Lowering the Carbon Footprint of Thermal Remediation Systems

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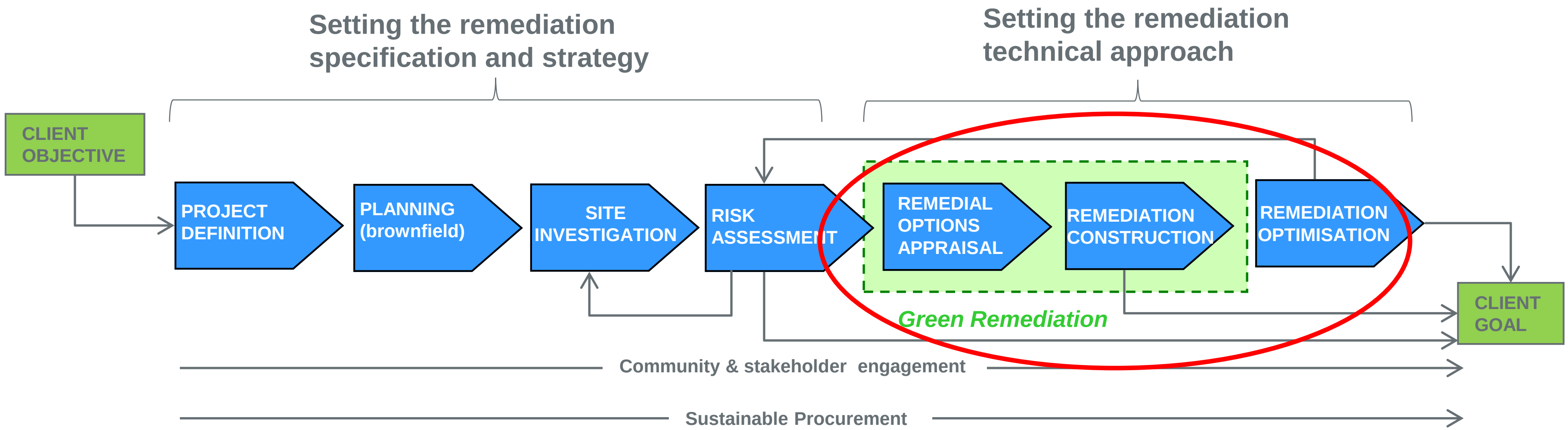
The business of sustainability

ERM

Carbon Footprint Reduction: Approach

ERM has integrated consideration of sustainability with key stages in project delivery

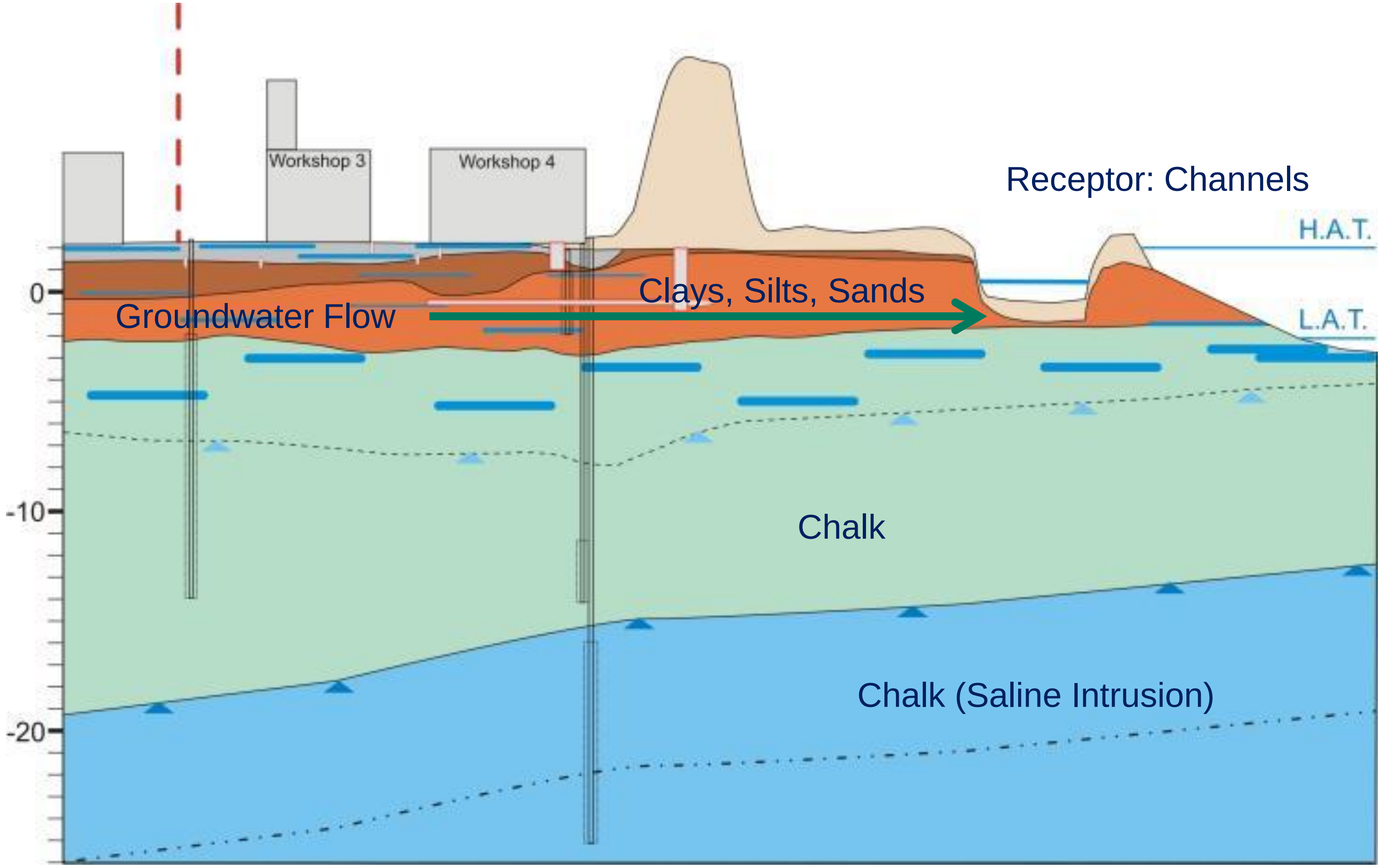


- Remedial Options Appraisal
  - Multi Criteria Analysis
- Remedial Design
  - Thermal Modelling
  - Equipment Design
  - BMPs
- Remedial Optimisation
  - Temperature Tracking
  - Low Temperature Volatilisation (LTV)
  - Post Thermal Biodegradation

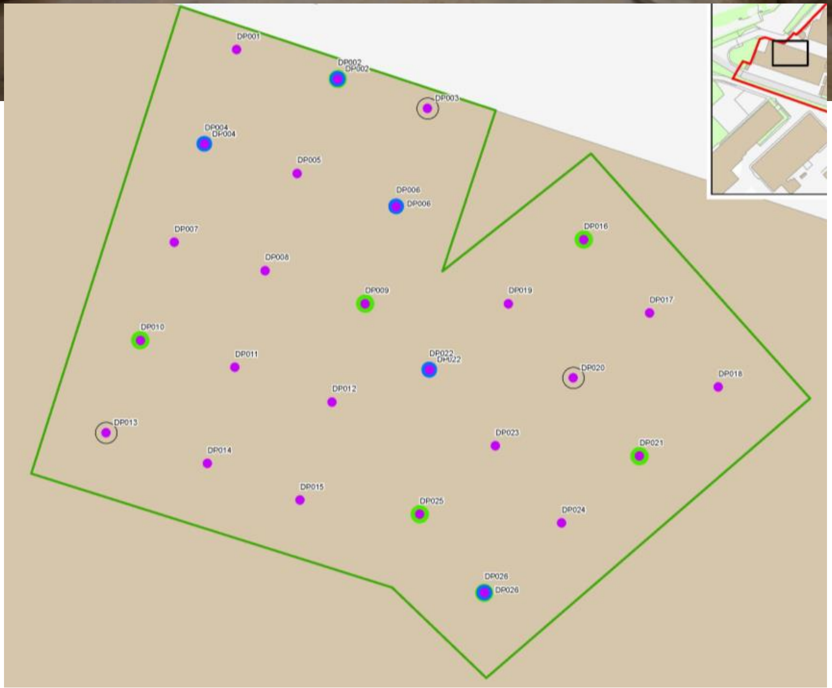
Background

- ERM designed an In-Situ Thermal Desorption (ISTD) system
- Implemented inside a building, at an operational manufacturing site in the UK
- Long manufacturing history
- The system was implemented following 10 years of unsuccessful operation of a pump and treat system
- Organic compounds mainly kerosene and chlorobenzene. Also localised TCE & methylene chloride. All at concentrations >100mg/l
- Method based approach agreed with regulatory authorities

Geology, Hydrogeology, Hydrology



System Installation



Completed Well Field

Vapour / Liquid Phase Treatment Systems

Heat Exchanger

Vapour Treatment Phase

Blower Units

Vapour Phase GACS and Vent Stack

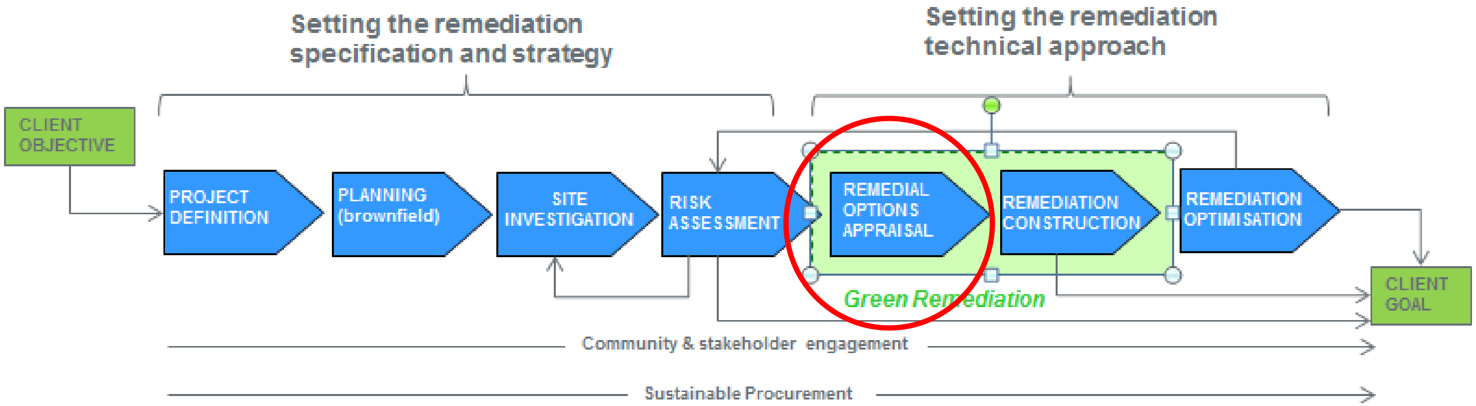
Condensate to Liquid Phase Treatment

Oil / Water Separator & Silt Trap

One Liquid Phase GAC

To Effluent Discharge Point

Remedial Options Appraisal



Multi Criteria Analysis (MCA) Methodology

Sustainability criteria	Weight (1-5)	Justification of Weighting and Comments
Environment		
Impact on water	5	pollutant linkage is through water
Impact on soil	1	soil impact is not the driver of risk
Impact on air	5	GHG emissions primary metric
Impact on ecology	3	eco-receptor is one of two drivers
Natural resource use and waste generation	4	magnitude of Corp Environmental Policy on CO2
Intrusiveness	3	impacts on site management and personnel
Social		
Human health	5	critical concern to site and ERM
Safety	5	critical concern to site and ERM
Ethical and equity considerations	1	'do nothing' would be poor corporate care
Policy and legislative compliance	5	Regulators have requested action on source area
Impact on surroundings	2	will be on a visible part of site
Uncertainty, evidence and verification	1	not critical consideration, effort driven
Community involvement & satisfaction	3	Local Authority and neighbouring amenity concerns
Economic		
Direct costs	3	to be confirmed by Corporate EHS
Indirect costs	3	costs due to partial site access closure, and vibrations may slow site works
Legacy and projects risks	5	Corporate concerns driving the project

First MCA exercise is to weight the importance of the different metrics in this specific circumstance.

Input from other stakeholders is very instructive – shows what is important to them

Currently, the most important factors (i.e. with biggest weight) are:

- impact on water and air
- natural resource use and waste
- human health and safety
- compliance with regulators
- legacy and project risk

MCA Results

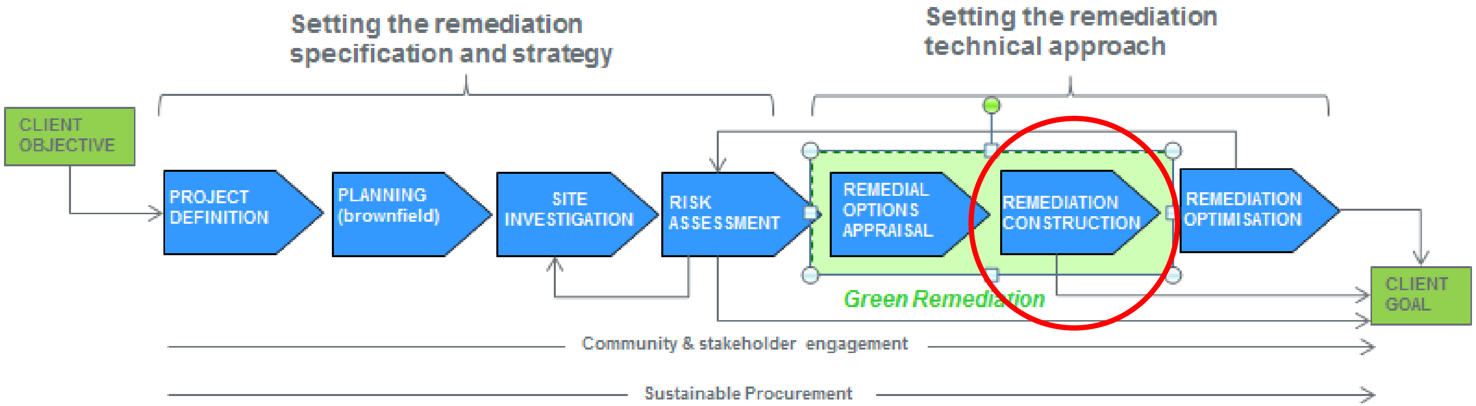
Sustainability criteria	Weighting (1-5)	Do nothing	Excavation	MPE Three years	Thermal	MPE 6 months
Environment						
Impact on water	5	-2	5	2	4	1
Impact on soil	1	-2	5	1	4	0
Impact on air	5	-1	-2	-3	-4	-1
Impact on ecology	3	-2	5	1	4	0
Natural resource use and waste generation	4	0	-1	-2	-3	-1
Intrusiveness	3	0	-5	-3	-1	-1
Social						
Human health	5	0	-1	0	0	0
Safety	5	0	-4	-2	0	-1
Ethical and equity considerations	1	-2	0	0	0	0
Policy and legislative compliance	5	-2	4	2	4	1
Impact on surroundings	2	0	-2	0	1	1
Uncertainty, evidence and verification	1	0	3	0	0	0
Community involvement & satisfaction	3	-2	-4	0	0	0
Economic						
Direct costs	3	5	-3	-2	-3	-1
Indirect costs	3	0	-3	0	0	0
Employment opportunities & human capital	1	0	0	0	0	0
Gearing	1	0	0	0	0	0
Legacy and projects risks	5	-2	5	1	4	1
Flexibility	1	0	0	0	0	0
Net environmental benefit		-23	16	-18	1	-7
Net social benefit		-18	-18	0	22	2
Net economic benefit		5	7	-1	11	2
Overall net-benefit (Sustainability)		-36	5	-19	34	-3
RANK		5	2	4	1	3

MCA Conclusions

Thermally enhanced DPVE (using conductive heating) was the preference for the following reasons:

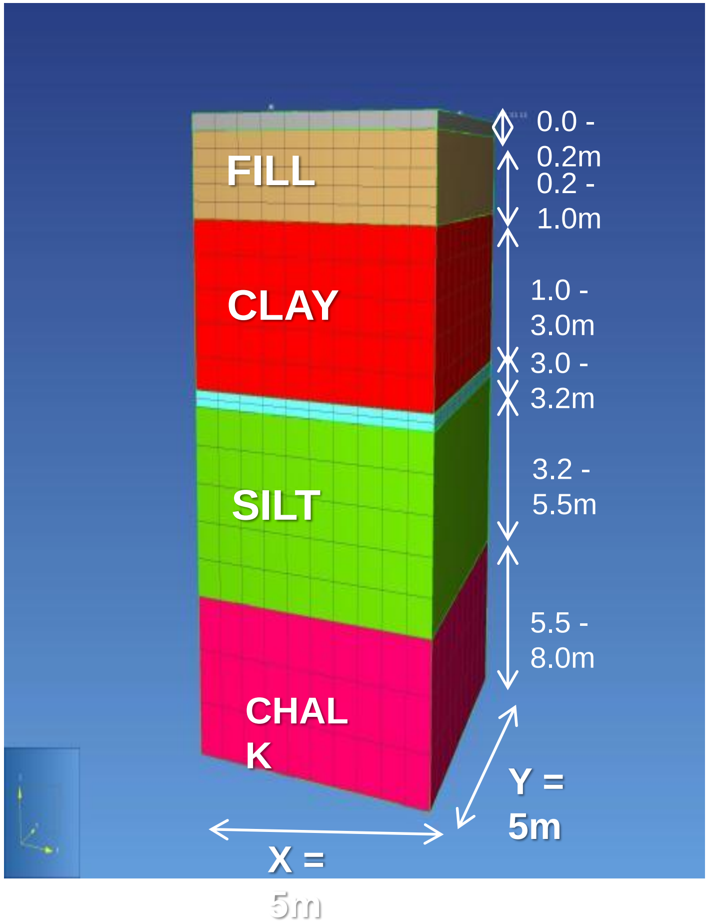
- Health & safety and logistical challenges of soil excavation alternative: **Social factors dominant**
- High probability of success compared to all other in-situ techniques.
- A higher maximum technically-achievable mass removal compared to other in-situ techniques
- The only in-situ technique that can realistically reduce the residual DNAPL contaminant mass (thought to be the majority) within relatively low permeability strata

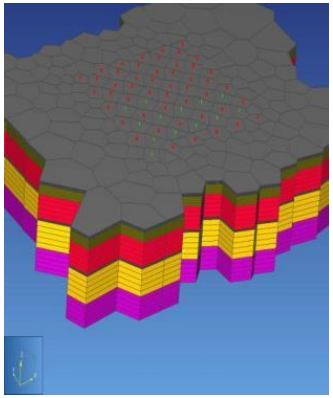
Remedial Design



Thermal Modelling

- A thermal model using Petrasim PC based software was carried out to:
  - Evaluate heating methodology and associated heat energy consumption;
  - Predict heating duration;
  - Determine the optimum well spacing to achieve the Target Treatment Temperature (TTT) in the most energy efficient manner





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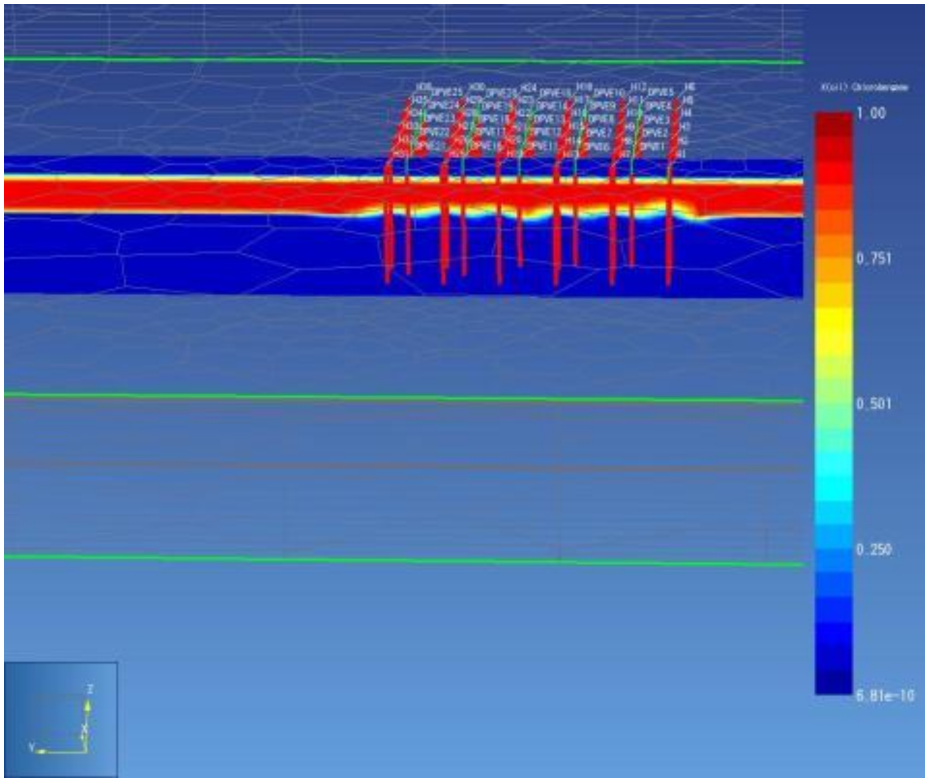
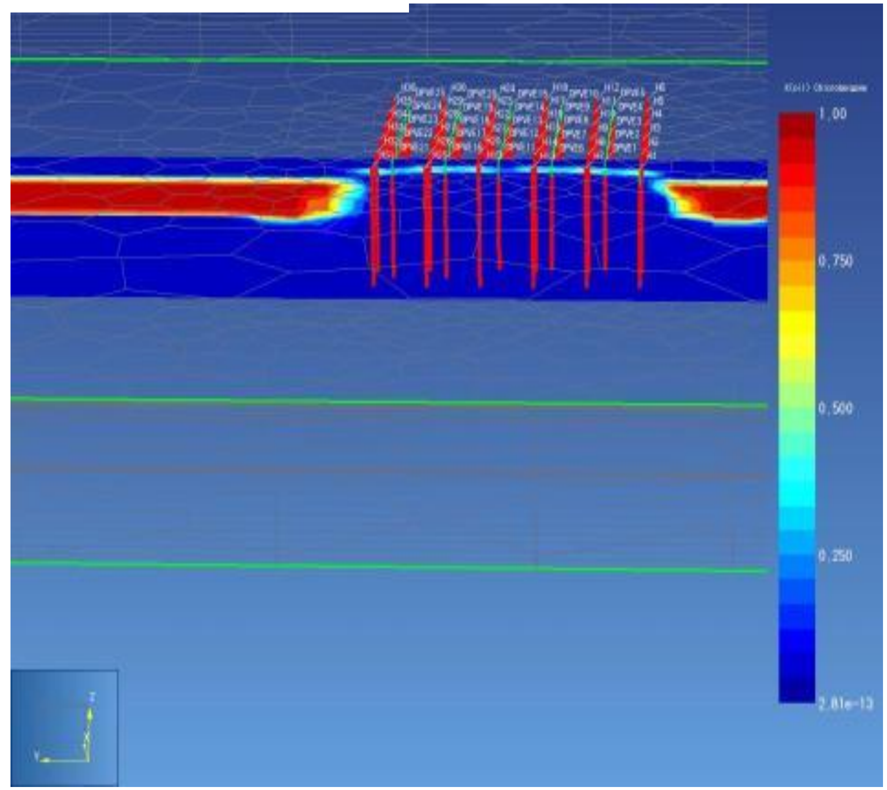
Model Results





A variety of well configurations were modelled

The optimum configuration showed that significant contaminant reduction was predicted to occur with 3.0m well spacing after 120 days of heating (co-boiling point of kerosene and water)

Equipment Design

- Sustainable procurement: Both gas and electric ISTD options considered – gas has a lower carbon footprint and cost in the UK so was selected (not the case everywhere!)
- Process engineering: heat exchangers added to minimise carbon use
- Real time monitoring: automated temperature collection data using thermocouples

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Best Management Practises

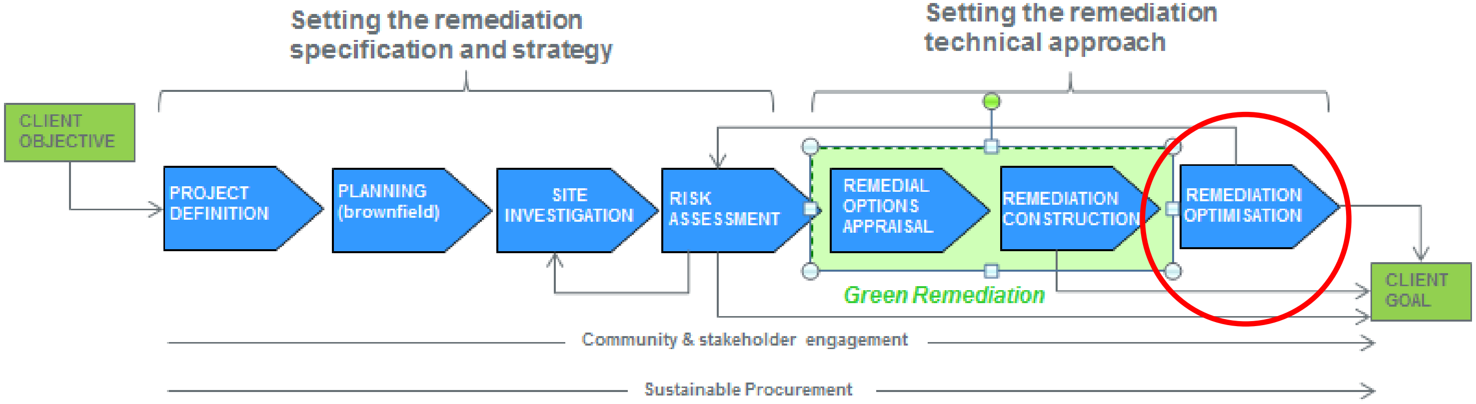
BMP	
Assure suitable sizing of in-well heating units, to optimize energy use	✓
Include feedback loops in the process control system, to allow precise application of heat and the desired temperature and duration	✓
Explore the use of natural gas-fired systems that enable in-well combustion of the contaminants and recovery of associated heat, resulting in lower energy demand	✓
Increase automation through use of equipment such as electronic pressure transducers and thermo-couples with an automatic data logger (rather than manual readings) to record data at frequent intervals	✓
Monitor soil temperatures on a regular basis to assure uniform heating in target areas and avoid unexpected heating and energy waste in non-targeted areas	✓

EPA United States Environmental Protection Agency

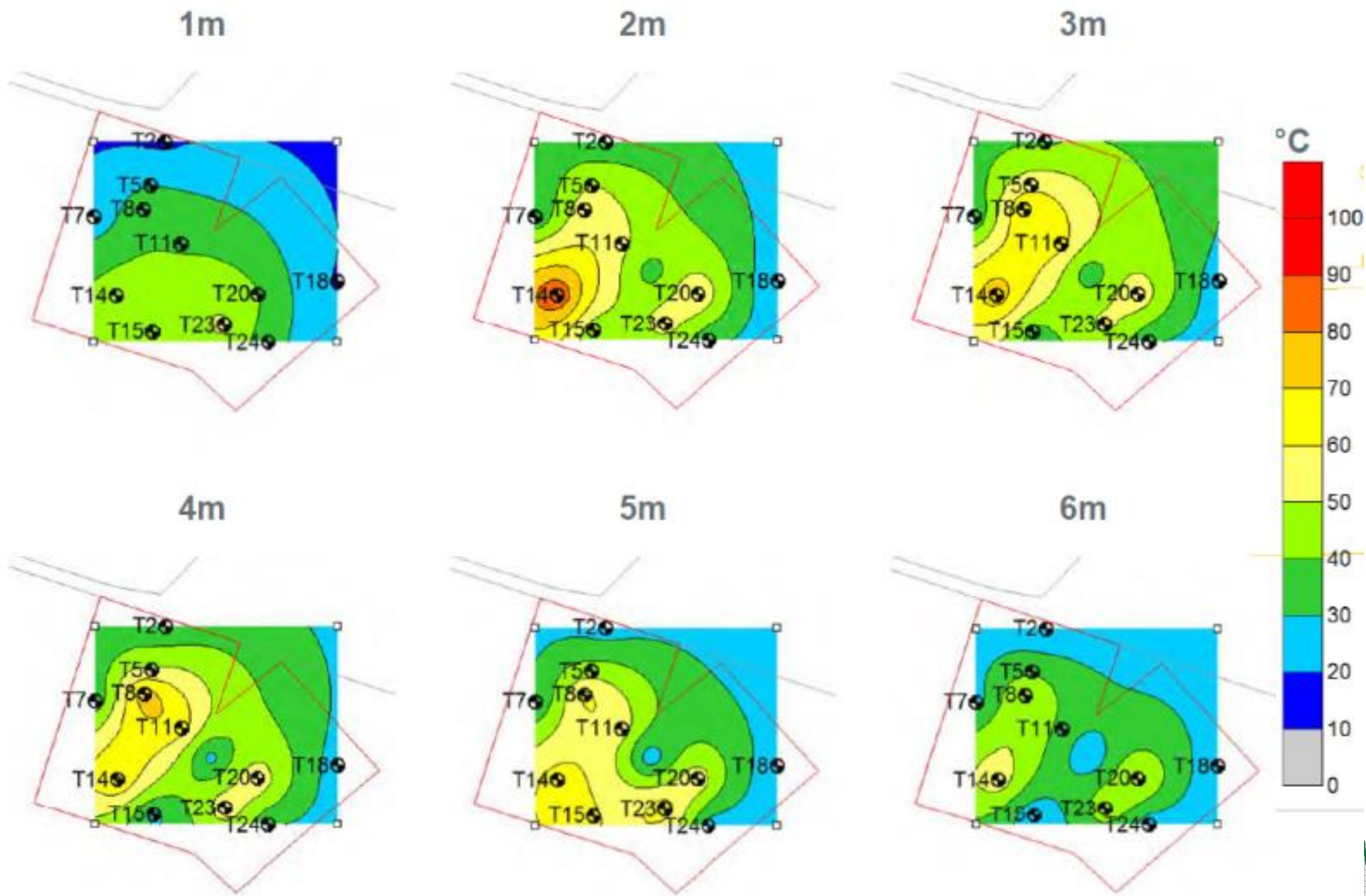
Office of Solid Waste and Emergency Response (5203P)

Green Remediation Best Management Practices:
Implementing In Situ Thermal Technologies

Remedial Optimisation



Temperature Tracking



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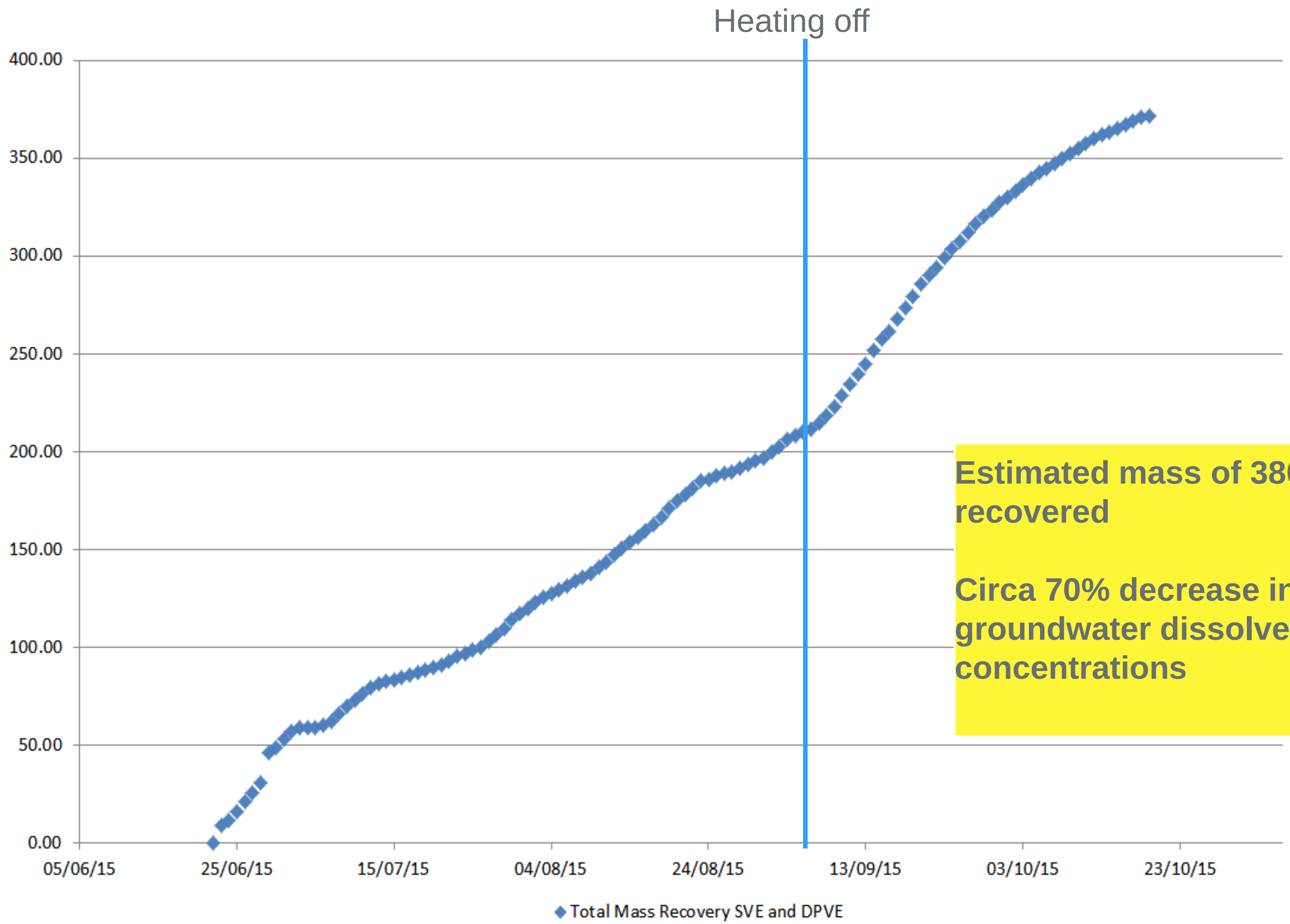
Low Temperature Volatilization (LTV)

- Initial target temperature based on traditional volatilization
- LTV Concept:
  - Groundwater contains dissolved gases
  - During in situ heating, chemical and biochemical reactions occur that increase the concentrations/partial pressures of the dissolved gases
  - CO_2 generated and released can also remove VOC contamination
- At this site lowered treatment temperatures from ~150˚C to an average of 80ºC (heating time 80 days compared to the 120 modelled)

- Benefits: lower energy use, carbon footprint, cost and time to complete

Mass Recovery

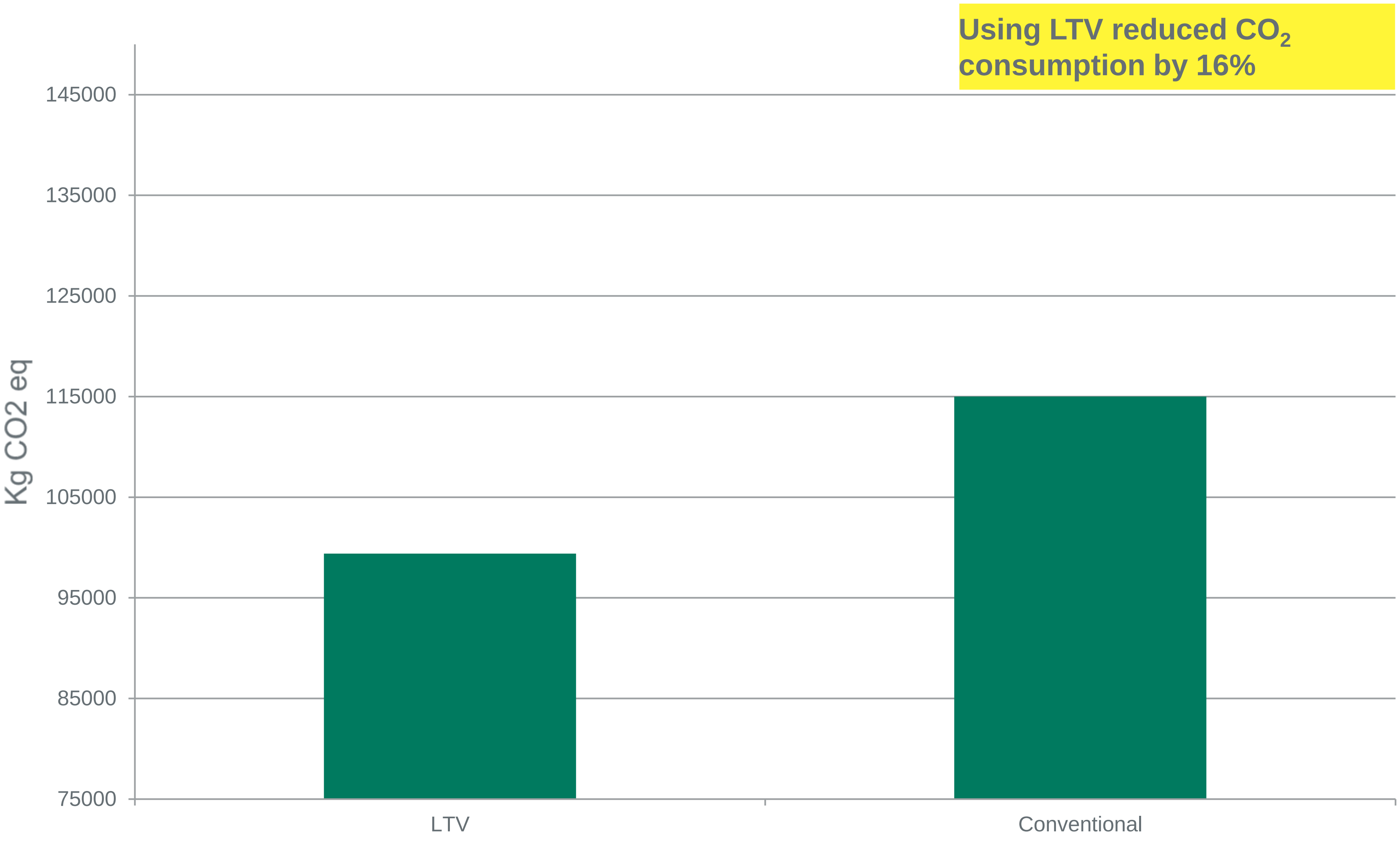


Estimated mass of 380kg recovered

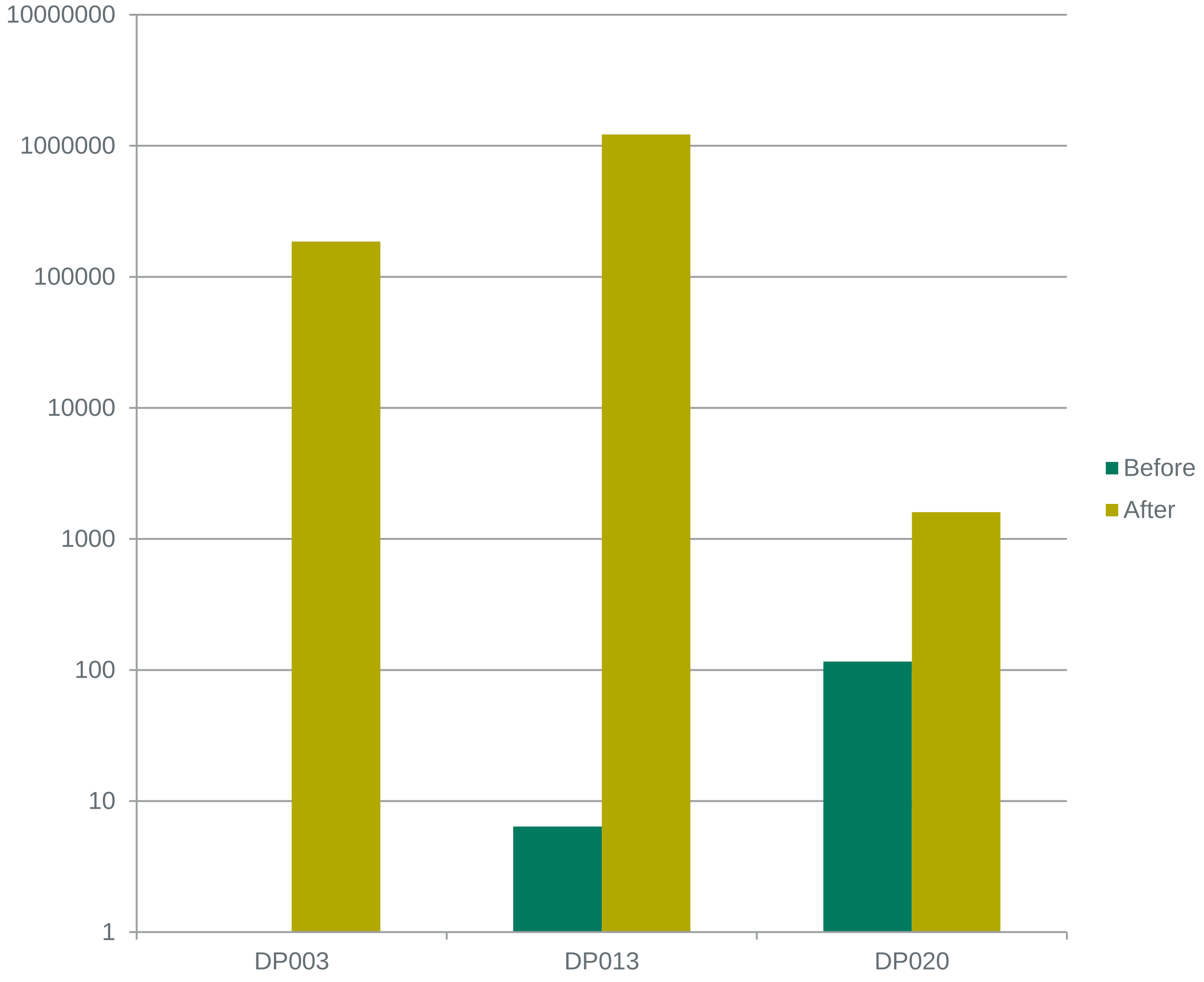
Circa 70% decrease in groundwater dissolved phase concentrations

VOC and CO_2 Concentrations Over Time

Carbon Footprint (kg CO_2 eq)



Post Thermal Biodegradation



Summary

Summary

- Thermal projects are energy intensive, but rapidly completed, meaning overall energy consumption may be lower than expected
- If a thermal remedy is selected a combination of sustainable design and implementation can reduce CO_2 footprint
- Target temperature was significantly lower than initially expected using the LTV approach in combination with real time monitoring, leading to CO_2 reductions
- LTV:
  - 10% reduction in both time and costs to be realised (heating equipment removed from site earlier)
  - CO_2 consumption reduced by circa 16%
- Longer term biodegradation can be successfully applied post thermal

- Endpoints achieved and the project was ‘closed’

Questions?