



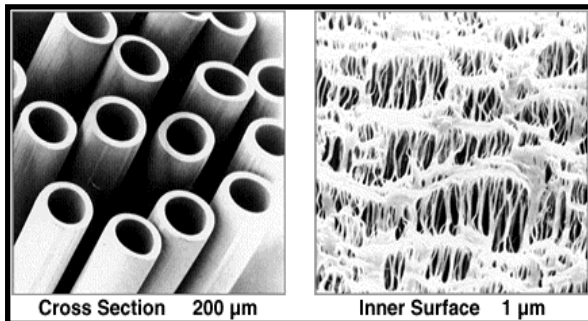
Chlorinated Hydrocarbon Remediation

gPRO[®] LP with Emulsified
Vegetable Oils

How does gPRO[®] LP Work?

- Thousands of microporous hollow fibers filled with holes
- Provides enormous surface area for mass transfer (7000 sq ft per cu ft)
- Water is saturated with dissolved Hydrogen (H₂)
- High levels of dissolved H₂ migrate to surrounding biomass
- Microbial population increases and degrade targeted compounds

Microporous Hollow Fiber



Mass Transfer Module



gPRO[®] LP





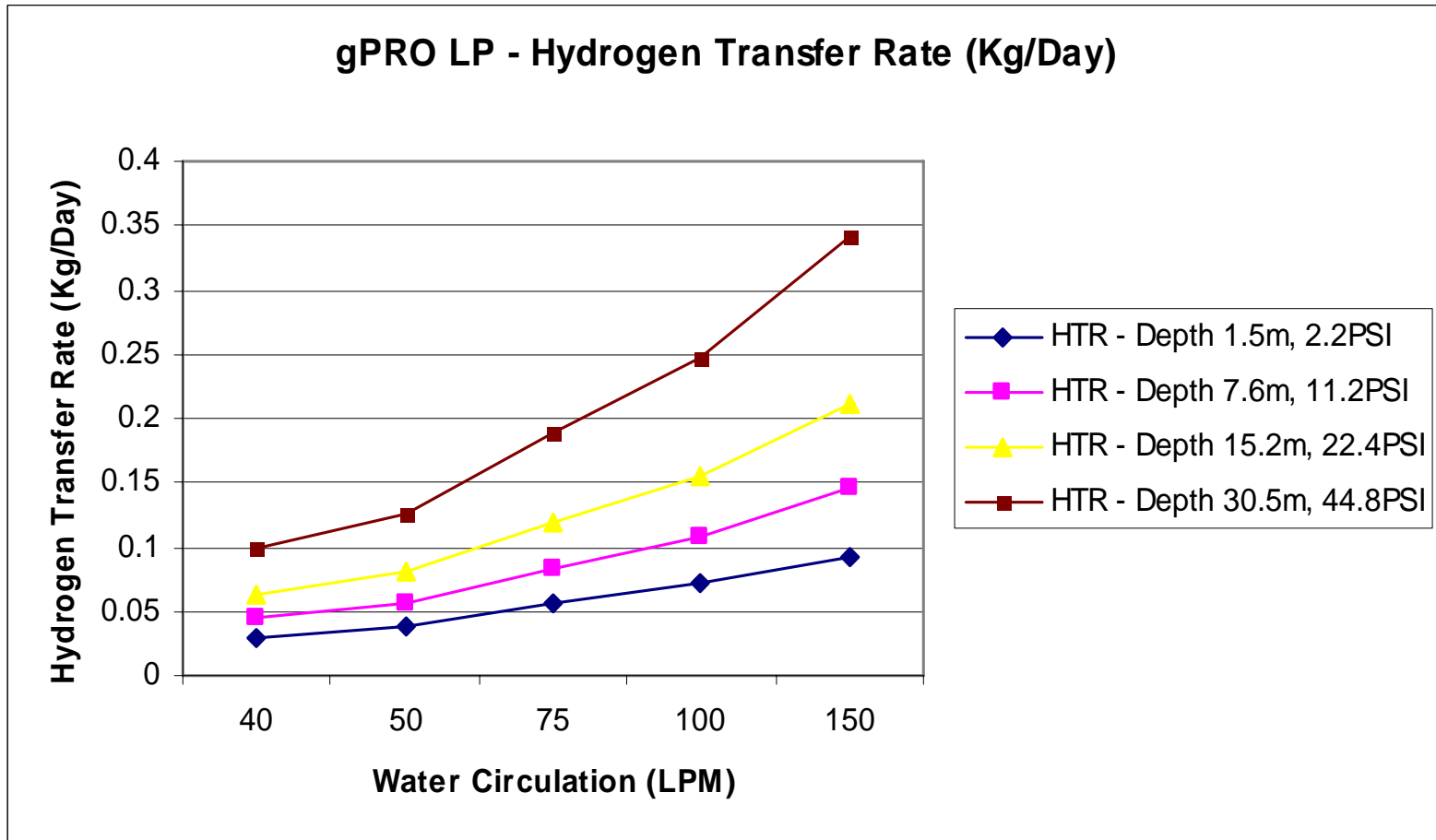
gPRO[®] LP System

- A superior gas delivery system based on inVentures' Gas inFusion Technology
- Mass transfer module delivers high amounts of dissolved H₂ to treatment zone
- gPRO[®] LP system is submerged directly into the body of water
- Gas enters the mass transfer modules through an inlet at the top of the gPRO[®] LP unit
- Water is pumped through an internal core and passes over the mass transfer module

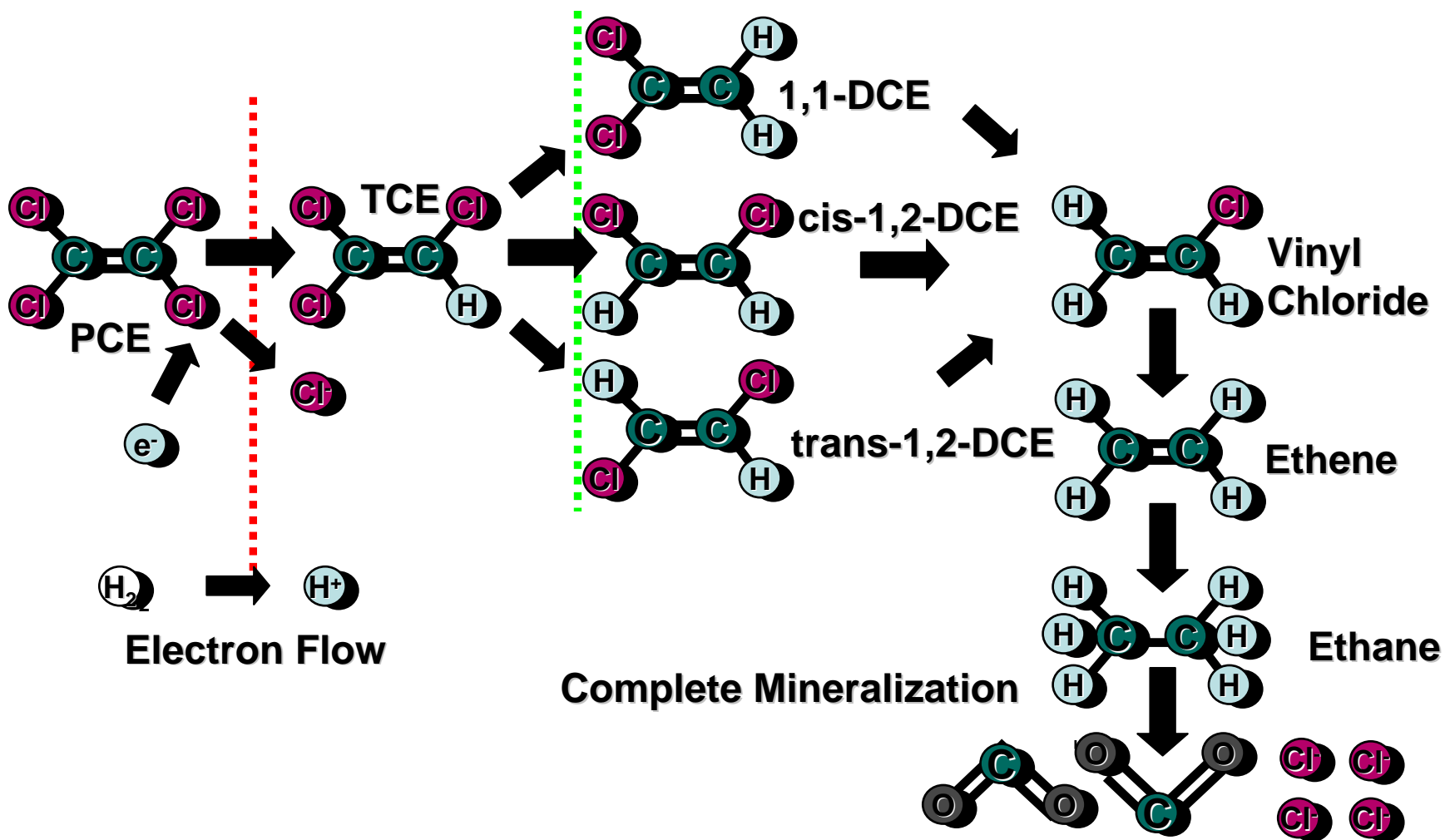




gPRO[®] LP H₂ Transfer Rates

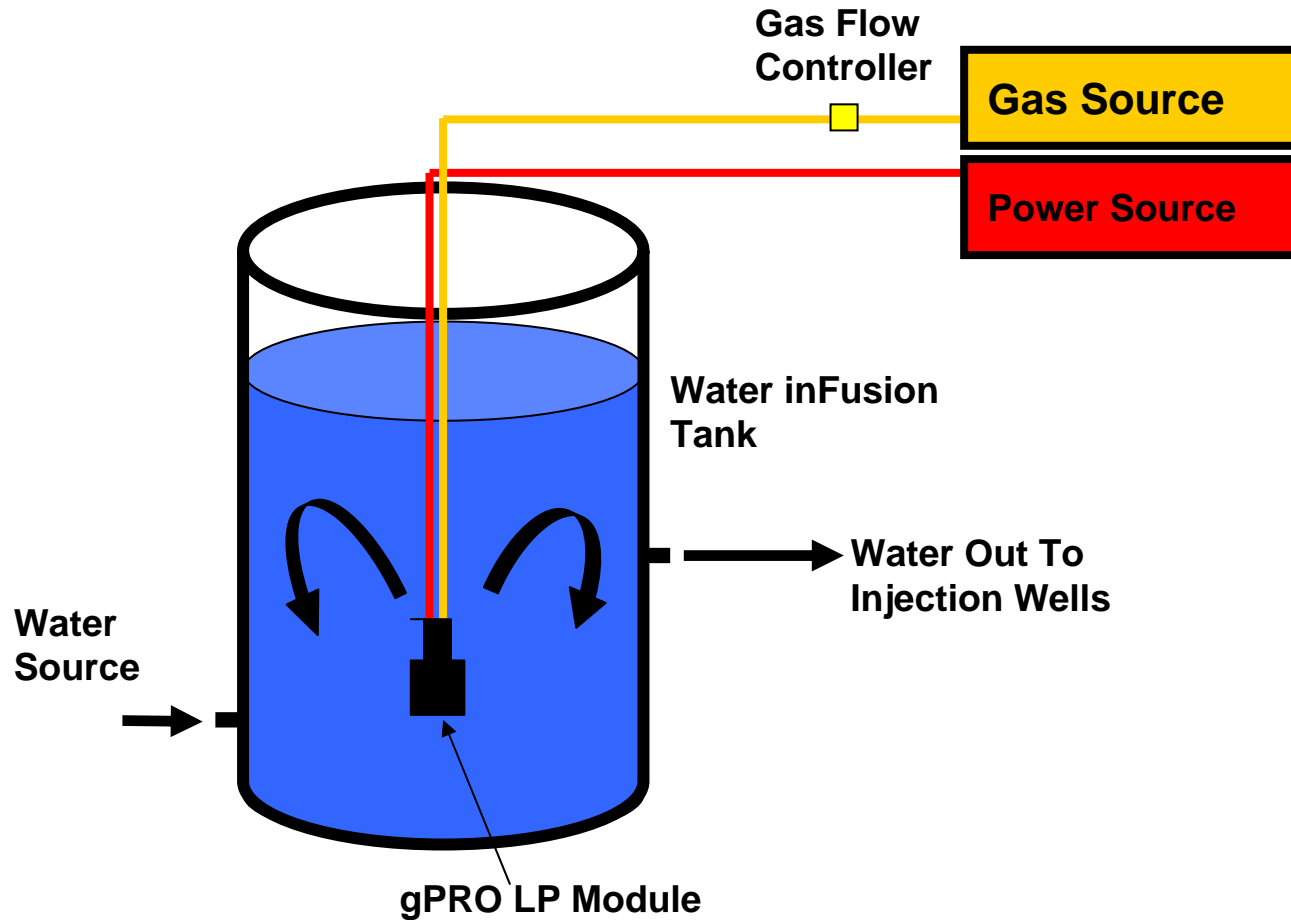


Anaerobic Reductive Dechlorination of Chlorinated Ethenes

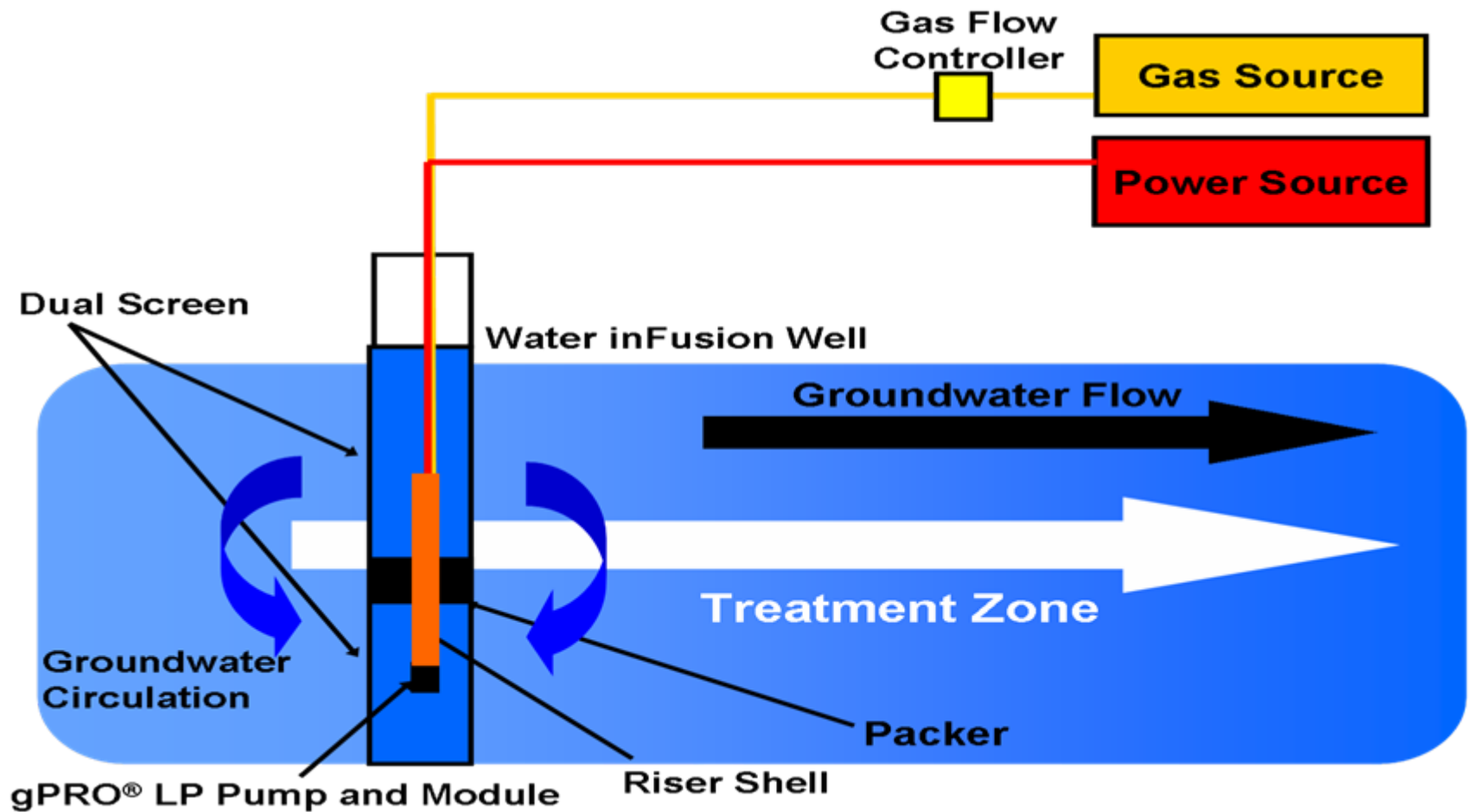


(Drawing Modified from AFCEE, Technology Transfer Division)

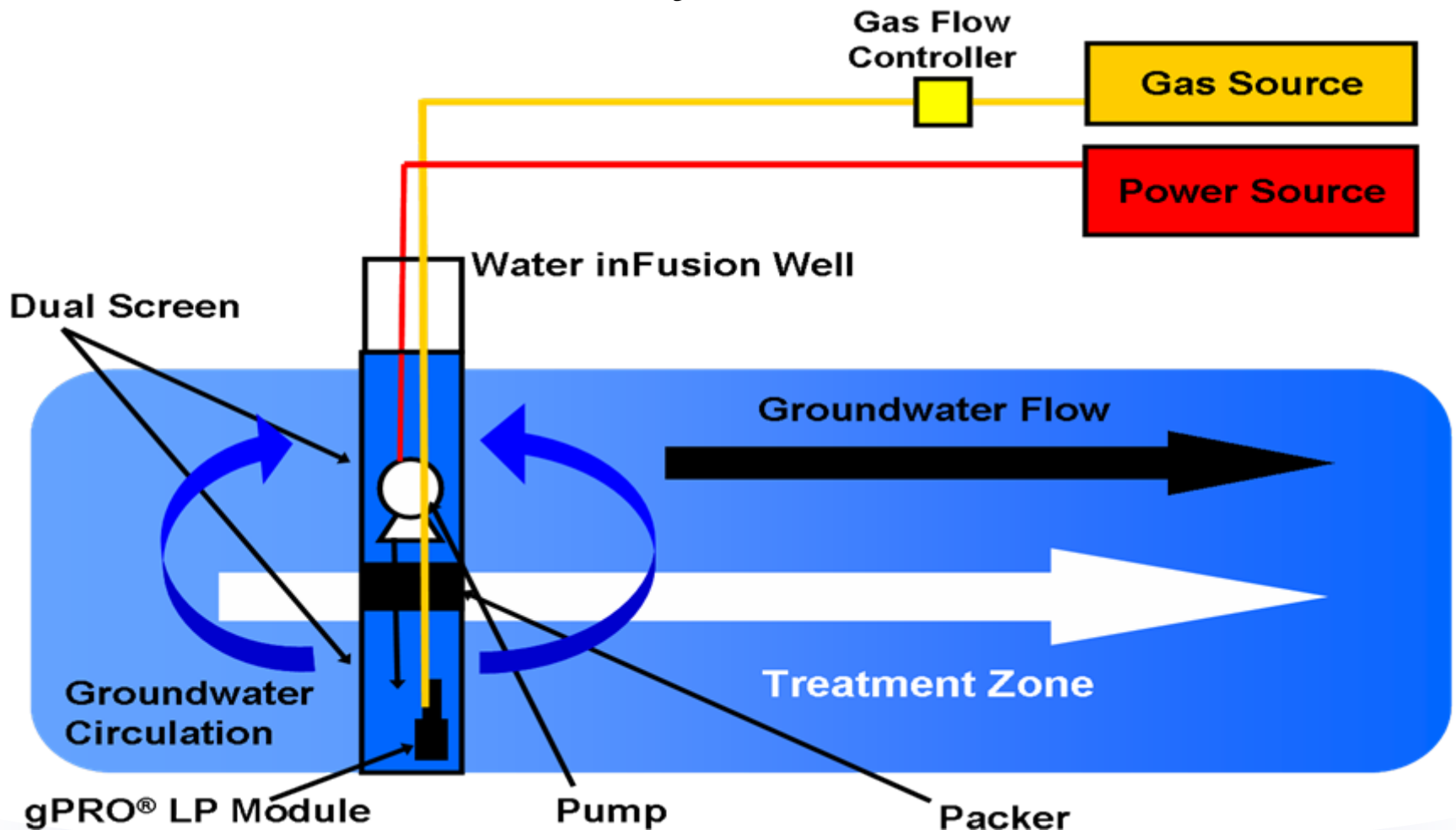
gPRO[®] LP Tank System



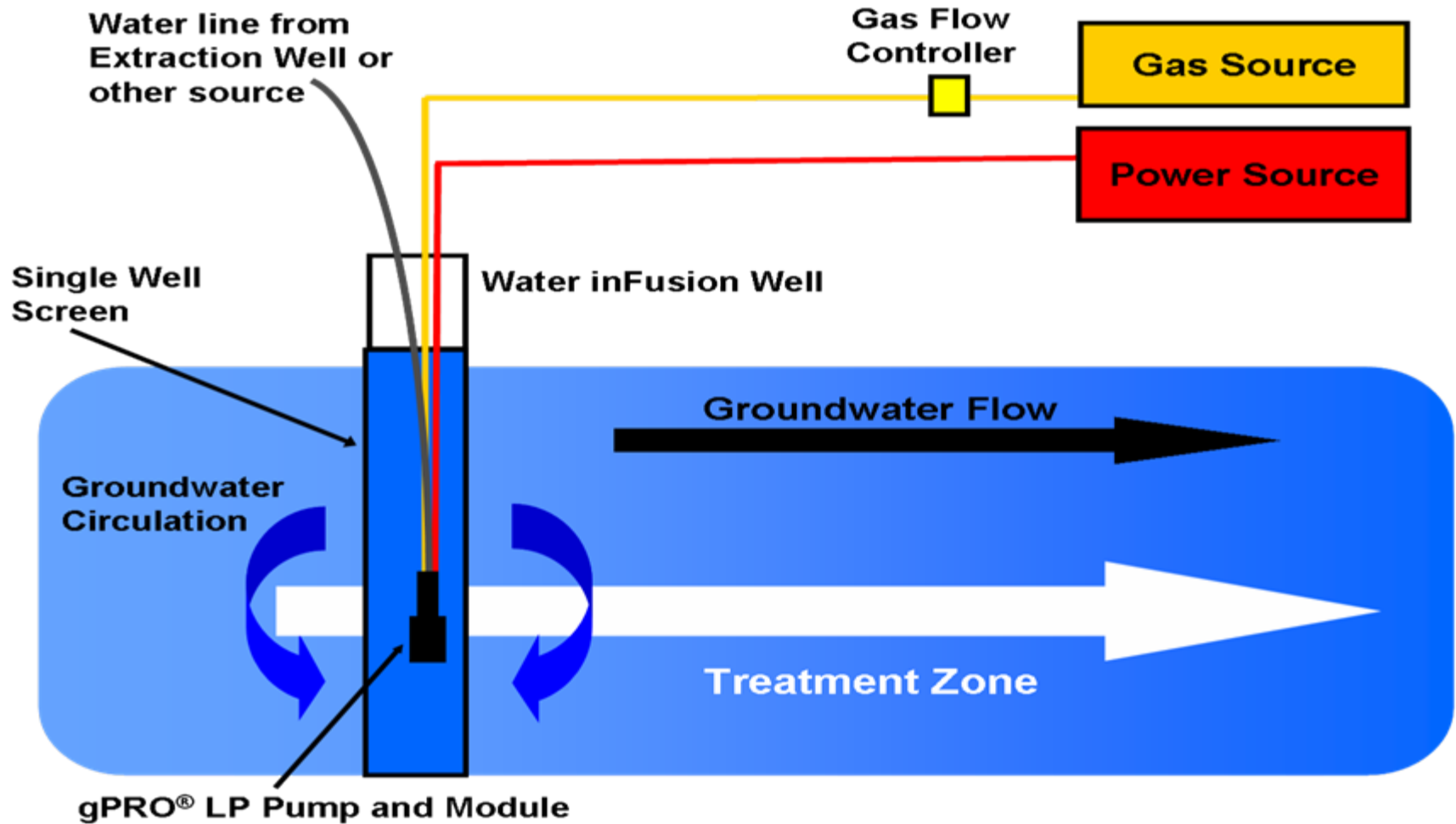
gPRO[®] LP Dual Screen in-Well System (Shallow to Deep)



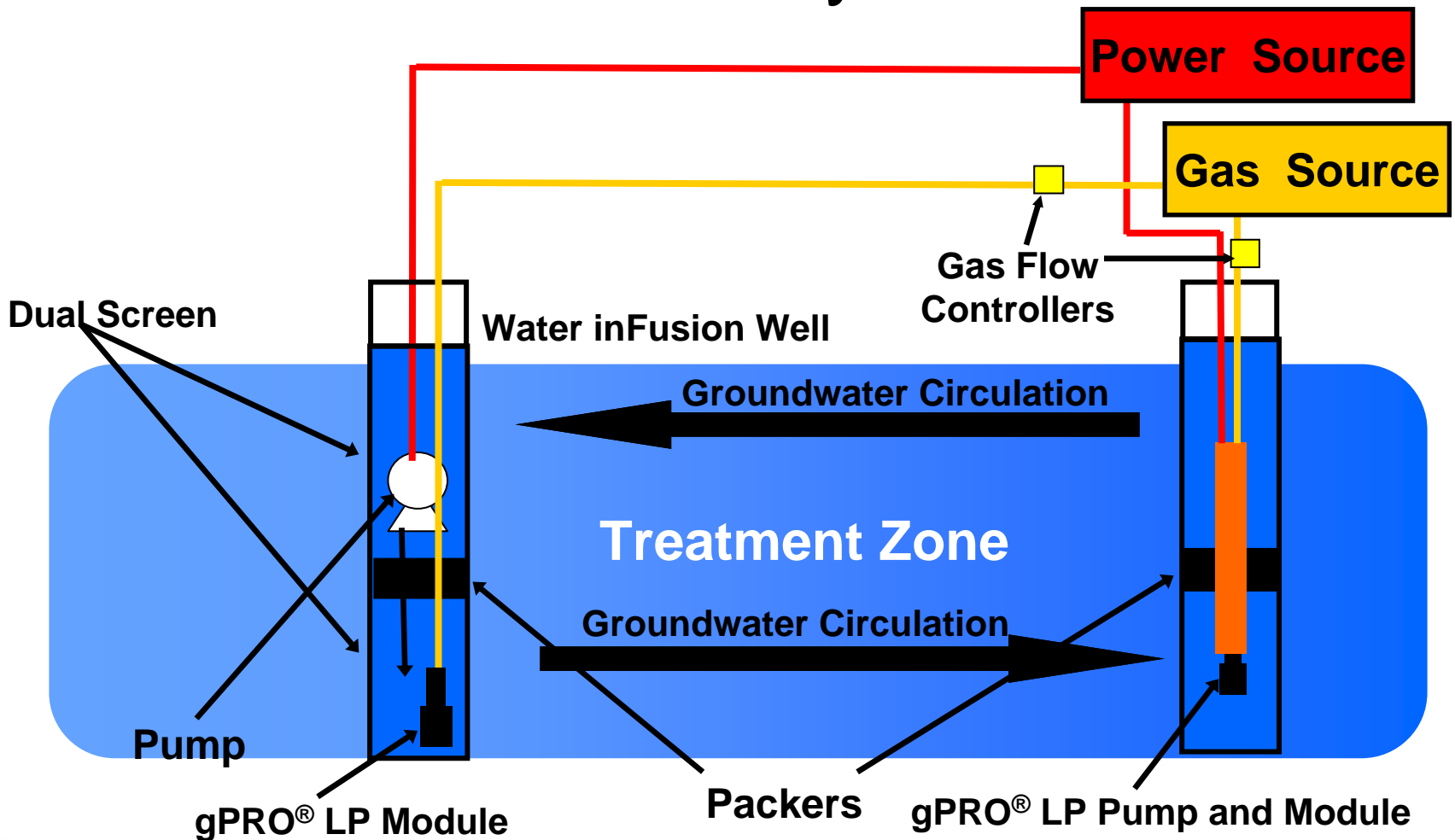
gPRO[®] LP Dual Screen in-Well System



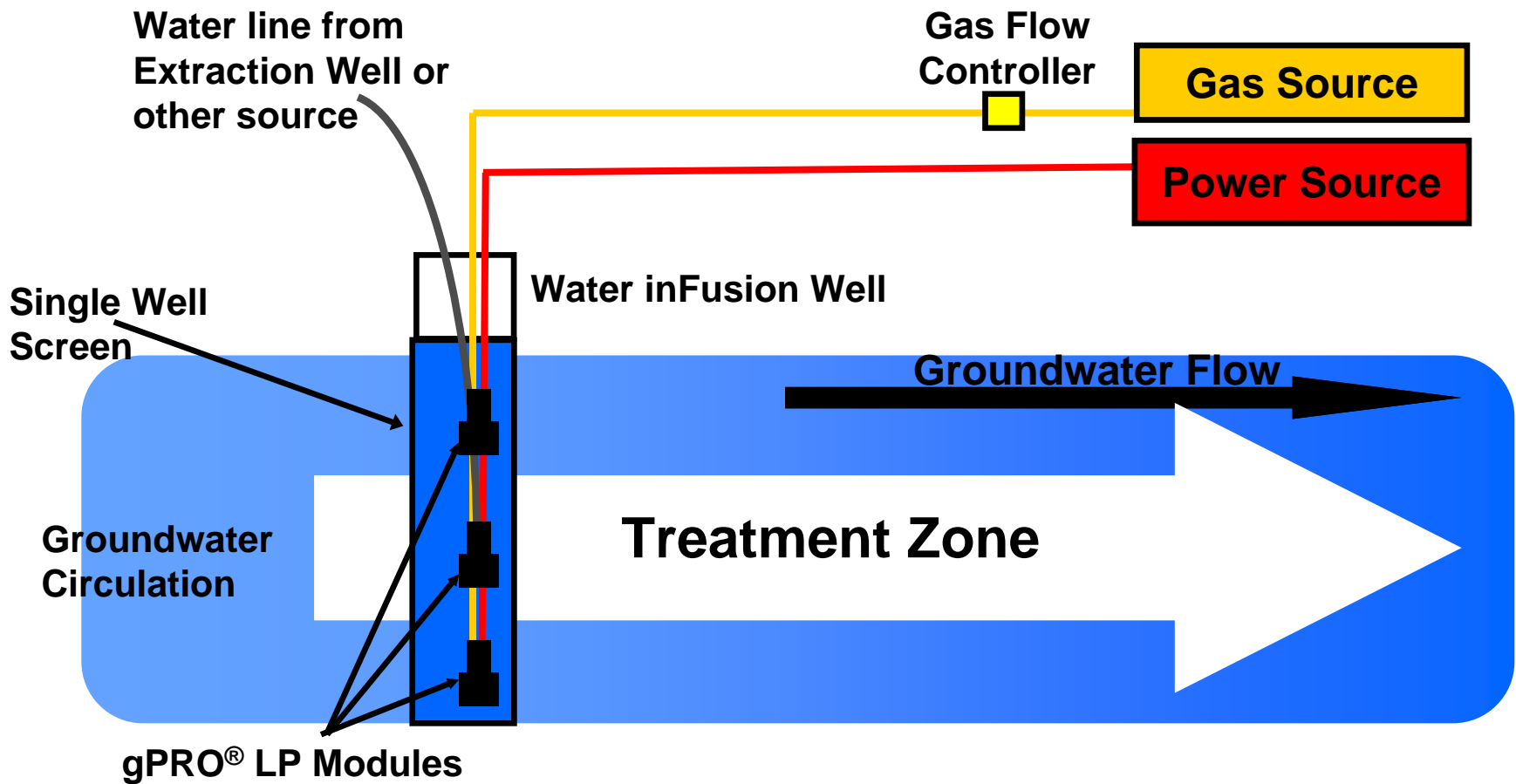
gPRO[®] LP In-Well Amended Groundwater Recharge System



gPRO[®] LP Dual Horizontal Flow In-Well System



gPRO[®] LP Stacked Delivery System for High Hydrogen Demand Sites





Hydrogen is Safe

- H₂ is a flammable gas used in numerous industrial applications
- Store gas cylinders in well ventilated cage or open shelter
- H₂ is 18 times lighter than air and will dissipate, not collect
- Use stainless steel tubing, fittings and required OSHA signage
- Use H₂ gas sensors in storage areas and well vaults



gPRO[®] LP and H₂

- H₂ is quickly used by dechlorinating bacteria (no fermentation time)
- H₂ gas is very inexpensive
- H₂ does not leave any environmentally unfriendly residue
- Much more flexible system than other chlorinated solvent remediation techniques
- Minimizes secondary water quality issues



gPRO[®] LP and H₂

- When coupled with lactate, direct H₂ addition has been observed to significantly lower dissolved iron concentrations; reducing iron fouling issues
- H₂ addition with lactate significantly increases the rate of complete degradation of PCE AND TCE to ethene over lactate alone



Use of Emulsified Vegetable Oil (EVO) Technology

- EVO creates conditions conducive for anaerobic biodegradation
- Oil slowly dissolves over several years:
 - Providing a carbon and energy source
 - Stimulate microbial growth
 - Develop an anaerobic groundwater treatment zone
 - Generate hydrogen through fermentation reactions



Disadvantages of Emulsified Vegetable Oil (EVO) Technology

- Processing oil emulsions on site may be limited by the type of equipment that can be used
- Uncertainty involved in estimating the mass of product needed for injection
- Decreased mobility, which may lead to non-uniform distribution in the subsurface



Disadvantages of Emulsified Vegetable Oil (EVO) Technology

- Depth limitations
- Slow release of Hydrogen
- pH decreases from fermentation can inhibit growth of dechlorinating microbes



Using gPRO[®] LP with Emulsified Vegetable Oil

- gPRO[®] LP provides dissolved hydrogen continuously to the treatment zone
- Initial gPRO[®] LP activity of hydrogen will promote rapid consumption of dissolved oxygen and other electron acceptors
- Emulsified Vegetable Oil will promote a slow fermentation process generated a long term supply of dissolved hydrogen



New Mexico TCE Site

gPRO[®] LP Hydrogen inFusion
System



Site Background

- AMEC Earth & Environmental Inc. is the current consultant
- Estimated mass of PCE DNAPL in the source zone: 300 pounds, Dissolved-phase plume: approximately 275 pounds of PCE and its breakdown products
- Major Concern: Contaminated ground water plume is in a sole-source drinking water aquifer



Consultant's Basis for Selecting gPRO[®]/EVO System

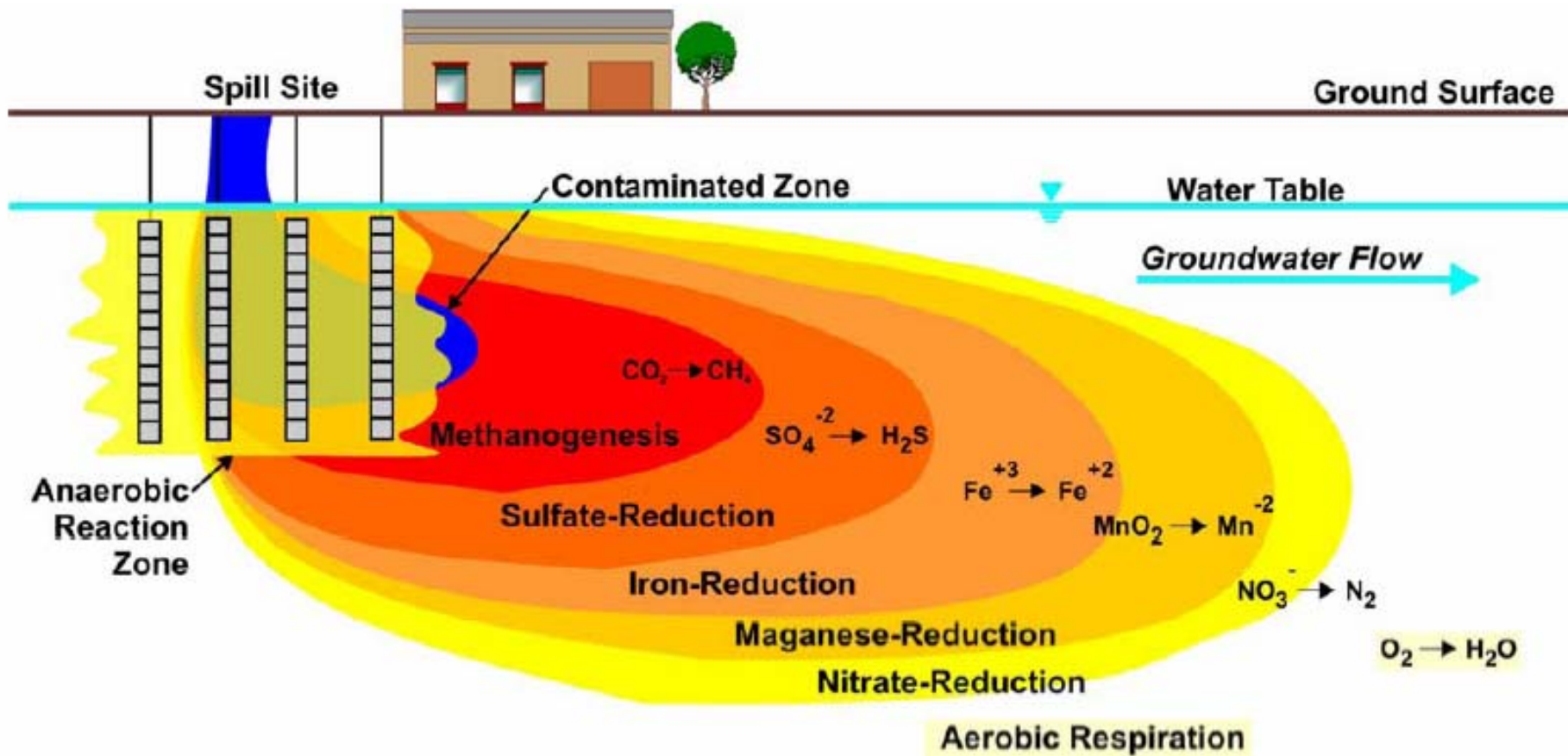
- All case studies and site statistics revealed that direct H₂ injection and EVO is the best solution for reducing PCE and TCE concentrations



Target Redox Conditions

Anaerobic dechlorination has been demonstrated under a range of reducing conditions including nitrate, iron, and sulfate reducing conditions, but the most rapid biodegradation rates, affecting the widest range of CAHs, at near methanogenic conditions (AFCEE 2004).

Reducing Zones Downgradient of H_2 inFusion



(AFCEE 2004)



Hydrogen Gas Supply





Gas inFusion Tank





gPRO[®] LP Module

