Elicitation of information on models

- Questionnaire circulated (11.12.2009) requesting information on models (applicable to NORM-legacy) used at each institute with a view to providing
  - an overview of availability : which institute has which model
  - Willingness to participate in potential scenarios
  - Compatability of the models, e.g. in terms of endpoints
- Builds on the information provided in NORM WG (EMRAS I) and the draft document (circulated by Richard O’Brien, Nov. 2009)

Questions asked

1. Model name,
   e.g. PC-CREAM

2. Model type,
   e.g. Gaussian plume module, compartmental model

3. Application,
   i.e. Screening or Detailed assessment, site characterisation etc.

4. Transport processes modelled,
   e.g. Gaseous and liquid discharge; Atmospheric dispersion of radionuclides (Gaussian plume) and transfer through terrestrial food-chains.

5. System dynamics
   i.e. Time dependent or steady-state

6. Endpoints calculated
   e.g. external dose-rate, activity concentrations in water

7. Limitations
   e.g. Radioisotopes with half-lives < 100 years not treated separately.

8. Method for analysing uncertainty (if relevant)
   e.g. Error propagation by Monte carlo

9. Participant - name/institute (D –developer; U – User in EMRAS NORM WG2)

10. Other comments

Specific models

Model name	Model type	Application	Transport processes modelled	Endpoints calculated	Participant - name/institute (D –developer; U – User in EMRAS NORM WG2)
CROM	Gaussian plume module, compartmental model	Screening	Gaseous and liquid discharge; Atmospheric dispersion of radionuclides (Gaussian plume) and transfer through terrestrial food-chains	External, inhalation and ingestion Dose . (Activities in soil, sediment and water ?)	Institutode Radiationprotection and Dosimetry-Brazilian Nuclear Commission (Dejanira da Costa Lauria)
PC-CREAM	Set of modules 1.PLUME: atmospheric dispersion 2. DORIS: marine (coastal) dispersion 3. FARMLAND: food chain calculations 4. GRANIS: gamma radiation from ground 5. RESUS: resuspended material 6. ASSESSOR: combines results from other modules and calculates annual doses	Routine continuous releases to atmosphere, river, estuarine, marine environments; detailed committed effective dose assessment, collective dose assessment; screening assessment available within the river model.	Atmospheric dispersion =- (Gaussian plume), Transfer of radionuclides through the terrestrial environment: wet deposition, resuspension of deposited activity, migration of nuclides in soil, transfer of radionuclides to plants, transfer of radionuclides in animals, transfer of tritium and C-14 irrigation, external irradiation due to surface deposition; Estuary models – simple interface; Marine model – MARINA II – water movement, sediments, sediment/water interaction, exposure pathways - exposure pathways from ingestion of seafood, exposure pathways from sediments; River models – simple dilution, hydraulic models, dynamic models – simple screening;	1. PLUME calculates average radioactivity concentrations in air. 2. DORIS is capable of calculating radioactivity concentrations in seawater, and marine sediments. 3. FARMLAND - The output is annual average radioactivity concentrations in the most popular foodstuffs. 4. GRANIS calculates external gamma exposure to an individual from deposited radioactivity in soil. 5. RESUS calculates annual average activity concentrations in air due to the resuspension of previously deposited activity. 6. ASSESSOR - individual or collective doses – exposure pathways considered are:	1.Westlakes Scientific Consulting Ltd (U) PC CREAM 08 (Paul McDonald) 2. Australian Radiation Protection and Nuclear Safety Agency (U) (Richard O'Brien) 3. Autoridad Regulatoria Nuclear (ARN) - Argentina (Valeria Amado – following leave)
RESRAD-OFFSITE	Suite of modules, e.g. guassian Plume for atmospheric discharges, semi-empirical models for sediment-water interactions (Kds) and transfer through food chains (transfer factors) etc	Detailed Solid waste - near surface disposal, surface disposal, landfill –screening or detailed assessment, site characterisation	Surface, near surface Multi soil compartments with one primary contaminated soil layer and secondary contaminated zone. Time-dependent soil processes: leaching, erosion and ground water transport. Equilibrium approach for external irradiation, ingestion and inhalation pathways.	Total annual effective dose, dose concentrations from individual pathways, activity concentrations in air, soil and water, etc.	1. Australian Radiation Protection and Nuclear Safety Agency (U) (Richard O'Brien) 2. Westlakes Scientific Consulting Ltd (U) PC CREAM 08 (Paul McDonald) 3. Autoridad Regulatoria Nuclear (ARN) - Argentina (Valeria Amado – following leave) 4. Institutode Radiationprotection and Dosimetry-Brazilian Nuclear Commission (U) (Dejanira da Costa Lauria) 5. *Norwegian Radiation Protection Authority Justin Brown (U)*

Specific models

Model name	Model type	Application	Transport processes modelled	Endpoints calculated	Participant - name/institute (D –developer; U – User in EMRAS NORM WG2)
COMPLY		Compliance	Gaseous and liquid discharge		?
ROOM			Radon exhalation into buildings		?
CARAIBE	Vertical diffusion and advection of radon 222 from the underlying soil into a building	Detailed assessment	Transport model of radon (underlying soil + building) and a model of air circulation inside the building. Models diffusive and advective flux of radon across multiple homogeneous layers representing the soil underneath the building, and also through levels of the building.	Activity concentrations of radon 222 in the air of the different levels of the building	Institute for Radiological Protection and Nuclear Safety, Thierry Doursout (D, U)
CITRON	Gaussian plume (point source or area source)	Detailed assessment	Atmospheric dispersion of radon and its progeny	Activity concentrations in air (Rn222, Pb214, Bi214, Po214, Pb210)	Institute for Radiological Protection and Nuclear Safety, Thierry Doursout (D, U)
PRG for Radionuclides	Spreadsheet calculator	For soil and water, derivation of risk-based cleanup levels and baseline risk assessment. For soil leaching to water, screening.	Soil to groundwater; Transfer through terrestrial food-chains	Activity concentrations in soil and water. The risk based concentrations in soil and water are based on cancer risk. The pathway of contaminants in soil leaching to water is primarily based on drinking water regulatory limits	U.S. Environmental Protection Agency, Stuart Walker (D, U)
IAEA SRS-19	The SRS models have distinct models for considering the dispersion of radionuclides following (i) atmospheric release (guassian plume), (ii) river (iii) small lake (iv) large lake (v) estuary and (vi) coastal	Generic-screening assessment. Routine release situations (long operation times for installations discharging liquid radioactive material) - equilibrium	Gaseous and liquid discharge; Atmospheric dispersion of radionuclides (Gaussian plume) and transfer through terrestrial food-chains.	Activity concentrations in soil (atmospheric model) water (aquatic models). Concentrations in sediment, plants and animals may be appropriately derived using Kds and concentration factors	Norwegian Radiation Protection Authority, Justin Brown (U)
ERICA Tool	Semi-empirical model	Screening tool but allows for more detailed assessment Environmental risk assessment	The modelled processes include dispersion and dilution of radionuclides in freshwater, marine and terrestrial ecosystems from radioactive discharge. Using IAEA SRS-19 models. Biota transfer modelled using concentrations ratios and doses derived using dose conversion coefficients	Concentrations in the soil, sediment and water. Whole body absorbed dose rates	Jozev Stefan Institute, Slovenia, Borut Smodis (U) Norwegian Radiation Protection Authority (D, U)

Modelling Tools/environments

Model name	Model type	Application	Transport processes modelled	Endpoints calculated	Participant - name/institute (D –developer; U – User in EMRAS NORM WG2)
AMBER	AMBER is a generic compartment modelling code for representing contaminant behaviour and impacts in environmental systems. The code provides users with the capability to implement models appropriate to each assessment context via a robust, fully probabilistic framework. For example, models of the EMRAS I NORM point and area source term scenarios were developed and implemented in AMBER	As a generic tool, AMBER models have been developed and applied to a wide variety of contexts at both a screening and detailed assessment level, including: - assessments of the disposal of wastes including NORM contamination; - operational and post-closure assessments of contaminated land; - post-closure assessments of waste disposal concepts, including near-field (engineering), geosphere, biosphere and total systems models; - foodchain models associated with routine discharges and accidental releases of contaminants to the atmosphere.	As a generic modelling tool, AMBER does not include predefined transport processes, however, the flexibility of the code enables users to implement models including a wide range of processes, as described below. Water mediated transport: diffusion, leaching, infiltration/percolation, groundwater advection, discharge and abstraction, surface water flow/dispersion. Solid mediated transport: sorption (equilibrium, Langmuir and irreversible), erosion, sedimentation, resuspension. Atmospheric transport: advection, dispersion (including Gaussian plume). Foodchain modelling: plant uptake from soil and soil adhesion, plant interception and weathering, translocation within plants (equilibrium and dynamic), animal ingestion and biokinetics (equilibrium and dynamic), uptake by aquatic organisms, food processing. Exposure modelling: external irradiation from the ground and immersion in air and water, dermal contact, ingestion, inhalation. Can be used to consider exposure to radionuclides, heavy metals and organic substances.	AMBER models are fully open and transparent, enabling the user to have access to any of the intermediate outputs from a model, including transfer fluxes and amounts. Models can make use of these outputs to provide fluxes and concentrations in any part of the system, which, in turn, can be used to calculate dose and/or intake rates from a wide variety of exposure pathways. All of these outputs can be explored graphically via charts, exported to Excel, reported to text files or exported for use in other codes.	Quintessa Limited, Russel Walke (D and U).
ECOLEGO					Facilia ? Norwegian Radiation Protection Authority, Justin Brown (U)

What it might be useful to do……

Table 2-7 Processes and parameters

Process and parameter	ANDRA	EPRI	JGC	Studsvik	Veszprem	YMP
Leaf Area Index	X			X		
Water storage per LAI	X			X		
Absorption of activity		X		X		
Interception fraction of nuclides	X	X		X	X	X
Interception fraction of irrigated water			X		X	
Irrigation rate/ events	X	X	X	X	X	X
Translocation	X	X	X	X[1]	X	X
Weathering	X	X	X		X	X
Harvest delay after irrigation		X				
Yield	X	X	X	X	X	X
Element chemical properties	X	X		X		
Fraction of spray irrigation						X
Loss of activity due to food processing			X			

BIOPROTA (2005). Model Review and Comparison for Spray Irrigation Pathway. A report prepared within the international collaborative project BIOPROTA: Key Issues in Biosphere Aspects of Assessment of the Long-term Impact of Contaminant Releases Associated with Radioactive Waste Management. Main Contributors: U Bergstrom (Task Leader), A Albrecht, B Kanyar, G Smith, M C Thorne, H Yoshida and M Wasiolek. Published on behalf of the BIOPROTA Steering Committee by SKB (Swedish Nuclear Fuel and Waste Management Co., Svensk Kärnbränslehantering AB), Stockholm, Sweden.

What it might be useful to do…(II)

Table 2-8 Parameters

Parameter	ANDRA	EPRI	JGC/ NUMO	Nirex/ MTA	Studsvik	Veszprem	YMP [4]
Irrigation Rate	150 mm/y	150 mm/y	See tables 2-3 and 2-4	150 mm/y		0.01 m/d for green veg, 0.005 m/d for root veg	Crop-dependent daily rate 5.4 mm/d for leafy veg., 7.6 mm/d for other vegetables
Translocation factor	0.5 for Ra-226, Pb-210, Np-237, U-233 and Th-229 for leafy veg; 0.01 for Ra-226, Pb-210, Np-237, U-233 and Th-229 for root veg. 0.6 for Se-79, Tc-99 and I-129 in leafy veg; 0.1 for Se-79, Tc-99 and I-129 in root veg	0.1 specific to root veg and iodine 1.0 specific to green veg and iodine [2]	See tables 2-3 and 2-4	TRS364 values	See Table 2-5	0.3 for green veg 0.05 for root veg	1 for leafy vegetables, 0.1 for other vegetables
Absorbed fraction		0.5 specific to iodine [2]	See tables 2-3 and 2-4		See Table 2-5		N/A

BIOPROTA (2005). Model Review and Comparison for Spray Irrigation Pathway. A report prepared within the international collaborative project BIOPROTA: Key Issues in Biosphere Aspects of Assessment of the Long-term Impact of Contaminant Releases Associated with Radioactive Waste Management. Main Contributors: U Bergstrom (Task Leader), A Albrecht, B Kanyar, G Smith, M C Thorne, H Yoshida and M Wasiolek. Published on behalf of the BIOPROTA Steering Committee by SKB (Swedish Nuclear Fuel and Waste Management Co., Svensk Kärnbränslehantering AB), Stockholm, Sweden.

Way forward; suggestions, once scenario(s) agreed

- Check information in tables and request further participation
- ”Specific models” =
  - Endpoints selected ➔ model compatability ➔ reduced suite of models for intercomparison
  - Agree on problem formulation, assessment context, input terms
- Generic models
  - Apply General Assessment Methodology Process guidance to produce mathematical models
  - Also draw on work that has already been performed using modelling tools/environment : AMBER; Facilia - ”Mathematical Models for Assessing Remediation of Radioactively Contaminated Sites”

Possibilites for data analyses

- Model-data intercomparison (e.g. act. concentration)
  - Test whether the modelled ‘distribution’ is significantly different to the empirical distribution
- Model-model intercomparison (e.g. dose) ➔Z score or standard score indicates how many standard deviations an observation or datum is above or below the mean.
  - dimensionless quantity derived by subtracting the population mean from an individual raw score and then dividing the difference by the population standard deviation.
  - Requires prior statistical analyses of data – normality test on underlying distribution, identification of outliers etc.
  - Gives an indication of bias and model performance