



**BENCH-SCALE AND PILOT TESTING  
LEADING TO COST-EFFECTIVE CHEMICAL  
OXIDATION: A CASE STUDY IN  
SWITZERLAND**

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**Helsinki**

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# Introduction

- Site History
- WSP's Involvement
- True International Project
- The Project
  - Site Works
  - Testing
- Lessons learned



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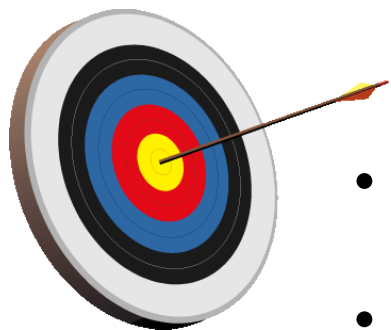
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# The Target Site

- Former resins and plasticizers manufacture 1938 -1992 site
- Operational release of PCE, TCE, cis1,2 DCE and VC plus BTEX
- Post 1992 MNA and monitoring has dominated the sites remedial strategy

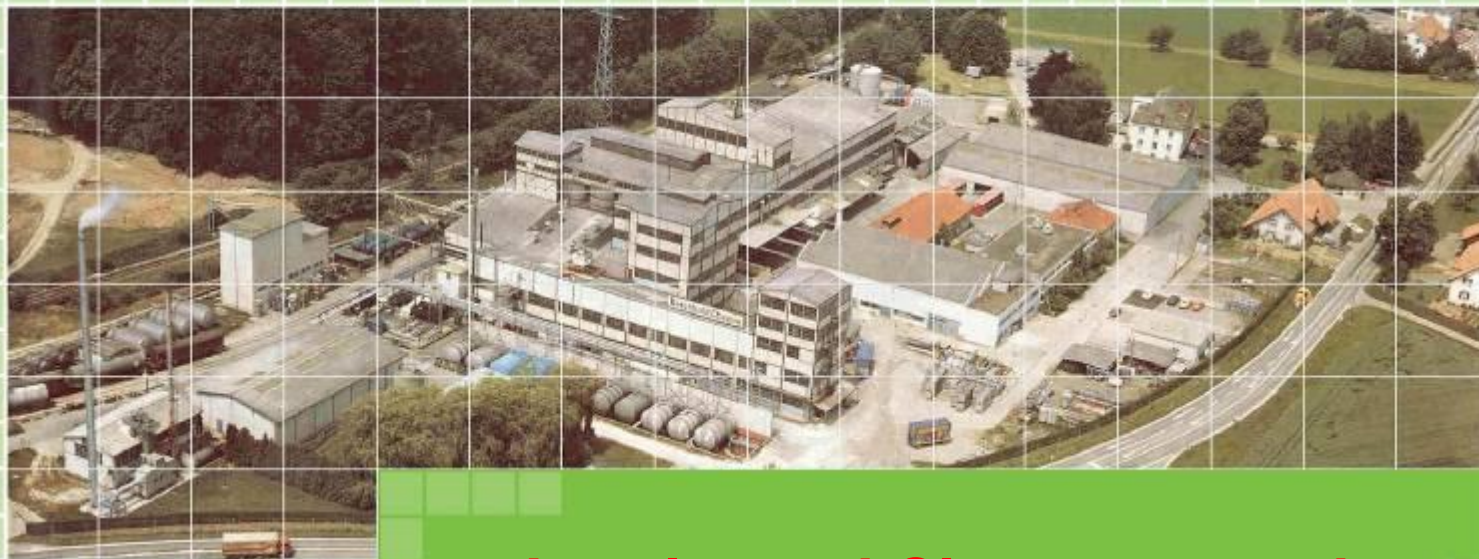
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Multiple Site investigations and time series data post 1992



**Accelerated Clean up sought under acquisition to a US client**

# The Deal - ACTIVE TRANSFER?

- **It is the transfer of the obligation to address the environmental liabilities of a site into a WSP Special Purpose Vehicle.**
- **WSP take responsibility for the management of the known & unknown environmental liabilities.**
- **For now and until an agreed period after the transaction**
- **For a one-off fee.**



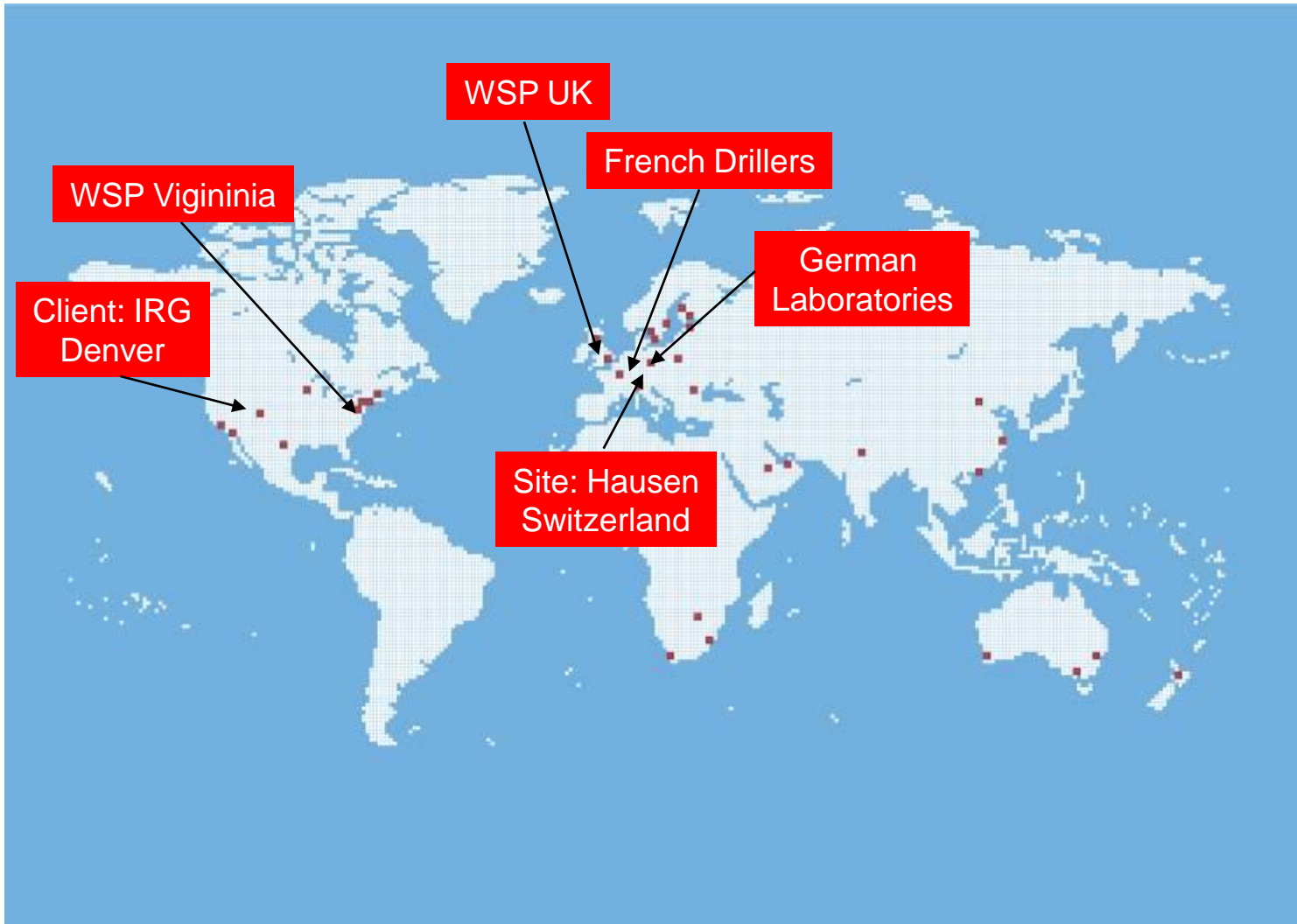
# Requires an alignment of Interest

Active Transfers work when everyone has the same interest.



# WSP Group

Truly international nature of the project:



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# Static Groundwater Plot

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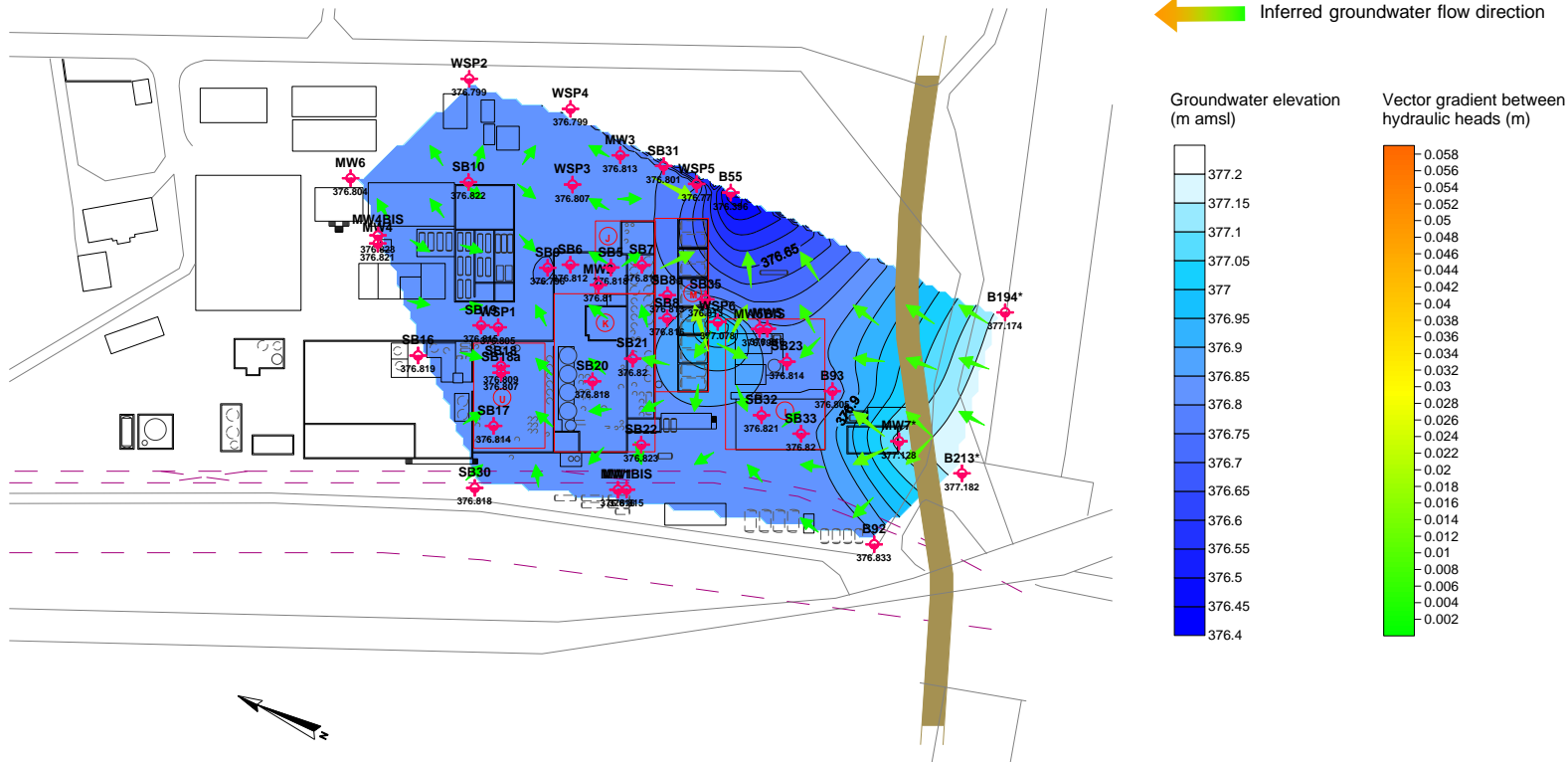
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# Legal Framework

- Ordinance of Contaminated Sites, Amended , March 2000 by Swiss Federal Environment Agency (OFEFP)
- In a Zone A area, if the concentration of constituents in groundwater exceeds **one half of the target limit down gradient of the site – Intervention is sought**

## Criteria for Fixing compliance points

$$D_{\max} = (2B + 0.5L + T) / 10$$

L = length of plume

B = width of plume

T = depth to GE table at centred point

Parameter	Concentration limit (µg/l)	Compliance Concentration (µg/l)
Benzene	10	5
Toluene	7000	3500
Ethylbenzene	3000	1500
Sum of Xylenes	10000	5000
Aliphatic Hydrocarbons (C5-C10)	2000	1000
cis-1,2-Dichloroethylene	50	25
Perchloroethylene	40	20
Trichloroethylene	70	35
Vinyl Chloride	0.1	0.05

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•[1] [http://www.umwelt-schweiz.ch/imperia/md/content/altlasten/altlasten\\_pdf/altlv\\_e.pdf](http://www.umwelt-schweiz.ch/imperia/md/content/altlasten/altlasten_pdf/altlv_e.pdf)

# Risk Drivers

- **Model validation indicates biodegradation likely to be occurring**
- **Supports previous assertions that MNA is viable**
- **Projected impact at in excess of the OCS at 100m -**
  - **Soil sources – TCE**
  - **Groundwater sources – DCE, PCE, vinyl chloride**
- **Risk-driving contaminant sources:**
  - **WSP3 – groundwater (PCE and DCE)**
  - **APC J – groundwater (TCE and DCE); soil (TCE)**
  - **APC M – groundwater (vinyl chloride)**

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# WSP delivery

- Enhanced plume delineation and site characterisation through various techniques
- Pilot testing in two phases
- Laboratory trialling of various oxidants
- Oxidant field trial based on results of laboratory trials



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# Delineation Investigations



- Verification of the Groundwater regime;
- Examination of hydraulic conductivity;
- Installation of delineation boreholes and window samples.



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# Source Delineation in the Vadose Zone in *SITU* FLUX MEASUREMENT

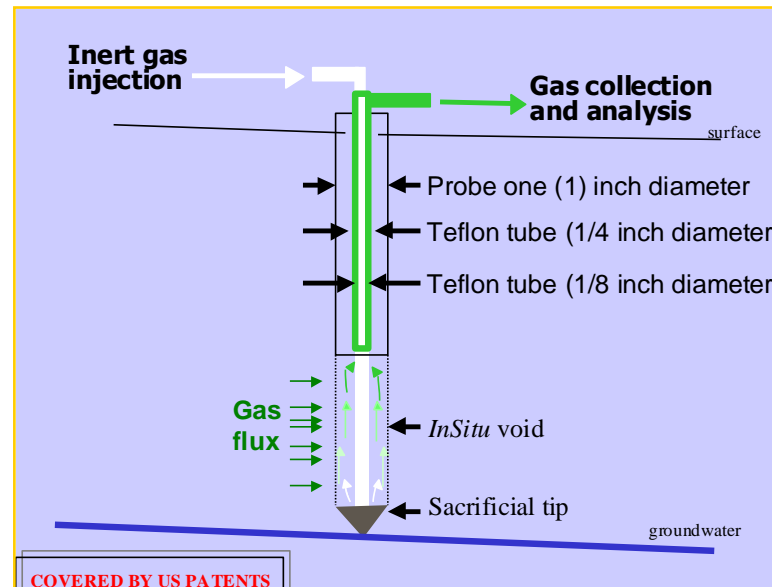
## Gas sampled :

- Methane (CH<sub>4</sub>) (with an Infrared detector (IR)) ;
- Carbon dioxide (CO<sub>2</sub>) (with an IR detector) ;
- Oxygen (O<sub>2</sub>) (with an electrochemical detector) ;
- VOC (with a Photoionisation detector (PID)).

## Objective :

- Find any potential source of Perchloroethylene
- (PCE) remaining in the vadose zone of this site around monitoring well WSP-15.

**COST EFFECTIVE**



Courtesy of EcoRemediation Inc USA

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# Source Zone Refinement

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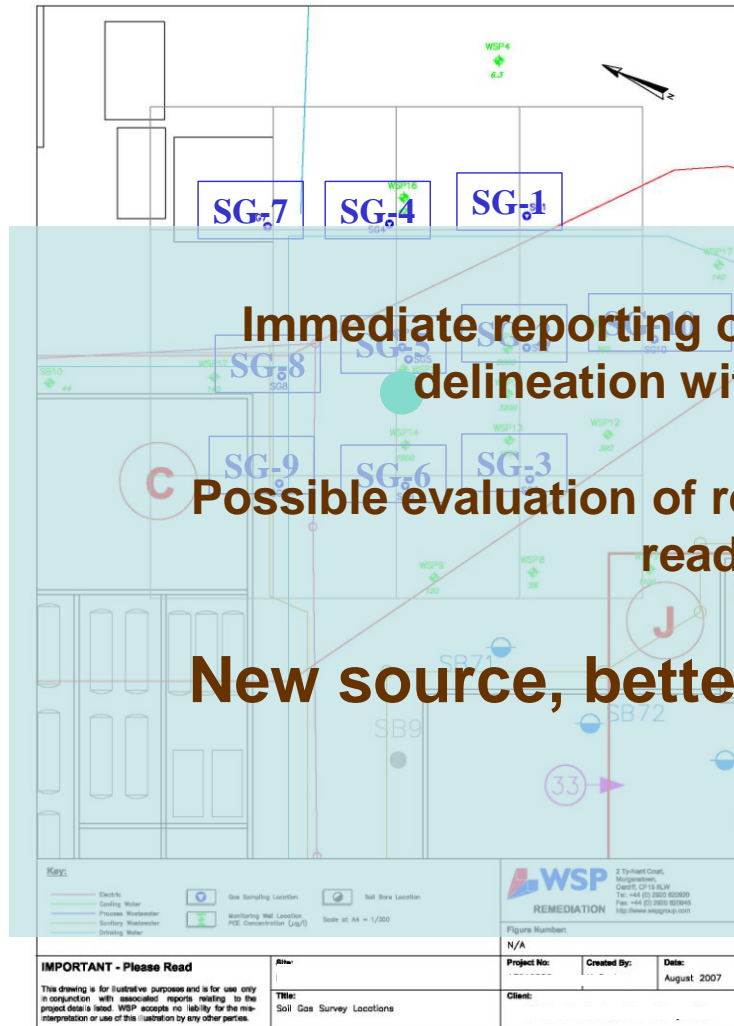
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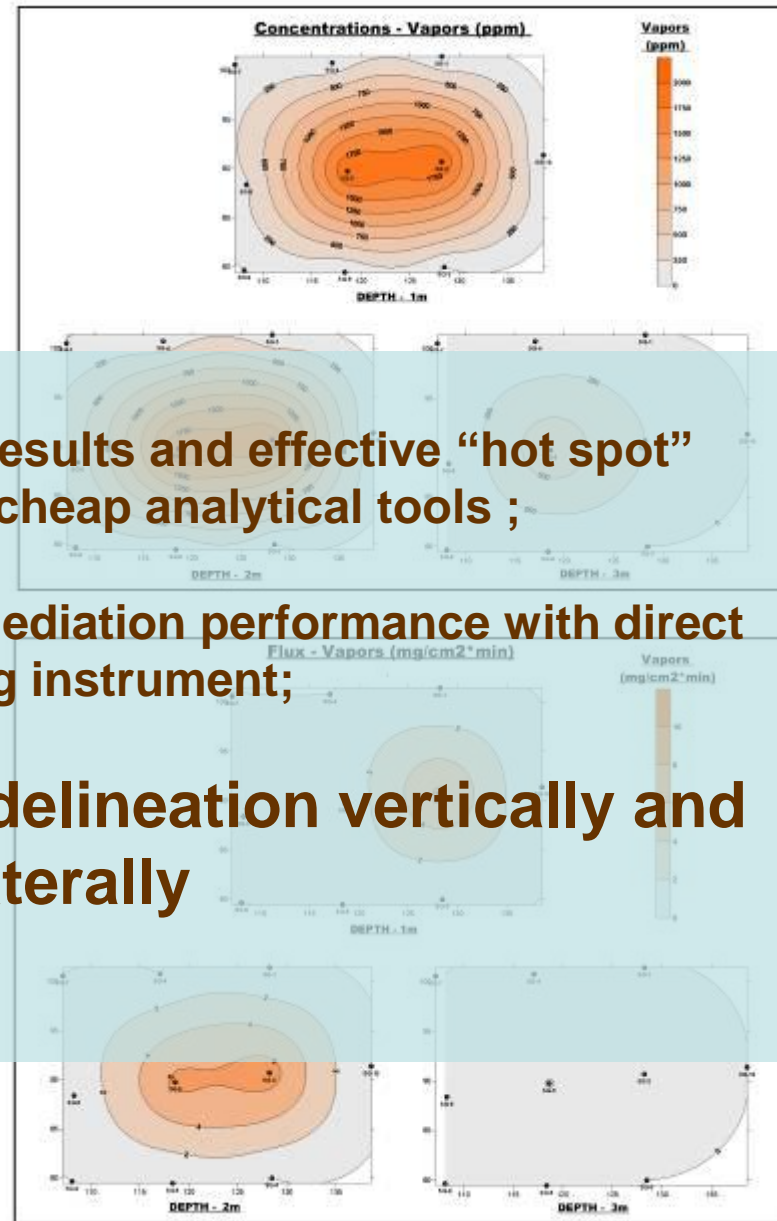
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**Immediate reporting of results and effective “hot spot” delineation with cheap analytical tools ;**

**Possible evaluation of remediation performance with direct reading instrument;**

**New source, better delineation vertically and laterally**



# The Laboratory Trials

## 3 no. oxidants

1. Potassium Permanganate
2. Sodium Persulphate
3. Sodium Percarbonate



Soils samples retained from top of the saturated zone plus clean areas

Testing delivered by Prima Environmental of Sacramento, California USA

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Testing included consideration of natural oxidant demand

# The Laboratory Trials Results

- Chemical oxidation is a feasible remedy
  - Permanganate was the most effective chemical oxidant for contaminants of concern under site specific conditions. CHCs reduced to 'non detect' within 24 hours of being treated with a 0.5 per cent permanganate solution.
  - Persulphate was not as effective at oxidizing CHCs, and percarbonate was minimally effective.
    - Activated persulphate was more effective at toluene removal than permanganate, but persulphate was not as effective at removing ethylbenzene or xylene.
  - Whilst permanganate was not effective in degrading benzene, CHCs and TEX compounds represent the most significant risk drivers**

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**Enabling  
business  
opportunities**

# The Field Trial

- Injections completed in three areas
- Injected a total of 800kgs permanganate at 10% solution
- Injection rate of 8 - 15 litres per minute in all locations
- Reached monitoring points within 2 days
- Well B-93 will not be activated until samples from APC M indicate that permanganate is not present

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# Field Trial



- Oxidant dose based on
- mass observed
- Single piston grout pump
- Regular injection intervals

Area of Potential Concern	Injection Interval
APC-J	7.5 – 12 m bgs
APC-M	8 – 14.5 m bgs
APC-I	7.6 – 15.6 m bgs

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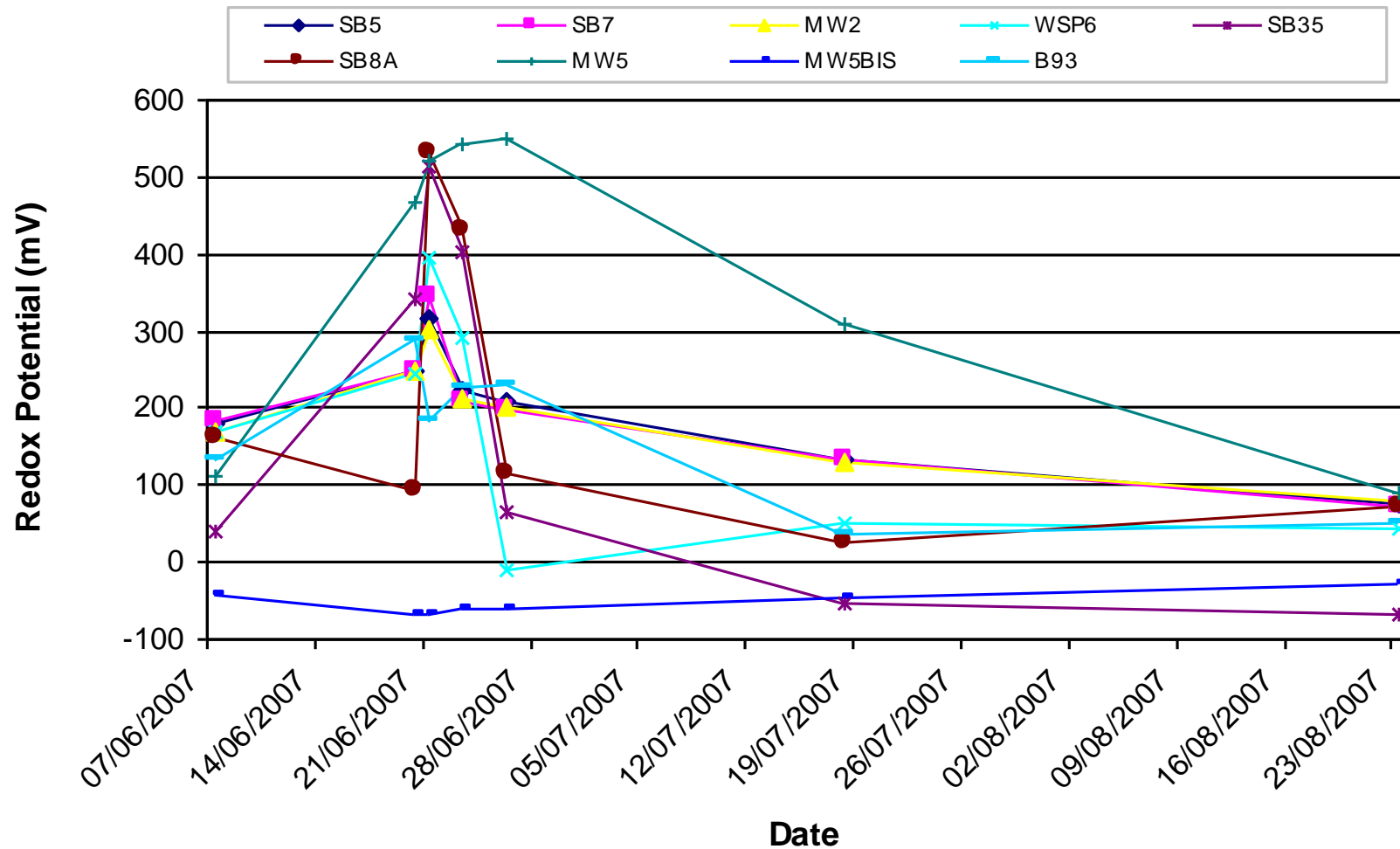
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# Field Trial Results



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# Pilot Tests

- Permanganate effective at reducing mass of COCs at the site
- Rebound noted though illustrated that Sodium permanganate may persist ~1mth
- Injection rates achieved during field trials suitable for full scale remediation works

Secondary water quality impact monitoring and modelling – sodium , chloride & manganese delivered

# Way Forward

- Full scale mobilisation
- Building Permit application
- Possible Public Consultation

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# Lessons – Communications

US Client  
 UK Delivery  
 Swiss Regulator  
 French/Dutch Drilling Contractors  
 Canadian Contactors  
 German Laboratory  
 Swiss Subcontractors

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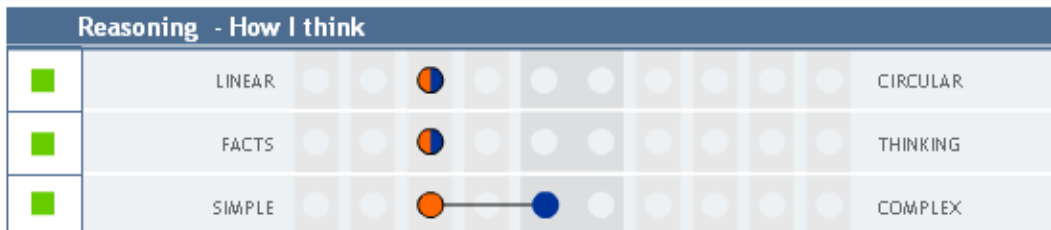
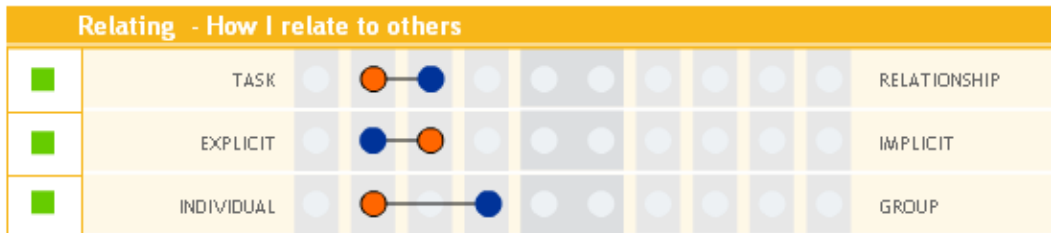
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**Key**

The scale positions are indicated as follows:

- = The American position
- — ○ = Overlapping position
- = The Swiss position

The traffic light colours indicate how closely the scores match

- = Maximum difference
- = Moderate difference
- = Minimal difference

We adapt our organisation to trends in our clients' businesses

# Lessons Learned

- **Front End Loading of additional intrusive works has lent significant delivery advantage and confidence;**
- **In situ Flux has proven cost effective and beneficial in lateral and vertical delineation**
- **Major challenge has been cultural**

Times spent on communication  
is never wasted

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DIAGEO



CLYDE&CO



ARLA FOODS



CREDIT SUISSE



SKANSKA



Thank you for listening

Balfour Beatty



alk CHEMICALS

mira



GALLAGHER ESTATES



Foster + Partners

m-real

PRICEWATERHOUSECOOPERS



Rentokil Initial



nationalgrid



PRUDENTIAL



Unilever

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