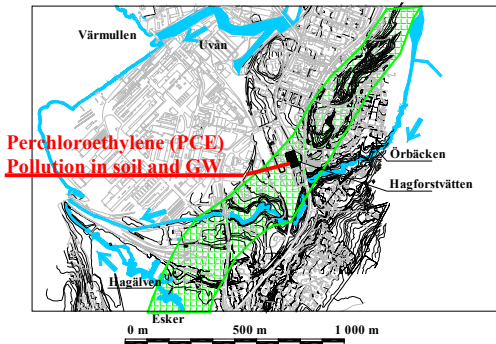


PCE remediation in Hagfors, Sweden

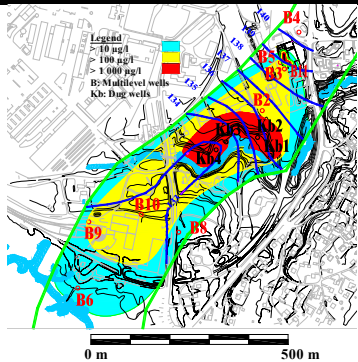
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Hagforstvädden



Groundwater pollution



Remediation conducted in Hagfors

There has been two remediation actions (in soil) in Hagfors:

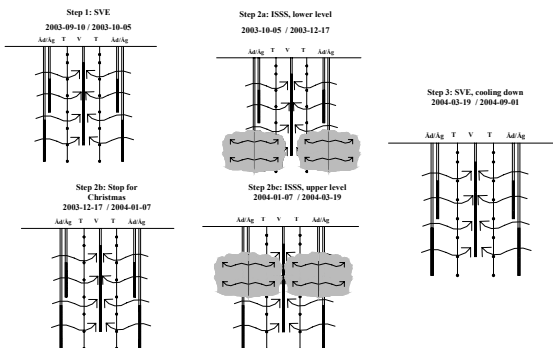
- 1996, Soil Vapor Extraction (SVE)
- 2003/2004, In Situ Steam Stripping (ISSS) (or Steam Enhanced SEV)
 - The only ISSS remediation in Sweden, and one of few in Scandinavia

No groundwater remediation has been conducted.

The plant 1995/1996 – 2003/2004



Remediation 2003/2004, cold + warm SVE



Problems

The following problems has been dealt with:

- Problem with steering of the ground water cooling pump
 - Solved by switching to continues operation
- Problem with water separation on the air ahead of the activated carbon filter.
 - Solved through rebuilding the air cooler
- Problem PCE in indoor air after start of step 2c, steam injection in the upper level
 - Adjustment of the steam injection. New SVE-well in the area of concern.
- Problem with high temperatures on the floor (60 °C)
 - No solution at hand. The worker had a leave for some weeks. Isolation of the floor had been possible- and favorable, but not easy due to traffic with heavy trucks.

Result PCE

Soil

- Soil contents up to 6 000 mg/kg TS was measured ahead of remediation
- After remediation 2003/2004 a soil sample from the most polluted area shows a content of 2 mg/kg TS. (The soil sampling was undertaken during the cooling period (about at 25 °C) and some PCE might have evaporated)
- RAO: 2,5 mg/kg TS in surface soil (proposal in the "Hållbar sanering" project)

Indoor air

- Prior to remediation tests showed 10 mg/m³ in the building and 240 mg/m³ in a badly vented area.
- During the period of steam injection 13 mg/m³ was measured (prior to the adjustment of steam injection in step 2c)
- Soon after the remediation 0,34 mg/m³ was measured (sept/nov 2004)
 - Later the readings where 0,033 mg/m³ (January 2005)
- RAO: 0,1 ppm or 0,7 mg/m³. (proposal in the "Hållbar sanering" project)

Lessons learned

- Groundwater pollution resist in spite of successful soil remediation
- PCE in GW is several mg/l. Solubility is 150 mg/l. PCE content thereby exceeds 1 % which indicates DNAPL PCE in saturated zone
- The amount of PCE transported off site in GW is of the same magnitude as the remediated PCE in soil
- It is imperative to set up proper RAOs ahead of remediation
- Welding and CHC, especially PCE - a high risk!
- The success of a remediation as complex as the ISSS remediation in Hagfors rely on adequate testing and design.

Hagfors an example in a "Hållbar sanering" project

SWECO, has, in cooperation with COWI och GeoSyntec worked with a Hållbar sanering project named: "Vägledning för efterbehandling av klorerade lösningsmedel i mark och grundvatten" (Remedial Alternatives Evaluation Process). Project leader is Peter Englöv, SWECO VIAK Malmö. Will soon be published.

- Tree remediation methods is considered applicable on PCE in soil in Hagfors
- 7 remediation methods is considered applicable on PCE in groundwater
- The different methods is weighted an the best method is washed out for soil and groundwater

Remedial action objectives (RAO) from "Hållbar sanering"

Primary RAO:

- PCE in indoor air < 0,1 ppm (= 700 µg/m³) due to risk of phosgene formation (when welding in PCE-atmosphere)

Secondary RAO:

- Reducing the concentration in shallow soils to 2,5 mg/kg TS (vegetables) in case of althering the land use to housing.
- Reducing the concentration in groundwater so that the concentration in the river Örbäcken does not exceed 3,5 µg/l (surface water)
- An RAO might concern the indoor air in houses situated over the plume. Another RAO could include the GW if drinking water is considered (Not investigated)

PCE and welding – a serious problem!

Electric welding in an atmosphere with PCE will form phosgene and trikloroacetylklorid (TCAC) in equal parts.

2 ppm PCE forms 1 ppm phosgene och 1 ppm TCAC.

TGV (A maximum tolerable level measured over a 15 minutes period of time) for phosgene is 0.05 ppm which means that 0.1 ppm should be the TGV for PCE under this conditions, and likewise the RAO

NGV (a tolerable level over a working day) for PCE is 10 ppm (100 times TGV calculated above)

