

**The IAEA's Programme on
Environmental Modelling for Radiation Safety
(EMRAS II)**

**EMRAS II
Reference Approaches for Human Dose Assessment
Working Group 2
Reference Approaches to Modelling for Management and Remediation at
"NORM and Legacy Sites"
MINUTES**

**of the Third WG2 Meeting held at IAEA Headquarters, Vienna
25–29 January 2010
(during the Second EMRAS II Technical Meeting)**

IAEA Scientific Secretary	Working Group Leader
<p>Ms Virginia Koukoulou (VK) Technical Assistance & Information Management Unit Regulatory Infrastructure & Transport Safety Section Division of Radiation, Transport & Waste Safety (Room B0732) International Atomic Energy Agency (IAEA) Vienna International Centre PO Box 100 1400 VIENNA AUSTRIA Tel: +43 (1) 2600-26770 Fax: +43 (1) 26007-26770 Email: V.Koukoulou@iaea.org</p>	<p>Ms Astrid Liland (AL) Head, Section for Health & Environmental Assessments Norwegian Radiation Protection Authority (NRPA) Grini Naeringspark 13 P.O. Box 55 1332 ØSTERÅS NORWAY Tel: +47 (67) 162-538 Fax: +47 (67) 147-407 Email: astrid.liland@nrpa.no</p>

Attending	
Name / Initials* / Email	Organization / Country
Mr Thamir A. Hadi Al-Khayyat (TAK) (thamir_alkhayat@yahoo.com)	Ministry of Science & Technology (MOST), IRAQ
Mr Ali Attarilar (AA) (aattari@aeoi.org.ir / attarilar@yahoo.com)	Iranian Nuclear Regulatory Authority (INRA), ISLAMIC REPUBLIC OF IRAN
Mr Rodolfo Avila (RA) (rodolfo.avila@facilia.se)	Facilia AB, SWEDEN
Mr Justin Brown (JB) (justin.brown@nrpa.no)	Norwegian Radiation Protection Authority (NRPA), NORWAY
Mr Daniel Salvador Cicerone (DSC) (cicerone@cnea.gov.ar)	Comision Nacional de Energia Atomica (CNEA), ARGENTINA
Ms Dejanira da Costa Lauria (DCL) (dejanira@ird.gov.br / dejanira.lauria@gmail.com)	Instituto de Radioproteção e Dosimetria (IRD/CNEN), BRAZIL
Mr Paul Dale (PD) (paul.dale@sepa.org.uk)	Scottish Environment Protection Agency (SEPA), Scotland, UK
Mr Thierry Doursout (TD) (thierry.doursout@irsn.fr)	Institut de Radioprotection et de Sûreté Nucléaire (IRSN), FRANCE
Mr Horst Richard S.M. Fernandes (HRF) (monkenhorst@yahoo.com.br)	International Atomic Energy Agency (IAEA), AUSTRIA
Ms Radostina Georgieva (RG) (r.georgieva@ncrrp.org)	National Centre of Radiobiology & Radiation Protection (NCRPP), BULGARIA
Mr Abdulhamid Hasan (AH) (hasan@kacst.edu.sa)	Institute for Atomic Energy Research (IAER), SAUDI ARABIA

*Initials used to refer to participants within minutes and actions as appropriate.

Attending	
Name / Initials* / Email	Organization / Country
Ms Tarja Katri Ikäheimonen (TI) (tarja.ikaheimonen@stuk.fi)	Radiation & Nuclear Safety Authority (STUK), FINLAND
Ms Kremena Ivanova (KI) (k.ivanova@ncrrp.org)	National Centre of Radiobiology & Radiation Protection (NCRRP), BULGARIA
Ms Jantanee Jamsangtong (JJ) (jantanee11@yahoo.com)	Thailand Institute of Nuclear Technology (TINT), THAILAND
Ms Grazyna Krajewska (GK) (krajewska@clor.waw.pl)	Central Laboratory for Radiological Protection (CLOR), POLAND
Mr Leandro Magro (LM) (leandro.magro@apat.it / leandro.magro@isprambiente.it)	Institute for Environmental Protection & Research (ISPRA), ITALY
Mr Juan Mora Cañadas (JMC) (jc.mora@ciemat.es)	CIEMAT, SPAIN
Ms Cristina Nuccetelli (CN) (cristina.nuccetelli@iss.it)	Istituto Superiore di Sanità (ISS), ITALY
Mr Richard S. O'Brien (ROB) (richard.o'brien@arpsansa.gov.au)	Australian Radiation Protection & Nuclear Safety Agency (ARPANSA), AUSTRALIA
Mr Stéphane Pepin (SP) (stephane.pepin@fanc.fgov.be)	Federal Agency for Nuclear Control/Agence Fédérale de Contrôle Nucléaire (FANC/AFCN), BELGIUM
Mr Konstantinos Potiriadis (KP) (cpot@eea.gr)	Greek Atomic Energy Commission (GAEC), GREECE
Mr Gerhard Proehl (GP) (G.Proehl@iaea.org)	International Atomic Energy Agency (IAEA), AUSTRIA
Mr Abou Bakr Ramadan (ABR) (ramadan58@yahoo.com)	Egyptian Atomic Energy Authority (EAEA), EGYPT
Mr Nafaa Reguigui (NR) (n.reguigui@cnsn.rnr.tn)	Centre National des Sciences et Technologies Nucleaires (CNSN), TUNISIA
Ms Tatiana G. Sazykina (TGS) (ecomod@obninsk.com)	Scientific & Production Association (SPA) "Typhoon", RUSSIAN FEDERATION
Mr Loren W. Setlow (LWS) (setlow.loren@epamail.epa.gov / setlow.loren@epa.gov)	U.S. Environmental Protection Agency (EPA), USA
Mr Borut Smodis (BS) (borut.smodis@ijs.si)	Jozef Stefan Institute, REPUBLIC OF SLOVENIA
Ms Malgorzata K. Sneve (MKS) (malgorzata.sneve@nrpa.no)	Norwegian Radiation Protection Authority (NRPA), NORWAY
Ms Lieve Sweeck (LS) (lsweeck@sckcen.be)	Studiezentrum für Kernenergie (SCK/CEN), BELGIUM
Ms Beáta Varga (BV) (vargab@oevi.axelero.net / varga.beata@t-online.hu)	Hungarian Agricultural Authority, Food & Feed Safety Directorate, HUNGARY
Ms Tamara L. Yankovich (YLY) (tamara.yankovich@areva.ca / tamara.yankovich@gmail.com)	AREVA Resources Canada, CANADA
Mr Charley Yu (CY) (cyu@anl.gov)	Argonne National Laboratory (ANL), USA

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Welcome address/Agenda (AL)

The Working Group Leader **AL** welcomed all participants and pointed out that it was a pleasure to see the large interest in WG2 and especially with new participants and countries being present this time. **AL** presented the Agenda (summarized version given below) and asked if there were any comments to it. **DSC** commented that he was surprised to see that the decision for the venue of the site visit was taken without involving the group. He felt that all decisions should be taken by the whole group. **AL** apologized that the site visit had been chosen without consulting the group and that the decision had

not been communicated to the group prior to the meeting. The arguments for choosing the site in France were that it is a uranium mining site which is of interest to both sub-groups (NORM and nuclear legacy), lots of data are available for the current situation, and the authority and operator of the site had already agreed to accommodate us. It was, however, recognized and agreed upon that all decisions should be taken jointly by the group from now on. No other comments to the Agenda were raised. All presentations given during the meeting are available for download from:

<http://www-ns.iaea.org/projects/emras/emras2/working-groups/working-group-two.htm>

Also see the summarized Agenda below.

Presentation of model questionnaire summary (JB)

JB summarised the findings of an exercise to elicit information on model availability and implementation within the group. A questionnaire had been circulated requesting information on models (applicable to NORM-legacy) used at each institute with a view to providing an overview of availability, willingness to participate in potential scenarios and compatibility of the models, e.g., in terms of endpoints. The survey built partly on the information provided in the NORM Working Group (of EMRAS Phase I, report available for download from:

<http://www-ns.iaea.org/downloads/rw/projects/emras/final-reports/norm-final.pdf>).

Information for a range of different models was supplied including PC-CREAM, RESRAD-Offsite, CROM, COMPLY, ROOM, CARAIBE, CITRON, PRG for radionuclides, IAEA SRS-19 and the ERICA Tool, plus the modelling environments ECOLEGO and AMBER with a view to inclusion of this information in the (final) Report from WG2. These models vary in their level of sophistication and in terms of their area of application. A way forward to exploring the similarities and differences in the models was also presented. *VK* asked if someone is just using simple mathematical equations instead of models.

Presentation of regulations related to remediation (MKS)

MKS gave the presentation on “Examples of Regulations and Regulatory Processes Related to Remediation”. During last WG2 meeting the following information was requested from all participants:

- Policy on environmental and human health protection, and industrial safety in relation to strategic objectives for final end-state for remediated nuclear legacy sites;
- National law on safety requirements, etc., intended to support achievement of national policy;
- Technical and derived standards;
- Guidance documents explaining how to comply with technical and derived standards;
- Rules developed by operators for internal operation within their organisations, by which control is exercised.

The examples were given from Belgium, Brazil, Bulgaria, Canada, France, Russia, UK and USA. The presentation included a short overview of the different approaches and recognized similar standards which are used in those countries. The next step will be to recognize how these examples could be useful in the work of the EMRAS II Programme.

The information submitted illustrates how the assessments need to be constructed in order to be useful, e.g., relevant definitions of exposure and risk for humans and the environment, and how to assess them. Some of the methods and data can be considered site or nationally specific, but there may be similarities with participants situations. Other aspects, such as monitoring methods, site characterisation techniques, radioecological data, may be more generally relevant.

WG2 might consider a larger compilation and analysis to identify usefully common features to support guidance on assessment methods that are currently under development in WG2.

LWS commented that apart from the EPA Superfund, there is a general framework for contamination with NORM and he will provide information on this.

ROB will send information for Australia.

LM commented that phosphogypsum legacy also contains other hazardous substances, which means different regulators are involved. Probably NORM sites will pose a greater hazard for workers than for the public. The NORM sites are very different, from simple ones to complex ones and with various protection end points to look at.

LWS informed that new IAEA safety and technical report series are coming out now describing specific industries.

Case study from Ukraine (RA)

RA presented uranium mining and milling in the southwest of Ukraine:

- Milling facility in operation 1948–1991;
- 9 tailing dumps, 42 million tons of waste;
- Close to town with 276 000 people;
- New enterprises established on the legacy site, not related to U mining and milling.

High levels of Ra-226 and high Rn exhalation. Monitoring programme started in 2005, substantial work done in 2008–2009. The goal is to provide data for evaluation of radiological risks and evaluation of remediation options. Lots of data available, also hydrological and meteorological. Chemistry data partly missing. Run off to Dnieper river. Modelling objectives:

- Estimate exposure to workers and the public for the current situation;
- Perform risk and safety assessment in support to decision making for remediation of the site (including future exposure).

Will use a screening model and a complex model. Focus 2010–2011: evaluation of the alternative remediation options. The Swedish Radiation Safety Authority (www.ssm.se) is leading the regulatory cooperation part of the project, but they have difficulties in relation to legal basis. Ukrainian regulations don't allow any remediation, so international standards are being used for deriving end point criteria.

Compostilla II Site in Spain (JCM)

JCM presented the Compostilla II Coal Fired Power Plant. Commissioned 1962, still in use. Gaseous emission data. Meteorological data available. Population data, soil concentrations, aerosols concentrations. Can calculate operational releases and subsequent doses to the public in nearby areas.

Site visit to France (TD)

TD presented information about the uranium mining in France that was performed during 1948–2001. The responsible organization for the sites was CEA (Commission à l'Énergie Atomique, www.cea.fr) until 1976, then COGEMA until 2002, then taken over by AREVA (www.aveva.com) who is currently responsible for the sites. In total there are 210 mining sites and 17 uranium tailing repositories (~50 mil. tons). Main remediation work carried out during 1995–2001.

The area Crouzille Mine Division in Limousin has 24 sites and 4 tailings. Near Bessines-sur-Gartempe there are 4 different tailing repositories – this is the place chosen for the site visit in 2010. In Bellezane there are 2 former open pit mines turned into tailing repositories. A prefectorial regulation from January 2004 imposed AREVA to produce a report on the remediation work performed. A new prefectorial regulation in December 2005 lead AREVA to ask IRSN to do an independent assessment of the site (Reports issued 2007 and 2008 - part 1, part 2, part 3). The monitoring performed today is both the obligatory by the prefectorial regulation + additional voluntary monitoring taken on by

AREVA. Unannounced controls of the sites are performed by the local authority (DRIRE). Data available:

- Gamma dose rates;
- Water;
- Sediments;
- Air;
- Foodchain.

Weekly or monthly measurements over several years post-remediation. Limited data pre-remediation (although *TLY* who represents AREVA in Canada said she might be able to get hold old data).

Visit Day 1: At Fontenay-aux-Roses near Paris with French authority ASN, French Ministry of Environment (MSNR) and expert organisation IRSN.

Days 2 and 3: site visits in Limousin

Proposed dates 11–13 May 2010 by IRSN.

It was discussed whether May would be too early, even if that was the original plan. June and September were also considered as possible times. By the end of the present WG meeting, it was decided to move the dates of the next (Fourth) Working Group Meeting to September 2010 and that IRSN/NRPA should send around (ASAP) a list with proposed dates in September for everyone to register availability.

It was also suggested to add a Day 3 and 4 for a WG2 meeting which was welcomed by participants. To save travel time, it was suggested to have the meeting in central Paris, either ASN, MSNR or OECD/NEA offices. If the Agenda could be adjusted to manage 2.5 days of WG meeting, this would be advantageous. IRSN and NRPA will try and accommodate these wishes when planning the joint meeting/site visit.

Various sites in Belgium (SP)

SP presented several NORM sites in Belgium:

(1) Tessenderlo's sites – phosphate industry

CaF₂ sludges as residues, disposal on landfills. 2 mill tons, > 50 ha (1935 – today). Ra-226 in sludges ~3.5 Bq/g before 1995, ~11 Bq/g later due to change in industrial process. 2.5 microSv/h, radon up to 500 Bq/m³.

Data on surface waters and hydrogeology.

Exposure scenarios assessed– normal situations max 0.5 mSv/y, but intrusion scenario (people building houses on the site) could give 350 mSv/y mainly due to radon exposure.

(2) Olen site – radium extraction and production of sources

Dumpsites D1 and S1 to be remediated.

Contamination of nearby riverbanks (remediation almost finished).

Average 20 Bq/g of Ra-226, but highly inhomogeneous up to 930 Bq/g. Approximately the same for Th-230. U-238 ~200 Bq/kg. Rn-222 up to 1300 Bq/m³. Doserates up to 10 microSv/h.

Data on groundwater, climate and diet of population available.

Contamination outside the dumps was studied by L. Sweeck et al. at SCK, Belgium.

Exposure scenarios – normal 2 mSv/y, but intrusion 50 mSv/y.

(3) Ghent - former dumpsite of ferro-niobium extraction

Radiological characterization to be carried out in 2010 (because the operator is going to do remediation since they want to set up new buildings on the site).

Phospho-gypsum stack, remediation foreseen. Operator recently went bankrupt which complicates things.

LWS commented that in the USA, all industries must have a performance bond in case of accidents or bankruptcy. Authorities are now looking to see whether the sizes of the bonds are sufficient.

VK informed **WG2** that in the EC, the industries are regulated for environmental hazards including paying for remediation, but radiological issues are not included in these directives. The directives are quite recent.

LM suggested that with the variety of existing NORM sites, **WG2** choose both simple and complex sites for the model intercomparison.

There were discussions on how to compare or include background radiation to the public and dose conversion factors for radon exposure, since the background values show high variability.

Oostende site – 2PG stacks. Ra-226 1 Bq/g, Rn-222 up to 40 Bq/m³. *Comment:* similar to the Gela site, could be nice for comparison.

VK presented many reports of interest to WG2

The reports are available for download from the EMRAS II WG2 file sharing folder:

<http://ns-files.iaea.org/fileshare/emras/default.asp?fd=347>

Site in Bulgaria (KI)

KI presented the Iskra area, close to Katina village:

- Classic uranium mining 1956–1962;
- From 1985 in situ leaching technology;
- Closed in 1992.

Technical remediation completed in 2005. Biological remediation completed in 2008. Actual situation: polluted water purified with sorption column for uranium. Need to evaluate whether this is still necessary. Data available for both pre and post sorption column in water. Data for U, Ra and Th in sediments and soil. pH and U and Ra in water.

KI today uses a conservative screening method. Tried to use CROM and RESRAD, but they demanded input parameters not available for this specific scenario. Is using ReCLAIM, an excel based model. Model target: 0.3 mSv/y. Predicted results without sorption column 0.5 mSv/y and with sorption column 0.37 mSv/y.

How to assess the uncertainties? It is difficult to take a decision using only dose assessment when the doses are low.

Discussions: **JCM** has some tricks that **KI** can use in CROM, and will provide her with guidance. Cristalball can also be used.

Another remediation option could be an aquifer clean up. The protection of the ground water should be dealt with separately. His institute is a technical control body to the regulator, and gives advice.

The calculations are only considering one exposure pathway and not radionuclide daughters, so even if it is a conservative assessment, the water purification seems justified and should be continued. If water is not treated, there will be acid water with heavy metals in addition to radionuclides.

RESRAD offsite was proposed by some participants as a suitable model for several exposure pathways and population groups (locals, campers, workers).

Ideas for a simplified approach to modelling the Gela site in Sicily (ROB)

ROB presented briefly the Gela site which was also presented in the former meeting:

- Phospho-gypsum stack, remediated for chemical hazards;
- Retaining wall around stack, natural clay layer underneath extending for hundreds of hectares;
- Surface water is drained into a well in one corner, pumped up and spread on the stack.

The characteristics matrix is rather complex even for this rather simple site. **ROB** presented a simplified matrix that yet included all the important FEPs (Features, Events, Processes). The available data for the site were presented.

Comments: elegant way of doing it. Could easily be implemented in AMBER, ECOLEGO or MODELMAKER.

The receptor is the well. **CN** has compiled data on U-234/U-238 ratio varying with time for well water and leachate that could be compared with modelling results.

A hypothetical scenario from Phase I of EMRAS was not modelled – tailings dam – but the scenario is well described, including necessary data. It is a good example of many tailing dam sites where surface water is the source for contamination around the site.

Determination of the criteria of possible land use – generic screening levels (BV)

BV would like to see isotope specific guideline levels for food, feed and soil from dose limits of inhabitants in the normal situation. Clear, definite regulations, defensible in the law courts.

From the regulatory point of view, there is a lack of homogeneous, internationally agreed and accepted guideline levels for the management of the agriculture or any kind of land-use in the field with elevated level of radioactivity, resulting either from a former contamination or technologically enhanced naturally occurring radionuclides or just an elevated level of natural background. Guideline levels should be isotope-specific concentrations applicable directly in the field or in the laboratory during the regular monitoring. These levels should be derived from the general dose constraints for the public published in the recommendations of the IAEA and ICRP. The work takes into account the results of Working Group 1 of Phase I of EMRAS (Revision of IAEA Technical Report Series No. 364 “Handbook of parameter values for the prediction of radionuclide transfer in temperate environments” Working Group), involves the collected and evaluated dataset of IAEA-TECDOC-1616 (Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments: http://www-pub.iaea.org/MTCD/publications/PDF/te_1616_web.pdf). The goal is to determine tolerance and acceptance levels for food, feed and soil, furthermore to work out a possible management structure of the land-use especially for agriculture (forest, energy plants, feed or food production...).

Screening assessments are intended to be conservative and have the objective to identify sites of negligible concern and to remove them from further consideration with a high degree of confidence. The screening levels should be well documented, easily understandable and more screening assessment approaches should be considered.

BV has back-calculated what the concentrations in soils should be in order to meet the generic dose levels for people in general situations taking standard Hungarian diets and land use habits into consideration. The presentation of the preliminary results entailed lots of discussions.

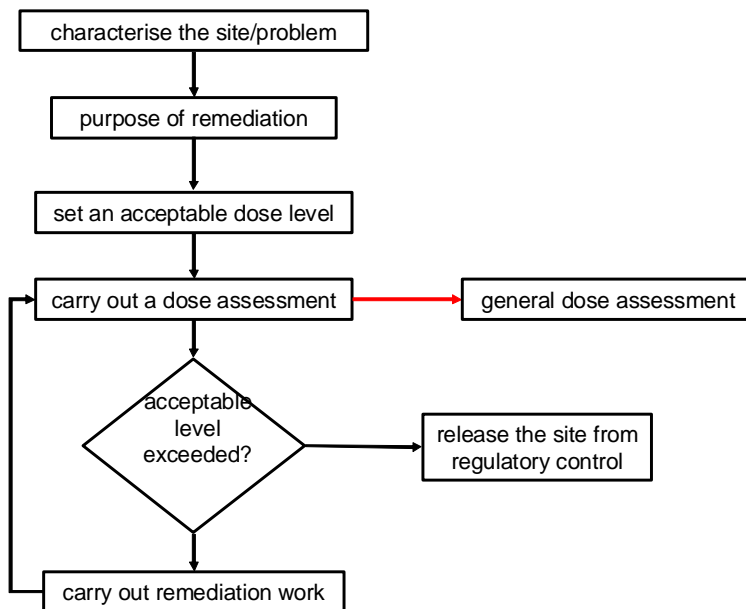
First of all: why generic levels instead of site specific ones? Generic levels are easy to deal with for the regulator, especially if they could be implemented in regulations. They would also be valid in all areas without having to perform site specific studies, which is particularly valuable if large areas are contaminated by former accidents or practices.

The derived values for natural radionuclides seemed very low, sometimes lower than normal background level. They seemed too conservative?

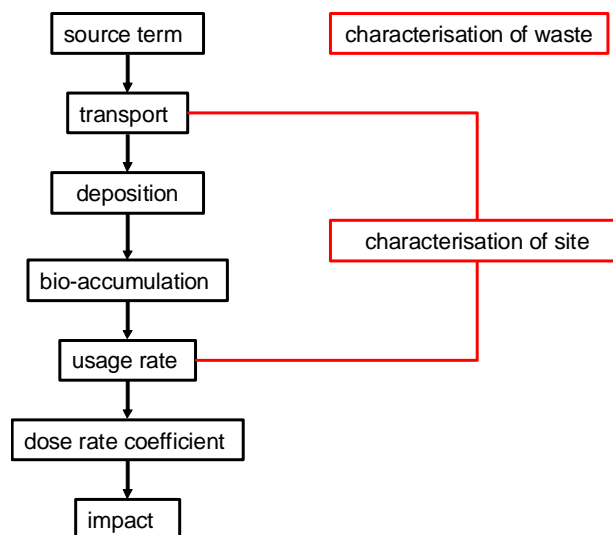
These were only preliminary results and **BV** will continue the work.

General Assessment Methodology Process (ROB)

ROB presented a rough flowchart for the general assessment methodology procedure (GAMP):



And the “general dose assessment” box:



Many issues and challenges were pointed out:

- How conservative? Realistic or worst case?
- Uncertainties in estimated doses;
- Method and costs of remediation;
- Stakeholder involvement.

Monitoring to characterise the waste and the site would most probably be necessary in all cases; the extent depends on the results for the first screening assessment.

The presented GAMP was welcomed by participants. Needs to be generic and robust, but not too prescriptive in order to allow for national and site adaption. We should also test the suggested GAMP to a real site.

LM suggested that perhaps it would be best to group into different industries and describe best practices for each. Easier to take into account other issues than the radiological one in this way.

CN commented that any real site would always be different from general described sites in international and national guidance.

RESRAD suite of codes (*CY*)

CY presented the RESRAD Family of codes:

- Onsite
- Offsite
- Build
- Recycle
- Chem
- Baseline
- Ecorisk
- Biota
- RDD
- (Probabilistic capability added around 2000 (for onsite, offsite, build)).

The RESRAD Off-site was presented more in detail:

Nine environmental pathways. Calculates homogeneous soil guidelines for each radionuclide. Basic dose limit: 0.25 mSv/y. Calculation for 1000 y post remediation. You can use the model to derive clean-up criteria using risk factors.

Typical scenarios:

Industrial, recreational, residential, subsistence farming. Special model for radon (222, 220) and progeny.

A range of site specific input parameters necessary, even though there are default values. Procedure to determine and apply site specific clean-up criteria.

Future exposure scenarios:

- Expected
- Plausible
- Unlikely

Verified and validated code. Can be downloaded for free. Pictures of sites can be imported in the code and the exposure pathway objects can be mapped to the picture. Can also be used for dose calculations for workers by changing the input parameters.

The model was of large interest to the group and entailed many questions and discussions. *CY* informed WG2 that there would be a training course on RESRAD Offsite in April 2010 in the USA.

IAEA-TECDOC on Mathematical Models for Assessing Remediation of Radioactively Contaminated Sites (*RA*)

RA presented the status of the report so far.

- Conceptual models – pathways, matrices, processes, interaction between models.
- Source term models – simplified assessment models, including applicability

- Atmospheric models
- Vadose zone models
- Ground water models
- Integrated sub-surface models
- Surface run-off models
- Surface water models
- Exposure assessment
- And uncertainties associated with these models
- Application for decision making in environmental remediation
- Assessment of remediation solution
- Demonstrative example

Report to be published in two years. Next meeting in March 2010 for the group involved in drafting the TECDOC (*HRF*, IAEA Waste Technology Section (NEFW-WTS)). Comments on the draft TECDOC are welcome from WG2 after that meeting. Please register interest with *RA* so that he can create user profiles on the TECDOC's web site.

Discussions on work plans for next year

General outline of assessment procedure:

- (1) problem formulation (by regulators);
- (2) assessment process, which includes:
 - (a) the use of models (with inherent limitations and capabilities);
 - (b) communication of results to regulators.

Suggestion that the draft GAMP will be tested by everyone for the Gela site, but this needs a clear problem formulation by *CN* and *LM*.

After revision based on Gela feedback, participants will test the revised version with real sites in their own country (or a group of countries could cooperate on a chosen site). Feedback to improve the GAMP.

This process can also be used to compare models as part of the discussions/feedback on GAMP.

Presentation on Gela phosphogypsum stack disposal (*CN*, *LM*)

Final destination of the area: sun power plant.

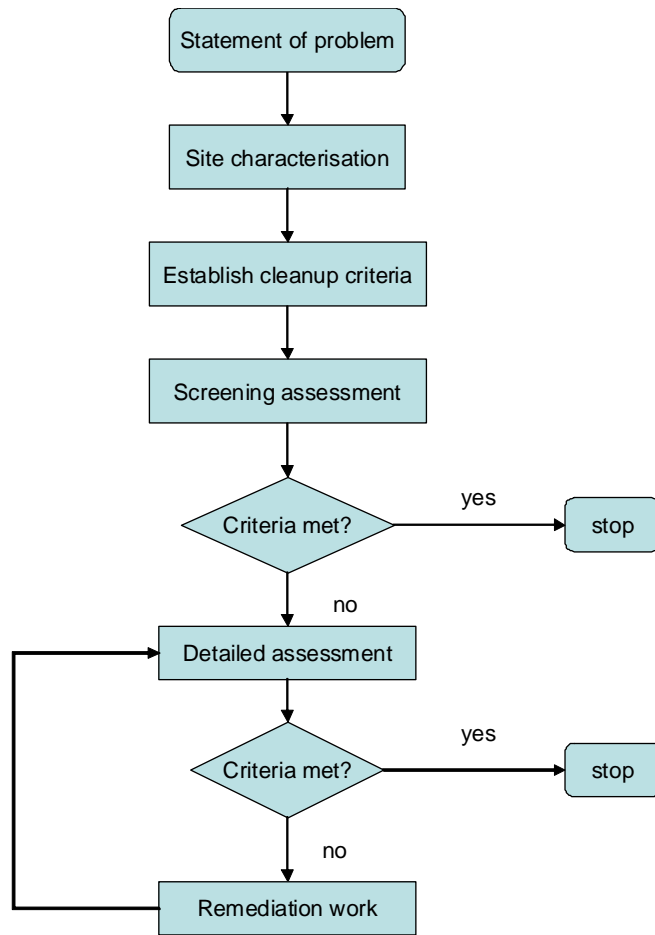
Key questions:

- (1) Is the remediation sufficient also for radiological issues?
- (2) Can the building be dismantled and waste from this disposed of at the confined site and will this inhomogenous situation still be safe? (30 000–40 000 m³)

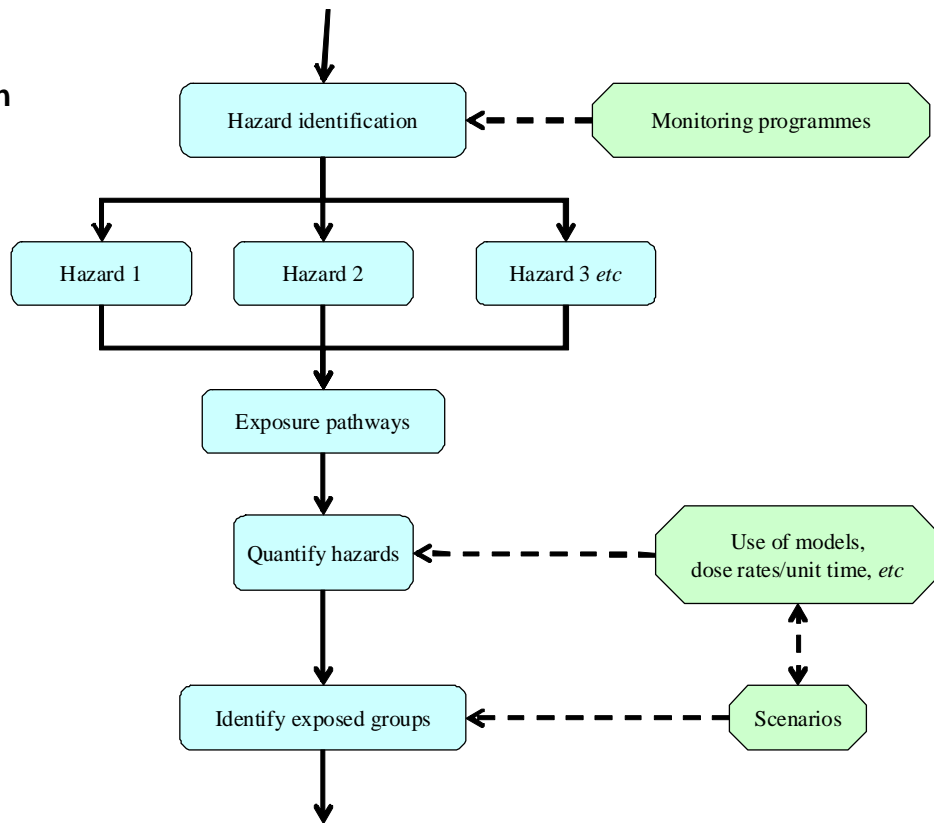
Confinement since 2000, before that the waste was in contact with the environment. Summary of available data given. *CN* and *LM* were asked to describe briefly the dismantling plans and the waste disposal from that and distribute it to the members of the group.

Discussion on draft outline of the GAMP

ROB presented a new flowchart for GAMP including a separate one on site characterisation:



Site characterisation methodology



Discussions:

- “Establish cleanup criteria” – remember first and secondary criteria (i.e., doses/risks and activity concentrations constraints). Primary criteria to be put up along with “Statement of problem”.
- Secondary criteria to come after “Screening assessment” / criteria not met.
- “Remediation work” box must be changed to “Remediation modelling for optimization” or similar.
- “Quantify hazard” – to be moved further down in the process.
- The communication with decision-makers/regulators must be highlighted at specific points during the process.
- The group decided that the outline with the proposed changes is a good starting point for the GAMP.

Action plan 2010

Action	Who	Deadline
Circulate possible dates for WG2 meeting with site visit in France, in accordance with IRSN and AREVA	NRPA, IRSN	15 February
Distribute description of plans for demolition and waste disposal, parameters etc. for Gela	CN, LM	21 February
Distribute draft GAMP	ROB	21 February
Draft minutes distributed to all	AL	28 February
Send information about review of the report “Mathematical methods...” to all	RA	March
Testing GAMP and models for Gela	All	15 May
Comments on the GAMP sent to ROB	All	21 May
Modelling testing results including parameters, considerations, etc. to JB and JMC	All	21 May
Comments on the report “Mathematical methods...”	All	1 June
Revised GAMP to all	ROB	21 June
Report on modelling feedback to all	JB, JMC	1 July
Test the GAMP (or parts of it) for a chosen site	All	15 September
WG2 meeting in France	All	September

The Action plan was agreed upon.

Tentative agenda for September meeting

- Site visit to remediated uranium site
- Discussions on modelling experience with Gela
- Reporting from GAMP national testing
- Plans for next interim meeting
- Plans for producing draft report
- Action plan for next 5 months

The next (Fourth) Working Group Meeting of EMRAS II WG9 will be held 27 September to 1 October 2010 (confirmed).

The next (Third) EMRAS II Technical Meeting is scheduled to take place at IAEA Headquarters in Vienna, 24–28 January 2011.

WG 2 MEETING AGENDA

Monday, 25 January 2010

09:30–13:00	Plenary Session	
13:00–14:00	LUNCH BREAK	
14:00–17:30	Working Group Leader introduction	Astrid Liland, WGL (NRPA, Norway)
	Summary of *available models	Justin Brown (NRPA, Norway)
	Summary of *regulatory examples related to remediation	Malgorzata Sneve (NRPA, Norway)
	Case study from *Ukraine	Rodolfo Avila (Facilia AB, Sweden)
	Presentations of site specific data not presented in the last meeting *Compostilla (Spain), *Belgium, *Olen Dump (Belgium) Fact Sheet, *Tessenderlo Dump (Belgium) Fact Sheet, *Katina (Bulgaria), *Zvezda (Belgium)	All Participants

Tuesday, 26 January 2010

09:30–16:30	Ideas for a simplified approach to modelling the *Gela site in Sicily	Richard O'Brien (ARPANSA, Australia)
	Determination of the criteria of possible *land use: forest, energy plants, feed production, food production	Beata Varga (OÉVI, Hungary)
	Presentation of site visit to *France in spring 2010	Thierry Doursout (IRSN, France)
	Progress with the IAEA *TECDOC on “Mathematical Models for Assessing Remediation of Radioactively Contaminated Sites”	Rodolfo Avila (Facilia AB, Sweden)
	Presentations of models not presented in the last meeting: *RESRAD	All Participants
	General Assessment Methodology Process (*GAMP)	Richard O'Brien (ARPANSA, Australia)
	Plenary discussions	All Participants

Wednesday, 27 January 2010

09:00–12:00	Plenary Session	
12:00–13:30	LUNCH BREAK	
13:30–17:00	Working plan for the coming year to be discussed. Suggestion: (a) Choose a limited number of site specific scenarios (hypothetical or real situations). (b) Participants to run environmental models to assess the activity concentrations in environmental compartments / matrices and doses to the public <i>using the same input parameters and model parameters</i> for a given scenario. (c) Compare the results (model-model intercomparisons) and explain differences.	

Thursday, 28 January 2010

09:30–17:00	Suggestion for further work – next year: (a) Choose one or several site(s) where remediation has been done and where environmental data are available for both pre- and post-remediation, and description of the remediation actions are available. (b) Use the models to predict the post-remediation situation. (c) Compare modelling results with real data and explain differences. This could form the basis for a guidance on which models are useful in which situations, their possibilities and limitations (comparing and contrasting models), as part of the General Assessment Methodology Process.	
17:00–17:15	Any other business, WG Meeting close	

Friday, 29 January 2010

09:00–13:00	Plenary Session	
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* Indicates the name of the presentation given on the WG2 web page
(<http://www-ns.iaea.org/projects/emras/emras2/working-groups/working-group-two.htm>)