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Deep Aquifer Remediation Tools (DARTs): A new technology for ground-water remediation

Potable ground-water supplies throughout the world are contaminated or threatened by advancing plumes containing radionuclides, metals, and organic compounds. Currently (1999), the most widely used method of ground-water remediation is a combination of extraction, ex-situ treatment, and discharge of the treated water, commonly known as pump and treat. Pump-and-treat methods are costly and often ineffective in meeting long-term protection standards (Travis and Doty, 1990; Gillham and Burris, 1992; National Research Council, 1994). This fact sheet describes a new and potentially cost-effective technology for removal of organic and inorganic contaminants from ground water. The U.S. Geological Survey (USGS) is currently exploring the possibilities of obtaining a U.S. Patent for this technology.

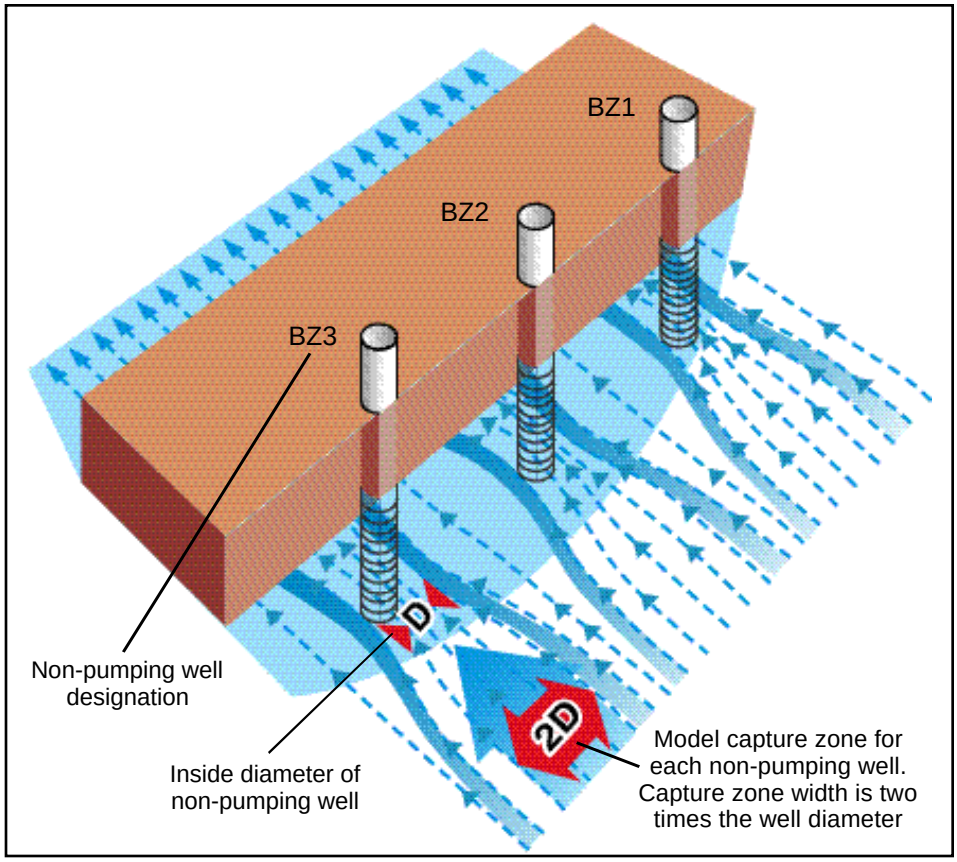

Figure 1: Schematic diagram showing non-pumping wells containing DARTs and modeled contaminant capture zones, Fry Canyon, Utah.

Instead of pumping water to the surface for ex-situ treatment, a tool has been developed to take advantage of the natural ground-water gradient to channel ground water into highly permeable reactive material(s). These Deep Aquifer Remediation Tools (DARTs) are used in conjunction with non-pumping wells and offer a low-cost and virtually maintenance-free alternative to ex-situ treatment methods. As the ground water passes through the permeable reactive material, the contaminant is immobilized or transformed to a non-toxic form by a variety of chemical reactions depending on the reactive material and contaminant of concern.

The DARTs are deployed into an aquifer and corresponding contaminant plume through a series of non-pumping wells (fig. 1). Wilson and Mackay (1997) have found that ground water will converge to arrays of unpumped wells in response to the difference in hydraulic conductivity between the well and aquifer. Numerical simulations conducted during DART development indicate that each well typically intercepts ground water in the upgradient part of the aquifer that is approximately twice the inside diameter of the well (fig. 1).

Trenching techniques are commonly used to emplace permeable reactive barriers (PRBs) for in-situ contaminant removal in shallow aquifers (Manz and Quinn, 1997; Schmithorst and Vardy, 1997). Trench emplacement of PRBs has a number of disadvantages that include: (1) limited to shallow treatment zones; (2) requires specialized trenching equipment; (3) increased health and safety concerns during installation; and (4) replacement and disposal costs of reactive material after breakthrough. Because DARTs are deployed through non-pumping wells, in-situ treatment of deeper contaminant plumes (greater than 100 feet below land surface) that could not be treated with currently available trenching technologies is now possible. In addition, DARTs allow for easy retrieval, replace-

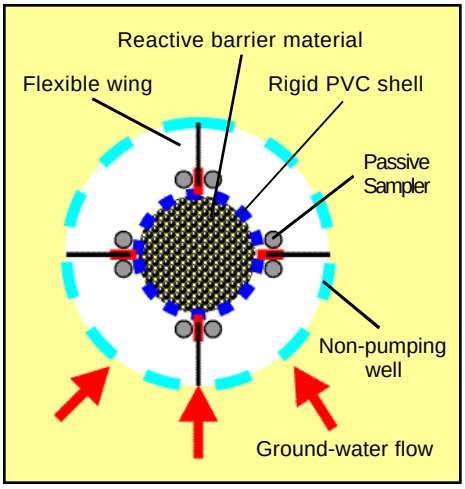

Figure 2: Schematic diagram of Deep Aquifer Remediation Tool (DART).

ment, and disposal of reactive material after chemical breakthrough.

DARTs are designed to fit a variety of well dimensions and plume geometrys. A DART is composed of three basic components (fig. 2): (1) a rigid PVC shell with high-capacity flow channels to contain the permeable reactive material; (2) flexible wings to direct the flow of ground water into the permeable reactive material; and (3) passive samplers to determine the quality of the treated water. Multiple DARTs can be joined together for the treatment of thicker contaminant plumes. DARTs also allow for "vertical stacking" of different reactive materials for the treatment of chemically segregated contaminant plumes.

Figure 3: Deployment of DART prototype into non-pumping well at Fry Canyon, Utah, during October 1998.

Since 1997, several DART prototypes have been field tested in non-pumping wells for the removal of uranium (U) from ground water at sites in Utah and Wyoming (fig. 3). The reactive material used during these field tests consisted of a mixture of bone charcoal and iron oxide pellets. The probable mechanism for U removal in this mixture is sorption or precipitation of insoluble uranyl precipitates. Results from the latest DART field test completed in July 1999 indicate an order of magnitude reduction in U concentrations compared to pre-treatment water samples. Additional field tests of the DARTs are currently (September 1999) in progress and include the testing of an additional barrier material (zero-valent iron). Previous research with zero-valent iron (installed using trenching techniques) has indicated greater than 99.9 percent U removal rates over extended field operations (Naftz and others, 1999).

For More Information

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