Presentation

Advanced In Situ Remediation Technologies in The Netherlands

Yvo M.M. Veenis
Managing Director Groundwater Technology BV
Yve@gtbv.nl
www.gtbv.nl
Introduction

Three Topics

1. Historical Overview
   - In Situ Remediation in The Netherlands
2. Site Soil Management
   - Interlinked with technology
3. Technologies
   - Phased & multi/technology implementation
   - Chemically enhanced degradation
   - Heat enhanced extraction
<table>
<thead>
<tr>
<th>Period</th>
<th>Events</th>
</tr>
</thead>
</table>
| <1970     | 1875: Nuisance Act  
           | 1928: Natural Beauty Act                                               |
           | 1979: Lekkerkerk                                                      |
           | 1986: Soil Protection Act (calls for remediation-to-natural-background, fixed concentrations) |
| 1990 – 2000 | 1993: Mandatory Assessment Industrial Sites  
                        | Assessment results may lead to remediation  
                        | 1997: Change of policy-implementation: pragmatic risk & cost based remediation |
| 2000 - present | 2001: Pragmatic approach implemented in guide lines  
                           | Number of authorities from 16 to 50+  
                           | 2003: Soil Protection Act (revised), implementing pragmatism |
Lessons learned

• Initial legislation was far too strict: clean-up levels unattainable at reasonable costs => remediation delayed. Typically, only excavation could achieve results

• Pragmatic implementation: opportunities for in situ, but closure criteria not pre-negotiable

• Pragmatic legislation: maximum ‘return on investment

• The most mobile factor in soil contamination is legislation
Site:
Medium size refinery, > 100 hectares
Started on pristine land
50+ years of operation
Significant ‘buried treasures’
Costs of full remediation: economically suicidal
<table>
<thead>
<tr>
<th>Layer</th>
<th>Top Elevation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>+5 msl</td>
<td>Made ground</td>
</tr>
<tr>
<td>L2</td>
<td>0 msl</td>
<td>Clay, old grade level</td>
</tr>
<tr>
<td>L3</td>
<td>-2 msl</td>
<td>Sand, silt &amp; clay</td>
</tr>
<tr>
<td>L4</td>
<td>-12 msl</td>
<td>Silt &amp; Clay</td>
</tr>
<tr>
<td>L5</td>
<td>-15 msl</td>
<td>Sand, silt &amp; clay</td>
</tr>
<tr>
<td>L6</td>
<td>-23 msl</td>
<td>Peat &amp; Clay, basis of Holocene</td>
</tr>
<tr>
<td>L7</td>
<td>-25 msl</td>
<td>First Aquifer (sand)</td>
</tr>
</tbody>
</table>
Site Soil Management Plan

Covers three levels:

• Agreement on Strategic approach next decades
• Live Atlas

• Implementation Plan for:
  • Shallow Soil Remediation
  • Containment deeper mobile contamination
  • Monitoring deep contamination
  • Procedures for future issues
  • Internal contaminated soil management
Implementation Plan for:

- Procedures for future issues
  - Dealing with new spills
  - Define risk-based approach to set future remediation goals

- Shallow Soil Remediation
  - Active remediation (in situ/ex situ)
  - Co-ordinate with (future) developments

- Internal contaminated soil management
  - Dealing with health & safety issues (dig-safe procedures)
  - On site Soil treatment (Biopile)
Implementation Plan for:

• Containment deeper mobile contamination
  • Monitored Natural Attenuation where possible
  • Active In Situ remediation where necessary

• Monitoring deep contamination
  • Monitored Natural Attenuation only

• Long term possibility:
  • Development of regional deep soil management entity
  • Overlapping multi source/multi site/multi ‘owner’ issues
  • Region-wide groundwater contamination
Technologies:

• New releases
  • Excavation where possible (within hours)
  • Active In Situ remediation

• Shallow
  • Excavate when redeveloped
  • In situ when moving off-site

• Deep:
  • Exploite nature’s remediation capacity
  • MNA
1. Massive benzene spill (600 m³)
2. Spill response
3. Heat Enhanced Remediation
Case Benzene spill

Spill of 600 m3 Benzene floods tank pit in just 2 hours at 18:00 hours.

- Disaster Plan put in action
- Regular operations terminated
- Explosion & High Exposure risks
Case
Benzene spill

Immediate Actions:

• Blanket area with triple-F foam
• Recover free standing product
• Cover Soil with sheeting
• In Situ remediation install started (operational in 2 weeks)
Case

Benzene spill

Technologies used:

• > 100 well High-vacuum multi-phase extraction (vapour, product & water)
• Biodegradation
• Vapour treatment via site vapour recovery unit.
• Enhanced Natural Attenuation (oxygen (gas), perchlorate & nutrients)
Results

Benzene spill

Initial 13 months
Results:

• 2 days: operations restored
• 2 weeks: remediation started
• 2 years: 99.something% of mass removed (residual mass < 500 kg)
• Enhanced Natural Attenuation (oxygen (gas), perchlorate & nutrients) to remove residual traces
Case
Leaking tank

- Tank bottom membrane failed
- Product spilled into tank mound, LNAPL on groundwater under tank
- Flamable & Toxic

Solution:
- Fix tank bottom membrane and operate tank
- Install remediation system underneath
- Operate (lump-sum-to-closure)
Case
Leaking tank
Results:

• Operations without incident

• After nine months: concentrations in extraction system and in soil & groundwater next to tank below detection

• Project closure applied for 7 months ahead of schedule

• (formal closure anticipated in a few months)
Case Leaking tank

Technologies used:

• Hi-vac, multi-phase extraction (extraction of vapours: promotes volitilization, enhancing biodegradation; extraction of liquids

• Gas/liquid separation

• No-dig installation under operating tank

• Liquid: Oil/water separation: water to site sewer system

• Catox vapour treatment
1. Diesel Fuel at Storage Depot
   - At start: free product
   - 4 months operation medium temperature, 2 months hot
   - After 6 months: 10,000 kg removed; residual TPG in soil < 750 mg/kg
     (<560 ug/l in groundwater)

2. Creosote L/DNAPL at railroad sleeper yard
   - At start: free product
   - 1 month Pump & Treat: <0.3 kg removed
   - 1 month heat enhanced remediation: 3000 kg removed

3. Gasoil (diesel type) at storage facility
   - At start: free product (>1 m in wells)
   - 2 months heat enhanced remediation: > 2500 kg removed
   - No detectable residual contamination
System Lay-out
Creosote L/DNAPL

injection point

injection point

injection point

injection point

injection point

injection point

injection point

injection point
Pilot project:

- 1 month pump & treat: 0.3 kg product removed (dissolved phase)
- 1 week steam injection: entire test area hot
- 1 month steam injection: 3000 kg removed
- Residual concentrations not determined
LATEST ‘Hot and Cooking’

Issue:

• Site (source zone 200 * 50 m, 5 m deep) contaminated with chlorinateds, non-chlorinateds, pesticides and other assorted nastinesses . . .

• Concentrations in soil: sky high, concentration of water in product < 50%

• Site in use as loading facility major chemical distributor

• Window of opportunity to install remediation scheme (three small areas accessible)

• Remediation technology unknown (but system must be capable of pump & treat, sparging, hi-vac extraction, ISCO, Enhanced anaerobic degradation, heat-enhanced extraction and must remain operational for minimum 15 years)
Our Solution:

• Horizontal wells, 5 lengths of 200 m each

• Wells & casing custom built from INOX 18/10 steel, 100 mm diameter, 0.2 mm continuous slot, in 6 m sections

• Installed in horizontal, directionally controlled borings

• Borings installed underneath fully operational facility, navigating through a maze of concrete vertical pilings

• Borings used BioBore as supporting mud. Spent Biobiore (not re-used) contained > 1,000,000 ug/l chlorinateds.
Groundwater Technology is interested to discuss opportunities for working together with one or more Canadian firms.