Actionable Science for Communities

PERFORMANCE ASSESSMENT OF A PERMEABLE REACTIVE BARRIER (PRB) FOR GROUND WATER REMEDIATION– SHC 3.61

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Purpose

- A granular iron permeable reactive barrier (PRB) was installed at U.S. Coast Guard Support Center located near Elizabeth City, NC.
- Well-documented, full-scale PRB designed and constructed for removing hexavalent chromium from ground water.
- Current research provides an update on contaminant removal efficiency of this PRB after 15 years of operation.
- Interest in site-specific evaluations of PRB performance is high:
  - Media longevity
  - Hydraulic performance
- Comparatively few long-term data sets are available in the literature that provide detail on performance.

Utility of Research

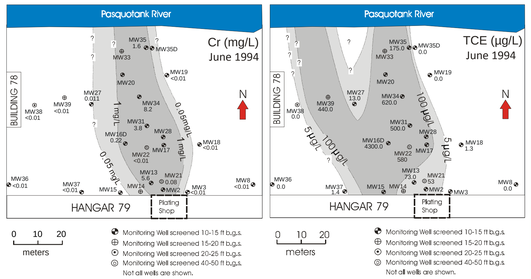
- This research supports EPA by providing technical expertise on application of PRBs at waste sites.
- Research provides regulators with scientific and economic framework for technology selection at impacted sites:
  - Basic processes research – basic chemical, physical, and biological processes of importance to PRB systems
  - Pilot-scale tests for technology development & assessment – evaluate applications of the PRB technology
  - Long-term performance – a unique feature of this research effort

Connection to SHC Portfolio

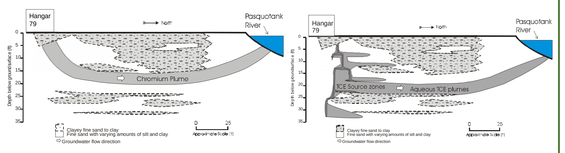
- ORD research in the Sustainable Healthy Communities program has a focus on sustainable solutions for contaminated sites.
- Remediating contaminated sites contributes to community sustainability by eliminating risks to receptors and bringing the properties back into commerce.
- Remediation technology itself can contribute to sustainability by having low cost and operating characteristics which are acceptable to the surrounding community.

Project Highlights

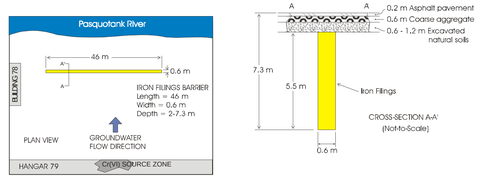
- Site is located 100 km south of Norfolk, Virginia on southern bank of the Pasquotank River (about 5 km southeast of Elizabeth City, NC).
- Surficial aquifer (coastal plain sediments) overlying dense clay. Water table at ~ 1.5 - 2 m bgs.
- Metal plating shop operated for more than 30 years about 60 m south of the river.
- Soils beneath the shop were found to contain chromium concentrations (up to 14,500 mg/kg), with a chromate plume extending to the river.
- Contaminant plume had high (> 10 mg/L) concentrations of chromate, elevated sulfate (up to 150 mg/L), and minor amounts of TCE, *cis*-DCE, and VC.
- June of 1996, a PRB (continuous wall configuration) was installed approximately 30 m from the Pasquotank River.
  Specifications:
  46 m long, 2-7.3 m deep,
  0.6 m wide,
  100% zero-valent-iron
  (Peerless™ granular)
- PRB was designed to remediate hexavalent chromium-contaminated groundwater and VCOCs.
- Evaluation of the Elizabeth City PRB consisted of
  - Groundwater sampling
  - Spatial and temporal changes in pore water geochemistry and hydrology
  - Core collection and solid-phase studies
  - Hydrologic characterization



Cr(VI) and TCE Plumes – Plan Views



Cr(VI) and TCE Plumes – Cross Sections



Plan and Cross-Sectional Views of PRB

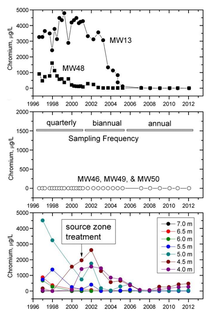
Groundwater Sampling

Pneumatic Slug Tests

Soil Core Sampling

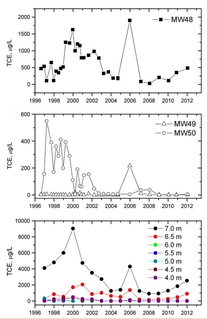
Findings

1. Removal of contaminants, Cr and TCE, continues after fifteen years of operation.
   - Chromium concentrations have been reduced to below regulatory thresholds.
   - In majority of sampling events, Cr was undetected in monitoring wells located downgradient from the PRB.
   - Concentrations of volatile organic compounds have been significantly reduced.
2. After fifteen years, ground water in the PRB is moderately alkaline (pH>9) and moderately reducing (negative EH values).
   - Time trends in pH suggest quasi-steady-state conditions.
   - Time trends in EH suggest that the PRB is gradually losing capacity to produce reducing conditions due to progressive exposure to ground water.
3. PRB has consistently removed inorganic carbon, sulfate, and calcium from influent ground water (precipitated out in the PRB or chemically transformed by biotic or abiotic processes).



Trends in chromium concentrations (µg/L) through time:

- Up-gradient monitoring wells MW13 and MW48
- Down-gradient monitoring wells MW46 MW49, and MW50
- Up-gradient multi-level cluster wells in ML21



Trends in TCE concentrations (µg/L) through time:

- Up-gradient monitoring well MW48
- Down-gradient monitoring wells MW49 and MW50
- Up-gradient multi-level cluster wells in ML21

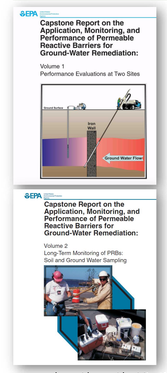
Partners and Intended End Users

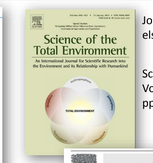
- **Partners**
  - Program Offices
  - Regions
  - Other federal agencies (including Federal Tri-Agency Research Initiative: EPA, DOD, DOE)
  - Academia
  - Industry
- **Intended End Users**
  - Program Offices
  - Regions
  - Other federal agencies
  - Tribal and State regulatory agencies
  - Environmental consulting community
  - Industry

Impact of Research / Lessons Learned

- PRB technology has grown, >100 applications worldwide
- ORD is a leader in providing research & technical assistance on PRBs
- 2003 "Capstone Report" is core research reference
- Future Directions:
  - Evaluation of reactive media (nano-materials, organic carbon)
  - Applying advanced analytical tools
  - Mega-Sites

Further Reading





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