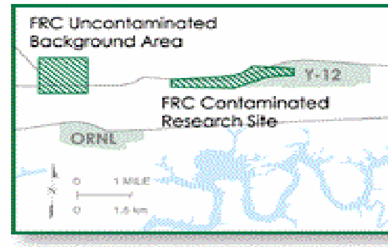


Fact Sheet

"Push-pull" experiments to understand uranium and technetium immobilization in groundwater

Uranium and technetium contamination at the NABIR FRC

Uranium and technetium are major groundwater contaminants at U.S. Department of Energy (DOE) sites. While several forms of uranium and technetium exist, those that are mobile in subsurface environments are of most concern because they have the potential to migrate to locations where they can be taken up by plants, animals, and humans. Uranium VI is mobile in subsurface environments, but uranium IV is of less concern because it is exists as a non-mobile and insoluble mineral. Similarly, pertechnetate may be the most mobile form of technetium.

Remediating groundwater contaminated with uranium or technetium poses many challenges. Few technically feasible and cost-effective options exist. The NABIR program is investigating one promising approach—using naturally occurring microorganisms to immobilize these contaminants *in situ* (in place, below ground).

Sites like those within Oak Ridge's Y-12 National Security Complex pose a formidable remediation challenges in general, and for bioremediation. For example, the high acidity and high concentrations of nitrate interfere with the ability of naturally occurring microorganisms to transform mobile forms of uranium and technetium into less mobile or immobile forms. In addition, the bedrock beneath the site is shallow, highly fractured, weathered, and unconsolidated. These conditions make the flow of the groundwater that contains and transports contaminants complex and not easily predictable.

For bioremediation, the microbiological characteristics of the subsurface environment are at least as important as physical and chemical characteristics. Key questions currently are unanswered with regard to the microorganisms that reside in the subsurface of the Y-12 site. Two examples are (a) whether, or the extent to which, naturally occurring microorganisms can be stimulated to immobilize uranium and technetium and (b) how to sustain that immobilization over time. These questions are among those under investigation at the NABIR FRC.

Field research using "push-pull" techniques

A research team headed by Jack Istok (Oregon State University, jack.istok@oregonstate.edu), Lee Krumholz (University of Oklahoma, krumholz@ou.edu), James McKinley (Pacific Northwest National Laboratory,

NABIR and the NABIR FRC—in brief

Historic research and production activities at sites owned by the U.S. Department of Energy (DOE) and its predecessor agencies created a legacy of below-ground contamination. Considering only contaminated groundwater, DOE currently is responsible for remediating 1.7 trillion gallons, equivalent to approximately four times the daily U.S. water consumption.

DOE's Natural and Accelerated Bioremediation Research (**NABIR**) Program (www.lbl.gov/NABIR) was created to help address some of the more difficult remediation challenges the agency faces. NABIR provides the scientific foundation for the development of bioremediation strategies for below-ground metal and radionuclide contamination. NABIR supports laboratory, field, and theoretical research in microbiology, ecology, chemistry, geology, and computer science. Research is focused on bioremediation of uranium technetium, plutonium, chromium, lead, and mercury.

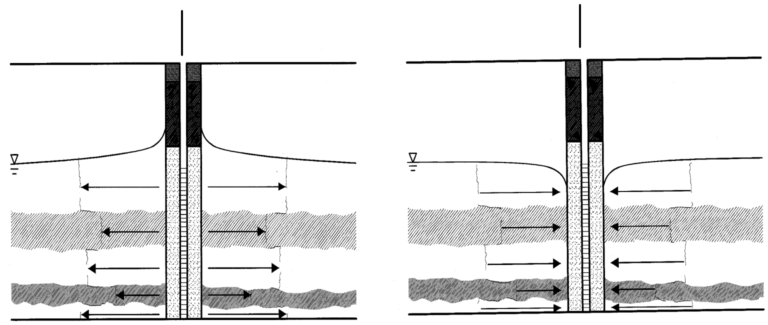
The **NABIR FRC** (www.esd.ornl.gov/nabirfrc) provides contaminated and uncontaminated field sites in which program investigators can conduct research and obtain samples useful in exploring how naturally occurring microorganisms can help remediate below-ground metal and radionuclide contamination in place.

james.mckinley@pnl.gov) and Baohua Gu (Oak Ridge National Laboratory, b26@ornl.gov) combines subsurface transport, microbiology, and geochemistry expertise to identify the conditions under which bioremediation may be effective for immobilizing uranium and technetium. These researchers want to discover whether naturally occurring microorganisms with the capability to immobilize uranium and technetium are present at the Y-12 site. Second, they seek to identify the optimum "feeding" conditions to stimulate the microorganisms to immobilize uranium and technetium at the highest possible rate. Finally, they want to determine the longevity of immobilized contaminants resulting from biostimulation.

The team uses a "push-pull" technique in the field in combination with laboratory analyses. As the name implies, push-pull tests consist of two main parts. The "push" refers to an injection into a well of a solution of site groundwater, tracers and nutrients whose quantity and composition is known. Over time, this solution migrates from the well into the adjacent subsurface environment. Later, the "pull" portion of these tests occurs. The "pull" consists of withdrawing from the same well the injected solution mixed with groundwater. Analyses of these samples can reveal a lot of information about both the microbiological and chemical characteristics of groundwater and directly quantify the microbial activity of the indigenous organisms.

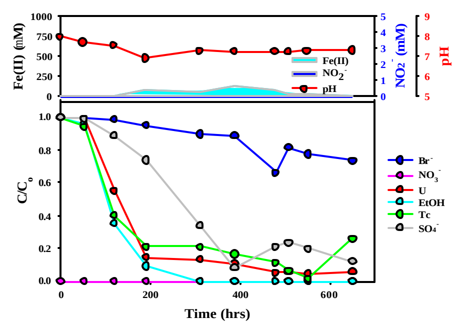
To test for microbial activity, site groundwater is mixed with tracers and nutrients in drums and injected into monitoring wells

Field push-pull tests (left) injection "push" phase (right) extraction "pull" phase



The team is working in over 20 wells at two FRC research sites. Some wells are identified as "controls," in which no nutrients are injected. Other "treatment" wells receive nutrient additions (acetate, ethanol, and glucose). Multiple wells are tested simultaneously to insure that field experiments are conducted under a wide range of conditions (contaminant levels, acidity, etc.) and therefore are representative of actual site conditions.

The team has demonstrated that it is possible to stimulate indigenous bacteria to immobilize uranium and technetium. Researchers also found that other bacteria that grow on the high nitrate contamination present at some sites are capable of remobilizing immobilized uranium (but not technetium). Current experiments are attempting to determine if it is possible to remove nitrate and uranium simultaneously, use humic materials to speed reaction rates, and determine if immobilized uranium can be stabilized by the addition of sulfate or other materials.



Simultaneous uranium (U) and technetium (Tc) immobilization during field push-pull tests

For more information about this project, see http://public.ornl.gov/nabirfrc/awards.cfm, or contact

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For more information about the NABIR FRC, see http://www.esd.ornl.gov/nabirfrc/, or contact

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