10/27/04 TA16 SWMU 16-021(c)

Table 1
Summary of Shaw's Recent PRB Projects

Site	Treated Contaminants	Scope of Services	Funnel and Gate Barrier	Continuous Wall Barrier	Multiple Barrier	Geotechnical Investigation	Monitoring Well Installation	Hydrologic Modeling	Geochemical Modeling	Groundwater Sampling and Analysis	Engineering Design	Barrier Construction/Installation	Performance Monitoring
DOE, S-3 Pond, Oak Ridge, Tennessee	Nitrate, Radioisotopes, Metals, CVOCs, Common Ions	Designed and installed a funnel-and-gate reactive barrier system consisting of HDPE membrane walls, a treatment module containing porous media, and groundwater collection piping. Barrier was installed using modular shoring and a biopolymer slurry. The treatment module is designed to allow for the testing of various treatment media.	✓				✓			✓		✓	
DOE, Mound Site, Rocky Flats Environmental Technology Site, Colorado	Chlorinated Organic Compounds, Metals, Radionuclides	Installed a funnel-and-gate reactive barrier system consisting of HDPE membrane walls, two treatment cells containing zero valent iron, and a groundwater collection system. The treatment cells are designed such that the treatment media can be easily placed and retrieved to facilitate regeneration or replacement of the medium. The barrier was installed using an open trench method with a track-mounted hydraulic excavator.	✓			✓	✓					✓	
DOE, East Trenches Plume, Rocky Flats Environmental Technology Site, Colorado	VOCs, Tetrachlorethene, Carbon Tetrachloride, Tetrachloroethene, Uranium-238	Designed and constructed a funnel-and-gate permeable reactive wall consisting of HDPE membrane walls and a subsurface groundwater collection system. The wall was constructed using an open-ended trench box pinned with H-pile to shore the excavation. Treatment media is granular zero-valent iron whcih can be easily placed and retrieved from cell.	✓			✓	✓	✓			✓	✓	
DOE, Solar Ponds, Rocky Flats Environmental Technology Site, Colorado	Nitrates, Radioisotopes	Designed and constructed a funnel-and-gate permeable reactive wall consisting of a subsurface collection system and a two-stage treatment module. Stage 1 contains organic media and granular iron to induce denitrification and reduce nitrate. Stage 2 contains granular iron to remove radioisotopes by chemical reduction. The system was installed using a track-mounted hydraulic excavator.	✓		✓	✓	✓	✓			✓	✓	
DOE, Monticello, Utah	Radionuclides, Metals	Constructed a funnel-and-gate permeable reactive wall consisting of two impermeable bentonite/soil slurry wing walls and a zero-valent iron reactive section installed using steel sheet pile cofferdam construction.	✓									✓	
Shaw Air Force Base, Operable Unit 4, Sumter, South Carolina	VOCs, TCA, DCE, BTEX	Designed and constructed a permeable reactive barrier consisting of four continuous walls containing a 50/50 mixture of filter media and zero-valent iron. The walls were 275 feet long and 24 feet deep installed using a chain treancher.		✓		✓	✓	✓	✓	✓	✓	✓	✓
US Army Corps of Engineers, Denver Federal Center, Lakewood, Colorado	Chlorinated Organic Compounds	Designed and constructed a funnel-and-gate permeable reactive wall consisting of impermeable sections of sealable-joint sheet piling and four permeable treatment cells constructed by steel sheet pile cofferdam methods. The treatment cells consisted of zero-valent iron and pea gravel.	✓			✓	✓	✓	✓	✓	✓	✓	
Confidential Client, Southern California	TCE, Cr+6	Designed, installed and tested Reactant Sand Fracturing as a method of installing permeable reactive barriers within fractured bedrock. Reactive proppants were pumped under high pressures into the fractures.		✓		✓	✓	✓		✓	✓	✓	
Confidential Client, Oregon	TCE, VOCs	Designed and constructed a funnel-and-gate permeable reactive barrier with a treatment cell containing zero valent iron filings. The impermeable walls were constructed using a continuous pass trencher and dry bentonite.	✓			✓	✓			✓	✓	✓	✓
Confidential Client, Colchester, Vermont	CVOCs	Designed and constructed a funnel-and-gate permeable reactive barrier with HDPE cutoff walls and four treatment zones consisting of iron filings mixed with sand. The system was installed using a continuous one-pass trencher and bipolymers to provide liquid shoring of excavations during construction.	✓				✓		✓	✓	✓	✓	✓
US Army Corps of Engineers, Kansas City, Missouri	Chlorinated Solvents, VOCs	Designed and constructed a permeable reactive wall consisting of an iron and sand mixture. A long-stick hydraulic excavator was used to excavate the trenches along with bipolymers used to provide liquid shoring of the excavations.		✓		✓	✓	✓	✓	✓	✓	✓	✓

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Degradation of Explosives at Cornhusker Army Ammunition Plant using a Zero-Valent Iron Permeable Reactive Barrier

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Tom Krug
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http://rtdf.org/PUBLIC/permbarr/minutes/102704/pdf/krug.pdf

- TNT and RDX impacted groundwater at many DoD and related contractor site
- Common practice involves P&T with GAC or UV and significant O&M
- Lab studies show ZVI promotes rapid degradation of TNT & RDX
- Degradation products of ZVI are more amenable to biodegradation

- Cornhusker Army Ammunitions Plant (CHAAP), Grand Island, Nebraska
- Former manufacturing of munitions
- Significant plume of TNT and RDX
- ZVI PRB install in Nov 2003
- 50 ft long, 17 ft saturated thickness

1. After 9 months, PRB continues to be effective for TNT

2. Tracer test data from 9 months after installation indicate that water is still flowing through the PRB

3. Some evidence of porosity loss in PRB
   (evidence from geochemical and tracer data - hydraulic head differences are still too small to measure)

SUMMARY OF THE REMEDIATION TECHNOLOGIES DEVELOPMENT FORUM
PERMEABLE REACTIVE BARRIERS ACTION TEAM MEETING
Best Western Winrock Inn
Albuquerque, New Mexico
October 26-27, 2004

Degradation of Explosives at Cornhusker Army Ammunition Plant Using a ZVI PRB
Tom Krug, GeoSyntec Consultants

Tom Krug, whose presentation is referenced in the above website (PDF, 43 pp., 771 KB), talked about research that is being performed to determine whether ZVI barriers have the ability to remediate ground water contaminated with hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and trinitrotoluene (TNT). These contaminants, which pose a problem at many Department of Defense (DoD) sites, are often addressed using ex situ pump-and-treat technology—an approach that is costly over the long term because it requires intensive operation and maintenance (O&M) activities. Therefore, interest has been expressed in identifying an in situ remedial strategy to address these contaminants. Laboratory studies suggest that ZVI degrades RDX and TNT rapidly. Based on this finding, the Environmental Security Technology Certification Program (ESTCP) provided funding to install a pilot-scale ZVI PRB at the Cornhusker Army Ammunition Plant (CHAAP), a site that has a TNT and RDX plume emanating from its manufacturing area. GeoSyntec Consultants and Oregon Health and Science University have joined forces on this project, with the former taking the lead on PRB design and installation and the latter leading the effort to assess the wall's performance.

Before discussing the pilot PRB in detail, Krug talked briefly about the degradation pathways that RDX and TNT undergo in the presence of ZVI. Although both disappear rapidly, it is unclear what degradation products are produced and how long they persist.

The following is known, however: the degradation products are more amenable to biodegradation than the parent compounds.

The 50-foot-long PRB at CHAAP was installed in November 2003 using trenching equipment and a biopolymer slurry that held the walls open long enough for the installation team to emplace a sand/iron mixture into the trench. Krug said that this installation technique—once regarded as novel—is now a well-accepted PRB emplacement technique. Installation was completed in one day; contractors worked into the night because they did not want to delay the backfilling process and risk encountering problems with trench stability. Monitoring wells and access tubes were installed during the PRB construction process. (The latter, which are intended to guide field workers to the front face of the PRB, will be used to assist with future soil coring efforts.) Noting that the PRB does not extend all the way through the saturated zone, Krug reminded attendees that the PRB is a research project and that limited funding prevented the research team from extending the wall to deeper depths.

Krug said that many ground-water samples were collected between November 2003 and August 2004, and that the research team is still reviewing the results reported for TNT, sulfate, conductance, alkalinity, ORP, and pH. (RDX, which was present in very low concentrations, was not included in the analytical suite because the analytical methods available do not have low enough detection limits.) Krug also noted that a bromide tracer test was performed at the site to analyze ground-water flow patterns. Attachment B provides details about the data collected to date. In summary, Krug said, the results suggest the following: (1) the PRB is effectively degrading TNT but it is unclear what is happening to the degradation products, and (2) the vast majority of the ground water is flowing through the PRB although some evidence suggests that a little ground water is flowing under it. In closing, Krug said that ESTCP is also supporting a project that involves using a biomulch barrier to treat TNT and RDX. He thought it would be interesting to compare the results obtained with the biomulch barrier against those obtained with the ZVI PRB.

One attendee asked whether the degradation products are more toxic than the parent compounds. Krug said that he did not have any information to share about the toxicity of the daughter products, but that evidence does suggest that these products biodegrade more readily than their parent compounds do. In response to another question, Krug said that the sulfate data suggest that interesting biological reactions are occurring at the site. Fielding other questions from the audience, Krug noted the following: (1) the PRB was designed to handle a ground-water flow rate of 1 foot per day, (2) no monitoring wells were installed at the wings of the wall to determine whether ground water is going around the wall, and (3) the site is characterized by a clean beach sand and has no clay lenses acting as contaminant repositories.

Permeable Reactive Barrier for Metals Treatment at the Newport, DE Superfund Site

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Abstract: DuPont has developed permeable reactive barrier (PRB) technology to treat metals, primarily barium and zinc, from a landfill at the Newport, Delaware Superfund site. For the first half of the 20th century, DuPont's Newport plant produced Lithopone pigment ($BaSO_4$*ZnS) by roasting barium and zinc ores. Waste sludges were deposited in a landfill, the waters of which today contain metals that exceed environmental standards. An EPA Record of Decision required the landfill to be remediated by in-situ treatment. Innovative technology has been developed which reduces the cost from $17,000,000 for the ROD remedy to $5,000,000, while being more protective of human health. It employs a PRB using calcium sulfate to precipitate barium, zero-valent iron for the adsorption of zinc and other metals, and magnesium carbonate to suppress manganese solubility, in a matrix of local mortar sand. The key to a projected PRB life measured in centuries is a low-permeability cap over the landfill that reduces infiltration and subsequent groundwater flow leaving the landfill to extremely low levels. This minimizes reactant losses from reaction and solubilization. Development of the technology included laboratory batch and column tests and thermodynamic modeling. The final demonstrations were field tests in zones of different groundwater contaminant composition.

Introduction: PRB technology has been accepted by the U. S. EPA as a key component of the treatment remedy for the Newport South Landfill. It is designed to remove metals to below the following levels (ppb): barium 7,800, zinc 120, and manganese 1,000. Other metals of concern are already below their mandated levels (ppb): cadmium 4, copper 18, lead 15, and nickel 730. The 2,200-ft. long, 18-in. wide, 10- to 20-ft. deep PRB will treat all waters leaving the landfill. Wall life is extended by the installation of a low-permeability cap that permits only small quantities of rainfall to enter the landfill, and hence ultimately pass through the PRB.

Batch Scouting Tests: Batch tests were employed for screening reactive materials for use in a PRB. Two types of water were tested, representing areas of high barium or zinc concentration. Appropriate materials were used for each type of water -- for barium-rich water: $CaSO_4.2H_2O$ (gypsum), and for zinc-rich water: zero-valent iron, millscale, steel slag, and iron sulfide. These tests covered a broad range of concentrations for each reactive material to determine the level at which each would potentially become effective.

Barium concentrations were reduced from 290,000 ppb to less than 500 ppb by the addition of 0.5 weight percent of $CaSO_4.2H_2O$, through the precipitation of $BaSO_4$. This was substantially lower than the required 7,800 ppb standard. Zinc concentrations were readily reduced from approximately 1,000 ppb to less than 10 ppb (vs. standard of 120 ppb) by several materials, including zero-valent iron (ZVI; Peerless -8 +50 mesh), iron sulfide, steel-process mill scale, and steel slag, with the first two showing exceptional activity. The mechanism for ZVI is probably sorption onto surfaces of hydrous iron oxides. Manganese was generally not reduced by the materials, and in some cases showed increases, although remaining below the limit of 1,000 ppb.

Full article available at:

http://www.containment.fsu.edu/cd/content/pdf/293.pdf

installed in 2001