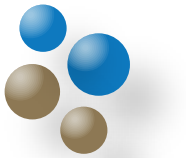
Residual LNAPL Impacted Sites – Conceptual Site Models and Effective Remedial Strategies

AIPG Kentucky Section
April 26, 2013

Barry Poling
REGENESIS
Central Region Manager

REGENESIS BACKGROUND

- ✓ Founded in 1994
  - ✓ 19 years in the remediation technology business.
- ✓ Leader in Remediation Technology Development
  - ➢ 17 commercially available technologies focused on soil, groundwater and vapor intrusion.
  - ➢ TECHNOLOGY CLASSES
    - Bioremediation
    - Chemical Oxidation
    - Chemical Reduction
    - Enhanced Desorption
    - Vapor Mitigation



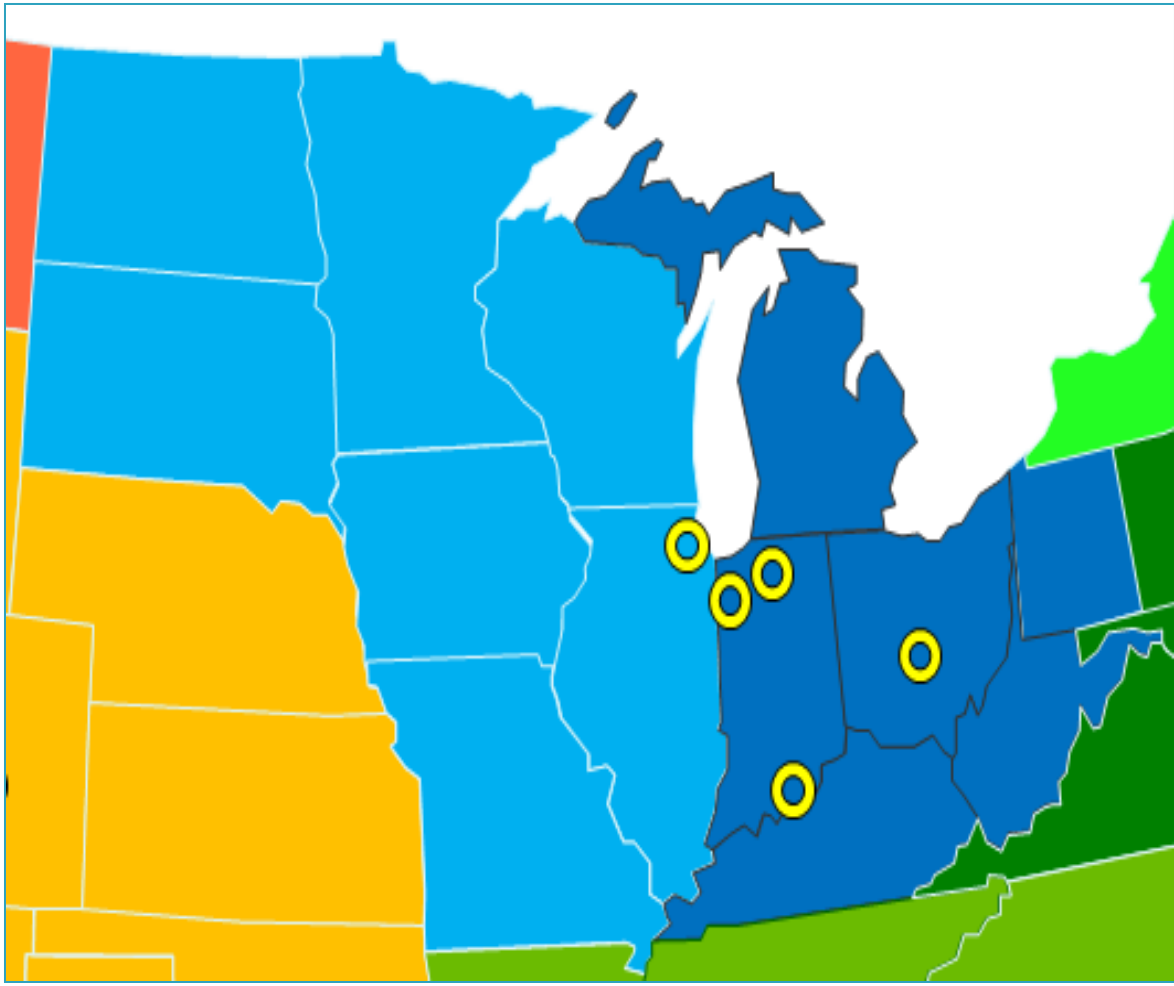
Services Provided

Technical Support:

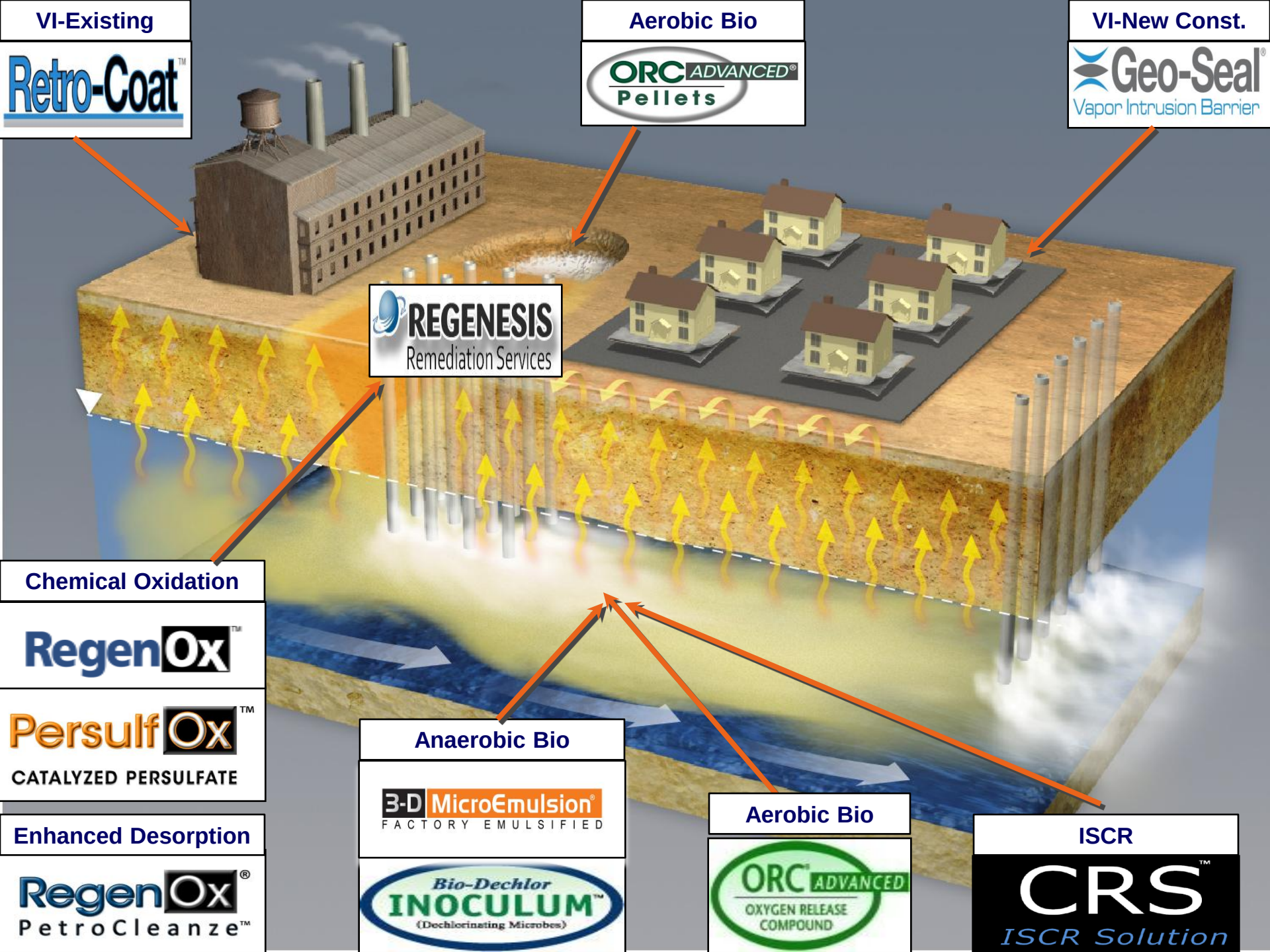
- ✓ **Pre-Remedial Design Support**
  - ✓ Recommendations on necessary data to be collected.
  - ✓ Site Evaluation and feasibility analysis.
- ✓ **Remedial Design Support and Generation**
  - ✓ Regulatory Approval Assistance
- ✓ **Onsite Application Services-Turn Key**
- ✓ **Performance review and recommendations**

REGENESIS–CENTRAL REGION TEAM

- Barry Poling
  Regional Manager
- Doug Davis
  Technical Services Manager
  - Ryan Moore
    Great Lakes District Manager
  - Scott Mullin
    Remediation Services Division Manager
    - Steve Barnes
      Remediation Services Project Manager
  - Adam Richards
    LST Regional Manager



REGENESIS


VI-Existing
Retro-Coat
Aerobic Bio
ORC ADVANCED Pellets
VI-New Const.
Geo-Seal
Vapor Intrusion Barrier
REGENESIS
Remediation Services
Chemical Oxidation
RegenOx
PersulfOx
CATALYZED PERSULFATE
Enhanced Desorption
RegenOx
PetroCleanze
Anaerobic Bio
3-D MicroEmulsion
FACTORY EMULSIFIED
Bio-Dechlor
INOCULUM
(Dechlorinating Microbes)
Aerobic Bio
ORC ADVANCED
OXYGEN RELEASE COMPOUND
ISCR
CRS
ISCR Solution

RegenOx® PetroCleanze™

RegenOx **PetroCleanze** is a custom formulation of the widely-used RegenOx *in situ* chemical oxidation technology.

- Chemical Oxidant with detergent-like properties
  - Designed to increase desorption rates of hydrocarbons bound to saturated soil
- Used in combination with
  - Mobile Extraction
  - Existing systems

RegenOx® PetroCleanze™

Treating Source areas

Treating Residual Sorbed Mass

- Excellent for treating smear-zones, source zones
  - Inject with direct-push rigs or wells
  - Rapidly recover hydrocarbon with wells or vacuum trucks

RegenOx® PetroCleanze™

RegenOx® PetroCleanze™

Technology Validation– Austrailia

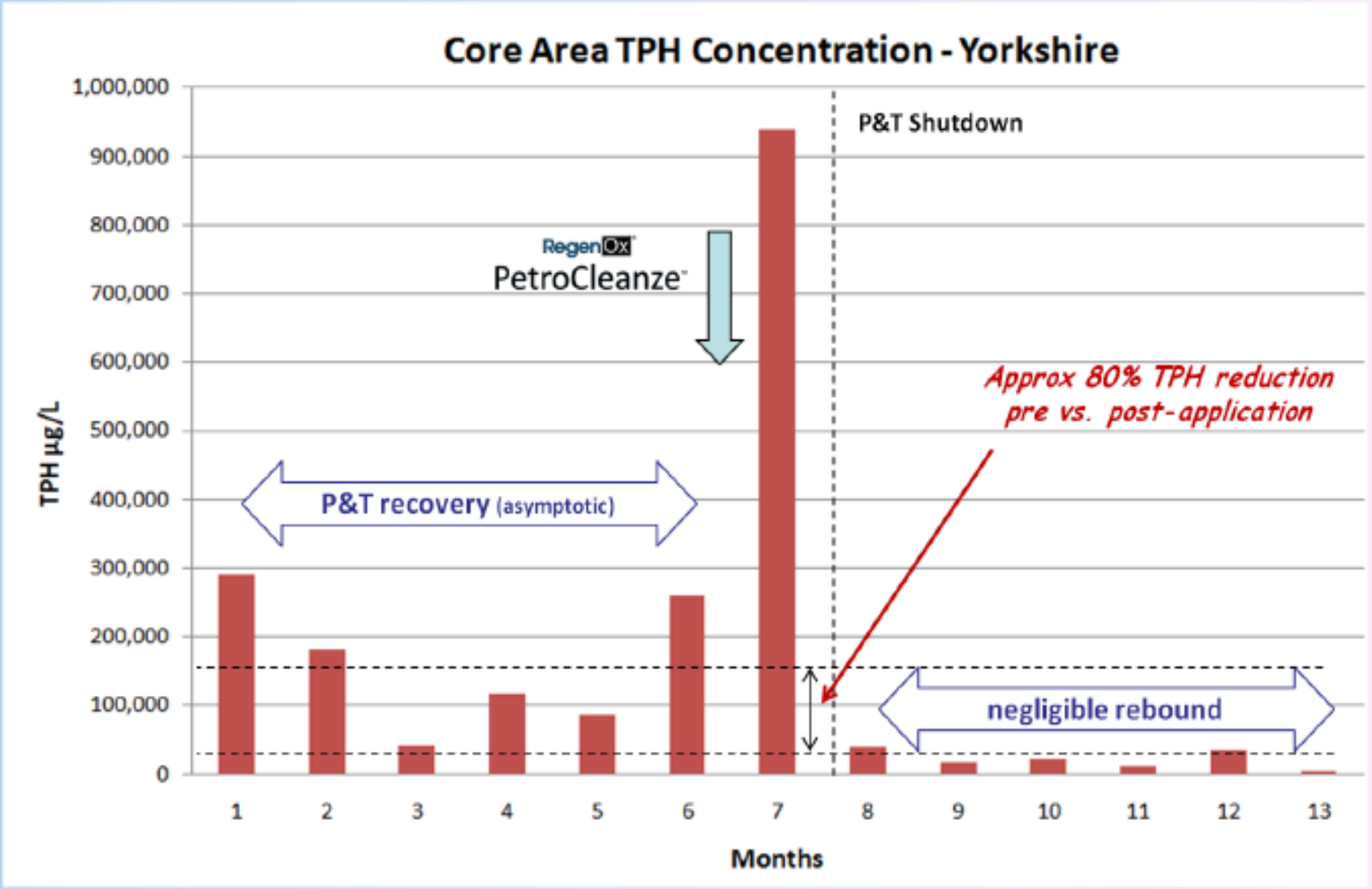
Event 1 Event 2 Event 3

Field Demonstration

- Injection/Extraction Application
  - Prototype formula
- 3 Cycles
- Extraction water
  - Cleaner water with each cycle

Case Study: — Yorkshire UK, Pump and Treat Enhancement

Background: Residential redevelopment of former filling station



Results: 80% TPH reduction achieved with two reagent applications augmenting DPVE recovery over four weeks.

No Rebound—augmentation process successfully removed sorbed-phase TPH and smear from soil.

PetroCleanze™—A New Product for Freeing Bound Hydrocarbons for more effective Enhanced Recovery and Chemical Oxidation

Kallum Nash, Jeremy Birnstingl PhD, Ben Mork PhD
Regenesis Ltd, Beehive Yard, Walcot Street, Bath, BA1 5BB, UK (www.regenesis.com) +44 1225 731448

REGENESIS

Description

PetroCleanze™ is a customized formulation of the widely-used RegenOx® *in situ* chemical oxidation technology. The primary function of PetroCleanze is to increase the desorption rates of hydrocarbons bound in saturated soil and make them available for more efficient and rapid treatment using enhanced recovery technologies.

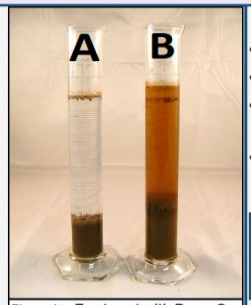


Figure 1: **Treatment with RegenOx PetroCleanze**

A. An untreated soil and hydrocarbon mixture in water

B. RegenOx PetroCleanze treated soil and hydrocarbon mixture with bound hydrocarbon clearly being released into the dissolved phase for removal or treatment

Features and Benefits

- Unique product chemistry proven highly effective on petroleum hydrocarbon contamination
- Detergent-like technology moves bound hydrocarbons from the soil into the dissolved phase for better and more efficient recovery via physical/ mechanical removal
- Designed to be used in conjunction with physical and/or mechanical recovery systems
- Powerful oxidation reactions equal to that of standard RegenOx oxidize more readily available hydrocarbons
- A two part integrated system comprised of standard RegenOx Part A and PetroCleanze, where the PetroCleanze component stays in-place providing an activation site for multiple applications if and when required.
- Engineered chemistry does not add surfactants but creates them aiding in enhanced hydrocarbon removal
- Avoids problematic carbon loading associated with the use of standard surfactant based technologies
- As part of an integrated site remediation approach RegenOx PetroCleanze reduces mass flux to facilitate risk-based and MNA site closures

Form and Function

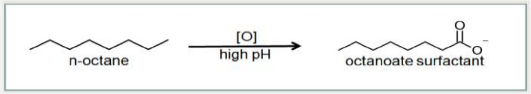
The PetroCleanze formula is optimized to desorb bound hydrocarbon mass and drive it from the soil matrix into the aqueous phase (Figure 1). Once contaminants are moved into the dissolved phase, other methods such as chemical oxidation using standard RegenOx or enhanced recovery techniques such as dual-phase extraction, vacuum enhanced extraction, pump and treat systems and even enhanced bioremediation using Oxygen Release Compound ADVANCED (ORC Advanced®) can be used.

PetroCleanze Desorption is Driven By

- Detergent-like reagent ingredients (silicates, carbonates)
- Alkaline conditions
- Formation of surfactants from the TPH through the PetroCleanze reaction
- Formation of more soluble organic species from the TPH from the PetroCleanze reaction

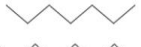
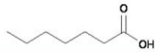
Soil Bound contamination is transferred into recoverable phases—dissolved phase and free phase may then be captured/removed by a variety of means.

Formation of Surfactants From The TPH



Partial Oxidation → Higher Solubility

Alkane +[O] → Alcohol +[O] → Organic Acid→ CO_2+H_2O

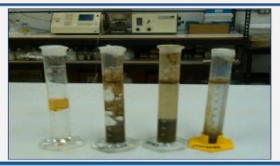
Chemical Name	Chemical Structure	Solubility in H_2O(g/L)
Heptane		0
Heptanol		3.3
Heptanoic Acid		241.9

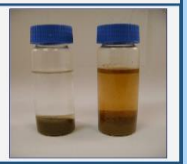
PetroCleanze is Not a Surfactant

- Surfactants have a high Biological Oxygen Demand (BOD) meaning that significant surfactant residues remain in the formation. These present a barrier to contaminate biodegradation and compete with contaminants for available oxygen
- At low concentrations (sub-CMC), surfactants increase sorption
- Surfactants are expensive and are ineffective unless at substantial concentrations
- Surfactants clog formations which is counterproductive to primary mass recovery objective and is a barrier to other remediation activities

Laboratory Studies

- Range of formulation adjustments explored
- Optimisation of performance, safety, and cost

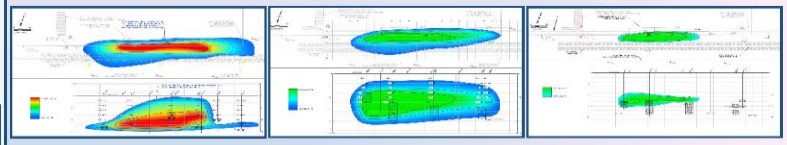




Case Study: — Florida USA, Mass-Reduction in Unsaturated Zone

Background: Pipeline spill in residential area
Diesel in soil > 10,000mg/l—500,000 L product solution

Application: Three 'push-pull' application events—Minimum 6m radius around each injection point

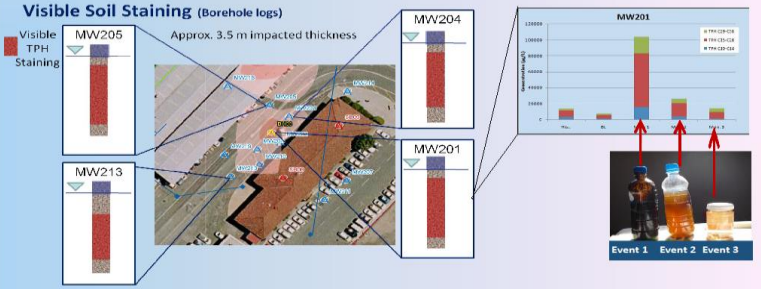


Results: Over one tonne of hydrocarbon recovered—calculated 85% overall removal—Over ... months?

Case Study: — Western Australia

Background: Former international Sea Port redevelopment
Pipe leakage, Diesel-range TPH GW TPH conc 10,000 to 100,000 µg/L and soil TPH conc. >5,000mg/kg

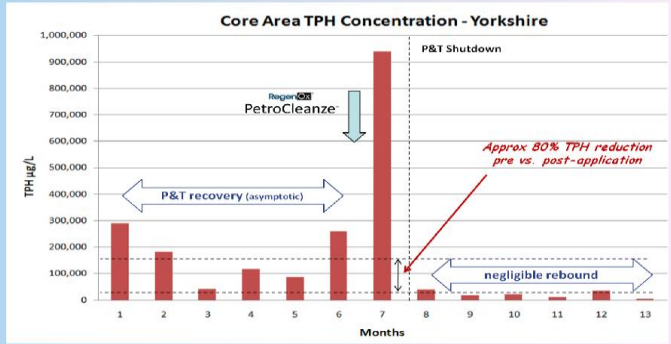
Application: Three events over 17 wells—application rate of 12 kg/m³ or treatment area at 5% solution—extraction from injection point—removing 20,000 to 40,000 L each event



Results: Average dissolved-phase reduction of 71% — 225 to 450 kg total hydrocarbon mass removed
Minimal rebound — GW remains below clean-up criteria 18-24 months post-treatment

Case Study: — Yorkshire UK, Pump and Treat Enhancement

Background: Residential redevelopment of former filling station



Results: 80% TPH reduction achieved with two reagent applications augmenting DPVE recovery over four weeks.
No Rebound—augmentation process successfully removed sorbed-phase TPH and smear from soil.
Regulatory closure achieved after three months post-DPVE

PETROCLEANZE™

- Stimulates desorption of bound hydrocarbons
  - Vadose zone or smear zone
  - source zone
  - body of plume
  - NAPL mobilization/emulsification
- Rapid and low cost removal of hydrocarbon mass
- Significantly enhances recovery methods (P&T, Vacuum Extraction, etc.)
- Creates oxygen-rich environment for aerobic bioremediation and natural attenuation
- No added BOD

KEY CONSIDERATIONS

- Well Defined Conceptual Site Model
  - Advanced Site Characterization Tools
    - Laser Induced Fluorescence (LIF)
- LNAPL Location more important than LNAPL Mass
- Physical Removal is required!
  - We recommend 120-200% of the injection volume be removed.

RegenOx® PetroCleanze™

THANK YOU

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