Challenges to Cleanup

Soils and Groundwater Remediation

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Meeting Challenges over the Life-Cycle

National Laboratories help meet EM challenges

- Near-term project driven needs
  - Focused on near-term issues requiring scientific basis for resolution
    - Reduces technical uncertainty of baseline
    - Enhances technical defensibility of decisions
- EM mission life-cycle challenges
  - Focused on intractable problems
    - Reduces technical uncertainty and risk over life-cycle
    - Provides transformational solutions and technical assistance

Areas of Near-Term Need that PNNL Supports at Hanford

- Complex hydrology at the groundwater/river interface and in Central Plateau
- Deep vadose zone characterization and remediation
  - Hydrology and geophysics
  - Remediation of deep vadose zone contamination
- Specific geochemistry issues
  - Sr-90 at 100N
  - U in 300 Area
  - U, Tc-99, CCl_4, and Pu in Central Plateau
- Reactive transport modeling of contaminants (e.g. U, Sr-90) in complex subsurface settings

Science-based Solutions used in Near-Term Products (examples)

Improving Conceptual Models for Migration of Radionuclides

- Cause for expedited Cs migration in SX tank farm (FIR)
  - High Na and C
- Reason for anomalous Cr retardation beneath SX-108 (FIR)
  - Basic hydrolysis of ferrous silicates
- Fate of 7 tons of U in the BX tank farm (FIR)
  - Precipitation of uranyl silicates
- U(VI) source in the B tank farm groundwater plume (FIR; DQO)
  - Distinct isotopic signature from BX-102
- Mobility of Sr-90 in the B-110 vadose zone plume (FIR)
  - Discovery of ion exchange phase in basalt lithic fragments
- Anomalous absence of ^{99}Tc in groundwater near BC cribs
  - Capillary retention and lateral spreading in silt lens
- Explanation for 300 A U(VI) plume stability (EPA IRoD Review)
  - Slow desorption kinetics/intraparticle reaction

Critical Elements for Success

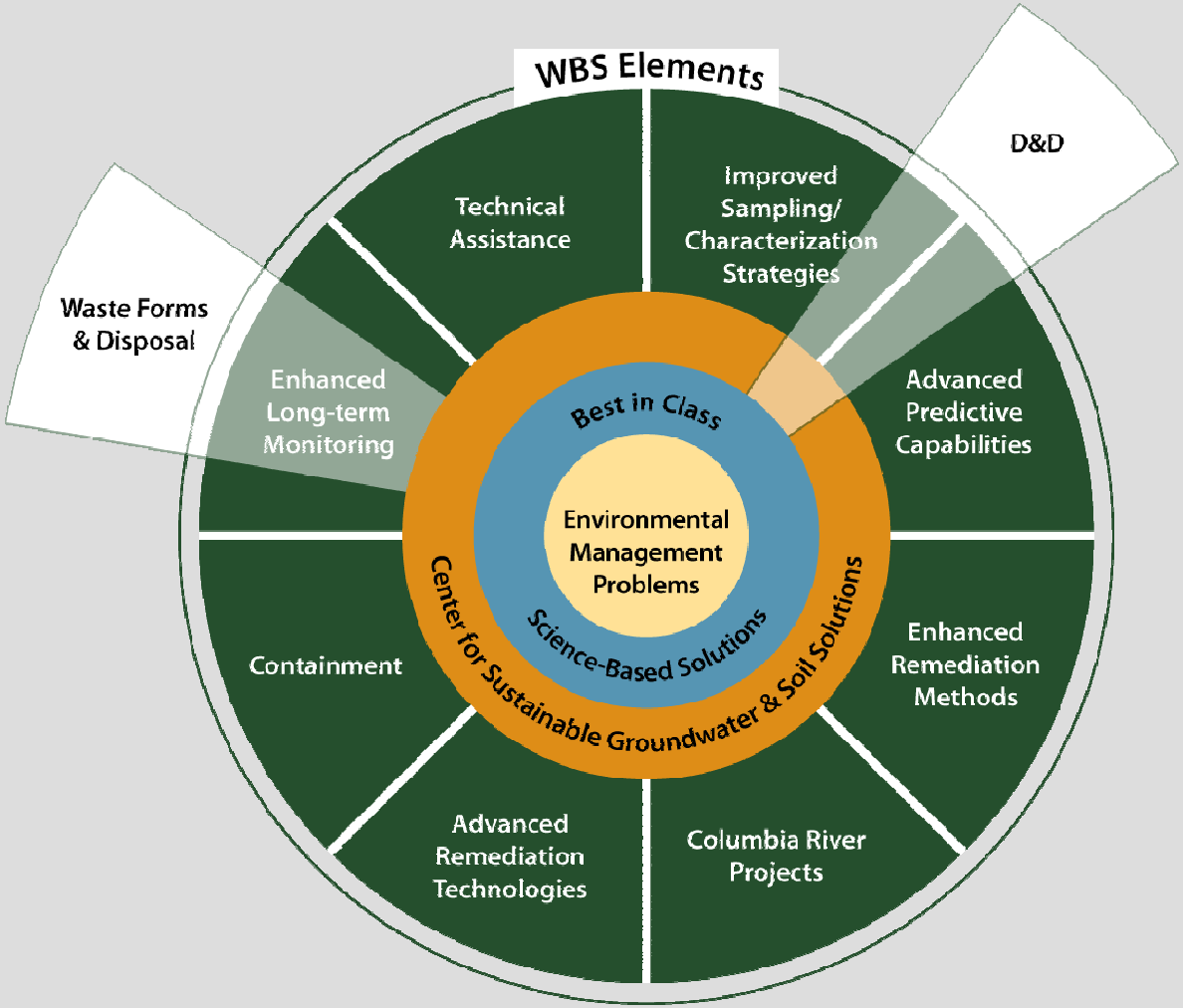
- Co-Investment
  - Significant and sustained S&T investment by site
  - Significant and sustained investment by Office of Science and Office of Engineering & Technology
- Partnership
  - DOE field office, site contractors and site National Lab
  - National Laboratories and Universities accessed and coordinated through site National Laboratory
- Results
  - Site issues successfully translated to scientific challenges
  - Scientific results successfully translated for use in site documents

EM Roadmap: Solving Site Priority Life-Cycle Needs

Site Needs (Hanford, ID, OR, SRS, Paducah, Portsmouth)	> 80 Needs in 6 Categories
S&T Roadmap	4 Strategic Initiatives
Multi-Year Program Plan Tech Dev & Deployment Technical Assistance	16 WBS Elements
Work Breakdown Structure (WBS) Elements	Goals & Objectives Focused Projects Solution to Site Needs

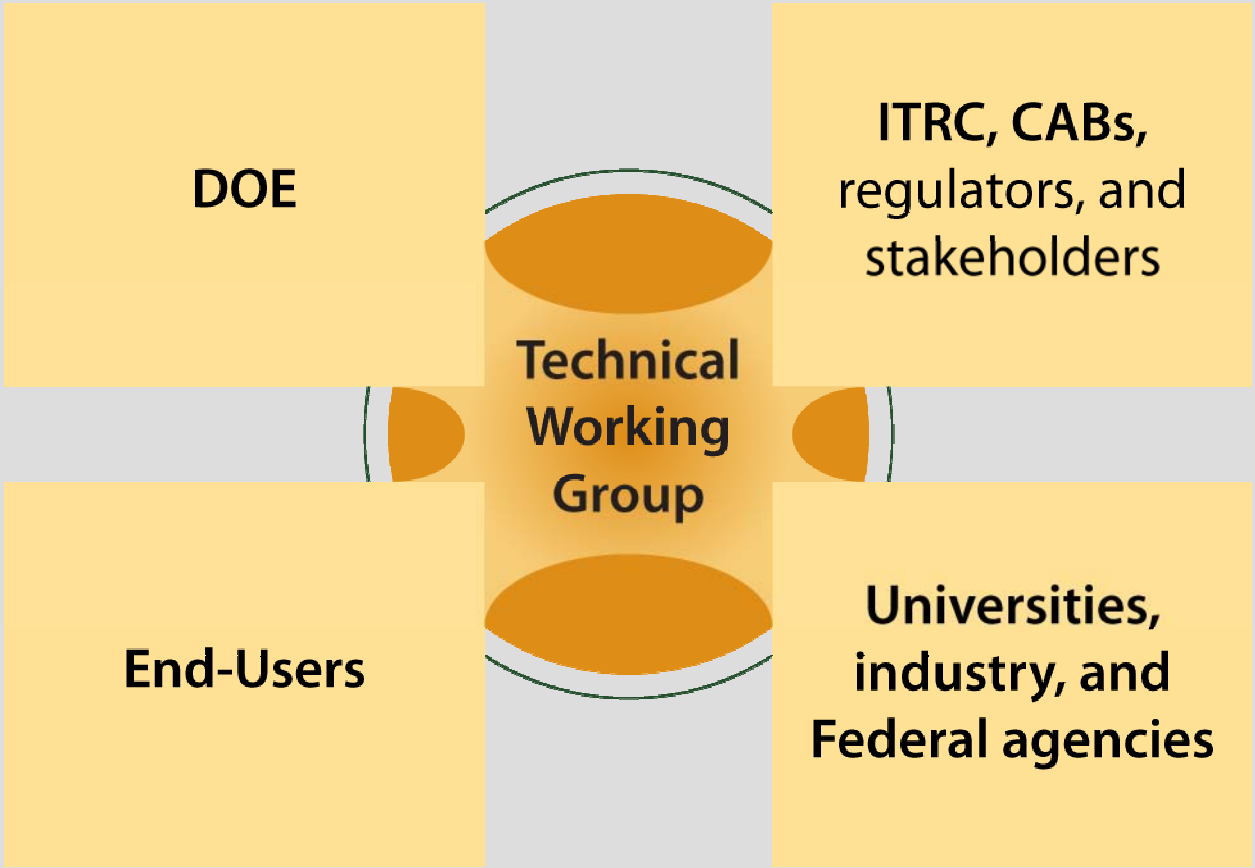
Work Breakdown Structure (WBS) Element Integration

Soils and Groundwater Remediation Program



National Laboratory Leadership

Technical Working Group Approach
Soils and Groundwater Remediation Program



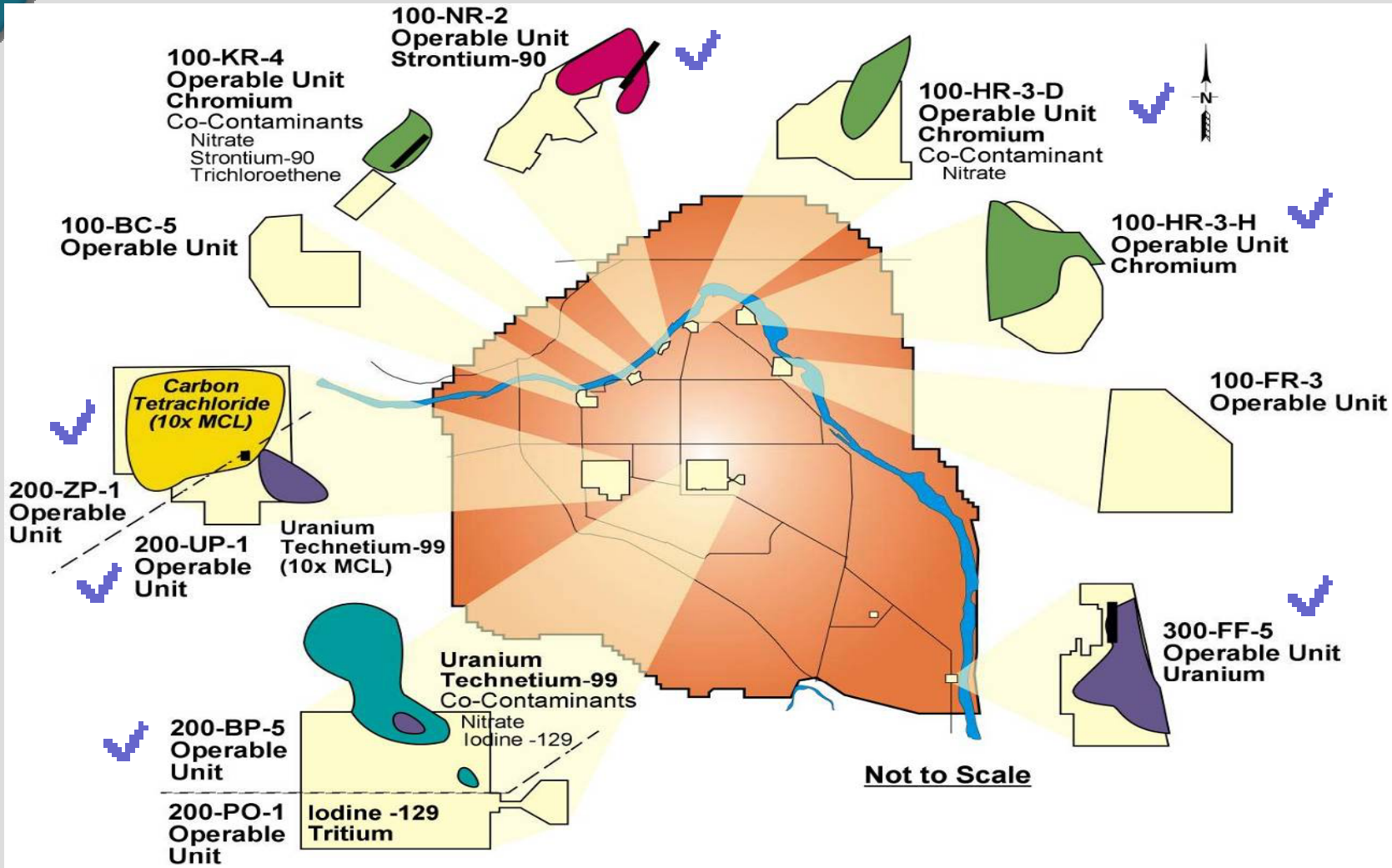
PNNL-Led Strategic Initiatives Align with Hanford Site Needs

- Advanced Predictive Capabilities
  - Develop Advanced Fate and Transport Models
    - Hanford Need - Develop Numerical Models of Groundwater and Vadose Zone Chemical Reaction and Transport
- Enhanced Remediation Methods - Organics
  - ✓ Demonstrate Methods to Reduce Transport of Chlorinated Organics through Deep Vadose Zone
    - Hanford Need - Develop Cost-Effective, In-Situ Remediation of Carbon Tetrachloride in the Vadose Zone
    - Hanford Need - Improved, Cost-Effective Methods for Sub-Surface Access to Support Characterization and Remediation

PNNL-Led Strategic Initiatives Align with Hanford Site Needs, con't

- Enhanced Remediation Methods – Rads & Metals
  - ✓ Scientific & Technical Basis for In Situ Treatment Systems for Metals & Radionuclides
    - Hanford Need - Develop and Test Cost-Effective, In Situ Remediation Technologies for Radionuclides in the Deep Vadose Zone
    - Hanford Need - Improved, Cost-Effective Methods for Sub-Surface Access to Support Characterization and Remediation
- Enhanced Long-Term Monitoring Strategies (SRNL and PNNL-led)
  - ✓ Develop Technical Basis for Paradigm Shift for Life-Cycle Monitoring and Develop Approaches for Integrating Life-Cycle Monitoring Data into Site Models
    - Improved, Remote, In Situ Detection of groundwater constituents (e.g., Sr-90, Cr^{6+})

Hanford Site Groundwater Challenges
EM-20 E&T Roadmap Focus



Advanced Predictive Capabilities

Problem/Need Statement

- Simple conceptualizations do not always adequately represent complex subsurface conditions for remediation of challenging sites
- Regulator-accepted approaches are needed to evaluate detailed conceptual models

Goals and Objectives

- Provide a technical framework for translating science into conceptual and numerical models for complex sites
- Develop methodologies for defining and assessing alternative conceptual models that address uncertainty
- Provide protocols for selecting and implementing numerical models to adequately address complexity
- Provide guidance for characterizing complex sites to obtain data for developing alternative conceptual and numerical models

Demonstrate Methods to Reduce Transport of Chlorinated Organics Through Deep Vadose Zone

Problem/Need Statement

- Cost-effective, *in situ* technologies are needed to remediate chlorinated organics in soils and groundwater
- Treatment of chlorinated organics in deep vadose zones or tight zones are particularly problematic

Goals and objectives

- Provide technical information to implement remediation methods to reduce transport of chlorinated organics in the vadose zone
- Provide technical information for monitoring remediation objectives for chlorinated organics in the vadose zone

Scientific & Technical Basis for In Situ Treatment Systems for Metals & Radionuclides

Problem/Need Statement

- Mobile ions such as Tc-99, U, and Pu prevalent at multiple sites are difficult to treat *in situ,* especially in the deep vadose zone

Goals and objectives

- Apply emerging scientific and technical knowledge to enhance understanding of contaminant behavior
- Introduce innovative remediation approaches based on applied science
- Initial target to integrate with field activities for Tc-99 at Hanford

Enhanced Long-Term Monitoring Strategies

Problem/Need Statement

- Cost-effective approaches are needed to
  - monitor residual contamination in soil and groundwater
  - verify remedial performance over many years, in some instances for decades or centuries

Goals and objectives

- Develop improved and optimized long-term monitoring systems
- Provide the computational tools and methodologies to integrate heterogeneous data sets from multiple lines of evidence
- Develop integrated risk management and decision support tools for a more system-based monitoring paradigm

Closing Thoughts

- Challenging problems exist
  - Complexity of the 300 Area
  - Deep vadose zone
  - Mobile contaminants
  - Finding sources
- Track record of science-based solutions established
  - Improved conceptual models
  - Enhanced *in situ* remediation
- Roadmap identifies strategies to reduce risks and uncertainties
  - Strategic Initiatives designed to solve sites' life-cycle problems

Closing Thoughts, con't

- Approach to roadmap implementation incorporates critical success factors – co-investment, partnerships, and results
  - Integration with the sites that result in use of new solutions
  - Leveraging resources for efficiency and to accelerate outcomes
  - Harvest science now from past science investments
  - Influence future focus of science

Questions?

Soils and Groundwater Remediation Program
WBS Elements – PNNL Led

2.0.0 Program Management

2.1.0 Improved Sampling & Characterization Strategies

- 2.1.1 Develop Next Generation Characterization Technologies and Strategies

2.2.0 Advanced Predictive Capabilities

- 2.2.1 Develop Advanced Fate and Transport Models

2.3.0 Enhanced Remediation Methods – Metals & Radionuclides

- 2.3.1.1 Scientific & Technical Basis for In Situ Treatment Systems for Metals & Radionuclides
- 2.3.3.1 Scientific Basis for Attenuation Based Remedies for Metal and Radionuclide Contaminated Groundwater
- 2.3.5.1 Idaho Sr-90 Immobilization/Uncertainty Reduction Project

2.3.0 Enhanced Remediation Methods – Organics

- 2.3.2.1 Enhanced Attenuation (EA) for Chlorinated Solvents Technology
- 2.3.2.2 Demonstrate Methods to Reduce Transport Rate of Chlorinated Organics through the Deep Vadose Zone

2.4.0 Center for Sustainable Groundwater & Soil Solutions at SRNL

2.5.0 Columbia River Projects Follow-On Activities

- 2.5.1 300 Area Uranium Plume Treatability Demonstration – U Polyphosphate Stabilization
- 2.5.2 100-N Area Sr-90 Treatability Demonstration (Phytoremediation)
- 2.5.3 Refine Location of Chromium Source

2.6.0 Technical Assistance

4.1.0 Enhanced Long-Term Performance Evaluation and Monitoring

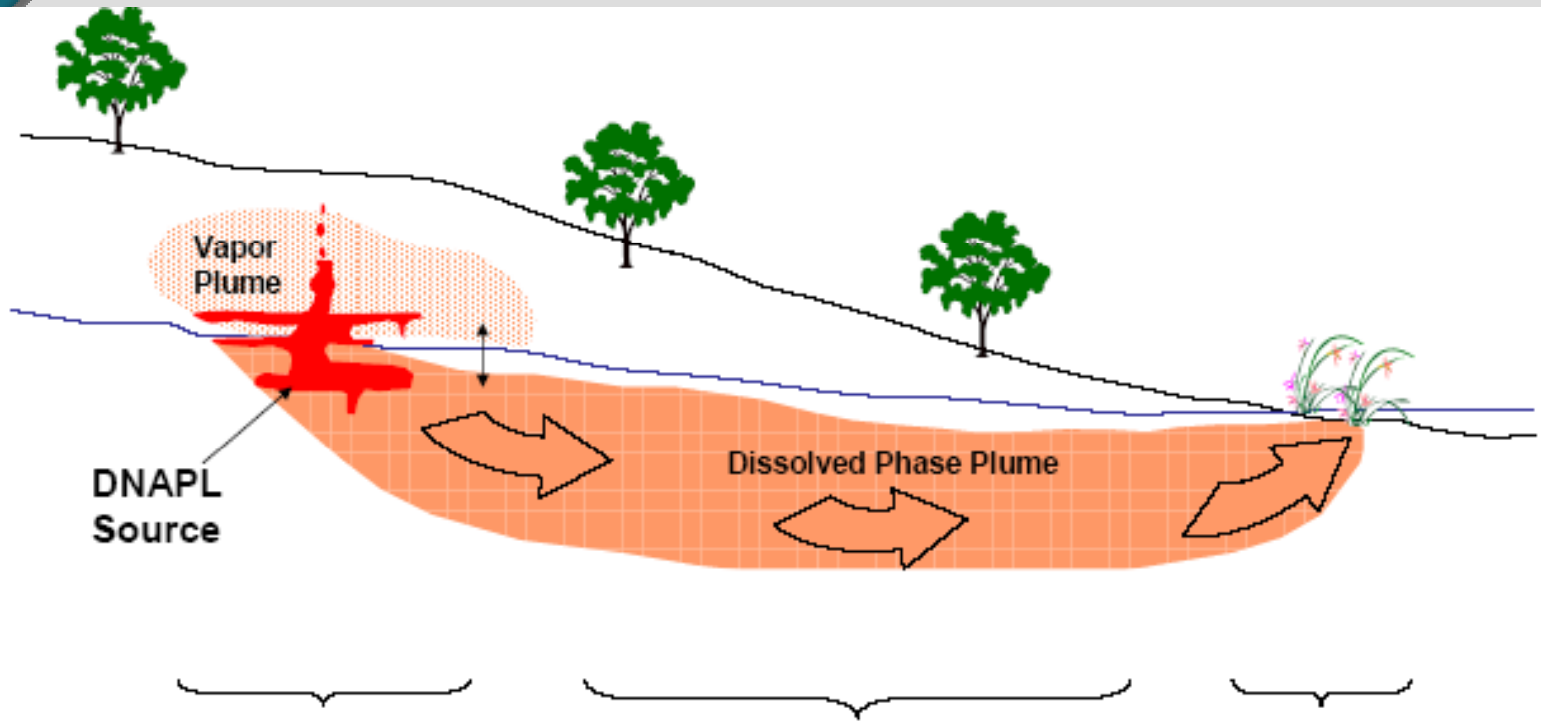
- 4.1.2 Develop Technical Basis for Paradigm Shift for Life-Cycle Monitoring
- 2.2.2 Develop Approaches for Integrating Life-Cycle Monitoring Data into Site Models

Soils and Groundwater Remediation Common Technical Challenges at DOE sites

- Sampling/Characterization Technology:
  - ✓ Low cost field characterization & monitoring techniques, including non-invasive detection techniques, that are acceptable to regulators
- Modeling:
  - ✓ Improved conceptual models and incorporation of science into modeling
  - ✓ Reactive transport models that account for unique subsurface characteristics, e.g., physical features such as fractured rocks or tight zones and biogeochemical features impacting transformation, mobility, and coupled transport
- In Situ Technology:
  - ✓ Cost-effective techniques during remedial action and post-closure, i.e. transition cost-effective solutions to LM
  - ✓ MNA and long-term monitoring
- Long-Term Monitoring Technology:
  - ✓ Low cost monitoring tools to reduce lifecycle costs
  - ✓ Long-term monitoring for MNA
  - ✓ Long-term monitoring of barrier performance

Enhanced Remediation Methods

Chlorinated Solvents



Source Zone

Hydraulic manipulation

- Interception/diversion of groundwater
- Reduce infiltration with covers and/or vegetation

Mass removal/destruction/stabilization

- Vapor extraction
- Bioremediation
- Partition barrier

Plume Zone

Hydraulic manipulation

- Plant-based methods

Mass removal/destruction

- Phytoextraction
- Bioremediation
- Abiotic methods
- Permeable reactive barrier

Discharge Zone

Mass removal/destruction

- Phytoextraction
- Constructed wetland
- Abiotic methods

Enhanced Remediation Methods

Metals & Radionuclides

Sr-90 Deep Vadose Zone	Tc-99 Deep Vadose Zone	Columbia River Projects
Innovative technologies to reduce transport to groundwater	Innovative technologies to reduce transport to groundwater	**Cr, U, Sr-90** Demonstrate technologies for *in situ* soil and groundwater treatment

Monitored Natural Attenuation of Metals & Radionuclides
Groundwater
Biogeochemical gradient evolution

Common challenges

Conceptual model advancement
Delivery system – deep vadose zone
"Process" monitoring
Coupling between biogeochemical processes and flow

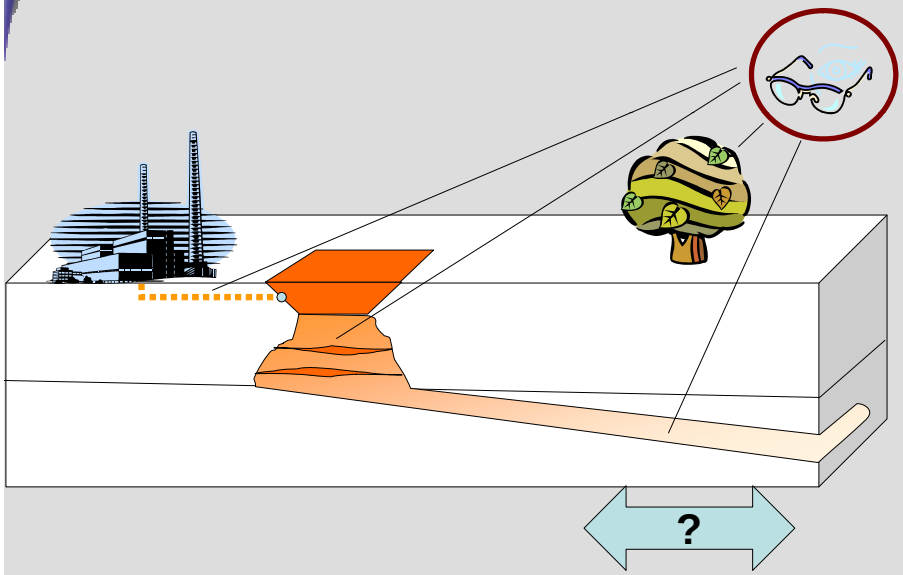
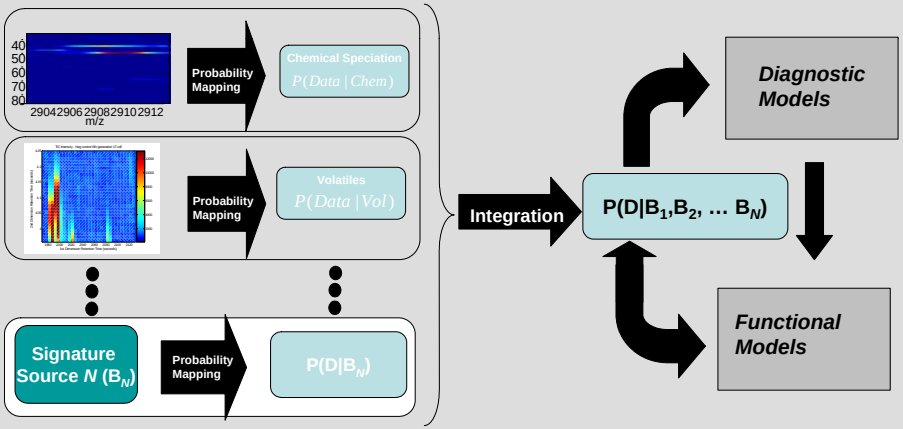
Columbia River Projects
Follow-On Activities

Problem/Need Statement

- Cost-effective, environmentally safe and compliant in situ remediation of hexavalent chromium, Sr-90, and uranium

Goals and objectives

- Perform laboratory and field tests of polyphosphate material to stabilize uranium in groundwater
- Investigate use of Coyote willow along the Columbia River corridor to extract or isolate Sr-90
- Determine the leaching characteristics of chromium from contaminated sediments in the 100 Area to update the conceptual model

Enhanced Long-Term Monitoring Strategies

SRNL – Led	PNNL – Led
Alternative Tools and Strategies	Computational Tools