



Risk Assessment of Nutrient Rich Ground Water Outwash to Surface Water

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Outline

- Objectives
- Relevance of course content
- Lake Hampen as case study for SW GW interaction
- Model setup
- Observation data
- Nitrate simulation
- Perspective



General objectives

The objectives of the study are by different methods to:

- Estimate lake water balance and **nutrient budget**
- Characterize groundwater lake interaction at different scales



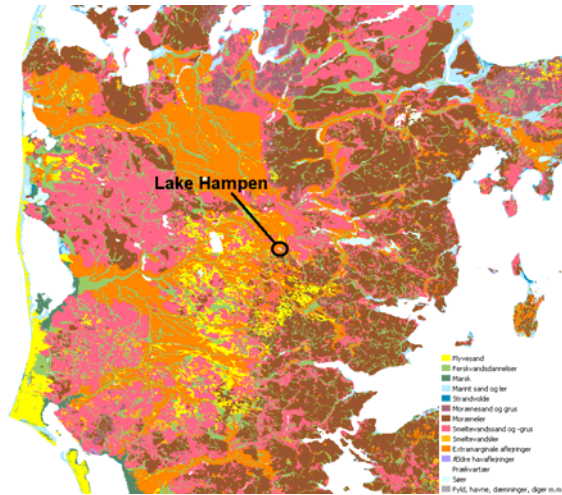
Relevant course subjects related to thesis

- Hydrological characterization of contaminated sites
- Solute transport, dispersion ect.
- Sorption dynamics
- Principles of chemical and biological degradation
- Risk assessment of contaminated sites
- Implementation of different geo-bio-chemical processes in a modeling framework



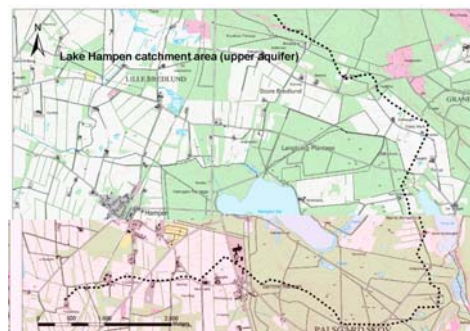
Lake Hampen

- West of the last glacial front
- Sandy melt water deposits
- Seepage lake, no major streams
- Lake level ~ 79 m.a.s.l.
- Area of ~ 0.8 km²
- Max depth ~ 13 m
- Precipitation ~ 850 mm/yr (1961-90)
- Near to groundwater divide between Gudenå and Skjern å catchments.



Nutrient outwash

- Nutrient enrichment during last 30 years
- Difficult to quantify nutrient outwash to a seepage lake vs. a "normal" lake with surface inlets.
- Inflow areas in from N, E and S.
- Area use lead to suspected nutrient outwash at eastern shore





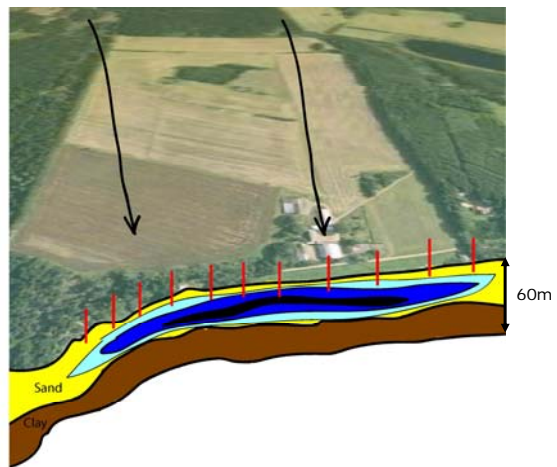
Nutrient outwash

- Only farm in the vicinity of the lake



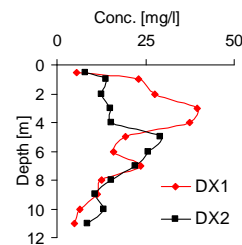
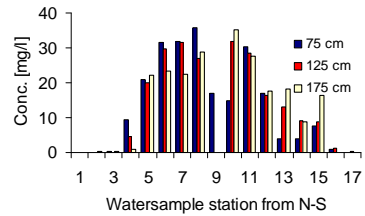
Nutrient outwash

- Possible nutrient outwash?





Measured nitrate outwash

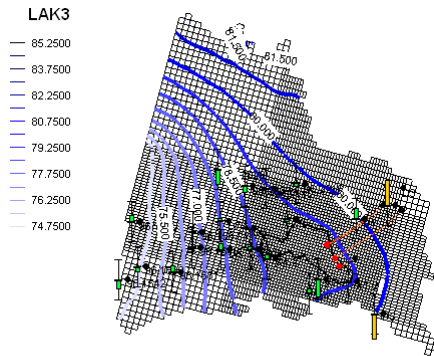


Numerical model setup

- Steady state MODFLOW model using HUF as flow package
- Four hydrogeological units:
 - Glacial sand
 - Glacial clay
 - Tertiary sand
 - Tertiary clay
- Boundary conditions:
 - Specified head
 - No-Flow
 - Two models: One using LAK3 and one using General Head to simulate the lake
- Discretization of 100x100 m and 50x50 m near the lake
- Calibration:
 - 23 head observation points, with special focus around the lake
 - K_{sand} and K_{lakebed} measured with slugtests
 - Recharge calibrated and compared with regional DK-model values.

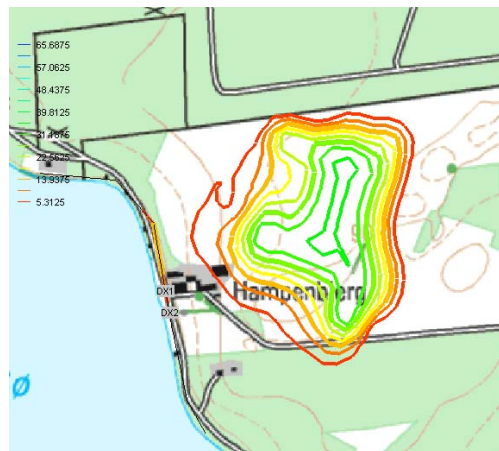


Numerical model - General flow pattern



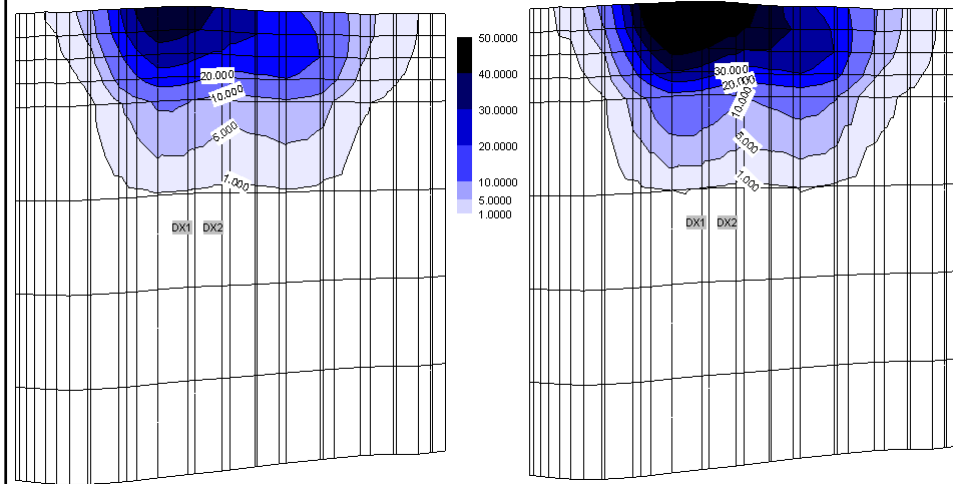
Simulation of nutrient outwash

- Simulation of the nutrient outwash from the crop fields with MT3D
- The 2D nutrient plume profile at the lake shore used as target for simulation
- After 7 years the outwash to the lake becomes steady



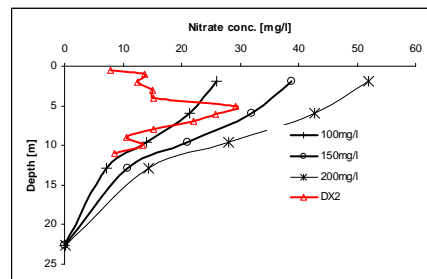


MT3D simulation – Shoreline profile



Conclusion – Shoreline profile

- Output files from the nitrate simulation show significant outwash between 8.5 -12.6 ton/yr



Perspectives

- **Achieve precise estimates of nutrient inflow**
- **Mass balance**
- **Regulate outlet from farm area**

Thank you!

