

determine the potential for natural microbial communities to immobilize radionuclides and metals. In particular, research focuses on: (1) Understanding the structure and function of microbial communities in the subsurface at DOE sites contaminated with metals and radionuclides; and (2) identifying and optimizing the *in situ* growth of microorganisms that transform radionuclides and metals. This research will enhance our ability to predict the effectiveness of intrinsic bioremediation and to optimize microbial community composition for *in situ* immobilization of these contaminants. Diverse microbial communities can be found in subsurface environments. These communities represent an untapped catalytic potential for biotransformation of radionuclides and metals. Most of these microbes, however, are as yet uncultured using current methods. One challenge is to determine if sufficient genotypic and/or phenotypic potential exists to support natural and/or accelerated (biostimulated) bioremediation. Knowledge of microbial community structure and function may ultimately provide the ability to control or stimulate subsurface communities capable of biotransformation of radionuclides and metals. A second challenge is to optimize the community structure and activity for immobilization and metals, and to determine the long term stability of bioremediative communities. Research is needed to address questions, such as:

- Is there sufficient biological activity and diversity in subsurface environments to support natural and/or accelerated bioremediation of metals and radionuclides?
- What are the effects of metal and radionuclide contamination on microbial community structure and function, particularly on populations that transform radionuclides and metals? What are the effects of key physical, chemical and hydrological factors on community structure and function, as it relates to immobilization of metals and radionuclides?
- What is the role of consortial interactions in subsurface environments contaminated with radionuclides and metals? Such interactions might include competition for electron donors and acceptors, or consortial interactions in the biotransformation of metals and radionuclides.
- What is the potential importance of gene transfer in natural microbial communities at subsurface sites contaminated with radionuclides or metals?

Those studies that link structure to function of microbial communities that

immobilize metals and/or radionuclides at DOE sites are especially encouraged.

Assessment: Assessment is a cross-cutting element with a goal to develop innovative methods to assess processes and endpoints in support of the NABIR Science Elements. Thus, assessment projects are being sought that support the Science Elements of Biogeochemistry, Biotransformation, and Community Dynamics/Microbial Ecology. Methods may range from molecular to field scale, but they should improve the understanding of *in situ* bioremediation processes in subsurface environments contaminated with radionuclides and metals. Priority will be given to research applications that could lead to fieldable, cost-effective, real time assessment techniques and/or instrumentation. NABIR will not fund projects that examine endpoints relating to human health risks. Research should address the development of innovative and effective methods for assessing or quantifying:

- Biogeochemical or biotransformation processes and rates, and microbial community structure and function relative to bioremediation of metals and radionuclides.
- Bioremediation end points, in particular, the concentration, speciation and stability of radionuclide and metal contaminants.

Techniques must enable NABIR science and address specific science needs of the program. The applicant should explain the potential impact and contribution to the NABIR program, as well as the relevance and potential usefulness of the innovation.

Integrative Studies: This solicitation especially encourages those studies that integrate research from more than one NABIR research element through laboratory and/or field research. This interdisciplinary research should focus on achieving the primary goals of the NABIR program through collaborative studies in which the experimental design integrates two or more NABIR elements. Interdisciplinary teams should include participation from two or more research areas such as microbiology, geochemistry, hydrology, environmental engineering, numerical modeling or other disciplines. Partnering with specific field experiments may provide information for hypothesis testing. Such integrative studies might include, for example:

- Employing numerical modeling to integrate information from more than one element, such as Biogeochemistry, Biotransformation, and Community Dynamics and Microbial Ecology, to better predict *in situ* immobilization of metals and radionuclides.

- Studies of the effects of key physical, geochemical and hydrological parameters on the structure and function of subsurface microbial communities engaged in metal/radionuclide biotransformation and immobilization.

- Integration of new methods in the Assessment element with actual application to studies of biotransformation or biogeochemistry of radionuclide/metal reduction and precipitation.

- Linking chemical speciation of radionuclides and metals in subsurface environments to the bioavailability of those contaminants to microorganisms.

- Studies on the changes of subsurface microbial community structure and function, and the effect on net rates of biotransformation during biostimulation experiments.

Field Scale Bioremediation Experiments

Although bioremediation of radionuclides and metals has been studied in the laboratory, and bioremediation technologies have been demonstrated in the field, there are few examples of carefully controlled, hypothesis-driven, *in situ* bioremediation research at the field-scale. The FRC provides opportunities for such field-scale experiments.

The S-3 Ponds were the primary source of contamination detected in the contaminated zone of the FRC. The S-3 Ponds consisted of four unlined ponds constructed in 1951 on the west end of the Y-12 Plant at Oak Ridge. Liquid wastes, composed primarily of nitric acid plating wastes containing nitrate and various radionuclides and metals (e.g., uranium and technetium), were disposed in the ponds until 1983. Waste disposal activities at the Y-12 Plant created a mixed waste plume of contamination in the underlying unconsolidated residuum (primarily saprolite and fill) and shale bedrock. The ponds were neutralized and denitrified in 1984, and capped in 1988, and the area is now a parking lot.

Three areas in the contaminated zone are currently identified as the primary targets for *in situ* studies. Areas 1 and 3 are located adjacent and directly south and west, respectively, of the S-3 Ponds parking lot and Area 2 is located several hundred feet to the southwest of the parking lot. Applicants may choose to propose research for Area 1 (a high nitrate, low pH site), Area 2 (a low nitrate, circumneutral site) or Area 3 (a very high contaminant concentration, very low pH site). More detailed information on Areas 1, 2 and 3 can be found on the NABIR FRC Web site