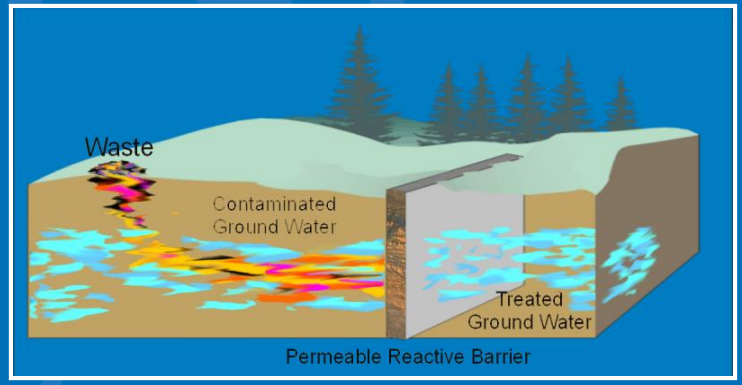
EPA
United States
Environmental Protection
Agency

Innovative Subsurface Remediation Technologies

Richard T. Wilkin



ERIS Board-EPA Joint Meeting
July 11, 2017

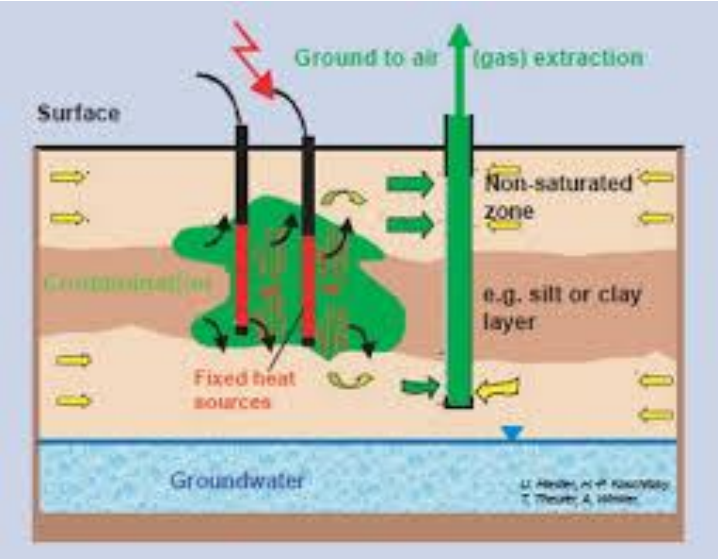
Problem & Approach

- **Development of groundwater remediation technologies to reduce reliance on pump-and-treat**
- Treatment of groundwater contaminated with VOCs, metals, and other inorganics
- Applied research to address common issues:
  - Long-term performance of treatment
  - Matching technology compatibility with site characteristics
  - Coupling multiple technologies
  - Site characterization & monitoring strategies
- Transfer of applied research results to technical support activities

Technologies for Groundwater Remediation

- Thermal remediation
- *In situ* chemical oxidation (ISCO)
- *In situ* chemical reduction (ISCR)
- Permeable reactive barriers (PRBs)
- Subsurface barriers/soil vapor extraction
- Monitored natural attenuation (MNA)
  - organic compounds
  - metals, metalloids, and other inorganics

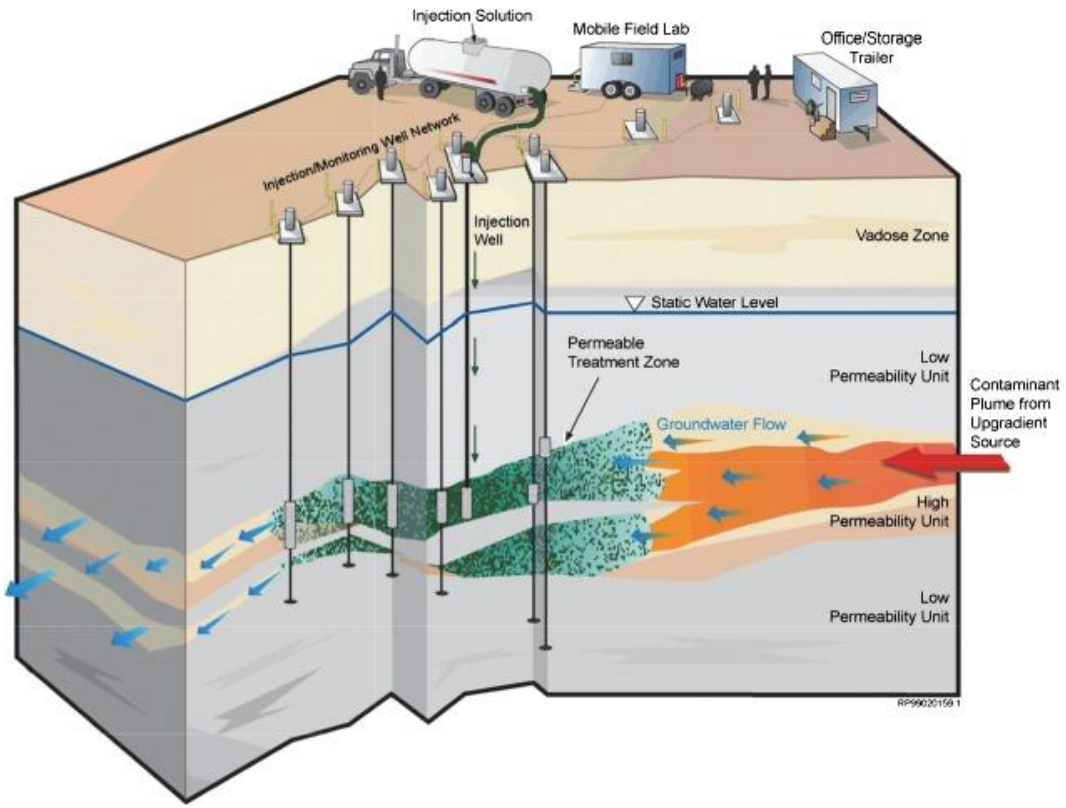
Thermal Remediation



- Electrical Resistance Heating
- Used for Volatile Organic Compounds (VOCs)
- Used in Soil and Groundwater
- Depths to 100 ft
- VOCs captured in vapor stream & then extracted

- Boiling points of common VOCs in water range from 31 ºC to 87 ºC

In Situ Chemical Oxidation (ISCO) & Reduction (ISCR)



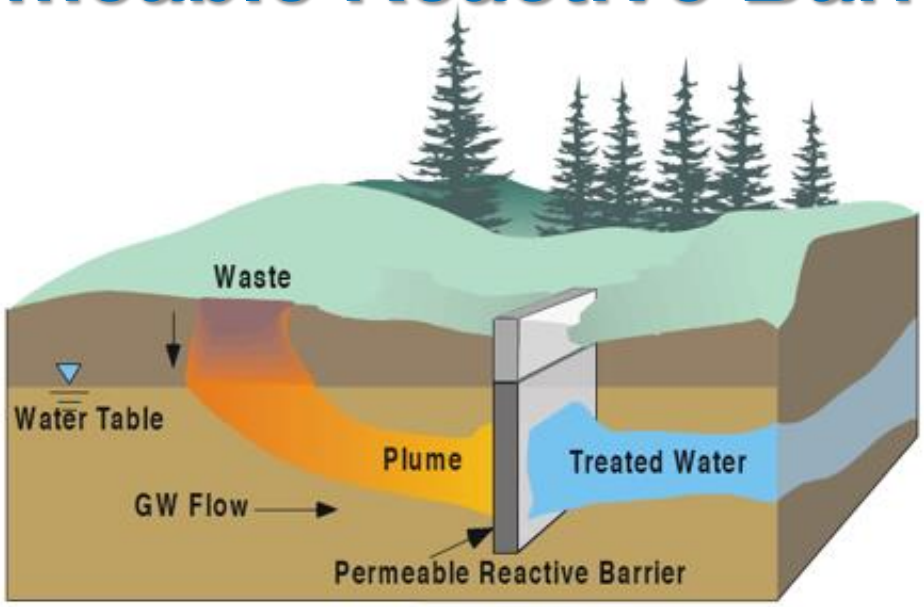
- ISCO
  - VOCs
  - Peroxide, permanganate, persulfate
- ISCR
  - VOCs/metals
  - Dithionite, hydrogen sulfide, ferrous sulfate, organic carbon, micro/nano-particles

- Issues: Delivery of reagent(s) to subsurface; Subsurface compatibility of reagent(s); Region of influence of the injected reagent(s)

Permeable Reactive Barriers

United States Environmental Protection Agency

Zero-valent Iron, Organic Carbon, or Zeolites used for solvents & inorganics



Advantages

- Subsurface treatment
- Plume capture complete
- Passive treatment
- Lower costs vs. Pump/Treat
- Adaptable, property use
- Focused monitoring

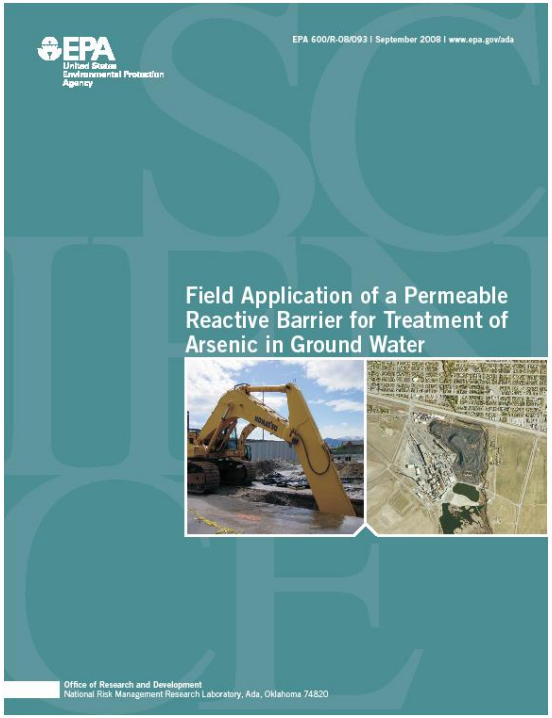
Limitations

- Greater initial investment
- Post-construction issues
- Longevity concerns
  - Treatment performance
  - Hydraulic performance

PRB Research

Groundwater, Watershed, and Ecosystem Restoration Division, Ada, OK

- Research Areas: *i)* Long-term performance evaluations at full-scale PRB installations; *ii)* Pilot-scale tests for technology development & assessment; and *iii)* Basic problem research
- Collaboration with EPA regions, states, other federal agencies, academia and industry



Science of the Total Environment 468–469 (2014) 186–194

Contents lists available at ScienceDirect

Science of the Total Environment

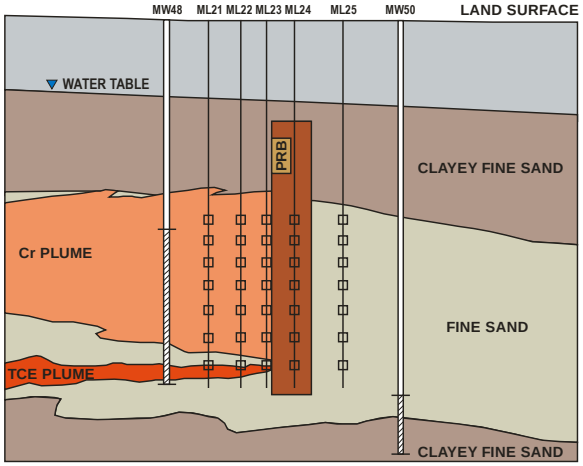
journal homepage: www.elsevier.com/locate/scitotenv

Fifteen-year assessment of a permeable reactive barrier for treatment of chromate and trichloroethylene in groundwater

Richard T. Wilkin [a,*], Steven D. Acree [a], Randall R. Ross [a], Robert W. Puls [b], Tony R. Lee [a], Leilani L. Woods [c]

[a] United States Environmental Protection Agency, National Risk Management Research Laboratory, Ground Water and Ecosystems Restoration Division, 919 Kerr Research Drive, Ada, OK, 74820, USA
[b] Oklahoma Water Survey, University of Oklahoma, 301 David L. Boren Blvd., Norman, OK, 73019, USA
[c] U.S. Coast Guard Base Elizabeth City, 1664 Weeksville Road, Bldg 981, Elizabeth City, NC, 27909, USA

HIGHLIGHTS



- Longest available record of a permeable reactive barrier
- Chromate effectively remediated over 15 years
- Continued system performance is expected based on geochemistry
- Trichloroethylene is also treated, but influent concentrations have increased with time

PRB Research: Nitrate Treatment in Groundwater

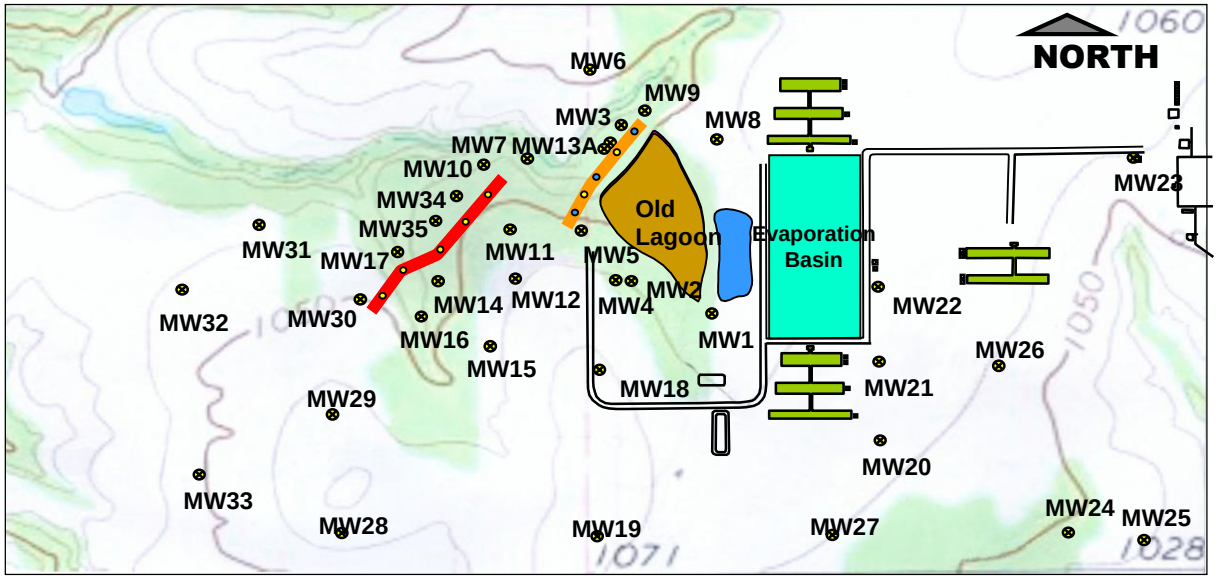
- Concentrated Animal Feeding Operation site located in OK
- Facility in operation for about 7 y, closed in 1999; groundwater impact from leaking lagoon
- Groundwater remediation strategy developed for separate ammonia and nitrate plumes
- Remedies implemented in late 2002 (site owner, OK Dept. Agriculture, EPA Region 6)

Nitrate Reactive Barrier

Ammonia Remediation Trench

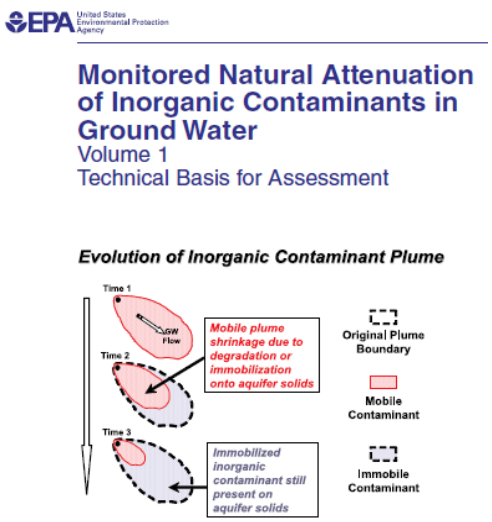
Observation Well Locations

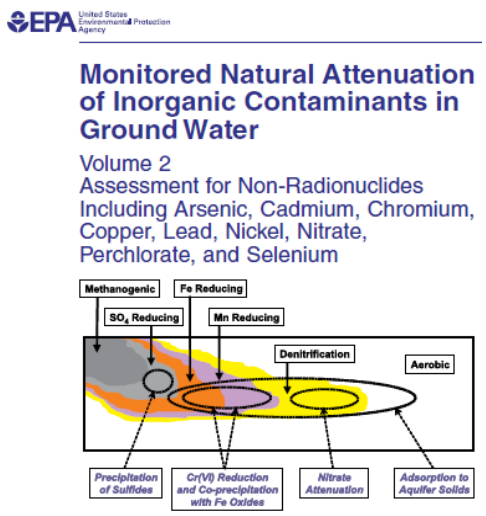
Pumping Well Locations

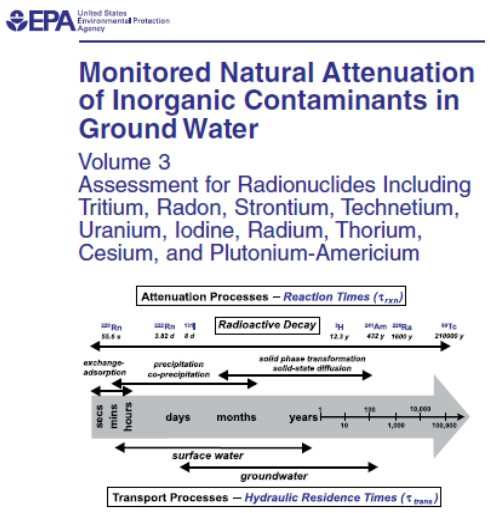


Monitored Natural Attenuation: Inorganics

- Natural attenuation relies on natural processes to decrease concentrations of contaminants in groundwater
- Applied with other more active remedial tools at sites where biogeochemical conditions favor natural processes that degrade or immobilize harmful contaminants
- Examples of inorganics: chromium, arsenic, lead, nitrate







Monitored Natural Attenuation: Inorganics

Technical/Regulatory Guidance

A Decision Framework for Applying Monitored Natural Attenuation Processes to Metals and Radionuclides in Groundwater

December 2010

Prepared by
The Interstate Technology & Regulatory Council
Attenuation Processes for Metals and Radionuclides Team

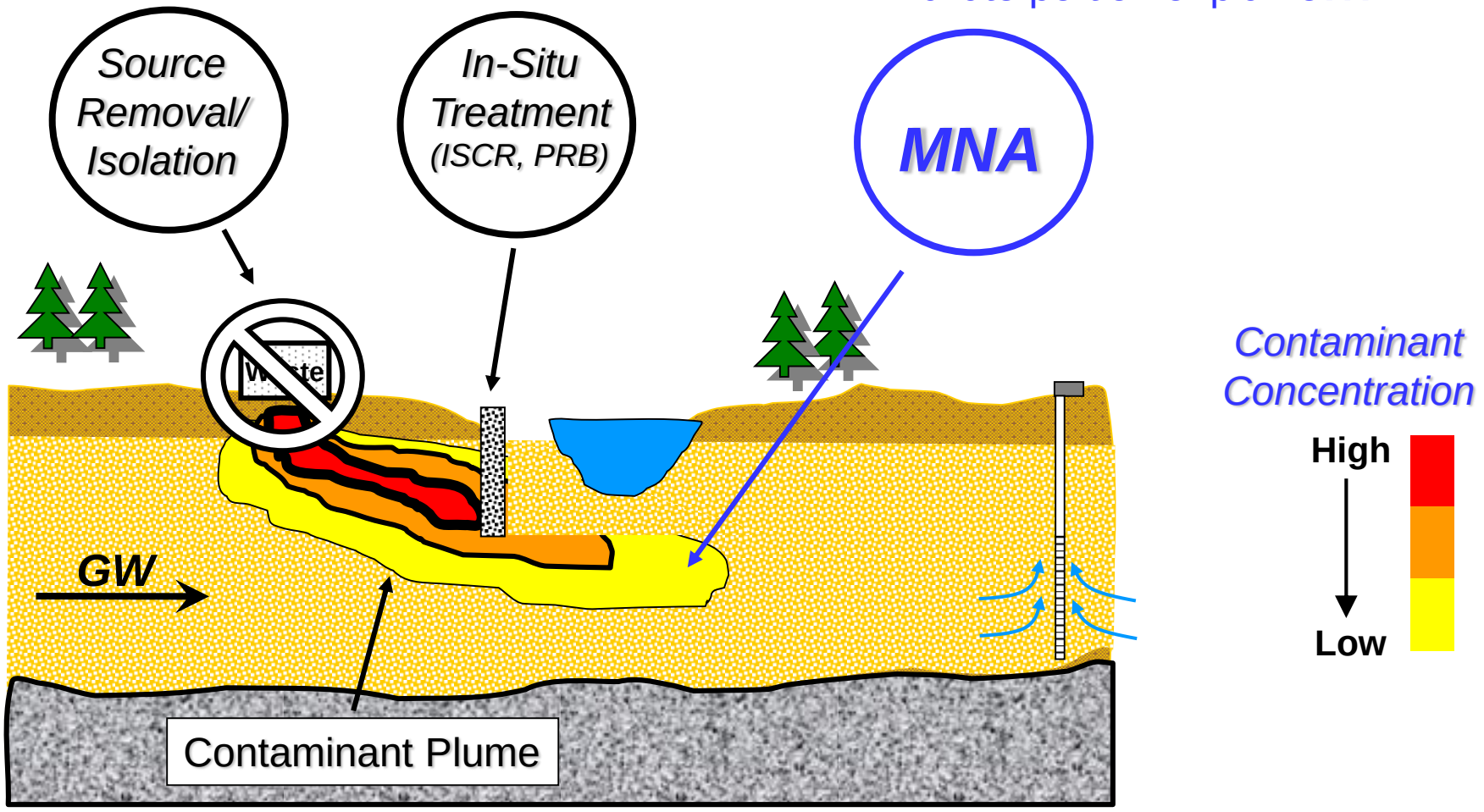
- Monitored Natural Attenuation: Interstate Technology & Regulatory Council (ITRC) guidance is based on 3-volume EPA Technical Guidance
- Training
- Technology transfer

Coupling Technologies

United States Environmental Protection Agency

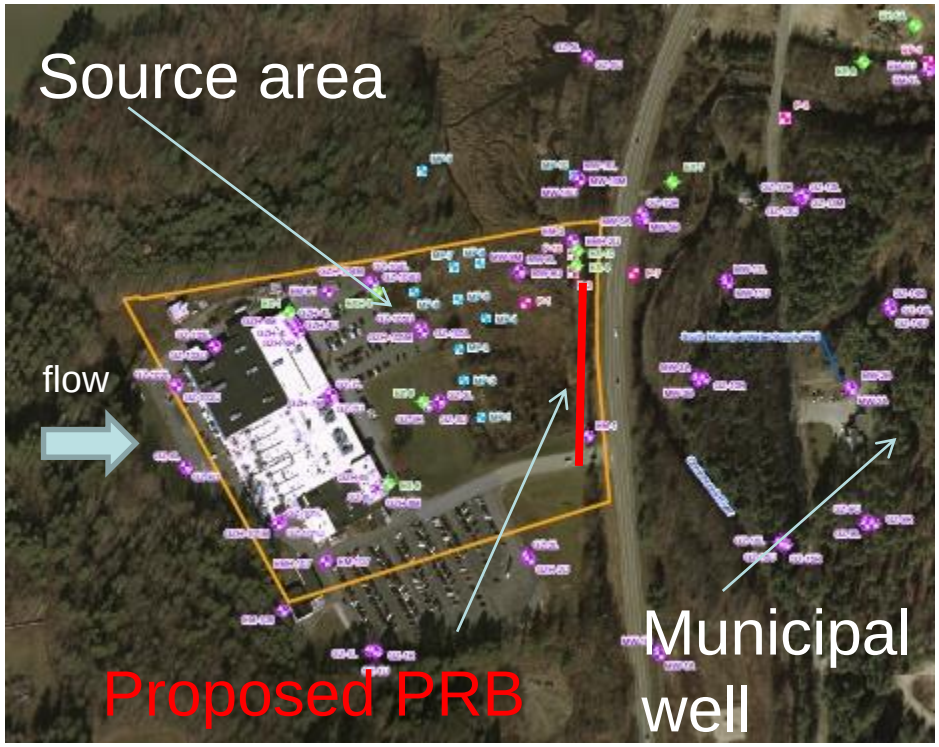
1 Reduce contaminant flux in subsurface…

2 Use of MNA to remediate dilute portion of plume…



Technical Support & Research Relating to PRBs & Thermal

- EPA Region 1 site, NH
- Chlorinated solvents & 1,4-dioxane
- Example of combined technologies: thermal remediation in source, w/ down-gradient PRB
- Access along road precludes conventional trenching installation
- Issue: frack-emplaced PRB will be thin and may not meet residence time requirements
- Application of natural tracers (Rare Earth Elements); C isotopic ratio of chlorinated ethenes

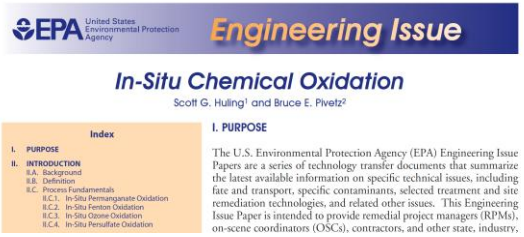


South Municipal Water Supply Well Superfund Site

Impacts of Applied Research

Take Home Messages

- Technical Guidance on remedy selection, application and performance
  - ISCO, PRBs, MNA
- Technical Guidance on site characterization for refining conceptual site models
- State-of-the-art tools
  - Provide guidance and support on use of new tools, e.g., sequential extractions, isotopic tools, synchrotron-based spectroscopy
- Research directions developed from national perspective


EPA United States Environmental Protection Agency Engineering Issue

In-Situ Chemical Oxidation

Scott G. Huling[1] and Bruce E. Pivetz[2]

Index

I. PURPOSE
II. INTRODUCTION
II.A. Background
II.B. Definition
II.C. Process Fundamentals
II.C.1. In-Situ Permanganate Oxidation
II.C.2. In-Situ Fenton Oxidation
II.C.3. In-Situ Ozone Oxidation
II.C.4. In-Situ Persulfate Oxidation

I. PURPOSE

The U.S. Environmental Protection Agency (EPA) Engineering Issue Papers are a series of technology transfer documents that summarize the latest available information on specific technical issues, including fate and transport, specific contaminants, selected treatment and site remediation technologies, and related other issues. This Engineering Issue Paper is intended to provide remedial project managers (RPMs), on-scene coordinators (OSCs), contractors, and other state, industry,

Contact Information

Richard T. Wilkin

US EPA Office of Research and Development
National Risk Management Research Laboratory
Groundwater, Watershed and Ecosystem Restoration Division
Ada, OK

580-436-8874
wilkin.rick@epa.gov