# Conceptualising geology

## - insight from updating the national water resources model for Denmark

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### Introduction

Conceptual models especially with regard to geological structures/simplifications are regarded as the dominant source of uncertainty in model predictions (Carrea 1993; Neuman & Wierenga 2003).

In updating the National Water Resources Model (NWRM) we implemented county models based on and refined from several years of county work on gathering new geological knowledge and mapping groundwater vulnerability. Special focus in updating NWRM were put into understanding assumptions regarding geological conceptualisation which is often a key issue in model credibility and usability (Beckers & Frind 2000).

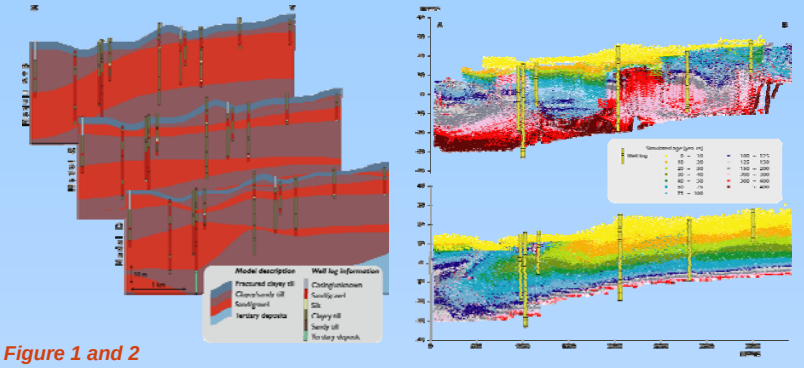

***Figure 1 and 2***
*Examples of dealing with conceptual uncertainty. Models with different geological conceptualisations each are calibrated against groundwater heads and discharge, their predictive capabilities are compared through age simulations (Troldborg 2004; Troldborg et al 2007)*

### Mini-seminar discussions

In a series of mini-seminars with county geologist and water managers more than 50 models ranging from 50 km² to 10,000 km² were discussed. The seminar discussions focused on documentation, quality and implementation of the different conceptualisation.

Document and digital models were processed in ArcView using Geomodel (DHI) that can process and present cross-sections and well logs with other available hydrogeological maps or data. At the seminars different subjects were discussed:

- Background and goal for a particular model
- Area of special focus within the county either groundwater, ecosystem or geology related
- Model specific strengths and weaknesses

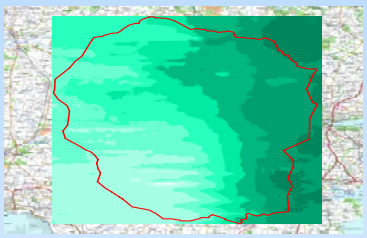

***Figure 3***
*Example of interpolation artefacts moving from 2D profile interpretation to 3D*

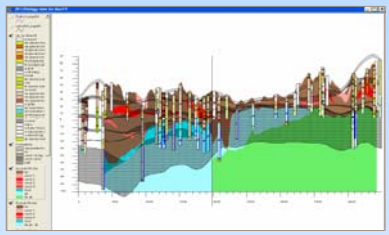

***Figure 4***
*Geoeditor profile with three different conceptualisations.*

Insight from the seminar series show two import aspect of 3D conceptualisations are important for evaluation: Firstly as subjectivity is inherent in conceptualisation the need for background knowledge is essential e.g. modelling goal, focus areas, interpretation methodology, data interpretation. Secondly moving from 1 or 2D conceptualisation to 3D digital models often results in undesired artefacts.


***Figure 5***
*Model area expanded way beyond focus area resulting in undesired boundary effects with regard to the interpolated pre-Quaternary surface*

### Conclusion

Experience taught from the seminars series comprise a catalogue of pitfalls in conceptualising hydrogeology and processing hydrogeological data as well as outlines the importance of transparent modelling protocols and consequent conceptualisation methodology.

Evaluation of conceptual models can (and should) be attempted independent on model performance, but it requires information of both subjective and objective nature. Important points of any pre-evaluation should include focus areas, consequent model formulation and digitalisation, interpolation quality and description of agreement between hard data and model simplifications.

If we want to use several conceptual models in evaluation of model uncertainty discrimination is an important step. A step that is virtually impossible to accomplish without acknowledging differences between technical errors and conceptual disagreements.

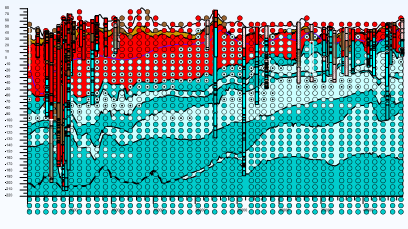

***Figure 6***
*Inter-comparison of well log data, NWRM interpretation (pixels) and county model interpretation (layers). Layer interpretation model suppresses aquifer differences and buried valleys.*

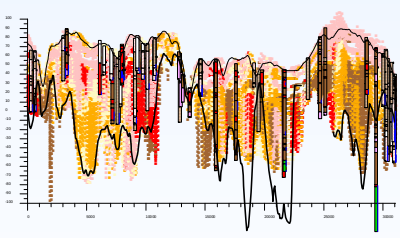

***Figure 7***
*Hydraulic conductivity is translated from directly from interpreted surface geophysics. Mixing flow properties and conceptualisation makes model evaluation difficult.*

### References

Beckers, J. and E.O. Frind (2000) Simulating groundwater flow and runoff for the Oro Moraine aquifer system. Part I. Model formulation and conceptual analysis, Journal Of Hydrology, 229(3-4), 265-280
Carrera, J. (1993) An overview of uncertainties in modeling groundwater solute transport, Journal Of Contaminant Hydrology, 13(1-4), 23-48
Neuman, S.P. and P.J. Wierenga (2003) A comprehensive strategy of hydrogeologic modeling and uncertainty analysis for nuclear facilities and sites. NUREG/CR-6805. University of Arizona.
Troldborg, L., Refsgaard, J.C., Jensen, K.H., Engesgaard, P. (2007) The importance of alternative conceptual models for simulation of concentration in a multi-aquifer system, Hydrogeology Journal, 15, 843-860
Troldborg, L. (2004) The influence of conceptual geological models on the simulation of flow and transport in Quaternary aquifer system. PhD thesis, Geological Survey of Denmark and Greenland report 2004/107