A Citizen's Guide to Permeable Reactive Barriers

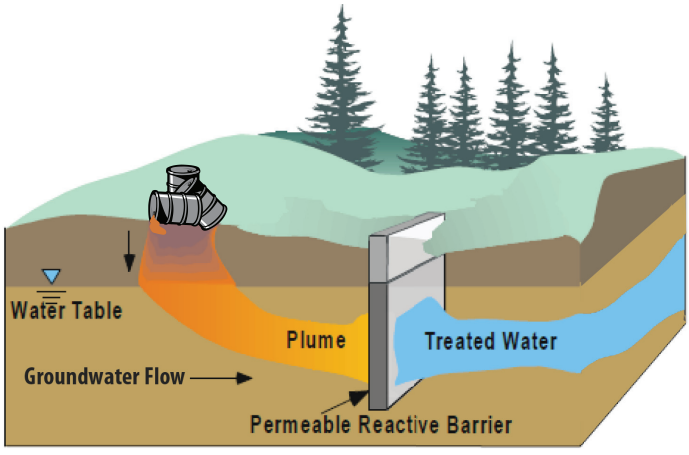
What Are Permeable Reactive Barriers?

A permeable reactive barrier, or "PRB," is a wall created below ground to clean up contaminated groundwater. The wall is "permeable," which means that groundwater can flow through it. Water must flow through the PRB to be treated. The "reactive" materials that make up the wall either trap harmful contaminants or make them less harmful. The treated groundwater flows out the other side of the wall.

How Do They Work?

A PRB is usually built by digging a long, narrow trench in the path of contaminated groundwater flow. The trench is filled with a reactive material, such as iron, limestone, carbon, or mulch, to clean up contamination. Due to limitations of excavation equipment, walls typically can be no deeper than 50 feet. However, a deeper but usually shorter PRB can be built by drilling a row of large-diameter holes or by using fracturing (See *A Citizen's Guide to Fracturing* [EPA 542-12-008]) and other new techniques.

The reactive material selected for the PRB will depend on the types of contaminants present in the groundwater. The material may be mixed with sand to make the wall more permeable so that it is easier for groundwater to flow through it, rather than around it. Side walls filled with an impermeable material such as clay may be constructed at an angle to the PRB to help funnel the flow of contaminated groundwater toward the reactive materials. The filled trench is covered with soil, and is not usually visible at the ground surface.



PRB treats a plume of groundwater contaminants.

Depending on the reactive material, contaminants are removed through different processes:

- Contaminants *sorb* (stick) to the surface of the reactive material. For example, carbon particles have a surface onto which contaminants, such as petroleum products, sorb as groundwater passes through.
- Metals dissolved in groundwater *precipitate*, which means they settle out of the groundwater by forming solid particles that get trapped in the wall. For example, limestone and shell fragments can cause dissolved lead and copper to precipitate in a PRB.
- Contaminants *react* with the reactive material to form less harmful ones. For example, reactions between iron particles and certain industrial cleaning solvents can convert the solvents to less toxic or even harmless chemicals.
- Contaminants are *biodegraded* by microbes in the PRB. Microbes are very small organisms that live in soil and groundwater and eat certain contaminants. When microbes digest the contaminants, they change them into water and gases, such as carbon dioxide. (*A Citizen's Guide to Bioremediation* [EPA 542-F-12-003] describes how microbes work.) Organic mulch frequently is used as reactive media in this type of PRB. Mulch barriers consist of plant-based materials, such as compost or wood chips, and naturally contain many different microbes. Groundwater flow through the PRB also releases organic carbon from the mulch wall, creating another reactive zone for contaminants just beyond the wall.

Over time, reactive materials will fill up with contaminants or treatment products and become less effective at cleaning groundwater. When this occurs the contaminated reactive material may be excavated for disposal and replaced with fresh material.

How Long Will It Take?

PRBs may take many years to clean up contaminated groundwater. The cleanup time will depend on factors that vary from site to site. For example, cleanup may take longer where:

- The source of dissolved contaminants (for instance, a leaking drum of solvent) has not been removed.
- The contaminants remain in place because they are not easily dissolved by groundwater.
- Groundwater flow is slow.

Are PRBs Safe?

The reactive materials placed in PRBs are not harmful to groundwater or people. Contaminated groundwater is cleaned up underground so treatment does not expose workers or others onsite to contamination. Because some contaminated soil may be encountered when digging the trench, workers wear protective clothing. Workers also cover loose contaminated soil to keep dust and vapors out of the air before disposing of it. Groundwater is tested regularly to make sure the PRB is working.

How Might It Affect Me?

During construction of the PRB, nearby residents may see increased truck traffic when materials are hauled to the site or hear earth-moving equipment. However, when complete, PRBs require no noisy equipment. Cleanup workers will occasionally visit the site to collect groundwater and soil samples to ensure that the PRB is working. When the reactive materials need to be replaced, the old materials will have to be excavated and hauled to a landfill.

Why Use PRBs?

PRBs are a relatively inexpensive way to clean up groundwater. No energy is needed because PRBs rely on the natural flow of groundwater. The use of some materials, such as limestone, shell fragments, and mulch, can be very inexpensive, if locally available. No equipment needs to be above ground, so the property may continue its normal use, once the PRB is installed.

Construction of a PRB in Sunnyvale, CA

PRBs have been selected or are being used at more than 30 Superfund sites across the country.

Example

A PRB with iron as the reactive material was installed in 1995 to clean up groundwater at a former semiconductor manufacturing site in Sunnyvale, California. Concentrations of industrial solvents in the groundwater plume were extremely high.

Due to changing groundwater flow directions, low-permeability walls were installed below ground and perpendicular to the PRB to direct the flow of contaminated groundwater toward the PRB. The PRB itself is about 8-feet wide, 40-feet long and 20-feet deep. The objective of the PRB is to reduce solvent concentrations to below the cleanup standards set by the State of California. As of 2009, solvent concentrations in groundwater samples collected within the treatment zone remain below the cleanup standards. Use of a PRB has allowed the metals machining facility currently at the site to continue operating during cleanup.

For More Information

For more information on this and other technologies in the Citizen's Guide Series, contact:

U.S. EPA
Technology Innovation & Field Services Division
Technology Assessment Branch
(703) 603-9910

Or visit:
http://www.cluin.org/prb

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