Climate change enhanced risk for mass failure of sediment into rivers - how do we manage such events?

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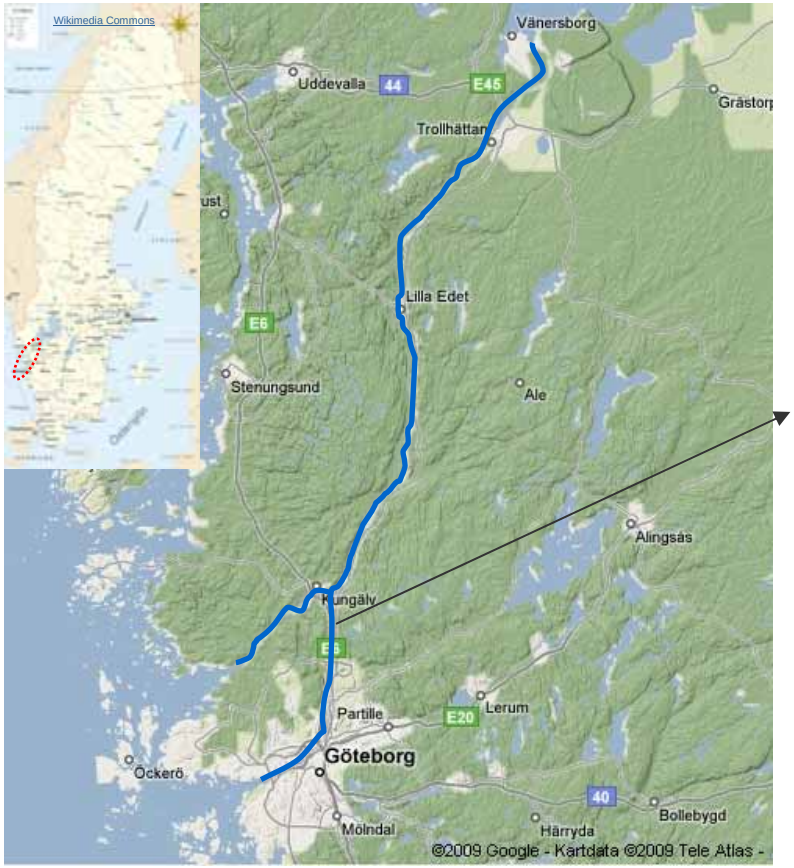
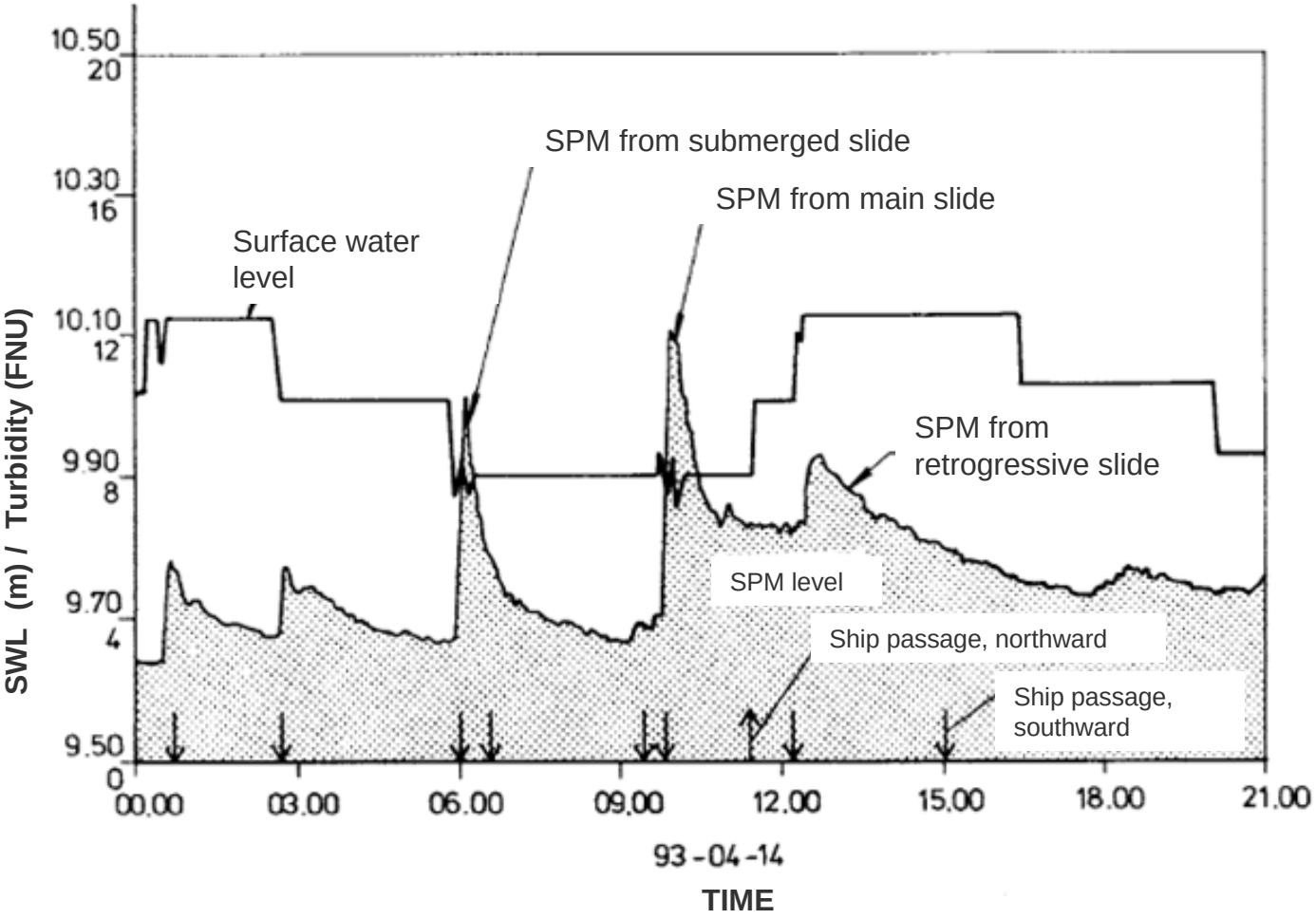
Outline of presentation

- Site description, geological development
- Landslide history and prerequisites for slope failure
- Climate change scenarios and impact on slopes
- Consequences and risks
- Actions

Göta Älv river valley

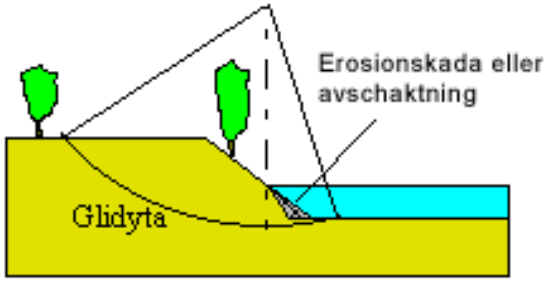


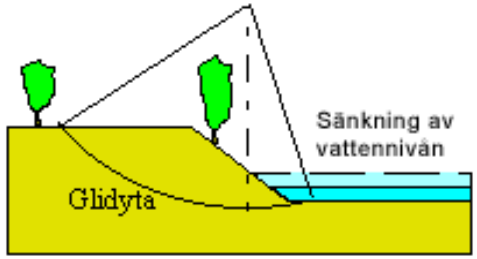
Historical slides



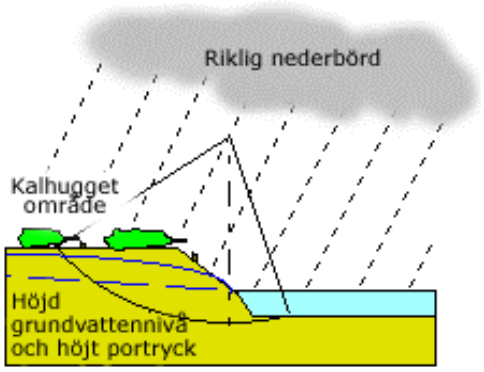
50 000 m²
70 000 m²
0 000 m²
00 m²
1830, >50 000 m²
. Surte yr 1950, 240 000 m²
. Göta yr 1957, 320 000 m²
. Agnesberg yr 1993, 2 500 m²
. Ballabo yr 1996, 7 000 m²

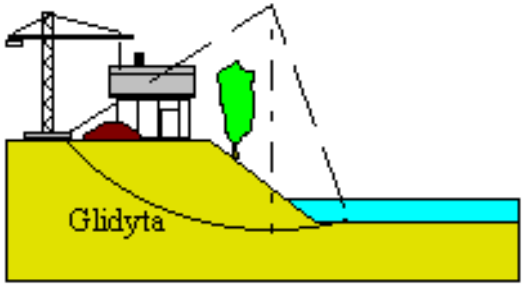
Prerequisites for slides

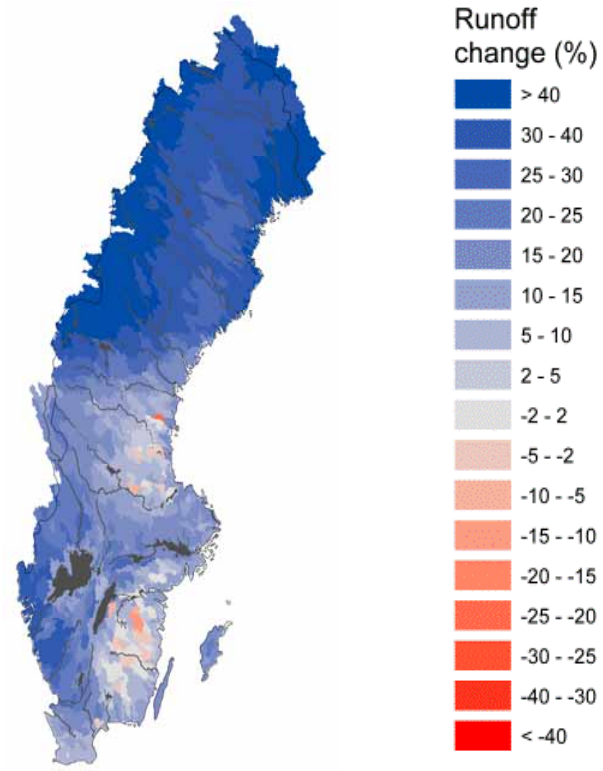




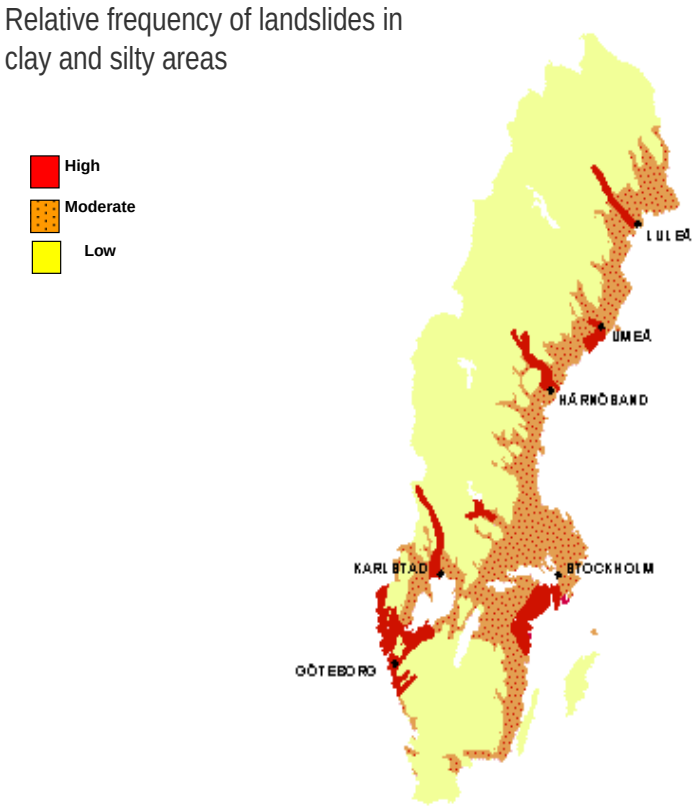
And… QICK CLAY







Simulated precipitation changes, year 2071-2100 compared with the period 1961-1990 (*SMHI Rossby Centre, Echam A2*)



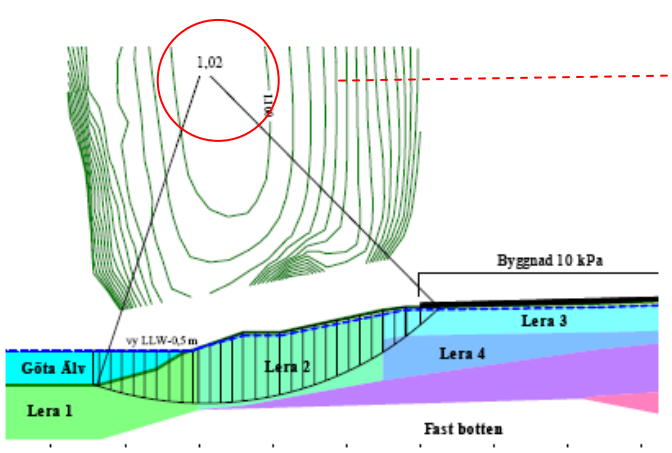
Map of Sweden showing the frequency of landslides and ravines (www.sgu.se, *2005)*

Expected climate change effects

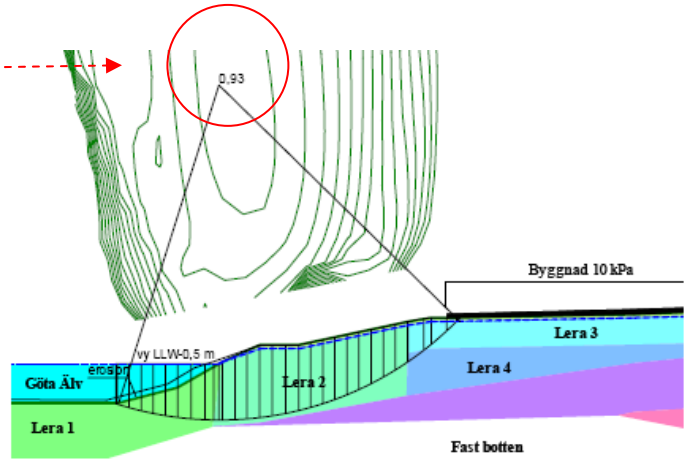
- Increasing precipitation
- Rising groundwater level and pore pressure in the ground
- Need for more outflow from lake Vänern (max 1030 m^3/s → 1400 m^3/s)
- Increasing water flow → increasing erosion
- Risk for giant landslide (even without CC) → giant surge, damming, flooding …

Changes in slope stability

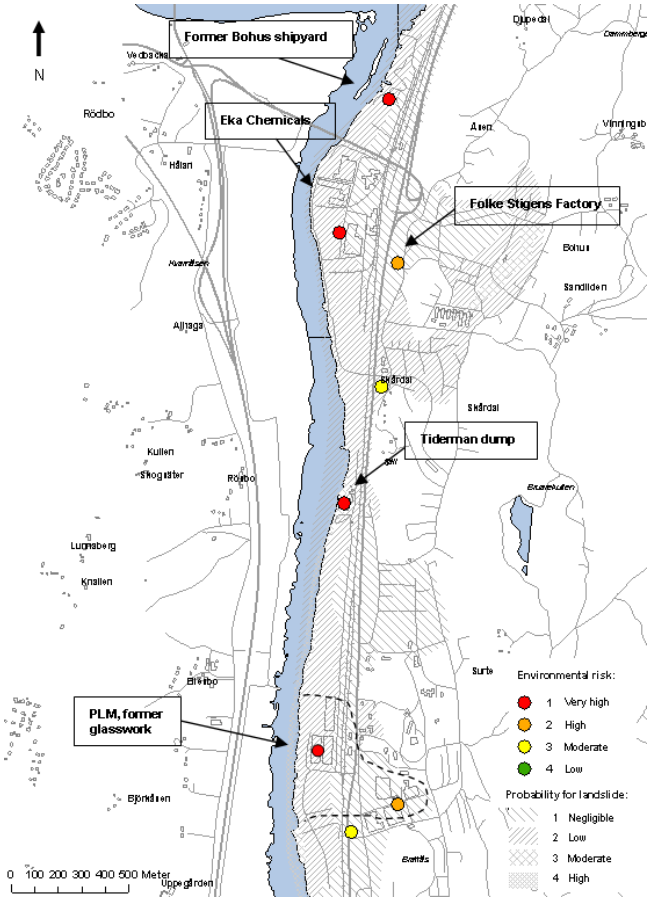
- Investigation commissioned by the Swedish Government, results:
  - 2-30 % lowering of slope stability for shallow cohesive slopes
  - ~15 % lowering of slope stability for steep sand/silty slopes



Slope safety after future erosion & increase in pore pressure

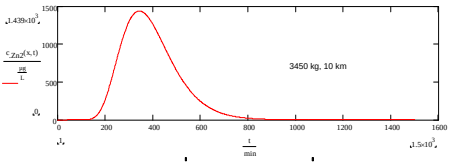


Contaminated sites at landslide risk

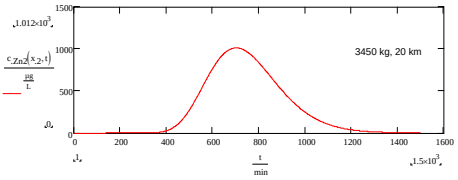


Göransson et al. (2009) *J Soils Sediments* **9**:33-45

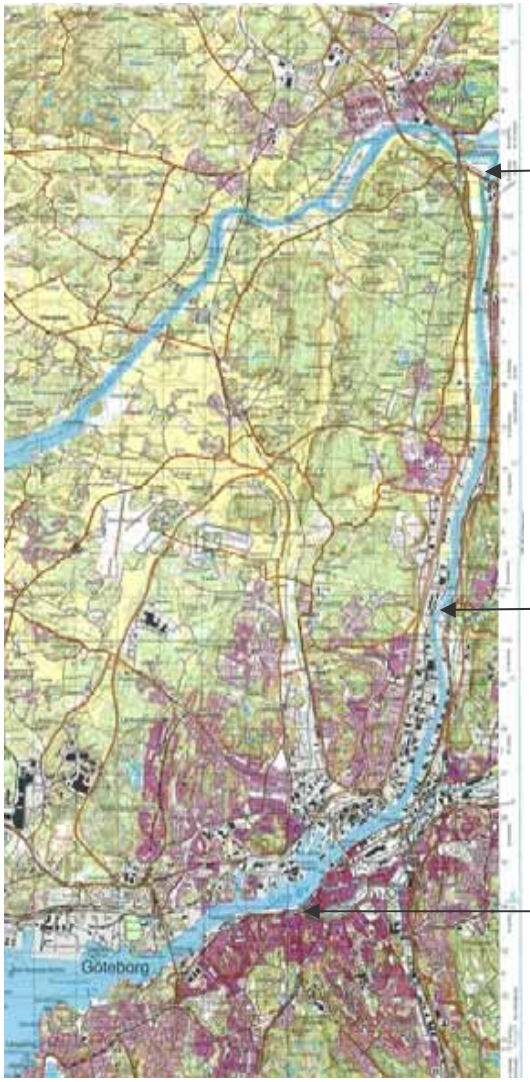
345 ton Zn in soil (also As, Pb, oil…)



Freshwater intake (10 km):
Time peak: ca 6 h
Time pulse passage: ca 12 h
Cons. peak: 1,4 mg/l



Göteborg C (20 km):
Time peak: ca 11,2 h
Time pulse passage: ca 16 h
Cons. peak: 1,0 mg/l



Instantaneous and long term effects

- Hydrodynamic consequences
- Flooding
- Damage on infrastructure
- Navigation….
- Huge amounts of sediments released
- Dredging of river and port

Expanded commission

- Basis for stability analyses
  - Flow, water levels, topography, sediment transport, land raise, maps
- Computational methods
  - FEM-analyses with non linear soil models, statistical methods, pore pressure forecasts, erosion forecasts)
- Investigations
  - Field (geotechnical, hydrogeological, environmental)
  - Lab (geotechnical, environmental)
  - Slope stability analyses (computations)
  - Slope stability mapping (field control, maps and water studies)
  - Risk analyses (choosing methodology, analyses)

- Projecting of type solutions
  - Erosion protection of shoreline (inspections, planning, stability analyses, type drawings)
  - Erosion protection of submerged slope (descriptions of work plans)
  - Embankment, silt-screen (stability analyses, design, work plan, inspection)
- Surveillance
  - Movements, erosion, inclination, pore pressure
- Maintenance
  - Erosion protection, dredging
- Presentation and data storage


A huge work we can not do alone
or
can we do it in another way?