

# Thermal In-situ Remediation of the Unsaturated Zone by Steam Injection – Final Presentation –

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## Overview

- 1 Mühlacker Field Site
- 2 Objectives of the Pilot Study
- 3 Design and Operation
- 4 New Experiences with Operating Steam Injection under Difficult Conditions
- 5 Comparison Pilot Study / Conventional SVE
- 6 Conclusions



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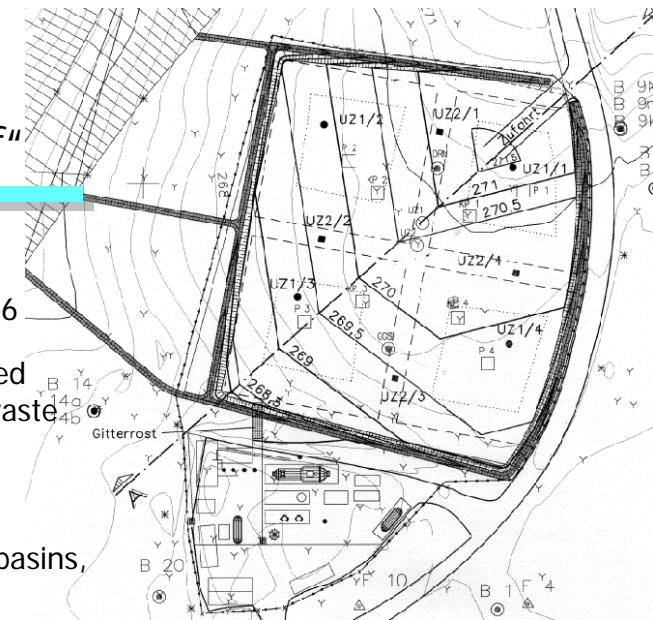


## Mühlacker Field Site



## Former Landfill „Eckenweiher Hof“

- Waste disposal site, operated 1968 to 1976
- Four earth basins, filled with local industrial waste
- Total volume about 5.400 m<sup>3</sup>
- No sealing below the basins, no drainage system



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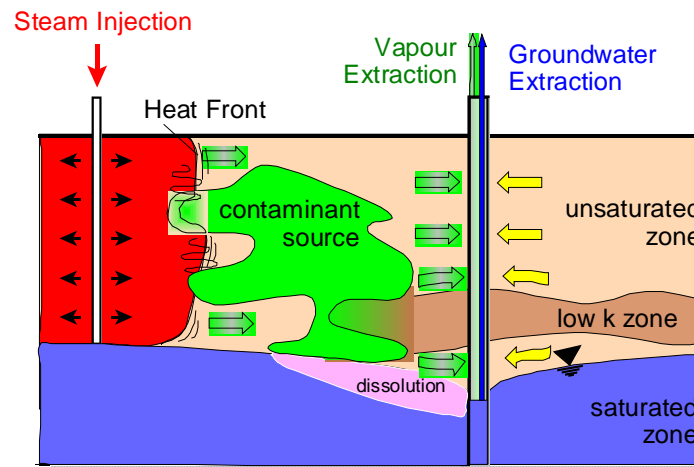
# Mühlacker Field Site



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# Difficult Condition for Steam Injection



Difficult conditions:

- Low permeability of the subsurface
- Contaminant denser than water

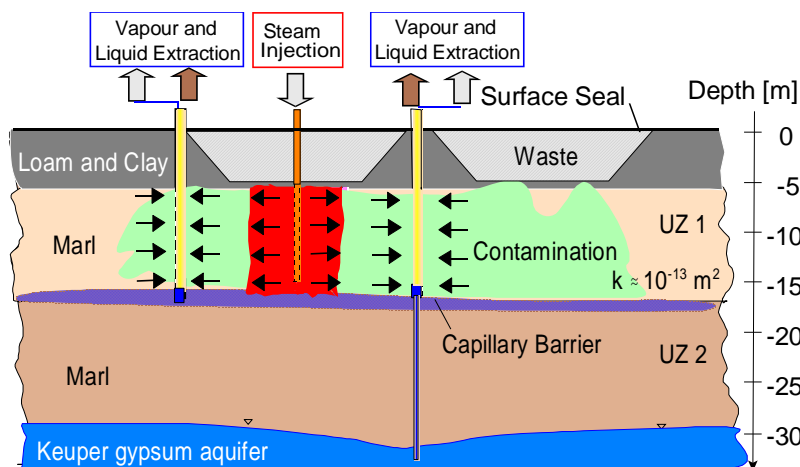


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# Mühlacker Field Site: Cross Section

- Top layer of clayey loam
- Low permeable marls up to 30 m bgs
- Perched water at soil interface



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# Site History and Situation

- **CHC = main contamination in the unsaturated zone** below a former hazardous waste disposal site
- **Unsaturated zone**
  - Two low permeable layers 30 m bgs
  - Highly contaminated area 7 – 15 m bgs
- **Technical equipment on site can be used**
  - Conventional soil vapour extraction system
  - Hydraulic P & T system running, → safety net for groundwater



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# Objectives of Pilot Study

- **Improve technical feasibility under difficult geological conditions**
  - Increase recovery of contaminants
  - Clean-up of target zone
- **Reduction of clean-up time and cost**
- **Optimization of operation**
- **Gaining data, operational parameters and experiences**



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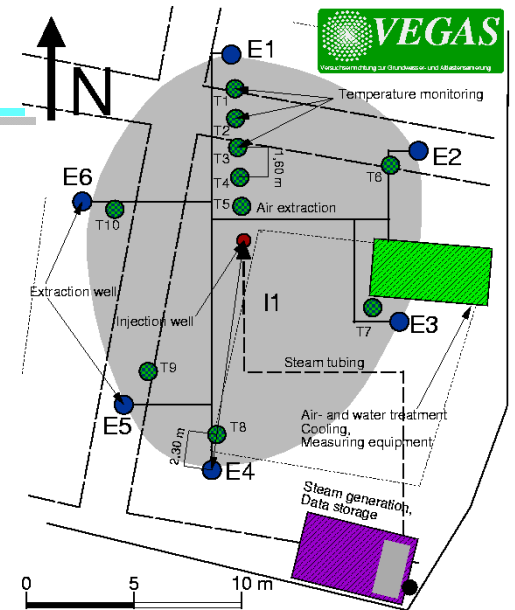


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# Layout

- One **steam injection (I1)** well in the center
- Six **extraction wells (E1-E6)** in a circle ( $\varnothing \approx 20$  m)
- **Temperature lances** down to 15 m bgs
- **Technical equipment** for SVE, steam injection, etc.



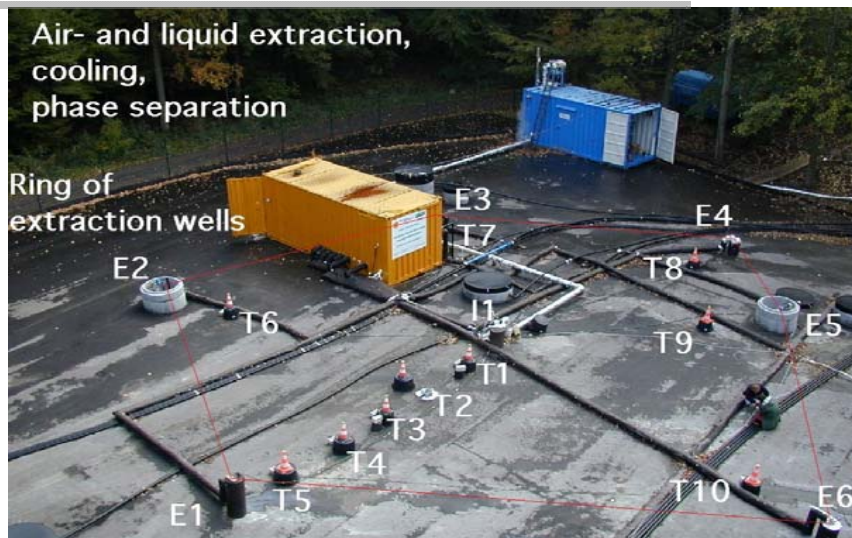
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# Top View of Field Site Setup



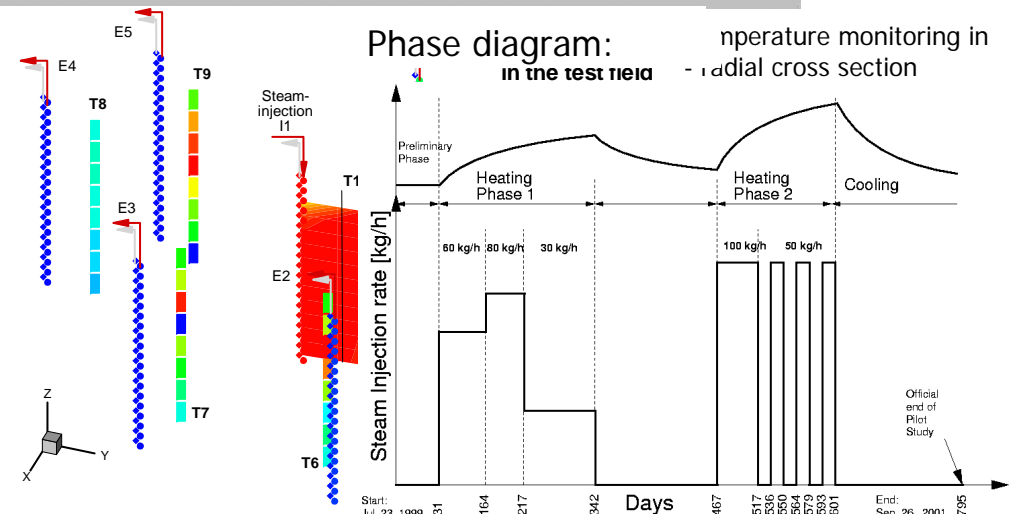
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# Phases of Pilot Study



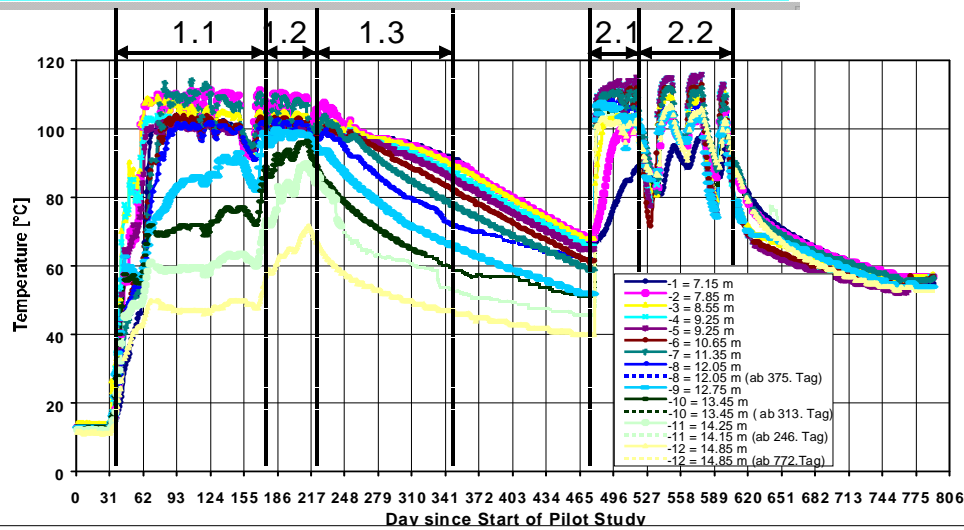
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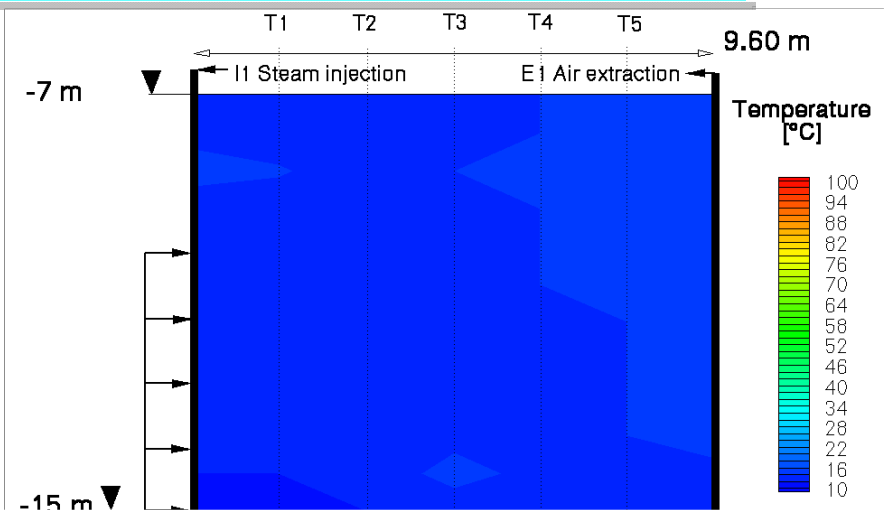
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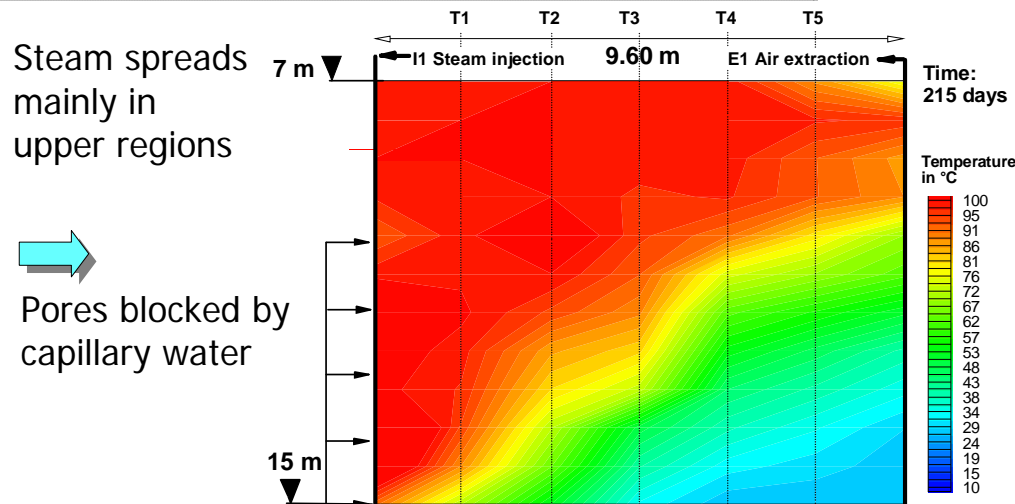
## Temperature near the Injection Well



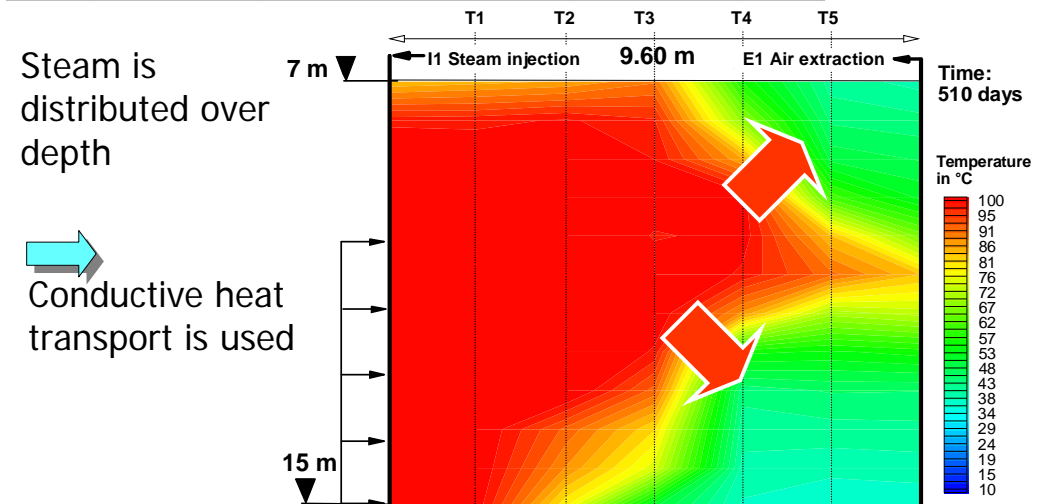
## Steam Propagation in the Subsurface



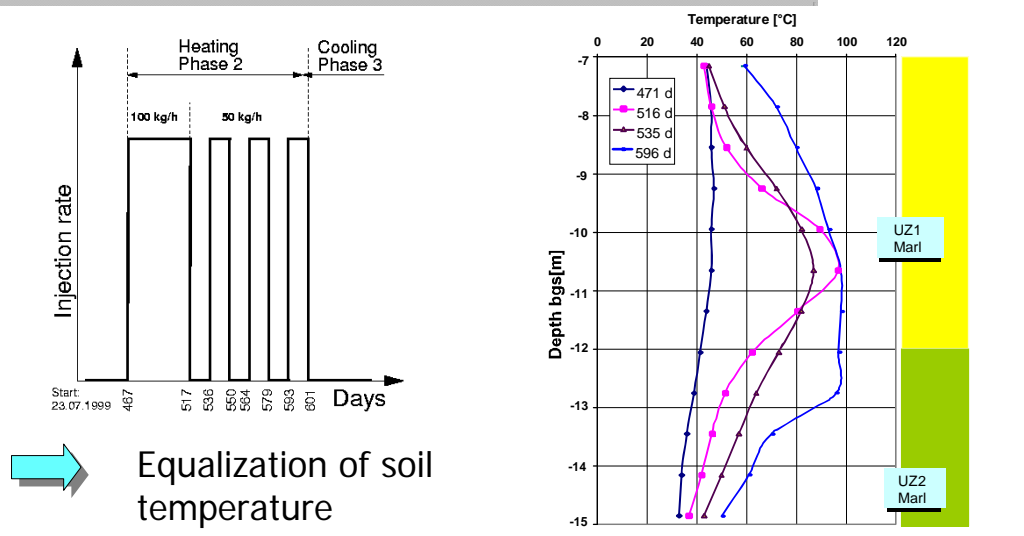
## Temperature Distribution – Phase 1



## Temperature Distribution – Phase 2



# Using intermittent steam injection



Equalization of soil temperature



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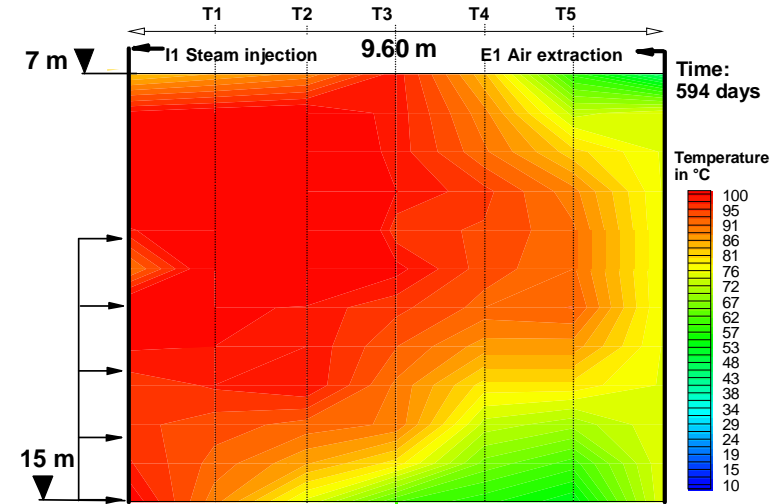
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# Temperature Distribution – End of Pilot Study

Subsurface is mainly heated above 80°C

Evaporation of TCE



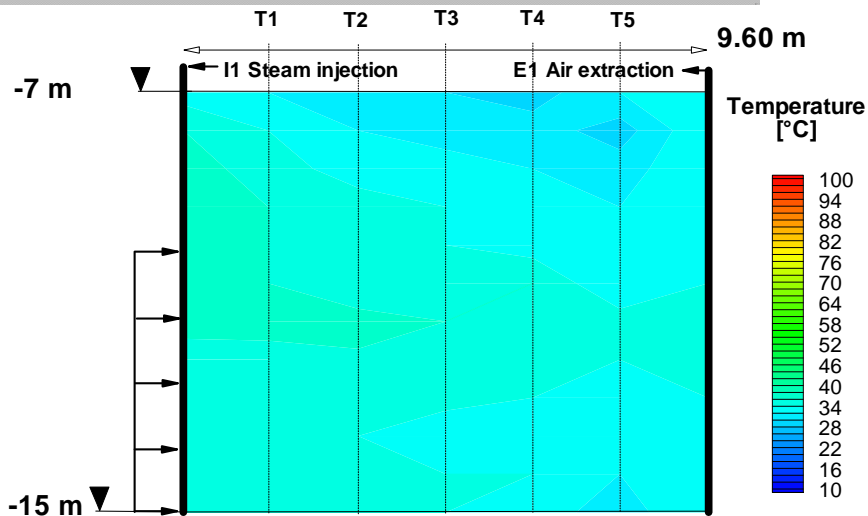
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# Temperature Distribution – August 2002



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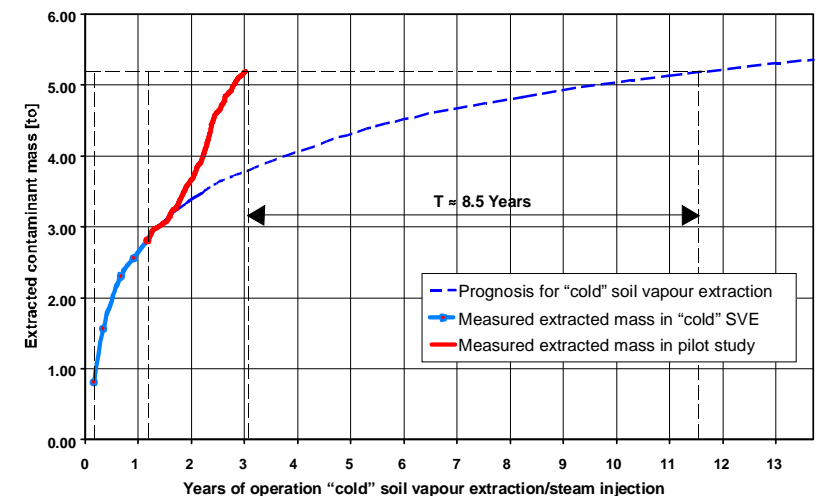


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# Comparison Pilot Study / Conventional SVE

Estimated time saving: 8.5 years



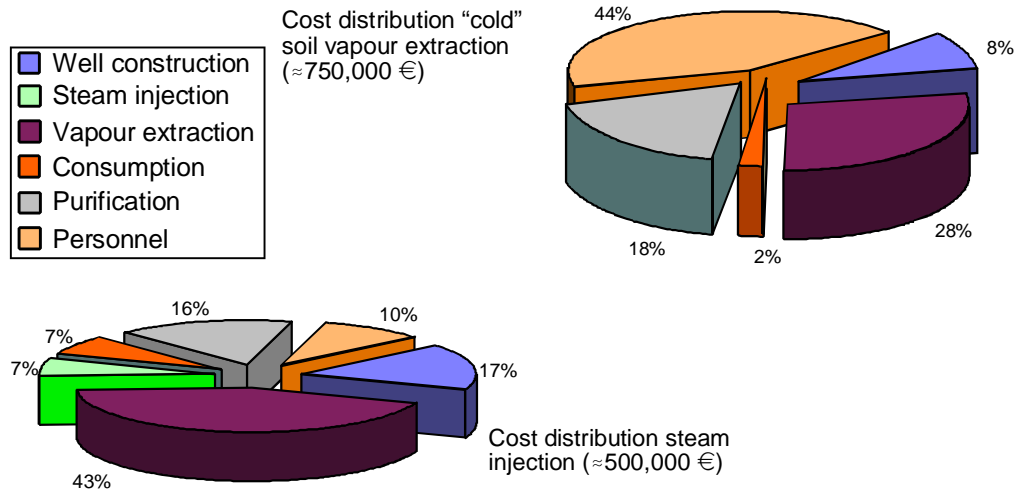
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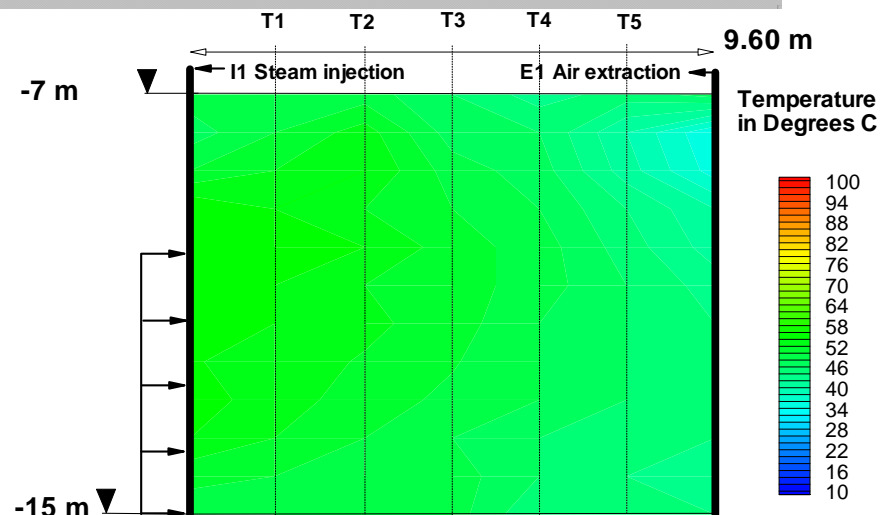
## Costs for Pilot Study / SVE



## Summary and Conclusions

- **Difficult conditions for steam injection**
  - Low permeability of the subsurface
  - Contaminant denser than water (DNAPL)
- **Measures**
  - Minimization of water input
  - Use of intermittent steam injection
- **Recent situation**
  - Cooling process not yet finished

## Temperature Distribution – Recent Situation



## Summary and Conclusions

- **Difficult conditions for steam injection**
  - Low permeability of the subsurface
  - Contaminant denser than water (DNAPL)
- **Measures**
  - Minimization of water input
  - Use of intermittent steam injection
- ➡ Economic remediation of 2.8 tons of TCE under difficult conditions was possible ✓

The End

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Thanks for your attention

Any questions ??



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