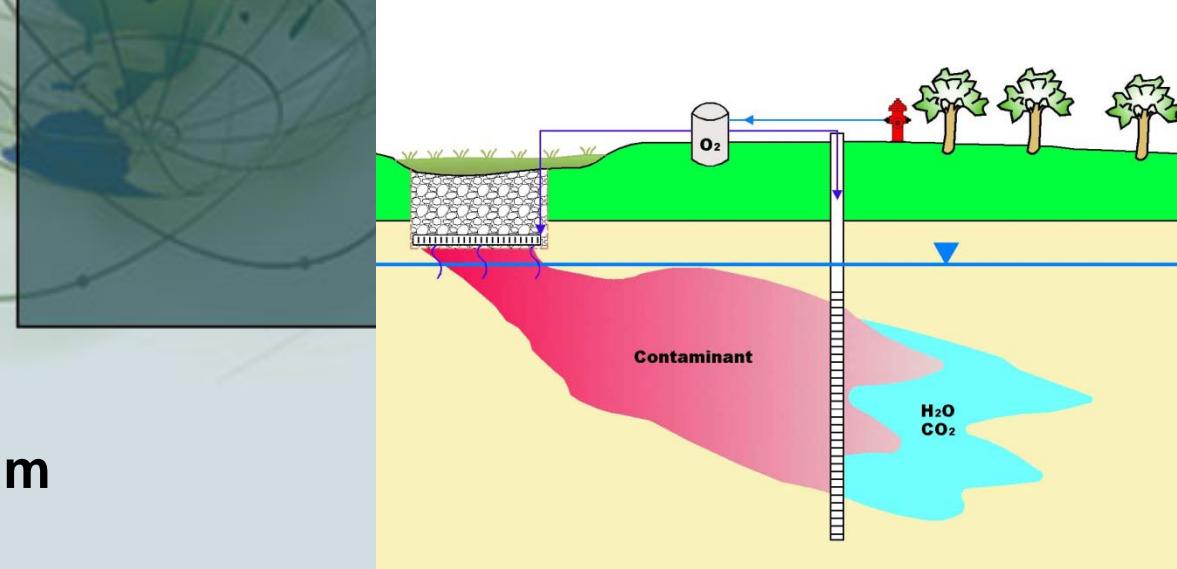


BIOREMEDIATION OF A FORMER TANK FARM

“INJECTION OF OXYGENATED WATER AS A SUSTAINABLE OPTION TO
REMEDIATE HYDROCARBON CONTAMINATION”



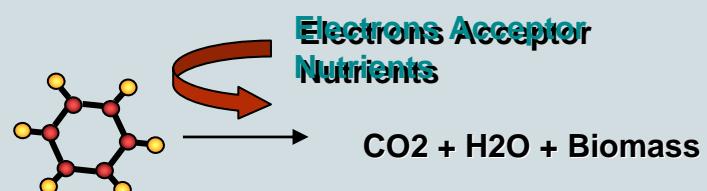
2009 Remediation Technologies Symposium

Presented by

Eric Bergeron, Eng., M.A.Sc.

Geosciences Group, Montreal

October 14-16, 2009

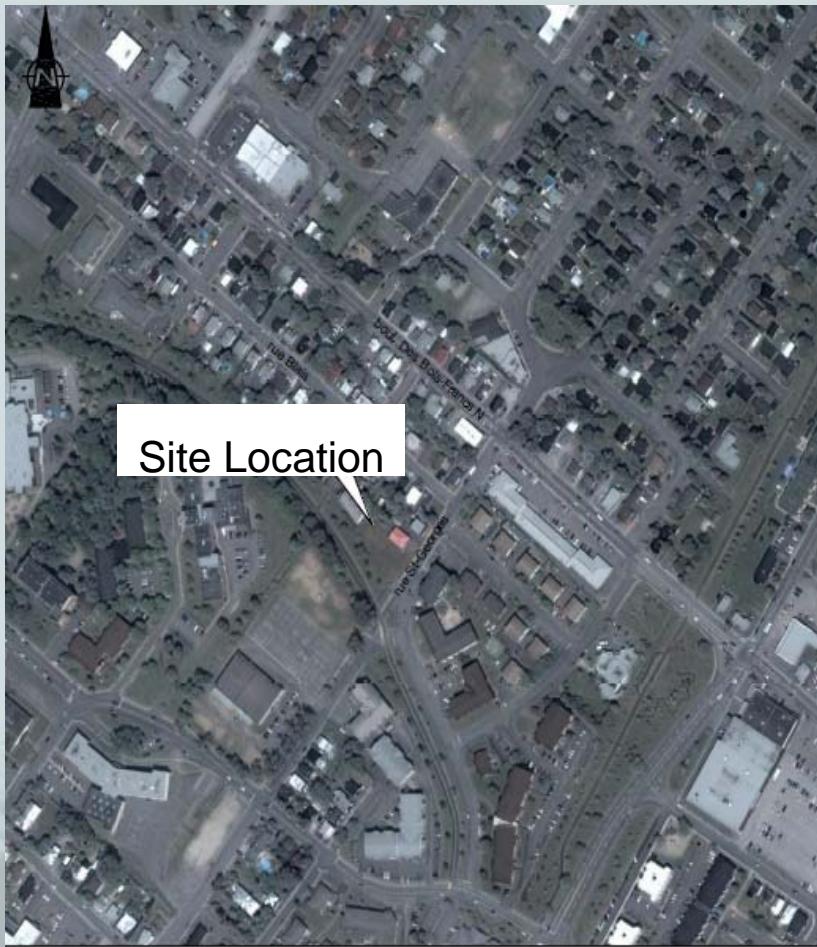


PRESENTATION OUTLINE

- Project site description
- Why the remediation option used is sustainable (GolderSET)?
- Remediation approach
- Remediation system description
- Results
- Conclusions

Project Site Description

- Location : Québec, residential area
- Former tank farm
- Closed at the end of 80s (40 years operation)
- Foot print: 1600 m²
- Zoning: residential
- Gas and diesel ASTs and fuelling station
- Petroleum equipment dismantled, building remains
- Monitoring : 30 monitoring wells on site



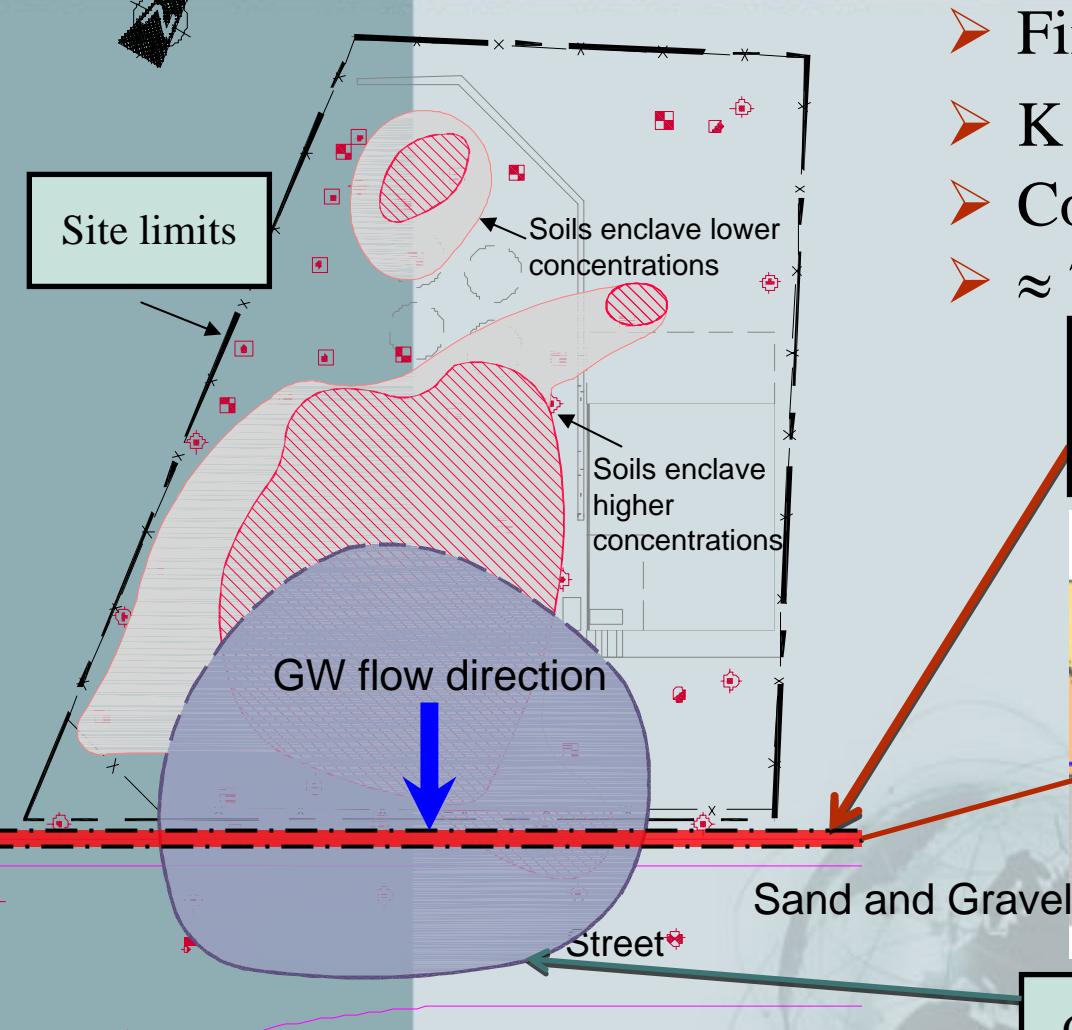
Source: _____
Google Earth

CONFIDENTIEL

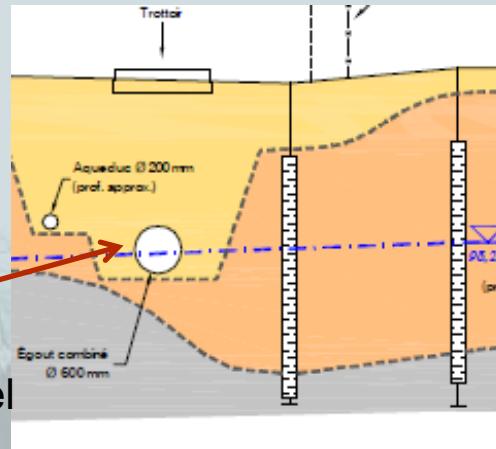


Project Site Description

- Fine sandy formation
- K : $2,9-3,76 \times 10^{-3}$ cm/sec
- Contamination : BTEX + C10C50
- ≈ 7000 kg of TPH



Impact on the municipal sewer
running under the street



Groundwater plume of BTEX extent to
outside site limits

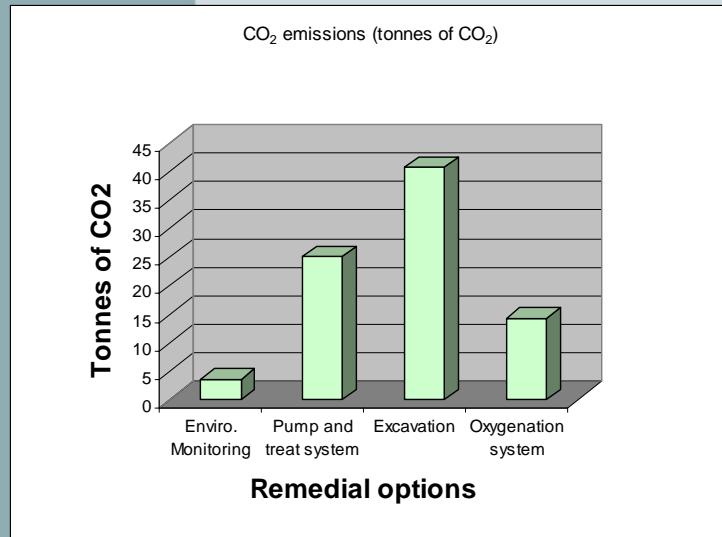
GolderSET – What is the best remediation option?

Sustainability
Decision
Support
Tool

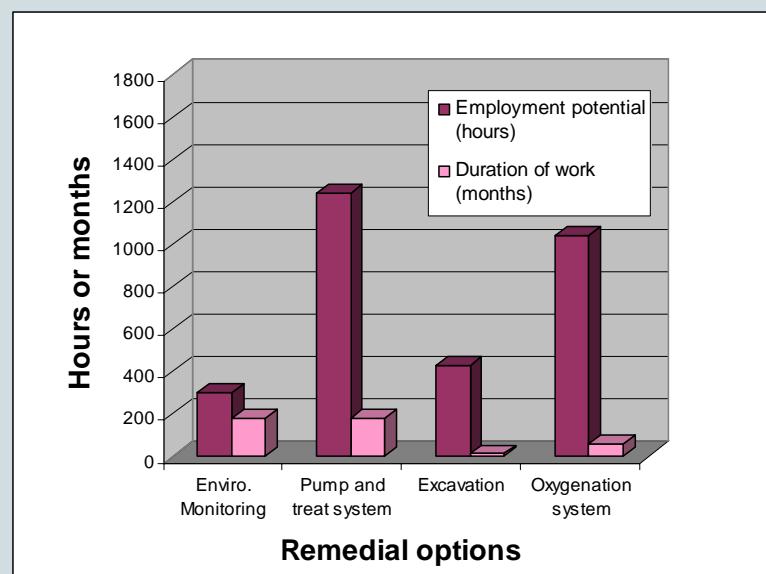
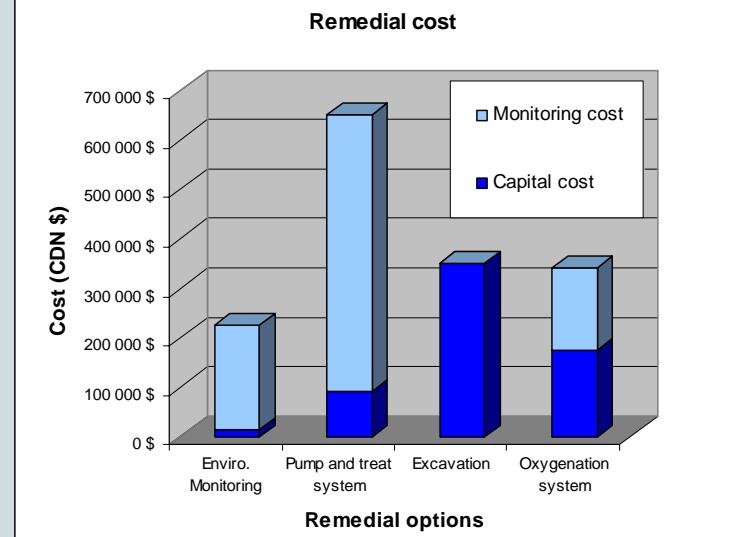
- Semi-quantitative multi-criteria decision support tool based on the principles of sustainable development
- Balanced, impartial and exhaustive yet simple to use and refer to
- Sustainability “checklist” before undertaking a project

Quantitative Indicators

Environmental Dimension



Economic Dimension

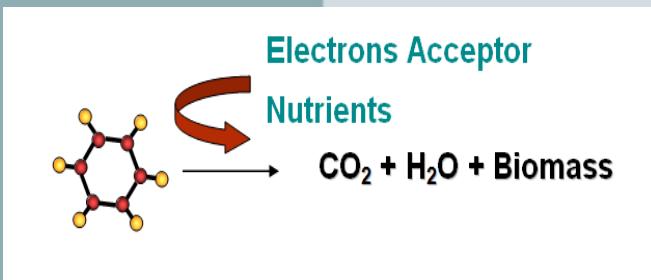


Social Dimension

Quantitative Indicators - Energy and GHG Emission

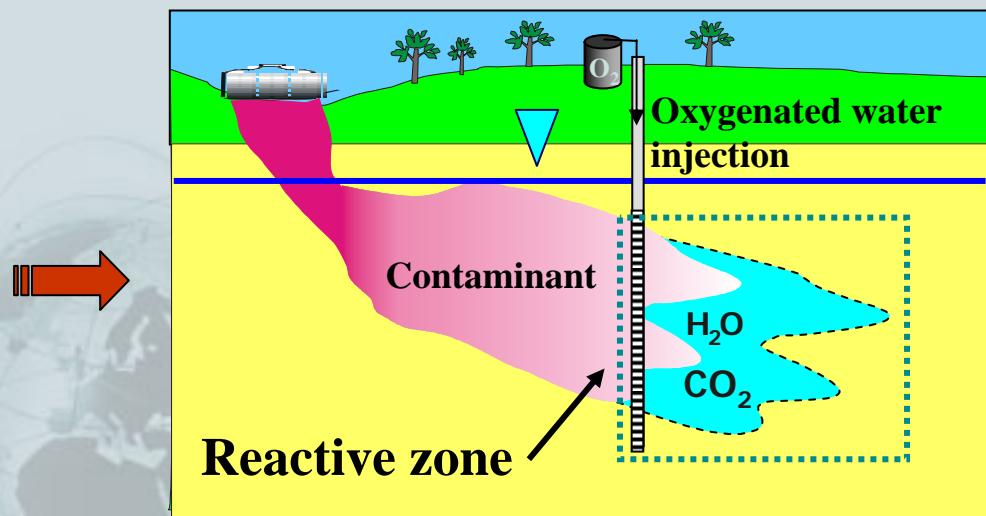
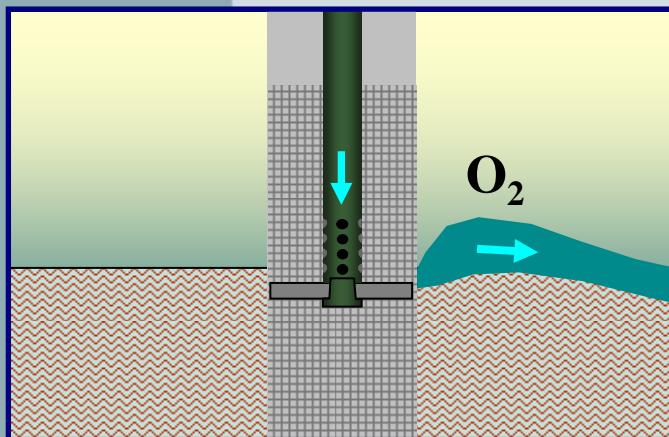
Option	Catégorie	Équipement	Énergie consommée	Combustible energy consumed	CO ₂ mass emission	
			(KWh)	(MJ)	(Tonne de CO ₂)	
Excavation	Transport sols B-C	12 roues	-	106 380	7,80	
	Transport sols >C	12 roues	-	106 380	7,80	
	Excavation	Pelle mécanique	-	137 850	10,11	
		Loader	-	103 578	7,59	
		Véhicule	-	105 361	7,23	
	Traitement en biopile	Pompe (150 CFM, 7,5 HP)	73 720	265 391	0,74	
	Transport vers site d'enfouissement - matériel de recouvrement	Pelle mécanique	-	137 850	10,11	
		Loader	-	103 578	7,59	
		12 roues	-	212 761	15,60	
		Véhicule	-	3 512	0,24	
			Total	1 282 639	74,81	
			321	MJ/kg d'HC	18,70 kg CO ₂ /kg d'HC	
Rabattement de l'eau et oxygénation	Installation	Véhicule	-	17 560	1,20	
		Rétrocaveuse	-	28 971	2,12	
	Oxygénéation (5 ans)	Câbles chauffants	38 325	137 970	0,38	
		Pompes submersibles (1/3 HP)	27 229	98 024	0,27	
		Pompe de transfert (2 HP)	6 535	23 526	0,07	
		Unité de préparation de l'air (3 HP)	49 012	176 444	0,49	
		PLC	8 760	31 536	0,09	
		Chauffage	61 320	220 752	0,61	
	Transport sols >C	Semi-remorque	-	19 946	1,46	
	Excavation	Pelle mécanique	-	27 570	2,02	
	Transport vers site d'enfouissement - matériel de recouvrement	Pelle mécanique	-	13 785	1,01	
		Loader	-	10 358	0,76	
		12 roues	-	19 946	1,46	
		Véhicule	-	21 072	1,45	
	Suivi (1X / mois sur 1 ans)	Véhicule	-	42 144	2,89	
			Total	889 605	16,30	
			222	MJ/kg d'HC	4,07 kg CO ₂ /kg d'HC	

Bioremediation by Oxygenated Water Injection

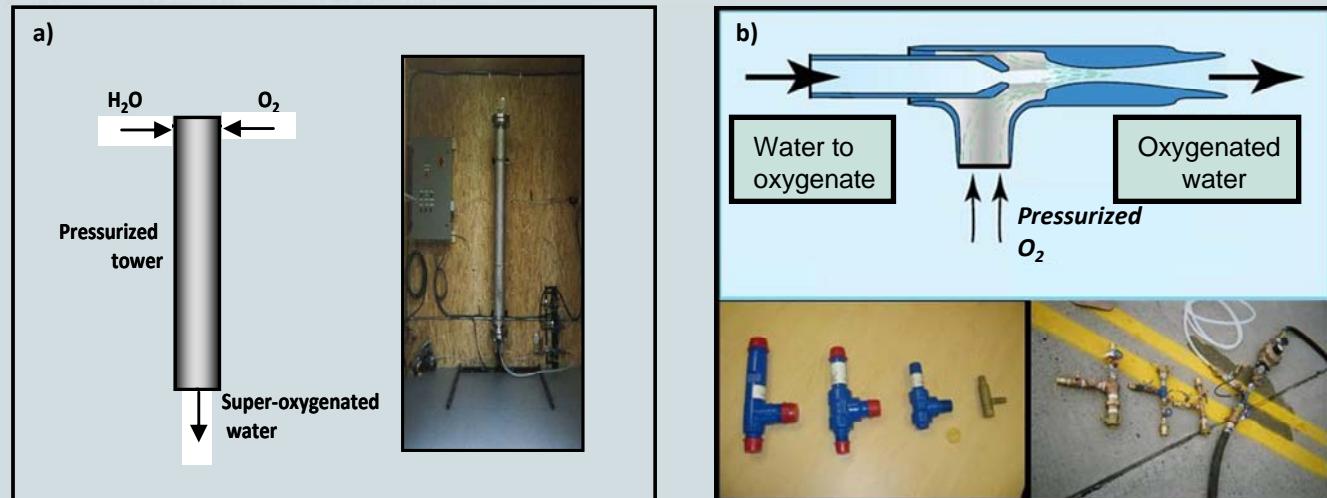


Strategy:

Create a reactive zone with high dissolved O_2 concentrations (45 – 60 ppm) and enough nutrient to degrade hydrocarbons into harmless products.



Golder Technology - SOW



Technology	Cost per Pound of O_2 Delivered	O_2 Transfer Efficiency	Cost per Pound of O_2 Transferred to Groundwater
Biosparging	\$106	2 %	\$5,300
O_2 Diffusion	\$194	70 – 100%	\$194 – \$270
H_2O_2	\$426	20 – 50%	\$852 – \$2,130
ORC®	\$487	25 – 50%	\$974 – \$1,948
Pure O_2 injection	\$1326	20 %	\$6,330
SOW	10-100\$	90 – 100%	10-100\$

Layout of the System



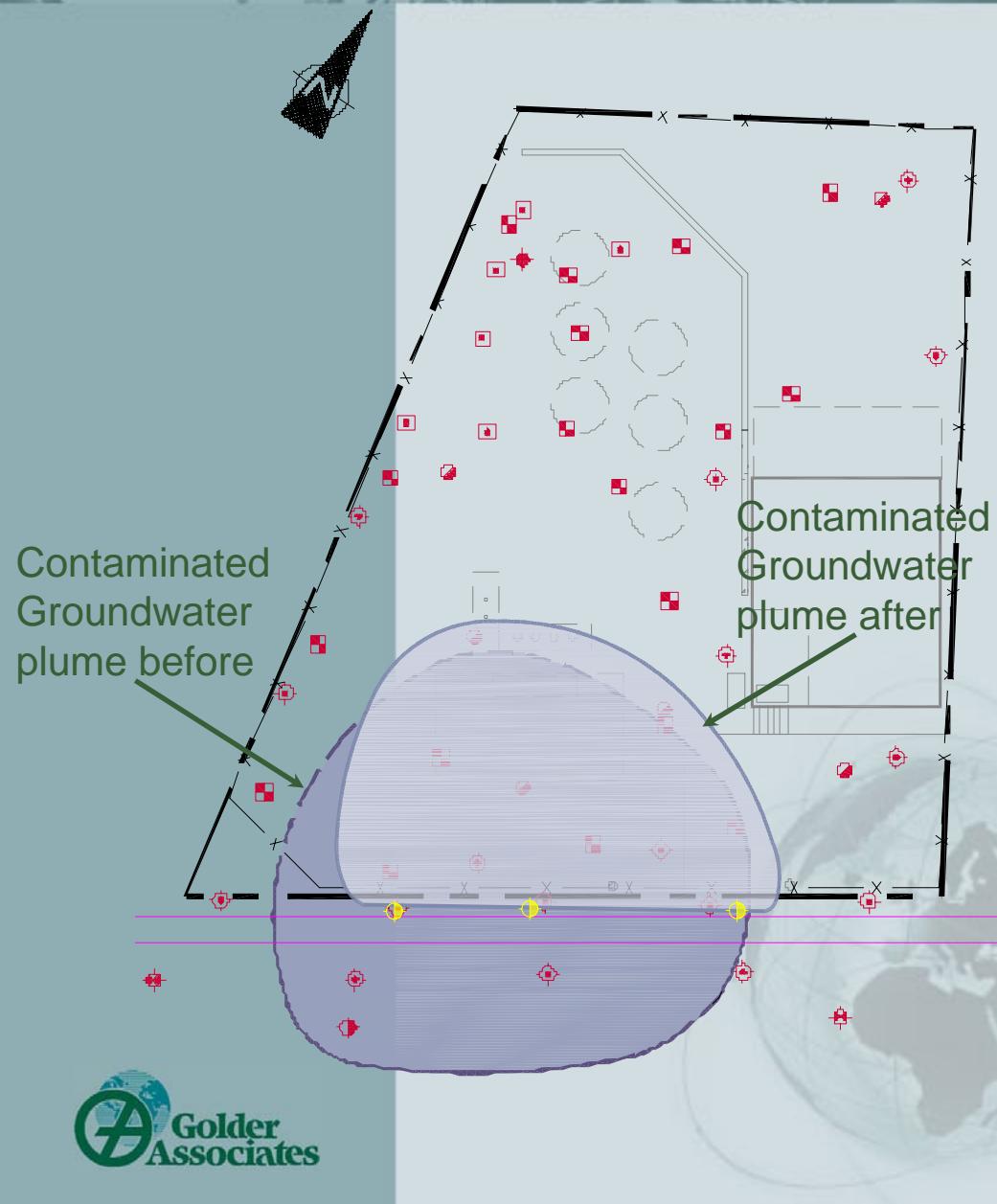
OXYGENATED WATER SYSTEM

- 21 injection wells
- 6 lines
- SOW system with 6 units
- 2 pumping wells to increase the injection flowrate
- Oxygen generator
- Heated underground pipes for winter operation

HYDRAULIC BARRIER

- 3 pumping wells
- Flow 6 L/min/well
- Recirculation loop operation

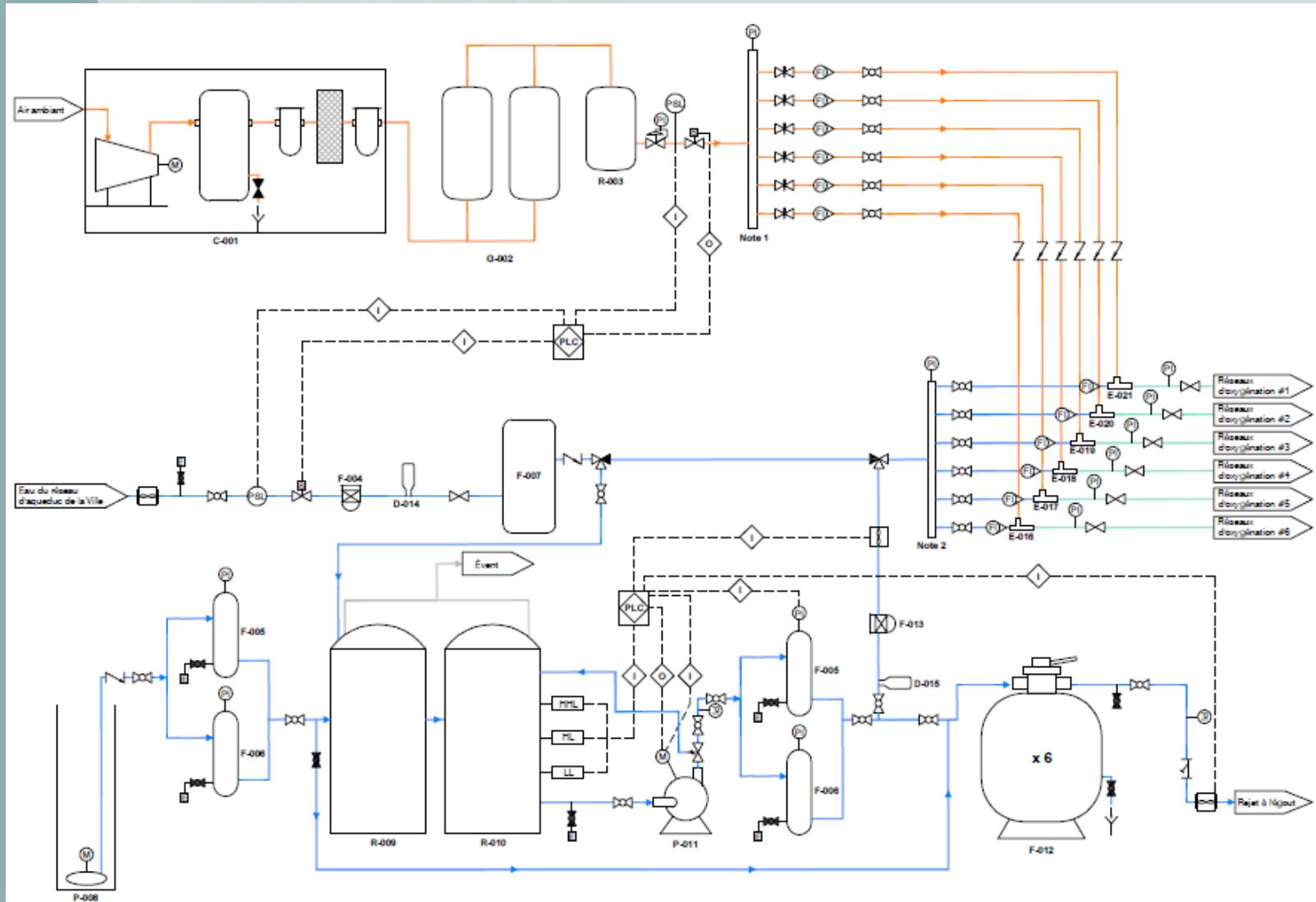
System Installation and Results



HYDRAULIC BARRIER

- Installed in the spring of 2008
- No further impact on the sewer
- Containment of contaminated water plume

SOW P&ID



System – Piping



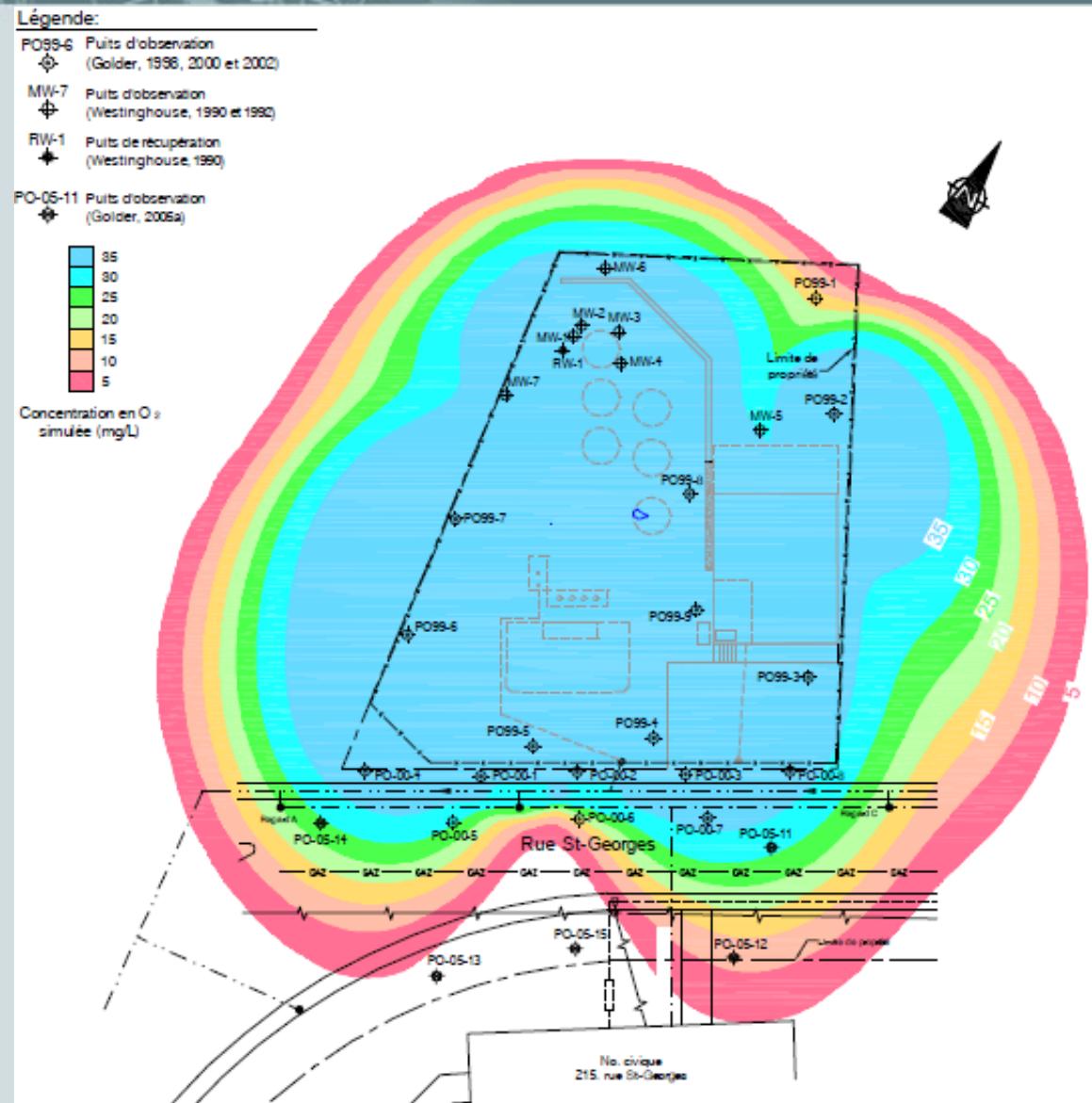
System – Recirculation



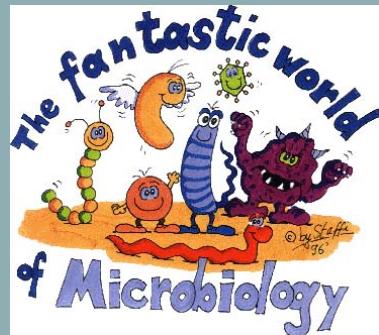
System – SOW



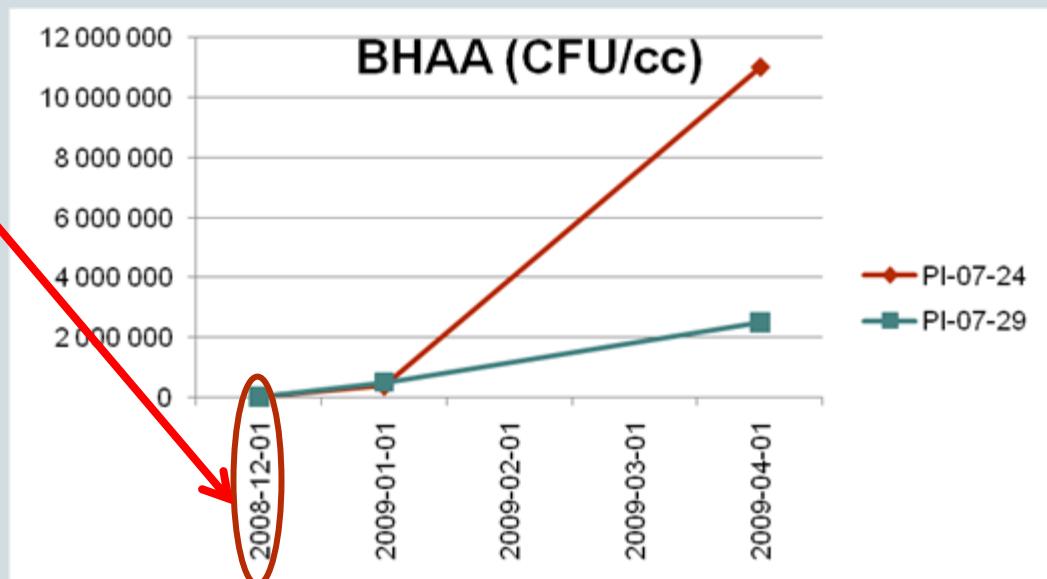
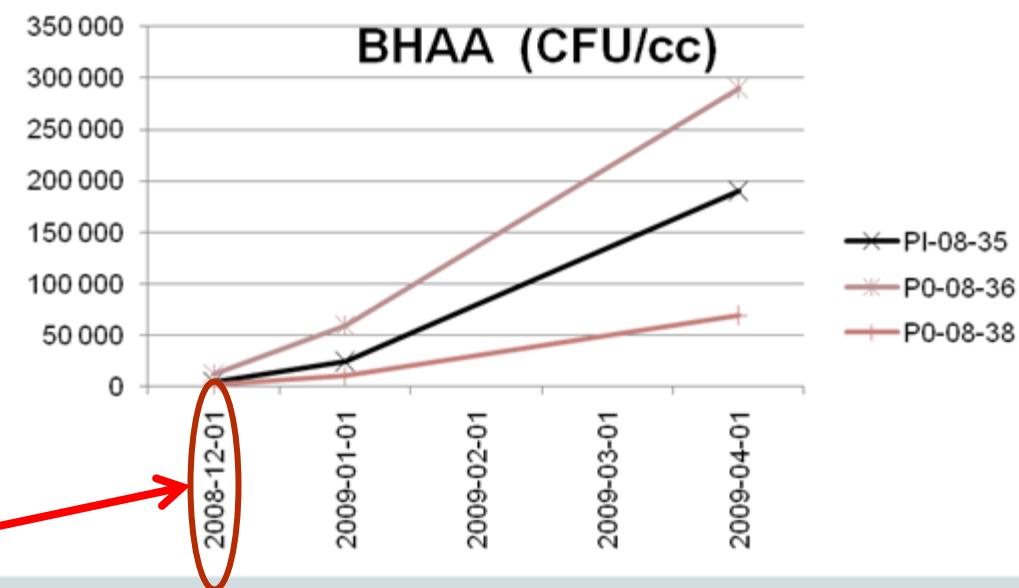
Results : Oxygen Dispersion – 1000 days



Results : Total Bacteria Plate Count



Prior Treatment
 $< 1000 \text{ CFU/cc}$



Results

➤ Nutrients:

- VB591® micro-encapsulated oleophilic powder
- Target : C:N:P = 100:10:1
- Mean value: 100:20:3

➤ DO :

- Injection wells: 46-71 ppm
- Control wells: 10-25 ppm

➤ Flowrate: 26-63 l/min

Conclusions

- SOW is a sustainable and efficient technology to remediate hydrocarbons impacted soil/groundwater
- GolderSET is a very comprehensive tool for remediation option selection
- Bioremediation through a recirculation loop is very effective
- Iron clogging = huge challenge for recirculation



THANKS! QUESTIONS??

Team work :

- The Environmental Site Assessment Group
- GAIA
- The Sustainable Development Group
- The client who let Golder use SOW
and the SD approach



Finalist in
*Category 2 - Sustainable Remediation
Technologies and Technological
Innovation*

