ARS Projects Coming to a Site Near You

California
Ferox[SM] project at former government facility in the San Francisco Bay Area

New Jersey
Pneumatic Fracturing and Ferox[SM] Treatment in Fractured Bedrock
Pneumatic Fracturing in Fractured Bedrock

Alabama
Chemical Oxidation for treatment of CVOCs and Hydrocarbons.
Pneumatic Fracturing and atomized injection of Biostimulation Substrates

South Carolina
CVOC source reduction using Ferox[SM] at Government Facility

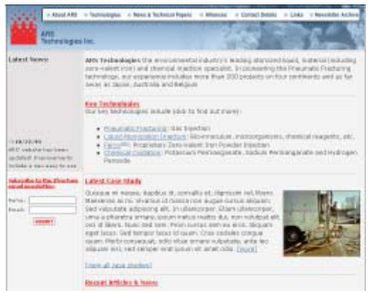
Tennessee
Ferox[SM] Application at Government Facility

Florida
Ferox[SM] Application at Private Client Site, Central Florida

Georgia
Ferox[SM] Project at Government Facility in Central Georgia
Ferox[SM] Project at Private Client Site
$KMnO_4$ Project at Large Government Facility

Technical Resource - www.arstechnologies.com

A great source for our Fracturing and enhanced injection information.Have you checked out www.ARSTECHNOLOGIES.com lately? Our website is regularly updated and is a great resource for the latest pneumatic fracturing and subsurface injection techniques. Recent additions include easier to use navigation and drop down menu's. All content has been further refined including our chemical oxidation section, state of the art Shockwave Flash animation and featured videos of our injection of emulsified nanoscale iron slurry. A new & improved search engine makes it even easier to locate specific terms in the vast resource of articles, case studies & white papers. If interested in our work, sign up for our quarterly electronic newsletter, ifracture.net. Keep checking back for regular updates!



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iFracture.net

a quarterly newsletter from the leader in subsurface injection & fracturing

ISSUE #2 VOL #4 SPRING 2004

ARS TECHNOLOGIES

Next Generation Ferox[sm] Injection System

ARS and Precision took delivery of the first of two large scale material mixing plants last fall (shown to the right). The systems are designed to mix and inject a wide range of reactive materials and chemical reagents. These custom designed units are capable of handling 5 tons of material per day and are able to inject slurries at rates up to 70 gpm and pressures up to 500 psig. The new unit was immediately put into service at a full-scale Ferox[sm] project being implemented on the west coast. The fully automated plant consists of a batch hopper, material screw feeder, colloidal mixer and injection pump. During operation, precise injection dosage or water-to-reactive material ratio is automatically achieved by the system once the parameters are input into the on-board computer by the operator. Digital load centers continually monitor the mass through-put of the system and record it to a data logger. This integrated system insures good data quality control is maintained during the mixing and injection process. In addition, the bulk bag (2,200 lb) loading system, eliminates the need for manual handling of any injection materials.

New large-scale material mixing and injection plant in use.

ARS Installs 90-foot Deep Ferox[SM] System to Treat Chlorinated VOC Source Zone

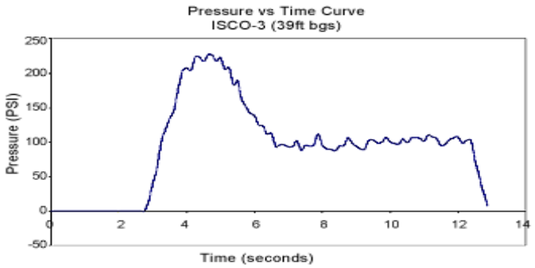
Recently, ARS completed the installation of a pilot scale Ferox[SM] system to treat a CVOCs source area with TCE and 1,1,2,2 PCA at a former military facility in Tennessee. The pilot test consisted of a grid of 4 injection wells to emplace 25,000 pounds of ZVI within the subsurface. During the injections, pressure influence at a distance of more than 25 feet was observed. Sampling results three months after the injections showing 1,1,2,2 PCA concentrations to have been reduced by as much as 93% from a maximum of 40,800 ppb to 3,010 ppb within the center of the treatment zone. The majority of the monitoring points within the treatment zone have shown at least a 90% reduction in 1,1,2,2 PCA levels within the 3-month post-injection monitoring timeframe. This project also represented the first field application of our new integrated deep well drilling/injection method. Using sonic drilling, a pressurized water column advanced a 4-inch casing to the target injection depth in each hole. Once at depth, atomized slurry injections were applied to the formation as the casing was retracted from the hole. This innovative method offers several key advantages over conventional injection methods including the ability to apply materials/chemicals at depths of several hundred feet, applicability in virtually all soil types, greatly reduced quantity of soil cuttings, reduced field personnel exposure to hazardous chemicals and the benefit of providing a very effective seal to facilitate good emplacement of the material into the subsurface.

Iron distribution is seen in this core sample taken after the Feroxsm injections were completed

in this issue...

Liquid Atomized $KMnO_4$ Injection Successful in Oklahoma

In 2003 ARS completed a pilot test by performing Pneumatic Fracturing/Atomized $KMn0_4$ injection into three boreholes at a DOD facility in Oklahoma. The complex site geology consisted of weathered siltstone and poorly sorted sandstone. During this project 3,530 gallons of $KMn0_4$, at a concentration of approximately 5% by weight was injected into the target source zone. Prior to the chemical oxidant injection, pressures up to 450 psig were required to first initiate fractures within the formation.



Pneumatic Fracture Curve at the 39 ft depth

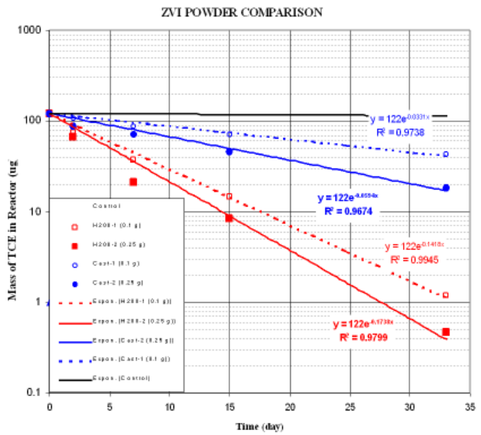
Upon completion of the fracturing step, liquid atomized injection (LAI) of the $KMn0_4$ was performed. During the injection events, evidence of chemical emplacement was observed radially outward to 90 ft. Within one month after the injections were completed, greater than 80% reduction of TCE was observed in ground water. More importantly, little to no contaminant rebound has been observed within the pilot test area. A limited amount of rebound was observed along the up-gradient fringe areas of the pilot test area, presumably due to the influx of some contaminated groundwater.

H-200 Powder out performs other Iron Powders

The H-200 ZVI powder used in the Ferox^{SM} process is a proprietary high reactive zero valent iron powder exclusively available through ARS. Directly reduced from iron ore and manufactured in the USA, this material contains no toxic levels of trace elements as may be found in cast iron or waste iron stocks from which conventional iron filings originate. The H-200 is codex "food-grade" certifiable due to its high purity and the manner in which it is produced. Internal porosities on the individual iron particles, along with other inclusions found within its structural matrix (not as a separate phase), result in greater reactivity than other powders of similar or smaller particle size on the market.

Several recently conducted studies further confirmed the enhanced treatment benefits of the H-200 powder. One study performed at Clemson University looked at the adsorption effect of a chlorinated solvent (TCE was used) onto different iron particles that may be miss-interpreted as actual reduction. The apparent decrease in the TCE concentrations in the presence of H-200 was mostly attributed to actual chemical breakdown of the compound and least caused by adsorption. The other commercial iron types from Connelly, Peerless, and Fisher exhibited higher absorption of the TCE.

ARS also recently completed an bench-top test to compare the reactivity of several different ZVI powders. They include the H-200 sponge iron, cast iron, and other proprietary ZVI powders of very fine particle sizes. The study was conducted using both sediments and actual groundwater contaminated with TCE. The H-200 showed the most significant reduction. The following graph shows the reduction of TCE mass by the different iron powders:



ARS also observed during this test the use of H-200 generated little or no daughter products such as cis-1,2-DCE and vinyl chloride compared to the other irons. This confirms the field data from several of our project sites in which the TCE was degraded preferentially by the beta-elimination process without creating the daughter products rather than by sequential dechlorination.

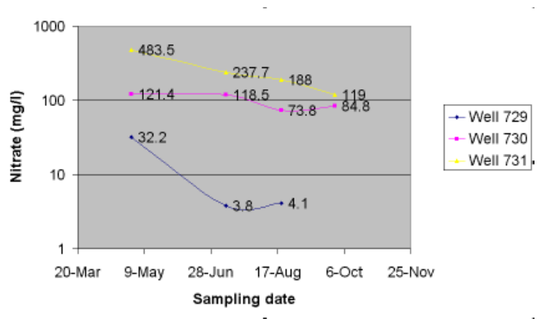
The test also showed that the reactivity of a iron powder is not dictated by particle size or surface area. As part of product R&D, ARS had previously tested other types of very fine powder that showed lower reactivities.

ARS believes the H-200 ZVI powder is the best, most cost effective and environmentally friendly ZVI powder on the market today. Visit www.zerovalentiron.com for more product information.

Ferox^{sm} Application in Tight Clay Geology in Tennessee

In designing a Ferox^{sm} system, the effects of other electron receptors (i.e. nitrate, sulfates), which compete with the target organic compound, need to be considered. A recent Ferox^{sm} application illustrates this point. Early this summer, ARS was contracted to install a Ferox^{SM} system at a southeast government site to address TCE source contamination. The site was a former leach/burn area for fuels and propellants. Previous remedial efforts involved the removal of contaminated soils within the former waste pits followed by ex-situ biological treatment of the excavated soils. Some of these biological treatment tests involved the use of chicken manure, which has extremely high nitrate levels. Historically, TCE concentrations in this area have been as high as 14,000 ug/L and elevated nitrate levels as high as 288,000 mg/l. Under anaerobic conditions, oxidants such as nitrate can act as an electron receptor and potentially interfere with the TCE-ZVI reduction reaction mechanism. Unfortunately, the reduction rate of nitrate to nitrite has been found to be faster than TCE reduction, therefore preferential reduction of the nitrate is expected. Based upon ground water sampling results, obtained 8 months after injections, TCE concentrations were reduced up to 95% in the source area. Additionally, the formation of elevated daughter products was not observed. Along with the TCE reductions, Nitrate reductions up to 94% were also observed.

An ARS Engineer Operating one of our Gas Injection Modules.



ARS' Projects to be Presented at Battelle Chlorinated Solvents Conference.

Five projects, in which included ARS' innovative processes will be featured in presentations by our clients at the upcoming Battelle Chlorinated Symposium in May. This bi-annual conference is regarded as one of the premier technical symposiums in the world related to chlorinated solvent remediation.

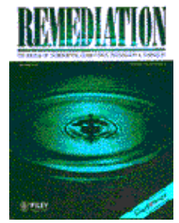
ARS is proud that our clients have selected projects including our technologies and the conferences peer selection committee deemed them worthy for presentation to the industry.

The five presentations are:

- **Strategic Approach to ZVI Pilot Testing Reduces Site Remediation Cost;**
- **Results From Three Pilot Tests Using Pneumatic Fracturing And Chemical Oxidation Injection Technologies;**
- **Comparison Of Pneumatic and Hydraulic Fracturing For Emplacement Of Treatment Materials In Low Permeability Formations;**
- **Demonstration of Zero-Valent Iron Injection for Insitu Remediation of Chlorinated Solvents at Hunters Point Shipyard, San Francisco, California;**
- **Abiotic in-situ Hexalent Chromium Reduction using Pneumatically injected ZVI under an active industrial building.**

Make your plans to see us in Monterey in May, 04'

Ferox^{sm} Article Published in Journal



In the April 2003 edition of Remediation Journal, an article titled *The use of zero-valent iron injection to remediate groundwater: Results of a pilot test at the Marshall Space Flight Center* was published. This journal article authored by Bill McElroy of CH2M Hill described the successful results of a Ferox^{sm} system installed at the NASA facility in 2000. For a link to the abstract click here. http://www3.interscience.wiley.com/cgi-bin/abstract/104520297/ABSTRACT