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Application of Ecolego in assessments of risks from contaminated lands

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Outline

- Short presentation of Ecolego
- Examples of applications in NORM problems
- Overview of relevant IAEA TECDOC currently under development

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Ecolego in a Nutshell

The development was supported by:

NRPA –Norwegian Radiation Protection Authory.

SSM – Swedish Radiation Safety Authority .

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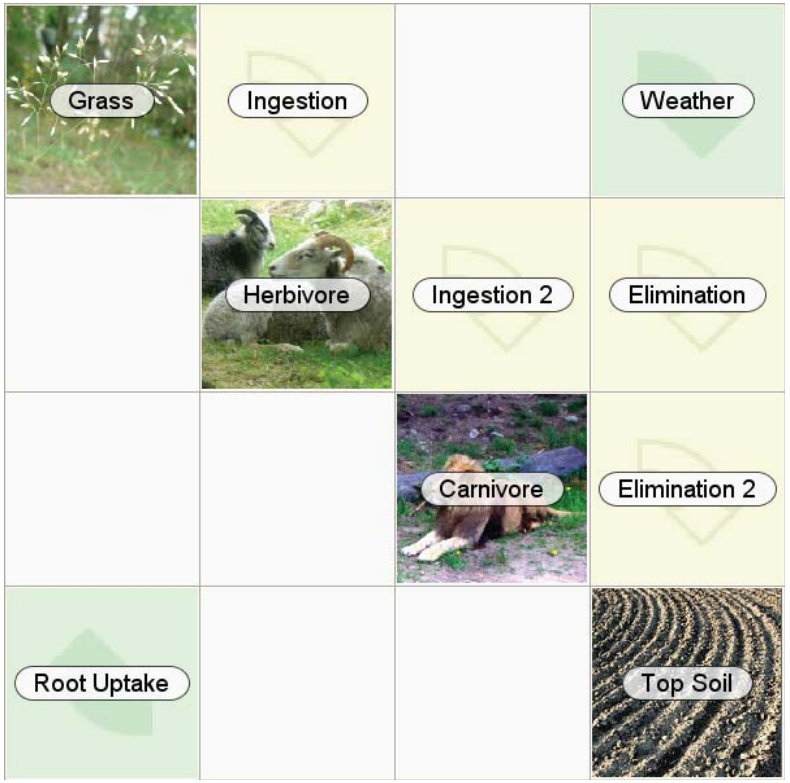
Ecolego - Simulation Modelling and Risk Assessment Software

Flexible software tool for creating dynamic models and performing deterministic or probabilistic simulations. Ecolego can be used for conducting risk assessments of complex dynamic systems evolving over time with any number of species. Ecolego has specialized databases and other add-ons designed for the field of radiological risk assessment.

Models are represented with the help of interaction matrices instead of the traditional flow diagrams.



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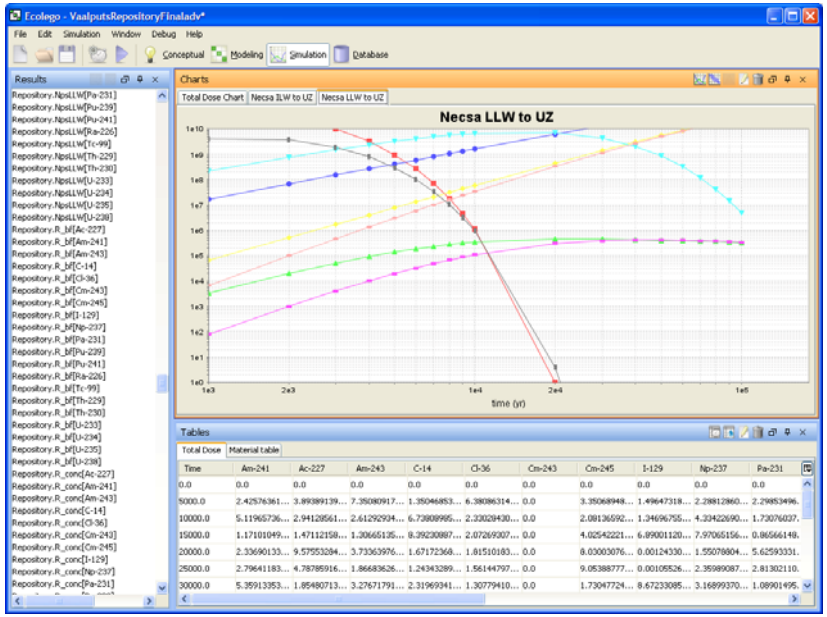
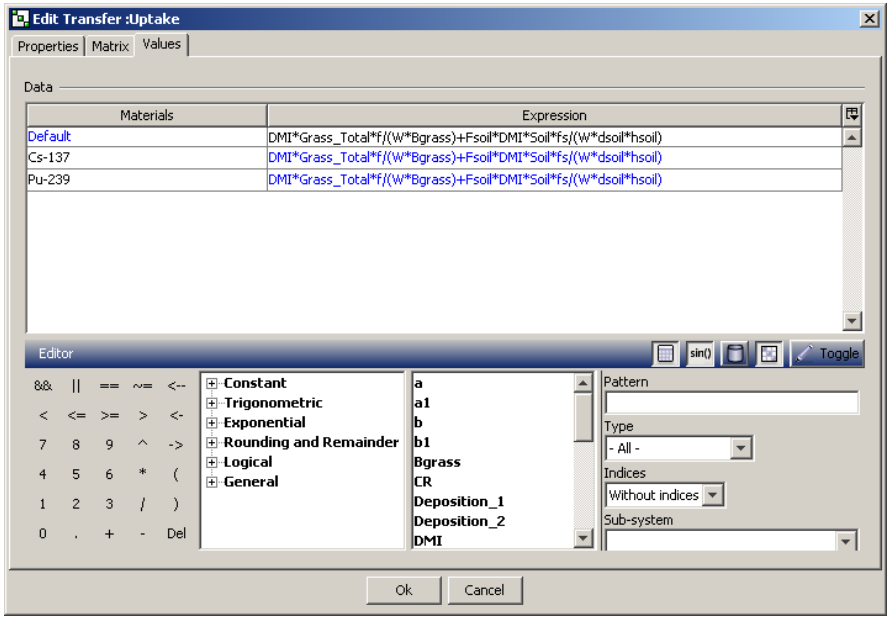
User interface

Ecolego has a modern user interface, where the latest techniques for customization and user-friendliness have been applied. A wide array of windows is available to support the many different tasks in modeling.





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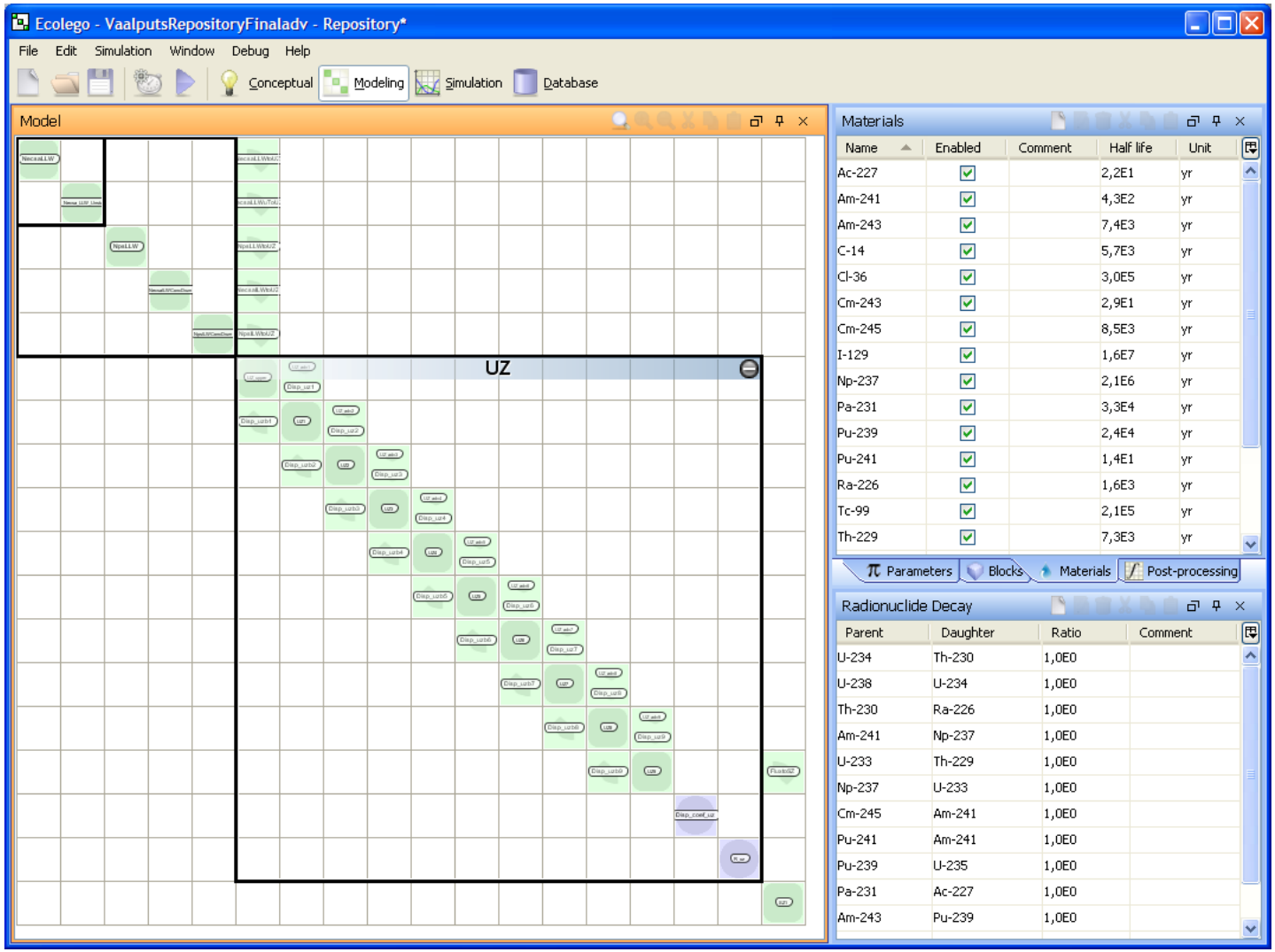
Hierarchical models



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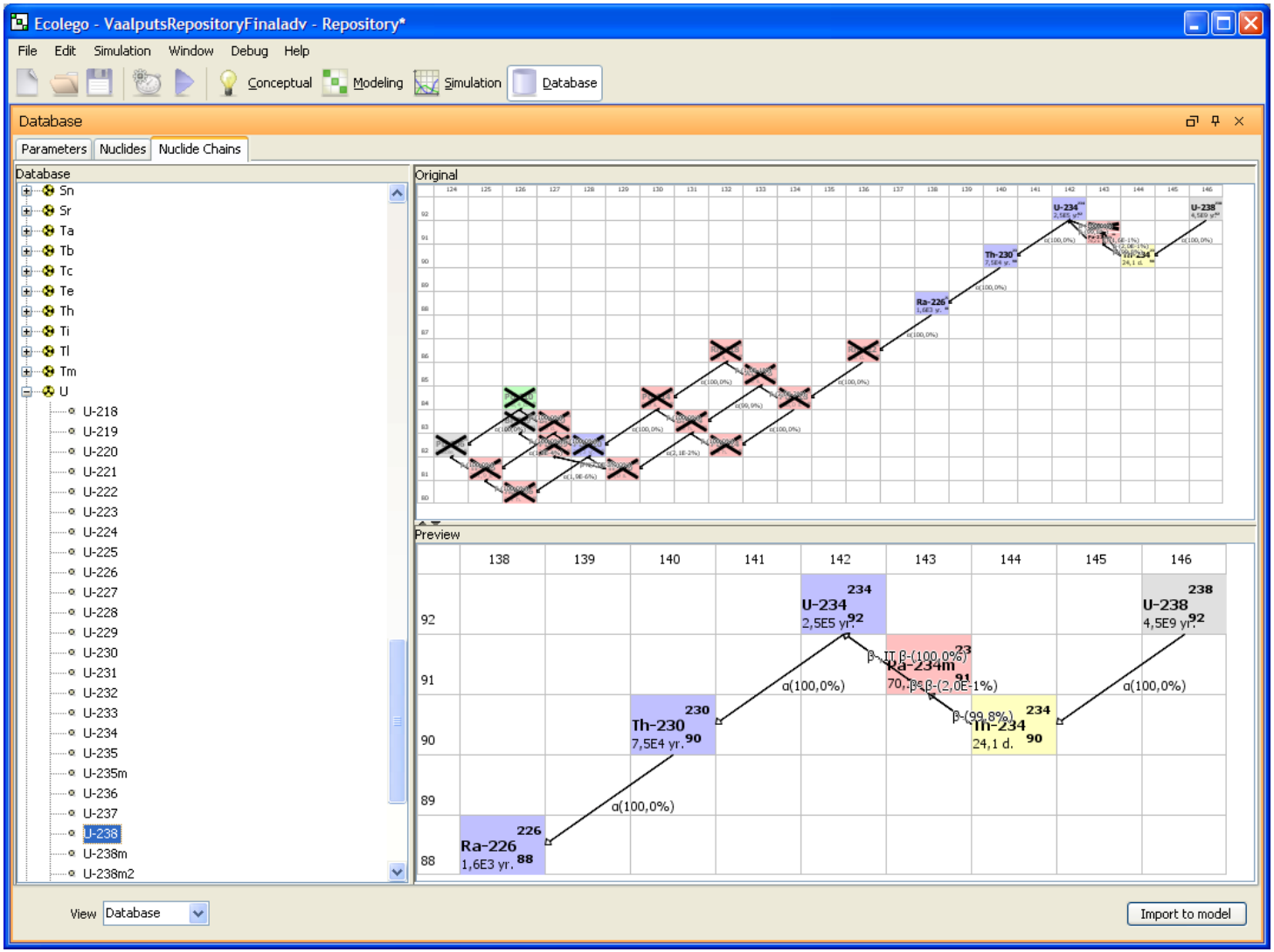
Database of radionuclides and parameters



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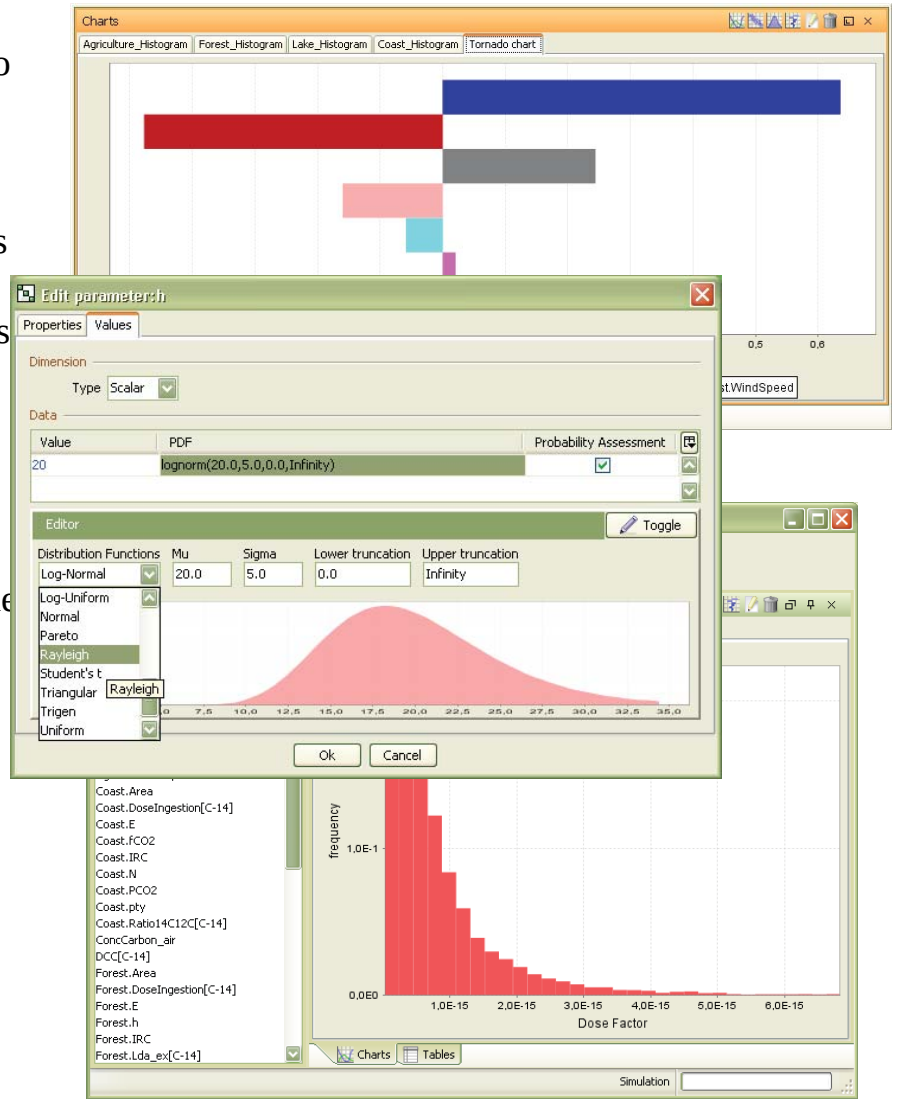
Simulations

Ecolego can handle everything from simple systems, to huge, stiff problems.

<u>Monte Carlo simulations</u>
With an impressive list of probability density functions (PDFs), together with Monte Carlo and Latin Hypercube sampling and parameter correlation settings Ecolego has everything needed for advanced probabilistic analysis.

<u>Sensitivity analysis</u>
Rank correlation coefficients are available for tornado plots or correlation tables. These can be used to find the parameters in a model that influence results the most.

<u>Post-processing</u>
Simulation outputs can be re evaluated using post-processing functions, without re-running simulations.



Ecolego Player

Ecolego Player is a free tool for running models created with Ecolego.

It allows for people not having Ecolego to perform simulations of any models created with Ecolego, including changing the parameter values etc.

The only restriction is that the structure of the model cannot be changed.

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Summary

- Ecolego can be used for development of specialized models which. These can be used to set up Assessment Models applicable to specific situations.

- Once the models have been implemented in Ecolego, these can be distributed with the help of the Ecolego player.

- Model sets based on Ecolego have been developed in other projects:

  SAFRAN (IAEA project) - Safety Assessment Framework for Radioactive Waste Management and Decommissioning.

  2-FUN (EC project): Integrated model for assessment of risk from radionuclides and chemicals

Assessment of current doses from uranium tailings

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CMSET
Center for Monitoring Studies
and Environmental Technologies
= EcoMonitor LLC

Strålsäkerhetsmyndigheten
Swedish Radiation Safety Authority

Summary

Presentation of results derived from two main studies:

- **<u>Swedish Radiation Protection Authority:</u> Assessment of Risks to Human Health and the Environment from Uranium Tailings in Ukraine -** Phase 1 report. Facilia ENSURE Report: TR/SIUS/01.

- **<u>IAEA:</u>** Apendix: "A**ssessment of doses from exposures to elevated levels of natural radionuclides in areas close to uranium tailings in Tajikistan and Uzbekistan**" of the IAEA Report: Safe Management of Residues from Former Mining and Milling Activities in Central Asia. *Regional Technical Cooperation Project RER/9/086.*

Investigated sites

Ukraine: Dniprodzerzhinsk

Tajikistan: Taboshar and Degmay

Uzbekistan: Charkesar

Contamination not spatially homogeneous with large variation of radionuclide levels in different areas within a given site.

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Dniprodzerzhinsk Site, Ukraine

42 M tonnes

3,2 x 10^{15} Bq

258 000 inhabitants

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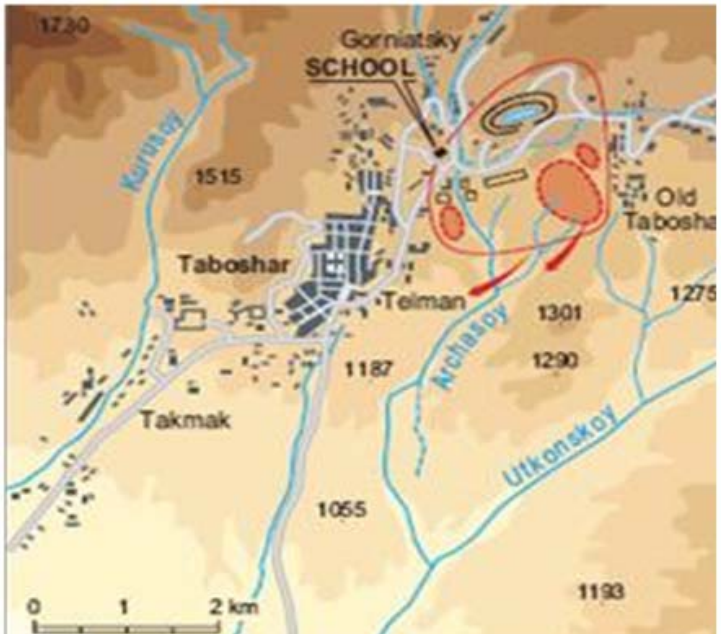
Two sites in Tajikistan

Taboshar tailing site



Degmay tailings near
Khudjand and Chkalovsk

7,6 M tonnes 12 000 inhabitants 20 M tonnes 16 000 GBq

salt covers with ^{238}U 10-20 Bq g^{-1} 164 000 & 22 000 inhabitants

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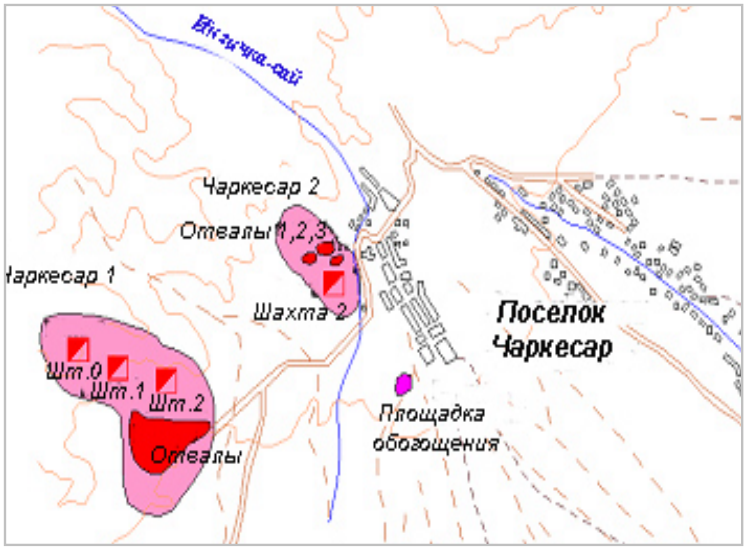
Mines and disposal areas near Charkesar village, Uzbekistan



482 000 m^3 3 x 10^{13} Bq 2 500 inhabitants

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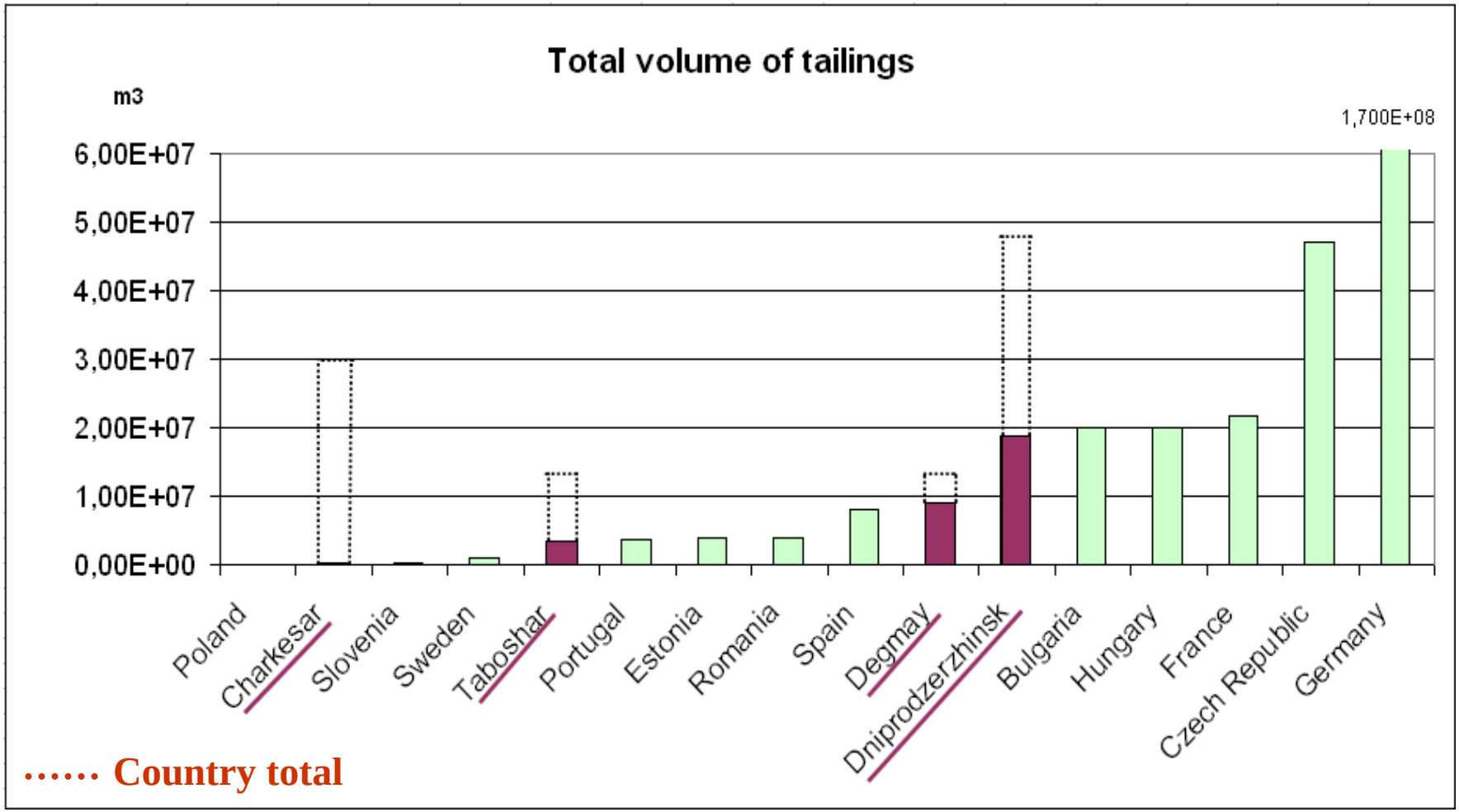

European data extracted from TREN report “Situation concerning uranium mine and mill tailings in an enlarged EU” (2006)

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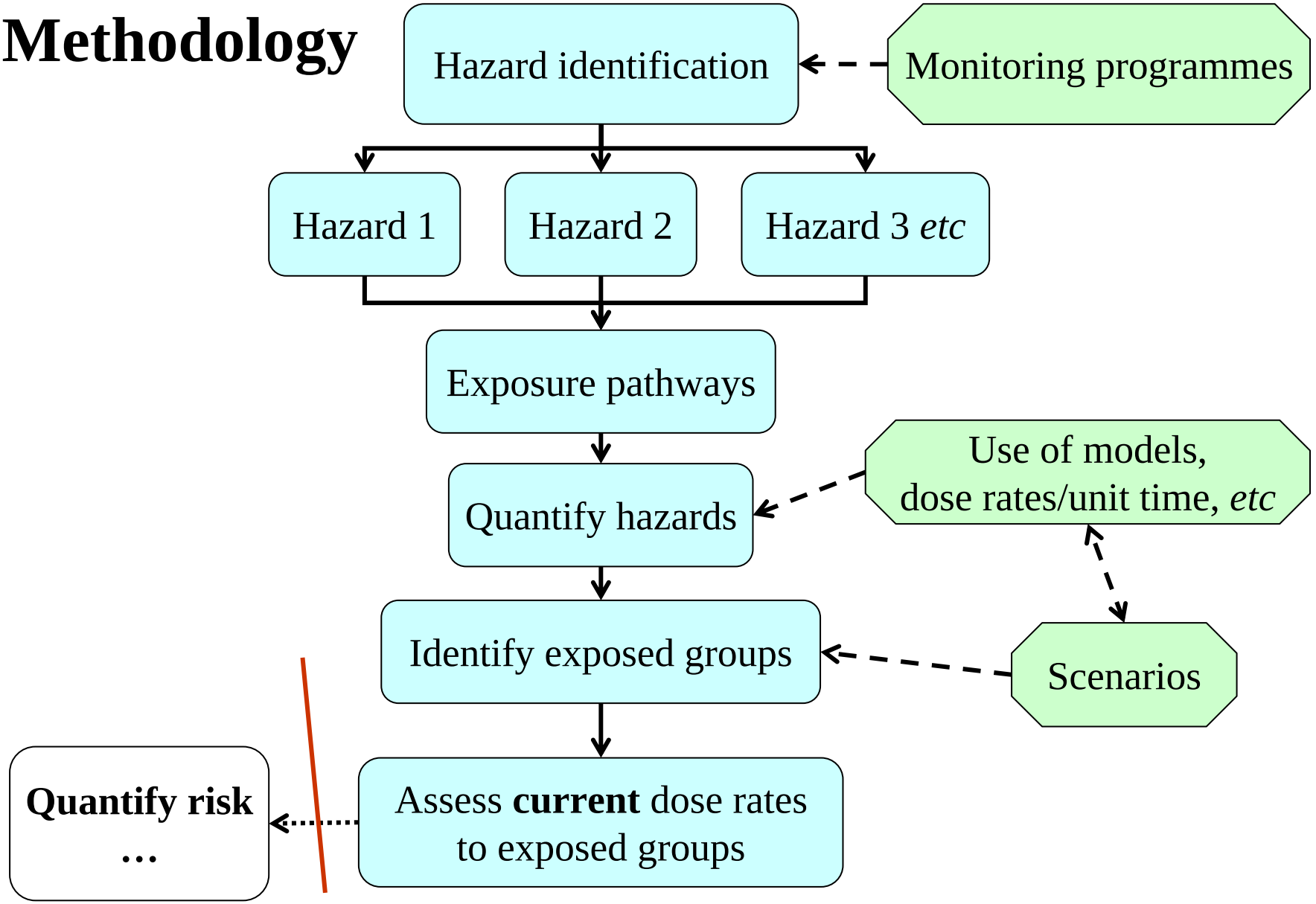
Methodology



Identification of hazards

Monitoring:

- Gamma dose rates outside and inside of buildings
- Radionuclide concentrations
  - aerosols, soils and tailing materials
  - in water and food products (not at the Ukrainian site)
- Radon concentrations outside and inside buildings

Identified hazards

Dniprodzerzhinsk	• Workers on the site get the highest radiation doses • Elevated radionuclide and radiation levels: a) inside and outside polluted buildings b) Hot Spots in the forest c) in the different tailing sites
Taboshar	• Elevated radionuclide and radiation levels: a) indoors and outdoors at settlement b) at tailings, locals go and animals graze c) at pits, locals visit and swim d) in waters contaminated by tailings or/and pits
Degmay	• External exposure to gamma radiation and radon • Elevated radionuclide and radiation levels: a) in the Degmay settlement b) at the uranium tailings c) in ground waters (water from local wells)
Charkesar	• Tailing materials used for house construction • Elevated radionuclide and radiation levels: a) areas close to and away from the industrial site b) at the industrial site c) in water bodies, e.g. springs, mine waters, rivers

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Derivation of doses

To provide a basis for necessary exposure assessments at these sites, we used the methodology (and models) highlighted by the German Federal Ministry for the Environment (BMU), Nature Conservation and Reactor Safety (1999):

" **Berechnungsgrundlagen zur Ermittlung der Strahlenexposition infolge bergbaubedingter Umweltradioaktivität (Berechnungsgrundlagen - Bergbau)"**

[Assessment principles for estimation of radiation exposures resulting from mining-related radioactivity in the environment (Assessment principles for mining)]

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Exposure pathways

- soil contamination for reference persons inside and outside buildings
- aerosols inside and outside buildings
- in, and exposure to, locally grown foodstuff (not yet included in the Ukraine project)
- exposure through the direct ingestion of soil
- inhalation of ^{222}Rn and its short lived progeny

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Chosen radionuclides

1. $^{238}U \rightarrow {}^{234}U \rightarrow {}^{230}Th \rightarrow {}^{226}Ra \rightarrow {}^{210}Po \rightarrow {}^{210}Pb$

2. $^{235}U \rightarrow {}^{231}Pa \rightarrow {}^{227}Ac$

3. $^{232}Th \rightarrow {}^{228}Ra \rightarrow {}^{228}Th$

This may lead to slight underestimation of these doses

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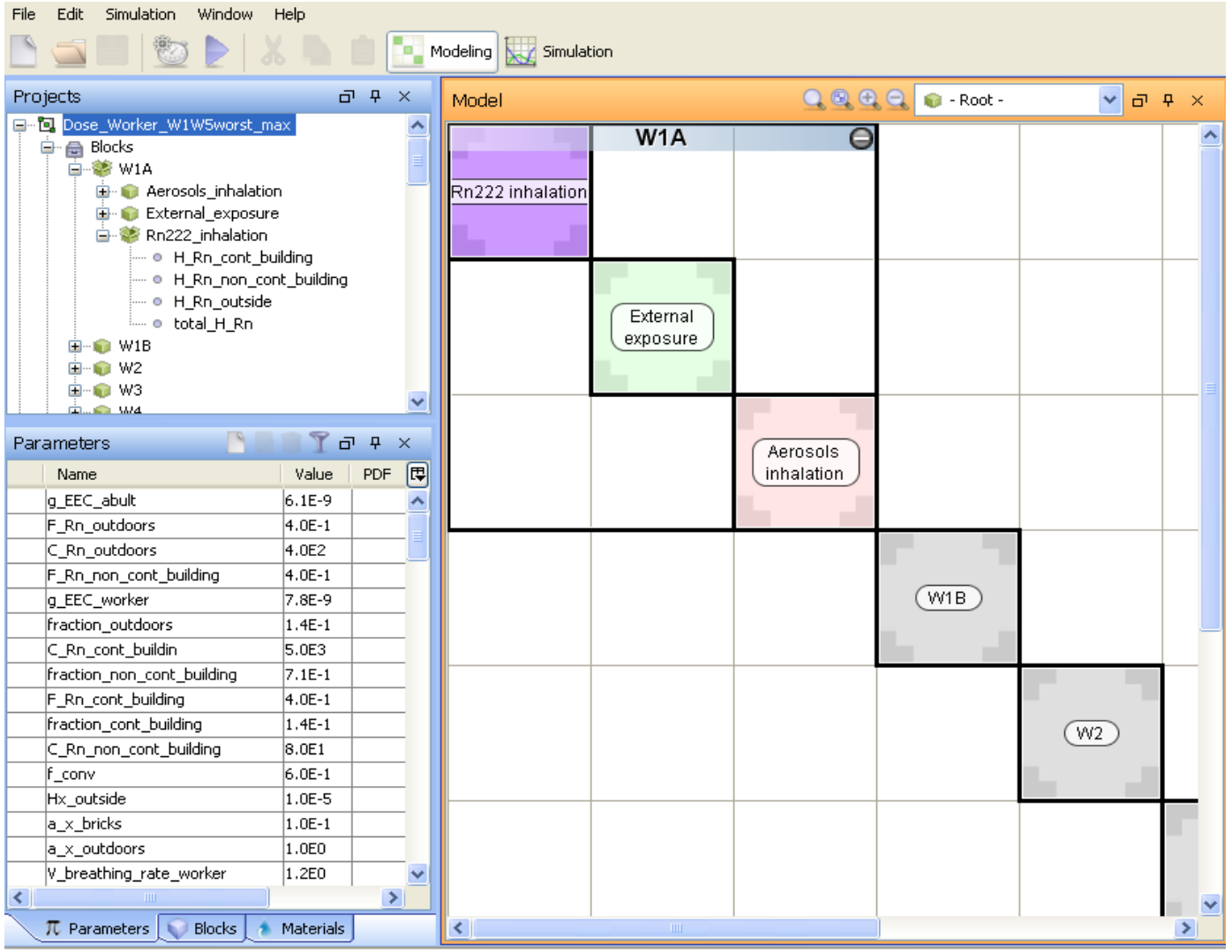
Screening models placed in Ecolego



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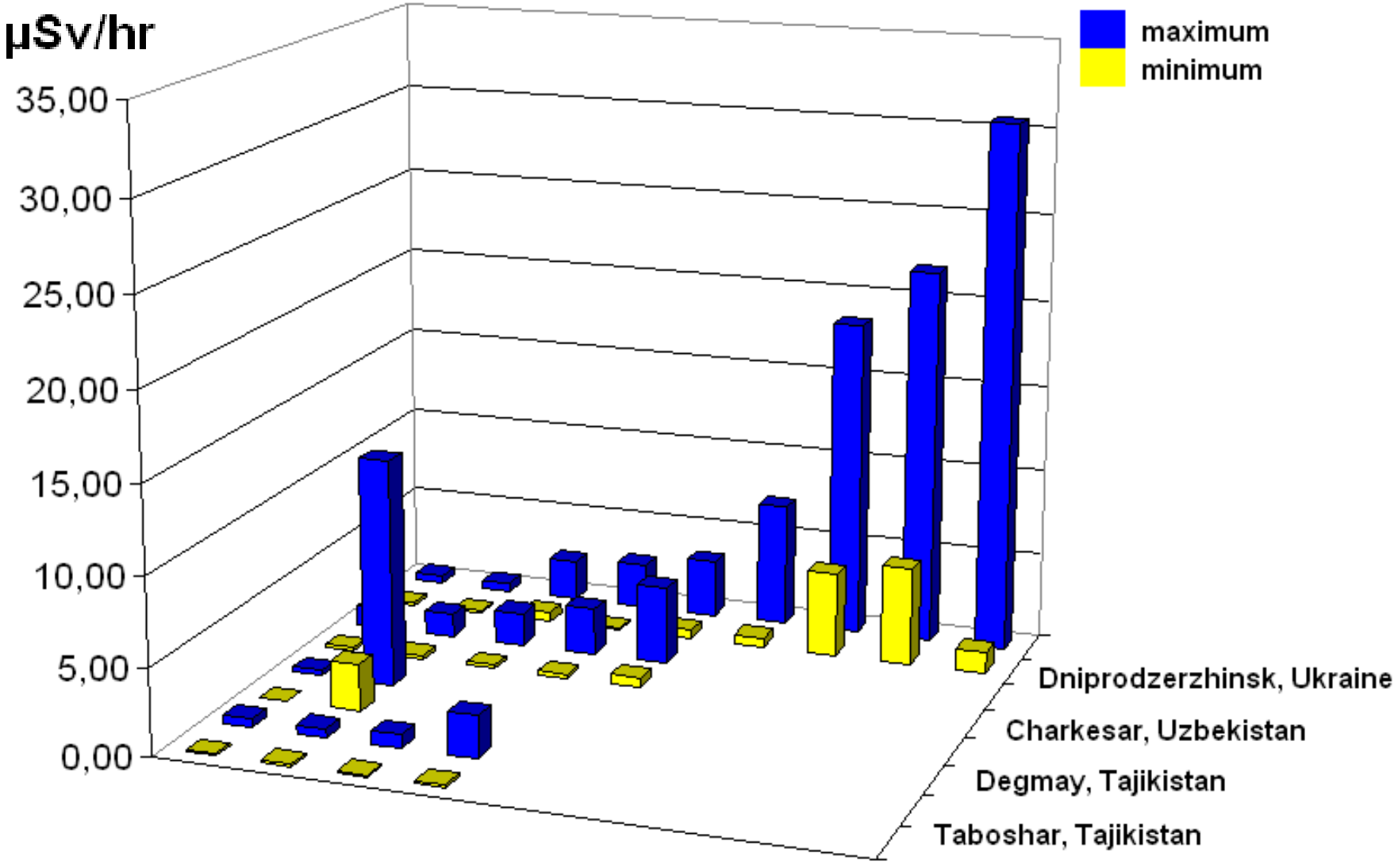
Comparison of doses between the four sites



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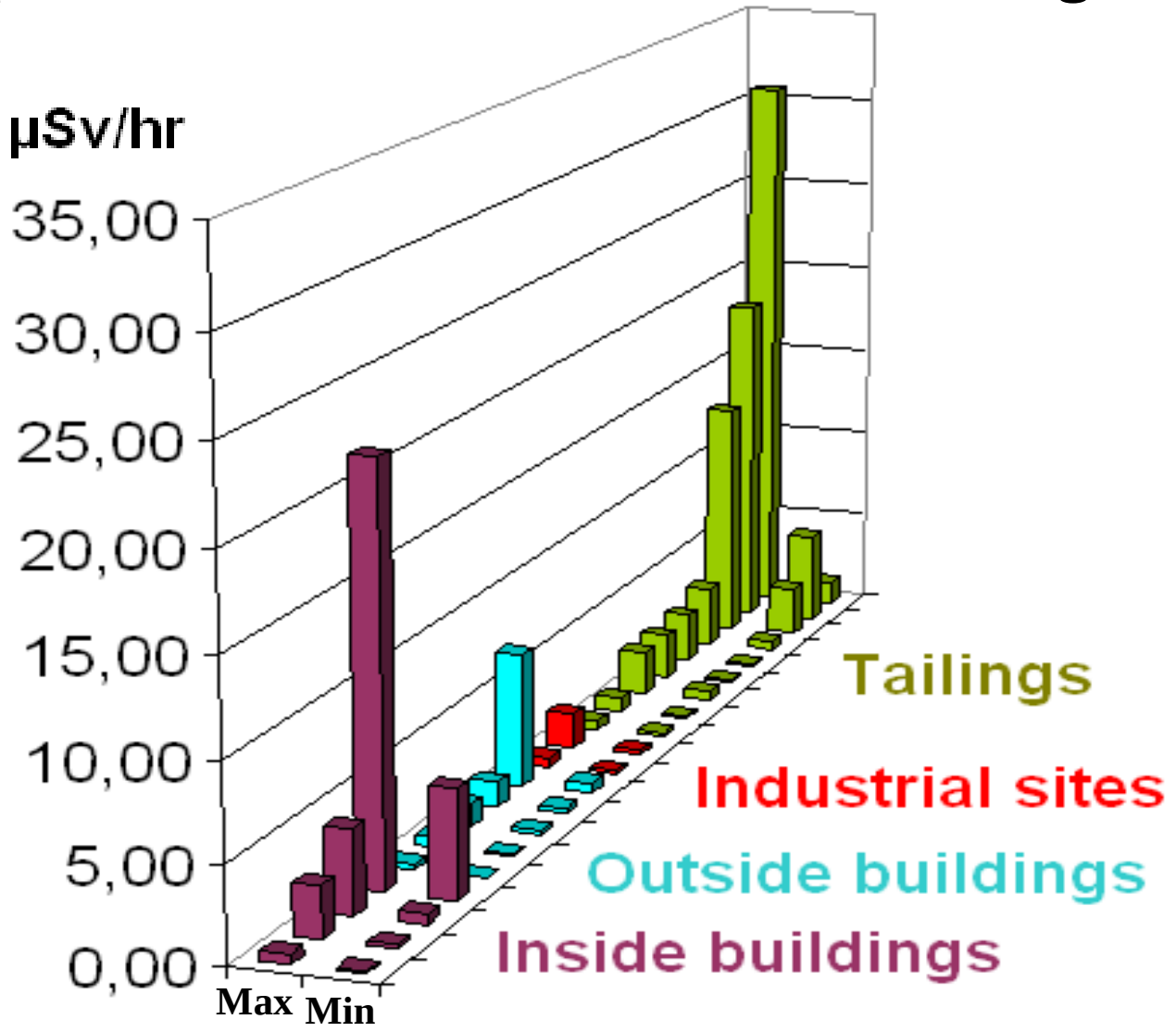
Comparison of doses between all site categories



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Example: current doses at Taboshar

Scenarios:

Group	Exposure (hr/y) to different hazards				Fraction of annual consumption		
	Outdoor at tailing	Outdoor at waste rock piles	Indoor in houses	Outdoor at the town	Meat and milk (water from tailing)	Irrigation of vegetables (water from mine)	Drinking water from mine
1	0	0	5840	2920	0 %	0 %	0 %
2	0	0	5840	2920	0 %	30 %	30 %
3	0	730	5110	2920	0 %	30 %	30 %
4	1460	730	5110	1460	30 %	30 %	30 %
5	0	1380	5110	2270	0 %	0 %	0 %

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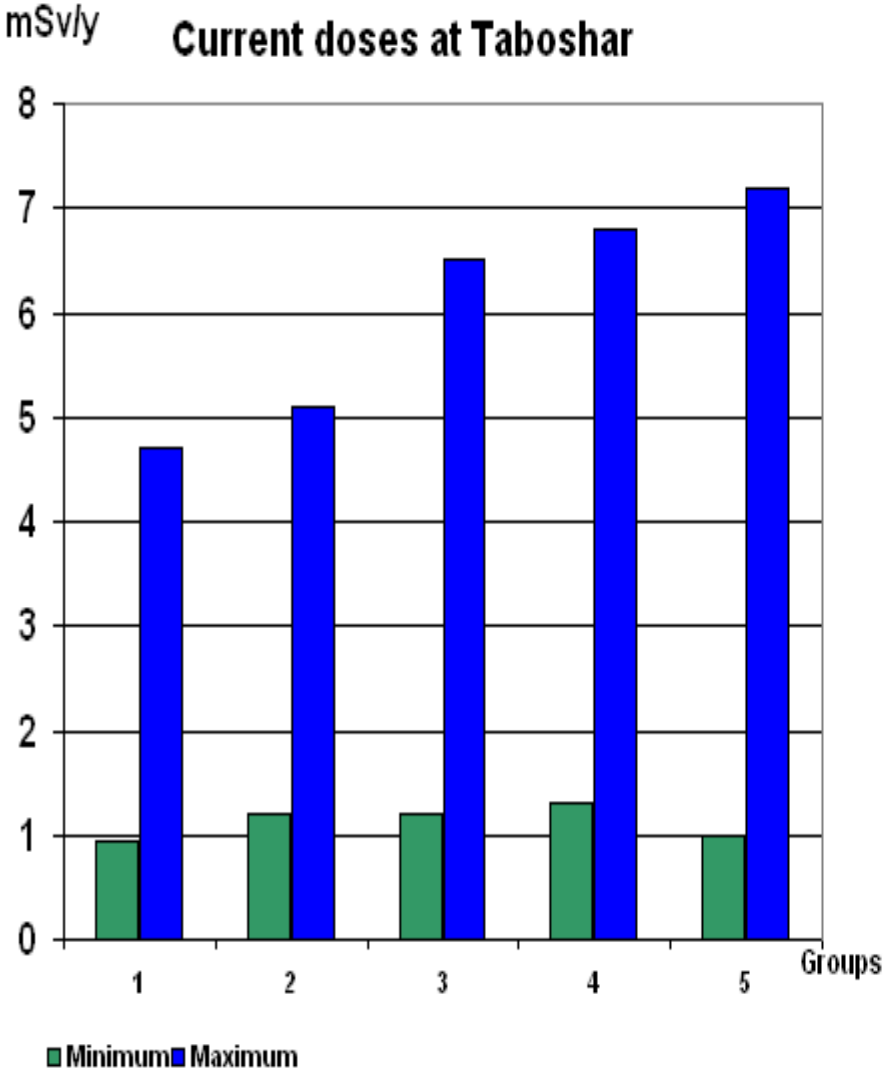
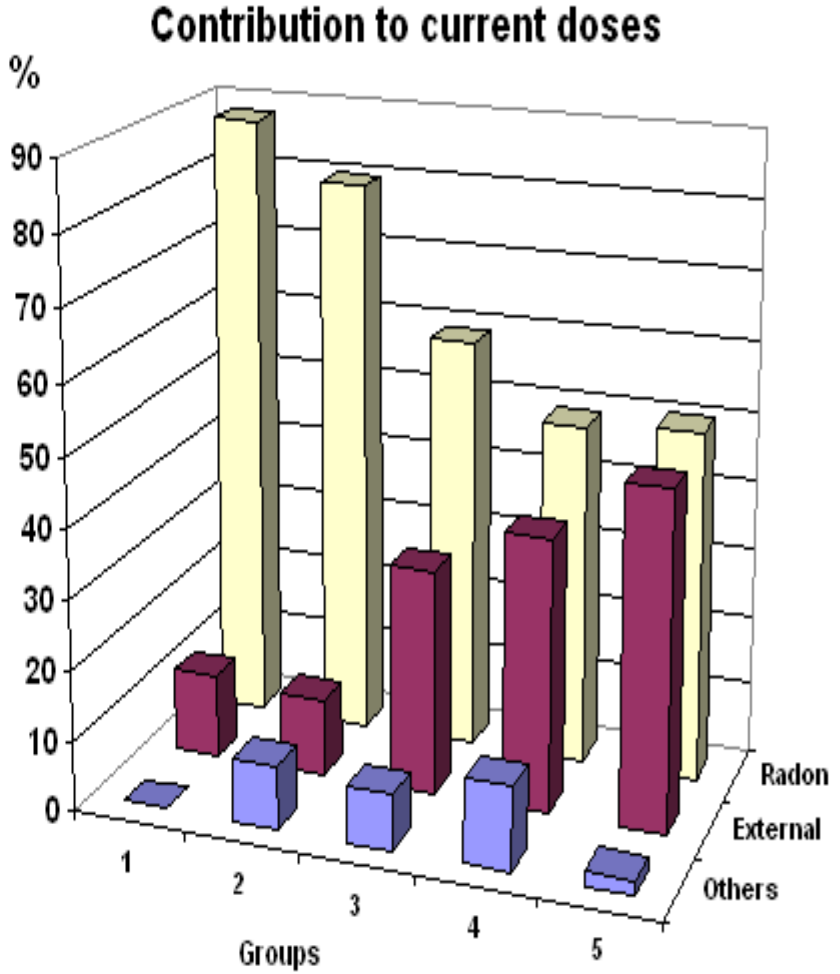

mSv/y
Current doses at Taboshar
8
7
6
5
4
3
2
1
0
1
2
3
4
5
Groups
Minimum
Maximum


Contribution to current doses
%
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Groups
Radon
External
Others

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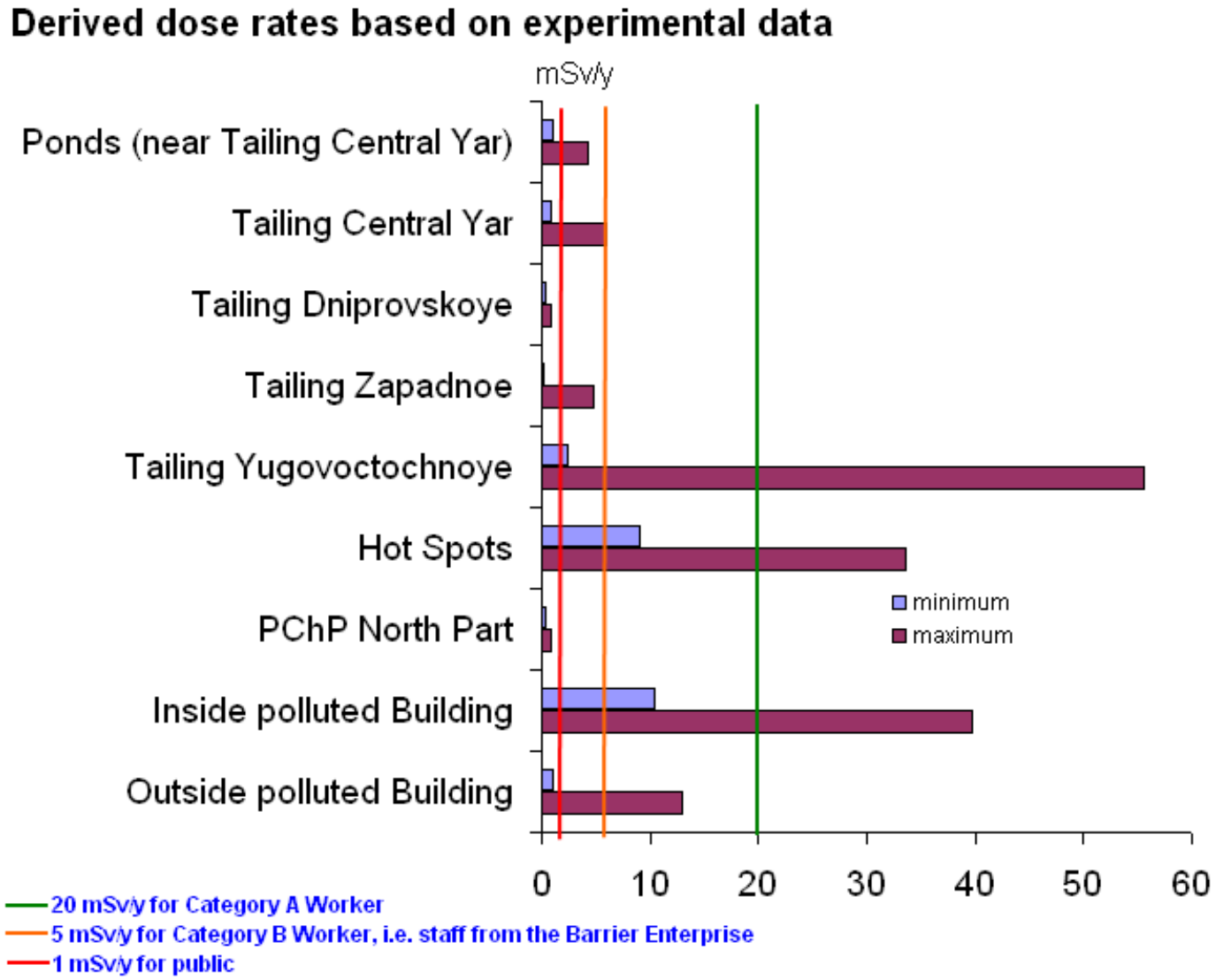
Dniprodzerzhinsk



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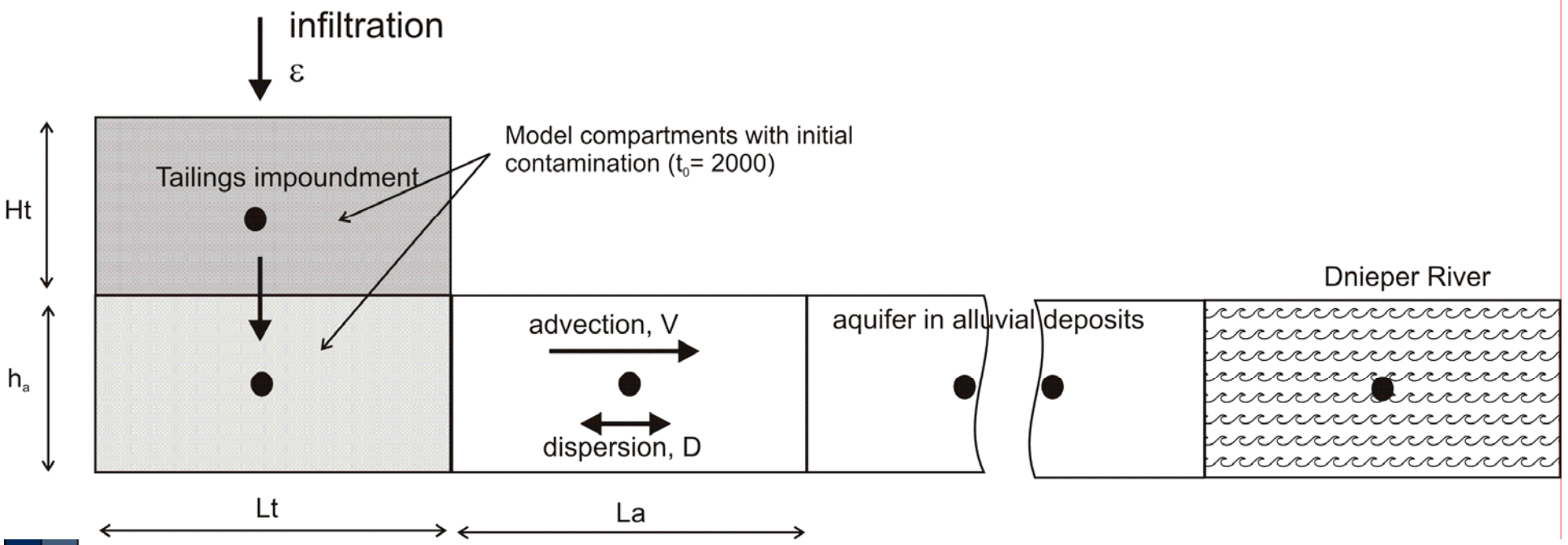
Migration from the tailings

Conceptual model of radionuclide migration from the “D” tailings



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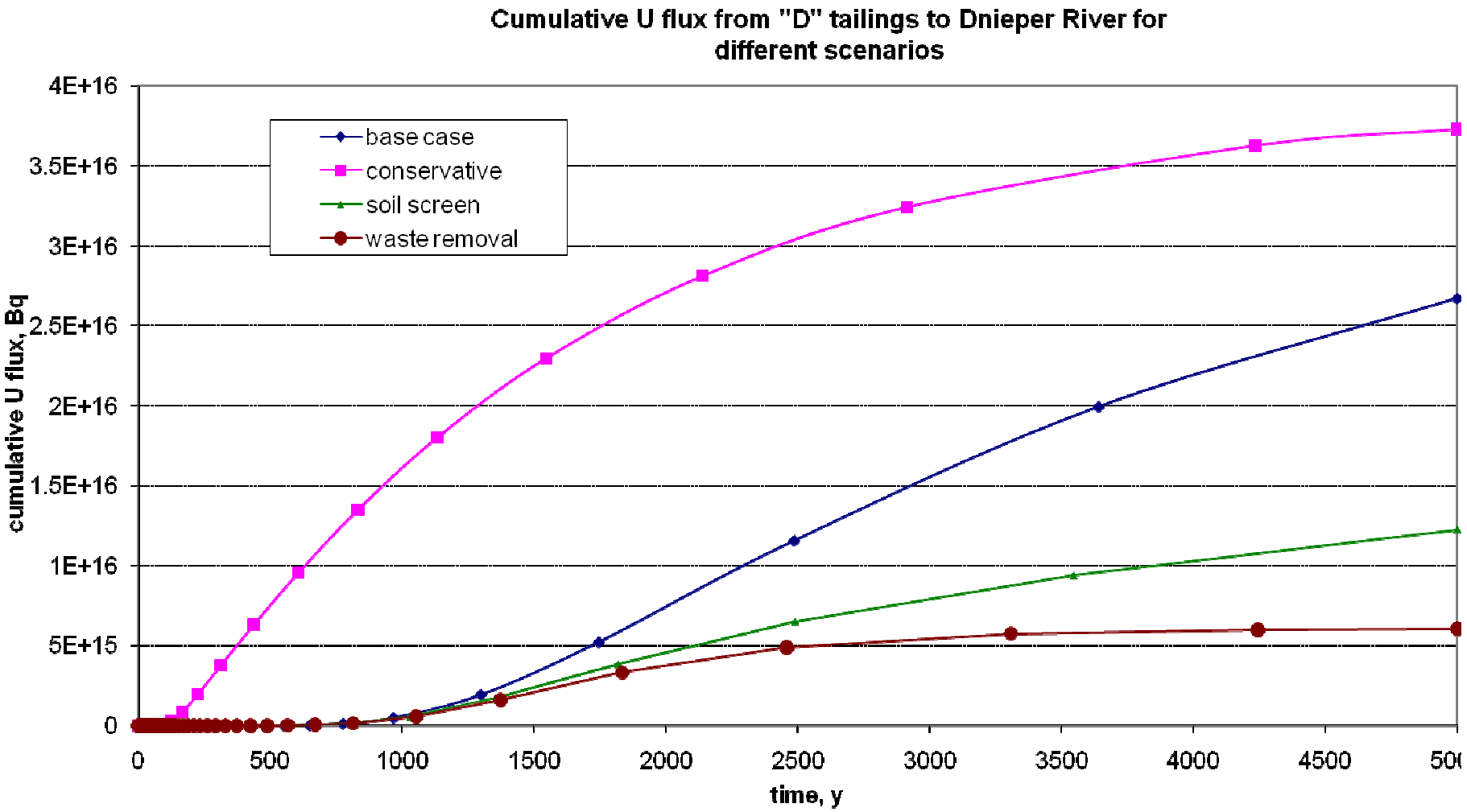
Prognoses for different remediation alternatives



Summary

A consistent approach to deriving doses to exposed groups of people to uranium tailing contaminants has been applied to four locations in Ukraine and Central Asia.

Dose rates can be calculated by identifying hazards and quantifying them based on exposure pathways.

This approach forms the basis for **quantifying the risk of exposure** to given groups of the population.

Test Cases based on these studies could be developed in the frame of the EMRAS WG 2

Mathematical Models for Assessing Remediation of Radioactively Contaminated Sites

IAEA TECDOC – under development

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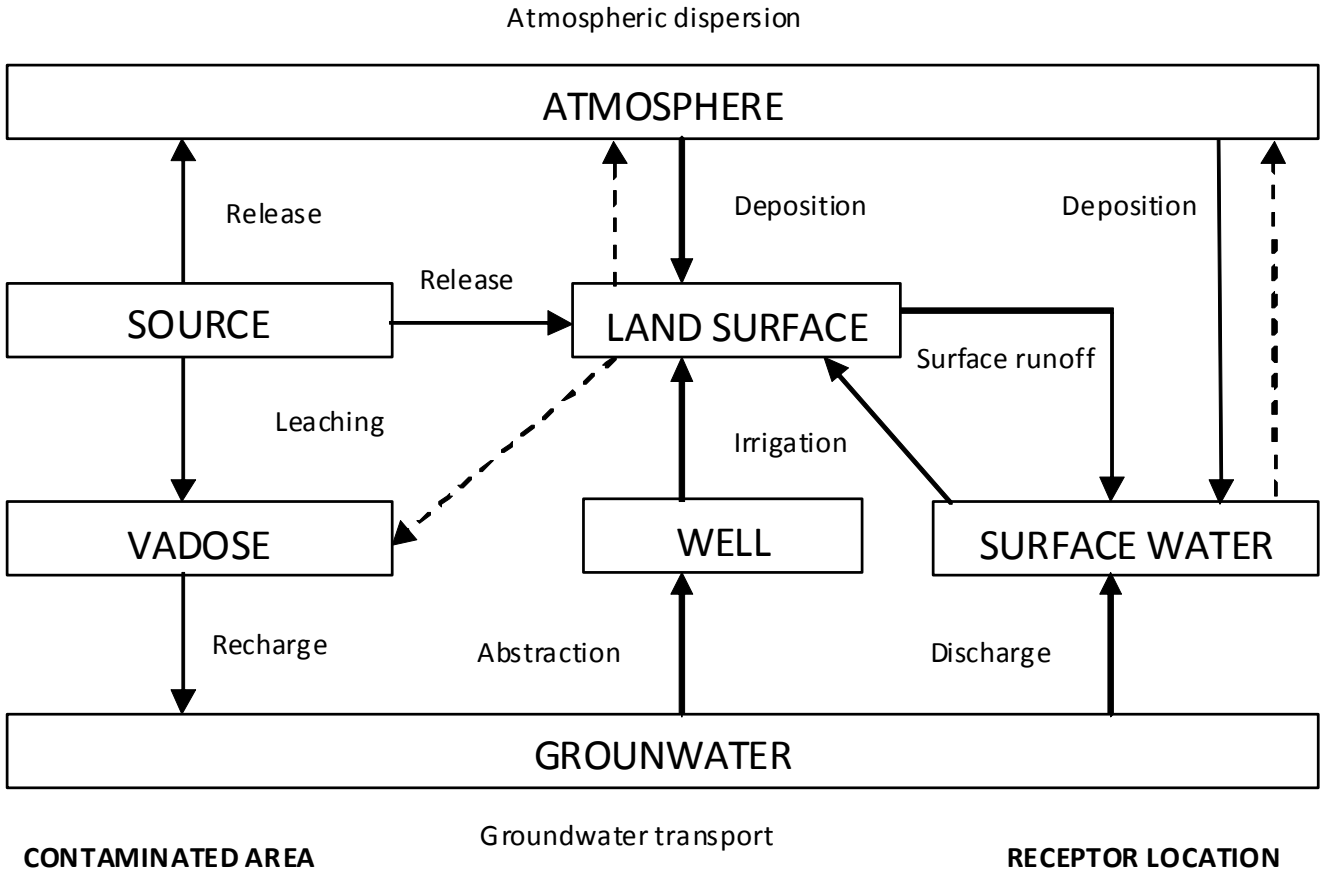
Main transport pathways



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Processes influencing the radionuclide transport

ATMOSPH	Rainfall Dry deposition Gas uptake			Rainfall Dry deposition Gas uptake	Rainfall Dry deposition Gas uptake	
Resuspension Volatilization/ Emanation Evaporation Transpiration	Source	Percolation Advection Diffusion Dispersion Colloid transp.		Erosion Surface runoff Sedimentation		
		Vadose	Recharge Advection Diffusion Dispersion Colloid transp.			
		Capillary rise Advection Diffusion Colloid transp.	GW		Discharge/Seepage	Pumping
Resuspension Volatilization/ Emanation Evaporation Transpiration		Inflitration Advection Diffusion Dispersion Colloid transp.		LAND SURFACE	Surface runoff	
			Recharge	Irrigation Flooding	SURFACE WATER	
				Irrigation		Well

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Processes in the source, the vadoze, the groundwater and the surface land compartments

INPUT						
	AQUEOUS	Adsorption / Surface complexation Ion exchange	Precipitation	Volatilization Heterogeneous reaction Diffusion Decay (Rn, Tn)		
	Desorption Ion exchange	SOLID	Co-precipitation	Decay (Rn, Tn)		
	Dissolution	Co-precipitation	SUSPENDED	Decay (Rn, Tn)		
	Condensation Diffusion Decay (Rn, Tn)	Decay (Rn, Tn)	Decay (Rn, Tn)	GASEOUS		
					MICROBES	
						OUTPUT

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Summary

- The models described in the TECDOC could be used in this WG for selected study cases,
- The models could be implemented in a toolbox that could be made freely available to member states