U.S. DEPARTMENT OF ENERGY

# EM Office of Groundwater and Soil Remediation Research and Development Program


## Mark Williamson for Kurt Gerdes

**Director**

**Office of Groundwater & Soil Remediation**


**EM SSAB Chairs Meeting**

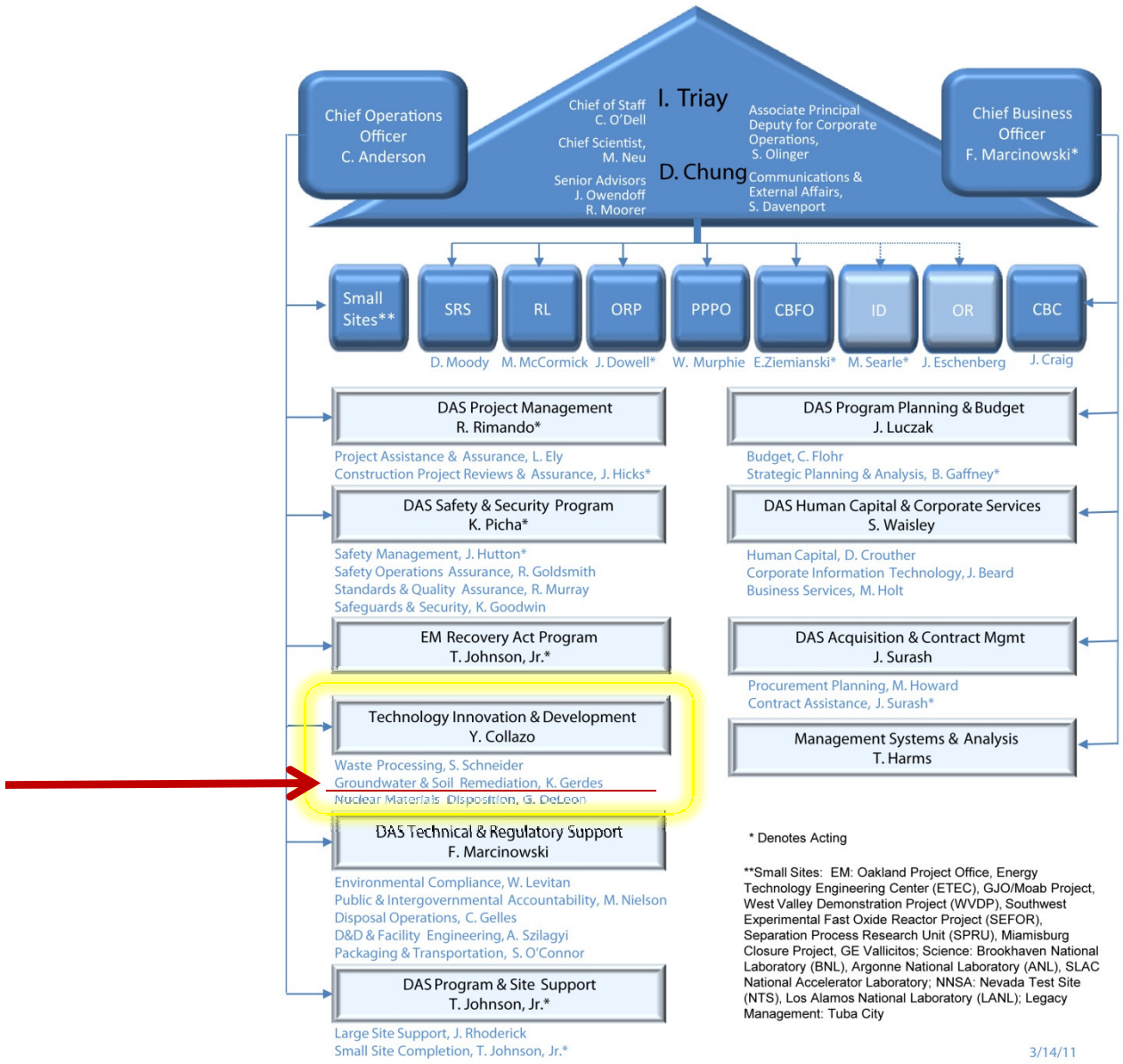
**June 16, 2011**

# Outline

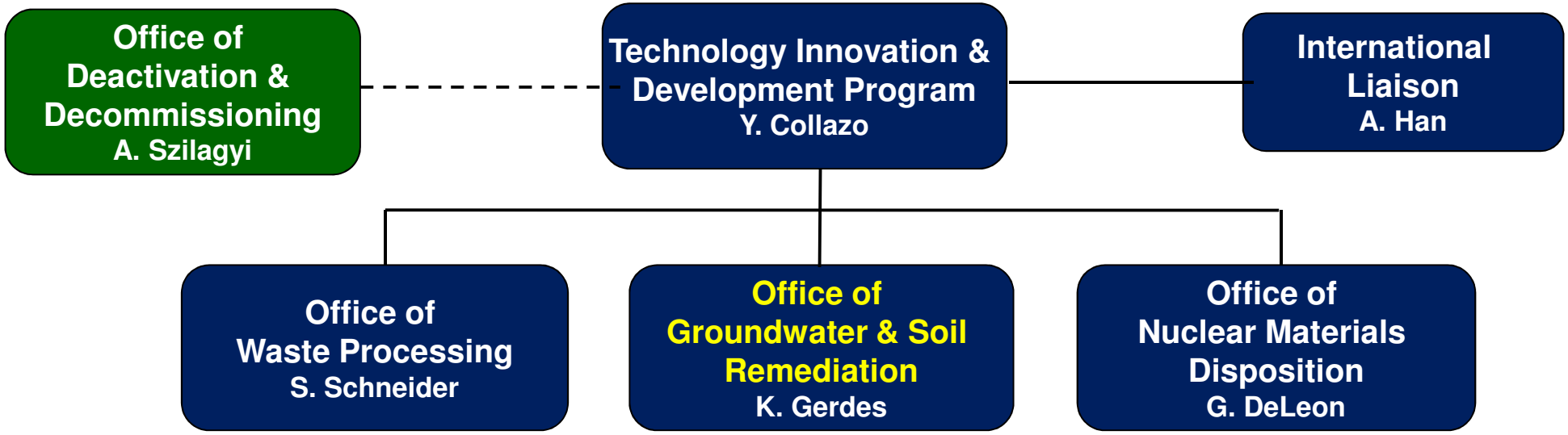
- Overview of technology development program
- Challenges in groundwater and soil remediation
- Recommendations by the National Academy of Sciences
- Solutions, impacts, and approaches
- Technology goals
- Applied Field Research Initiatives (AFRIs)
- Advanced Simulation Capability for Environmental Management (ASCEM)
- Technical assistance
- Examples of technology development

# EM Organization

## The EM Leadership Pyramid



# Office of Technology Innovation & Development



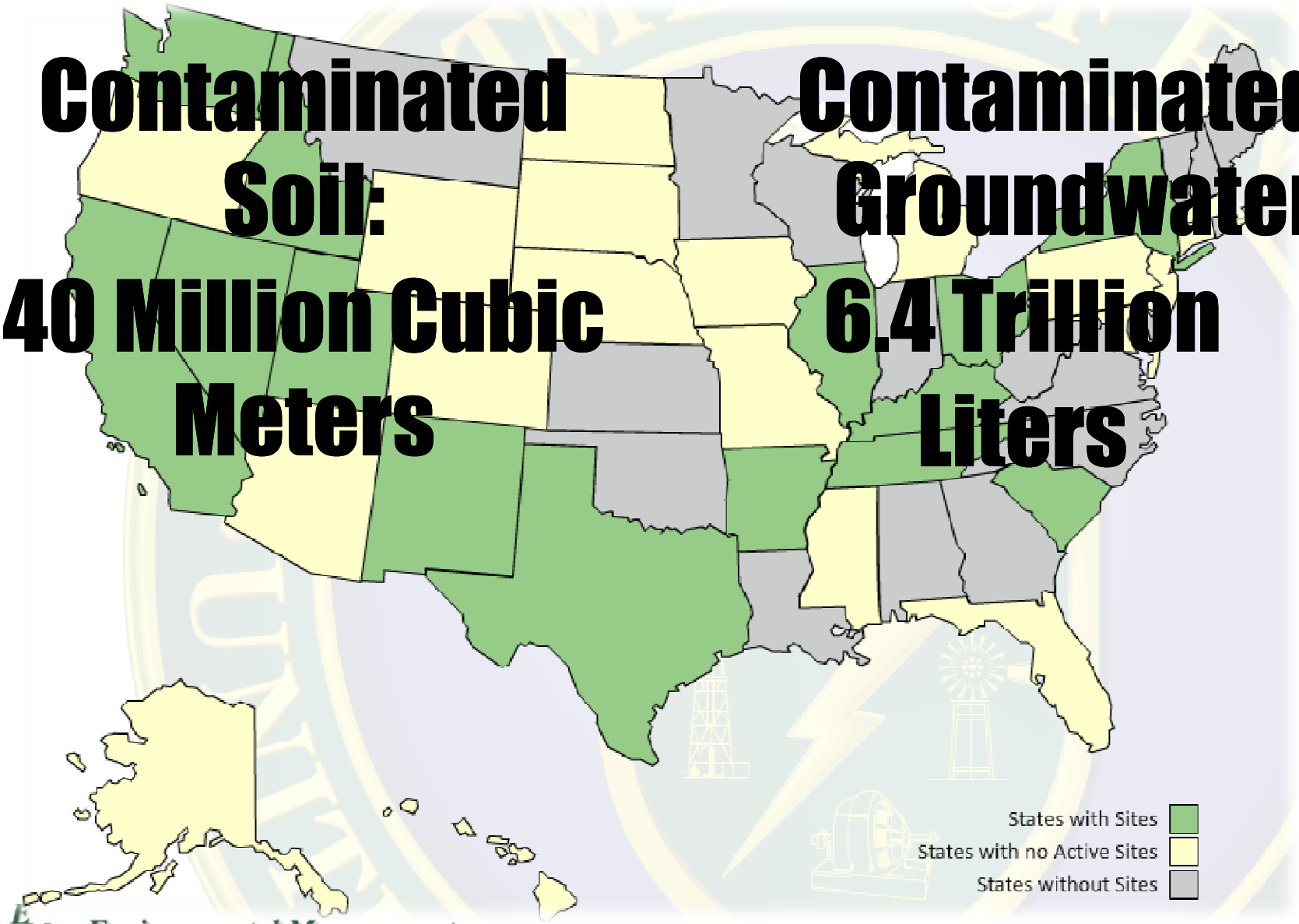

## Guiding Principles:

- Scientific advancement
- Integration
- Collaboration
- Communication

# Challenges

**Contaminated Soil: 40 Million Cubic Meters**

**Contaminated Groundwater: 6.4 Trillion Liters**

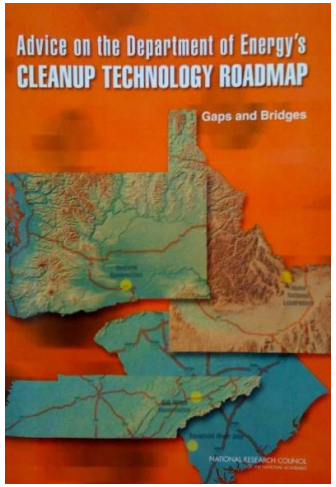


# Challenges, *continued*

- **Many subsurface contamination problems at DOE sites have no practical remedy.** Alternatives are needed to meet regulatory requirements and minimize reliance on costly systems.
  - Hanford pump and treat systems for the 200 Area cost ~$10M/year
  - Remediation of mercury in debris, soil, groundwater, and streams at Oak Ridge is estimated at $1B

# Recommendations: National Academy of Sciences

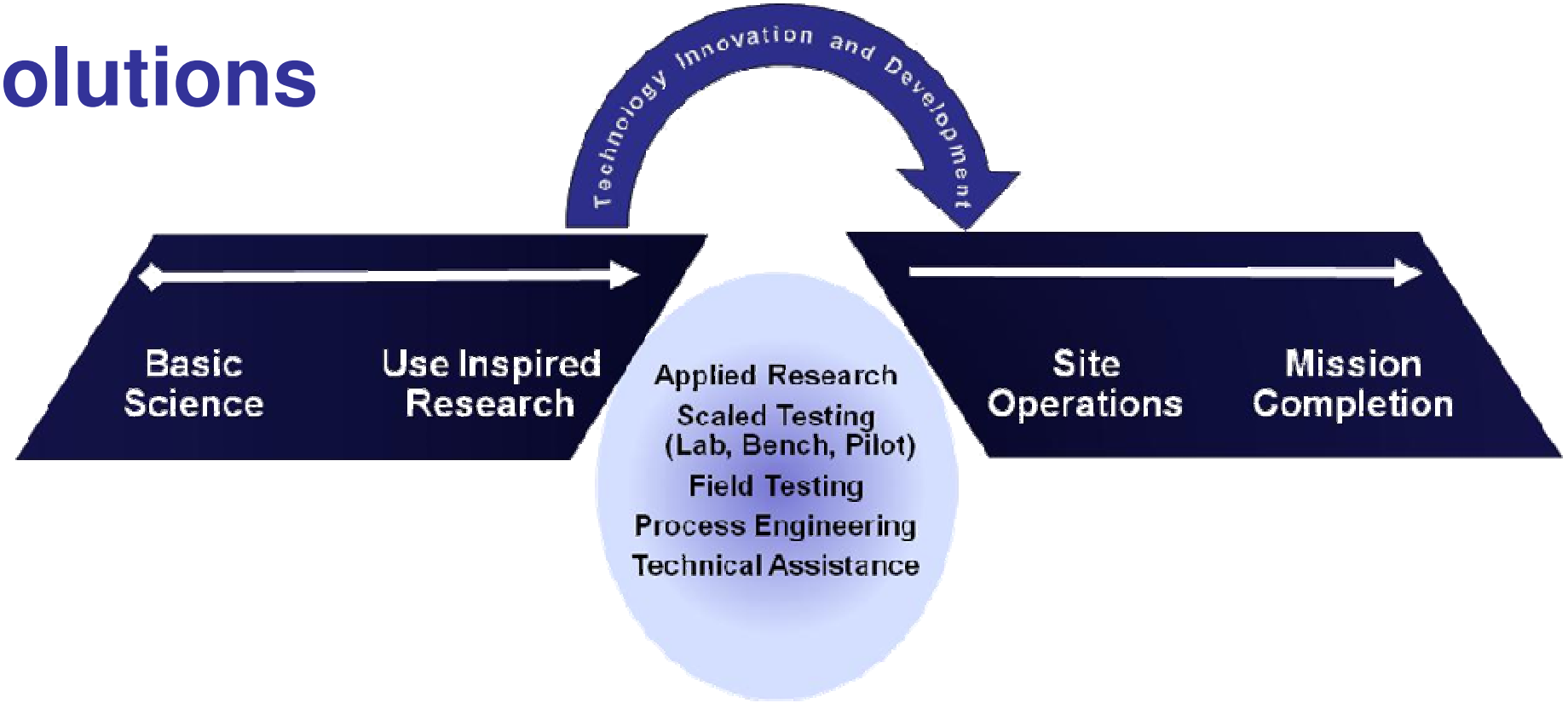
- **EM Technology Roadmap issued March 2008**
- **NAS reviewed and validated the EM Technology Program in the document: *Advice on the Department of Energy's Cleanup Technology Roadmap: Gaps and Bridges* (2009)**




## NAS-identified priorities for Groundwater and Soil Remediation:

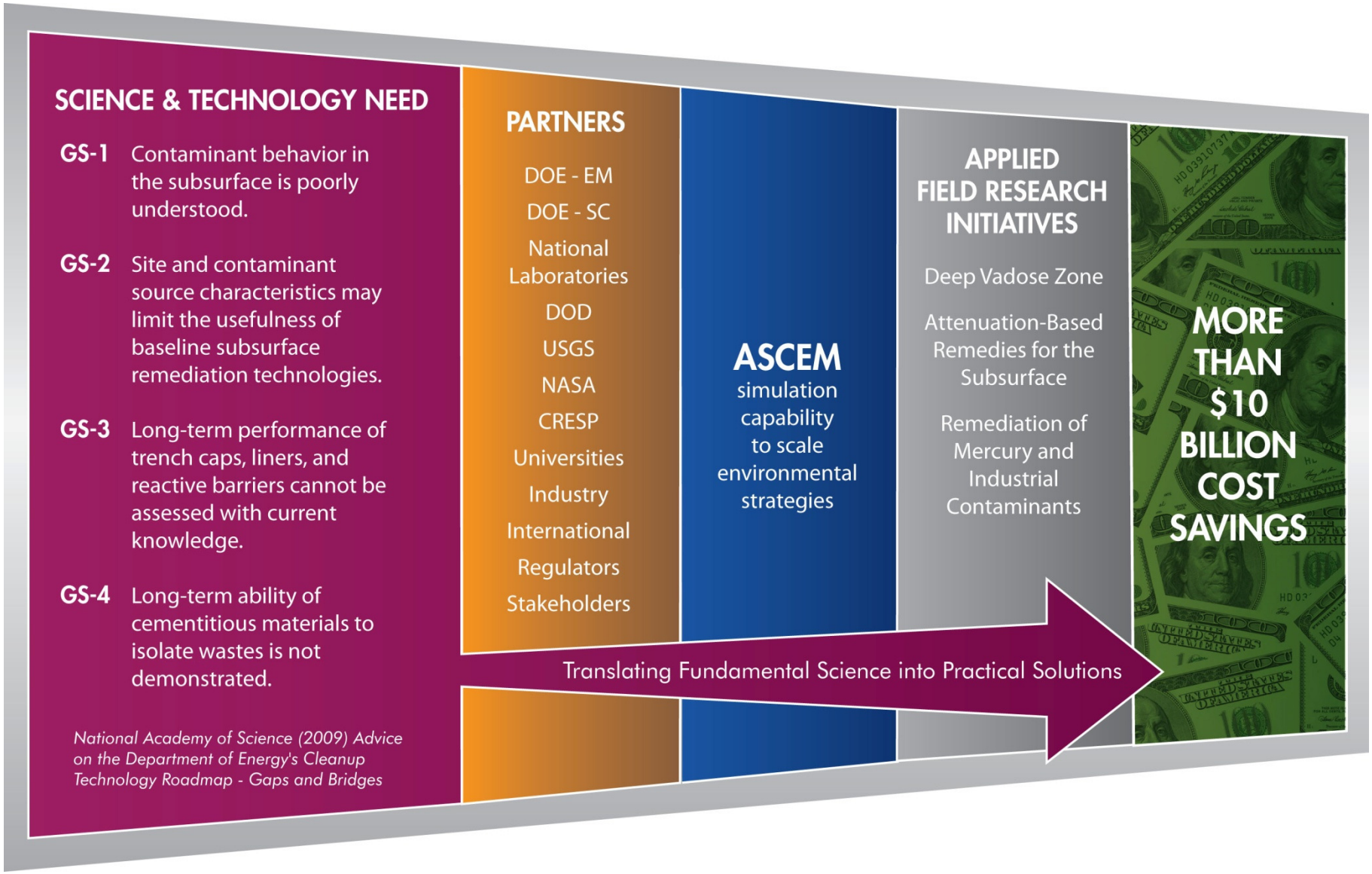
| GS# | Gap | Priority |
|---|---|---|
| GS-1 | Contaminant behavior in the subsurface is poorly understood. | high |
| GS-2 | Site and contaminant source characteristics may limit the usefulness of baseline subsurface remediation technologies. | medium |
| GS-3 | Long-term performance of trench caps, liners, and reactive barriers cannot be assessed with current knowledge. | medium |
| GS-4 | Long-term ability of cementitious materials to isolate wastes is not demonstrated. | high |

# Solutions




- Scientifically-defensible, sustainable, economically viable, effective remedial strategies
  - Develop from scientifically defensible data
  - Transfer to field operations
- Consistent approach to decision making and broad implementation of remedial strategies across the EM complex

# Impact: Reducing the EM Footprint



# Approach

- **EM Applied Field Research Initiatives (AFRIs)**

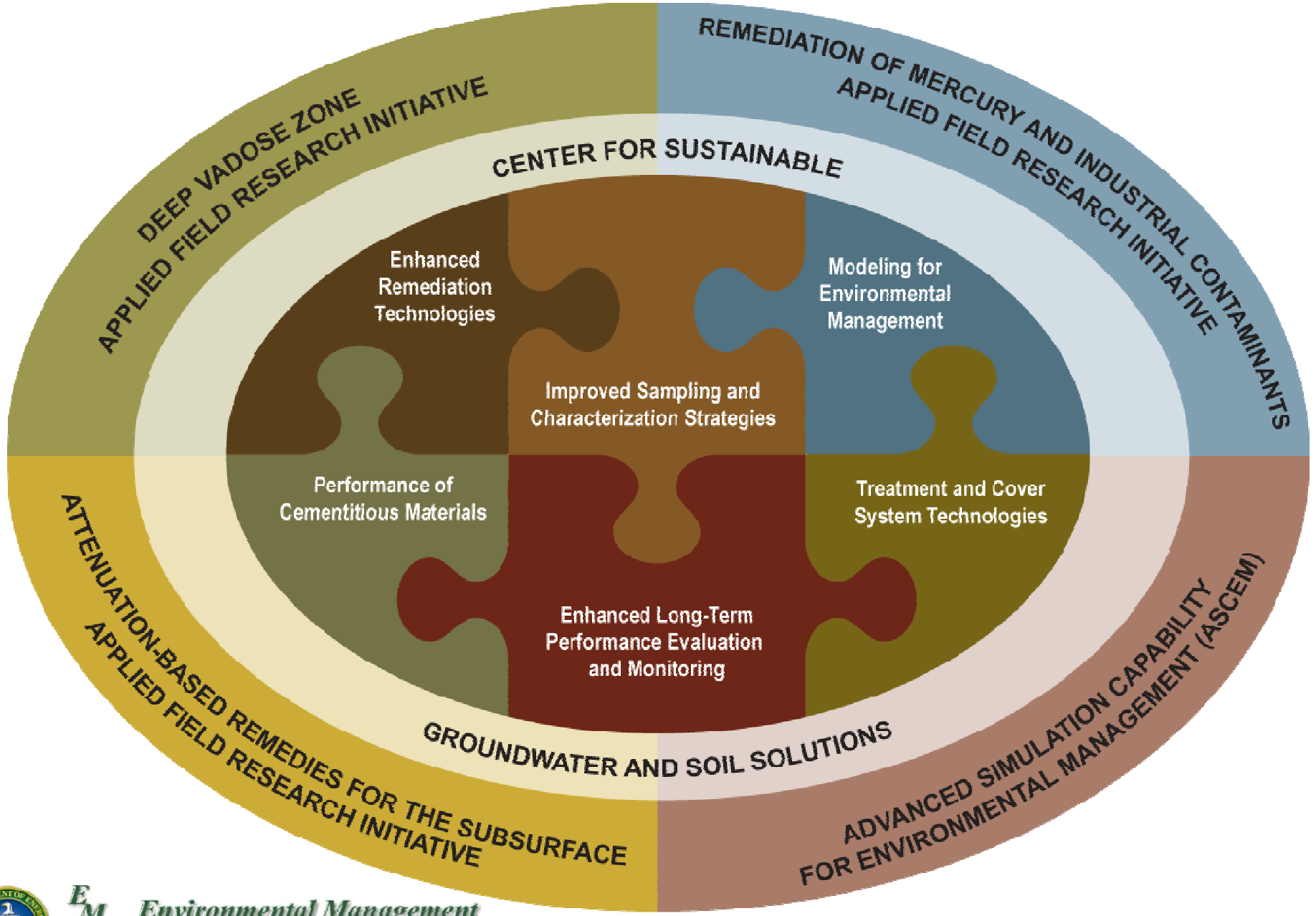
  Develop, test, and demonstrate technologies for environmental sensing, monitoring, characterization, and remediation in representative DOE environments

  - Hanford
  - Savannah River
  - Oak Ridge

- **Advanced Simulation Capability for Environmental Management (ASCEM)**

  Translate results of field technology demonstrations and DOE Office of Science research into integrated remedial strategies that serve as a new baseline for site remediation and closure

# Approach, *continued*



# Expectations for Applied Field Research Initiatives

- **AFRIs will support applied environmental research to help sites meet milestones and achieve regulatory compliance economically and effectively**
  - Develop, compare, and demonstrate technologies
  - Promote regulatory acceptance of technologies and approaches
  - Transition technologies to site contractors and across the EM complex
  - Focus on characterization, remediation, monitoring, modeling
  - Target both short- and long-term goals
  - Accelerate remediation
- **AFRIs will support linked, cross-cutting activities and will leverage resources**
- **AFRIs will integrate the expertise of the Office of Science, site managers, national laboratories, site contractors, and external collaborators**

# Expectations for ASCEM

- **ASCEM will provide simulation capabilities to standardize and support remedy selection and achievement of regulatory compliance goals economically and effectively**
  - Evaluate remedial strategies prior to significant investment
  - Optimize and monitor remedial activities
  - Provide standardized visualization, data management, parameter estimation, uncertainty quantification, risk and decision support across the EM complex
- **ASCEM will strongly link to the AFRIs and other DOE programs, including:**
  - Fossil Energy
  - Nuclear Energy
  - Office of Science

# Near-Term Technology Goals (1 – 3 years)

- Technologies to **eliminate contaminant fluxes** to water
- **Minimally-invasive access and delivery** methods for remedial amendments
- **Advanced characterization** technologies for contaminant and amendment distribution, hydrological connections, remediation performance monitoring, etc.
- Scientific and technical understanding enabling ASCEM to **predict contaminant fate and remedial performance**

# Long-Term Technology Goals (4 – 10 years)

- Practical, innovative solutions derived from **advancing basic science**
- **Scientifically Defensible Actions** to enhance regulator and stakeholder acceptance of attenuation-based remedies for metals and radionuclides
- **Integrated approaches to modeling and site characterization** for robust, standardized performance and risk assessment
- Use of **mass flux-based approaches** to establish new remediation baselines and transition from “active” to “passive” technologies
- **Reduction in cost and time frame** needed to achieve remediation goals and footprint reduction

# Deep Vadose Zone
# Applied Field Research Initiative

## Challenge

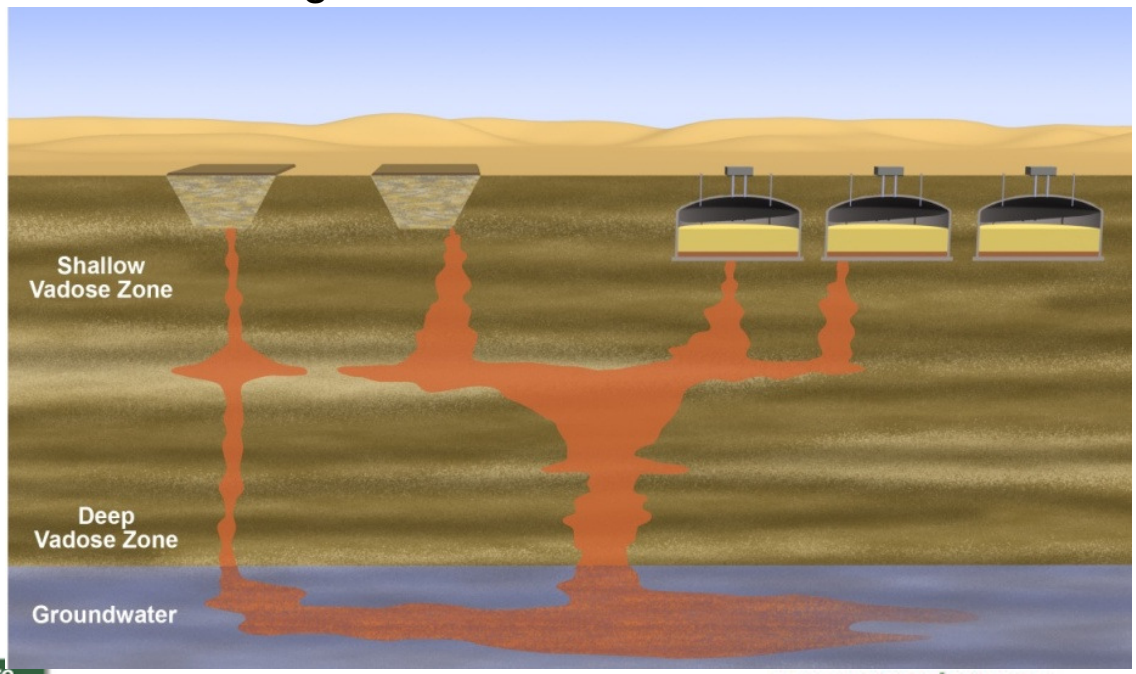
- The deep vadose zone (DVZ) is a current and potential source of groundwater contamination

## Solution

- Collaboration (PNNL, EM-30, Office of Science, site operations)
- Address characterization, monitoring, predictive modeling, and remediation challenges

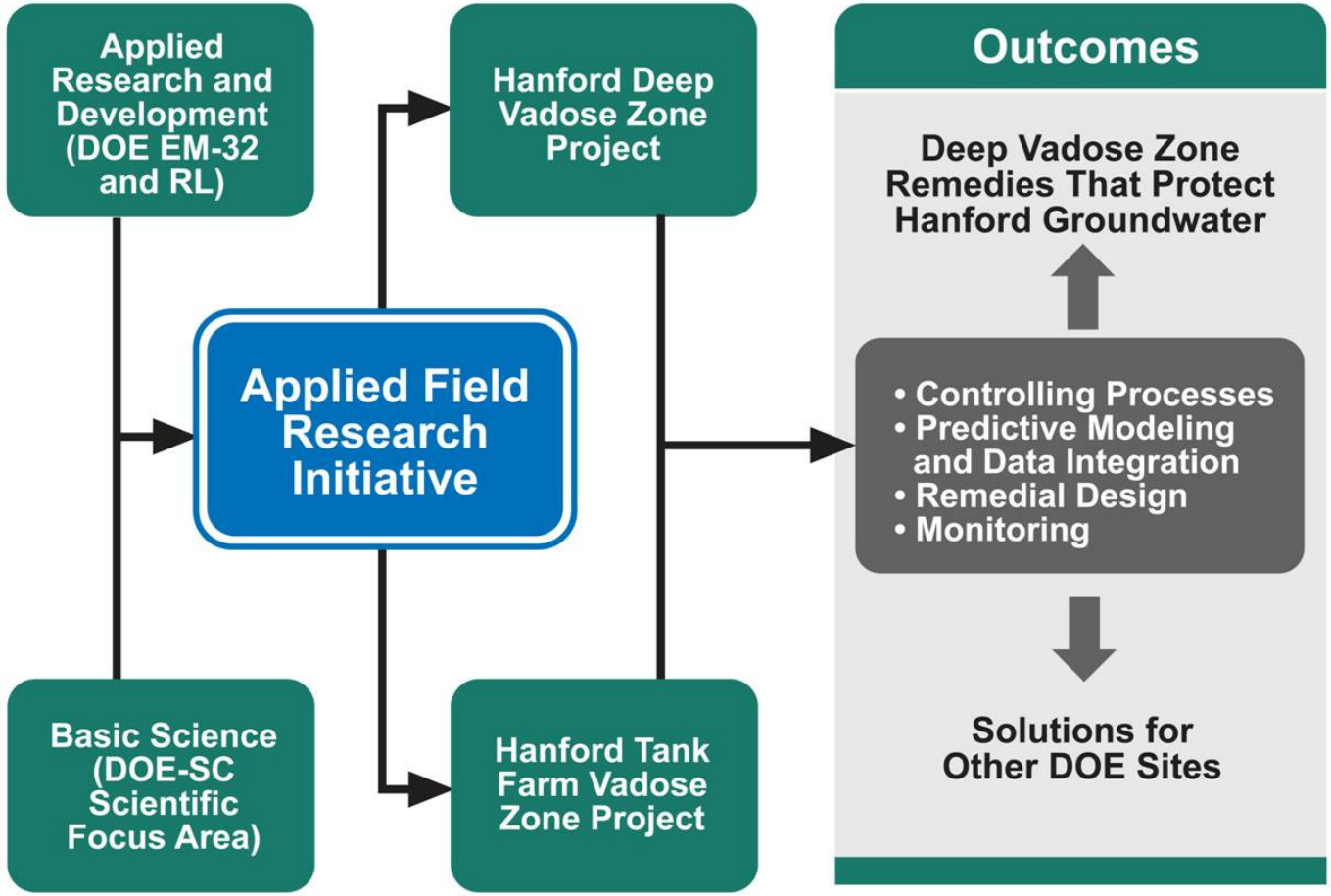
## Impact

- Provide technical basis to quantify, predict, and monitor natural and post-remediation contaminant discharge from the vadose zone to groundwater
- Develop in situ solutions to limit contaminant discharge into groundwater
- Support development of economical, sustainable solutions that are broadly applicable throughout DOE deep vadose zone environments



# Deep Vadose Zone
# Applied Field Research Initiative

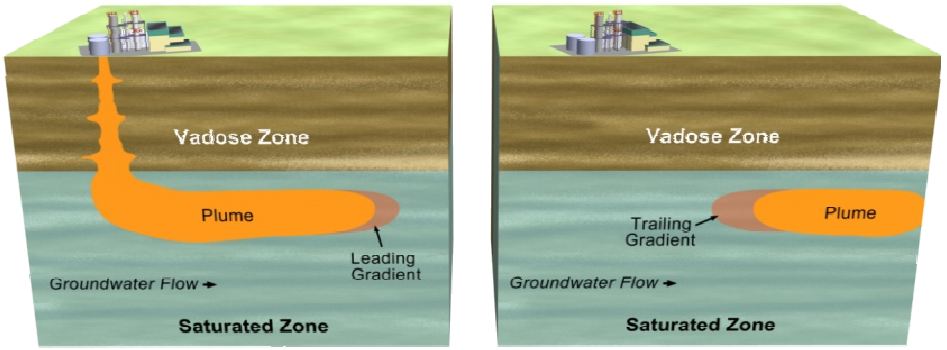
**Mission:** Ensure long-term protection of water resources through development and application of effective solutions for DOE's deep vadose zone challenges in characterization, monitoring, remediation, and prediction.



# Attenuation-Based Remedies for the Subsurface Applied Field Research Initiative

## Challenge

- Transform groundwater remediation strategies from active to passive treatment




## Solution

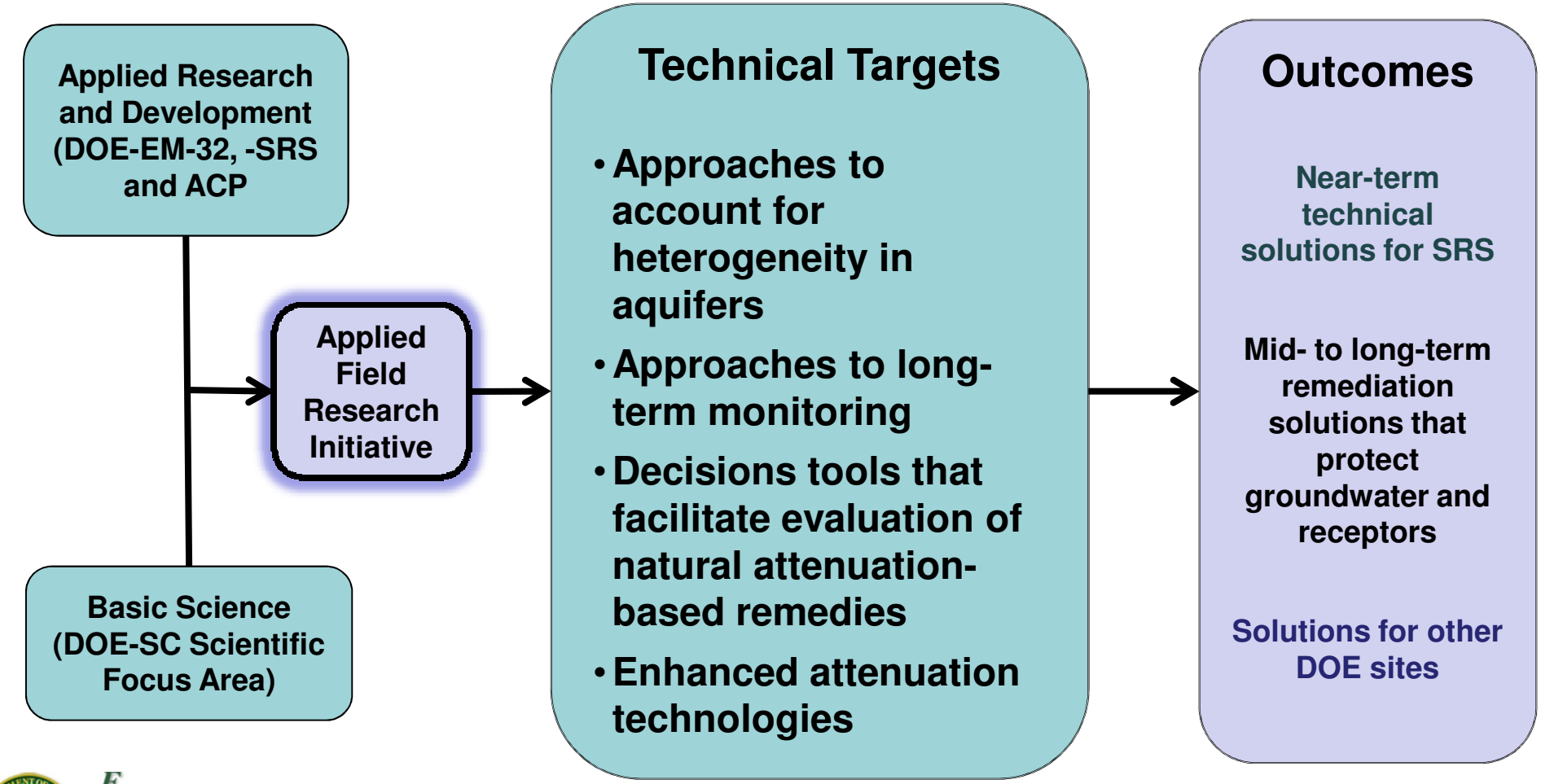
- Develop, test and deploy passive solutions for groundwater contamination that limit contaminant mobility
- Provide scientifically-defensible, sustainable, economical, effective remedial strategies
- Offer consistent approaches to decision making and broad implementation of groundwater remediation strategies across the DOE complex


## Impact

- Reduce risk, schedule, and cost for site closure through transformational applications

# Attenuation-Based Remedies for the Subsurface Applied Field Research Initiative

**Mission:** Seek holistic solutions to DOE's groundwater contamination problems that consider technical aspects of a waste site and the concerns of regulators, end-users, and stakeholders.



# Remediation of Mercury and Industrial Contaminants (RoMIC) Applied Field Research Initiative

## Challenge

- Mercury contaminates East Fork Poplar Creek despite 90% reduction in mercury inputs
- Distribution of mercury is poorly known

## Solution

- Identify mercury source zones, develop conceptual models for contaminant distribution
- Utilize point-source remediation and water treatment
- Characterize subsurface contamination, analyze transport pathways
- Develop numerical models of fate and transport
- Develop innovative methods to stabilize mercury in soil and debris

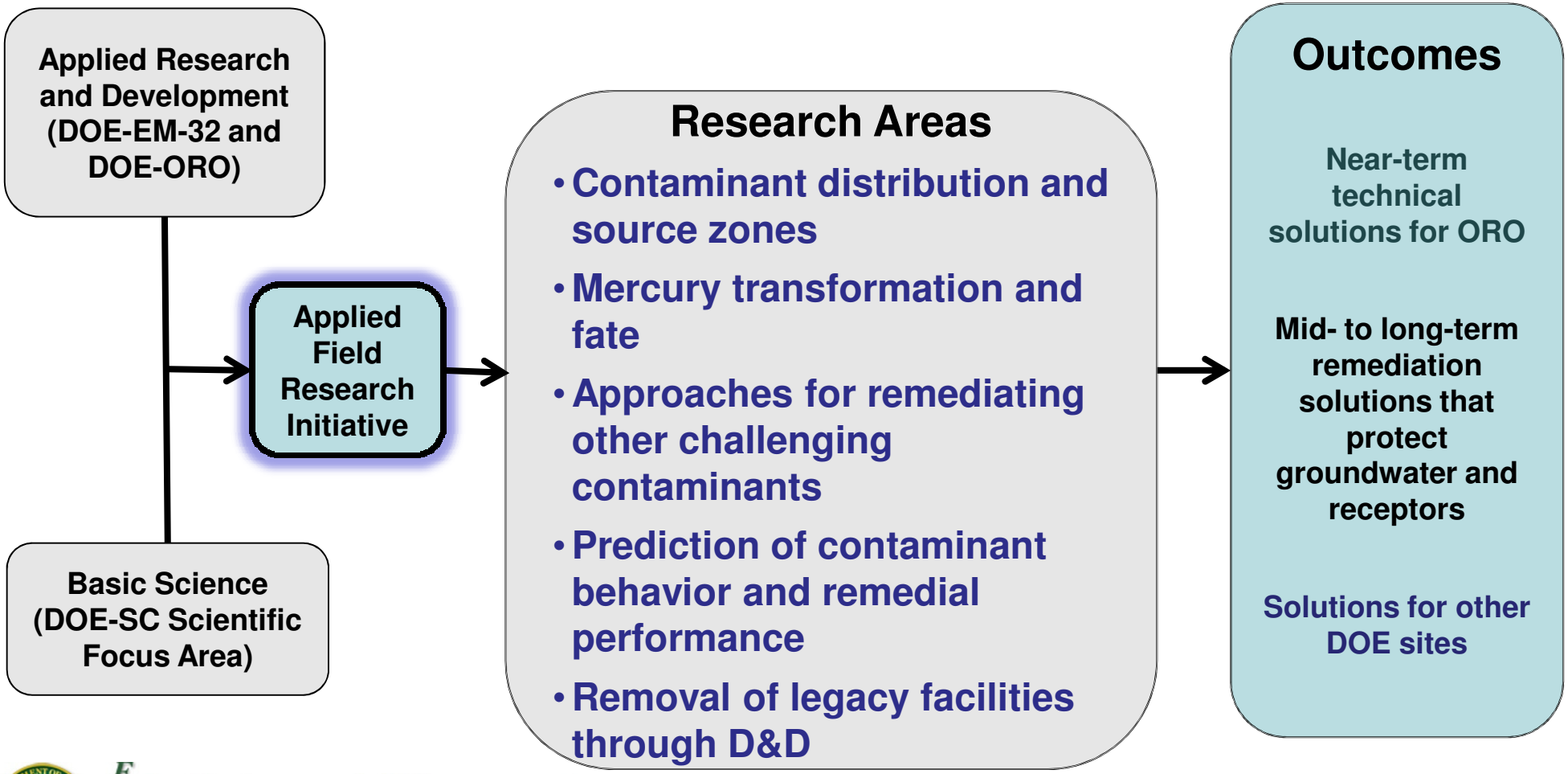
## Impact

- Improved understanding of mercury sources, transport pathways, and flux at the Y-12 National Security Complex
- New remediation approaches to protect surrounding ecosystems and water resources

**Oak Ridge, TN**

# Remediation of Mercury and Industrial Contaminants (RoMIC) Applied Field Research Initiative

**Mission:** Develop and demonstrate technologies for characterization, remediation, and prediction of mercury and other contaminants in complex subsurface and surface water environments.



# AFRI Status

- **Deep Vadose Zone (DVZ)** - Hanford
  - **Site selected:** Inner Area of the Hanford Central Plateau
  - **Implementation plan:** completed
  - **Research underway:** foam-based amendment delivery for vadose zone treatment, geophysical characterization and monitoring studies, numerical modeling
- **Attenuation-Based Remedies in the Subsurface (ABRS)** - Savannah River
  - **Site selected:** groundwater plumes associated with F-Area waste basins
  - **Implementation plan:** in preparation
  - **Research underway:** collaborative, complementary field studies by SRNL, LBNL, universities, and Arcadis focused on metals and radionuclides
- **Remediation of Mercury & Industrial Contaminants (RoMIC)** - Oak Ridge
  - **Site(s):** not yet
  - **Implementation plan:** in preparation
  - **Research:** water treatment studies, soil gas sampling, membrane interface probe development, soil core characterization, assessment of fate of tin (beginning)
  - ***Oak Ridge's unique challenge:*** address multiple complex environments (surface water, groundwater, fractured rock, debris and rubble, stream sediments)

# Advanced Simulation Capability for Environmental Management (ASCEM)

**Challenge**

- Reduce time and cost of remedial actions at EM sites by providing scientifically-defensible predictions of contaminant fate

**Solution**

- Develop an integrated, high-performance computer modeling capability to simulate waste degradation, contaminant release, and multiphase, multicomponent, multiscale subsurface flow and contaminant transport
- Provide tools for decision making: parameter estimation, visualization, uncertainty quantification, data management, risk analysis, and decision support
- Leverage investments made by other DOE offices and federal agencies

**Impact**

- Provide scientifically-defensible, standardized risk and performance assessments across the EM complex
- Simulations will allow for optimizing remedial actions and monitoring strategies.

Los Alamos NATIONAL LABORATORY EST. 1943

BERKELEY LAB

OAK RIDGE National Laboratory

Pacific Northwest NATIONAL LABORATORY

SRNL SAVANNAH RIVER NATIONAL LABORATORY

# Groundwater and Soil Remediation Technical Assistance Program

- Provides independent technical expertise to address challenging environmental problems at DOE sites
- Coordinated by Savannah River National Laboratory for the Office of Groundwater and Soil Remediation
- Expert teams assess technical problems, scope, historic and current site information, any past remediation efforts
  - Engage site personnel, regulators, stakeholders
- Team recommends technology approaches and alternatives, facilitates regulatory acceptance

# Example Technical Assistance Projects

## Technical evaluation of soil remediation alternatives at the Building 812 Firing Table, Lawrence Livermore National Laboratory Site 300 (2009)

- Team reviewed a proposed soil washing strategy for sediments contaminated with depleted uranium that was favored by site regulatory groups
- Team determined the strategy would be ineffective and proposed a phased remediation approach including:
  - a radiological surface survey
  - strategic excavation
  - physical separation
  - off-site disposal of highly contaminated material
- ***Impact:*** The proposed strategy will yield projected cost savings of $40M and reduce impacts to sensitive ecological habitats

# Technical Assistance Projects, *continued*

## Development of initial conceptual model and technical strategy for mercury at Y-12 (2008)

- Joint effort with Oak Ridge National Laboratory
- The conceptual model divided the Y-12 watershed into four domains, based on site-specific conditions and common scientific needs
  - Buildings and rubble piles
  - Shallow source zone soil
  - Outfall 200 area
  - Upper and lower reaches of East Fork Popular Creek
- Team identified three Quick Win projects: relatively inexpensive, low health and safety risk, potentially significant site benefit
- ***Impact:*** ORNL implemented one of the Quick Win proposals--stannous chloride treatment of mercury contamination in Outfall 200 water. Studies showed successful removal of mercury.

# Technical Assistance Projects, *continued*

## Identification and evaluation of alternative solutions for remediation of remote-handled transuranic (TRU) soil at the Corehole 8 Site, Oak Ridge (2004)

- Technical assistance team reviewed the proposed strategy prepared by the site contractor for using proprietary in situ grouting technology.
- ***Impact:*** The team recommended a lower-risk, lower-cost alternative (freezing/excavation) to grouting of TRU-contaminated soil.

# Technology Accomplishments

# Evaluation of Cone Penetrometer-Based Tools for the Characterization of Elemental Mercury

Dennis G. Jackson, Carol Eddy-Dilek, Brian B. Looney

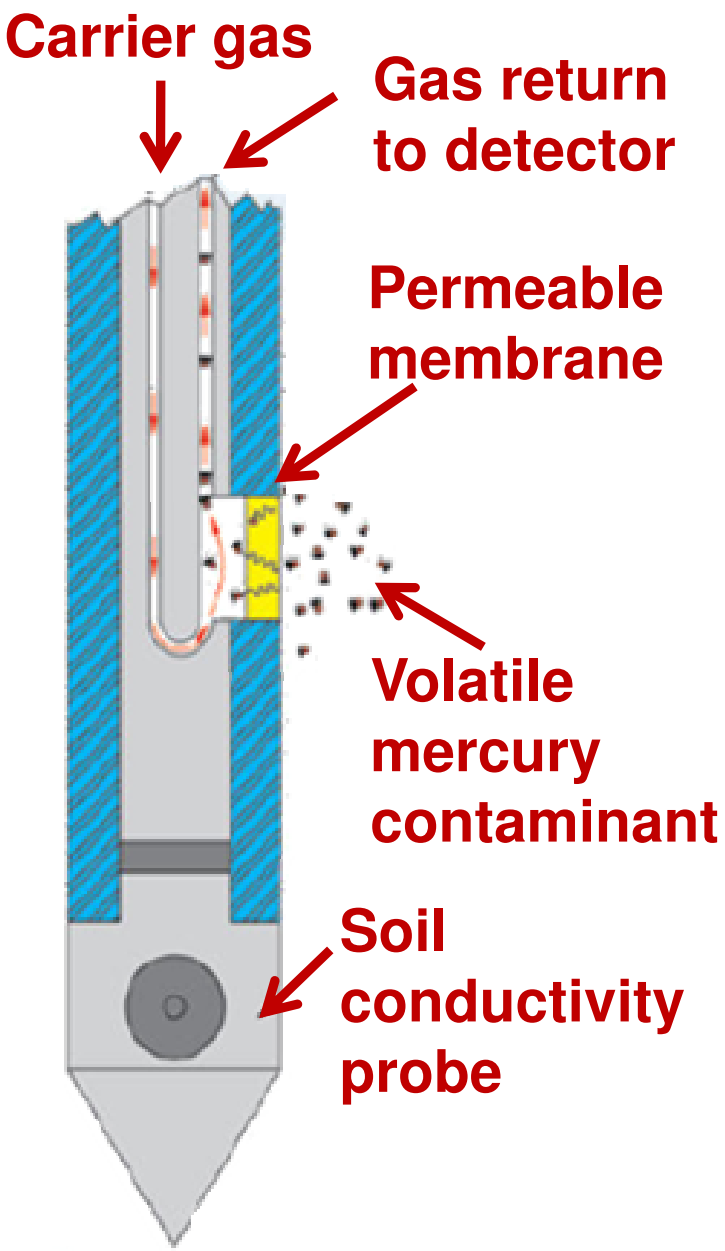
SRNL SAVANNAH RIVER NATIONAL LABORATORY

- **Goal:** Develop and demonstrate an economical, minimally-invasive tool for characterizing **elemental mercury source zones** in the subsurface by adapting existing technology for a unique application.

# Mercury Characterization, *continued*

## Membrane Interface Probe (MIP)

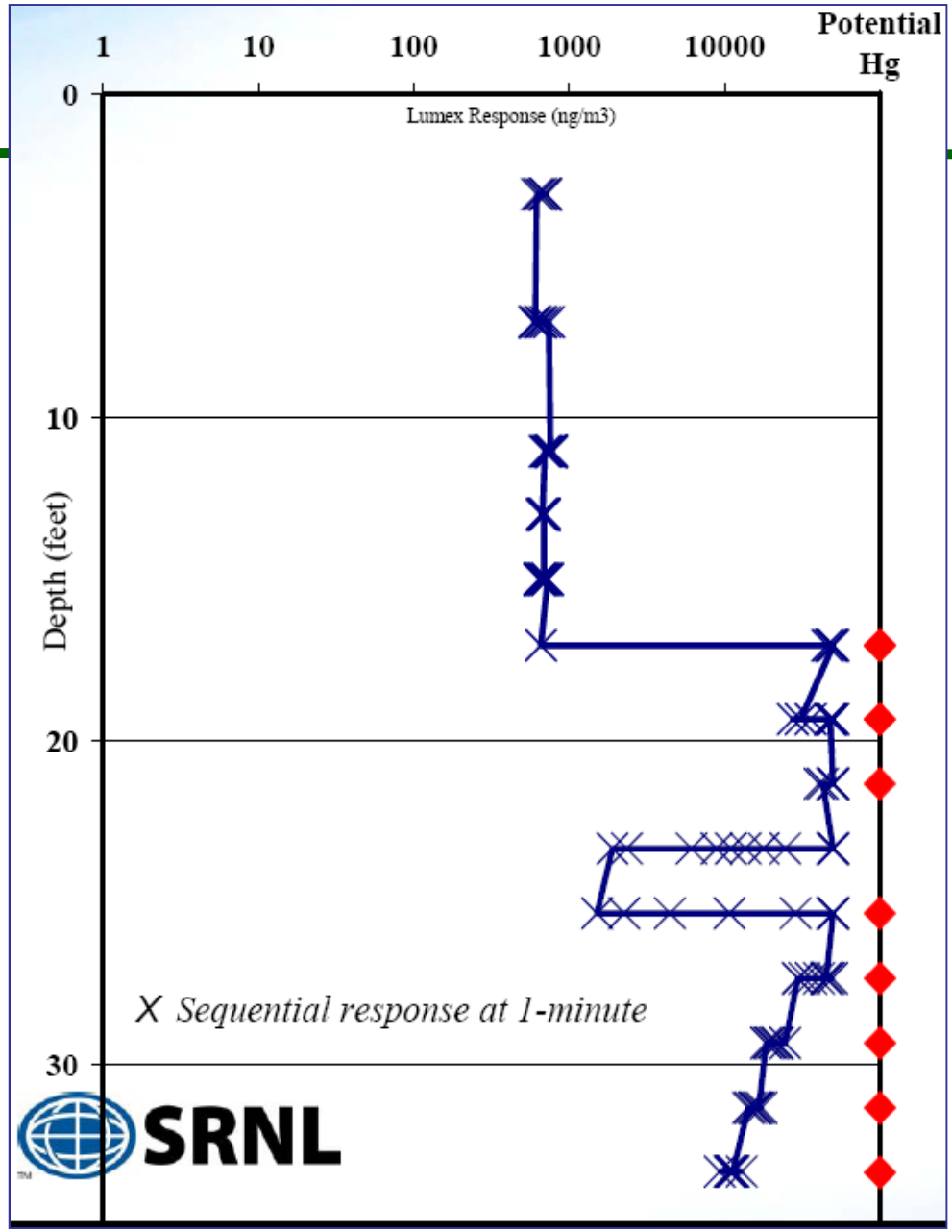
- Geoprobe-mounted; probe driven into subsurface
- Heated probe volatilizes elemental mercury in the vicinity
- Mercury vapor permeates MIP's porous membrane
- Carrier gas transports vapor "sample" to surface
- Real-time analysis with appropriate detector




# Mercury Characterization, *continued*

## MIP demonstration at a former mercury-retorting area at Y-12 (81-10 Site, Aug. 2010)

- MIP analysis correlated compellingly over depth with visible liquid mercury in extracted cores
  - **Cores:** mercury found 15-30 ft deep
  - **MIP:** elemental mercury detected at 17-21.3 ft and 25 ft; also likely between 27-33.3 ft
- A second demonstration is planned
- Oak Ridge contractors and DuPont are interested in deploying this technology

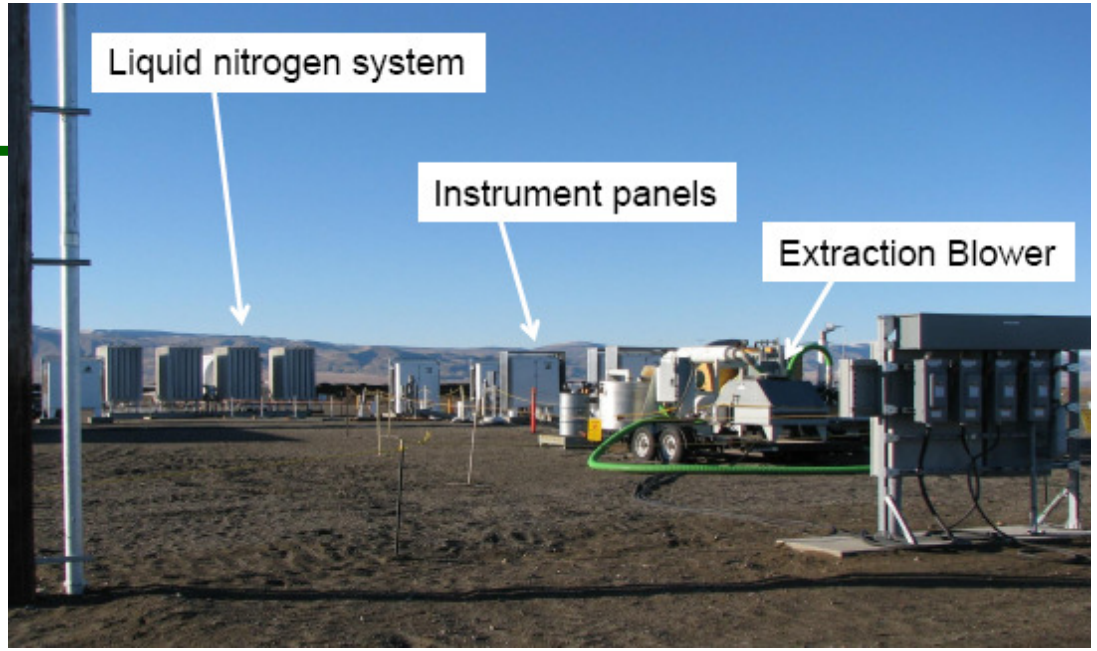



**Red diamonds: mercury in cores**

**Blue Xs: signal from MIP**

# Desiccation to Mitigate Radionuclide Transport in the Deep Vadose Zone

Lead: Mike Truex, PNNL

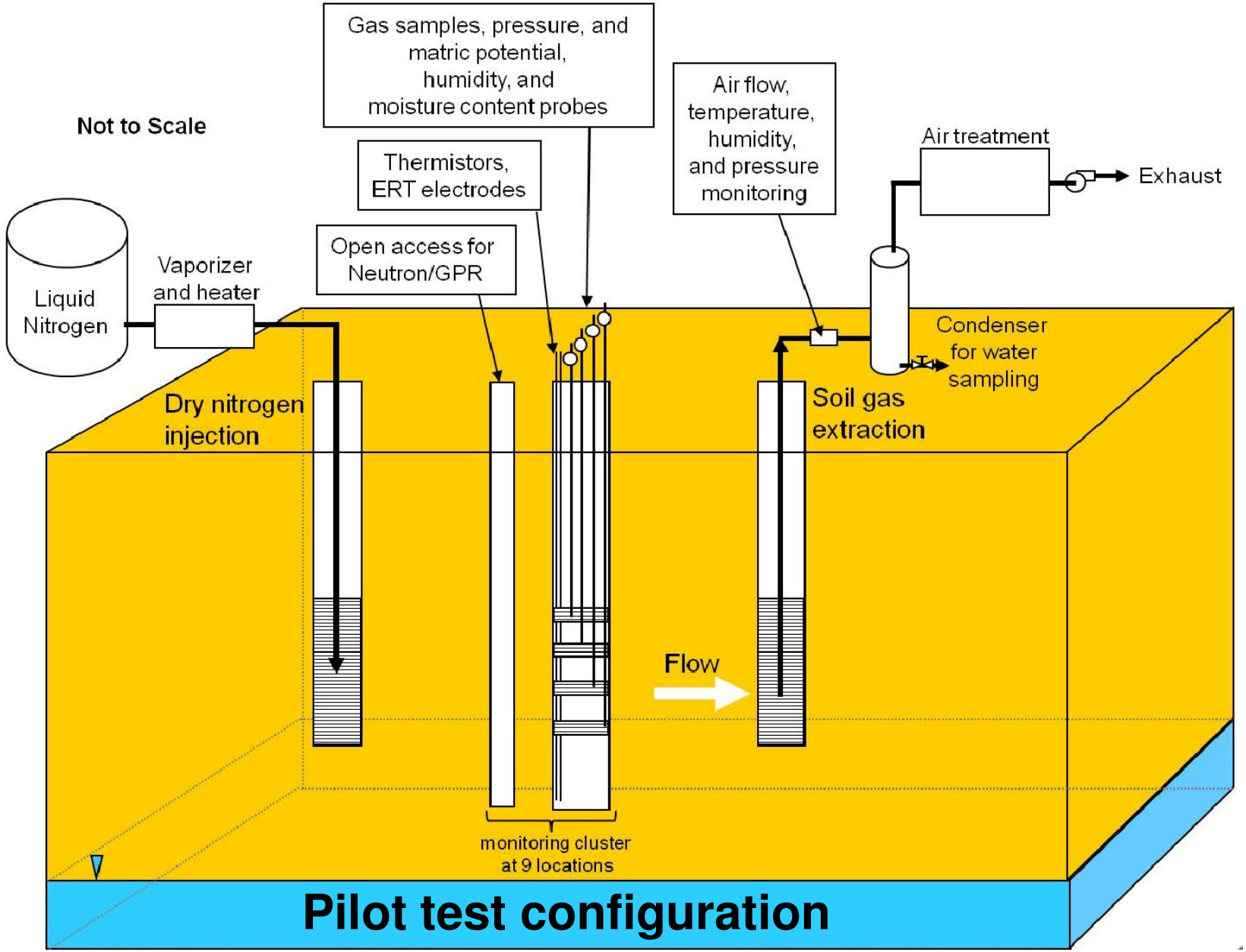



**Overarching goal:**
Develop and demonstrate technologies to minimize flux of contaminated water through the vadose zone to groundwater

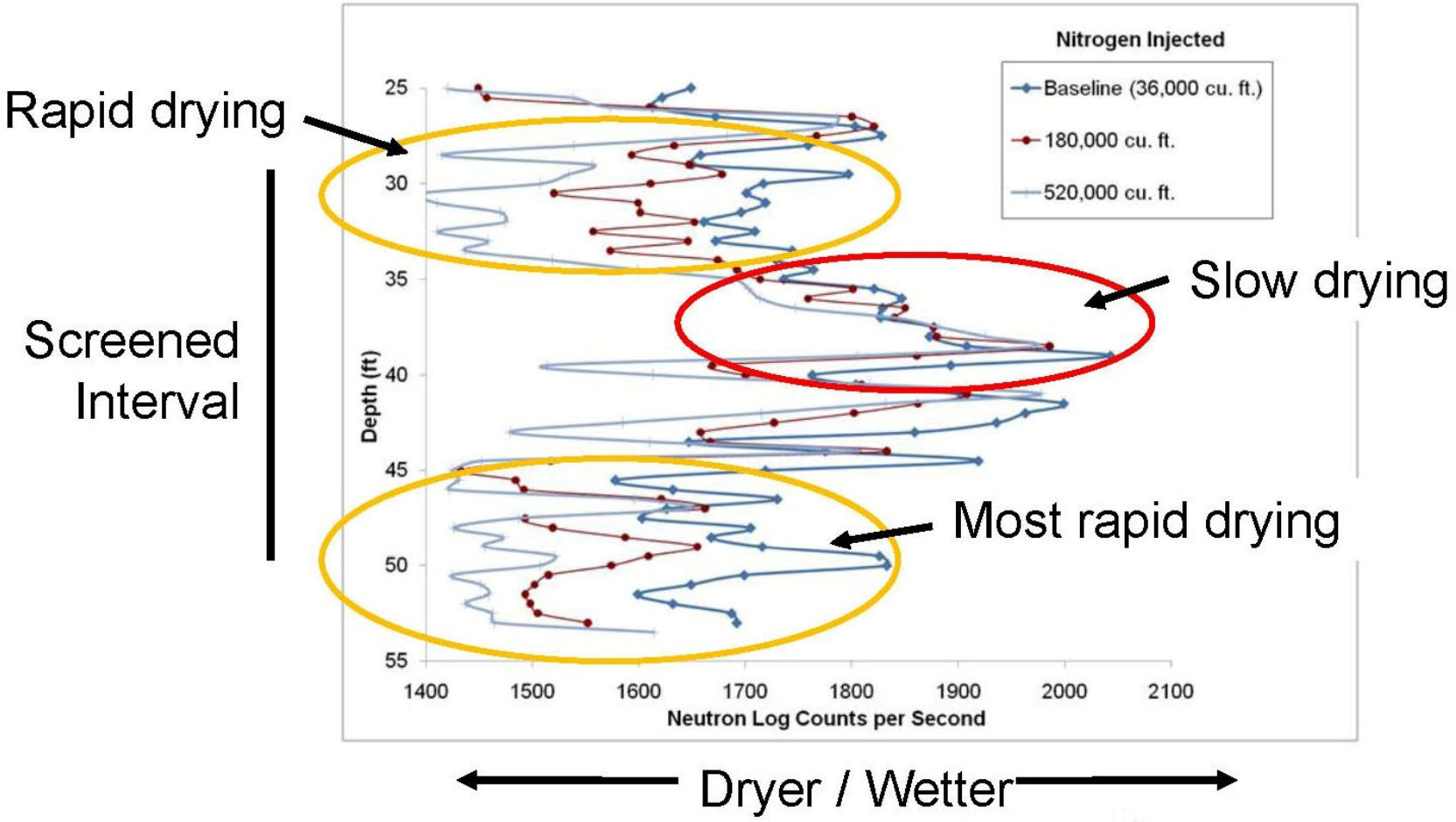
## Demonstration project objectives:

- Test the impact on desiccation of:
  - evaporative cooling
  - porous media heterogeneity
  - solutes
  - operating conditions
- Evaluate:
  - rewetting after desiccation
  - gas tracers for monitoring
  - in situ sensors

# Desiccation, *continued*



# Desiccation, *continued*




**Early results:**
Neutron logging of injection well shows drying as a function of depth, with most rapid drying where the flow of injected dry nitrogen is highest.

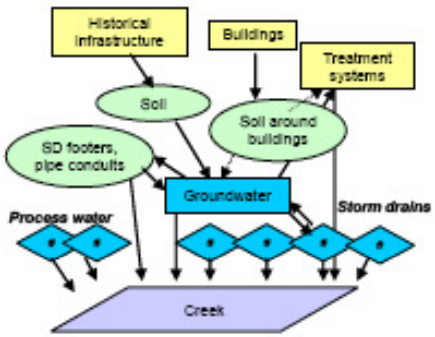
# A New Conceptual Model for Mercury Sources, Fate, and Transport at the Y-12 National Security Complex

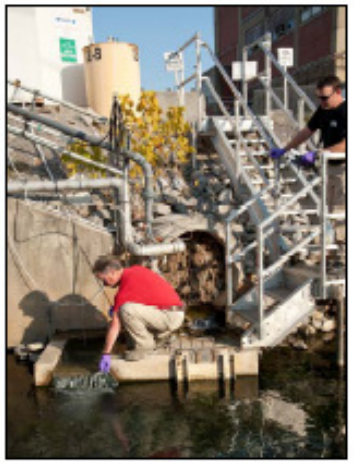
Lead author: Mark Peterson, ORNL


UT-BATTELLE

ORNL/TM-2011/75

**Conceptual Model of Primary Mercury Sources, Transport Pathways, and Flux at the Y-12 Complex and Upper East Fork Poplar Creek, Oak Ridge, Tennessee**



March 2011

OAK RIDGE National Laboratory

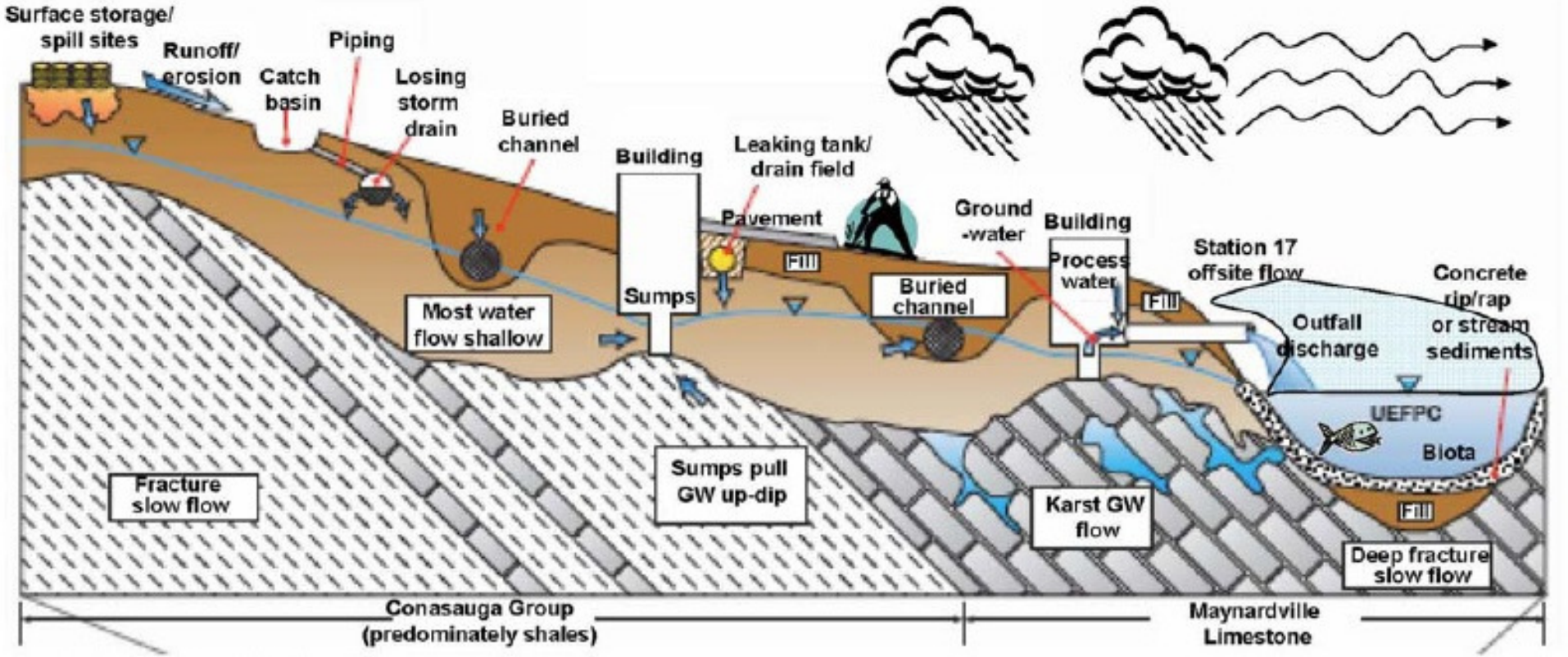
SRNL

Environmental Management

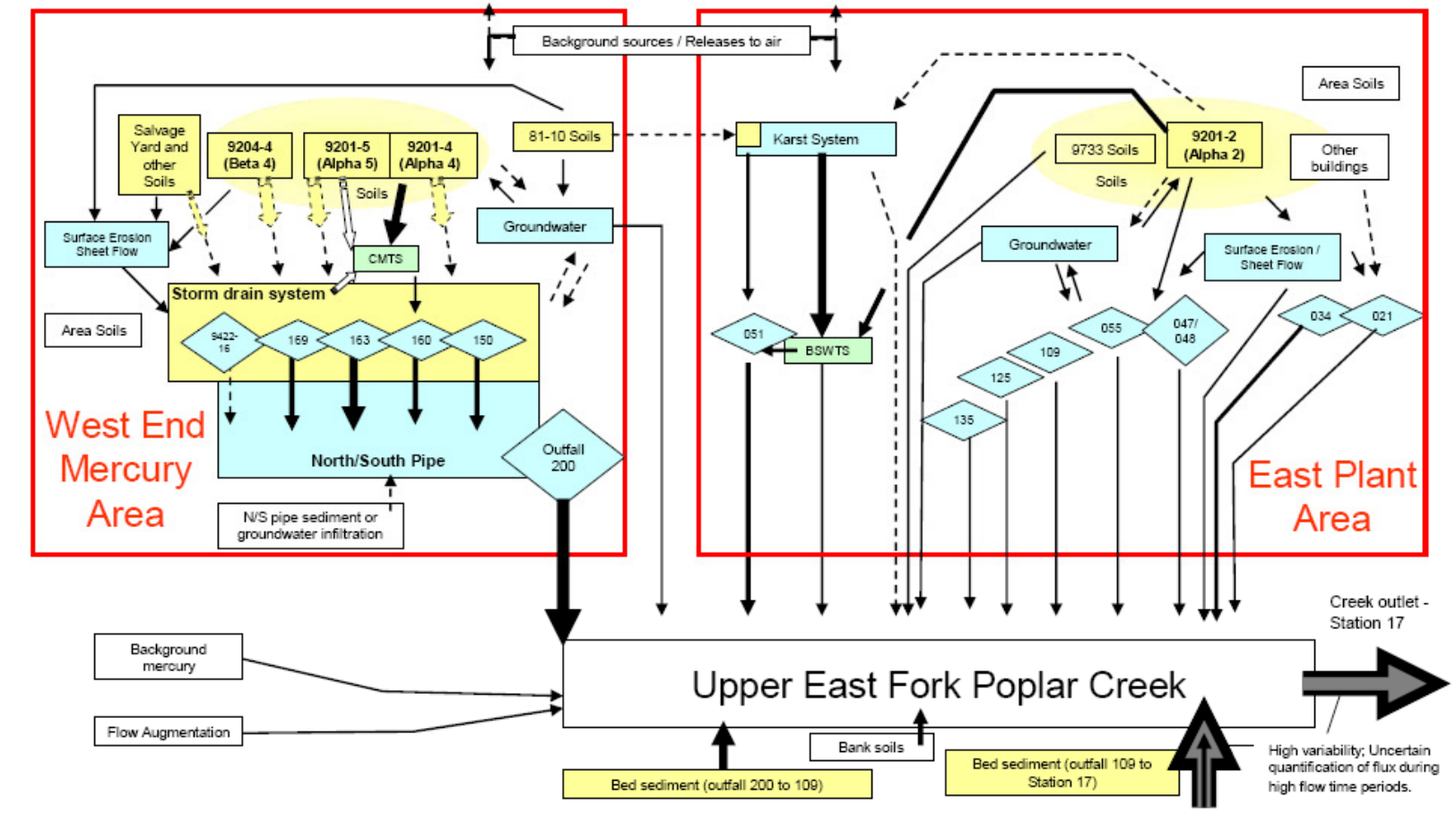
safety ❖ performance ❖ cleanup ❖ closure

# Mercury Conceptual Model

- Identifies mercury sources, transport pathways, and flux based on the most recent data
- Provides a powerful tool for environmental decision making
  - evaluation of past and present remediation activities
  - technical basis for prioritizing and optimizing responses



# Mercury Conceptual Model




**Y-12 Mercury Conceptual Model**

Title: Conceptual model for mercury showing primary source areas, transport pathways, and flux (grams/day) at the Y-12 Complex.
Model Version: 03/09/2011.

*[1]To the extent possible, longer-term average fluxes used in model, reflecting dry and wet weather conditions.*

**Legend**

- Primary Source Areas
- Secondary Source Areas
- # Transport paths (sampling locations)
- Treatment systems

*# - Numbers refer to SD outfalls, basins*

**Flux in grams/day[1]**

- 15-25
- 6-15
- 2-6
- 0.5-2
- 0.1-0.5
- < 0.1
- Potential, but unknown
- Flux no longer treated

# For more information, contact:

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