Groundwater, its treatment and protection

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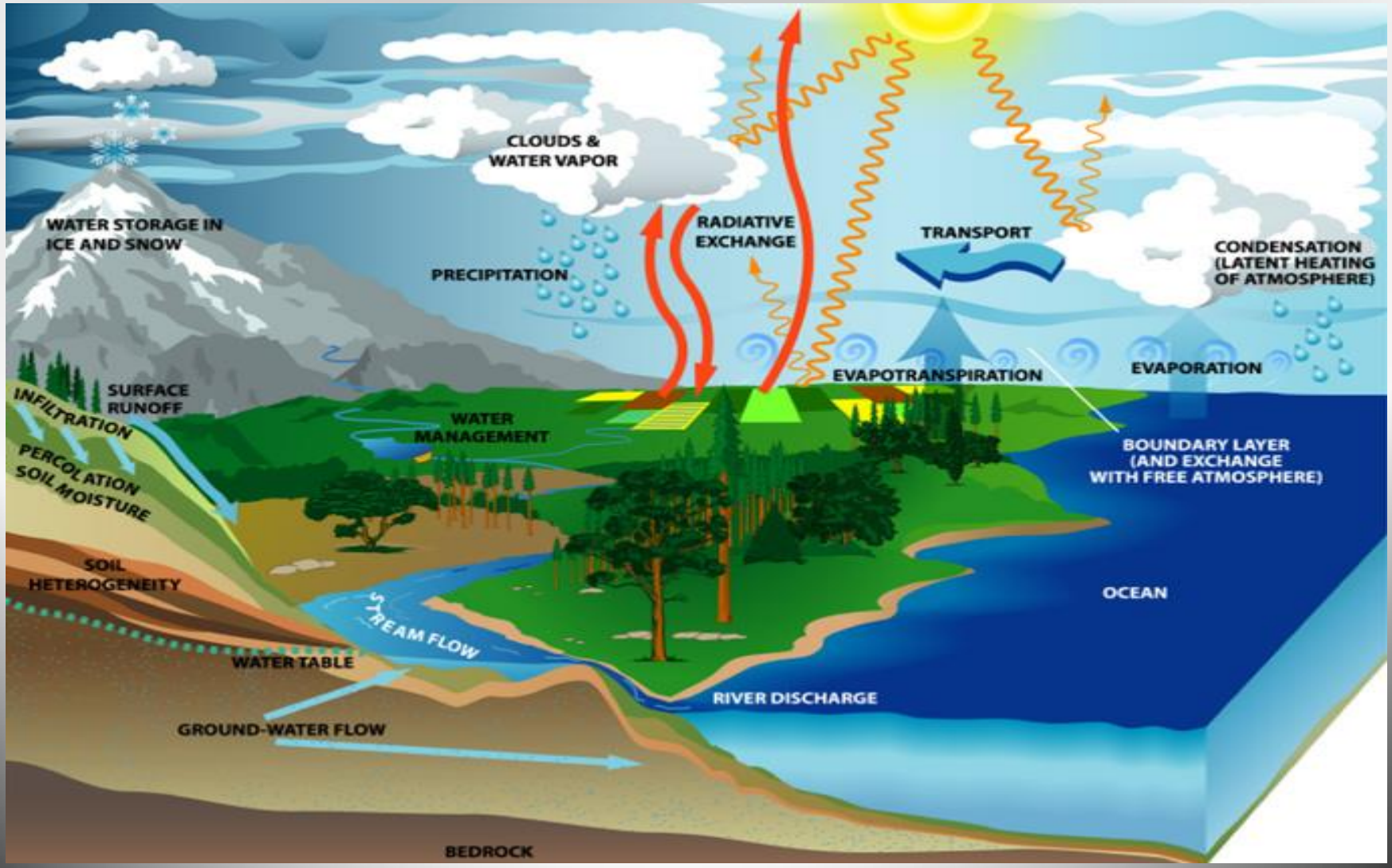
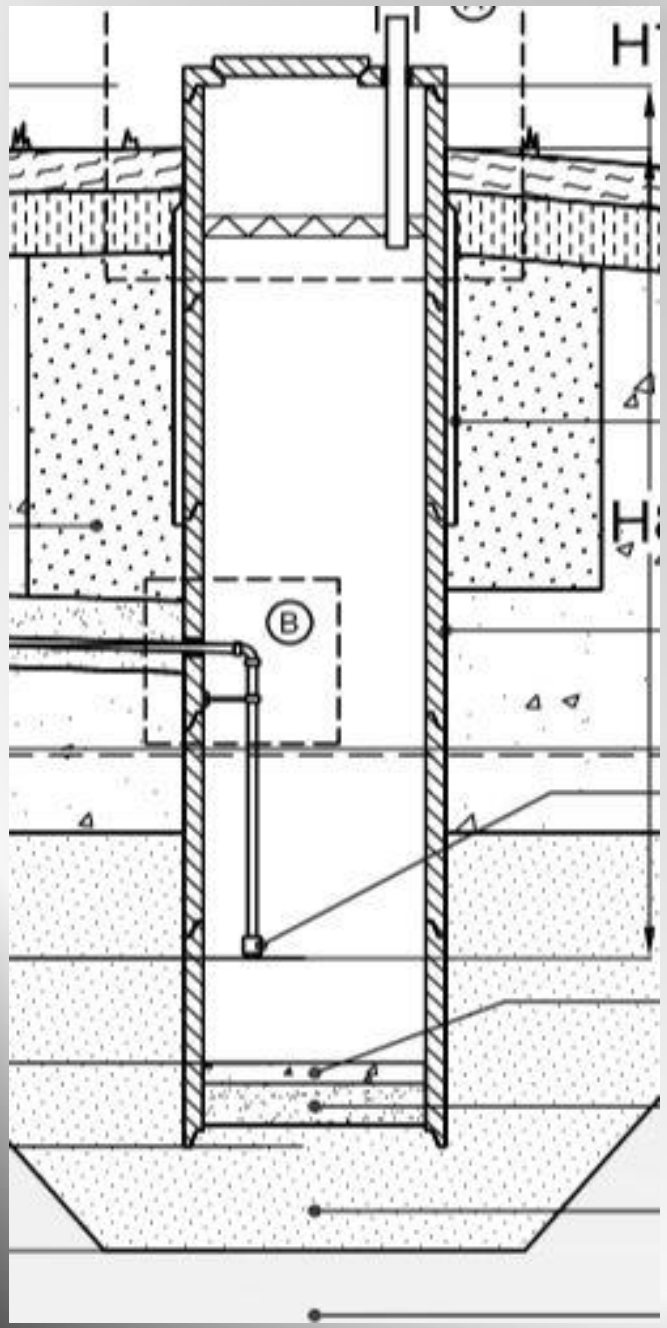
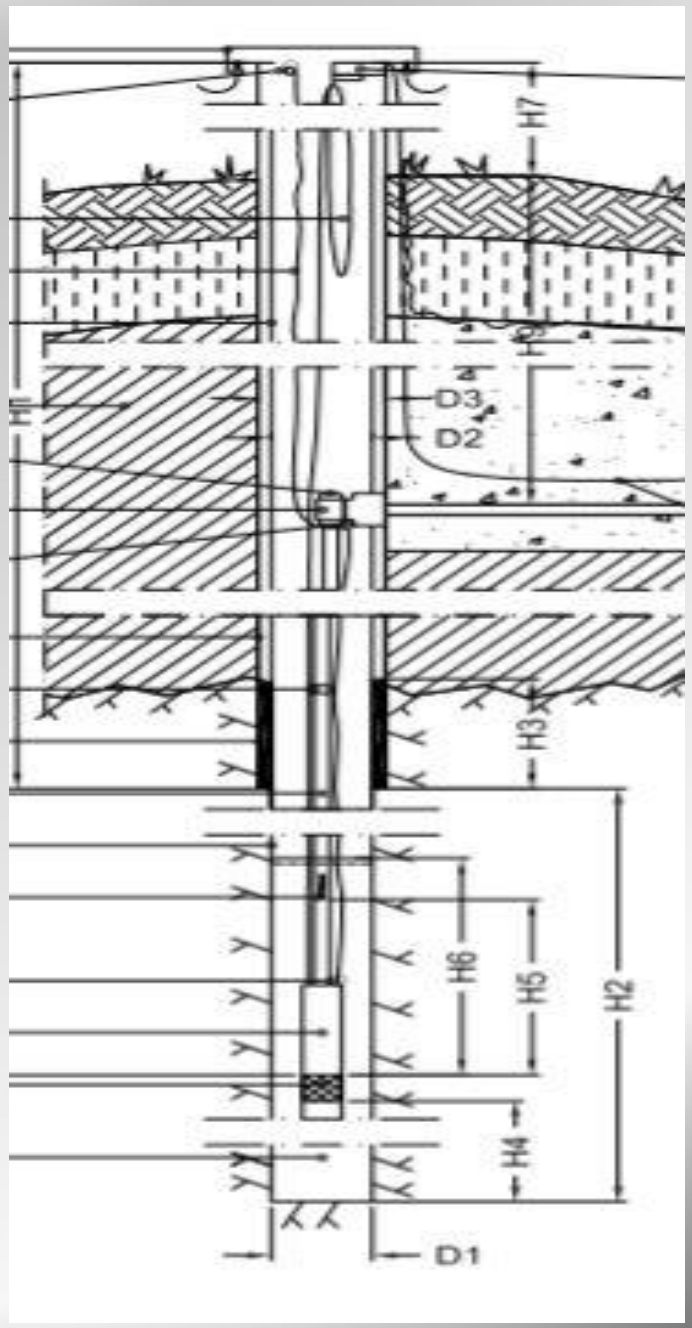
General

- **Groundwater forms only 0,53 % of all water resources (worldwide).**
- **In Finland, more than 2/3 of all raw water is groundwater or artificial groundwater**
- **Advantages of groundwater when compared to surface water:**
  - **No need for disinfection (in normal situations)**
  - **Temperature is rather constant (and low)**
  - **Little or no chemicals involved in treatment**

The hydrological cycle

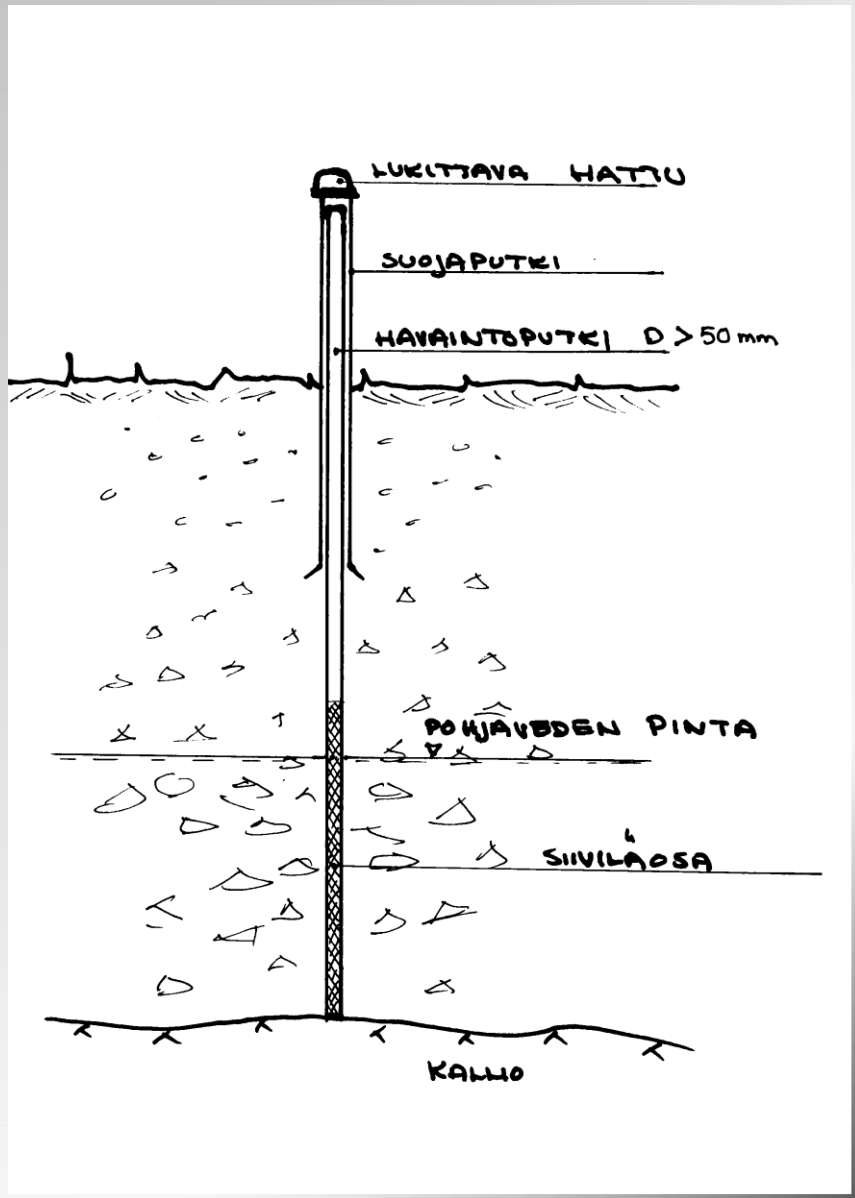



B

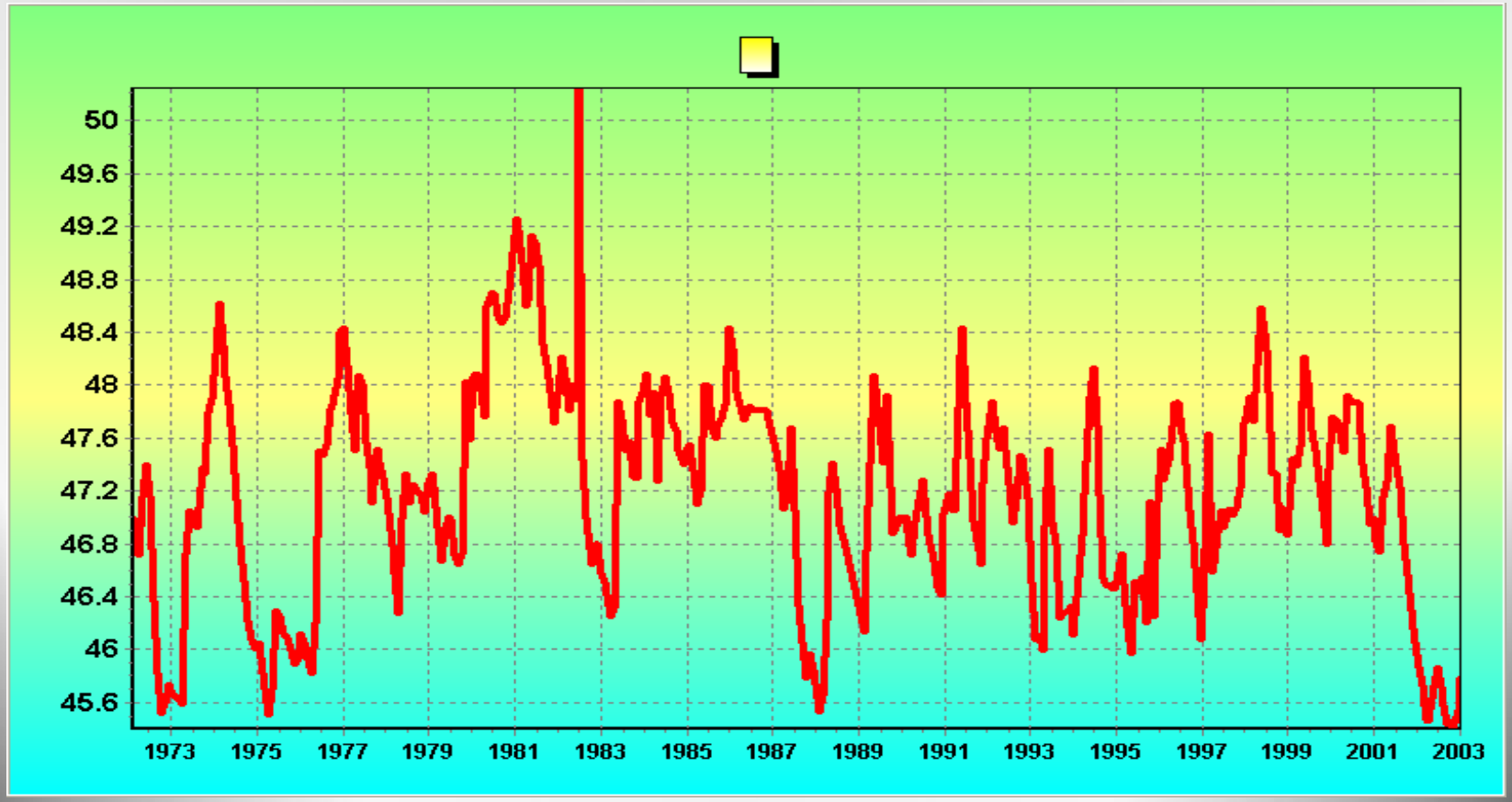

H7
D3
D2
H3
H6
H5
H2
H4
D1

Observation tube (well)

- Usually PVC pipe
- DN > 50 mm
- Screen in the depth of the groundwater layer



An example of groundwater depth variations (Tuusula, Finland)



The need for groundwater treatment

- **optimum situation: no treatment**
- **most common reason is prevention of corrosion**
- **Fe or Mn (in Finland)**
- **organic material**
- **fluoride**
- **salts**
- **radon**
- **arsenic**

pH -value

- **Depends on soil around the groundwater well**
- **Sometimes rain water can be acidic**
- **pH of groundwater in Finland is normally between 5 - 7**

Nitrate compounds

- **ammonium, nitrate, nitrite, nitrogen**
- **Very rarely in Finnish groundwaters**
- **Usually means pollution by agriculture or industry**
- **Sometimes also because of wastewater in groundwater!**

Sulfate

- **Can be diluted in groundwater for example from minerals rich of sulphur beacause of high pH.**
- **Important factor in corrosion**
- **limit 50 mg/l**

Iron and manganese

- **Most common problems in groundwater (specially in Finalnd)**
- **No health hazard – technical and/or aesthetical problems**
- **Fe < 0,2 mg/l, Mn < 0,05 mg/l**
- **Causing also sedimentation in networks and that's why harmful**

Chloride

- **Normally because of nearby sea but also because of deicing the roads in winter**
- **In nature < 10 mg/l, taste limit 200 – 300 mg/l, recommended maximum 250 mg/l, target 25 mg/l**
- **Very important factor in corrosion**

Hardnes

- **Ca- ja Mg –salts**
- **1 mmol/l = 5,6 º dH**
- **Should be 3 – 5 º dH**
- **The most interesting parameter to customers due to washing machines**
- **sometimes high also in Finland, even >10**

Aluminium

- **Can be diluted from the soil (like Fe and Mn), specially when the soil in acidic**
- **The maximum limit allowed 0,2 mg/l**

Arsenic

- **Carcinogenic, max allowed 0,01 mg/l**
- **Mainly in deep boreholes**
- **In Finland about 7% of all the deep wells are contaminated**

Boron

- **Max allowed 1,0 mg/l**
- **Is indicating pollution by wastewater**
- **Appears very seldom**

Fluoride

- **WHO: max allowed 1,5 mg/l (note, drinking water should have 0,5 mg/l)**
- **Defluoridation is considered as an expensive task => 1. change the source if possible, 2. dilute water with another one with less flouride, 3. treatment**

Copper

- **Max allowed 2,0 mg/l (an average / week)**
- **Rather seldom in groundwater**
- **Mainly because of corrosion in pipelines (green colour on basins)**

Bacteria

- **E.coli is the most important indicator**

Viruses

- **Very difficult to analyze => difficult to separate/destroy from water**

Dilutants

- **Altogether about 70 compounds**
- **Hydrogarbons, alcohols, aethers, esters, aldehydes, ketones**

MTBE, TAME

- **Additives in petrol**
- **Are diluted very easily in water => the first compounds found in case of pollution**
- **Easy to detect by smell and taste (0,03 mg/l)**

Pesticides

- **Hundreds of compounds**
- **Max allowed 0,0005 mg/l (total)**
- **The smallest amounts which can be detected are normally 0,00001 – 0,00002 mg/l**

Radioactivity

- **Mostly in deep wells (in the rock)**
- **No smell, no colour, no taste !**
- **Radon is the most common one in groundwater**
- **Max allowed 1000 Bq/l)**

=> 1. new water source, 2. treatment (aeration, active carbon filtration)

Uranium

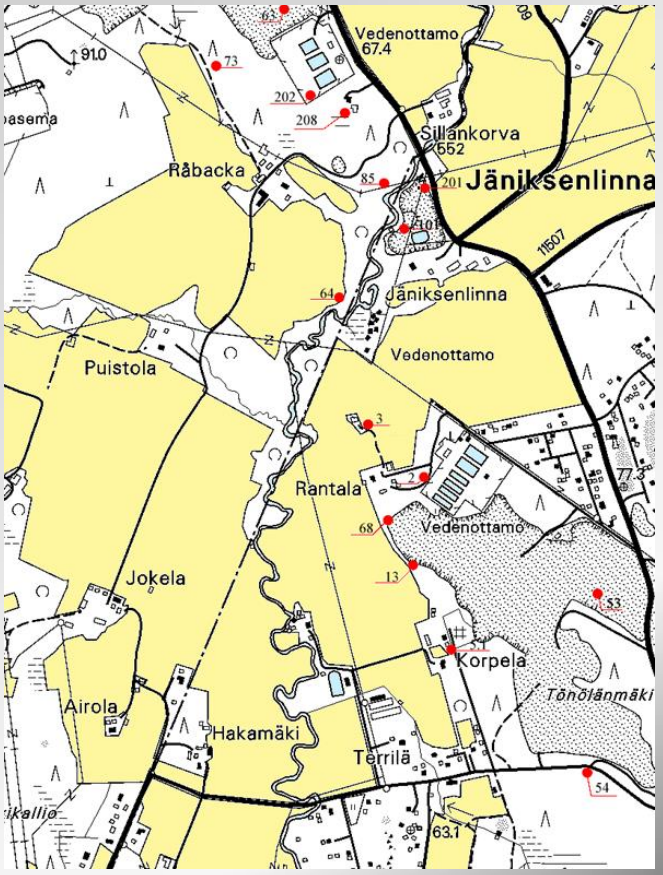
- **Lack of knowledege concerning health effects**
- **Earlier max by WHO 0,15 mg/l, today 0,002 mg/l**

Corrosion

- **pH > 7,5**
- **alkalinity > 0,6 mmol/l**
- **calsium > 10 mg/l**
- **oxygen > 2 mg/l**

Maps and aerial photographs

- **Swamps, springs, ditches, etc.**
- **Humidity changes out of photgraphs**
- **Old maps might give valuable information**



Geophysical methods

- **Seismic sounding**
- **Electrical probing (resistance)**

Drillings

- **Manually**
- **Machinery**

Iron and manganese

- **Most common quality problem with ground waters**
- **Coagulation happens immediately with ozygen**
- **Iron can be removed also biologically**

Removal of Fe and Mg

- **In small scales**
  - **aeration**
  - **sand filtration**
  - **ion exchange processes**
- **Lime stone filtration**
- **Slow sand filtration**

Slow sand filtration

- **Water is filtered slowly through a sand layer**
- **Surface load 0,05 – 0,2 m/h**
- **Water per one 1 m2: 50 – 200 l/h**
- **Iron content max 1mg/l**
- **Pretreatment could be done by a filter containing crushed stone**

Sand filtration

- **Aeration needed almost always**
- **Dissolved iron is oxidized => can be filtered out of water**
- **Surface load normally 4 – 5 m/h**
- **Small filters require backwashing more often**
- **Might be expensive ?**

UV desinfection

- **Generally, ground water is microbiologically clean**
- **Sometimes we have experienced pollution**
- **UV-desinfiction is applicable method for ground waters (no turbidity nor colour)**
- **UV-desinfection is not affecting the taste of water unlike chlorination**

- **Note: in Finland, all water utilities must prepare themselves for disinfection**

Ground water protection !