Integration of Chemical and Biological Technologies for Remediation of Contaminated Soil and Groundwater

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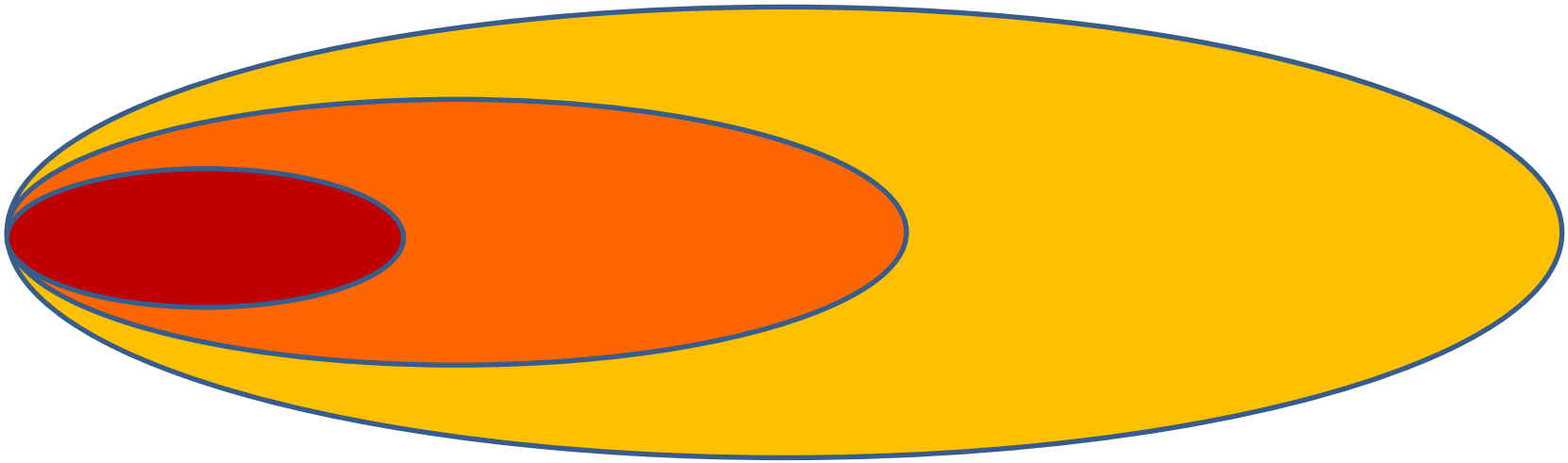
About Canada Colors

- Sole Distributor for Regenesis Products in Canada
- Largest independent distributor in Canada
- Full service provider of over 5,000 commodity and specialty products
  - Environmental & Water Treatment
  - Industrial Solvents
  - Food and Fine chemicals
  - Coatings & Polymer additives
  - Oil & Gas
  - Soap & Detergent
  - Mining
  - Pulp & Paper

Treatment Train



Source Area:
Dig & Dump
Thermal
SVE
ISCO
Stabilization

→

Core Plume Area:
ISCO
Bioremediation
Pump & Treat

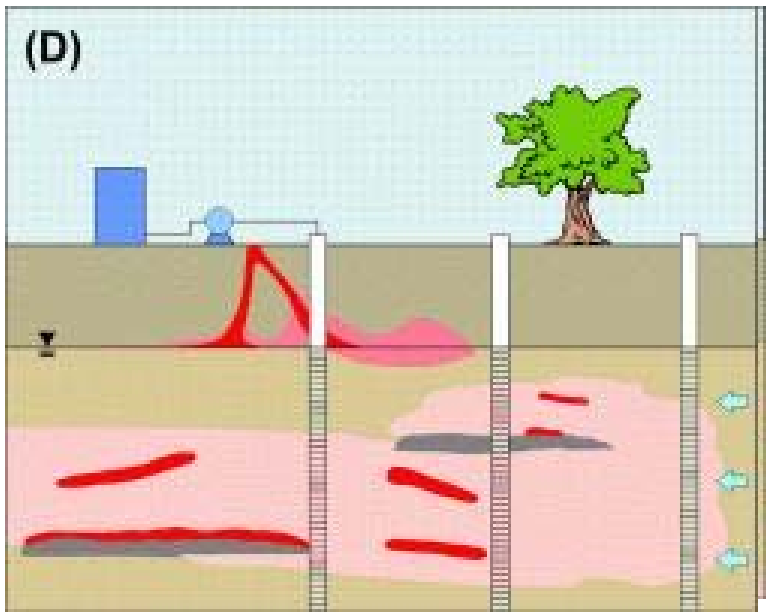
→

Dissolved Plume Area:
Bioremediation
Natural Attenuation
ISCO

Contaminant Concentration

In-Situ Chemical Oxidation (ISCO)

- Chemical oxidation reaction involves the breaking of chemical bonds and the removal of electrons
- Electrons are transferred from the contaminant to the oxidant
- The contaminant is oxidized and the oxidant (electron acceptor) is reduced



Bioremediation

- The process of using microorganisms, fungi, or enzymes to treat environmental contaminants
- Aerobic degradation
  - BTEX, TPH, PAHs
- Anaerobic degradation
  - PCE, TCE, DCE, TCA, DCA
- Biostimulation: the addition of nutrients to stimulate bioremediation

In-Situ Remedial Design

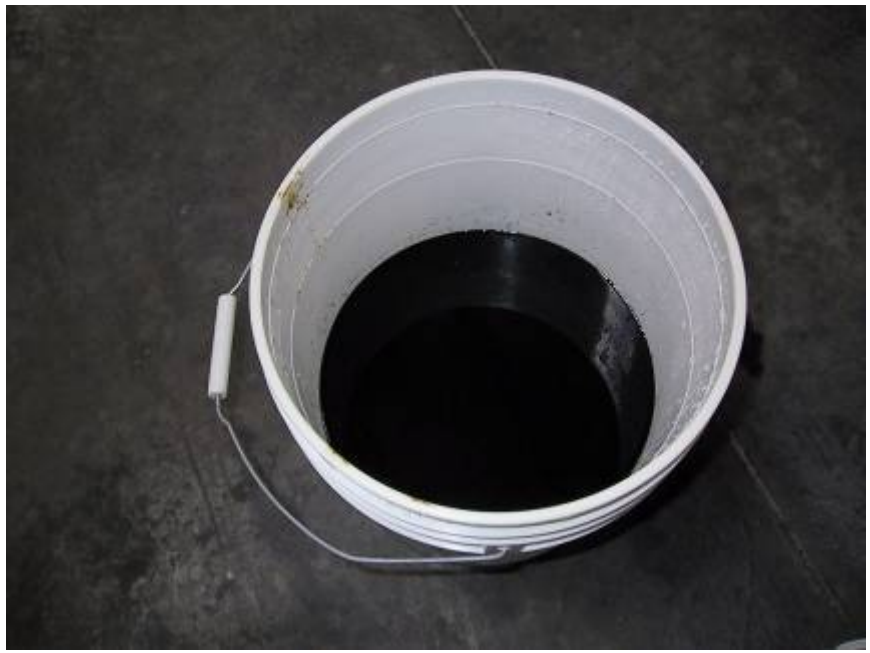
- Oxidants or substrates typically injected using direct-push equipment
- Spacing of injection points is dependent on:
  - Geology
  - Plume Size
  - Product
- Product is injected across the vertical length of the contaminated saturated zone
  - Include the smear zone
- When treating soil, spacing must be closer and water should be added
  - Water is the transport medium

A key to success…

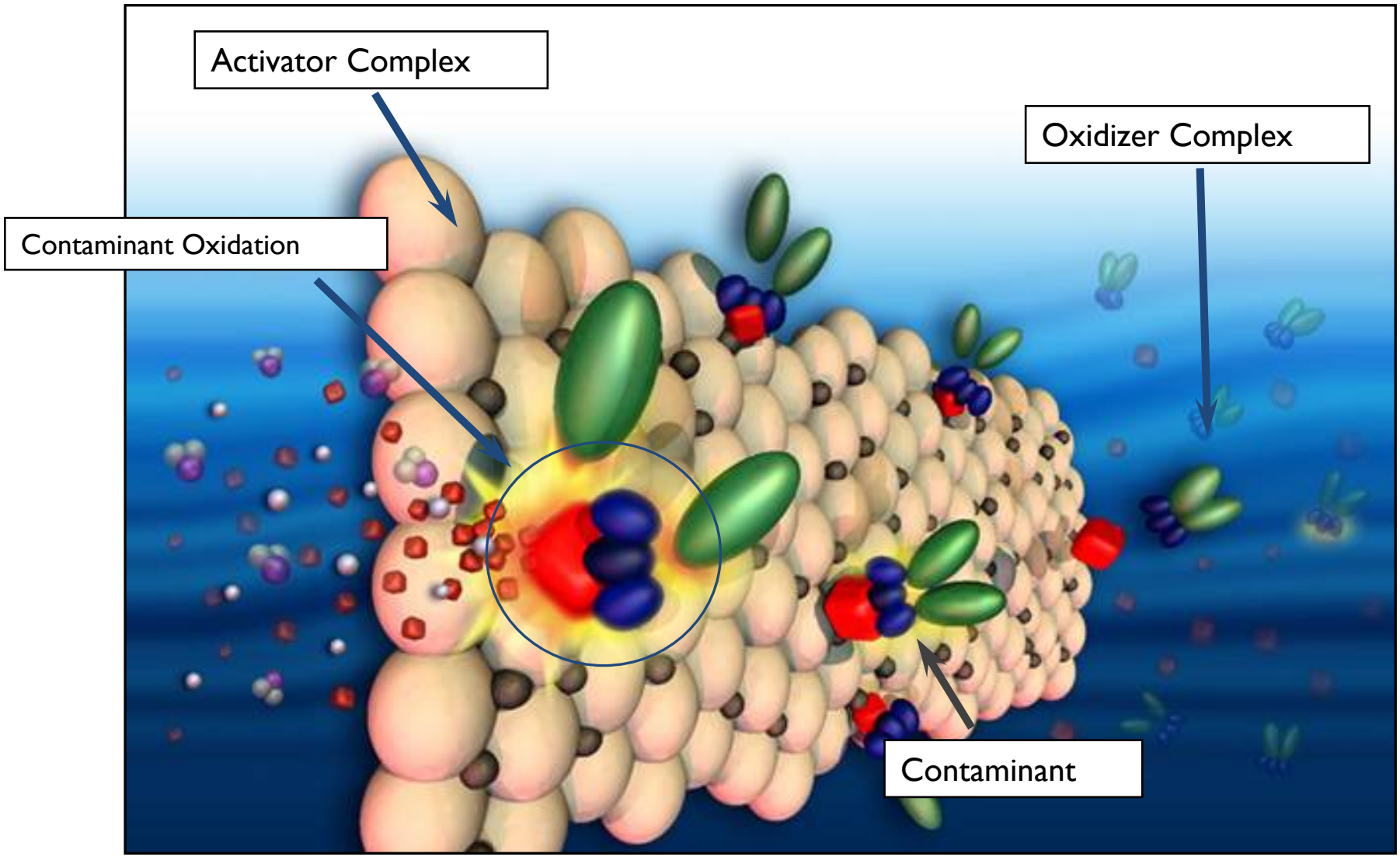
RegenOx™

CHEMICAL OXIDATION REDEFINED...

Part A: Sodium Percarbonate

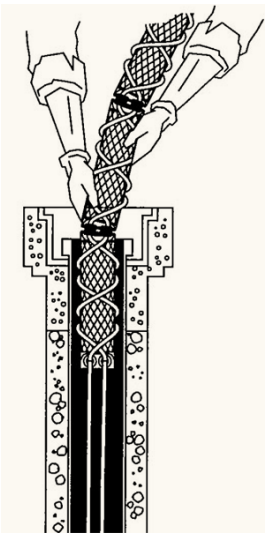


Part B: Catalyst and Silica


Activator Complex
Oxidizer Complex
Contaminant Oxidation
Contaminant

ORC ADVANCED™

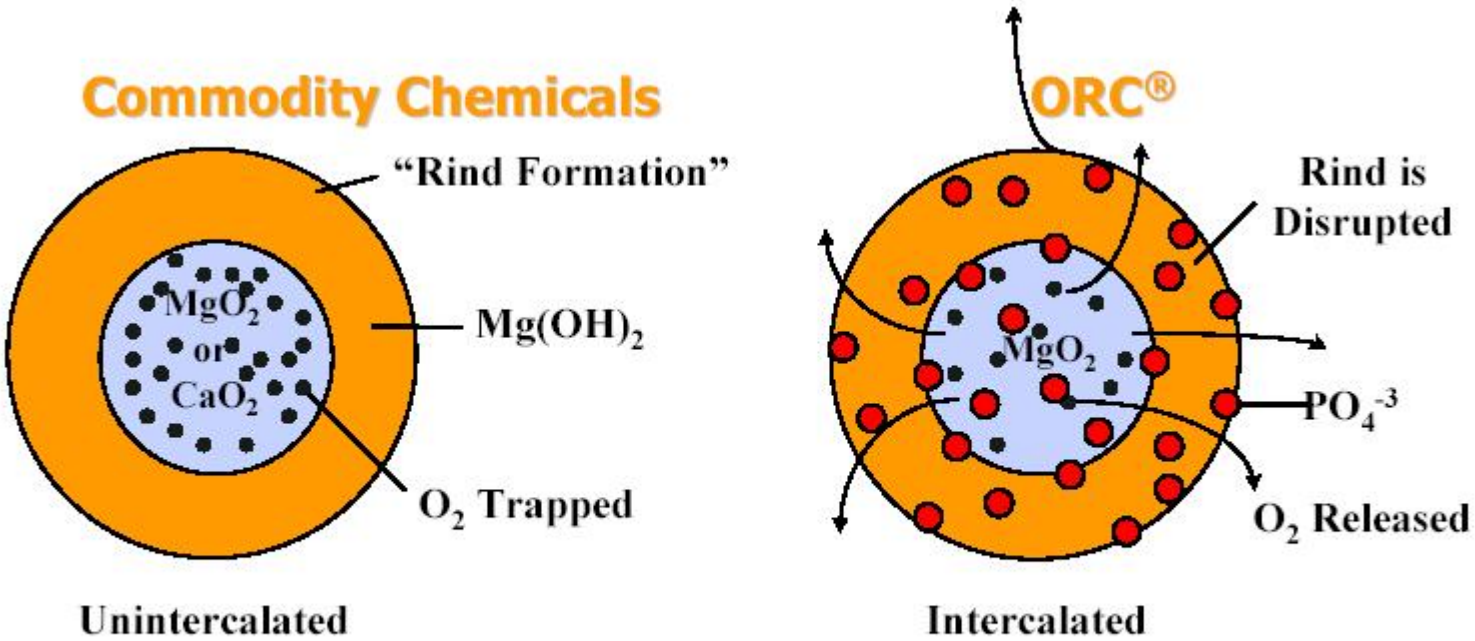
- ORC releases oxygen in the subsurface over a period of a year
- Oxygen is used by microorganisms in the aerobic degradation of compounds
- ORC can treat TPH, BTEX, DCE, and VC



- ORC comes in pails as a white powder
- ORC can be applied to the subsurface:
  - By injection
  - Using ORC socks (left)
  - Application in trenches or excavation backfill

Controlled Release Technology (CRT)

- Unintercalated peryxogen is subject to "oxygen lock-up"



This unique process separates ORC from commodity magnesium and calcium peroxides in form and function!

RegenOx™

- Chemical Oxidation
- Concentration in ppm
- Reaction times weeks to month

ORC ADVANCED™
OXYGEN RELEASE COMPOUND

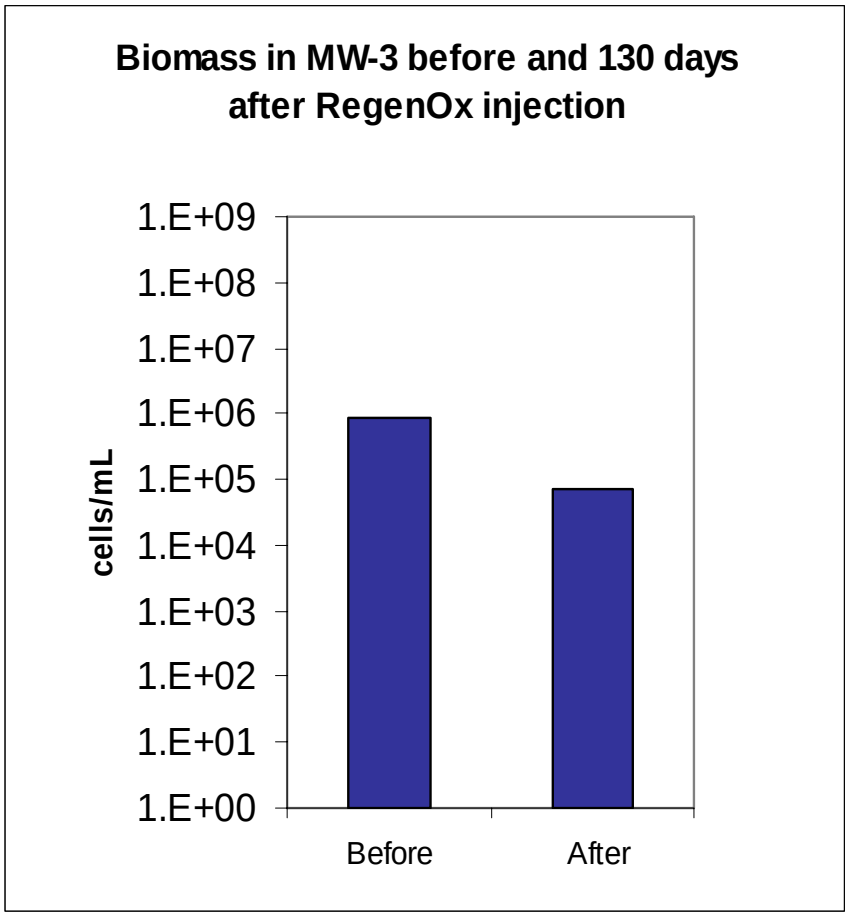
- Biological Oxidation
- Concentration in ppb
- Reaction times months to year

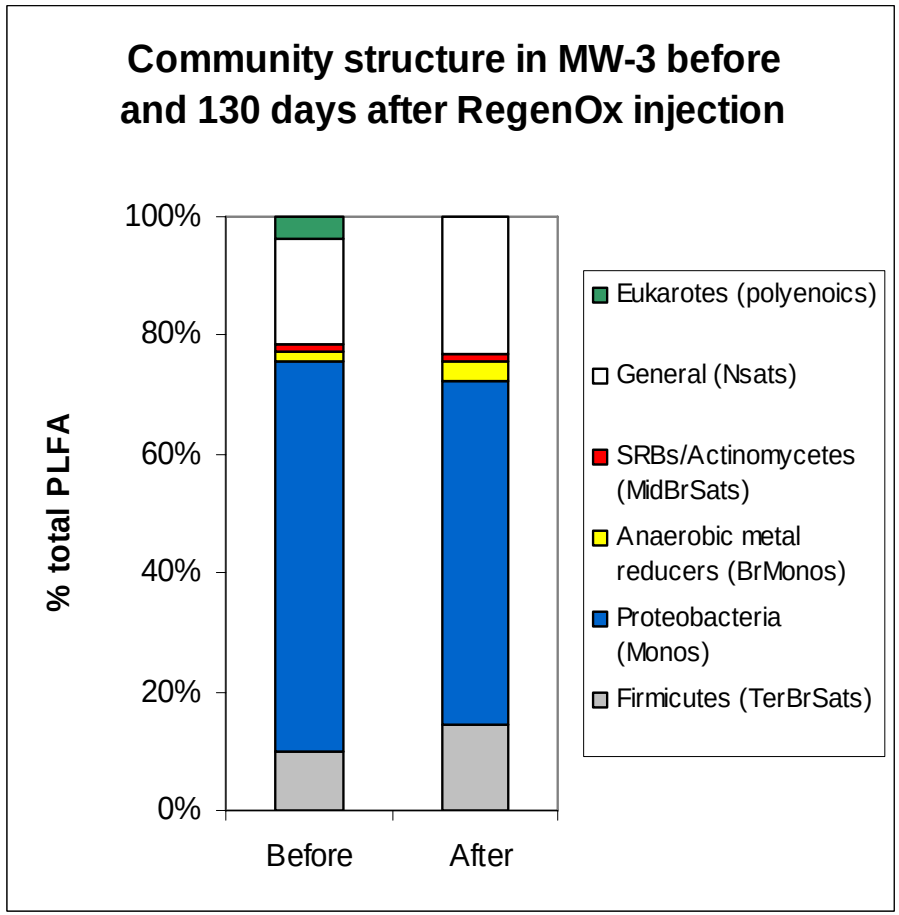
Combined Remedies: Chem to Bio (Oxidation)

- Chemical Oxidation
  - Establishes high ORP
  - Results in high dissolved O_2
  - Colorless, non-toxic, mineral-like residuals (RegenOx™)
- Aerobic Bioremediation
  - Biological Oxidation process
  - Enhanced by adding O_2
  - ORC-A can be co-applied directly after or with RegenOx™

Coupling of the two oxidations is seamless

RegenOx does not inhibit microbial growth





Typical Application

Direct Push

For RegenOx

- 10-20 lbs/ft.
- 20-60 gal./ft.
- 5-10 ft. Spacing

For ORC/ORC-A

- 4-10 lbs./ft.
- 1-3 gal./ft.
- 10-30 ft. Spacing

Mix the RegenOx Part A into water until it dissolves into a milky liquid

Add Part A and Part B together to form a slurry

Mix the two parts thoroughly

Mix the ORC-A into the RegenOx

Site 1: Manufacturing Facility

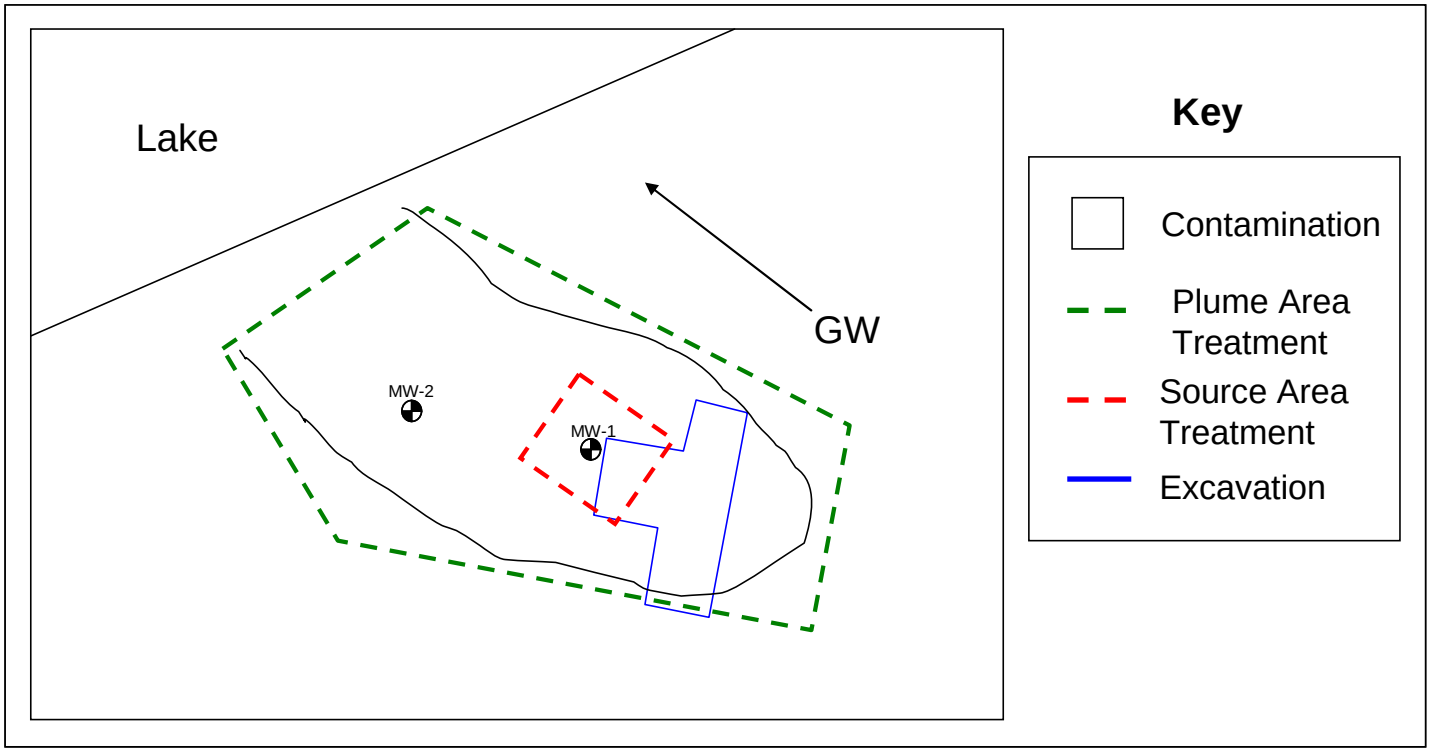
- BTEX Contamination, 46 ppm
- Excavation Treatment
- Source/Plume Treatment
- Treatment area: 9,800 ft^2 x 12 ft
- Depth to GW: 5-7 ft
- Soil Type: Sand
- GW Velocity: 0.33 ft/d

Remediation Approach

- Solution: RegenOx & ORC Advanced
- Application Type:
  - RegenOx: Direct Push Injection
  - ORC Advanced: Direct Push and Excavation Backfill
- Quantity Applied:
  - RegenOx: 12,480 lbs
  - ORC Advanced: 6,350 lbs

RegenOx™

ORC ADVANCED™
OXYGEN RELEASE COMPOUND



- Treatment Area:
  - ORC-Advanced in the plume: 9,800 ft^2
  - ORC Advanced in excavation pit: 2,200 ft^2
  - RegenOx + ORC-Advanced in the Source: 1000 ft^2

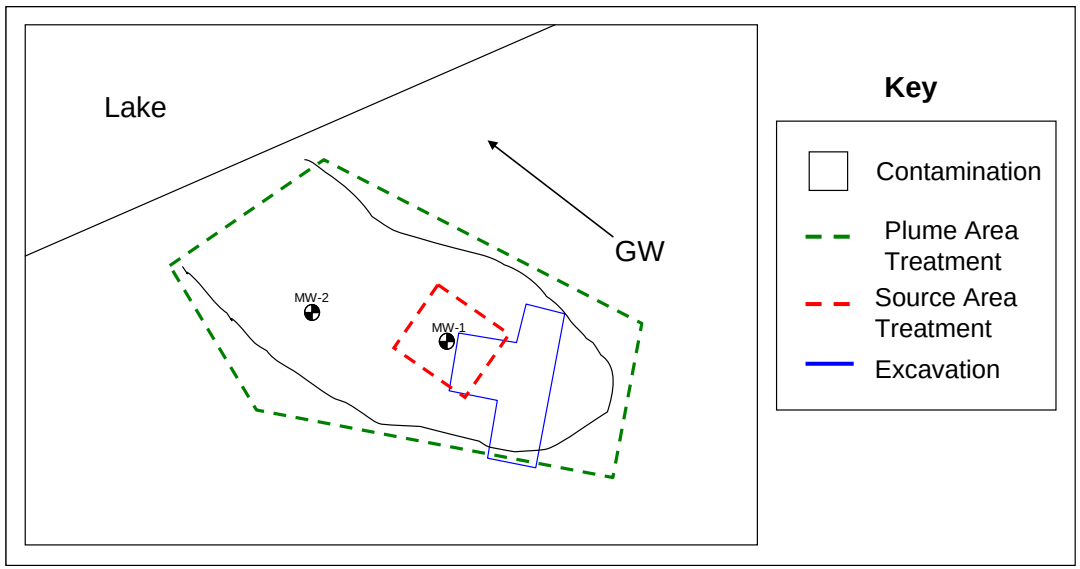
Contaminant Concentrations

Well MW-1 Pre-treatment Concentrations	
Contaminant	**Concentration**
Benzene	2.62 μg/L
Toluene	21,400 μg/L
Ethylbenzene	4,200 μg/L
Xylenes	20,500 μg/L

Total BTEX = 46 ppm

Application

- After Excavation, 950 lbs ORC-Advanced applied to pit
- RegenOx applied in source area (downgradient edge of pit)
- 6 RegenOx Applications, through November 2006
- 6th injection: RegenOx + ORC-Advanced in source area
- ORC-Advanced injected across entire plume



Results: January, 2007

MW-1 Results (ppb)					
Contaminant	Initial Concentration	Post Concentration	Reduction		
Benzene	3	BQL	-		
Toluene	21,400	BQL	**>98 %**	1700	Goals
Ethylbenzene	4,200	730	**82%**	320	
Xylenes	20,500	2,000	**90%**	630	

Source Area

Results: January, 2007

MW-2 Results (ppb)				
Contaminant	Initial Concentration	Post Concentration	Reduction	
Benzene	BQL	BQL	-	
Toluene	BQL	BQL	**-**	1700
Ethylbenzene	672	364	**46%**	320
Xylenes	2,570	91	**96%**	630

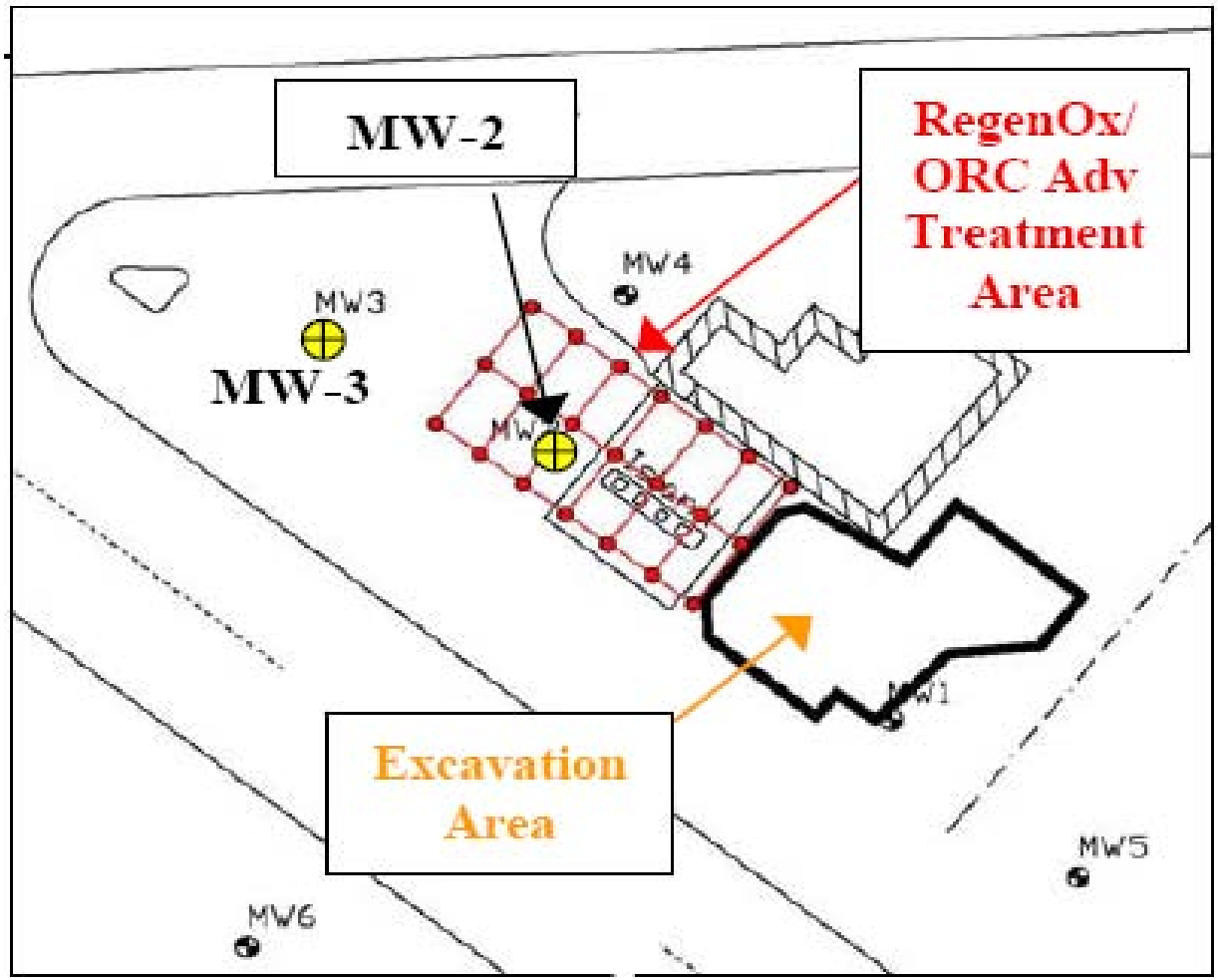
Goals

Plume Area

Summary

- Combined RegenOx/ORC-Advanced application
- 2 months into bioremediation phase, BTEX levels at or near goals in all wells.
- In hottest well, total BTEX from 46 ppm to 2.7 ppm
- GW concentrations indicate that contaminant mass reduced significantly

Site 2: LUST Site in Alabama



Site Characteristics

- Service Station in Central Alabama
- Tanks excavated years before RegenOx and ORC-A injections
- Shallow silt overlying silty sand
- Depth to water – 5 ft bgs
- Treatment thickness – 12 feet (5-17 ft bgs)

Contaminant	Baseline (MW-2)	Baseline (MW-3)
Total BTEX	17.5 mg/L	0.220 mg/L

Remediation Approach

- Direct-push injection

Product	Vertical Thickness	Inj. Pts	Spacing
RegenOx	12 ft	28	8 x 8 ft
ORC Advanced	12 ft	20	8 x 10 ft

- Product Amounts
  - RegenOx – 4,650 lbs
  - ORC Advanced – 1,200 lbs
- Product Cost
  - RegenOx – $9,068
  - ORC Advanced – $10,500

Remediation Timeline

	RegenOx	ORC Advanced
January '06	1350 lbs	
Feb '06	1630 lbs	600 lbs
October '06	1680 lbs	
November '06		600 lbs

Ground Water Results

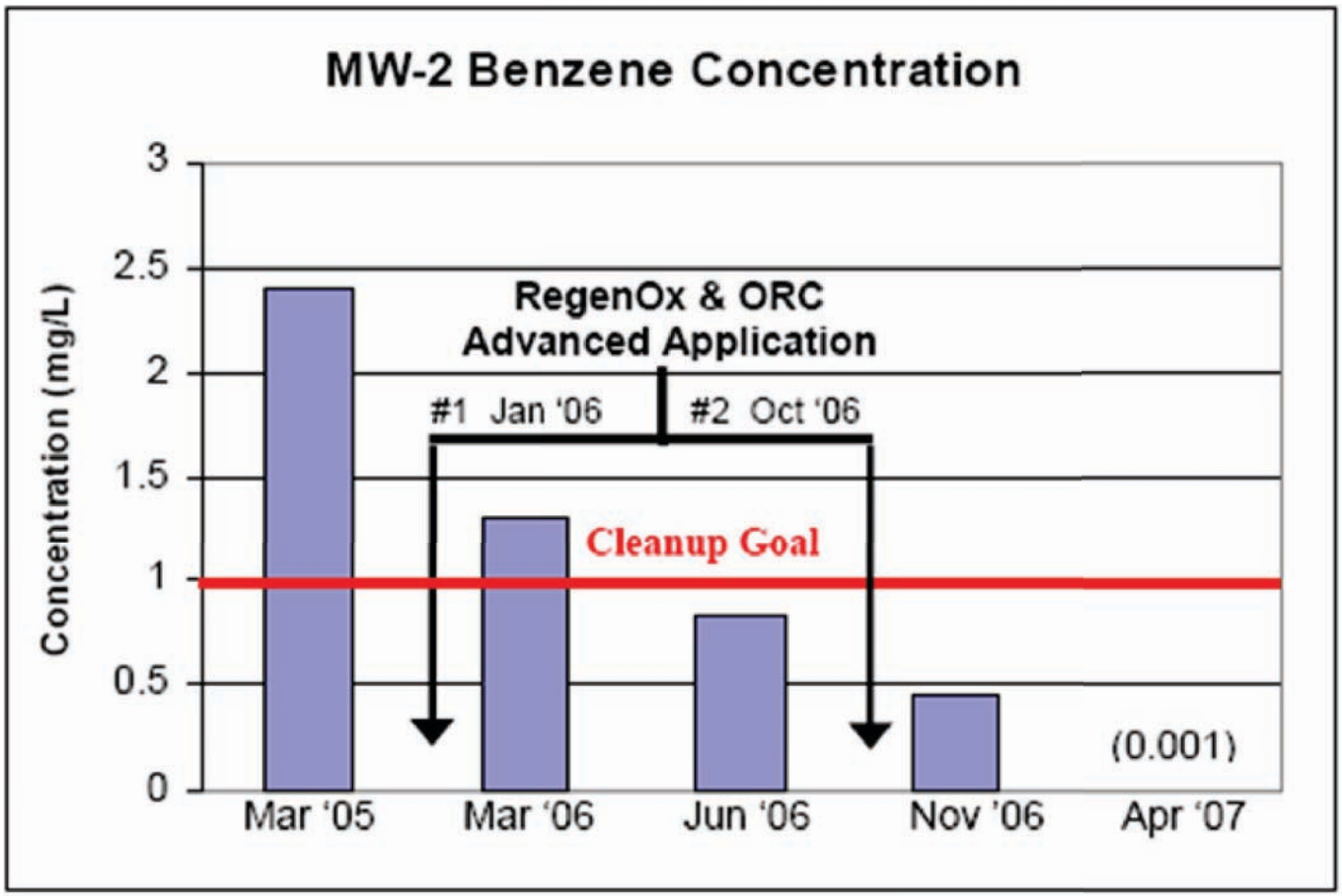
MW-2

	Baseline	3/2006	6/2006	11/2006
BTEX	17.5 mg/L	10.90 mg/L	0.973 mg/L	0.588 mg/L

MW-3

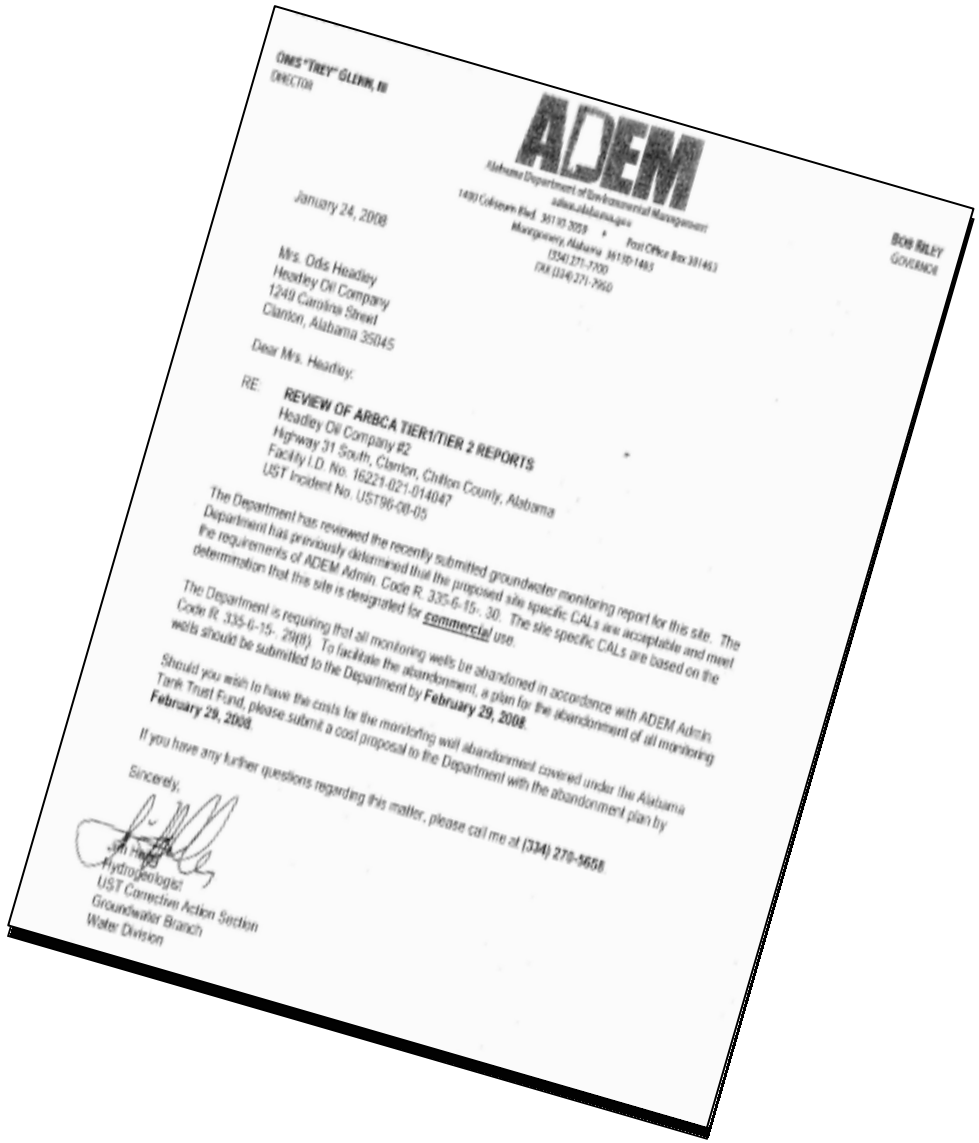
	Baseline	3/2006	6/2006	11/2006
BTEX	0.220 mg/L	0.128 mg/L	0.242 mg/L	0.042 mg/L

Contaminant	Pre-Treatment Concentration (ppm)	Post-Treatment Concentration (ppm)	Cleanup Goal	Percent Reduction
Benzene	2.4	0.001	0.99	99%
BTEX	17.5	0.004	NA	99%



Conclusions

- Clean-up goals reached within 6-months
- BTEX level maintained for 1 ½ years
- Closure was granted and the property has been redeveloped



ADEM
Alabama Department of Environmental Management

January 24, 2008

Mrs. Odis Headley
Headley Oil Company
1249 Carolina Street
Clanton, Alabama 35045

Dear Mrs. Headley:

RE: **REVIEW OF ARBCA TIER1/TIER 2 REPORTS**
Headley Oil Company #2
Highway 31 South, Clanton, Chilton County, Alabama
Facility I.D. No. 16221-021-014047
UST Incident No. UST96-08-05

The Department has reviewed the recently submitted groundwater monitoring report for this site. The Department has previously determined that the proposed site specific CALs are acceptable and meet the requirements of ADEM Admin. Code R. 335-6-15-.30. The site specific CALs are based on the determination that this site is designated for **commercial** use.

The Department is requiring that all monitoring wells be abandoned in accordance with ADEM Admin. Code R. 335-6-15-.29(8). To facilitate the abandonment, a plan for the abandonment of all monitoring wells should be submitted to the Department by **February 29, 2008**.

Should you wish to have the costs for the monitoring well abandonment covered under the Alabama Tank Trust Fund, please submit a cost proposal to the Department with the abandonment plan by **February 29, 2008**.

If you have any further questions regarding this matter, please call me at **(334) 270-5658**.

Sincerely,

Hydrogeologist
UST Corrective Action Section
Groundwater Branch
Water Division

Conclusions

- Chemical oxidation (RegenOx) is good at reducing mass quickly and effectively
- Bioremediation (ORC) is a good polishing step
- The combination of these two technologies is an effective, low-cost solution for treating aerobically degradable compounds