

Conceptual Model Development: *Approaches, Assumptions and Level of Detail*

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**Workshop on Performance Assessments of Near-Surface Disposal Facilities: FEPs
Analysis, Scenario and Conceptual Model Development, and Code Selection**

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Outline

- Part 1 - ISAM methodology
 - Definition of Conceptual Model
 - Role in a Safety Assessment
 - Approaches to development
 - Level of detail
- Part 2 - Experiences from application
 - Examples of conceptual models
 - From Conceptual Models to Mathematical Models
 - Analysis of conceptual uncertainties

CONCEPTUAL MODELS

ISAM METHODOLOGY

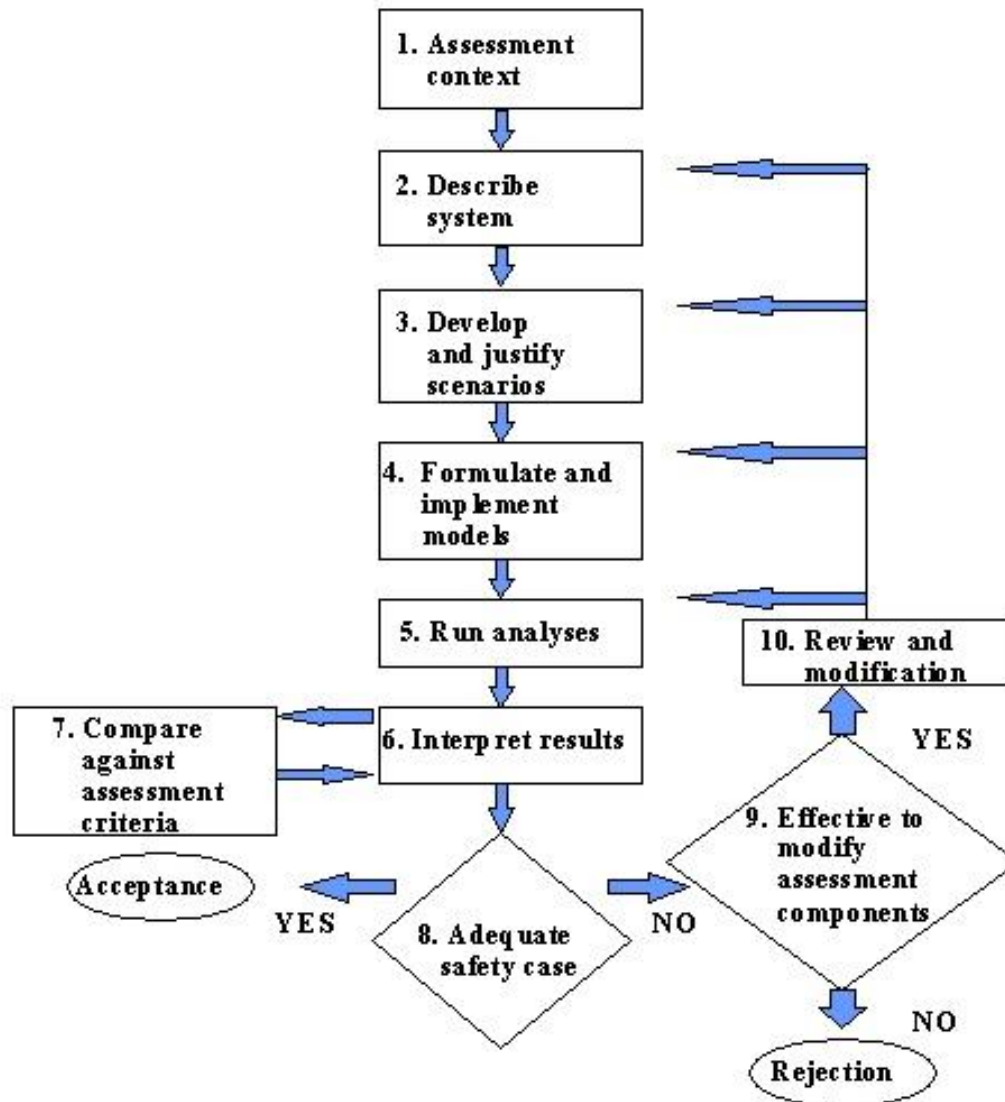
Conceptual Model Definition

The conceptual model is a set of model-level assumptions (about dimensionality, boundary conditions, FEPs, FEPs relationships, etc) defined for each scenario included in the Safety Assessment.

Components of a conceptual model

A conceptual model should comprise a description of:

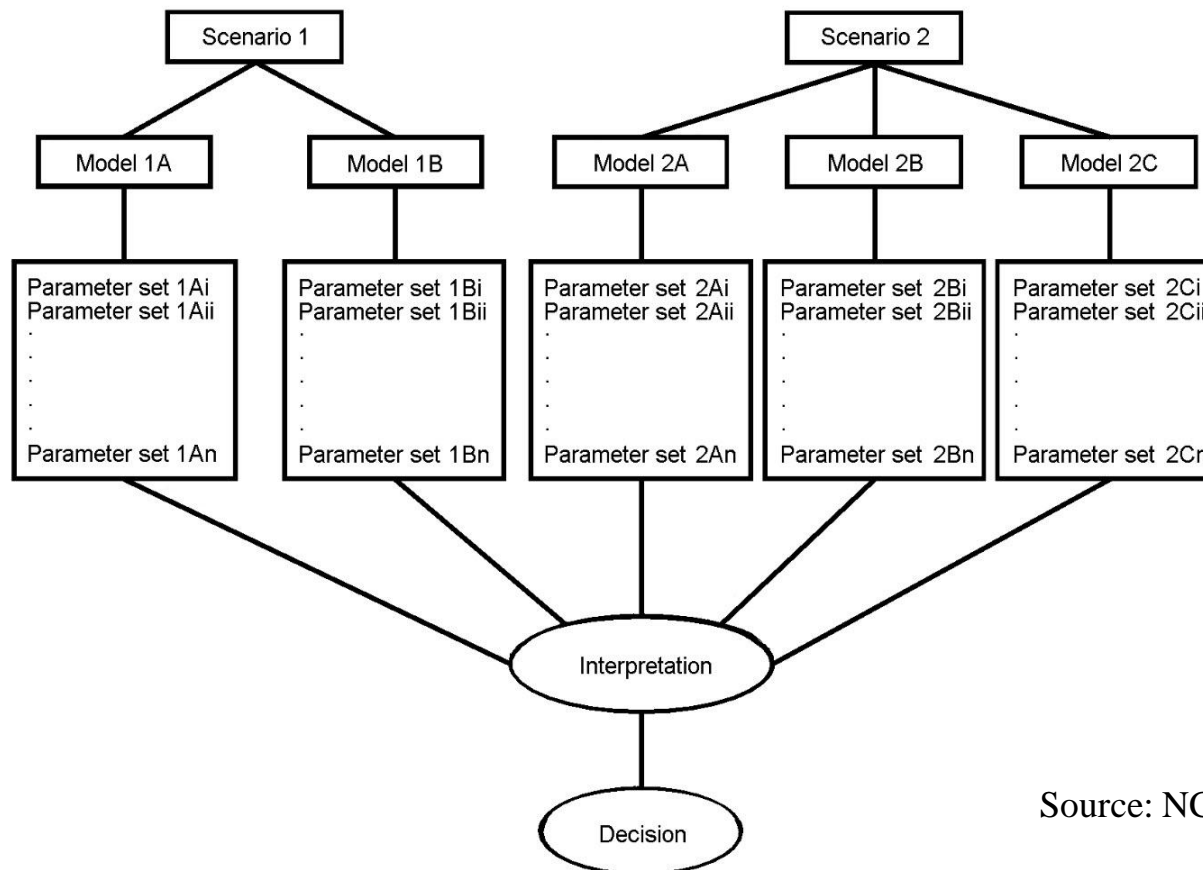
- The model FEPs
- The relationships between these FEPs
- The model's scope of application in spatial and temporal terms (the model domain) – this includes the initial and boundary conditions



In the ISAM methodology the development of the Conceptual Models is an initial step of the formulation of mathematical models

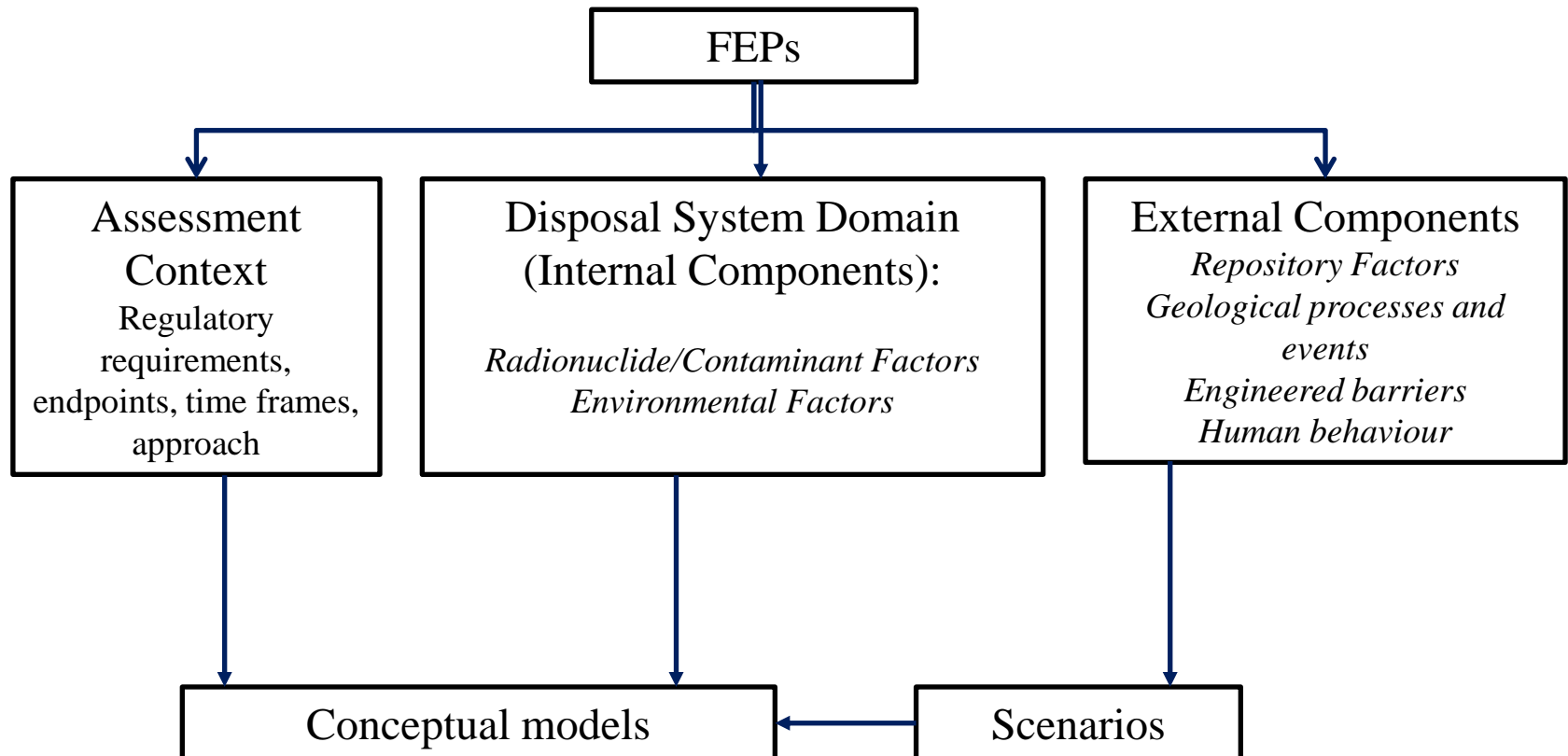
Source: IAEA, 2004

From scenarios to models



Source: NCRP Report 152

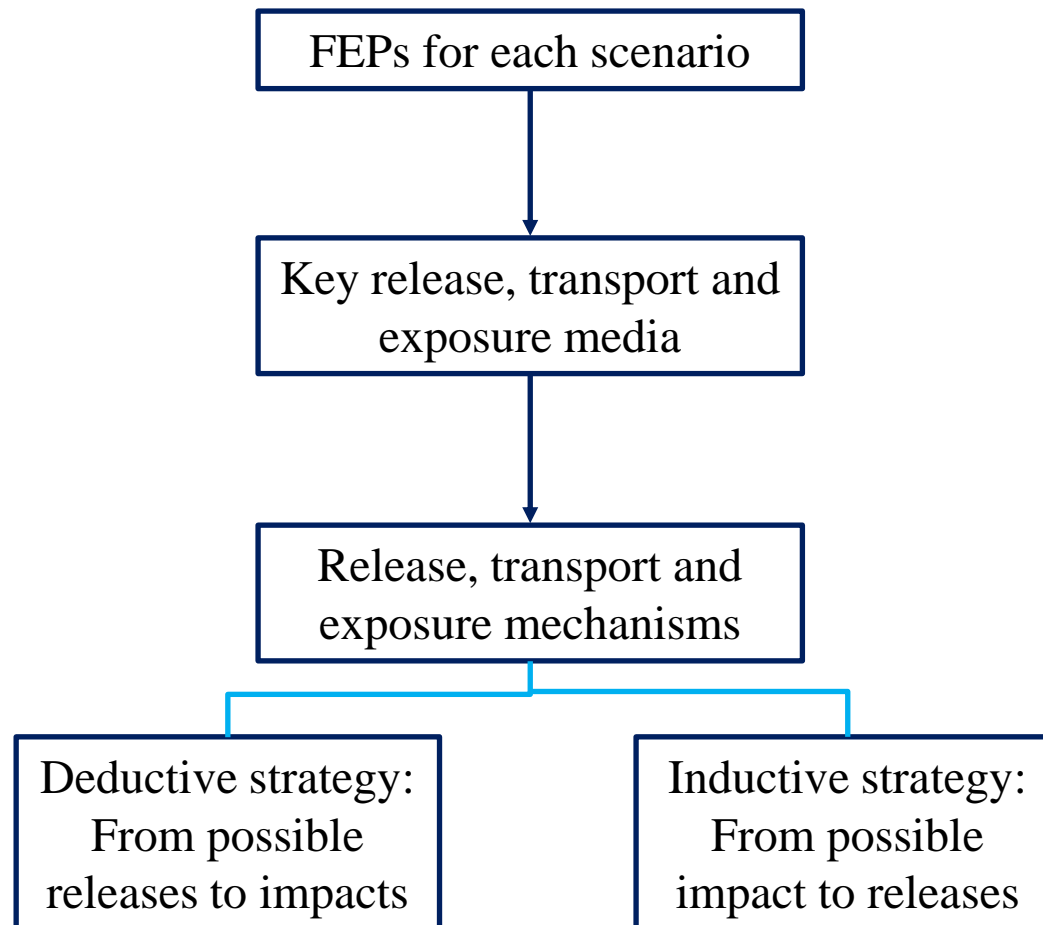
FEPs - Scenarios - Conceptual Models



Approaches to conceptual model development

- SACO approach
- Influence diagram approach
- Interaction matrix approach

The SACO approach



The interaction matrix approach

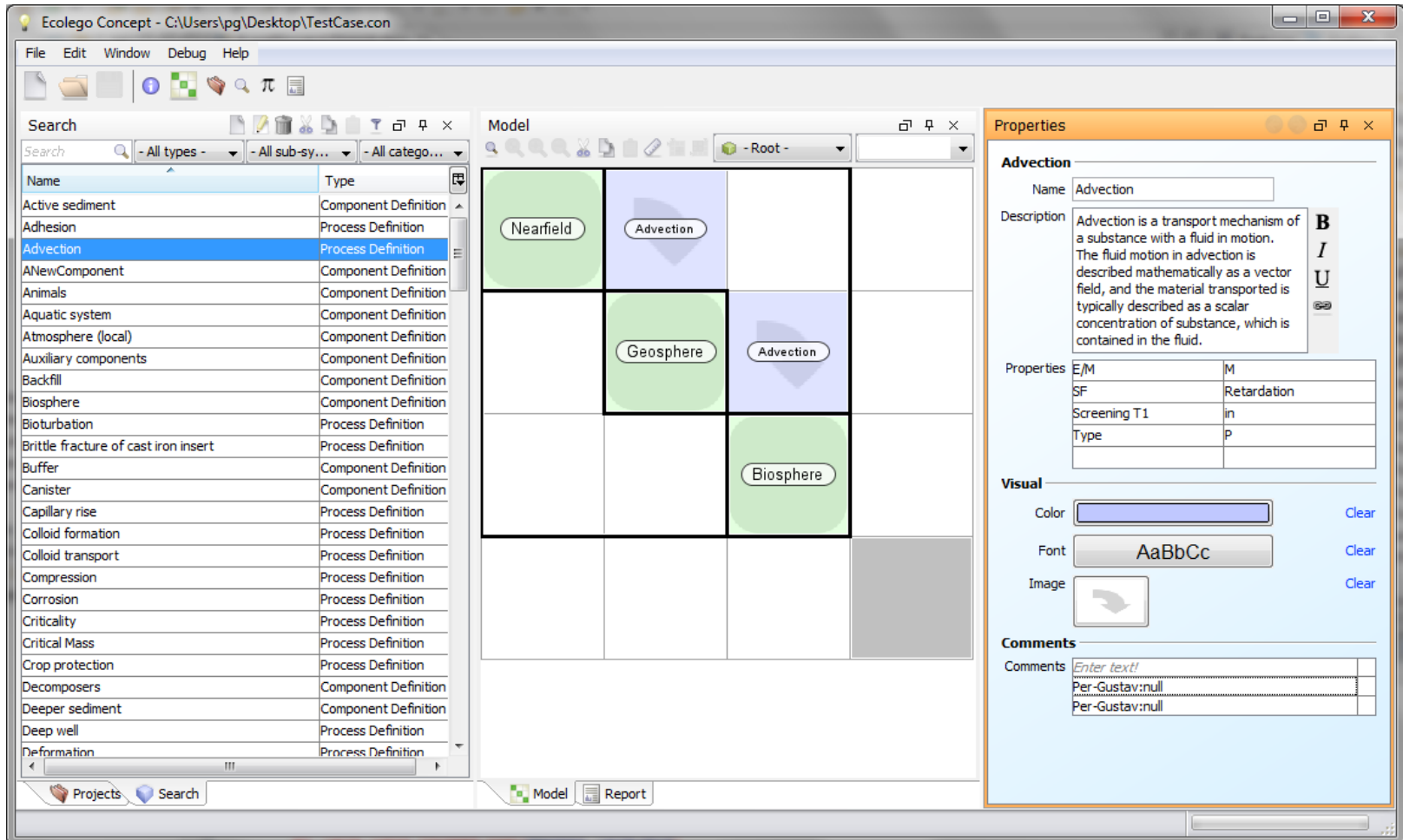
Component A 1,1	Influence of A on B 1,2
Influence of B on A 2,1	Component B 2,2

A connected chain of interactions through the matrix is called a PATHWAY

Ecolego Concept

- Tool for development and hierarchical visualization of conceptual models using interaction matrices
- Link to a FEP database
- Possibility for screening and ranking of FEPs by several criteria
- Recording of reviewers comments
- Version handling
- Automatic report generator.

Graphical User Interface

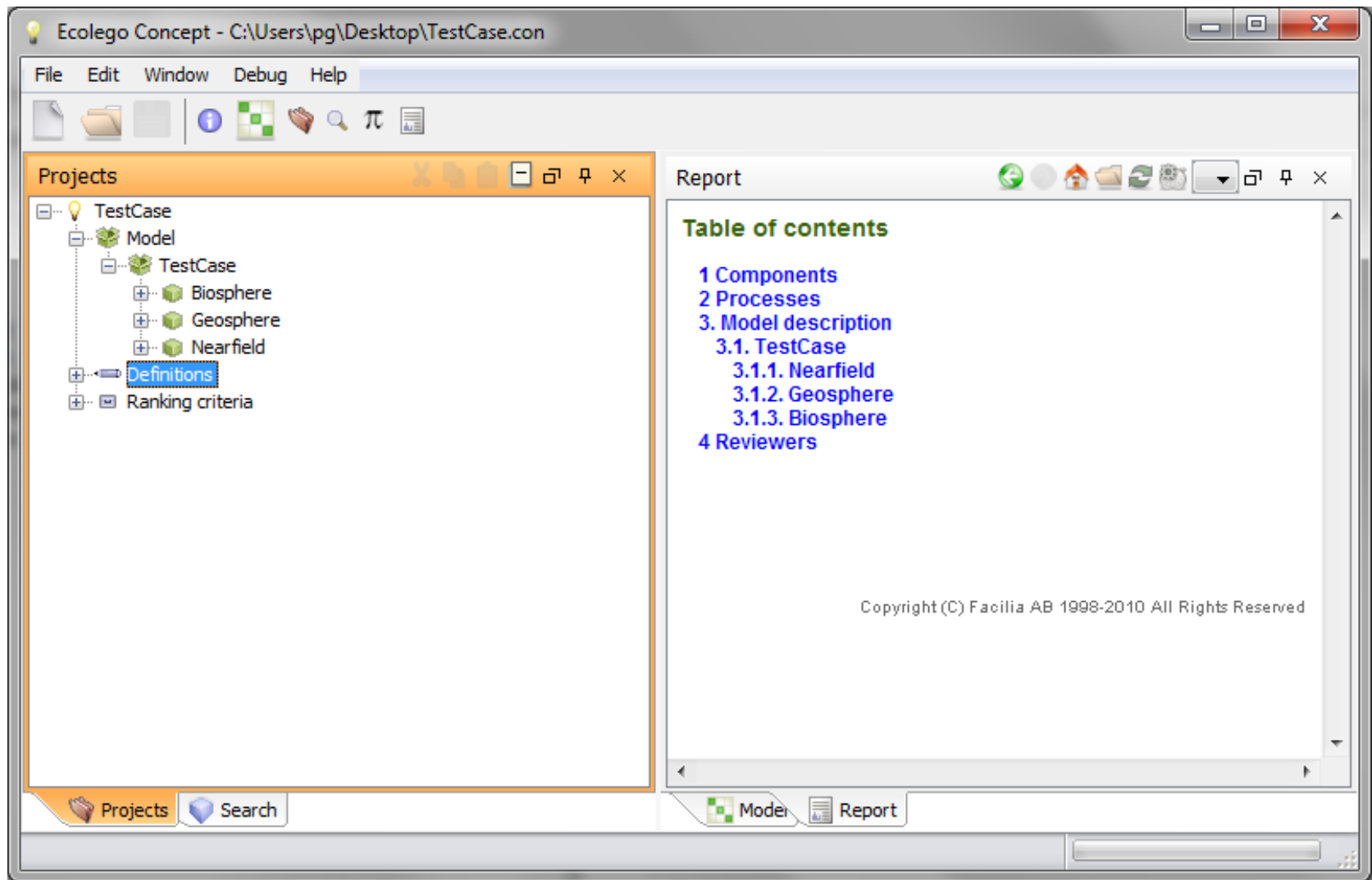


The screenshot displays the Ecolego Concept software interface. The window title is "Ecolego Concept - C:\Users\pg\Desktop\TestCase.con". The interface is divided into several panels:

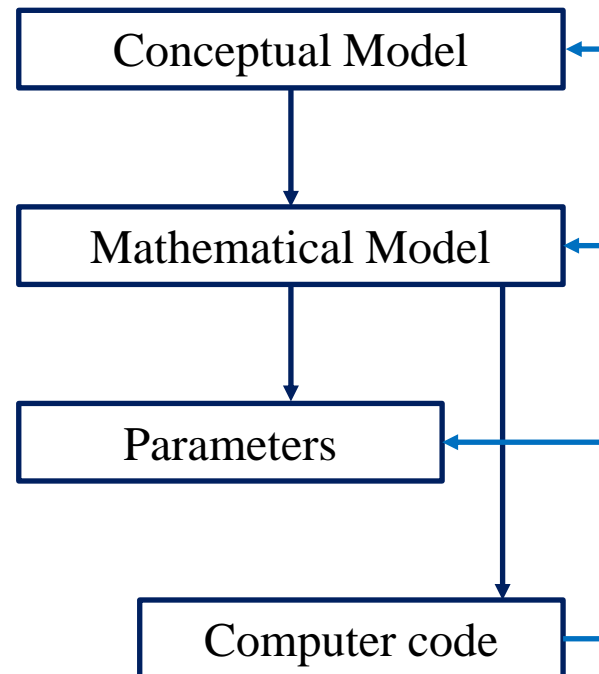
- Search Panel (Left):** A list of components and processes. The "Advection" component is selected. The list includes: Active sediment (Component Definition), Adhesion (Process Definition), **Advection (Process Definition)**, ANewComponent (Component Definition), Animals (Component Definition), Aquatic system (Component Definition), Atmosphere (local) (Component Definition), Auxiliary components (Component Definition), Backfill (Component Definition), Biosphere (Component Definition), Bioturbation (Process Definition), Brittle fracture of cast iron insert (Process Definition), Buffer (Component Definition), Canister (Component Definition), Capillary rise (Process Definition), Colloid formation (Process Definition), Colloid transport (Process Definition), Compression (Process Definition), Corrosion (Process Definition), Criticality (Process Definition), Critical Mass (Process Definition), Crop protection (Process Definition), Decomposers (Component Definition), Deeper sediment (Component Definition), Deep well (Process Definition), and Deformation (Process Definition).
- Model Panel (Center):** A hierarchical diagram showing the structure of the model. The root node is "Root". Under "Root", there are three main branches: "Nearfield", "Geosphere", and "Biosphere". Each branch contains sub-nodes, with "Advection" being a prominent process in the "Nearfield" and "Geosphere" branches.
- Properties Panel (Right):** A panel for editing the properties of the selected "Advection" component. It includes:
 - Name:** Advection
 - Description:** Advection is a transport mechanism of a substance with a fluid in motion. The fluid motion in advection is described mathematically as a vector field, and the material transported is typically described as a scalar concentration of substance, which is contained in the fluid.
 - Properties:** A table with two columns:

E/M	M
SF	Retardation
Screening T1	in
Type	P
 - Visual:** Options for color, font, and image. The color is set to a light blue, the font is "AaBbCc", and the image is a circular arrow.
 - Comments:** A section for adding comments, with a text area and a "Comments" button.

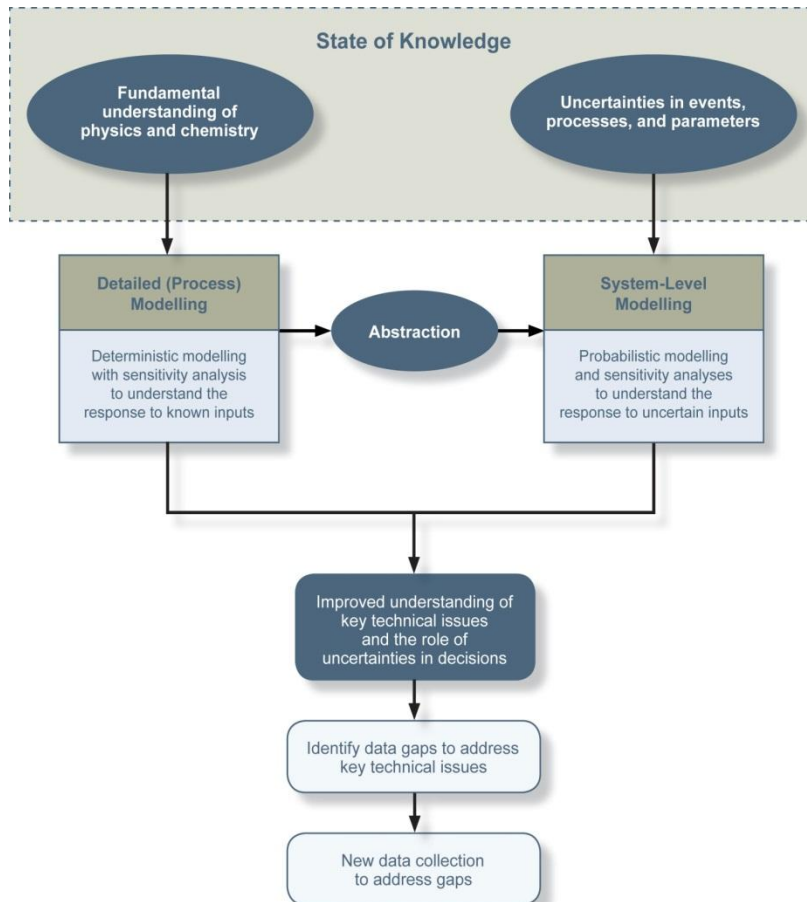
Report generator - html and PDF reports



Development of models for quantitative assessments



Types of models and level of detail

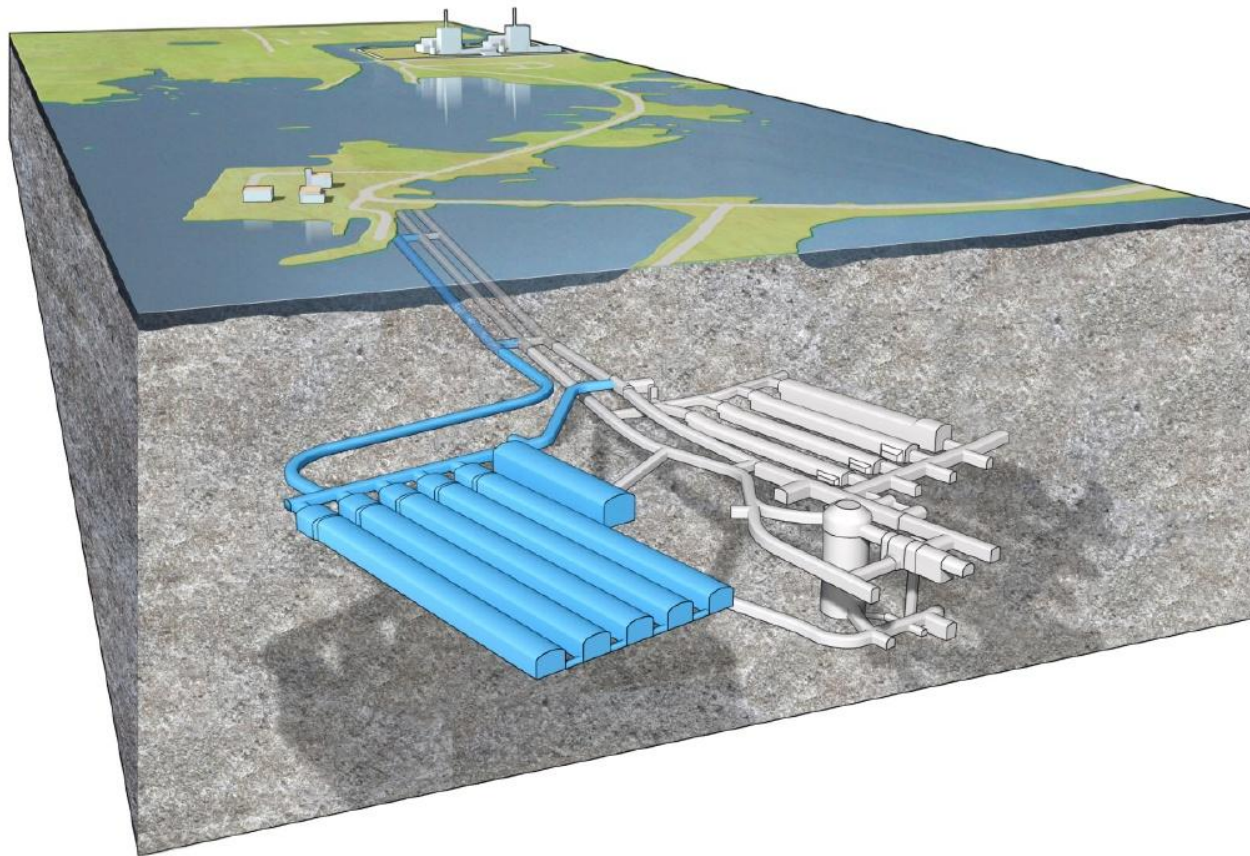


Structure of a safety assessment model showing the relationship between process and system-level modeling

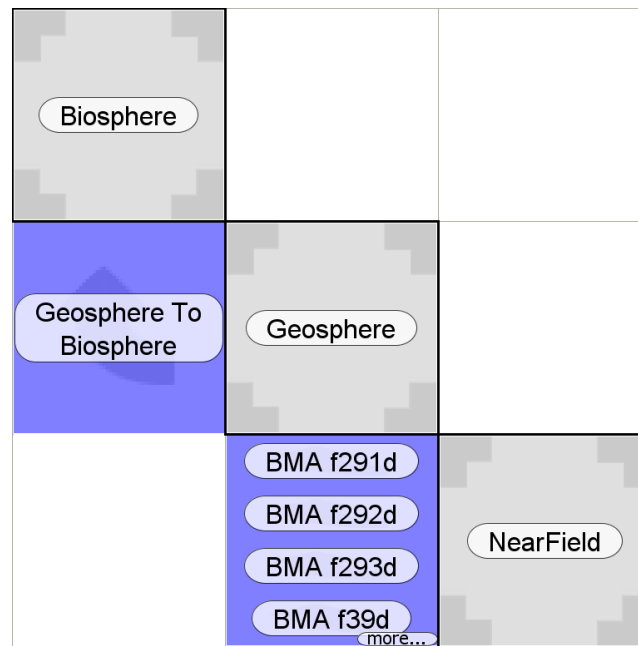
Courtesy from Matt Kozak

EXAMPLES OF CONCEPTUAL MODELS

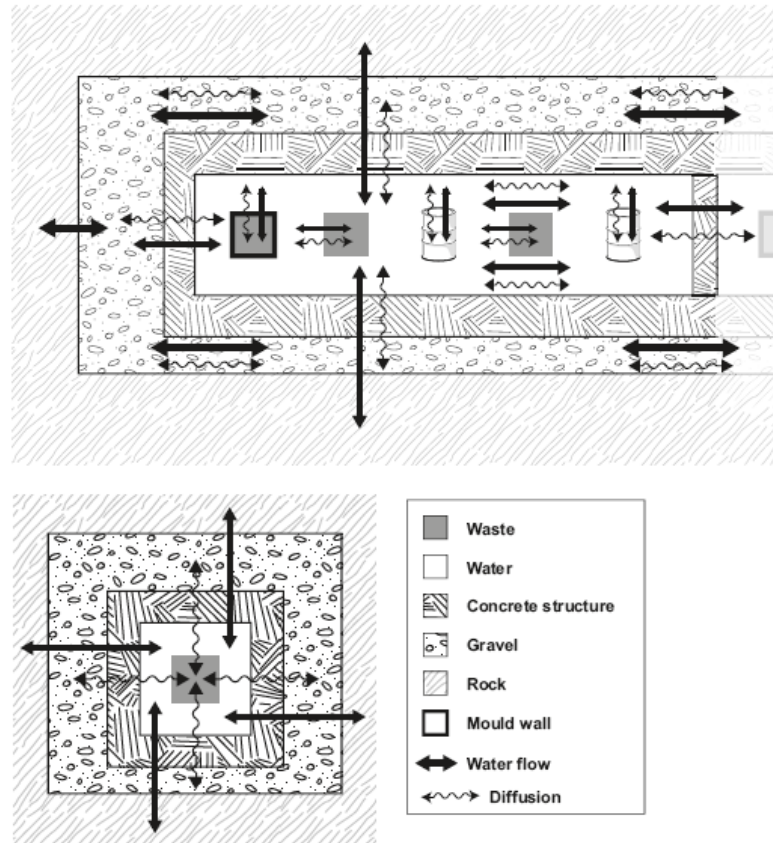
SFR-2020



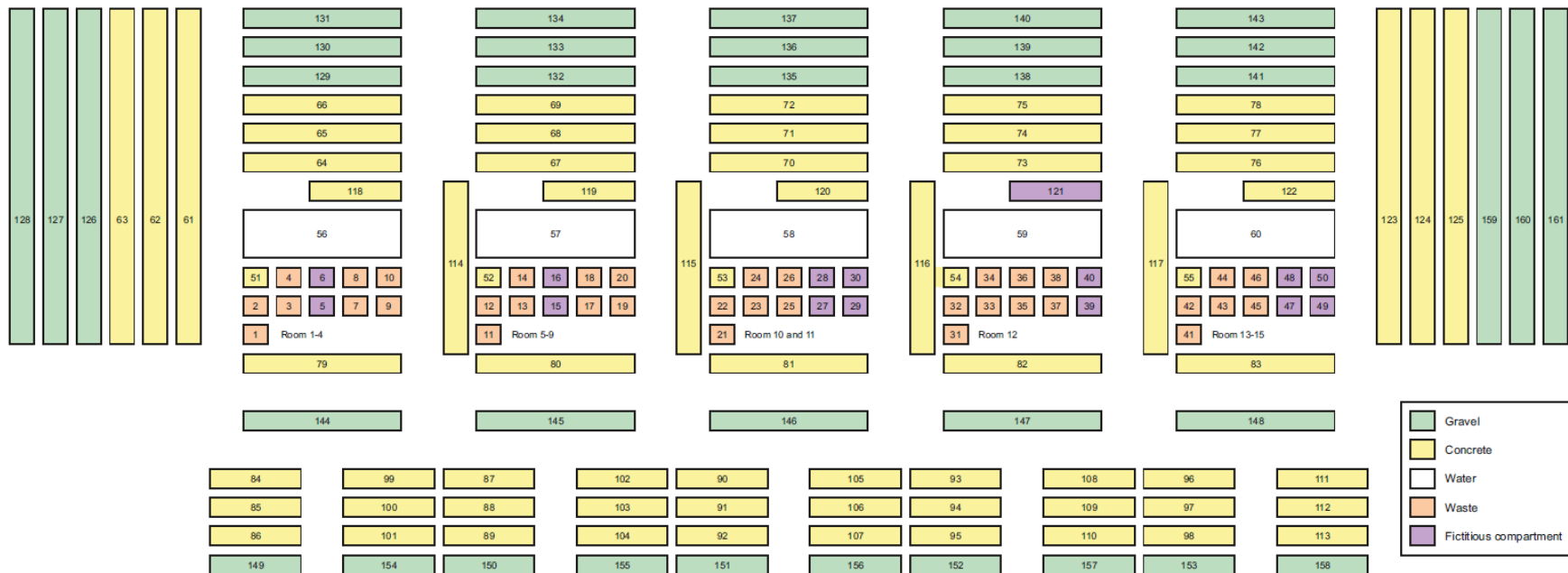
Model of the whole disposal system



Near field conceptual model (BMA)



Near field model discretisation (BMA)



1-2, 11-12, 21-22, 31-32, 41-42
 3-4, 13-14, 23-24, 33-34, 43-44
 25-26, 35-36, 45-46
 7-8, 17-18, 37-38
 9-10, 19-20
 5-6, 15-16, 27-30, 39-40, 47-50
 51-55
 56-60

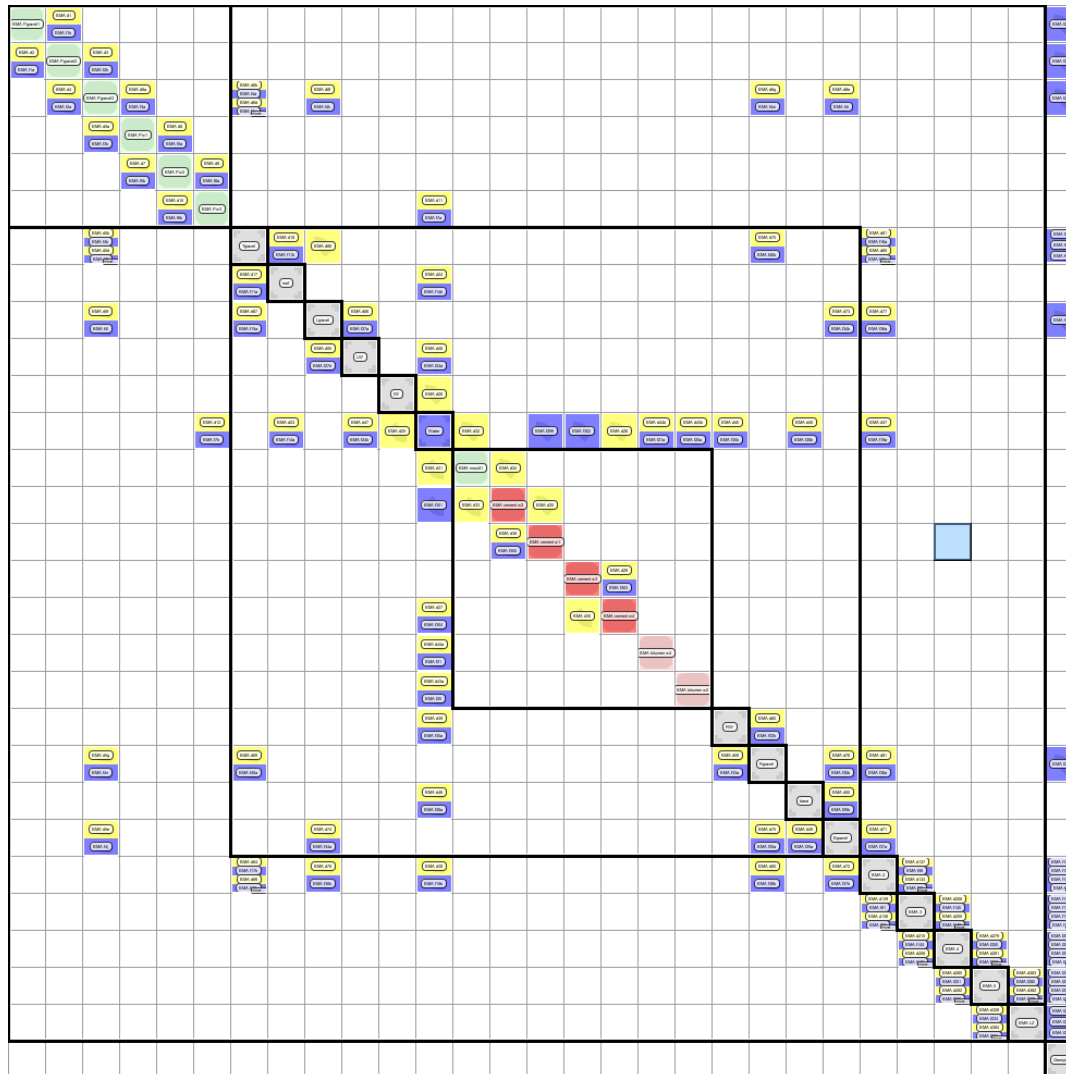
Waste stabilised with cement in concrete moduls
 Waste stabilised with cement in steel containers
 Waste stabilised with cement in steel drums
 Waste stabilised with bitumen in steel containers
 Waste stabilised with bitumen in steel drums
 Fictitious source terms
 Walls of concrete moduls
 Water inside encapsulation

61-63 Wall at short side of the structure (passage)
 64-78 Ceiling of the structure
 79-83 Bottom of the structure
 84-98 Wall on left side of the structure
 99-113 Wall on right side of the structure
 114 Inner wall between room 4 and 5
 115 Inner wall between room 9 and 10

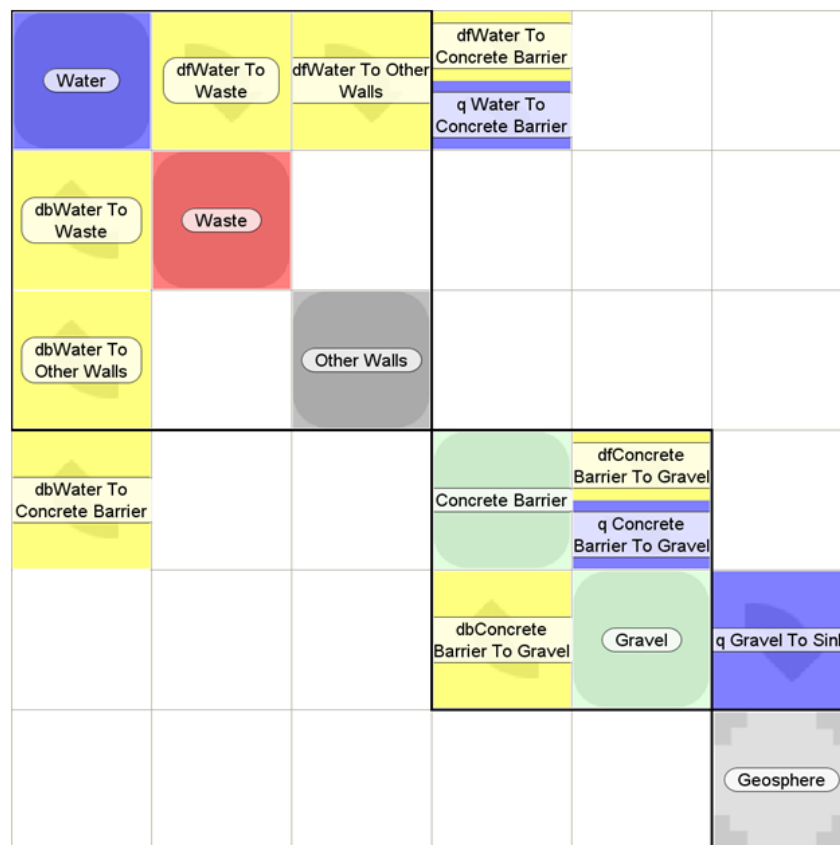
116 Inner wall between room 11 and 12
 117 Inner wall between room 12 and 13
 118 Inner wall between room 1 and 2, 2 and 3, 3 and 4 (sink)
 119 Inner wall between room 5 and 6, 6 and 7, 7 and 8, 8 and 9 (sink)
 120 Inner wall between room 10 and 11 (sink)
 121 Fictitious compartment (no inner wall, only one room)
 122 Inner wall between room 13 and 14/15 and between room 14 and 15 (sink)

123-125 Wall at short side of the structure (loading zone)
 126-128 Gravel at the end of the tunnel (passage)
 129-143 Gravel at the top of the tunnel
 144-148 Gravel at the bottom of the tunnel
 149-153 Lateral gravel on the left side of the tunnel
 154-158 Lateral gravel on the right side of the tunnel
 159-161 Gravel at the end of the tunnel (loading zone)

Near field model in Ecolego (BMA)



Simplified near field model (BMA)



Comparison simple between simplified and detailed near field models (BMA)

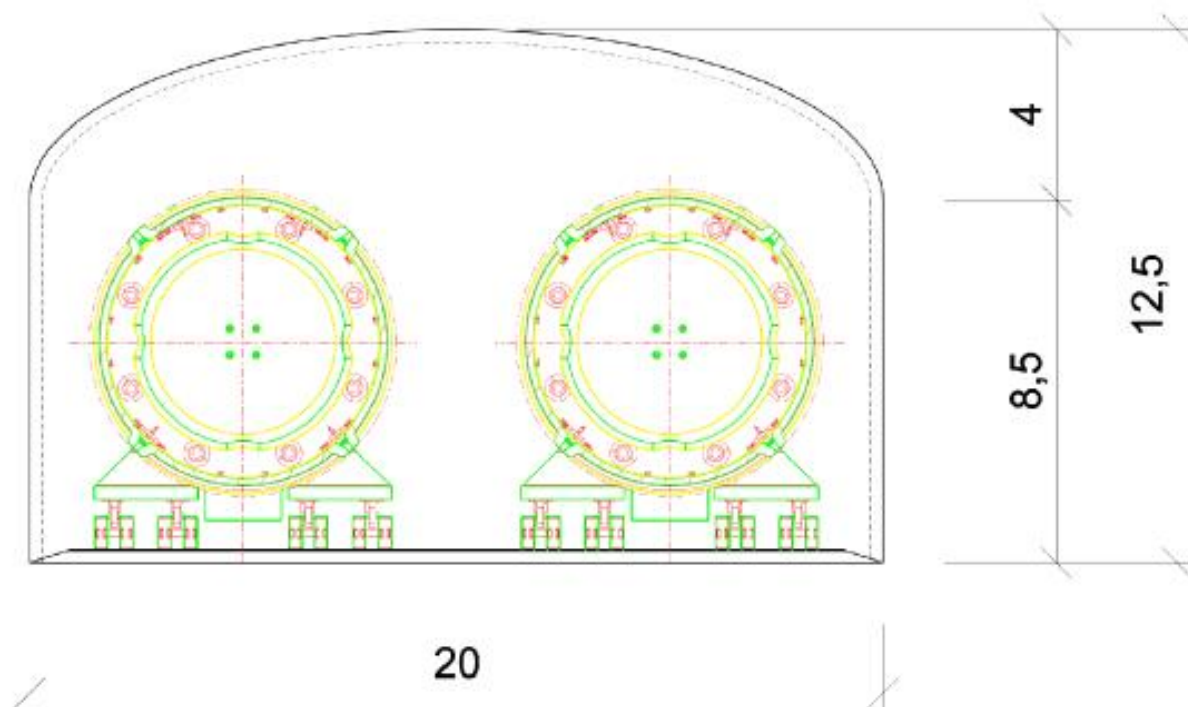
Nuclide	Max value [Bq/y]	Time for max [y]	Original max value [Bq/y]	Original time for max [y]	Ratio [-] simple/original
C-14-in	8.70E+05	5.61E+04	1.26E+06	5.61E+04	0.69
C-14-org	6.88E+07	1.00E+03	2.79E+08	1.05E+03	0.25
Cs-135	1.99E+05	5.60E+04	1.13E+05	5.60E+04	1.76
Ni-59	1.02E+08	9.10E+04	2.00E+08	9.10E+04	0.51
Pu-239	1.28E+02	9.10E+04	3.26E+02	9.10E+04	0.39
Se-79	1.47E+05	5.61E+04	1.68E+05	5.61E+04	0.88

Reactor tank disposal



Source: SKB R-04-44webb.pdf

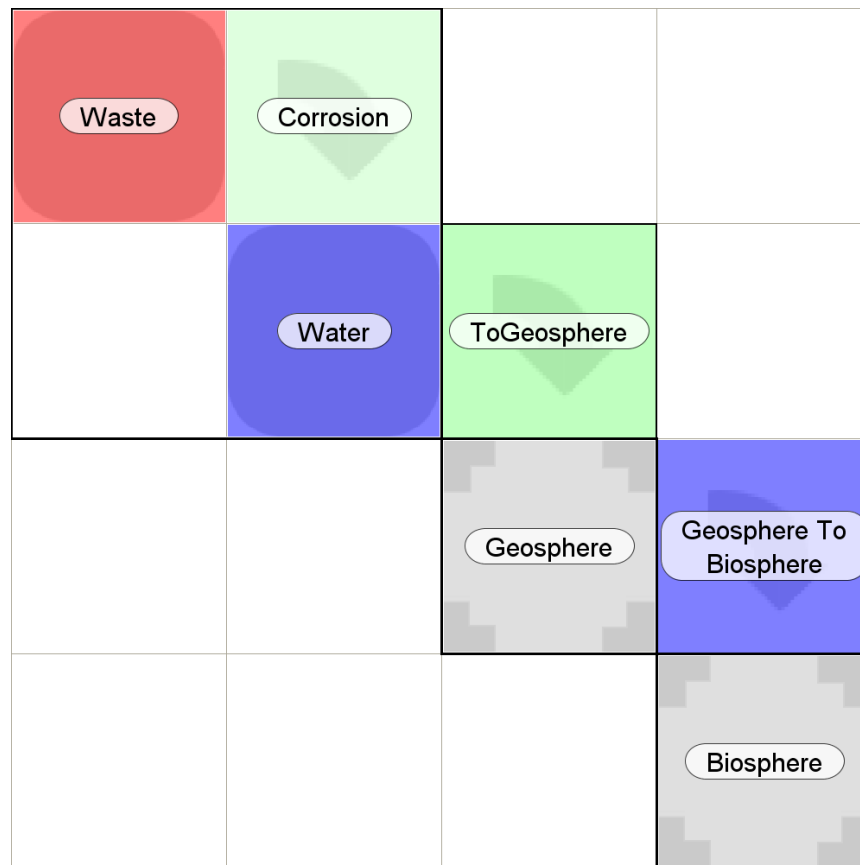
BRT for reactor tanks



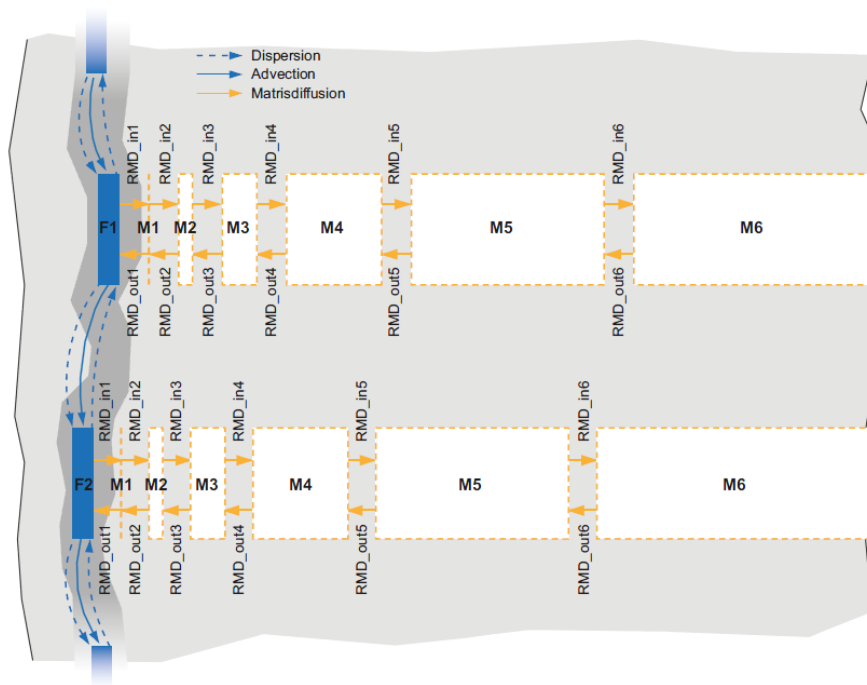
Reactor tanks inventory

Nuclide	On surface [Bq]	Inside Steel [Bq]
Co-60	-	2.20E+13
Ni-63	-	4.00E+13
Ni-59	-	3.80E+11
C-14	-	4.90E+10
Cl-36	-	3.00E+07
Mo-93	-	1.40E+10
Nb-94	-	7.60E+09
Tc-99	-	2.20E+09
Pu-240	3.70E+07	-
Cm-244	1.50E+08	-
Pu-241	4.30E+09	-
Pu-239	2.30E+07	-

Reactor tank repository model without barriers

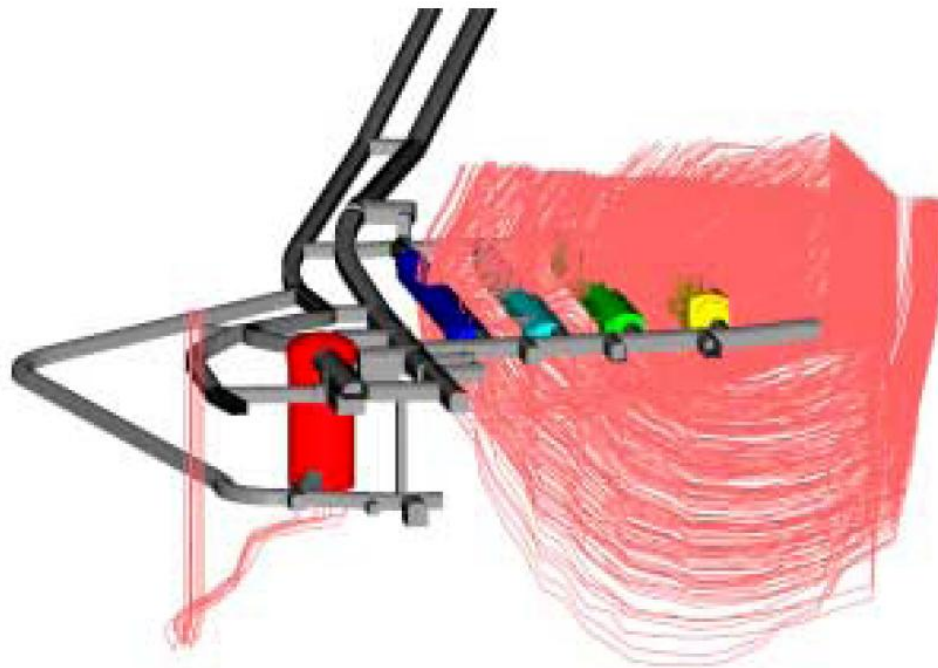


Geosphere conceptual model



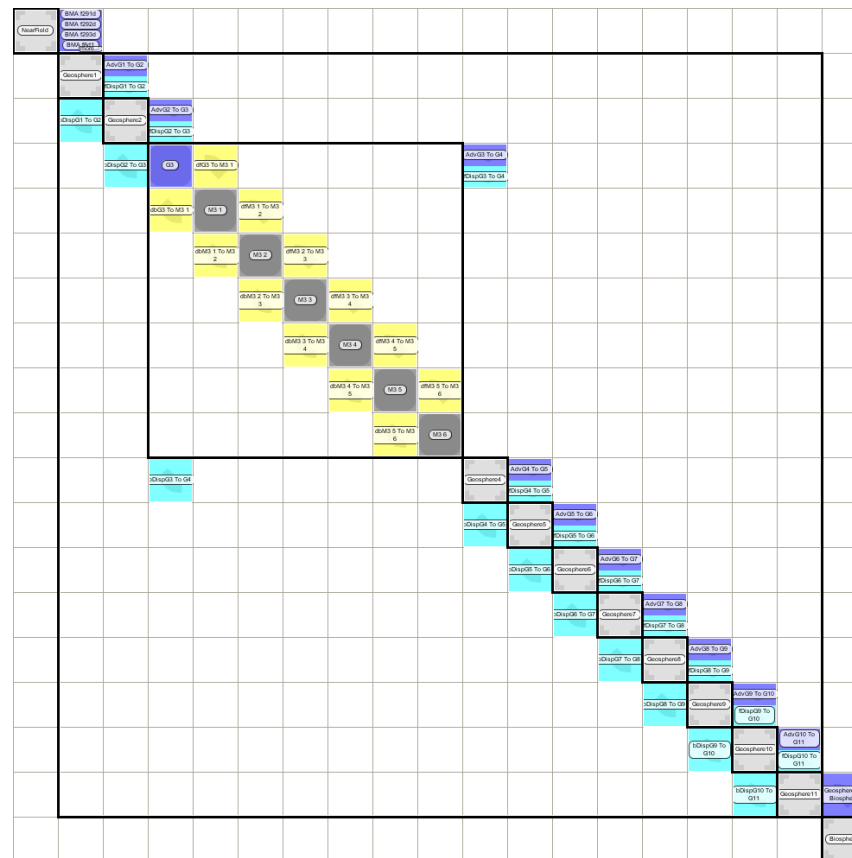
- Processes
 - Advection
 - Dispersion
 - Matrix diffusion
- Parameters
 - Water travel time
 - Path length
 - Flow wetted area
 - Peclet number
 - Rock matrix properties
 - K_d , D_e , porosity

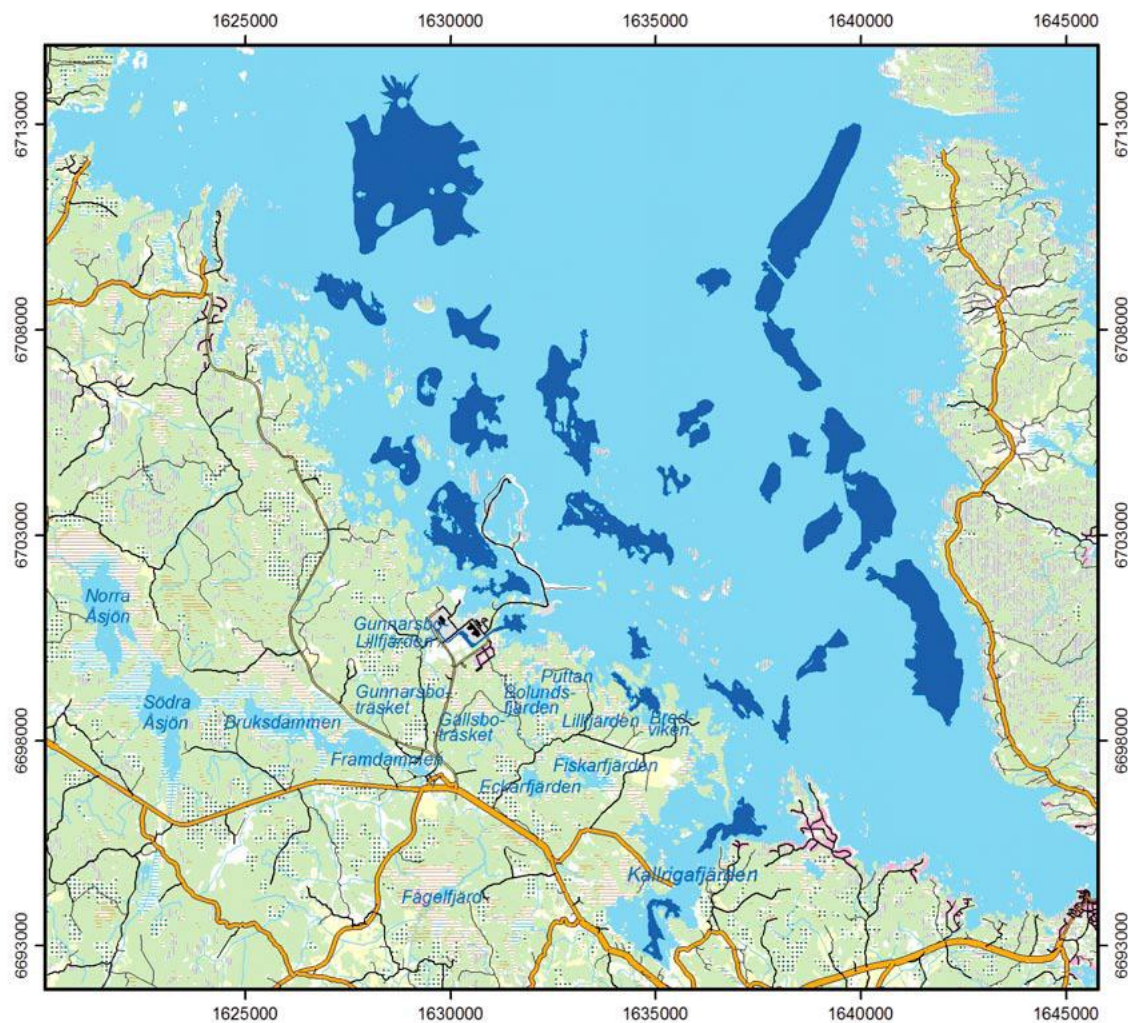
Geosphere process level model



Detailed particle tracking model is used to derive parameters used in a simpler compartment model – system level model.

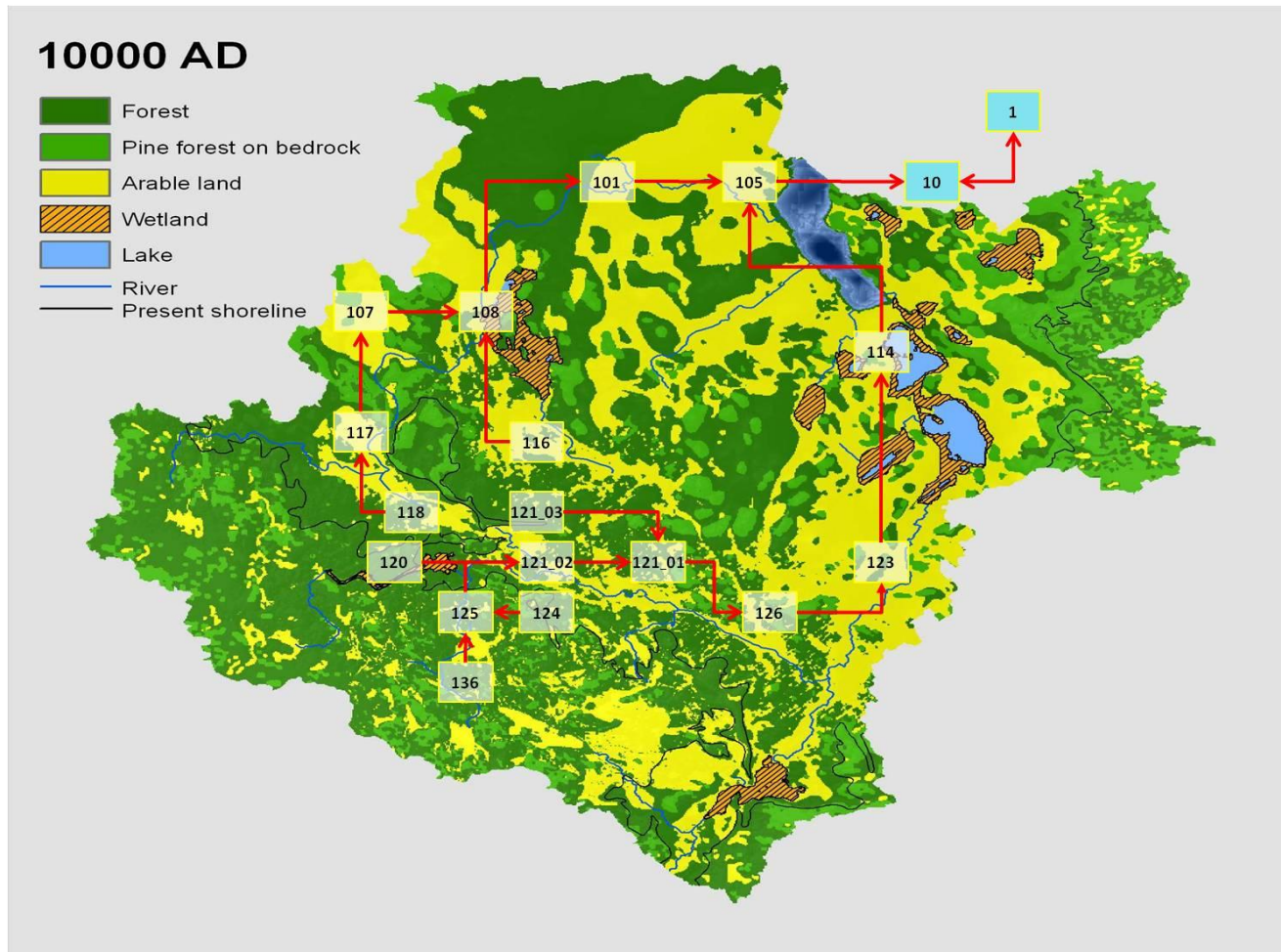
It is also used for comparisons with the system level model



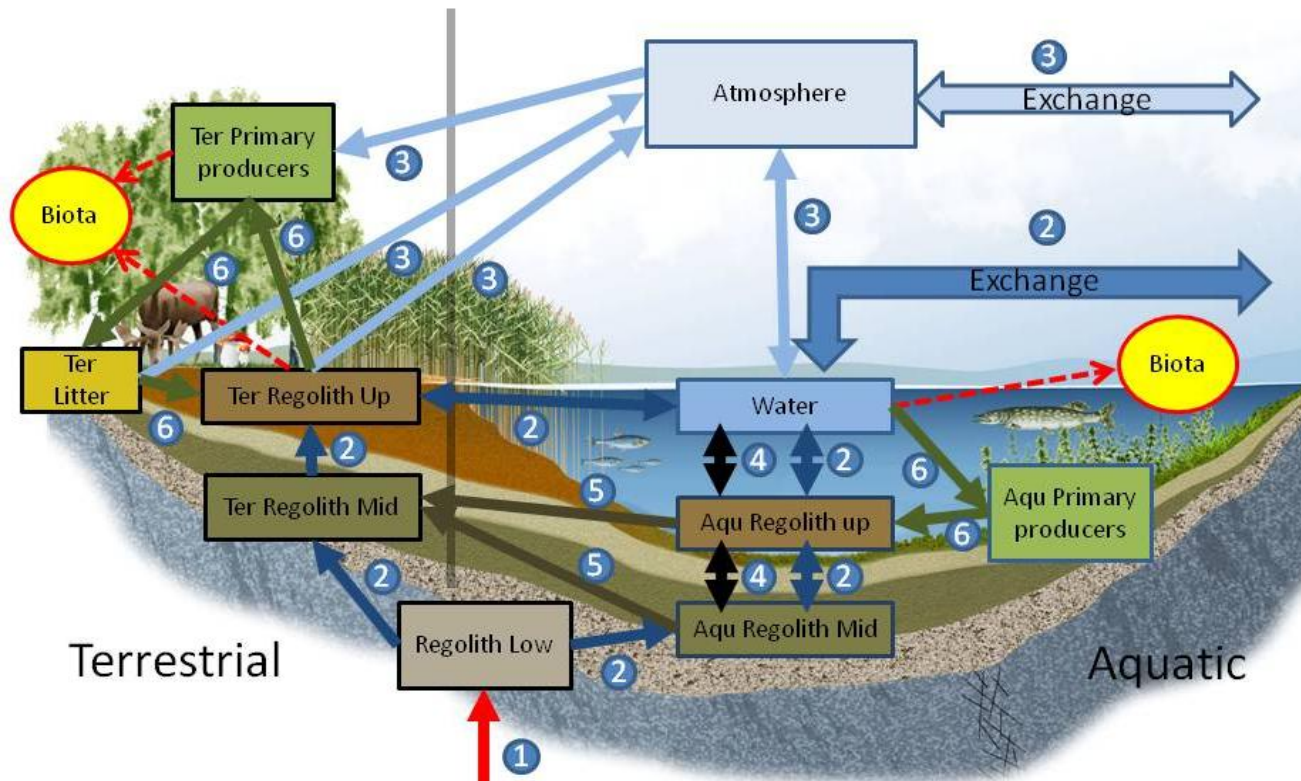


Present and future lakes in
the potentially affected
area

The landscape at year 10000 AD

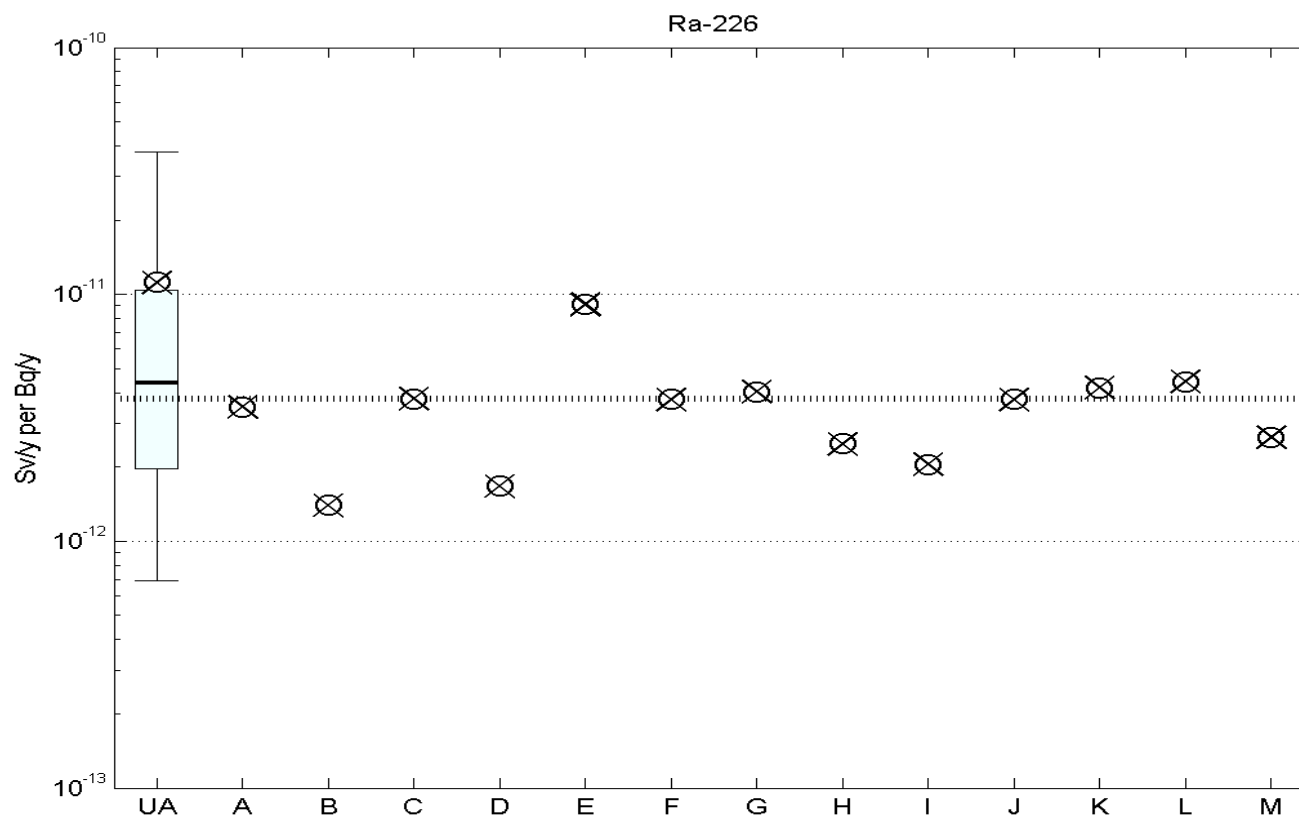


Biosphere conceptual model for SFR



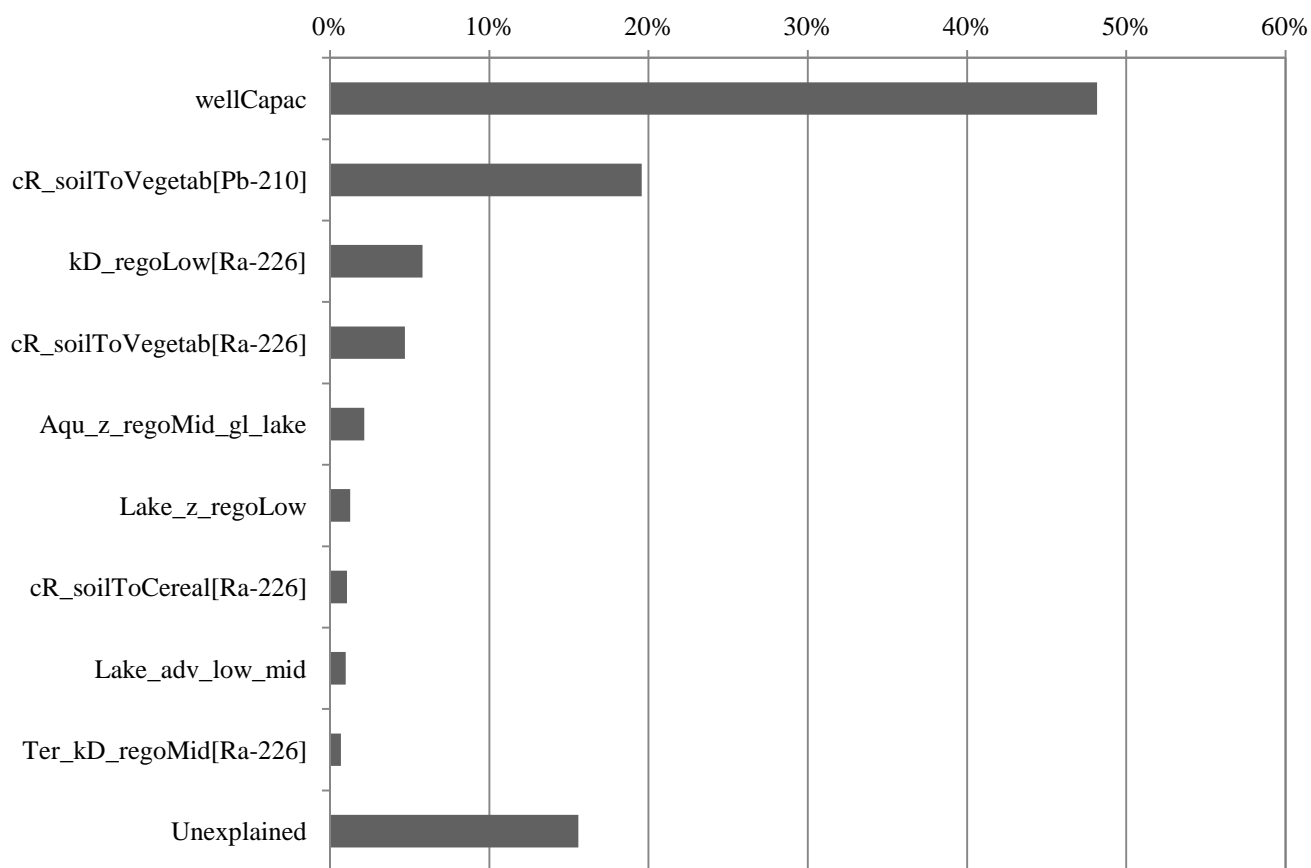
Analysis of conceptual uncertainties

Peak doses for Ra-226



Sensitivity Analysis

Ra-226



Concluding remarks

- Conceptual models contribute to the transparency of a safety assessment and are also the focus of attention of independent reviewers.
- They are useful for designing and justifying qualitative assessments of scenarios.
- Are the basis for the development of mathematical models, which are used in quantitative assessments of scenarios.
- A systematic approach to the development and documentation of conceptual models is recommended.

Concluding remarks

- Use of several conceptual models of different level of detail is recommended.
- Combination of system and process level models in the safety assessment has proven useful and practical.
- An iterative and graded approach to the development of conceptual models is nearly a necessity.
- Uncertainty analyses of the conceptual model should be an integral part of the overall uncertainty analysis and are best performed in combination with analysis of system and parameter uncertainties.

References

- IAEA-ISAM-Vol1
- SKB reports:
 - R-01-18-web
 - R-08-13 -web
 - R-08-14-web
 - R-08-15-web
 - R2225-r2-InfFinal-6-final-draft
 - TR-10-06webb
 - TR-10-07webb-2011-10