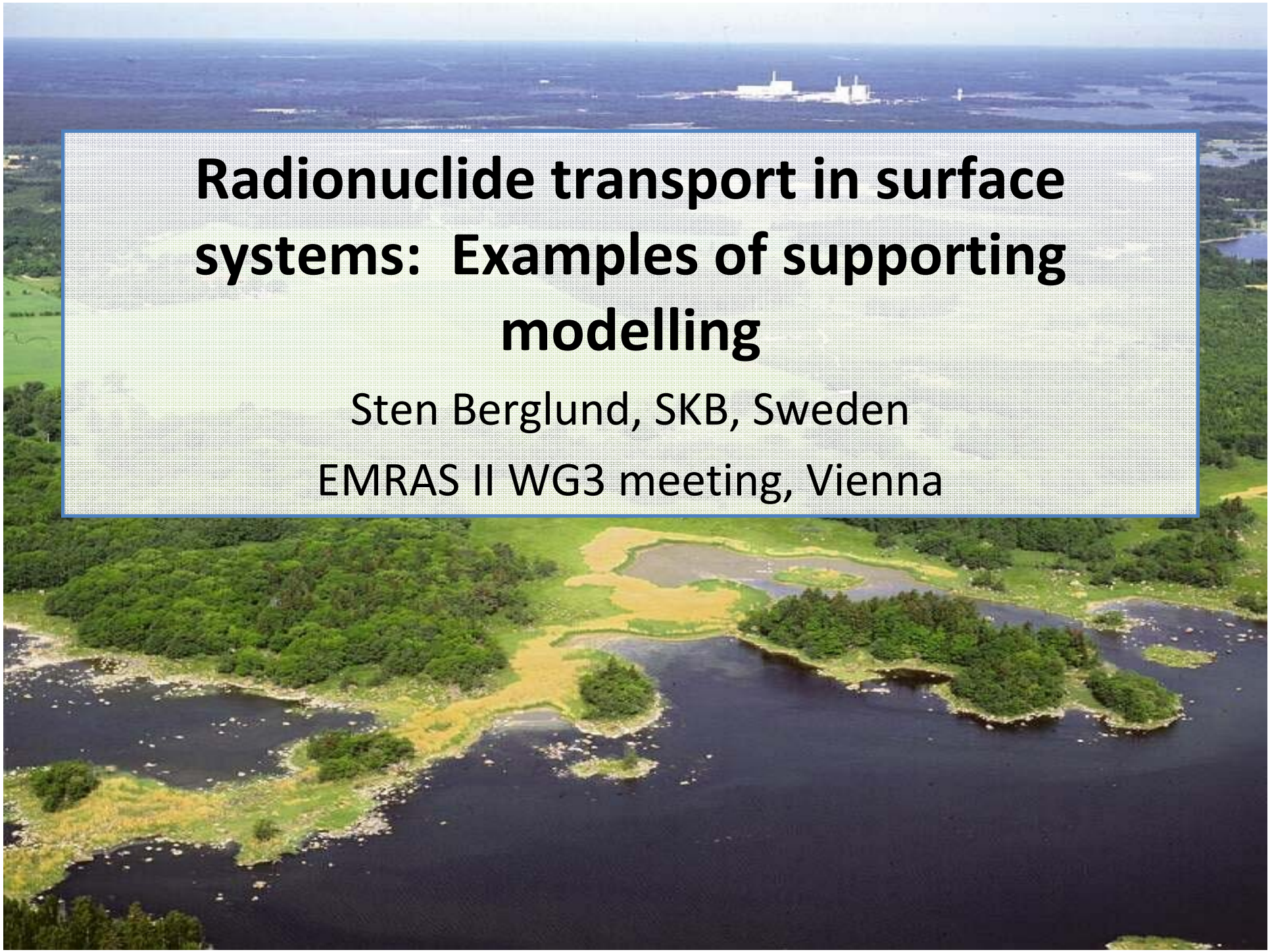


Radionuclide transport in surface systems: Examples of supporting modelling

Sten Berglund, SKB, Sweden

EMRAS II WG3 meeting, Vienna

Objective and contents

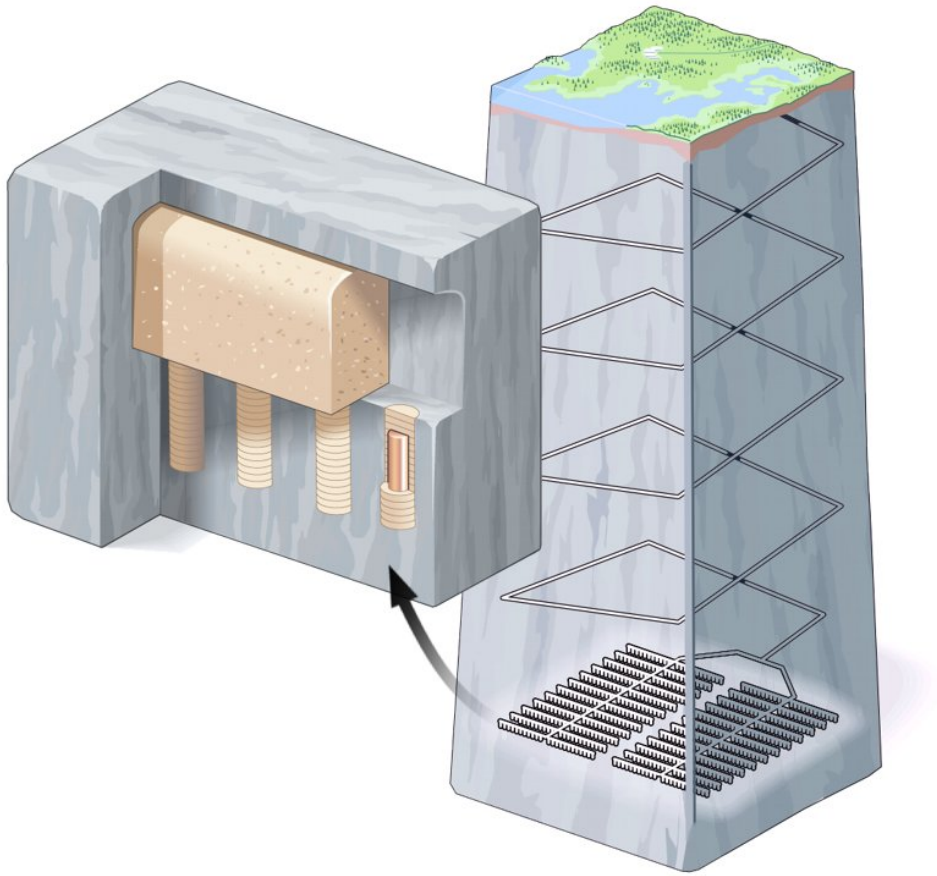
- Background on the Swedish concept and geological conditions.
- Examples of modelling performed to support the dose modelling and PA.
- Questions for further discussion.

When a programme is at the stage where specific sites are considered, site data and site models provide the main support to the PA.

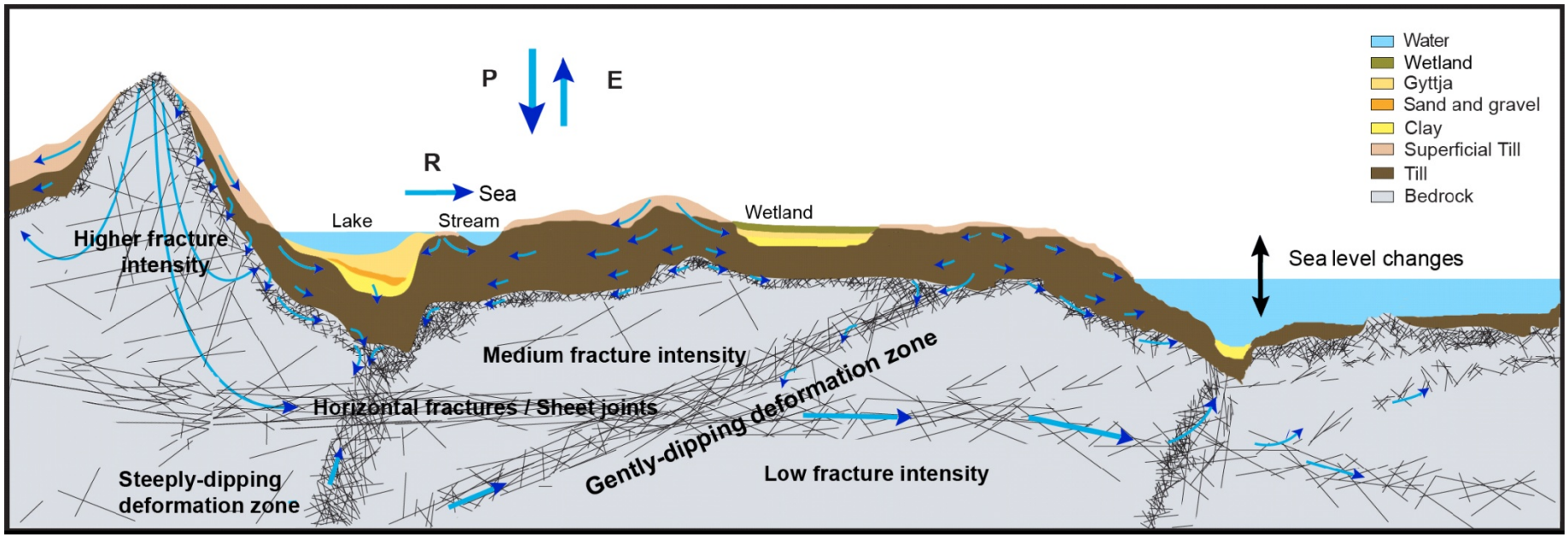
The aim is to show some examples of how this is done in the Swedish programme.

Background: The Swedish repository concept

- Repository depth: 400–700 m
- Underground facilities: 2–4 km^2
- 6,000 canisters

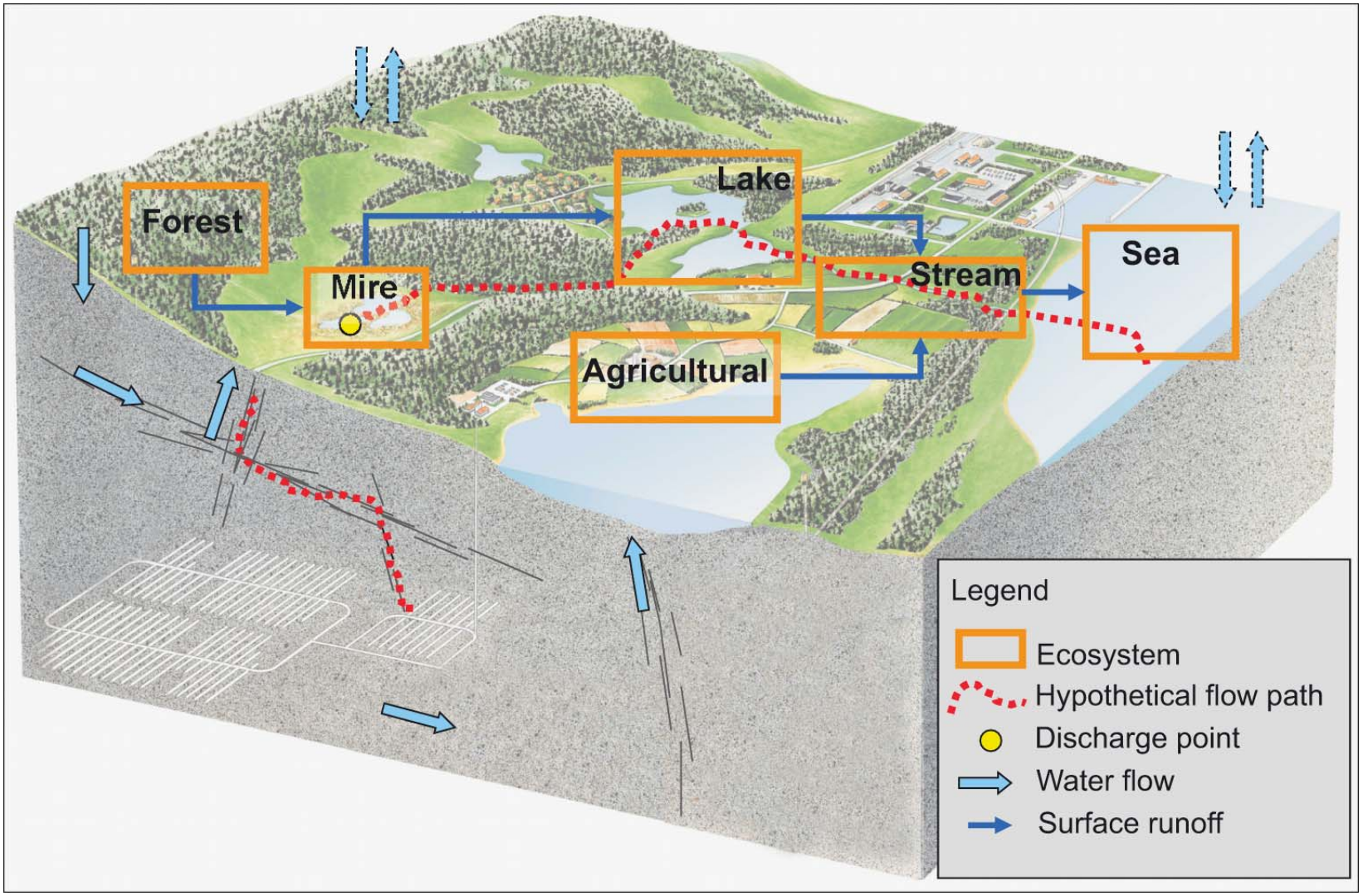


Background: Geology and hydrogeology



- "Old" rock (~ 10^9 years), "young" soils/deposits (~ 10^4 years).
- Thickness of deposits: a few metres, up to 30m in valleys.
- Clays and organic deposits in potential discharge areas.

Background: Transport from repository to surface



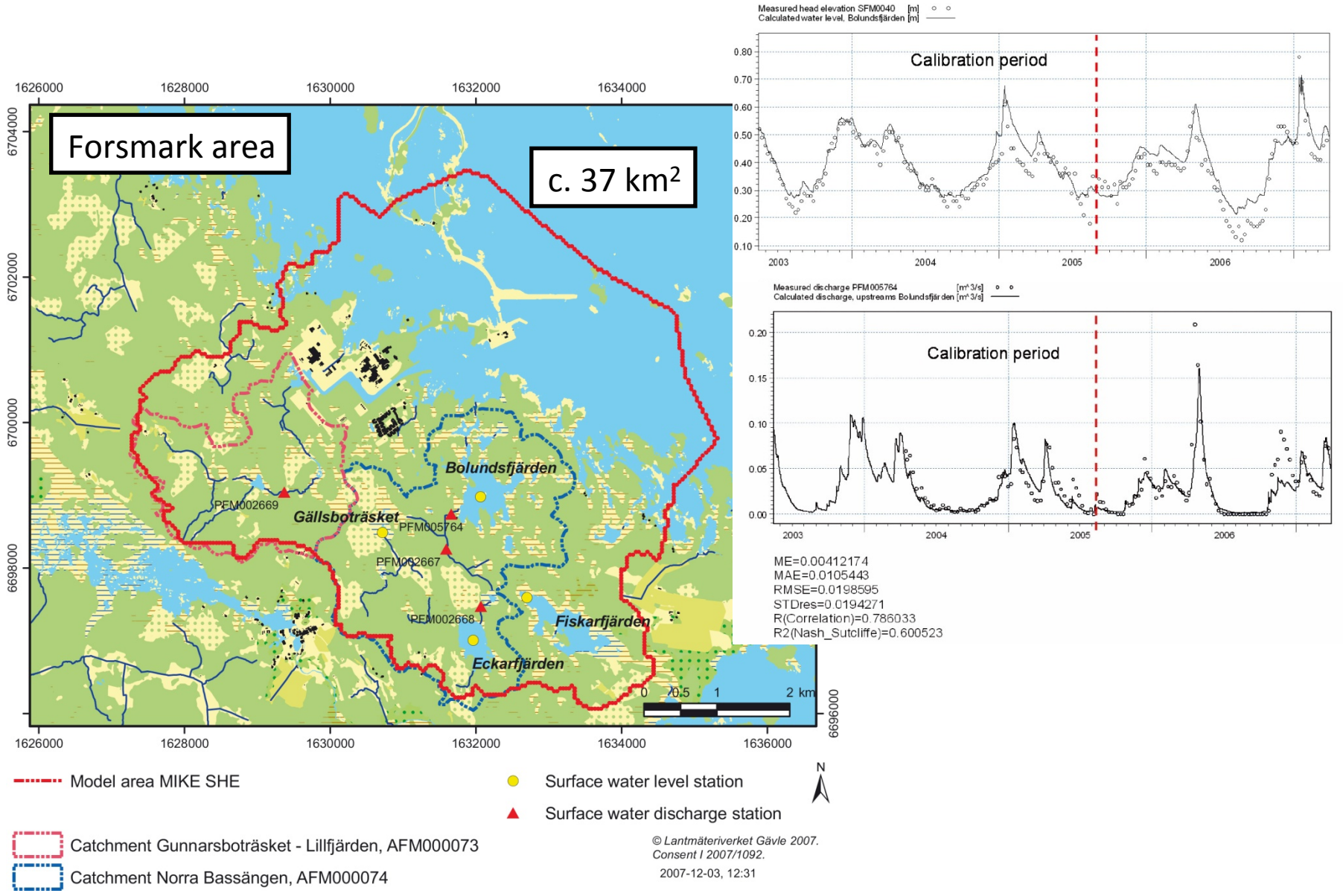
Notes on different types of models

- Models used in performance assessment are by necessity simplified:
  - Coarse discretisation (box models)
  - Simplified hydrology (turnover times)
  - Processes described by distribution factors (e.g. Kd).
- Simplifications need to be tested and motivated.
- Some inputs need to be calculated by more detailed models (e.g. water fluxes).

Examples of modelling tasks

- Flow and transport in hypothetical discharge areas:
  - Model discretisation
  - Detailed flow paths and discharge locations
  - Quantification of water fluxes
- Analysis of retention processes:
  - Identification of processes that can be active at the site
  - Process quantification in numerical model
- Flow and transport in a changing landscape

Discharge areas I: Develop flow model



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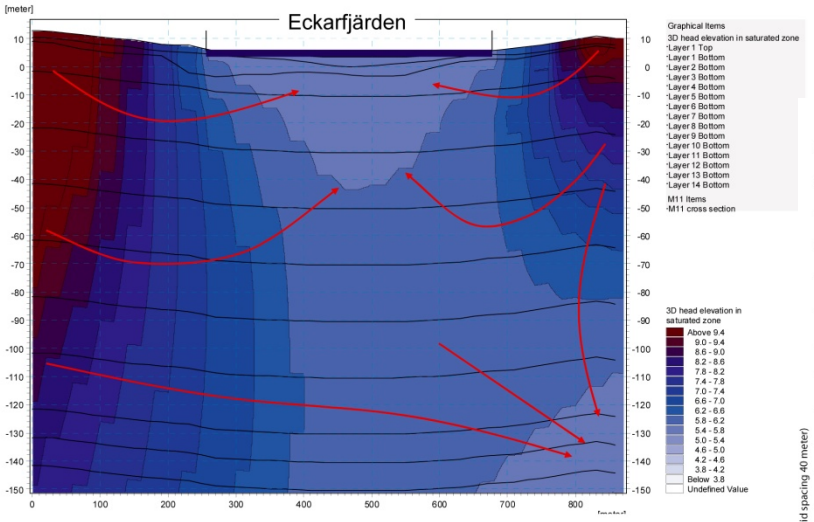
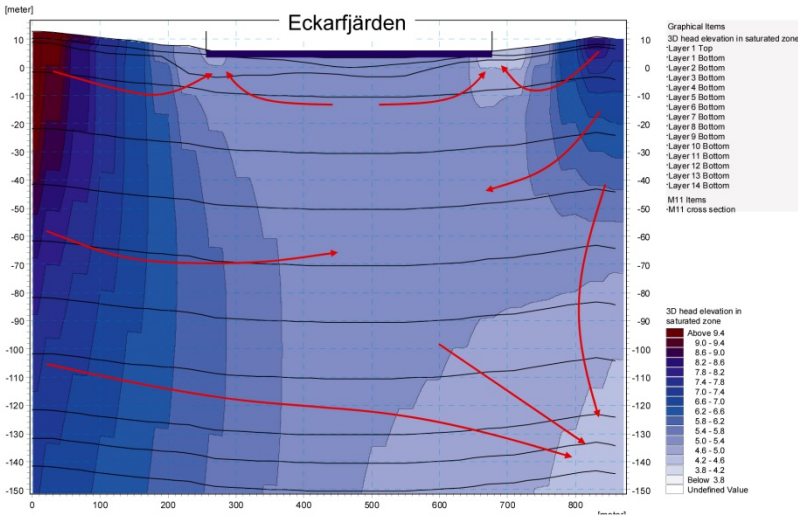
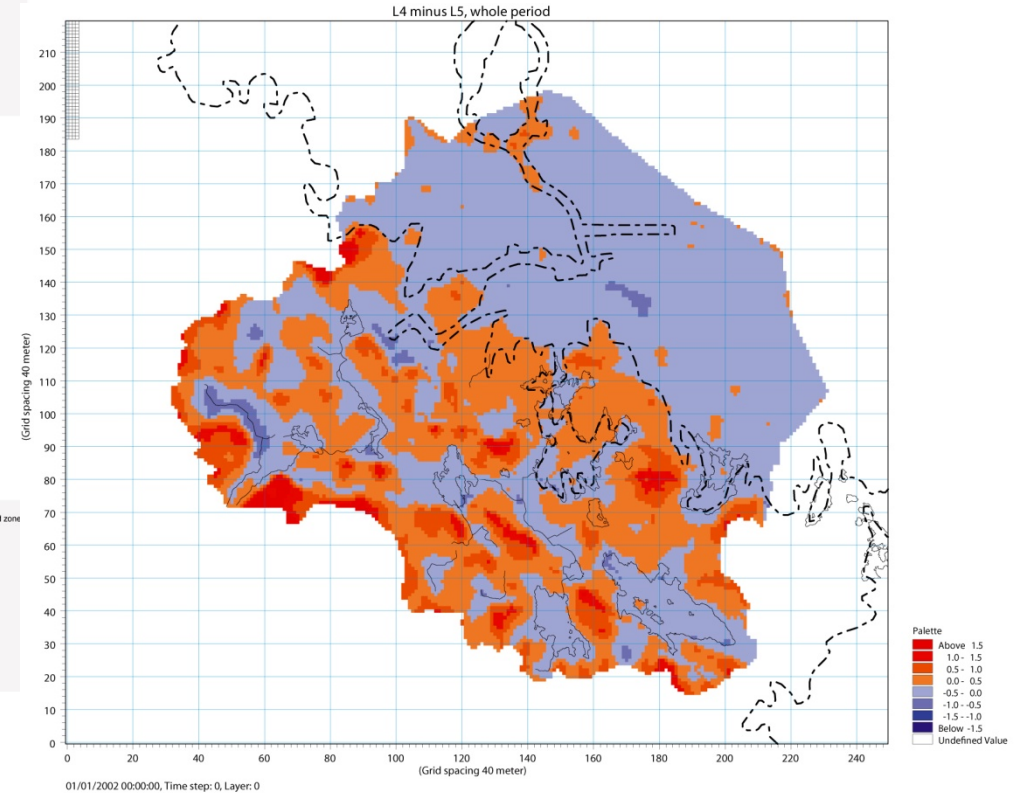
MAE=0.0105443
RMSE=0.0198595
STDres=0.0194271
R(Correlation)=0.786033
R2(Nash_Sutcliffe)=0.600523

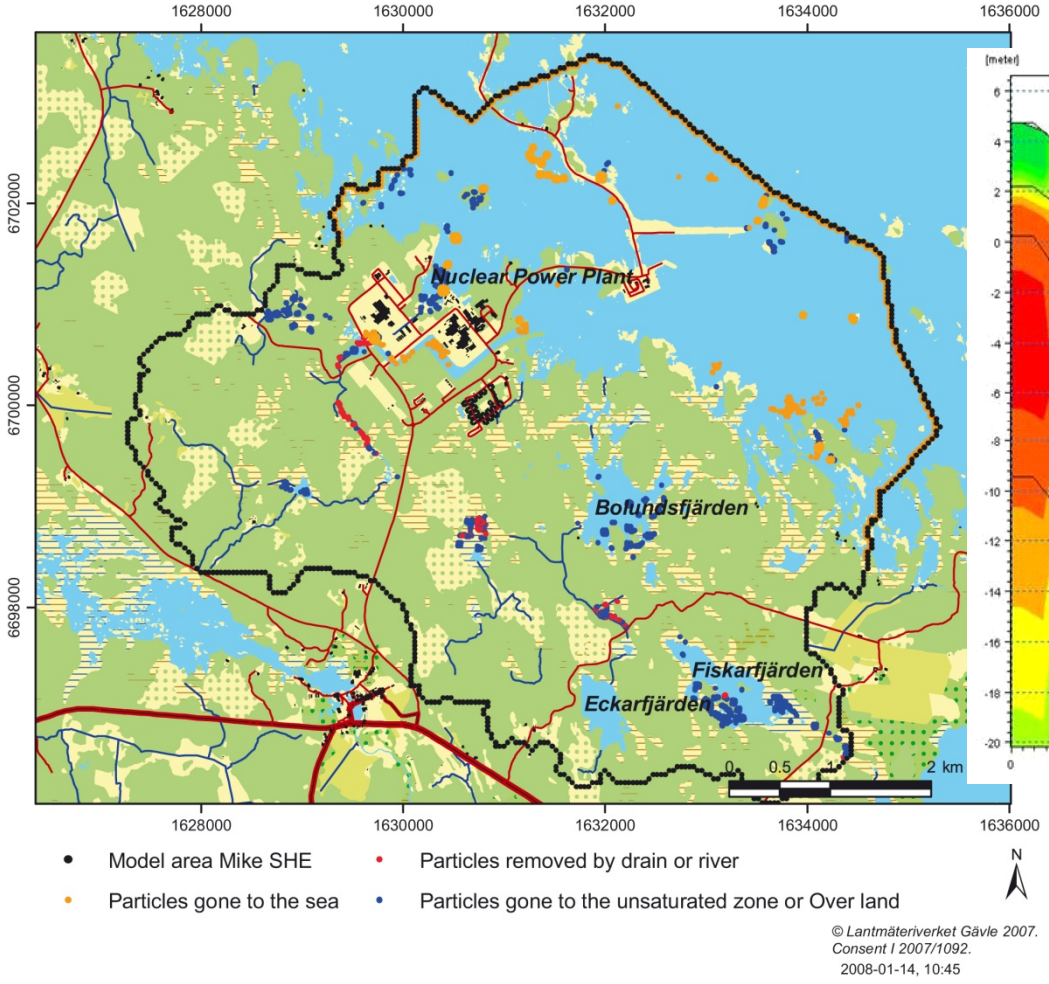
Discharge areas II: Illustrate flow directions and identify recharge and discharge areas







Discharge areas III: Transport modelling



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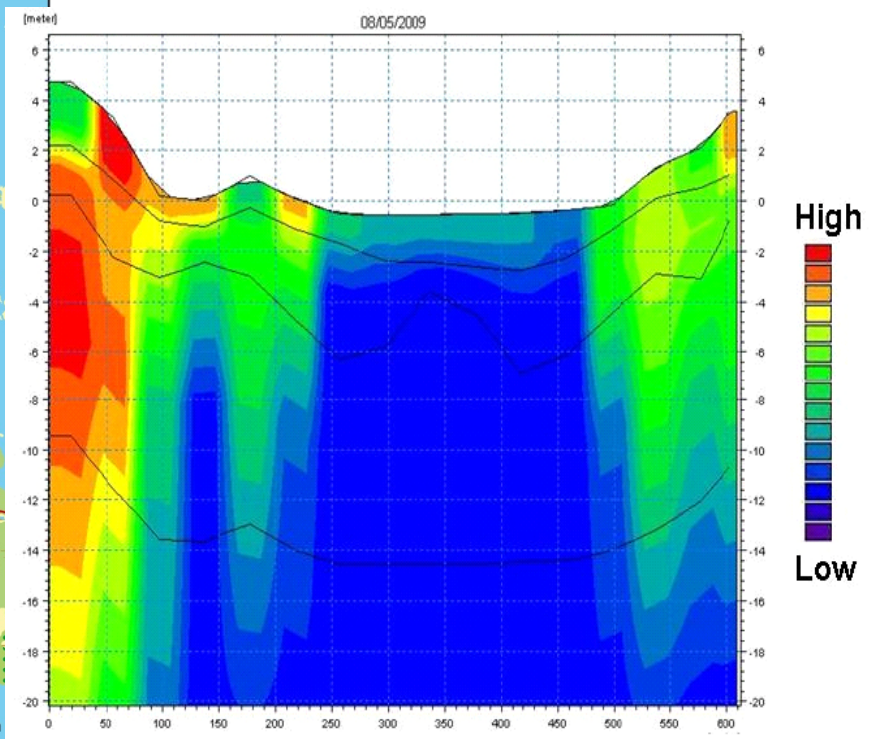
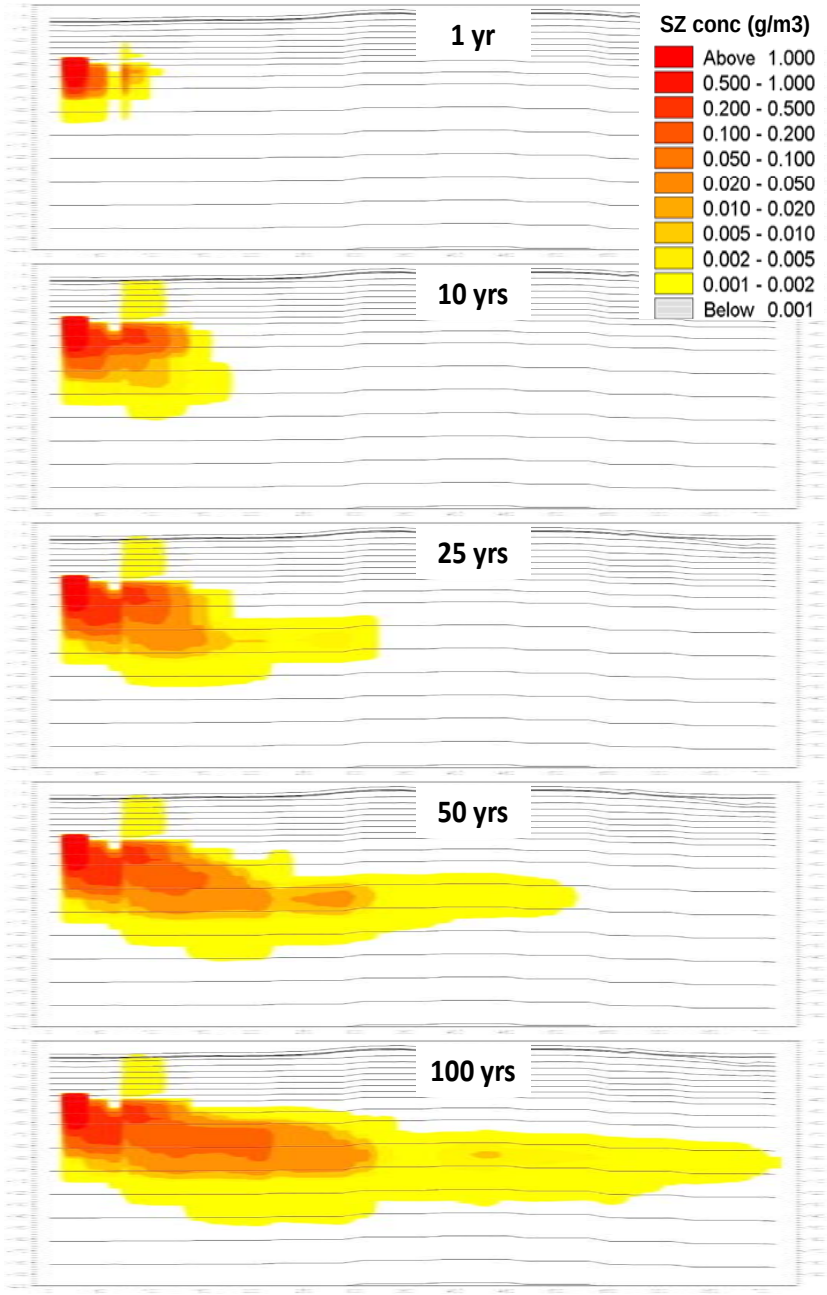
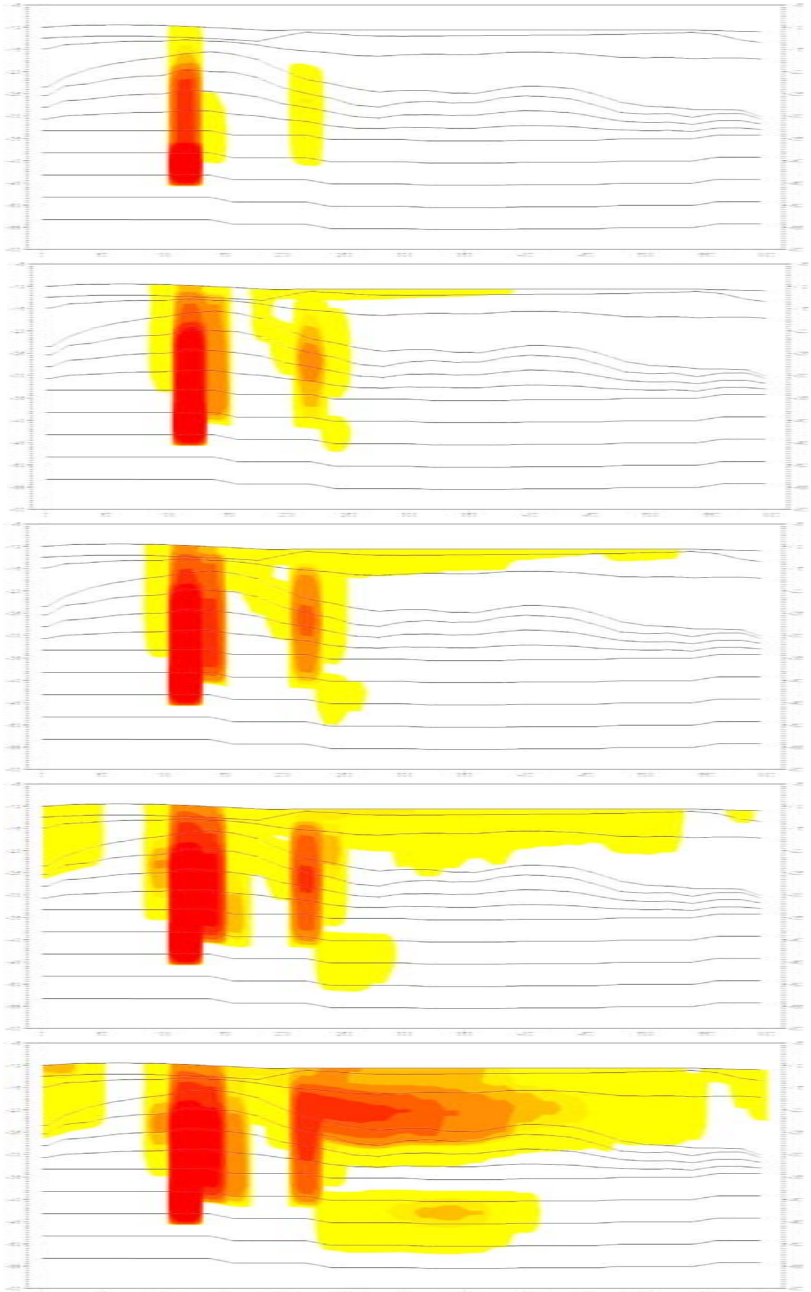
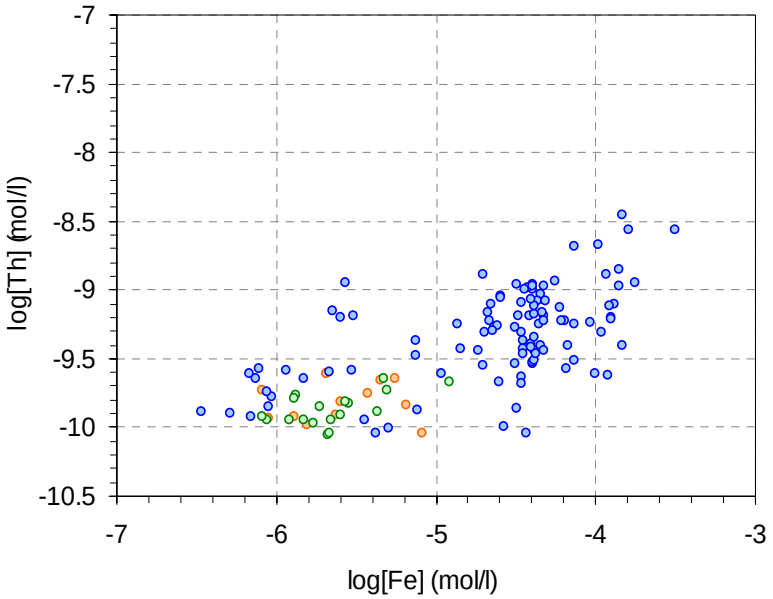
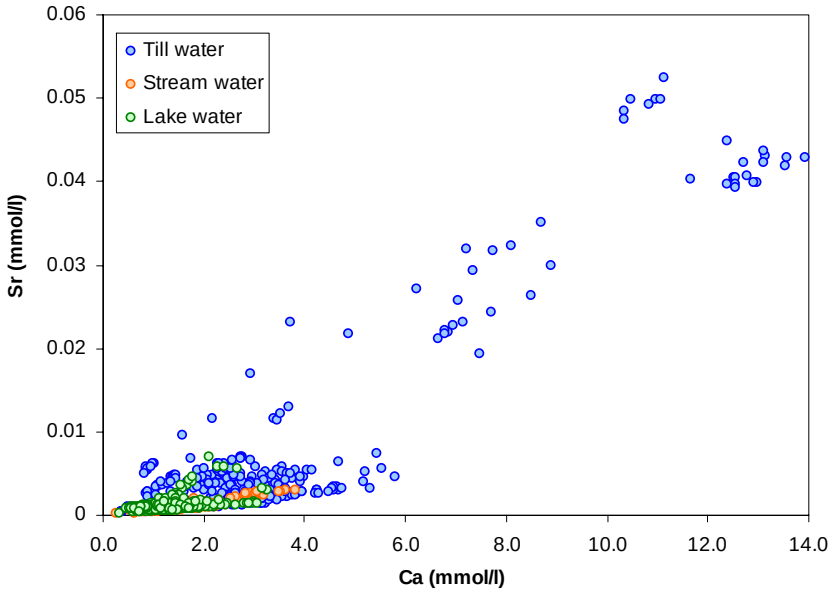


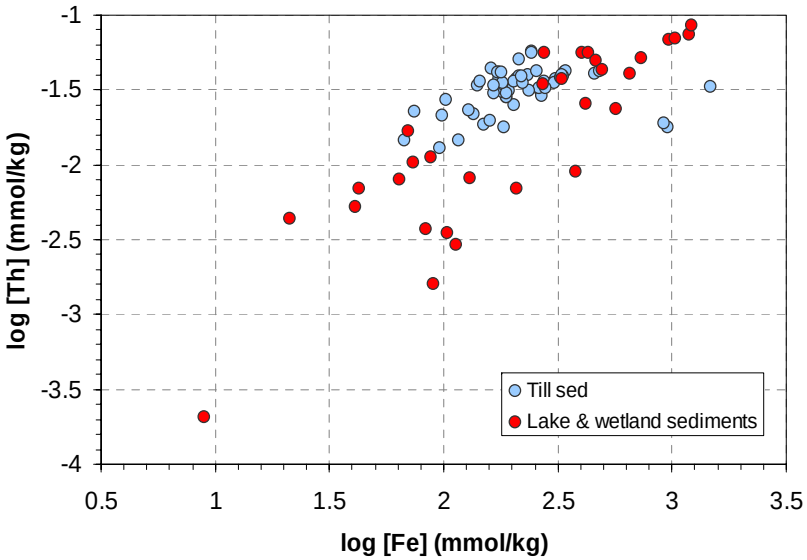

1 yr
10 yrs
25 yrs
50 yrs
100 yrs
SZ conc (g/m3)
Above 1.000
0.500 - 1.000
0.200 - 0.500
0.100 - 0.200
0.050 - 0.100
0.020 - 0.050
0.010 - 0.020
0.005 - 0.010
0.002 - 0.005
0.001 - 0.002
Below 0.001

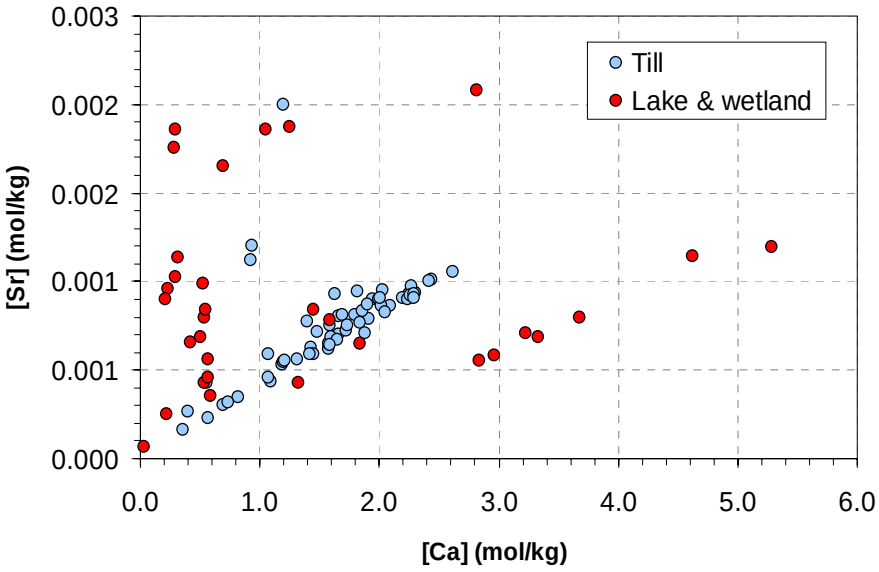


Retention I: Evaluate chemical data from the site









Retention II: Identify processes and develop conceptual model for selected radionuclides

Retention process	^{14}C	^{129}I	^{36}Cl	^{94}Nb	^{59}Ni	^{93}Mo	^{79}Se	^{99}Tc	^{230}Th	^{235}U	^{135}Cs	^{90}Sr	^{226}Ra
Sorption onto organic matter									✓	✓			
Sorption onto Fe-Mn-Al oxyhydroxides					✓		✓			✓			
Sorption onto phyllosilicates					✓				✓	✓	✓	✓	
Precipitation as pure phases	✓			✓	✓	✓	✓	✓	✓	✓			
Association with sulfides													
Association with carbonates												✓	
Incorporation into bacteria													
Association with phosphates													
Association with sulfates													✓

Processes likely to be active in the QD of Forsmark

Processes not likely to be active in the QD of Forsmark

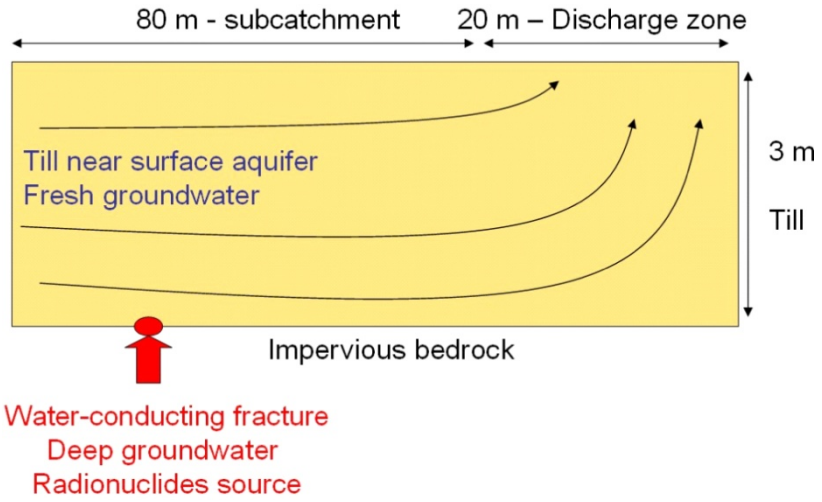
Retention processes not relevant for the indicated element

✓ Available thermodynamic data

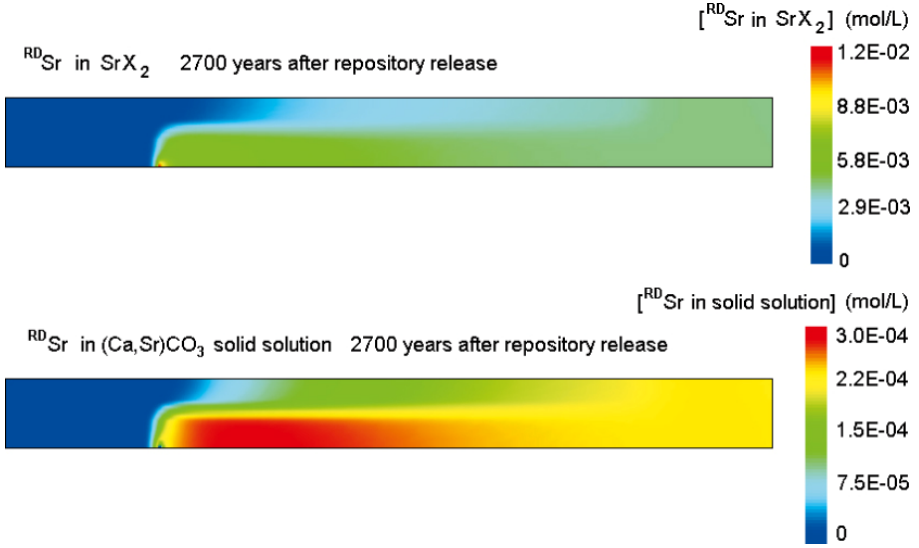
Note: preliminary results!

Retention III: Quantify effects of processes using transport model

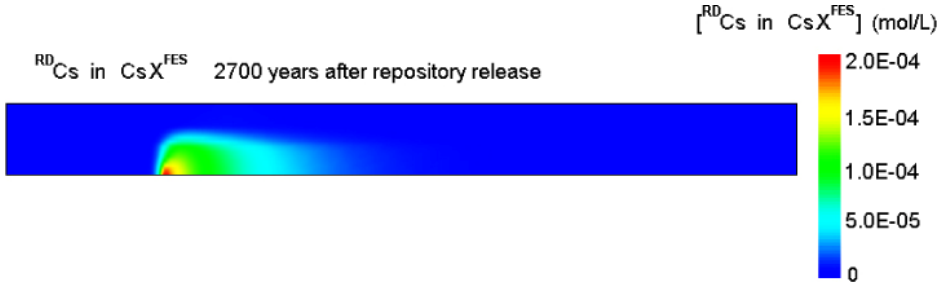
2D model domain



Sorption of Sr by two different processes

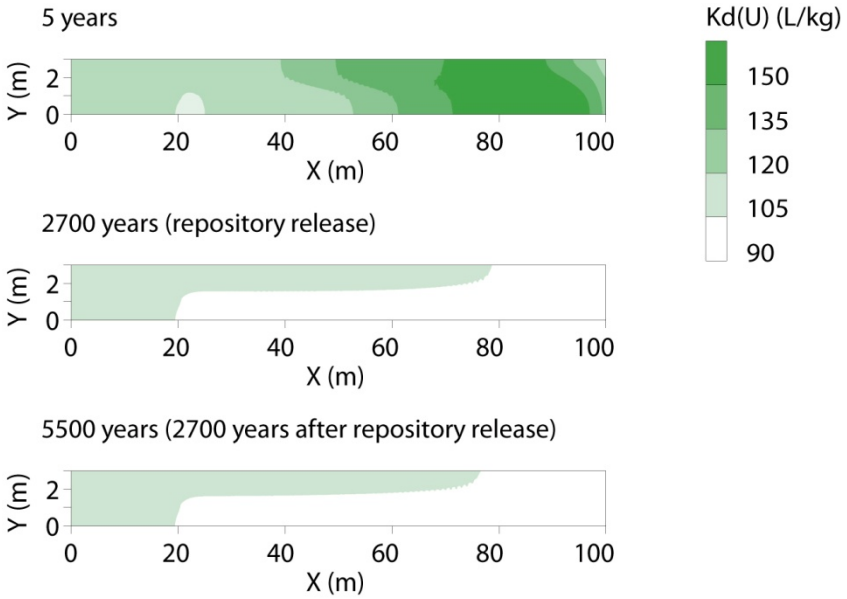


Sorption of Cs

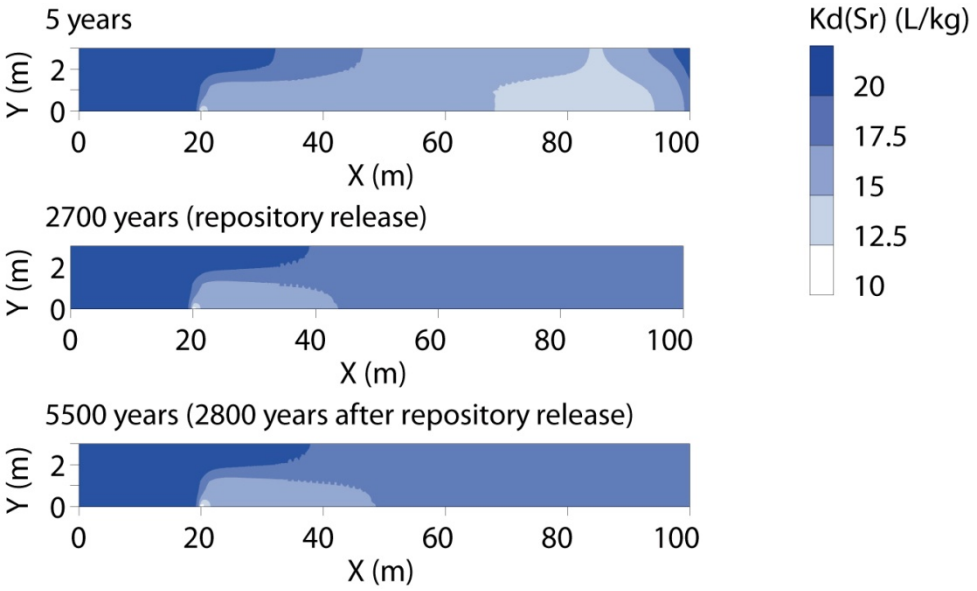


Retention IV: Calculate ”Kd values” (concentration ratios)

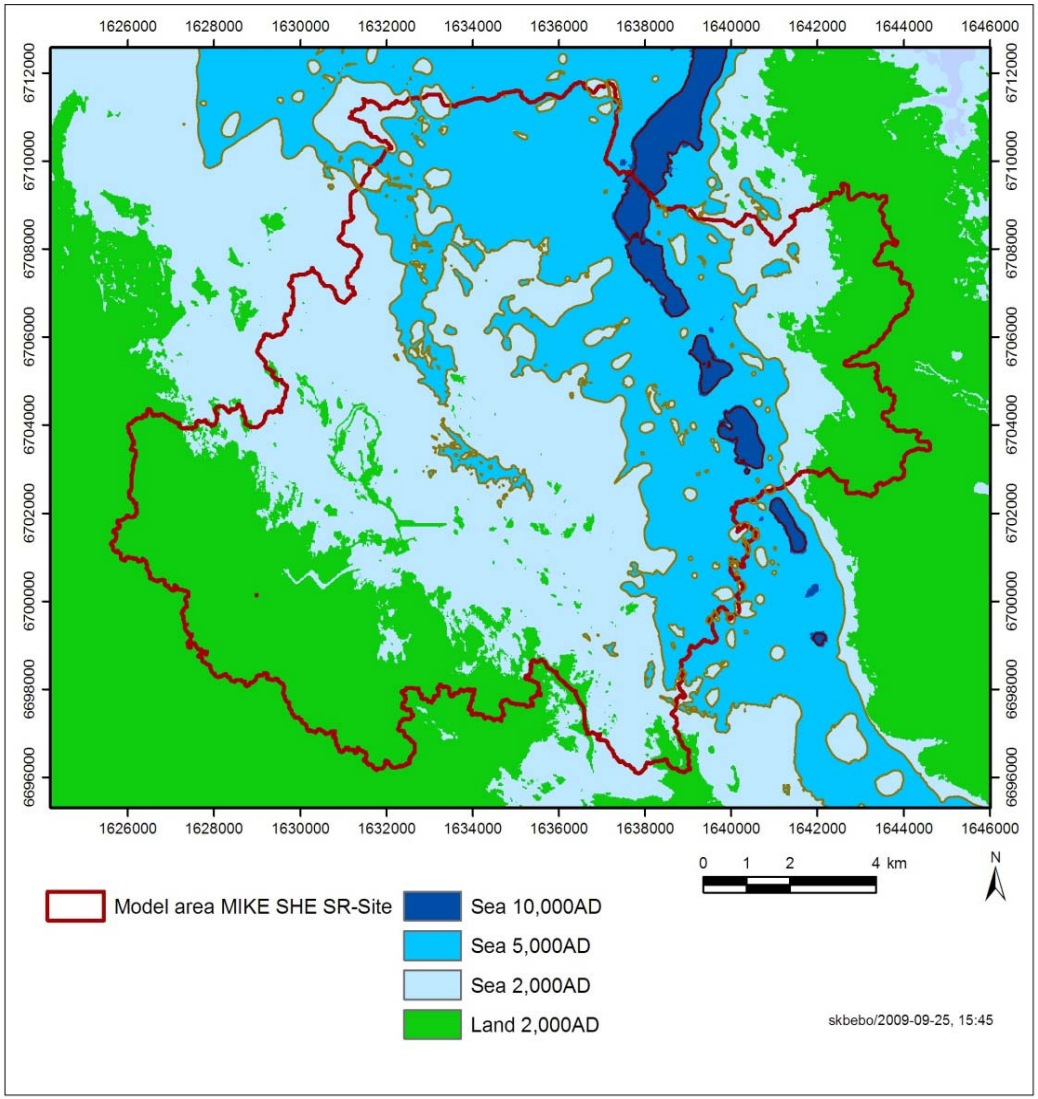
Uranium



Strontium



Changing hydrology I: Shoreline displacement and model areas

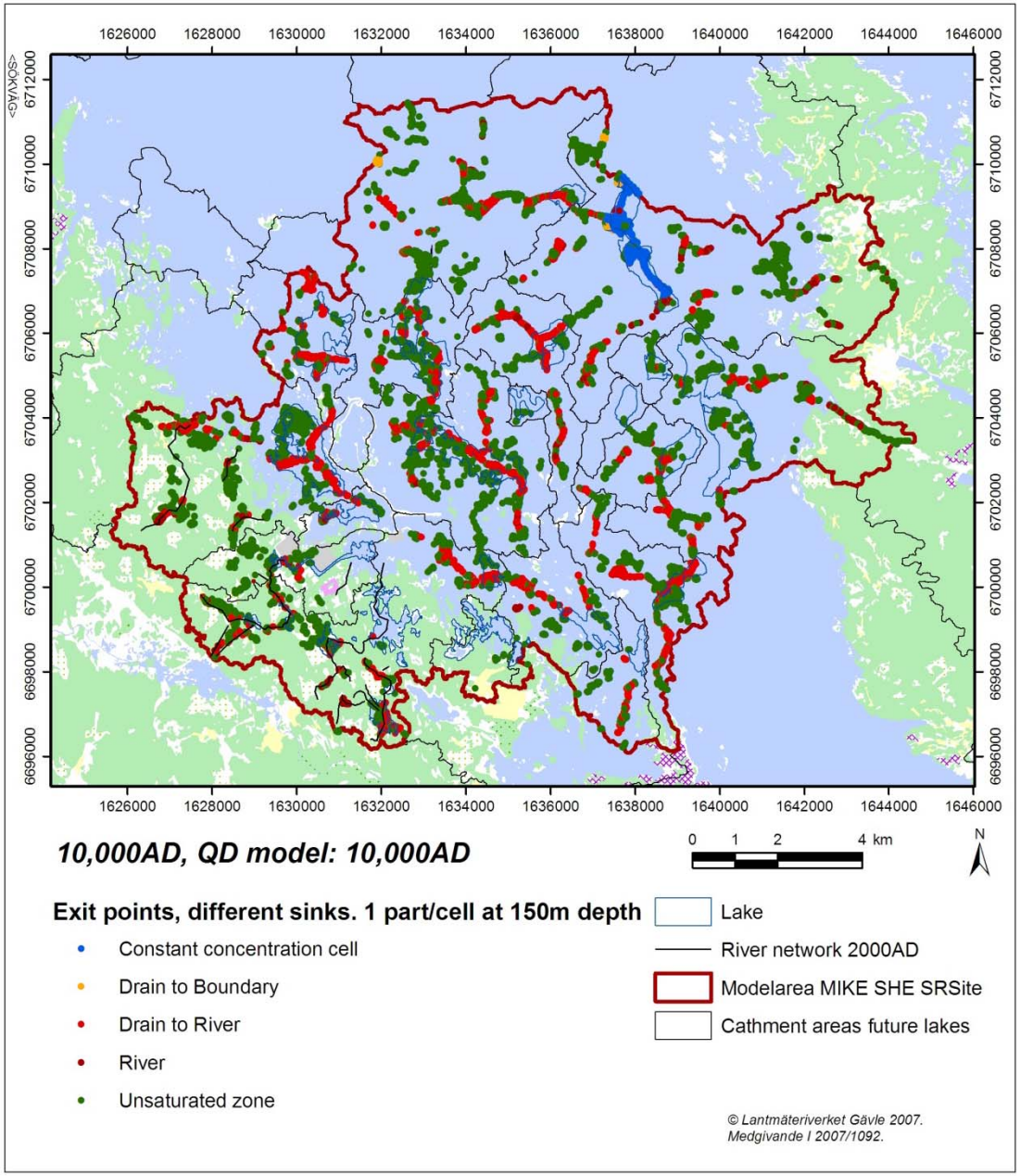


Changes affecting hydrology:

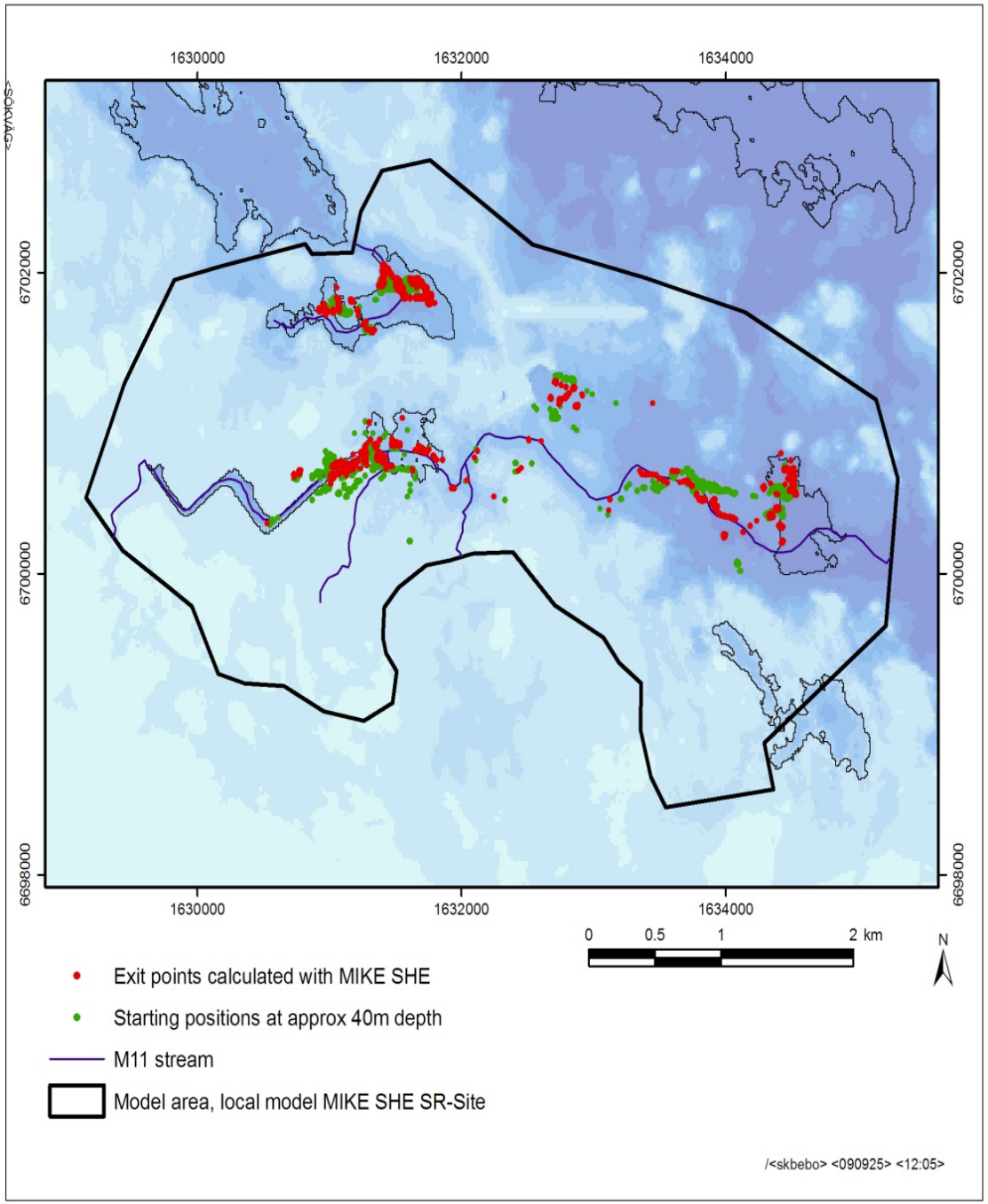
- Shoreline displacement
- Processes affecting deposits
- Lake succession
- Stream network
- Climate: glaciation cycle (permafrost conditions), possibly ”delayed” by global warming

Changing hydrology II: Discharge areas in future land areas

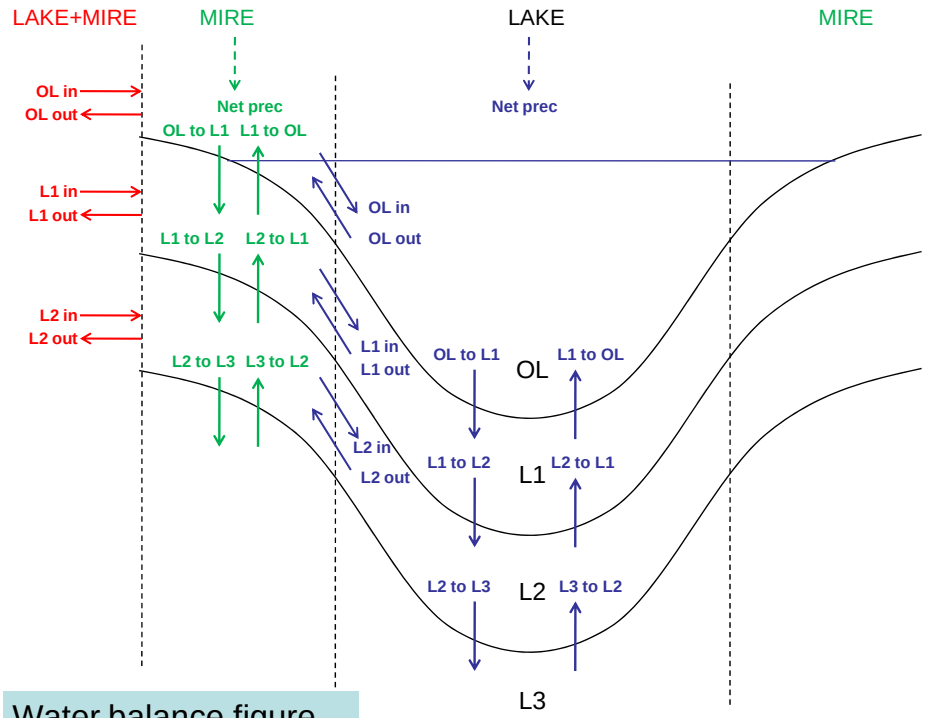
Are the new land areas different from the present ones?



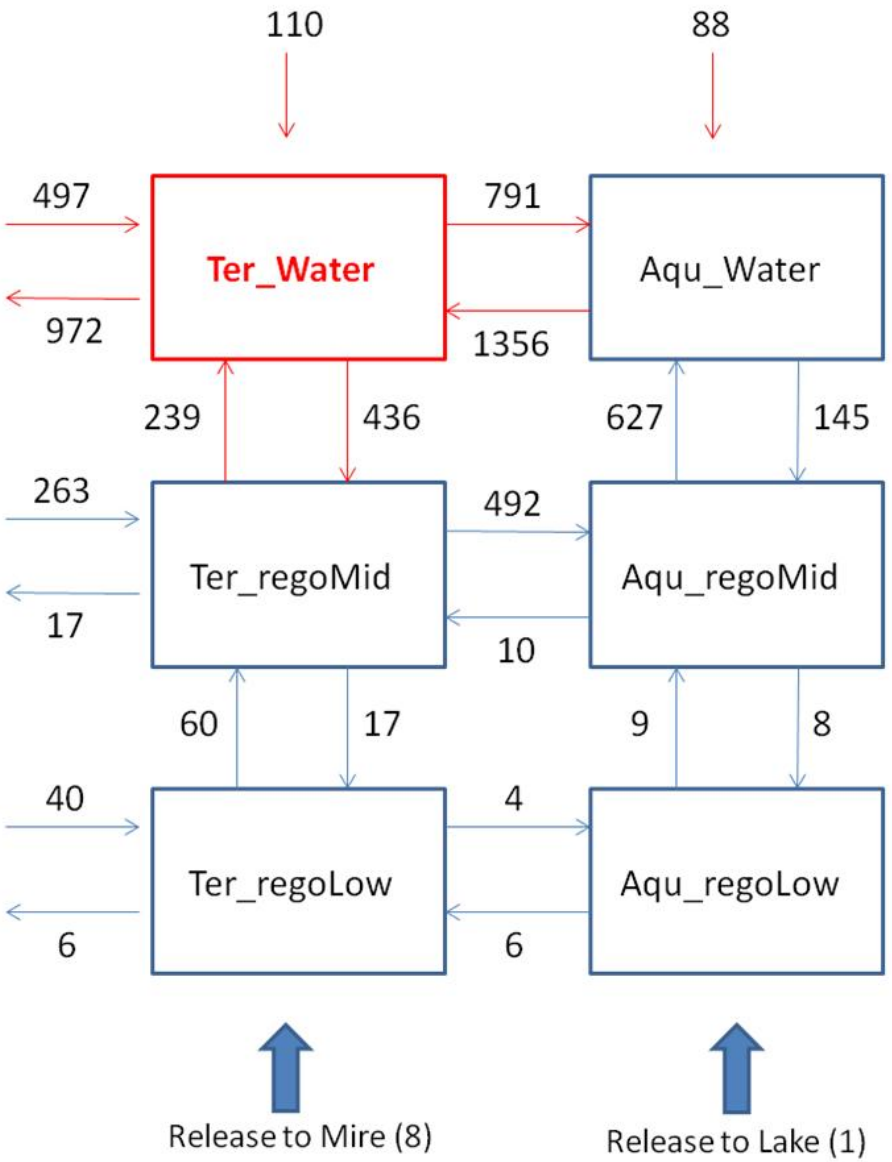
Changing hydrology III: Discharge from repository release in/around future lakes, streams and wetlands



Changing hydrology IV: Export to dose models



Water balance figure



Questions for discussion

- Which aspects of PA models need support and how much modelling should be done for this purpose?
- Generic vs site specific assessments – what can and should be done at different stages?
- Distributed models vs box models – how to organise and discretisise models?
- …