

6.1.2 Sample reception

Upon arrival at the laboratory each sample is uniquely labelled according to a system prescribed by the quality assurance procedure.

6.1.3 Sample preparation

Samples are packed in different geometries, Marinelli beakers (1 l) or cylindrical plastic containers (100 mL and 200 mL) depending on the matrix and the size of the sample. Iodine cartridges are measured directly.

Cellulose air filters sampled by high volume air samplers are directly packed into plastic containers. Soil samples are dried at room temperature, sieved, then dried at 105°C followed by ashing at 450°C.Water samples are evaporated to a volume of 1 l and put in Marinelli beakers.

Foodstuffs and feeding stuffs are dried at 105°C followed by ashing at 450°C (for gamma spectrometry) or at 650°C (for determination of Sr-90).

The radiochemical separation procedure used for Sr-90 analysis follows HASL procedures (U.S. Department of Energy, Environmental Measurements Laboratory (EML) procedures manual HASL 300 Series, 1957-1997).

The radiochemical separation procedure for Ra.226 (i.e. precipitation with $BaSO_4$) follows the method described in Publication No. 999-RH-27 by the U.S. Department of Health, Education and Welfare (USDHEW), "Radio-assay procedures for environmental samples", Environmental health series, Radiological health, Public Health Service. U.S. Government Printing Office, Washington (1967) 5.49–5.52.

6.1.4 Sample measurement

6.1.4.1 Gamma spectrometry

Several measuring systems are available in the laboratory, one with a *EG&G ORTEC* Ge(Li) detector, one with a *EG&G ORTEC GMX Ser*ies n-type HPGe detector (70% relative efficiency) and one *ORTEC* system with a p-type *GEM Series* HPGe detector. Spectrum analysis uses *Ortec GammaVision* Software. Results are calculated through validated in-house developed *Excel* tables.

Calibration and maintenance procedures are implemented using quality assurance according to ISO/IEC 17025. Calibration standards are acquired from the Czech Metrology Institute.

The team witnessed the three gamma spectrometers having the following characteristics: resolution below 1.5 keV at 40 keV and below 2.5 keV at 1.33 MeV; relative efficiencies from 16% to 70%; number of channels in spectrum at least 4096; energy interval where spectrometer is calibrated from 40 to 2700 keV; calibration uncertainty below 10% in the energy interval from 40 to 2700 keV for all detectors; peak background correction in the entire spectrum in the energy range of 40-2700 keV without sample is under 2 s-1. Peak background corrections are well below 0.01 counts per second over the entire energy range.

Counting times used generally are between 80 000 and 250 000 seconds.

6.1.4.2 Alpha and beta measurement

The laboratory operates a low-level beta GM multi-counter system type *RISØ GM-25-5*. The efficiency for Sr-90 on a filter paper on a thallium disc is ~50%.

The alpha-spectrometer available is from *Canberra*. The Passivated Implanted Planar Silicon (PIPS) detector has a surface area of 450 mm^2 and a resolution of <20 keV for 5.5 MeV (Am-241). The device uses 1024 channels for the spectra; the energy range is 3 to 8 MeV.

Spectrum analysis is done using *Canberra Alpha Analyst* software. Results are calculated through validated in-house developed *Excel* tables.

6.1.5 Measurement results

All results are stored on a password protected server system accessible to authorized personnel.

6.1.6 Sample storage

The samples are stored in the laboratory up to 1 year, namely until the final report is delivered to SORNS.

6.1.7 Quality assurance

IMROH (Technical Service) is accredited according to ISO/IEC 17025 for all the measuring methods used on performing radiation protection. Control of quality assurance is performed by the competent authority (Croatian Accreditation Agency) by verifying the methodology of evaluating the results of measurements and verifying the availability of documentation on the basis of which the evaluation of measurement results is performed.

6.1.8 Intercomparison exercises and proficiency tests

IMROH constantly participates in national and international (JRC-IRMM, IAEA) inter-laboratory comparisons. IMROH is a member of the IAEA's ALMERA network.

The verification of IMROH does not give rise to recommendations. Nevertheless the verification team expresses its support for the building project under consideration which would offer a marked improvement in the working environment which could also be of additional benefit concerning the overall management of the measuring techniques employed.

6.2 RUĐER BOŠKOVIĆ INSTITUTE, DIVISION FOR MARINE AND ENVIRONMENTAL RESEARCH

The verification team visited the Laboratory for Radioecology of the Ruđer Bošković Institute, Division for Marine and Environmental Research, situated at Bijenička road 54, 10000 Zagreb.

It is, responsible for radioactivity measurements in marine bio-indicator organisms (mussels *Mytilus galloprovincialis*). Measurement results produced by the laboratory are reported to SORNS.

During the visit the verification team were given in depth explanations concerning the analyses carried out on environmental samples. Detailed procedures are in place for all aspects of the measurements performed, in accordance with the laboratory's ISO 17025 accreditation.

6.2.1 Sample reception, identification and registration procedures

After sampling and fresh sample preparation, each sample is annotated with a unique laboratory code.

6.2.2 Sample preparation

Fresh collected shells are weighted upon arrival and then treated in a microwave oven. Resulting mussel-tissue and -shells are weighted and lost seawater is calculated. Mussel-tissues are weighted before and after drying to constant weight.

After milling of the dry sample and homogenisation, the sample is placed into a counting vessel, weighted, closed and stored for 4 weeks (ingrowth period for radiochemical equilibrium – Ra-226 and Rn-222 and its short-lived progenies).

6.2.3 Sample measurement

6.2.3.1 Gamma spectrometry

The laboratory for radioecology has three *Canberr*a HPGe detector systems for gamma-spectrometric measurements.Measurements of composite samples of mussel-tissue are performed using one of the three available devices. Depending on the sample mass and activity, the spectra are measured for 80 000 to 200 000 seconds. The measured spectra are analysed using *Canberra Genie 2000* software.Naturally occurring K-40, Th-232, Ra-226, U-238 and cosmogenic Be-7 as well as artificial Cs-137 are determined regularly.

The detector systems are calibrated using mixed radionuclide standards supplied by *Eckert & Ziegler Analytics Inc.*, USA. The efficiency of the system is checked regularly during inter-comparison exercises. Radionuclide activity calculations are provided in "home made" *Excel* template sheets. Efficiency is calculated in function of energy and geometry based on experimental data. Measured uncertainty, multiplied by a coverage factor k = 2, is calculated as the sum of net peak area uncertainty, efficiency uncertainty and background fluctuation uncertainty.

Detection limits of respective radionuclides are calculated for each measurement depending on measurement parameters. Calculated results lower than detection limits are reported as below detection limit obtained in that measurement.

6.2.3.2 Other measurement techniques

The institute also analyses a number of samples from the Krško NPP using liquid scintillation counting, low-level alpha/beta proportional counting and X-ray counting. Full details can be found in the 2006 report,
http://ec.europa.eu/energy/nuclear/radiation_protection/doc/art35/tech_report_slovenia_en.pdf

6.2.4 Recording and archiving

Recorded and analysed spectra, as all other relevant data in electronic form are archived on the server of the laboratory information system. Annual reports to SORNS are archived in the Laboratory for Radioecology as well. Peak analysis reports and obtained results in printed version are stored also in a laboratory archive.

There are no provisions for sample archiving.

6.2.5 Data handling and reporting

The laboratory for radioecology reports the results obtained in the form of an annual report (in printed and electronic form) to SORNS.

6.2.6 Quality assurance and accreditation

The Laboratory for Radioecology has been accredited in 2007 by the Croatian Accreditation Agency for gamma-spectrometric measurements (HRN EN ISO/IEC 17025:2007). The laboratory for radioecology participates regularly in international inter-comparison exercises. Quality assurance and control procedures are implemented according to accreditation rules.

The verification of RBI does not give rise to recommendations.

7. REPORTING OF OFF-LINE MONITORING OF ENVIRONMENTAL RADIOACTIVITY RESULTS

Under Article 36 of the Euratom Treaty, national authorities are required to communicate periodically to the Commission data referred to in Article 35. Further, Commission Recommendation 2000/473/Euratom stipulates which monitoring results should be provided: from the environmental matrices (airborne particulates, air, surface and drinking water) and from foodstuffs (milk and mixed diet). As Croatia became an EU Member State on 1 July 2013, it will be obliged to deliver such data to the Commission from 2013 onwards.

Based on the national off-line monitoring system for environmental radioactivity in place, SORNS proposed in March 2013 a list of sample locations to be used to fulfil data requirements for the dense and sparse monitoring networks, as described in the Recommendation. This list was reviewed by the Commission and agreed with SORNS before this verification visit took place.

For the dense network, the sampling locations (listed by sample type and measurement categories stipulated by the Recommendation) are:

- airborne particulates (Cs-137 and total beta measurements): Zagreb (IMROH) and Zadar;
- drinking water (Cs-137 and Sr-90 measurements): Zagreb, Osijek, Rijeka, Split and Dubrovnik;
- surface (river) water (Cs-137 and Sr-90 measurements): Zagreb, Harmica, Sisak and Županja on the Sava river; Varaždin and Osijek on Drava; and Batina and Vukovar on Danube;

- surface (sea) water (Cs-137 measurements): Rovinj, Rijeka, Split and Dubrovnik;
- milk (Cs-137 and Sr-90 measurements): Zagreb, Osijek, Varaždin and Zadar;
- mixed diet (Cs-137 and Sr-90 measurements): Zagreb.

For the sparse network, the sampling locations are:

- airborne particulates (Cs-137 and Be-7 measurements): Zagreb (IMROH);
- surface (river) water (Cs-137): Zagreb on the Sava river;
- drinking water (Cs-137 and Sr-90 measurements): Zagreb;
- milk (Cs-137, Sr-90 and K-40 measurements): Zagreb;
- mixed diet (Cs-137 and Sr-90 measurements): Zagreb.

While the verification visit only left time to discuss data delivery for the sample types and measurement categories stipulated by the Recommendation, the verification team invites SORNS to also submit data on the other types and measurement categories covered by their national programme to the REM Database. All these data are potentially useful for dedicated studies or in case of special enquiries arising from the European Parliament or other authorities.

To prepare for data delivery to the Commission, two members of SORNS staff attended the REM Data Submission training course, held at the JRC in 2012 and 2013 respectively. Firstly, they learned how their data will be used for the EUR monitoring reports and how to submit data through the REM Data Submission Tool. Secondly, they had prepared trial datasets from their national data, and were able to verify, together with JRC staff, their compliance with input requirements for the REM Database.

As a first delivery, SORNS expects to send its monitoring data from 2013 to the Commission during spring of 2014, thus meeting the 30 June deadline stipulated by the Recommendation. In a next step, SORNS plans to submit data from the previous 10 years.

Moreover, IMROH has extensive archives of older data in analogue format (e.g. Sr-90 measurements from 1963 onwards and Cs-137 measurements from the 1970s onwards), and has proposed to enter them in the SORNS digital database. Additional resources for this work should be available.

The verification team supports these plans for digitizing older data and eventually submitting them to the Commission. Apart from historical studies, the data may be used to extend sparse-network time-series in the EUR monitoring reports backward in time.

8. MOBILE MEASUREMENT SYSTEMS

Mobile measurement systems are to be procured within the project IPA 2011 ("Upgrading the systems for the on- and off-line monitoring of radioactivity in the environment in Croatia in regular and emergency situations"). The project is on-going; the tendering documentation was published on 25 June 2013.

IMROH housed mobile measuring systems during the past 35 years. Some equipment is still used for that purposes.

9. CONCLUSIONS

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

(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 in Croatia are adequate. The Commission services could verify the operation and efficiency of these facilities..

(2) Under the co-ordination of SORNS a detailed monitoring programme for environmental radioactivity has been elaborated and proposed for Croatia. The verification team noted that the facilities for monitoring environmental radioactivity on the territory of Croatia are adequate. On the basis of the verification findings the Commission services request the Croatian authorities to continue to fully implement the monitoring programme as projected for the near future. The Commission services might conduct in due time a re-verification in Croatia to verify the state of implementation of this programme. The verification team notes the foreseen further development of the environmental radioactivity monitoring system as defined in an IPA project.

(3) A few topical recommendations are formulated. These recommendations aim at improving some aspects of the surveillance of environmental radioactivity in Croatia. The recommendations do not discredit the fact that this environmental monitoring is in conformity with the provisions laid down in Article 35 of the Euratom Treaty. With regard to food import controls the verification team strongly recommends Croatia to produce a detailed report of all implementation measures taken in this context and to forward it to Commission services before 1 October 2014.

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

(5) The Commission services would like to stay informed about any changes and progress with regard to the implementation of the IPA project mentioned in point (2).

(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

Verification Programme

Art. 35 Euratom Verification Croatia – 16 to 20 September 2013
National monitoring system for environmental radioactivity

	Team 1	Team 2
Sat, 14 Sep/Sun, 15 Sep	Travel to Zagreb	
Mon, 16 Sep	Opening Meeting (Zagreb, SORNS)	Travel to Zagreb
	Verification of measuring station in Karlovac	
	Verification of measuring station in Savudrija	
Tue, 17 Sep	Travel to Split	Discussion Meeting (Zagreb, SORNS)
		Verification of measuring station and samplers (air etc.) in Zagreb
		Verification of RBI laboratory (Zagreb)
	Verification of measuring station in Split	Verification of IMI laboratory (Zagreb)
Wed, 18 Sep	Travel to Dubrovnik	Verification of measuring station Osijek
		Verification of measuring station Slavonski Brod
		Verification of measuring station and air monitor Batina
		Verification of data centre (SORNS, Zagreb)
Thu, 19 Sep	Verification of measuring station in Dubrovnik	Closing Meeting (SORNS, Zagreb)
	Travel to Rijeka	Return to Luxembourg
Fri, 20 Sep	Verification of measuring station in Rijeka	
	Travel to Zagreb	
Sat, 21 Sep	Closing Meeting	
	Return to Luxembourg	

Team 1: C. Gitzinger, E. Henrich
Team-2: A. Ryan, S. Mundigl, T. Tollefsen

APPENDIX 2

Documentation received and consulted

Documents

File name	Content
Filled in by Croatia_Art35 preparatory questionnaire! Croatia.docx	Preparatory questionnaire filled in by Croatia
Appendix 1-CEWS_Description.docx	EuropeAid/126553/D/SUP/HR, report 2011
Appendix 2- Verification EURATOM Article 35_IMROH.doc	IMROH programme and equipment
Appendix 3 RBI-Art35 preparatory questionnaire.doc	RBI marine programme
Lokacije za MO 6.2.2013engl.docx	Locations of monitoring stations
Izvjestaj DZRNS 2012.pdf	INSTITUT ZA MEDICINSKA ISTRAŽIVANJA I MEDICINU RADA, ZAGREB: PRAĆENJE STANJA RADIOAKTIVNOSTI ŽIVOTNE SREDINE U REPUBLICI HRVATSKOJ (IMI-CRZ-93)

Web sites

Ministry of Health	http://www.zdravlje.hr/en/ministry
SORNS/DZRNS	http://cms.dzrns.hr/
CEWS	http://cms.dzrns.hr/en/aktivnosti/tpc/emergency_preparedness/early_warning_system
IMROH	http://www.imi.hr/index.php?lan=EN
Ruđer Bošković Institute	http://www.irb.hr/eng
IPA project	http://ec.europa.eu/enlargement/pdf/financial_assistance/ipa/2011/pf5-hr_systems_for_on_and_offline_monitoring_of_radioactivity.pdf