



# Jacques Whitford

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## Application of In-Situ Chemical Oxidation to Remediate a Fractured Bedrock Dissolved Heating Oil Plume

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FEDERAL CONTAMINATED SITES  
SITES CONTAMINÉS FÉDÉRAUX

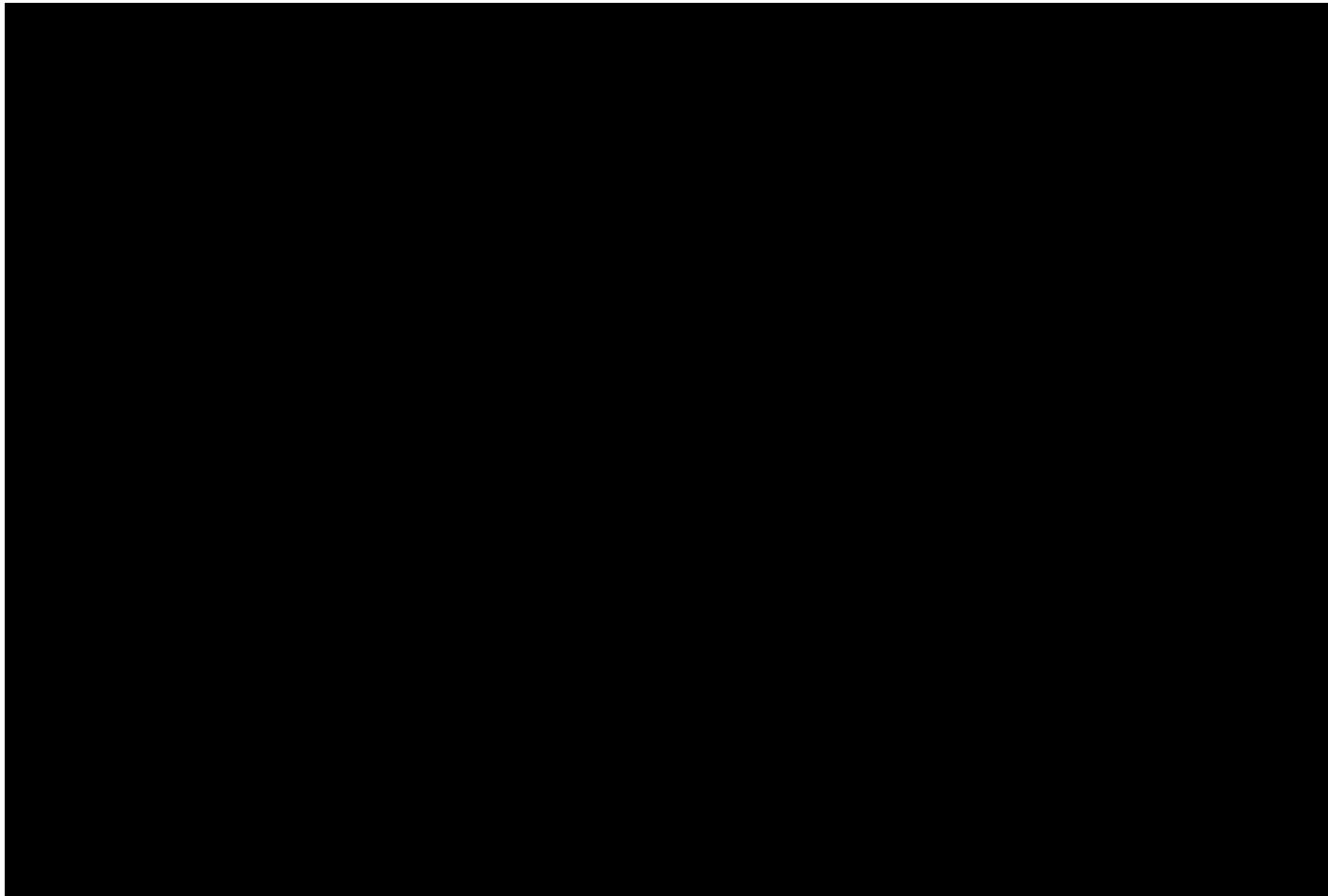


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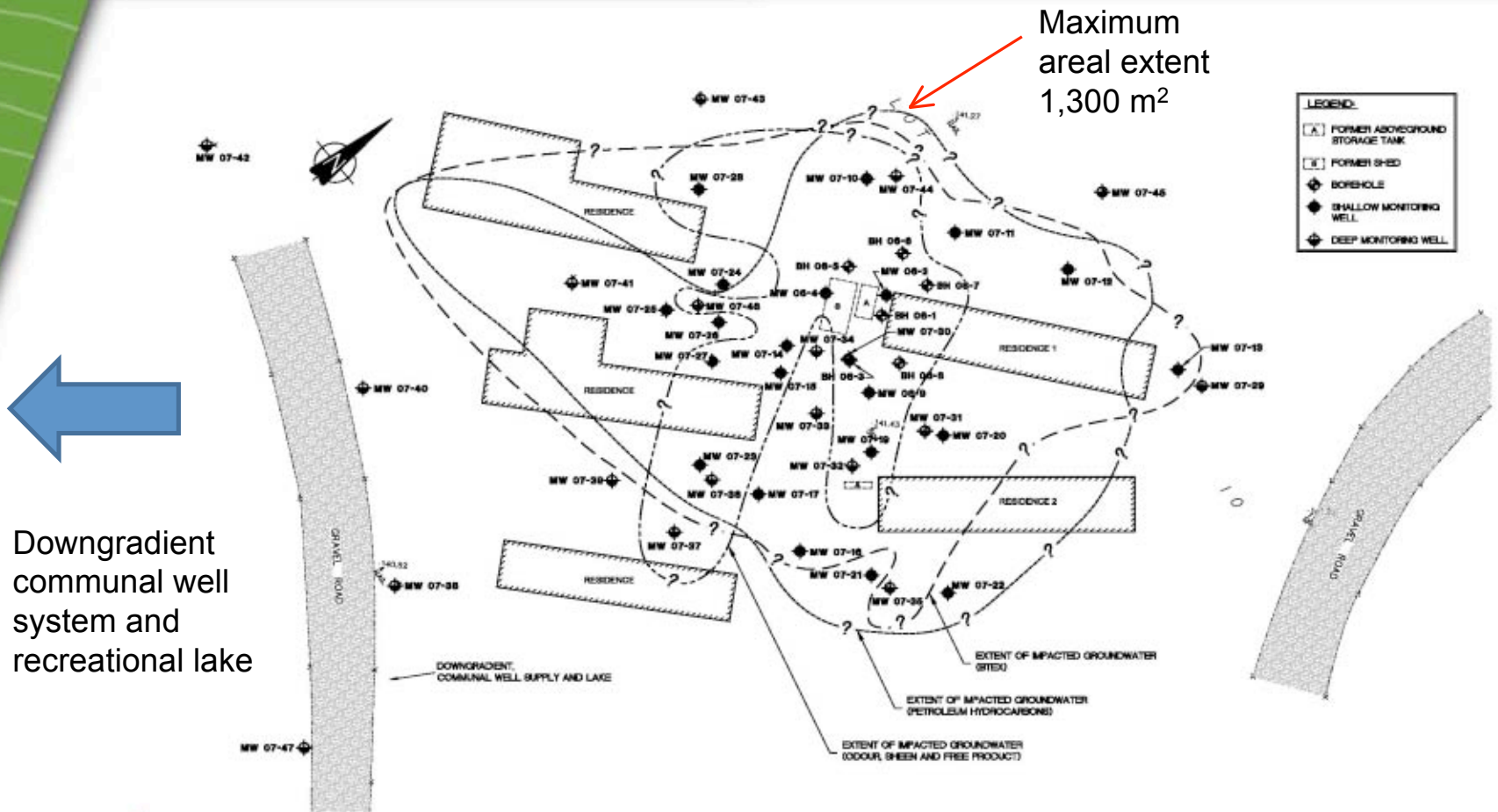
# OVERVIEW

- Background / Site Setting
- Source Removal and Characterization
- Remedial Options
- Insitu Chemical Oxidation (ISCO) Program
- Lessons Learned

# Conceptual Cross Section



# Estimated Areal Plume Extent



Downgradient communal well system and recreational lake

Maximum areal extent 1,300 m²

LEGEND:

	FORMER ABOVEGROUND STORAGE TANK
	FORMER SHED
	BOREHOLE
	SHALLOW MONITORING WELL
	DEEP MONITORING WELL

# Regulatory Requirements For Groundwater

Parameter	Table 2 Standard (µg/L)	Maximum Groundwater Concentrations
Benzene	5.0	280 <sup>a</sup>
Toluene	24	630 <sup>a</sup>
Ethylbenzene	2.4	230 <sup>a</sup>
Xylene	300	780 <sup>a</sup>
PHC F1 Fraction	Sum of F1 & F2 ≤ 1000	50,000 <sup>a</sup>
PHC F2 Fraction		8,400 <sup>b</sup>
PHC F3 Fraction	Sum of F3 & F4 ≤ 1000	1,300 <sup>b</sup>
PHC F4 Fraction		<100

a – observed in hot zone shortly following fuel release

b – observed north of the hot zone shortly following fuel release

# Site Characterization

- Found subsurface behavior varied from shallow versus deeper installations;
- Potentially influenced by well installation methods employed;
- Horizontal gradients (0.001 – 0.031);
- Vertical gradients (0.003 – 0.23);
- Hydraulic conductivity estimates from pump testing ( $2 \times 10^{-5}$  cm/sec);
- Pore Water Velocity = 0.6 m/day
- Seasonal Water Table Fluctuation 2 – 3 metres
- Potential travel time to downgradient communal well system approximately 244 days (based on seepage velocity) versus 750 days (based on actual observed plume migration).

# Remedial Options – Site Constraints

- Dense residential setting;
- ‘Retirement’ community;
- Shallow contaminated overburden excavated – remaining impacts located within underlying fractured bedrock;
- ‘Strained’ public relations;
- Solution required:
  - Minimal disturbance
  - Quick project ‘close out’
  - Balanced with cost considerations

# Remedial Options Considered

- Bedrock Excavation;
- Pump and Treat;
- Monitored Natural Attenuation;
- In Situ Dual Phase Chemical Oxidation;
- In Situ Chemical Oxidation (ISCO) with Enhanced Bioremediation  
Sodium Percarbonate  $\rightarrow (2\text{Na}_2\text{CO}_3 \bullet 2\text{H}_2\text{O}_2)$

***ISCO with Enhanced Bioremediation deemed most desirable for site setting (safety concerns, minimal disturbance) and economical***

# Insitu Chemical Oxidation

- Undertaken in conjunction with Vertex Environmental
- Oxidation and Enhanced Bioremediation
  - Employ multiple in situ injections under pressure using liquid chemical oxidant, followed by ORC polishing
- Constraints:
  - Effectiveness reduced if free product more than 10 cm;
  - ‘Rebound’ effects could occur, reducing effectiveness;
  - Process dependant on ‘good hydraulic connection’ between injection wells

# Pilot Test

- Implemented in July of 2007;
- Injections in various locations under varying pressures;
- **pH and water levels** monitored in surrounding locations to assess 'connection';
- Radius of influence on the order of 5 metres;
- Favourable results, recommended proceeding with full scale injection program

# Pilot Test

Set-up



Water tank



Injection Port



Distribution Monitoring



# Summary - Injections 1 and 2

Injection Number	Injection Product	Timeline	Injection Volume (litres)	Relative Water Table	Concentration Fluctuation
Pilot Test	Sodium Percarbonate	July 2007	375	Low	Not Determined
Injection 1	Sodium Percarbonate	August 2007	13,100	Low	Reduced by 50 -80% within the source zone
Injection 2	Sodium Percarbonate	October 2007	12,100	Rising	Increased by 700 – 850% within the
Injection 3	Sodium Percarbonate	November 2007	12,500	Higher	Monitoring pending
Polishing Injection	ORC	Spring 2008	TBD	Anticipated High (melt)	Monitoring pending

# Final Monitoring - Pending



Delayed as a result of excessive snow cover (Early April 2008)



Final ORC injection will be scheduled following monitoring

# Anticipated Outcome

Similar Project undertaken by Vertex Environmental

- Residential
- Leaking heating oil tank
- Release volume ~600 L
- Excavated overburden; however, fractured dolostone contained sheen and dissolved phase
- Max PHC groundwater 64,200 µg/L including low levels of BTEX
- Used RegenOx – 3 injections of 3,500 L each, ~2,500 kg of oxidant

# Lessons Learned

- Use of ISCO can be used to remediate impacts in fractured bedrock;
- ISCO can be used to remediate within a reasonable timeframe and can meet stringent drinking water quality criteria;
- Source removal is required to increase effectiveness;
- Well / delivery system must ensure good delivery of product can be achieved;
- The Natural Oxidant Demand (NOD) of the subsurface materials needs to be considered;
- Water table seasonal fluctuations can create a significant smear zone;
- Plan injection times to correspond to high water table levels

# Contact Information

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