True Blue Technologies
Remediation and Characterization Products and Support

23000 Dyke Road, Unit 21
Richmond, BC V6V 2H3
North CA (415) 390-5483
South CA (714) 924-5483
Canada (604) 562-7836

Hydrogen

Many donors can anaerobically fermented to hydrogen and acidic fermentation products such as carbon dioxide (CO_2) and volatile fatty acids. The acidic fermentation products often causes a drop in aquifer pH.

Hydrogen is what counts in enhanced reductive dechlorination projects. Blending of electron donors in the field prior to injection into the aquifer is a common practice. Infusing hydrogen into the dilution water can enhance the performance of electron donor substrates. Infusing hydrogen into water may also reduce the demand for the carbon-based electron donors. Many practitioners simply add the hydrogen-infused water to electron donors for dilution, pre-conditioning, recirculation or chase water. Further, you can inject the hydrogen-enriched water with your bioaugmentation cultures. The hydrogen is immediately available for the bacteria. The other advantage is that adding hydrogen will not cause a drop in pH, like carbon-based electron donors.

Please call if you have any questions.

Regards,
John Sankey,
True Blue Technologies

Material Safety Data Sheet

Hydrogen

Section 1. Chemical product and company identification

Product name : Hydrogen

Supplier : AIRGAS INC., on behalf of its subsidiaries
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Product use : Synthetic/Analytical chemistry.

Synonym : Dihydrogen; o-Hydrogen; p-Hydrogen; Molecular hydrogen; H2; UN 1049; UN 1966; Liquid hydrogen (LH2 or LH2)

MSDS # : 001026

Date of Preparation/Revision : **3/7/2013.**

In case of emergency : 1-866-734-3438

Section 2. Hazards identification

Physical state : Gas or Liquid.

Emergency overview : WARNING!

GAS:
CONTENTS UNDER PRESURE.
Extremely flammable
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely flammable
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

Do not puncture or incinerate container. May cause target organ damage, based on animal data.

Contact with rapidly expanding gases or liquids can cause frostbite.

Target organs : May cause damage to the following organs: lungs.

Routes of entry : Inhalation

Potential acute health effects

Eyes : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Skin : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Inhalation : Acts as a simple asphyxiant.

Ingestion : Ingestion is not a normal route of exposure for gases Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Potential chronic health effects

Chronic effects : May cause target organ damage, based on animal data.

Target organs : May cause damage to the following organs: lungs.

Medical conditions aggravated by over-exposure : Pre-existing disorders involving any target organs mentioned in this MSDS as being at risk may be aggravated by over-exposure to this product.

See toxicological information (Section 11)

Section 3. Composition, Information on Ingredients

Name	CAS number	% Volume	Exposure limits
Hydrogen	1333-74-0	100	Oxygen Depletion [Asphyxiant]

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training.If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus.It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Inhalation : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Ingestion : As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

Flammability of the product : Flammable.

Auto-ignition temperature : 500 to 571°C (932 to 1059.8°F)

Flammable limits : Lower: 4% Upper: 76%

Products of combustion : No specific data.

Fire hazards in the presence of various substances : Extremely flammable in the presence of the following materials or conditions: oxidizing materials.

Fire-fighting media and instructions : Use an extinguishing agent suitable for the surrounding fire.

Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk.

Contains gas under pressure. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions : Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Methods for cleaning up : Immediately contact emergency personnel. Stop leak if without risk. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Handling : High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Never allow any unprotected part of the body to touch uninsulated pipes or vessels that contain cryogenic liquids. Prevent entrapment of liquid in closed systems or piping without pressure relief devices. Some materials may become brittle at low temperatures and will easily fracture.

Storage : Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).
For additional information concerning storage and handling refer to Compressed Gas Association pamphlets P-1 Safe Handling of Compressed Gases in Containers and P-12 Safe Handling of Cryogenic Liquids available from the Compressed Gas Association, Inc.

Section 8. Exposure controls/personal protection

Engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Personal protection

Eyes : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts.

When working with cryogenic liquids, wear a full face shield.

Skin : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93

Hands : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Insulated gloves suitable for low temperatures

Personal protection in case of a large spill : Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name	
hydrogen	Oxygen Depletion [Asphyxiant]

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

Molecular weight : 2.02 g/mole

Molecular formula : $H2$

Boiling/condensation point : -253°C (-423.4°F)

Melting/freezing point : -259.15°C (-434.5°F)

Critical temperature : -240.15°C (-400.3°F)

Vapor density : 0.07 (Air = 1) Liquid Density@BP: 4.43 lb/ft3 (70.96 kg/m3)

Specific Volume (ft^3/lb) : 191.9386

Gas Density (lb/ft^3) : 0.00521

Section 10. Stability and reactivity

Stability and reactivity : The product is stable.

Incompatibility with various substances : Extremely reactive or incompatible with the following materials: oxidizing materials.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data

Chronic effects on humans : May cause damage to the following organs: lungs.

Other toxic effects on humans : No specific information is available in our database regarding the other toxic effects of this material to humans.

Specific effects

Carcinogenic effects : No known significant effects or critical hazards.

Mutagenic effects : No known significant effects or critical hazards.

Reproduction toxicity : No known significant effects or critical hazards.

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Environmental fate : Not available.

Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation.Return cylinders with residual product to Airgas, Inc.Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1049 UN1966	HYDROGEN, COMPRESSED Hydrogen, refrigerated liquid	2.1	Not applicable (gas).		**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: Forbidden. **Cargo aircraft** Quantity limitation: 150 kg
TDG Classification	UN1049 UN1966	HYDROGEN, COMPRESSED Hydrogen, refrigerated liquid	2.1	Not applicable (gas).		**Explosive Limit and Limited Quantity Index** 0.125 **ERAP Index** 3000 **Passenger Carrying Ship Index** Forbidden

						Passenger Carrying Road or Rail Index Forbidden
Mexico Classification	UN1049 UN1966	HYDROGEN, COMPRESSED Hydrogen, refrigerated liquid	2.1	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations : **TSCA 8(a) IUR**: This material is listed or exempted.
United States inventory (TSCA 8b): This material is listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: hydrogen
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: hydrogen: Fire hazard, Sudden release of pressure

Clean Air Act (CAA) 112 accidental release prevention - Flammable Substances: Hydrogen

Clean Air Act (CAA) 112 regulated flammable substances: hydrogen

State regulations : **Connecticut Carcinogen Reporting**: This material is not listed.
Connecticut Hazardous Material Survey: This material is not listed.
Florida substances: This material is not listed.
Illinois Chemical Safety Act: This material is not listed.
Illinois Toxic Substances Disclosure to Employee Act: This material is not listed.
Louisiana Reporting: This material is not listed.
Louisiana Spill: This material is not listed.
Massachusetts Spill: This material is not listed.
Massachusetts Substances: This material is listed.
Michigan Critical Material: This material is not listed.
Minnesota Hazardous Substances: This material is not listed.
New Jersey Hazardous Substances: This material is listed.
New Jersey Spill: This material is not listed.
New Jersey Toxic Catastrophe Prevention Act: This material is not listed.
New York Acutely Hazardous Substances: This material is not listed.
New York Toxic Chemical Release Reporting: This material is not listed.
Pennsylvania RTK Hazardous Substances: This material is listed.
Rhode Island Hazardous Substances: This material is not listed.

Canada

WHMIS (Canada) : Class A: Compressed gas.
Class B-1: Flammable gas.

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is not listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

United States

Label requirements : GAS:
CONTENTS UNDER PRESURE.
Extremely flammable
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely flammable
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

Canada

Label requirements : Class A: Compressed gas.
Class B-1: Flammable gas.

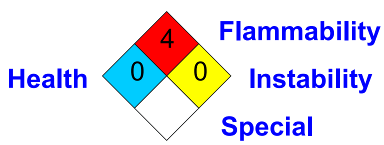
Hazardous Material Information System (U.S.A.) :

Health	0
Flammability	4
Physical hazards	0

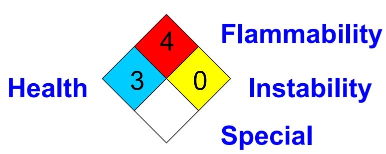
liquid:

Health	3
Fire hazard	4
Reactivity	0
Personal protection	

National Fire Protection Association (U.S.A.) :



liquid:



Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

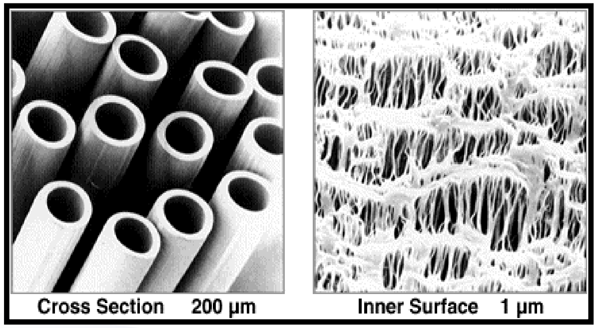
Chlorinated Hydrocarbon Remediation

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 (H_2)
- High levels of dissolved H_2 migrate to surrounding biomass
- Microbial population increases and degrade targeted compounds

Microporous Hollow Fiber



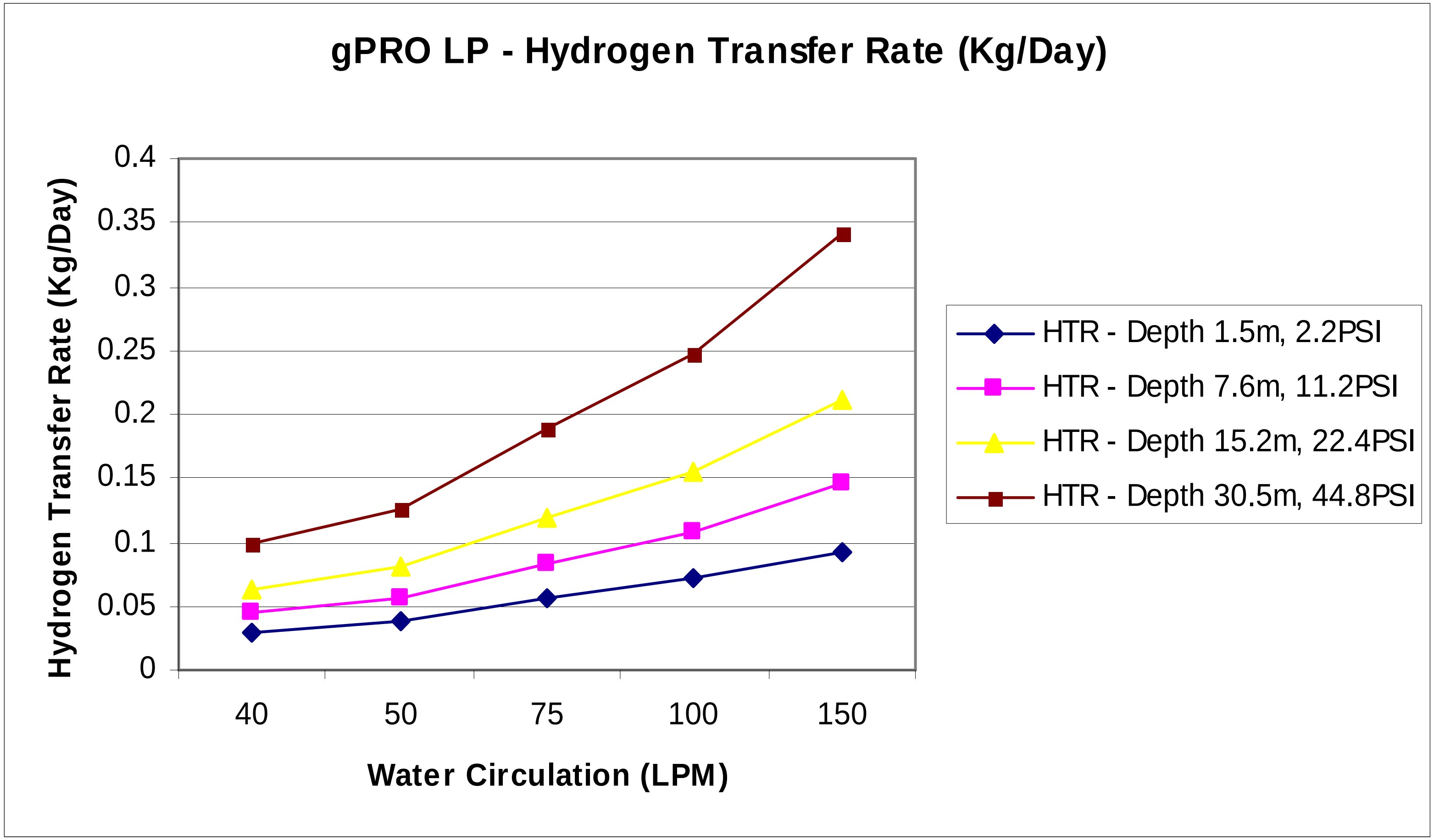
Mass Transfer Module

gPRO® LP

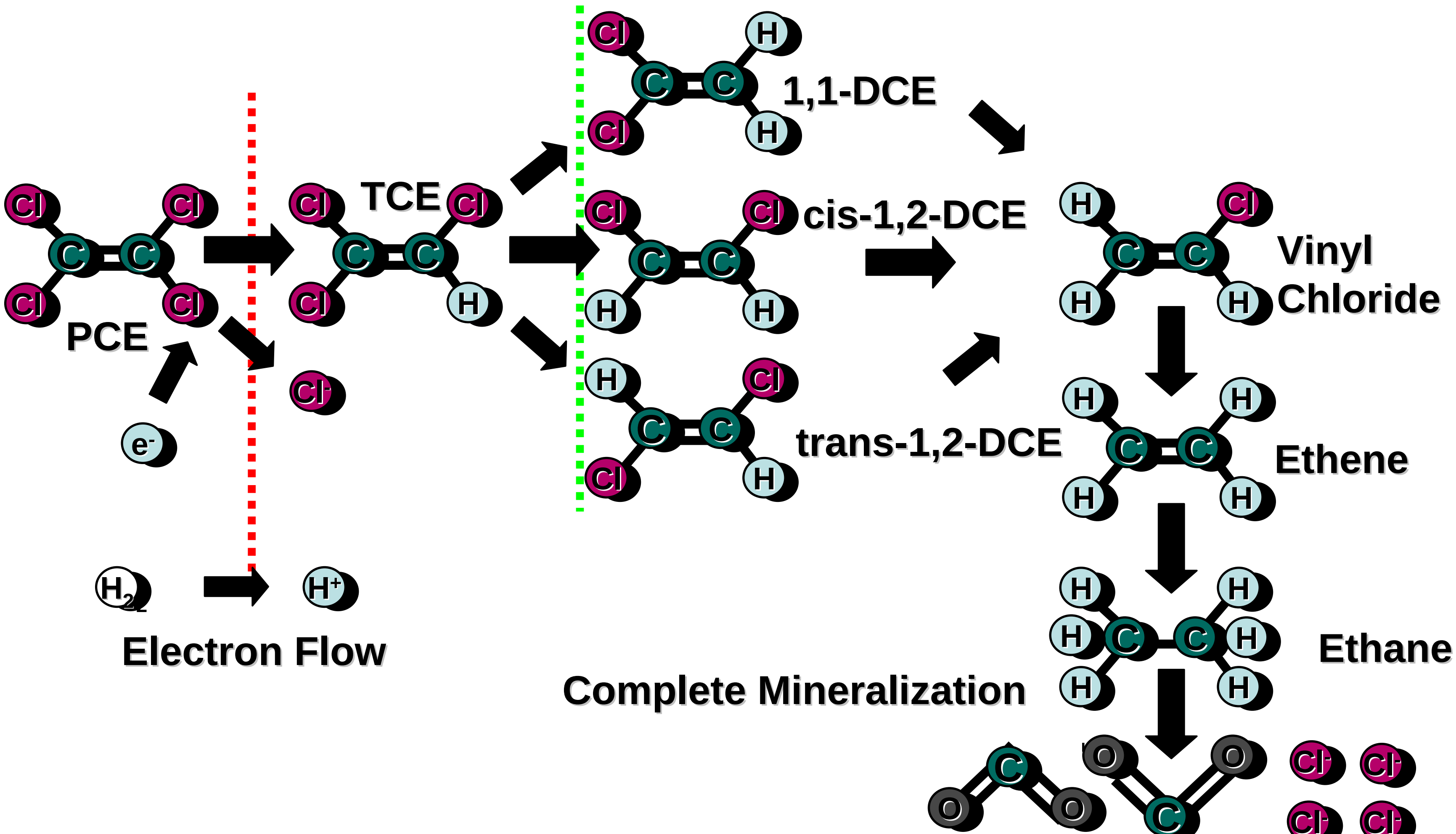
gPRO® LP System

- A superior gas delivery system based on inVentures' Gas inFusion Technology
- Mass transfer module delivers high amounts of dissolved H_2 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 H_2 Transfer Rates

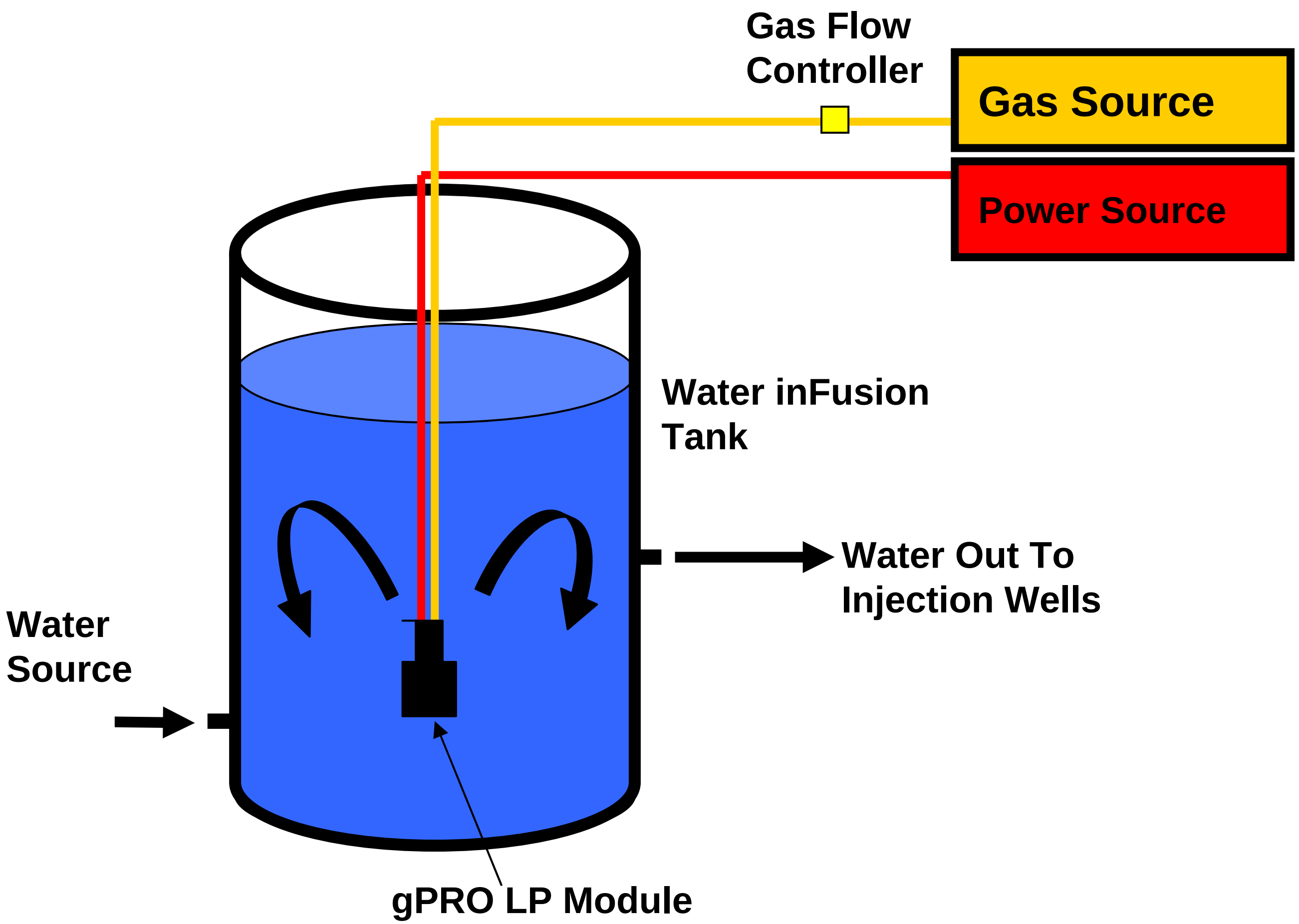


Anaerobic Reductive Dechlorination of Chlorinated Ethenes

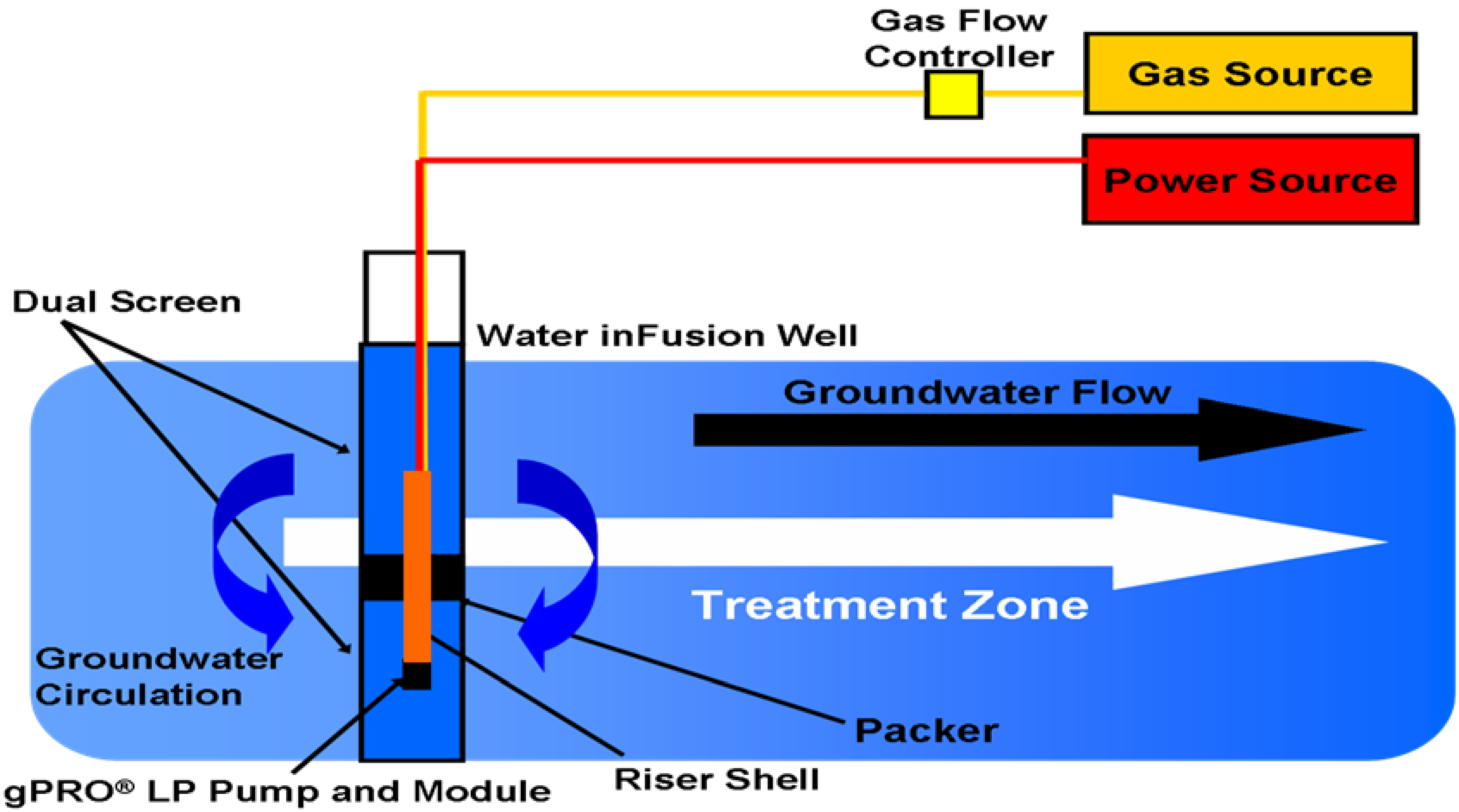


(Drawing Modified from AFCEE, Technology Transfer Division)

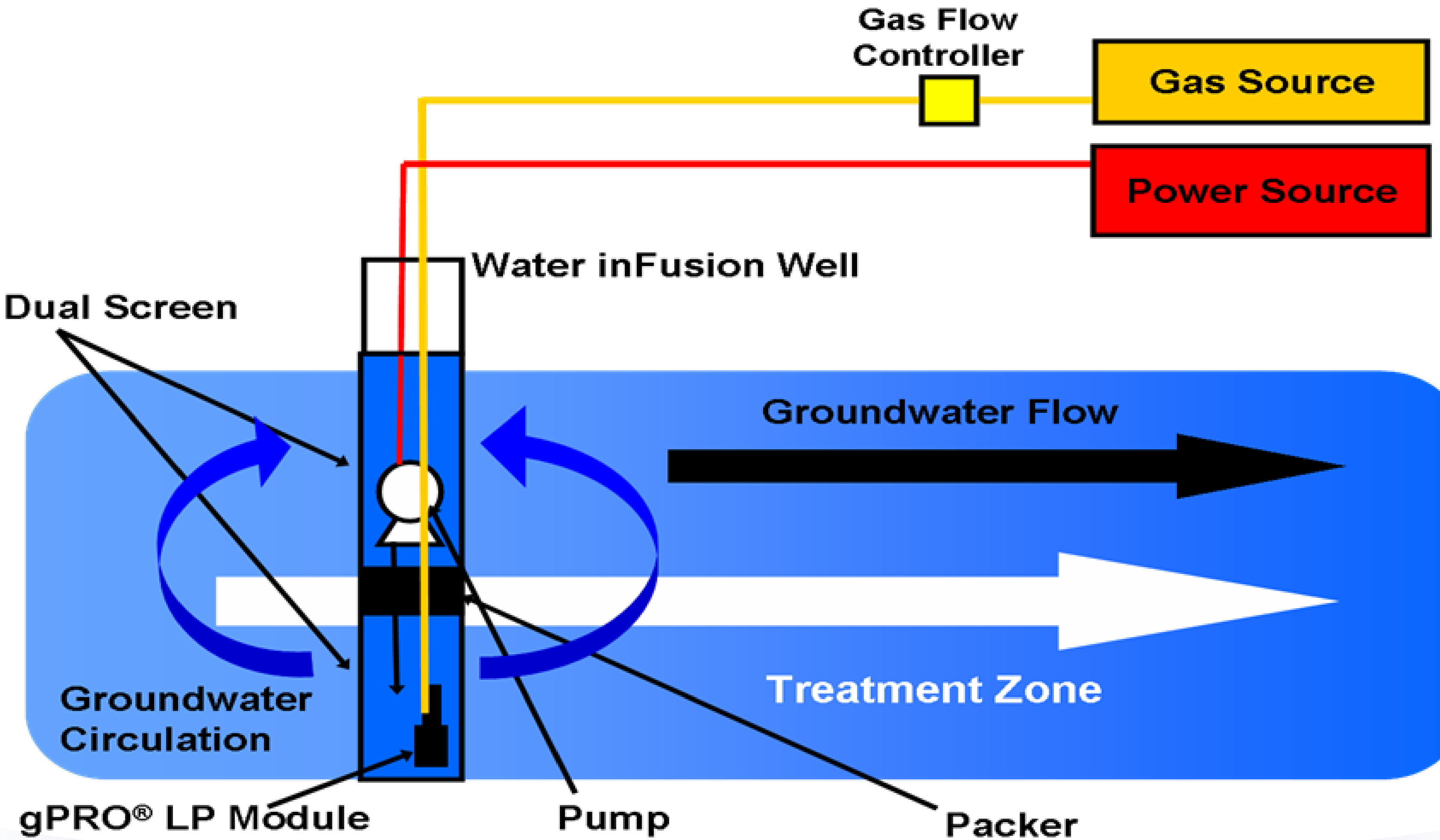
gPRO® LP Tank System



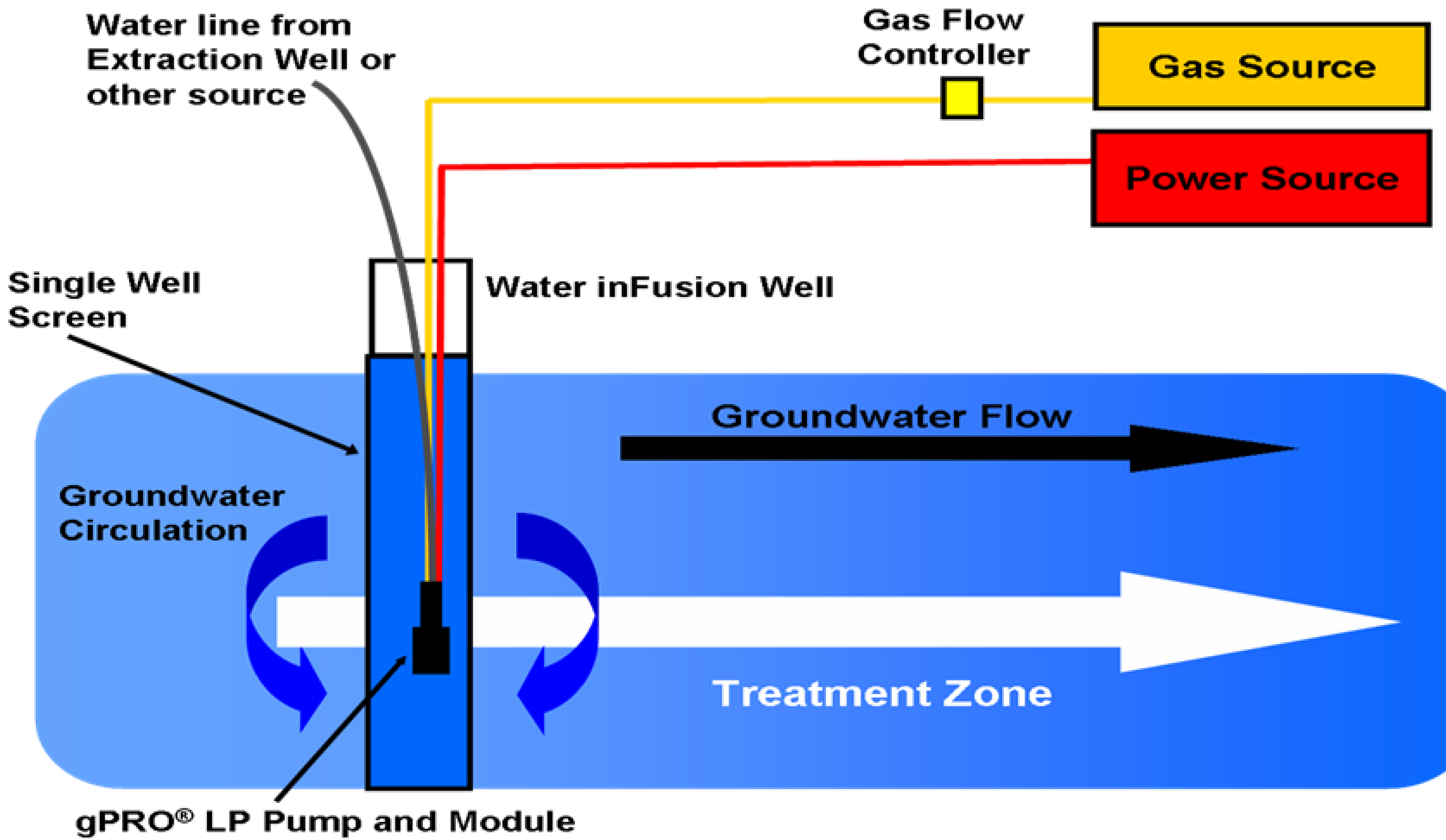
gPRO® LP Dual Screen in-Well System (Shallow to Deep)



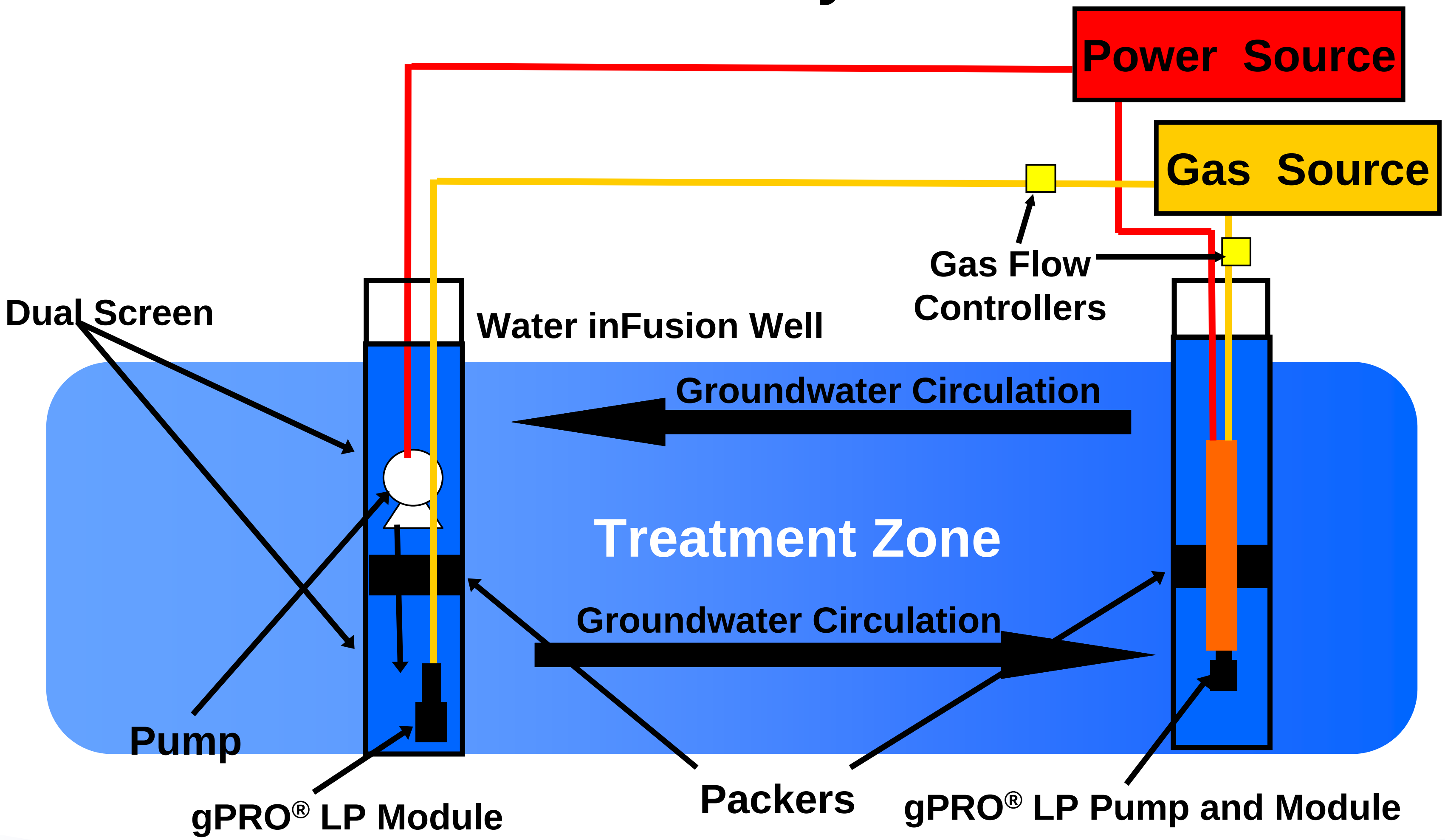
gPRO® LP Dual Screen in-Well System



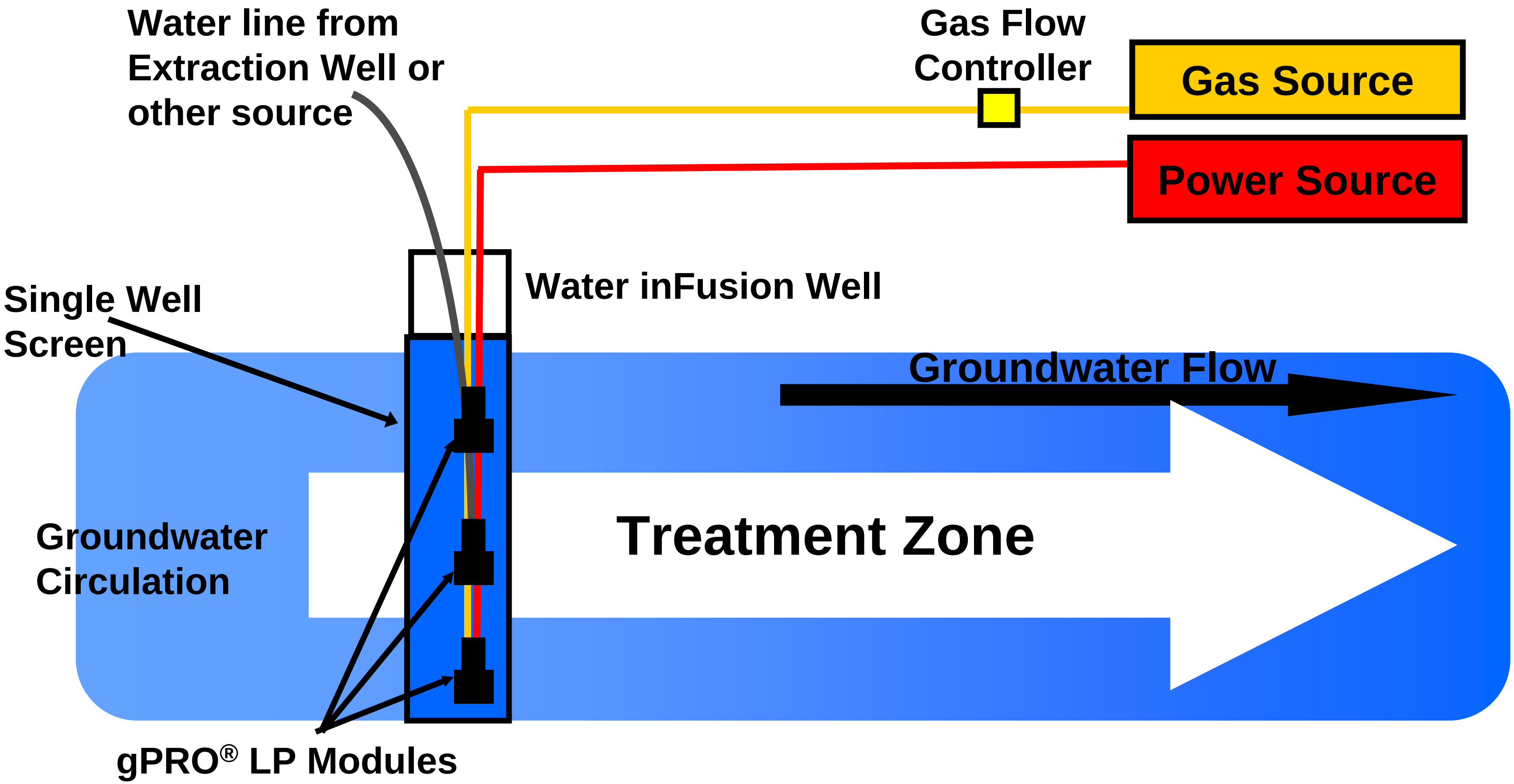
gPRO® LP In-Well Amended Groundwater Recharge System



gPRO® LP Dual Horizontal Flow In-Well System



gPRO® LP Stacked Delivery System for High Hydrogen Demand Sites



Hydrogen is Safe

- H_2 is a flammable gas used in numerous industrial applications
- Store gas cylinders in well ventilated cage or open shelter
- H_2 is 18 times lighter than air and will dissipate, not collect
- Use stainless steel tubing, fittings and required OSHA signage
- Use H_2 gas sensors in storage areas and well vaults

gPRO® LP and H_2

- H_2 is quickly used by dechlorinating bacteria (no fermentation time)
- H_2 gas is very inexpensive
- H_2 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 H_2

- When coupled with lactate, direct H_2 addition has been observed to significantly lower dissolved iron concentrations; reducing iron fouling issues
- H_2 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

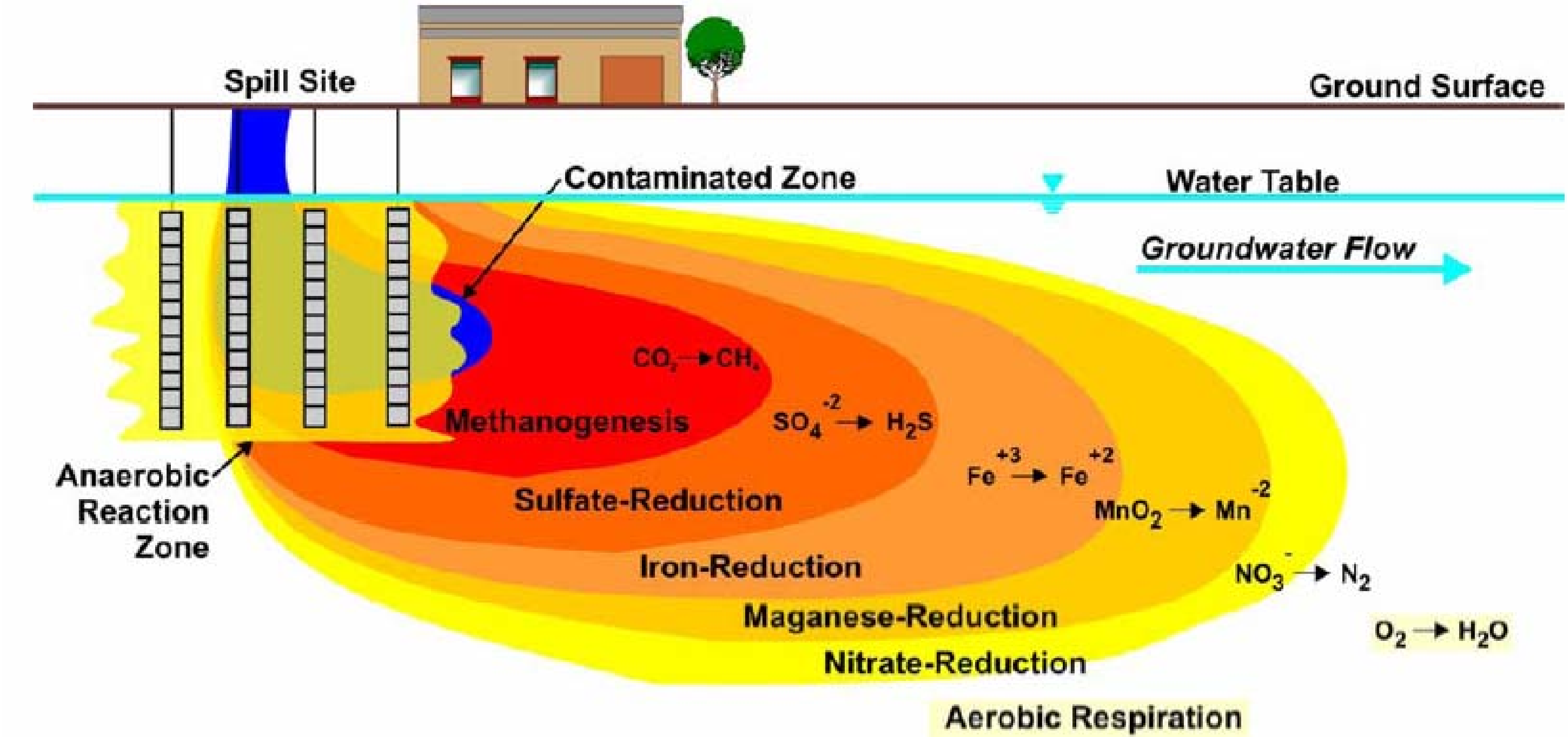
Consultant's Basis for Selecting gPRO®/EVO System

- All case studies and site statistics revealed that direct H_2 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

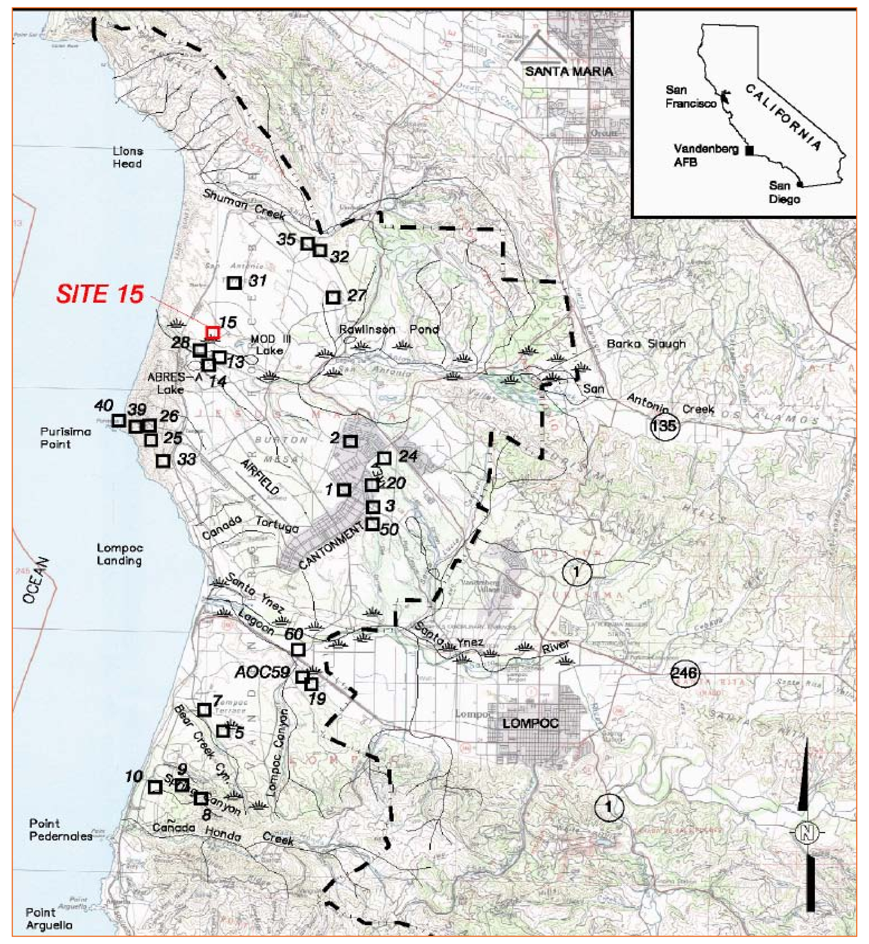
gPRO® LP Module

Shaw® a world of Solutions™

Field-Scale Treatability Study for In Situ Bioremediation of Trichloroethene Using a Groundwater Recirculation System

Kim D. MacFarlane, David A. Cacciatore, Daniel P. Leigh, and Michael G. Yurovsky
Shaw Environmental, Inc., 4005 Port Chicago Highway, Concord, CA
Aaron Archibald and James Begley *InVentures Technologies, Inc., 670 Wilsey Road, Fredericton, New Brunswick, Canada*
Kathleen Gerber *Vandenberg Air Force Base, 1028 Iceland Avenue, Vandenberg Air Force Base, CA*

For more information, contact:
Kim D. MacFarlane at kim.macfarlane@shawgrp.com, 925-288-2023

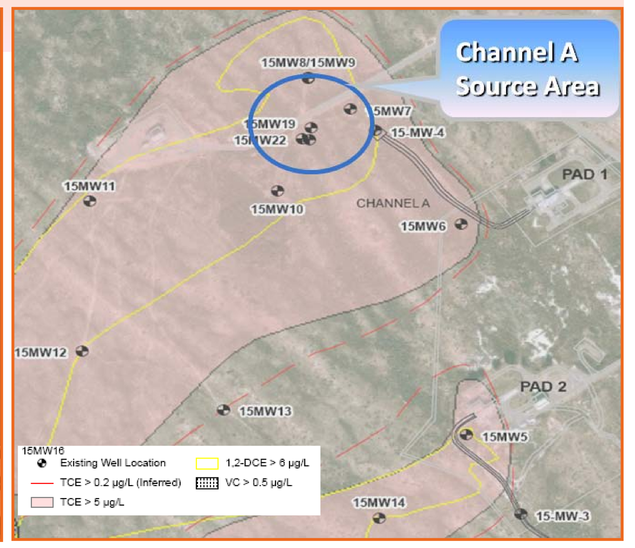


Background

Trichloroethene (TCE) in groundwater biodegrades to nontoxic ethene under reducing conditions in the presence of certain dechlorinating microorganisms. The process, referred to as in situ bioremediation (ISB), can be implemented by adding biodegradable substrate and a dechlorinating microbial culture to the subsurface via an injection-extraction well recirculation.

Installation Restoration Program Site 15, Vandenberg Air Force Base, was used to launch Atlas D missiles from 1960 to 1967. Prior to launches, TCE was used to degrease rocket engines; during launches, this material along with thousands of gallons of deluge water, used for noise and fire suppression, were washed down the drainage channels and discharged to the ground surface. This practice impacted the groundwater with dissolved TCE and its degradation products. Two TCE source plumes with concentrations greater than 1,000 µg/L have been identified at Site 15: one at Channel A and another at Channel B. As part of a treatability study, an ISB recirculation system was installed at Channel A in early 2010 to reduce the mass of TCE and its degradation products in the source area and mitigate further contaminant migration.

Between 1959 and 1967, 62 Atlas-type rockets were launched from Site 15.

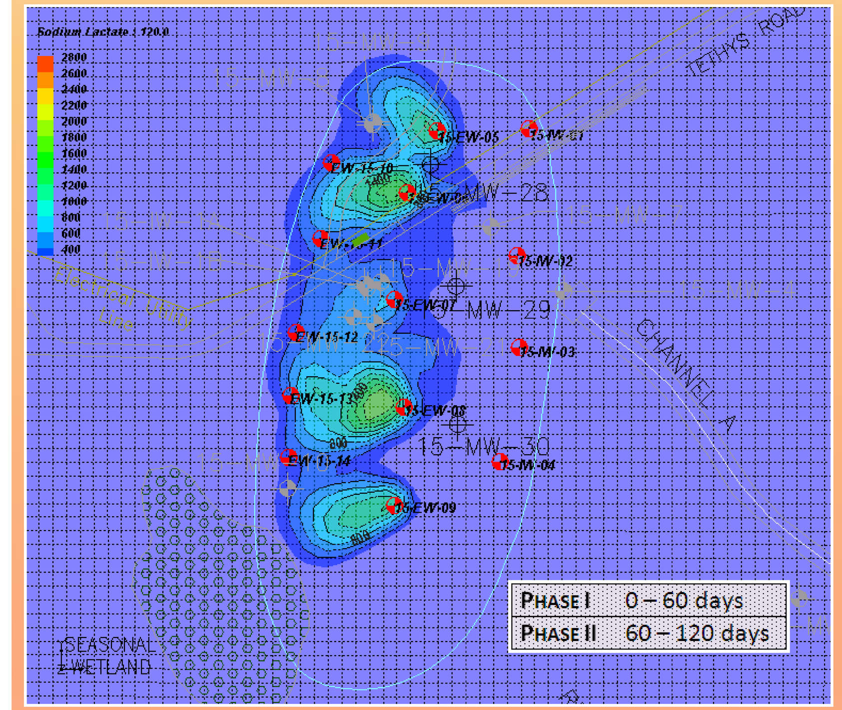


Channel A source area at Site 15 and estimated extent of VOC plume.

System Design

Shaw proposed to reduce the mass of TCE in the source area of Channel A using a recirculation system and in situ bioremediation. Engineered in situ bioremediation is the process of creating a biologically-active zone in the subsurface to encourage reductive dechlorination by adding a carbon source. Microbes use the carbon source (in this case sodium lactate) and produce hydrogen which in turn is used by other dechlorinating bacteria as an electron donor. The electrons are accepted by the chlorinated compound and a chloride ion is released into solution. This process of reductive dechlorination or (reductive dehalogenation) reduces toxic TCE to the non toxic, non-chlorinated ethene. By also adding hydrogen to the system, the sodium lactate requirements are reduced. Bioaugmentation was also proposed using the dechlorinating microbial culture, SDC-9™ to reduce the treatment time.

The challenges with most ISB projects is substrate delivery and distribution. Although recirculation is an effective means of distributing introduced organisms and substrate throughout the aquifer, placement of the recirculation wells is key. Because the treatment area was so large, Shaw modeled several scenarios to determine the most effective location of the extraction and injection wells.



The VAFB Channel A model was set up to represent three distinct zones: bedrock, alluvium and dune sand. Each of these zones represented a layer within the model. Layers were established by first creating x, y, z data sets for each of the different materials based upon direct push boring logs from previous work conducted at the site.

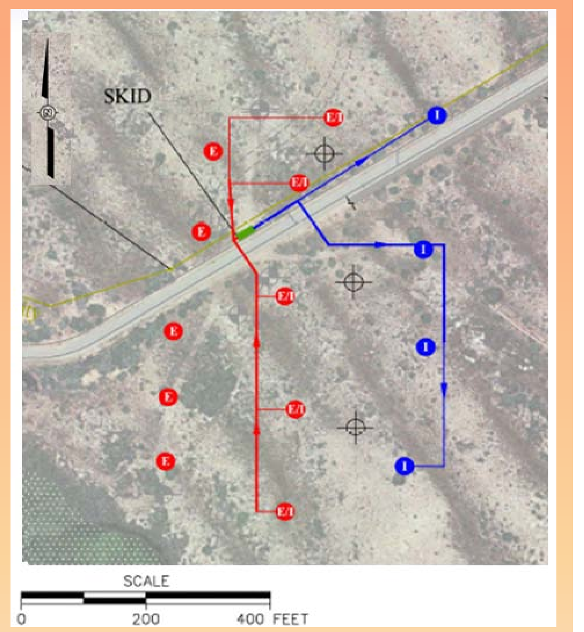
Groundwater elevations within the modeled area ranged from 48 to 80 feet msl. Gradients were correlated to May 2007 groundwater contours.

The model represented two phases of work, of approximately 60 days each.

Based on the modeling results, the system was constructed as shown below.

The substrate was injected through 4 injection wells and pulled across the treatment zone by 5 extraction wells (Phase I). Once the substrate reached the extraction wells, those wells were converted to injection wells, and the pumps in the next set of extraction wells further to the west were activated, pulling the substrate across the remainder of the treatment zone (Phase II).

Once the substrate reaches the final extraction wells, the pumps will be shut down, and the distributed substrate in the treatment zone will continue to ferment.



The recirculation system consists of 4 injection wells (blue wells shown as 'I'), 5 extraction wells (red wells shown as 'E') and five combination extraction/injection wells (red wells shown as "E/I"). Three monitoring wells were also installed in between the injection and extraction wells. All wells are 4-inch in diameter.

Treatment Zone = ~8 acres

System Construction

System construction began in October 2010 with the installation of the injection, extraction and monitoring wells. All drilling locations were pre-cleared for federally endangered El Segundo Blue butterfly habitat and unexploded ordnance. All wells were installed by hollow stem auger drilling, using a Diedrich D-120 all-terrain drill rig. The D-120 has nearly 22,000 foot-pounds of torque at the drive spindle and produces more drilling torque than the CME 85 rig. Additionally, the D-120 is mounted on a 4-wheel drive all-terrain carrier with 25-inch wide traction grip rubber flotation tires giving it the capability to access steep or soft terrain. All wells were installed to bedrock and have screen intervals spanning the groundwater saturated thickness. Baseline sampling was conducted in November 2010.

Installed extraction wells

Extraction well assembly

Injection well assembly

The remedial system treatment skid arrived at VAFB in March 2011. Skid electrical components include a 480 Volt (V) power distribution panel with individual pump controllers, a 480V-120V transformer, and a 120V panel housing a programmable logic controller and human-machine interface.

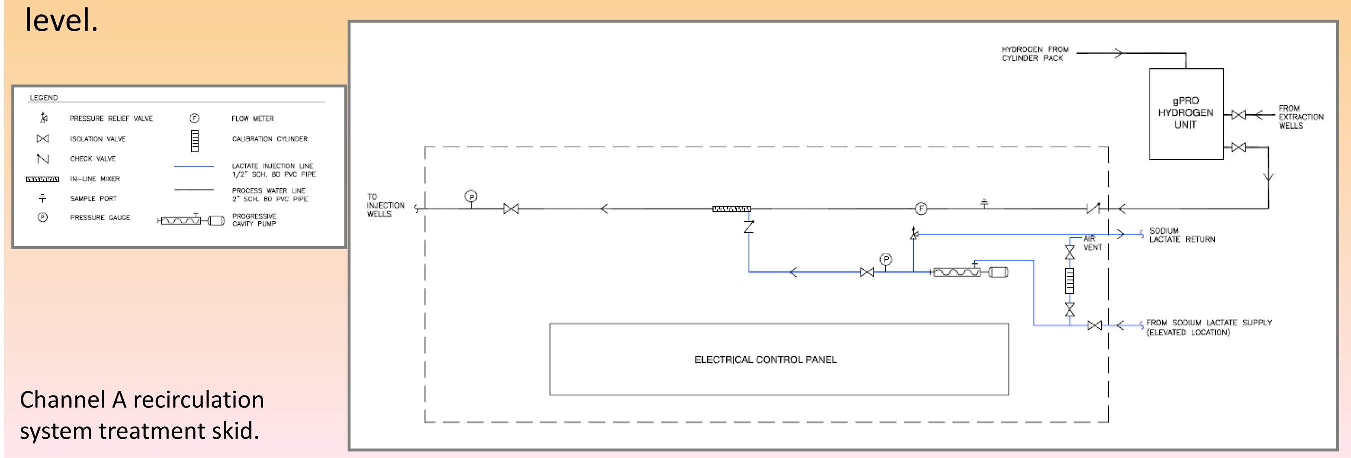
Skid connection in progress

Hydrogen gPro unit

Hydrogen supply

The skid also houses a progressive cavity substrate pump and a piping manifold designed to spike water from the extraction wells with the substrate and deliver the amended solution to the injection pipeline.

Additional substrate in the form of hydrogen gas was added to the injected groundwater via the groundwater Pressurized Remediation Optimizer (gPro) unit provided by inVentures Technologies, Inc. Two six-pack cylinders of compressed, industrial grade hydrogen provide the hydrogen for the system, added continuously at approximately 50 percent of the saturation level.



Channel A recirculation system treatment skid.

Field Monitoring and Optimizations

Monitoring

Shaw conducts quarterly sampling of the monitoring and extraction wells in addition to weekly monitoring of groundwater parameters such as alkalinity, dissolved oxygen, oxidation-reduction potential, pH and sulfate. Alkalinity measurements serve to determine if substrate is present in monitoring and extraction wells.

System Start-Up: May 5, 2011

Optimizations

Cleaning of Fittings

Despite pulsing the substrate, biofouling was suspected at the injection wells based on the increase in system pressure. The substrate pump was upgraded to allow for higher flow rate pulses over a shorter period of time. Groundwater began surfacing at injection wells 15-IW-02 and 15-IW-03 by mid-May 2011; the flowrate at these wells had to be reduced to avoid further surfacing. The following day, all fittings at the injection wellheads were physically cleaned of any fouling. Although there was some fouling in the fittings, none was evident within the wells.

Replacement Wells

The recirculation system at Channel A was taken offline in July 2011 due to the continued leaking of the two injection wells, 15-IW-02 and 15-IW-03. To mitigate the leaking, pressurized grout injections were performed at both wells. The two injection wells were put back online after approximately a week but with little improvement. By August 2011, the team decided to install four 1-inch diameter injection wellpoints in the general vicinity of the malfunctioning injection wells – two at each location – to improve substrate distribution. The new wellpoints performed very well and by January 2012, the system moved into Phase II. In April, three additional 1-inch wellpoints were installed to replace two Phase II injection wells.

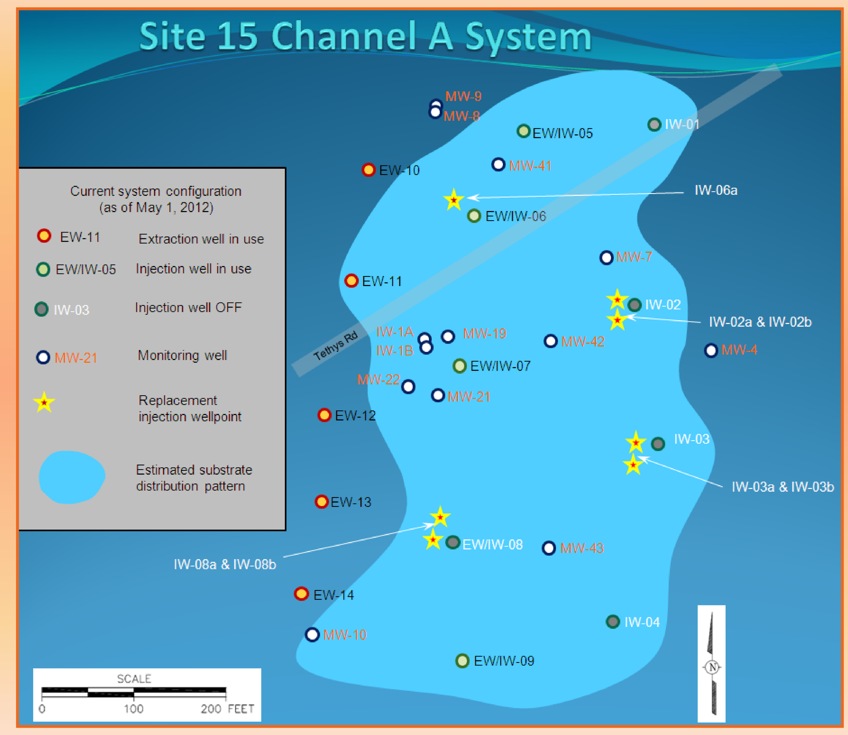
Biofouling inside a fitting

Change of Pumps

From system start-up in May 2011, the flowrate at extraction wells 15-EW/IW-05 and 15-EW/IW-06 (two extraction wells north of Tethys Road, an area with the highest TCE concentration) had been very low. Two Phase II extraction wells (15-EW-11 and 15-EW-13) were brought online almost immediately to compensate for the lack of groundwater extraction at 15-EW/IW-05 and 15-EW/IW-06. To increase operation efficiency and ensure that the substrate was distributed in the location with the more elevated VOCs, the electrical pumps in the two extraction wells, 15-EW/IW-05 and 15-EW/IW-06, were replaced with pneumatic pumps in December 2011.

Current Conditions and Path Forward

Substrate will likely be distributed throughout the Phase II treatment zone by Summer 2012, at which time the 30 day monitoring program will begin (Day 30, Day 60, Day 90 sampling) to assess the VOC degradation. Since the system began operating in May 2011 until December 2011 (Phase I), approximately 4,000 ft³ of H_2 gas and 12,000 gallons (128,000 pounds) of WILCLEAR® (sodium lactate) solution were injected. The total volume of groundwater recirculated during Phase I was approximately 5 M gallons. As of April 2012, an additional 1,500 gallons of substrate have been injected and 1.5 M gallons of groundwater recirculated.



Estimated substrate distribution based on alkalinity results at the Channel A recirculation system as of May 1, 2012.