Challenge

In a residential area in Reerslev, Denmark a vast mass of contamination of Tetrachloroethylene (PCE) was found. A considerable hot spot was situated in an 8-10 m thick layer of impermeable clay till. The contamination caused a serious risk to the local groundwater resource, one of the most important in Denmark, supplying water to 50,000 homes in the Copenhagen metropolitan area. To prevent further spreading of the contamination, a soil vapor extraction (SVE) system was installed in the unsaturated zone of a high-permeable sand layer beneath the clay, combined with a pump and treat (P&T) system in the underlying shallow aquifer.

The motivation for remediating the hot spot was to considerably shorten the operation period of the SVE and P&T systems. Given the yearly flux of contamination migrating from the hot spot, the timeframe for these activities was estimated to be in the order of 100 years or more. To obtain an acceptable time frame for the operation period for the SVE and P&T systems, all dense non-aqueous phase liquids (DNAPL) had to be removed and soil concentrations in the clay layer had to be reduced to a maximum of 1 mg/kg.

The hot spot contamination was situated in a residential area with single-family houses and beneath an existing graveyard adjacent to a church. These circumstances combined with some very complicated geotechnical conditions made excavation both economically and ethically unsuitable.

Solution

To ensure an effective removal of DNAPL, 147 heaters were placed from ground level and down to 10-12 m, corresponding to at least 2 m deeper than the hot spot contamination in the whole treatment area.

The treatment area, including the graveyard area and one of the front gardens, was covered by an insulating vapor cap. Beneath the vapor cap, horizontal venting drains were installed to secure pneumatic control and effectively collect the evaporated contamination during the heating period. Moreover, the existing SVE system supported by some additional venting wells in the underlying unsaturated zone was maintained during the whole treatment period.

In spite of some very sensitive circumstances regarding six grave sites, the relatives accepted the remediation to be completed. To ensure proper re-establishment the grave sites were carefully recorded and registered by photo documentation before any work was initiated. To reduce the disturbance of the neighbors, one of the implicated families were temporarily re-housed during the treatment period.

Heating started in June 2009 and ended in November 2009. The treatment period was 169 days and the target temperature was 100 °C.

Key facts

- Contaminant: PCE
- Recovered mass of PCE: 2.350 kg
- Treatment area: 1.300 m²
- Treatment volume: 11.100 m³
- Depth of treatment zone: 10-12 m
- Geology: Glacial till
- Location: Residential area/graveyard

For further information:

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Results

By the end of the heating period, 28 soil samples were taken to document the effect of the remediation.

- 23 soil samples were below the detection limit
- Average post-treatment concentration: 0.012 mg/kg
- Maximum post-treatment concentration: 0.057 mg/kg

### Key facts

- **Number of heater wells:** 147
- **Target temperature:** 100 °C
- **Remediation target:** 1 mg/kg
- **Heating period:** 169 døgn
- **Avg. end concentration:** 0.012 mg/kg PCE

### Client

- **Capital Region of Denmark**

### Consultant

- **NIRAS**

### Contractor (ISTD)

- **Krüger A/S**

### Contractor (drilling, pipes and vapor cap)

- **Zacho-Lind**

### Energy balance

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume, total</td>
<td>11,100 m³</td>
</tr>
<tr>
<td>Power input</td>
<td>900-1,200 kW</td>
</tr>
<tr>
<td>Total energy</td>
<td>3,990,000 kWh</td>
</tr>
<tr>
<td>Total energy/m³</td>
<td>342 kWh/m³</td>
</tr>
<tr>
<td>Energy extracted</td>
<td>895,000 kWh</td>
</tr>
<tr>
<td>Average temperature within TTZ</td>
<td>100 °C</td>
</tr>
</tbody>
</table>

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