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Application of Thermally Enhanced Soil Vapour Extraction to Remediation of the Unsaturated Zone at the Western Storage Area (WSA), Harwell

Anna-Maria Kozlowska
Senior Engineer

AIG Engineering Group

Western Storage Area – Background

- Former Disposal Pits now removed
- Residual suite of VOCs & hydrocarbons in unsaturated zone of Chalk up to c. 25m bgl
- UKAEA objectives: target contaminants, reduce loading significantly & minimise emissions
- Pilot Trial - Design & configure remediation evaluating multiple techniques
- Undertake phased remediation as better suited to UKAEA's annualised funding arrangements

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Pilot Trial Objectives

- Site characterisation to gain **current** data on unsaturated zone contamination profile

- Test Soil Vapour Extraction (SVE) technology application

- Examine:
  - ➔ Conventional SVE
  - ➔ Targeted depths
  - ➔ Assistance of air/ozone sparging
  - ➔ Thermal enhancement

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Pilot Trial Conclusions

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Remediation Techniques

Un-enhanced SVE	Focussed SVE	Air/Ozone Sparging	Thermally Enhanced SVE
Conclusions			
• Reasonable recovery rates achieved	• Limited benefit due to variable distribution of contaminants • No significant increase in radius of influenced • No significant increase in Mass Removal Rate	• No increased volatilisation or apparent mobilisation observed • No significant increase in mass removal	• Significant Increased contaminant mass removal rate • Significant increase in radius of influence • Increase in contaminants mobilisation & volatilisation • Displacement of NAPL • Increased dissolution and desorption of contaminant mass in extracted water

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Pilot Trial Recommendations

- Recommended that full scale remediation of the unsaturated zone is undertaken within the WSA comprising the following:
  - ➔ SVE across the central part of the site in the vicinity of the former chemical waste disposal pits.
  - ➔ Thermal enhancement of the SVE in areas of gross contamination beneath the footprint of the most severely contaminated disposal pits, including Pit Nos. 2, 3 and 18 in the north western part of the WSA.

Phased Remediation Works

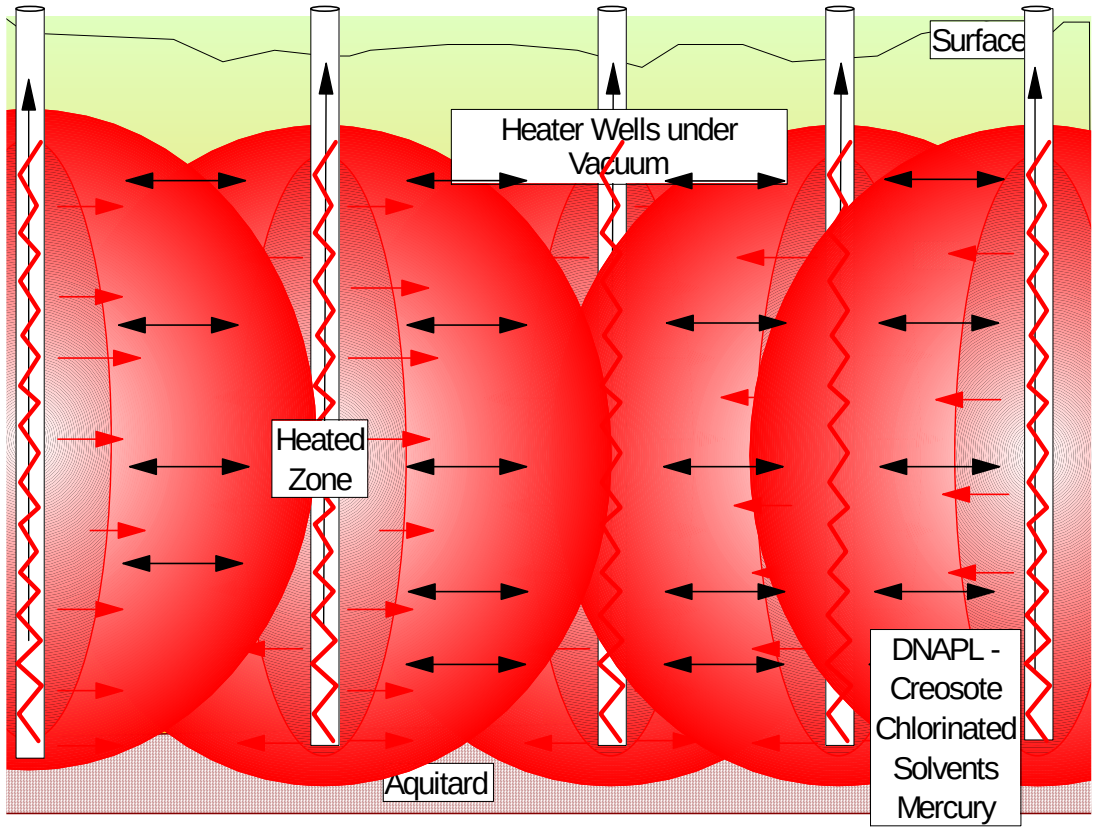
- Phased remediation focussed on pit areas and intermediate zones commencing in the most highly impacted
- Progressive broad-scale SVE from a network of extraction wells targeted at depths from 6m bgl to 20m bgl
- Hexagonal spacing of 3m in and around pit locations
- Heating of the highly contaminated zone beneath pit areas at depths between 5m and 15m bgl

What Happens on Heating?

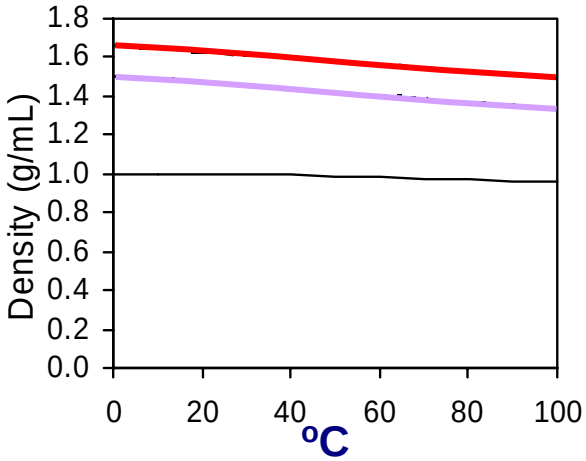
- As heat is transmitted into soil/rock various processes can occur to enhance contamination removal:
  - ➔ Vapour pressure of organic materials increases
  - ➔ Viscosity of separate-phase liquids decreases
  - ➔ Diffusion rates and solubility increase
  - ➔ Abiotic degradation rates (eg oxidation) increase
  - ➔ Biological degradation rates increase

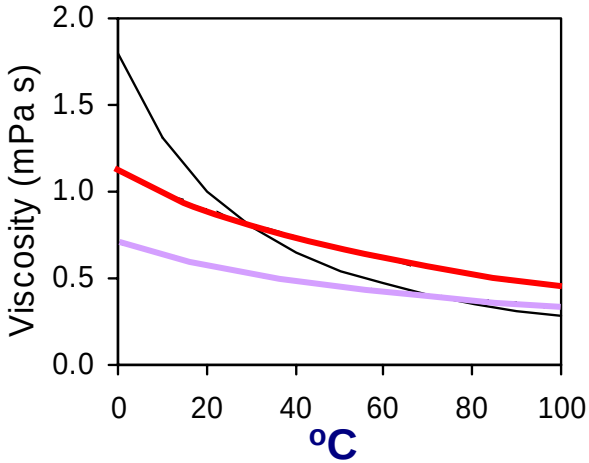
Thermal Conduction Heating

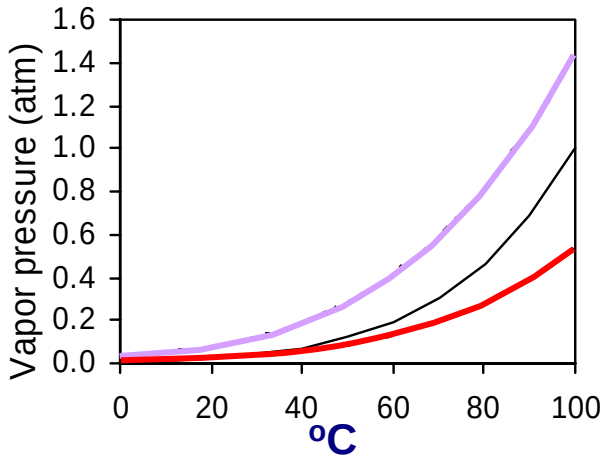
- **High** remediation **Efficiency**
- Effective in highly **Heterogeneous Formation**
- Very **controllable**
- Very **High Operating Temperature** - thermal destruction
- TTZ under **Vacuum** - **Migration** of mobilised **Contaminants Limited**

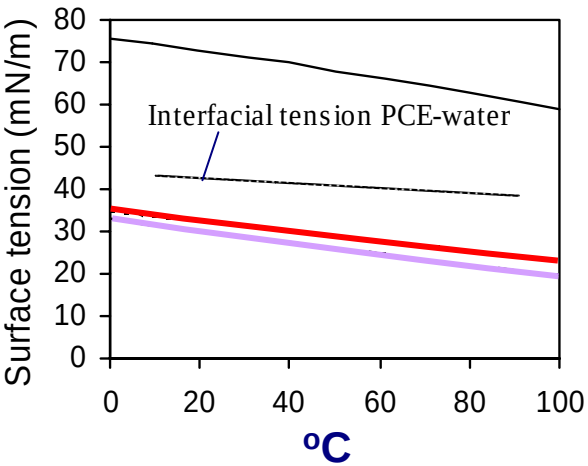


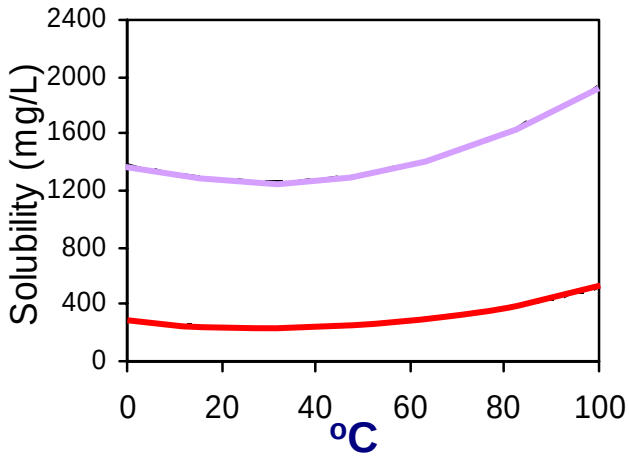
Physical Properties of TCE and PCE

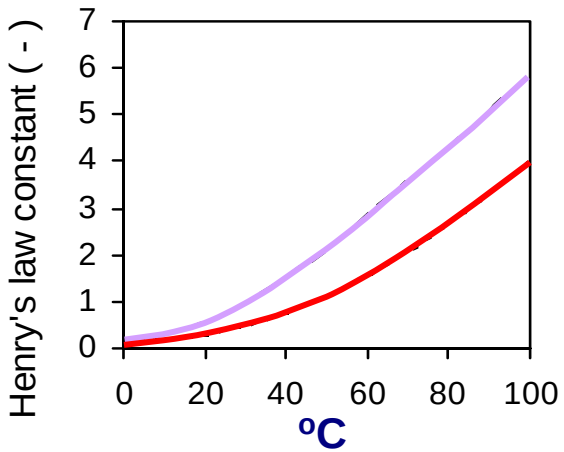












Water

TCE

PCE

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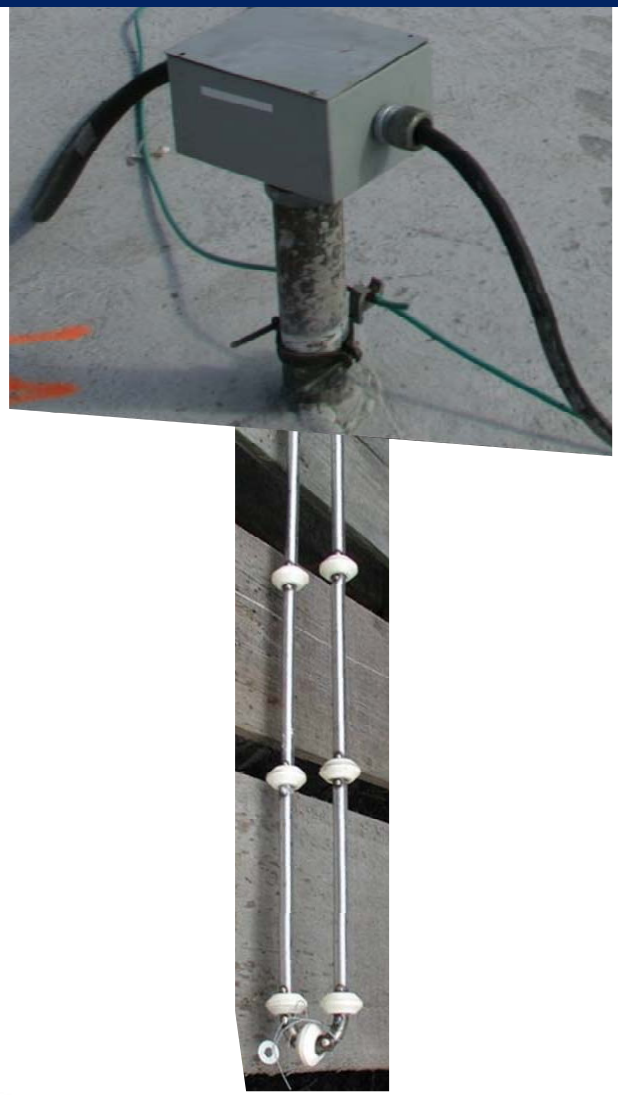
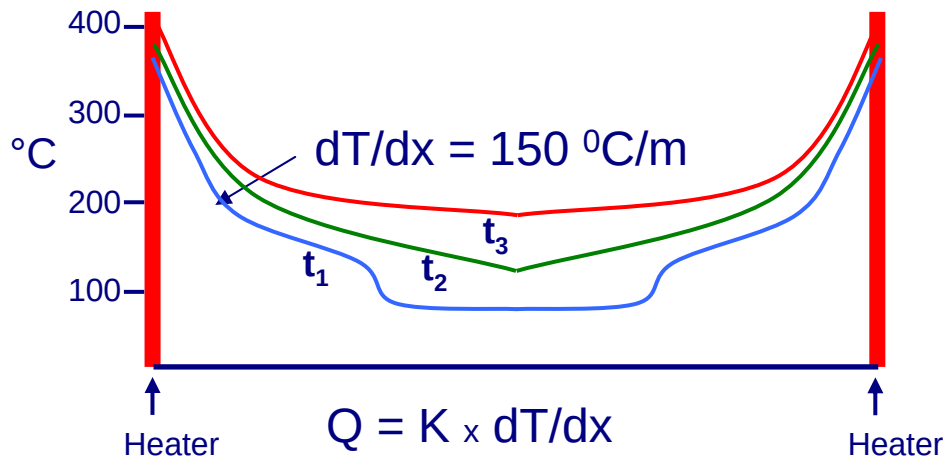
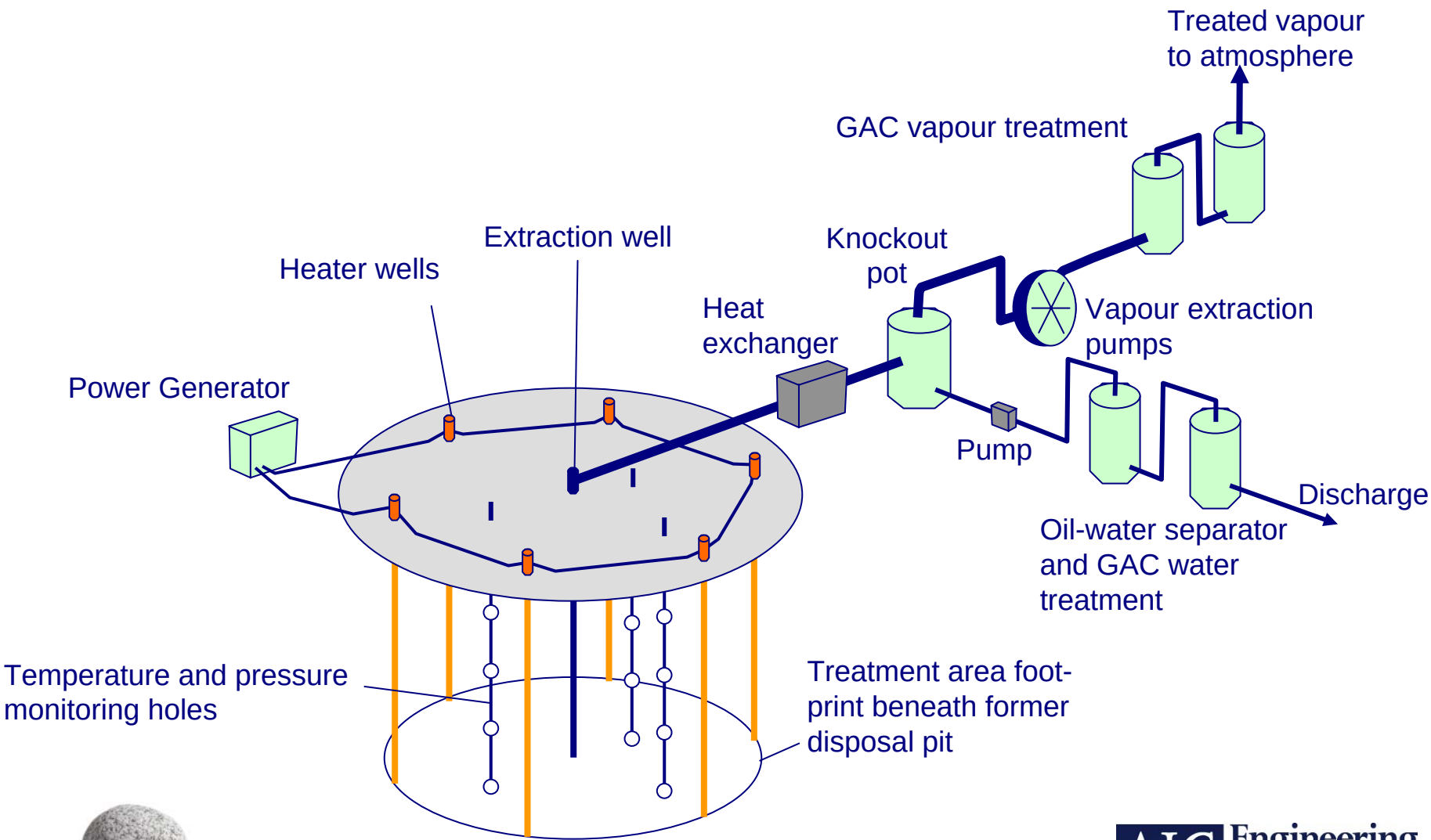
Thermal Conduction Heating

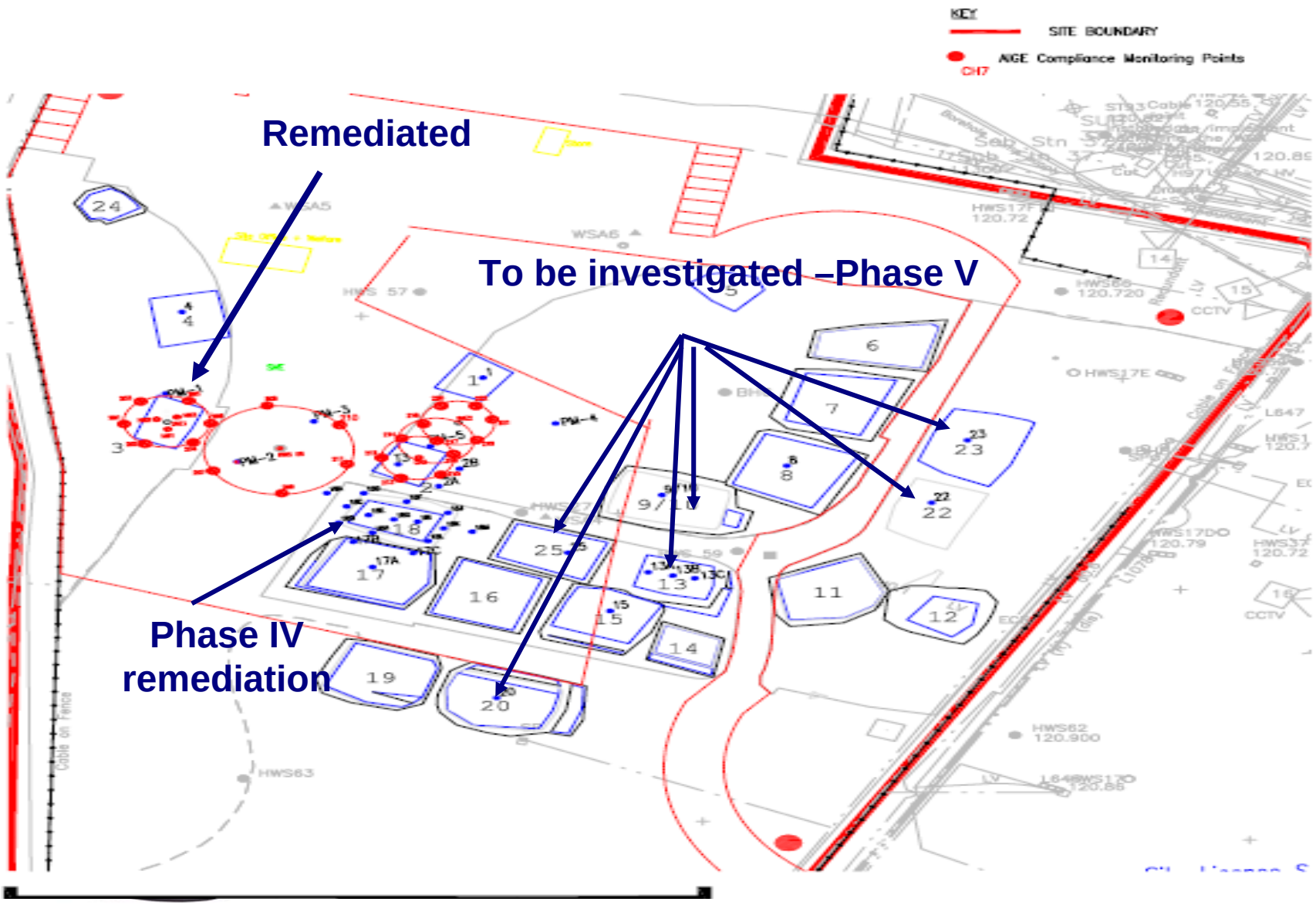




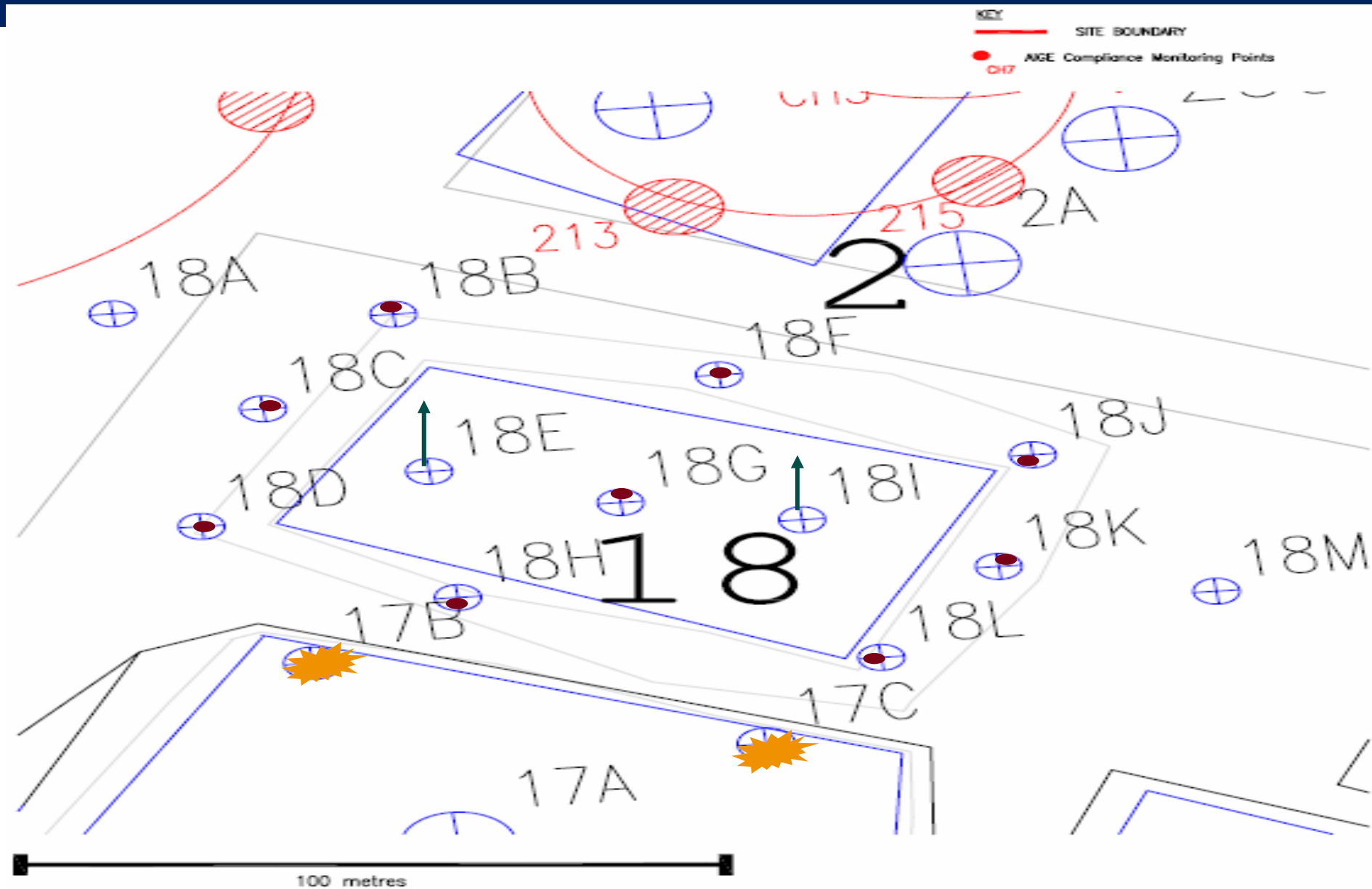
Phased Remediation Works – Plant Layout



Phased Remediation Works – Well Configuration



Pit 18 – Well Configuration



WSA – present situation

PIT 3

- Remediated, extraction rates 0.2kg/day
- Checking for active microbial population

PIT 18

- Identified as potentially the most contaminated one
- Phase 4 – commenced May – cold SVE - – 3.5 kg/day
- Thermally enhanced SVE – postponed – high GWL
- TESVE will commenced beginning August
- So far approximately **600 kg** of contaminants removed

PITS 4, 8, 9/10, 13, 14, 18, 22, 23, 25

- Being checked for potential contamination with conventional SVE
- Mass extraction rates to be estimated for each well respectively
- Nominate the next candidate for Phase V remediation works.

Estimated total mass of contaminants removed from WSA up-to-date .

- Pit 3 (cold, hot, cool down), Pit 1 & 2 (cold) - **1000kg**
- Pit 18 (cold, hot) – **587kg**

Summary
In-situ Thermal Desorption Can Shine When:

- Stringent Cleanup Levels Must be Achieved
- Rapid Clean-Up Required
- Relatively High Concentrations of Contaminants
- Excavation is Expensive or Impractical
- The Treatment Zone is Deep
- There is a Mixture of Contaminant
- The Site is Complex
- LNAPL present
- DNAPL present

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