Advanced Remediation Methods for Metals and Radionuclides in the Vadose Zone

How and When Will We Impact Site Milestones?

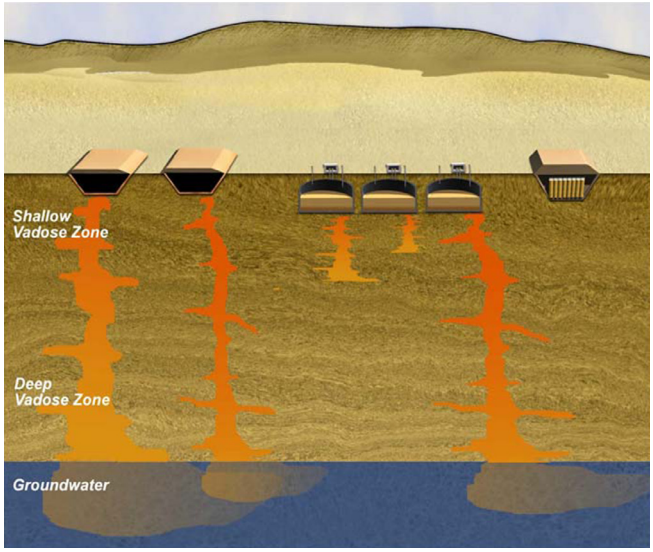
- *FY11: Provide advanced remedial delivery and monitoring techniques that are effective in vadose zone environments.*
- *FY11: Design effective in situ remedial strategies to remediate vadose and low-permeability zones.*
- *FY12: Demonstrate advanced remedial technologies as alternative techniques to baseline approaches.*
- *FY12: Provide additional detailed information to help sites meet specific milestones (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] and Remedial Investigation/Feasibility Study [RI/FS] processes).*
  - *Tri-Party Agreement (TPA) Milestones M-015-51 (9/30/2010)—Deep Vadose Zone Desiccation Testing for 200-BC-1 Feasibility Study/Record of Decision (FS/ROD).*
  - *TPA Milestones M-015-54 (1/31/2010)—Deep Vadose Uranium Sequestration Reactive Gas Testing for 200-BP-5 FS/ROD.*

How Is Vadose Zone Contamination Impeding Site Closure?

The vadose zone is a source and primary conduit for metal and radionuclide (i.e., ^{99}Tc, U, Cr, and ^{90}Sr) contaminant transport from the ground surface to groundwater. Baseline remedial methods are highly constrained, costly, and inefficient for a deep vadose zone environment.

What Did National Academy of Sciences Identify as the Key Technical Challenges?

- *Contaminant subsurface behavior is poorly understood (high risk)—complex interaction between hydrologic and biogeochemical processes.*



U.S. DEPARTMENT OF ENERGY

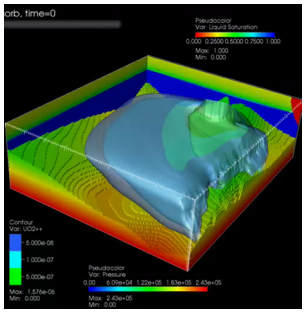
EM Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

For more information:
www.em.doe.gov/Pages/GroundwaterSoilCleanup.aspx

- *Site and contaminant source characteristics limit usefulness of baseline (traditional) approaches.*
- *Computational models do not adequately incorporate site geohydrology and contaminant geochemistry to predict remedial implementation or performance.*
- *Framework to gain regulatory approval for transitioning from active to passive (monitored natural attenuation) remediation is lacking.*

Why Advanced Remediation?



Physical removal methods such as pump-and-treat or excavation are cost prohibitive, impractical, and ineffective for deep vadose zone environments. Developing in situ remediation technologies and defensible remediation strategies for enhanced attenuation is the only feasible, cost-effective path to long-term stewardship of sites contaminated with metals and long-lived radionuclides.

How Will this Research Meet the Technical Challenges?

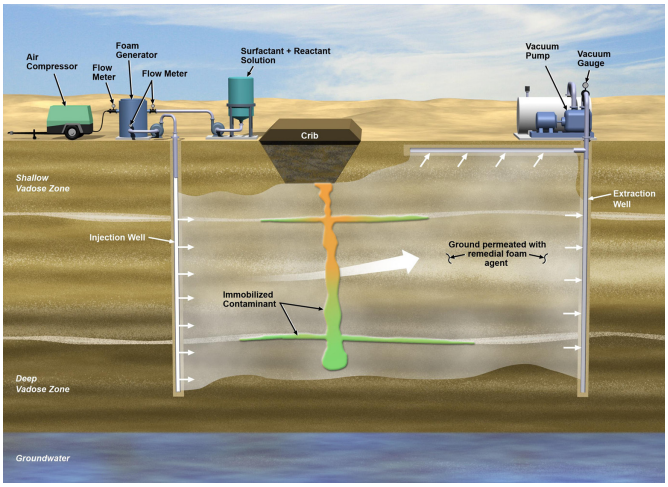
- *Transform state-of-the-art science and engineering into best-practice technical solutions for environmental remediation.*
- *Provide minimally invasive delivery and emplacement methods.*
- *Provide real-time monitoring systems for continuous oversight of plume behavior and remedial strategy performance.*
- *Provide advanced tools for supporting site-wide assessment and remedial decisions that are accepted by regulators and stakeholders.*

What Are the Transformational Concepts Advancing this Effort Over Others?

Effective delivery and monitoring systems are paramount to implementing successful remedial technologies. Conventional techniques are limited by the extreme hydrologic and geochemical challenges present in heterogeneous, deep vadose zone environments.

Foam Delivery Technology (FDT)

FDT can distribute remedial amendments to the deep vadose zone with minimal change in water content and infiltrate low-permeability source zones. Low volume of liquid required for delivery and emplacement by FDT mitigates contaminant mobilization to groundwater.



Reductive Encapsulation Gas Injection Technology (REGIT)

REGIT is a completely gas-phase technique for uniformly emplacing remedial amendments within deep vadose zone environments. REGIT is a cost-effective method to treat unsaturated systems, irrespective of subsurface heterogeneities, and without the mobilization of soil water and associated contaminants.

Novel Measurement, Modeling, and Monitoring

Conventional monitoring techniques are ineffective in deep vadose zone environments. Integrating innovative geophysical methods will allow tracking of remedial implementation, performance, and containment verification. Advanced modeling and geophysical tools will improve remedial technology selection and optimization and provide cost-effective strategies to remediate legacy waste sites.

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PROJECT IMPACT TO SITE MILESTONES

- Technical basis for remedial action decisions on metals and radionuclides in the vadose zone
- Advanced remedial strategies to current baseline methods
- Approaches to measure, predict, and monitor the long-term impacts of remedial strategies
- Life-cycle framework for remedial strategies—reducing cost, risk, and time-frames for site closure.