Implementing ISCO on an industrial EX-rated site
Contents

• Site / Pollution
• Remediation Plan
• Results phase 1
• Phase 2 (tank yard)
• Conclusions
VOPAK Terminal ACS, Antwerp harbour
Pollution situation – Feb 2011

Groundwater concentrations

- **PCE** ~ 36 mg/L
- **TCE** ~ 8 mg/L
- **DCE** ~ 28 mg/L
- **VC** ~ 4 mg/L
- **1,1,1-TCA** ~ 342 mg/L
- **1,1-DCA** ~ 143 mg/L
- **BTEX/TPH** > 100 mg/L
Defined remediation target concentration levels for groundwater (µg/L)

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<thead>
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<tbody>
<tr>
<td><strong>Chlorinated ethenes</strong></td>
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<tr>
<td>PCE</td>
<td>400</td>
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<tr>
<td>TCE</td>
<td>700</td>
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<td>DCE</td>
<td>500</td>
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<tr>
<td>VC</td>
<td>50</td>
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<td><strong>Chlorinated ethanes</strong></td>
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<tr>
<td>1,1,1-TCA</td>
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<td>1,1-DCA</td>
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<td><strong>BTEX</strong></td>
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<td>Benzene</td>
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<td><strong>Petroleum hydrocarbons</strong></td>
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<td>C5-C8</td>
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<td>C8-C10</td>
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<td>C10-C40</td>
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Installed remediation system

LEGEND

ISCO injection point
MPE well
Excavation (~585 T)
Extraction unit
SVE hor.drains
SVE hor.drains (sec. series)
Ozone / peroxide injection

2 \( \text{O}_3 \) + \( \text{H}_2\text{O}_2 \) → 2 \( \text{OH}\cdot \) + 3 \( \text{O}_2 \)  
(Hydroxy-radical)

\( \text{OH}\cdot \) = 2.86 V  
\( \text{O}\cdot \) = 2.42 V  
\( \text{O}_3 \) = 2.07 V  
\( \text{H}_2\text{O}_2 \) = 1.78 V  
\( \text{O}_2 \) = 1.23 V  

Very high oxidation power!
Pollution situation – Feb 2011
Pollution situation – Dec 2014
Monitoring well results

- sum chloroethenes
- sum chloroethanes
- sum BTEX
- sum TPH C5-C40

Graphs showing concentration over time for wells P483 (1.5-3 mbgl), P464 (0.5-2.5 mbgl), and P463 (0.5-2.5 mbgl), with date ranges from 18-10-10 to 2-3-14.
Monitoring well results (2)
Remediation phase II – Tank Farm
(March 2015 - )
Avoid ozone emissions (corrosion of the installations/infrastructure)

- Discontinuous air injection (2 Nm³/h/filter; 2 min on /16 min off)
- SVE continuously operational (rate 58x rate air injection)
- PID, LEL, O₂ and O³ measurements in SVE influent air and monitoring wells
- Pressure in observation wells (tank bases)
- Leaks detection (visual and PID)
- Ozone/peroxide (50 g O₃/h + peroxide 7% 120 mL/min)

Phased start-up!

Subsidence monitoring of solvent tanks 68 and 70
Consumables
Results

- Ozone emissions
  - Concrete floor repaired
  - Soil air monitoring wells
  - Well sealings at ground level
  - SVE influent

- No subsidence detected

- Estimated pollutant mass removed:
  - ~ 5 - 10 ton by excavation
  - ~ 1 ton by MFE/SVE
  - ~ 1 ton by ISCO
Thank you for your attention!

Questions?

EU Life+ “VOPAK-EXPER03”