


SERDP & ESTCP DNAPL Projects

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A stylized silhouette of a mountain range in shades of teal, located in the bottom right corner of the slide.

DoD's Environmental Technology Programs



Demonstration/Validation

Basic and Applied Research

Environmental Drivers: Sustainability of Ranges and Range Operations



Maritime Sustainability

Threatened and Endangered Species

Toxic Air Emissions and Dust



**Unexploded
Ordnance**



Urban Growth **Noise NOX and PM**
& Encroachment



Environmental Drivers: Reduction of Current and Future Liability

Current Liabilities



Contamination from Past Practices

- Chlorinated Solvents
- UXO
- Emerging Contaminants (Perchlorate)

Future Liabilities



Control Life Cycle Costs

- Elimination of Hazardous Materials
- Achieve Compliance Through Pollution Prevention

Environmental Restoration Program Characteristics

- ◆ 200+ active projects
- ◆ Projects range from \$100K to 1.0M/year, average size is \$400K/year
- ◆ 95% of projects are partnered
- ◆ Project length runs 1 to 5 years
- ◆ Turn over roughly 25% of the program each year

Environmental Restoration Research Focus Areas

- ◆ Chlorinated Solvents
 - Dissolved Phase
 - DNAPL Source Zones
- ◆ Munitions Constituents
 - Perchlorate
 - Energetics
 - Heavy Metals
- ◆ Sediments
- ◆ Risk Assessment
- ◆ Site Characterization and Monitoring
- ◆ Performance Assessment & Optimization

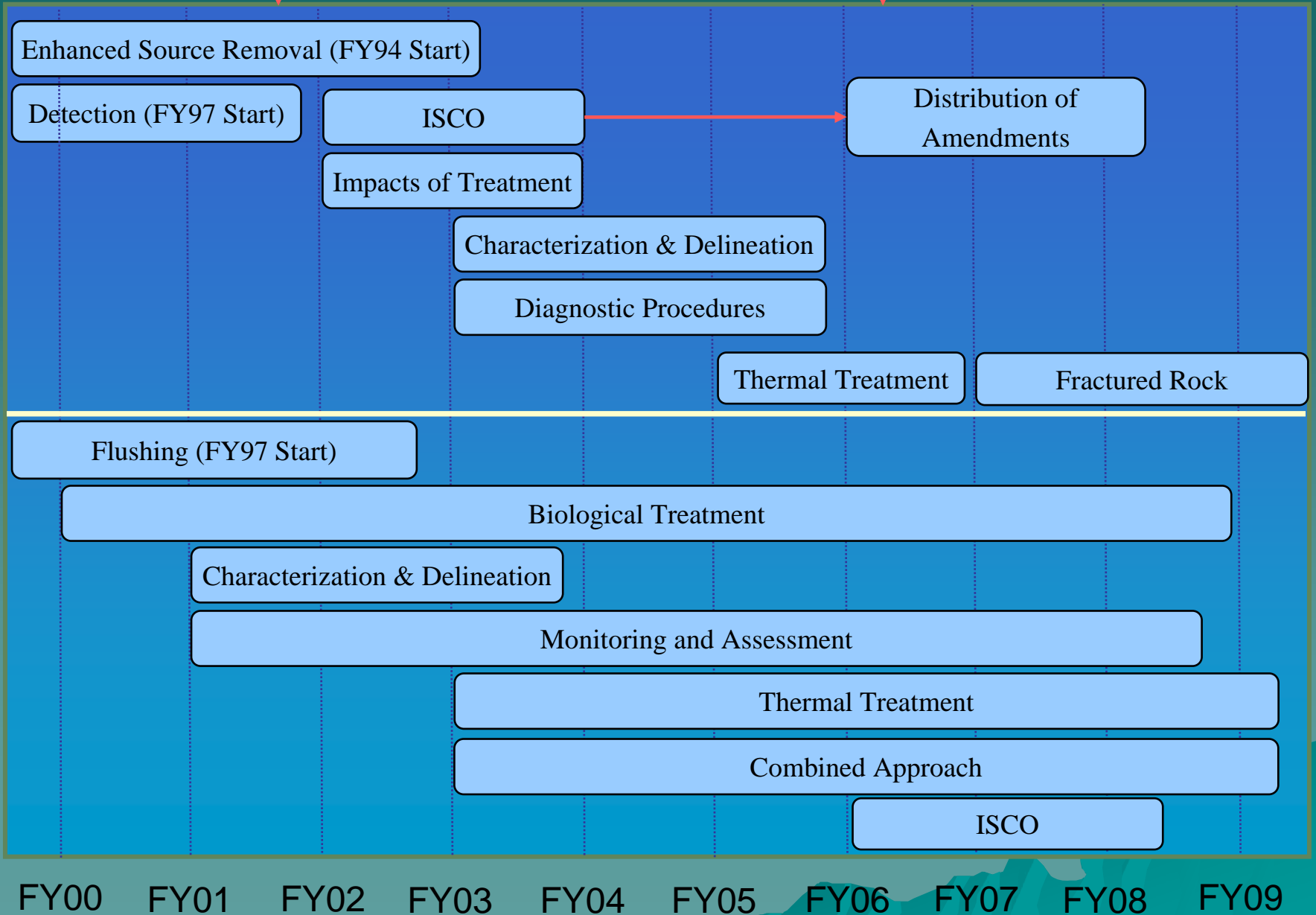
DNAPL

Chlorinated Solvents Workshop

DNAPL Workshop

S&T

Dem/Val



FY00

FY01

FY02

FY03

FY04

FY05


FY06

FY07

FY08

FY09

2001 Chlorinated Solvent Workshop: Research Needs

- ◆ Effects of source zone treatment and benefits of partial mass removal from sources
 - ◆ Source delineation, characterization and flux analysis
 - ◆ Source zone bioremediation and bioaugmentation
 - ◆ New technologies not needed, but better understanding of existing technologies is
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SERDP-Funded Projects

- ◆ ER-1293: Development of assessment tools for evaluation of the benefits of DNAPL source zone treatment (Linda Abriola, Tufts University) *FY07 Completion Date*
- ◆ ER-1294: Mass transfer from entrapped DNAPL sources undergoing remediation: characterization methods and prediction tools (Tissa Illangasekare, Colorado School of Mines) *Complete*
- ◆ ER-1295: Impact of DNAPL source zone treatment: experimental and modeling assessment of benefits of partial source removal (Lynn Wood, U.S. EPA) *FY07 Completion Date*

ER-1294 Key Findings

- ◆ Objective: To understand, quantify, and model the process of mass transfer from source zones in heterogeneous aquifers where DNAPLs are undergoing physical, chemical and biological transformation during remediation.
- ◆ Key Findings:
 - PITT was inaccurate in estimating vertical distribution of DNAPL. Underestimation of mass due to hydrodynamic inaccessibility of pools for tracer partitioning.
 - Surfactant-enhanced remediation effectiveness decreases as source-zone heterogeneity increases. G-S obtained from column tests undergoing surfactant-enhanced remediation are not appropriate to parameterize mass transfer in multidimensional flow systems at field scales.
 - The source zone characterization technique emphasizes the importance of installing multi-level samplers. This suggests the need to develop monitoring methods that are different from the conventional methods that are used at most DNAPL sites.
 - Flow paths through heterogeneous sources can be highly irregular resulting in water bypassing some high-saturation zones. This can limit delivery of chemicals to sites of active DNAPL dissolution and reaction, and adversely impact remediation effectiveness. Research to develop protocols for optimizing delivery of reactants in highly heterogeneous sources is needed.

DNAPL Workshop

- ◆ Approx. 40 experts – 2 days – March 2006
- ◆ Identify Key Issues:
 - Characterization
 - Remediation
 - Monitoring
- ◆ Identify R&D Needs

Research Needs

Critical Priority	High Priority
Improved Methods for Characterization & Monitoring	Better Understanding of DNAPL Architecture
Improved Understanding of Plume Response to Source Depletion	Improved Understanding of the Relationship Between Mass Removal & Mass Flux
Development of Treatment & Monitoring Approaches for Flow-Limited Portions of DNAPL Source Zones	Improved Delivery Mechanisms
Assessment of the Impacts of Implementing Combined Remedies	Quantification of Uncertainty
Improved Remedial Methods for Karst & Other Complex Sites	
Better Understanding & Monitoring of Vapor Transfer from Sources	

Demonstration Needs

Critical

Improved Methods for Reduction of LTM/Characterization Costs

Focused Data Mining to Assess Long-Term Responses

Development of Decision Guidelines for Source Zone Characterization & Remediation

Enhanced Technology Transfer

High Priority

Improved Methods for Evaluating Plume Response

Collection & Publication of Lessons Learned from Technologies

Development of Guidance on “Observational Approach”

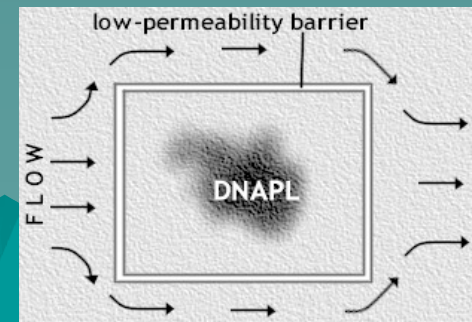
Better Tools for Handling Industrial Infrastructure

Improved Understanding of Plume Response to Source Depletion

- ◆ Reduced plume size, strength, and longevity are usually key remedial objectives
- ◆ Better predictive models are needed for decision-making

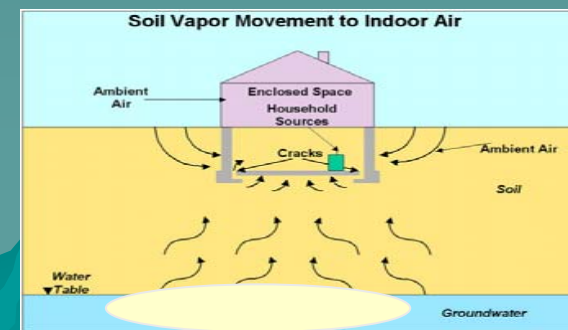
Development of Treatment & Monitoring Approaches for Flow-Limited Portions of DNAPL Source Zones

- ◆ “Advectively-challenged” zones are esp. difficult to treat and monitor
- ◆ But treatment generally involves the movement of fluids through DNAPL source zones
- ◆ Chemicals diffusing from flow-limited to flow-accessible zones are long-term sources
- ◆ Can we better treat flow-limited zones, or control continuing discharge from those zones?




Better Understanding and Monitoring of Vapor Transport

- ◆ Vapor transport through the vadose zone represents a key uncertainty and potential liability
- ◆ Processes controlling vapor attenuation, improved monitoring techniques, and methods to discern between sources
- ◆ Some concern that recent screening limits could trigger site-specific evaluations at nearly all sites where buildings overlie solvent plumes



Focused Data Mining to Assess Long-Term Responses

- ◆ Post-mortem analyses of cost and performance at sites that have undergone source treatment
 - ◆ Goal would be to improve decision-making and allow more realistic expectations
 - ◆ Many sites with 25 years or more of monitoring data - a huge investment in data that to date has been under-utilized
 - ◆ May be significant barriers to obtaining and using historic data - difficult to access, methods may have changed, data considered essential today may not have been collected
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FY08 SERDP SON

- ◆ To improve our understanding & ability to predict response of chlorinated solvent dissolved phase plume to the architecture & possible depletion of the DNAPL source zone.
 - To integrate & assess current understanding of DNAPL source zones with field-observed phenomenon
 - To develop techniques by which cost-effective measurements may be made of key parameters defining the DNAPL source zone that will enable the prediction of the source zone's impact on the resulting plume. Research should focus on one or more of the following specific objectives:
 - ◆ Improve our understanding and assess the role and impact at field sites of the sorption and diffusion of DNAPLs into low-permeability matrices.
 - ◆ Improve our understanding of the relation of the ganglia-to-pool ratio to DNAPL source zone dissolution and its significance under field conditions.
 - ◆ Improve our understanding of impact of DNAPLs located in low-permeability matrices on contaminant concentrations in more permeable media.
 - ◆ Improve our understanding of how the depletion of DNAPLs in flow-limited and/or flow-accessible zones impacts plume response in terms of plume size, strength, and longevity.
 - ◆ Develop and/or improve predictive models of the impacts of the DNAPL source zone on plume response in terms of plume size, strength, and longevity that are relevant to assist in cleanup decision making.
 - ◆ Develop cost-effective methods for evaluating source function and other key parameters, such as the ganglia-to-pool ratio.
 - ◆ Develop cost-effective methods for assessing the DNAPL source zone architecture.
 - ◆ Develop guidelines for determining level & type of characterization required at a site.

Current SERDP Projects

- ◆ [ER-1419](#): Investigation of Chemical Reactivity, Mass Recovery and Biological Activity During Thermal Treatment of DNAPL Source Zones
- ◆ [ER-1423](#): Large-Scale Physical Models of Thermal Remediation of DNAPL Source Zones in Aquifers
- ◆ [ER-1458](#): In Situ Thermal Remediation of DNAPL Source Zones Ongoing
- ◆ [ER-1484](#): Control of Manganese Dioxide Particles Resulting from In Situ Chemical Oxidation Using Permanganate
- ◆ [ER-1485](#): Fundamental Study of the Delivery of Nanoiron to DNAPL Source Zones in Naturally Heterogeneous Field Systems
- ◆ [ER-1486](#): Multi-Scale Experiments to Evaluate Mobility Control Methods for Enhancing the Sweep Efficiency of Injected Subsurface Remediation Amendments
- ◆ [ER-1487](#): Development and Optimization of Targeted Nanoscale Iron Delivery Methods for Treatment of NAPL Source Zones
- ◆ [ER-1489](#): Enhanced Reactant-Contaminant Contact Through the Use of Persulfate ISCO
- ◆ ER-1553: Contaminant Mass Transfer During Boiling in Fractured Geologic Media
- ◆ ER-1554: DNAPL Dissolution in Bedrock Fractures and Fracture Networks

Current ESTCP Projects

- ◆ ER-9714: Surfactant Enhanced DNAPL Removal
- ◆ ER-0113: Cyclodextrin-Enhanced In Situ Removal of Organic Contaminants from Groundwater
- ◆ ER-0008: Biodegradation of Dense Non-Aqueous Phase Liquids (DNAPL) Through Bioaugmentation of Source Areas
- ◆ ER-0116: Remediation of Dense Non-Aqueous Phase Liquids through Sequential In-Situ Chemical Oxidation & Bioaugmentation
- ◆ ER-0218: In Situ Bioremediation of Chlorinated Solvent Source Areas with Enhanced Mass Transfer
- ◆ ER-0314: Critical Evaluation of State-of-the-Art In Situ Thermal Treatment Technologies for DNAPL Source Zone Treatment
- ◆ ER-0318: Diagnostic Tools for Performance Evaluation of Innovative In-Situ Remediation Technologies at Chlorinated Solvent-Contaminated Sites
- ◆ ER-0319: Sequestration of a DNAPL Source with Vegetable Oil
- ◆ ER-0424: Development of a Protocol and a Screening Tool for Selection of DNAPL Source Area Remediation
- ◆ ER-0431: Emulsified Zero-Valent Nano-Scale Iron Treatment of Chlorinated Solvent DNAPL Source Areas

Current ESTCP Projects (cont'd)

- ◆ ER-0438: Reductions in DNAPL Longevity Through Biological Flux Enhancement
- ◆ ER-0530: Protocol for Selecting Remedies for Chlorinated Solvent Releases
- ◆ ER-0623: In Situ Chemical Oxidation for Groundwater Remediation: Technology Practices Manual
- ◆ ER-0632: Field Demonstration, Optimization, and Rigorous Validation of Peroxygen-Based ISCO for the Remediation of Contaminated Groundwater
- ◆ ER-0704: Decision and Management Tools for DNAPL Sites: Optimization of Chlorinated Solvent Source and Plume Remediation Considering Uncertainty
- ◆ ER-0705: Assessment of the Natural Attenuation of NAPL Source Zones and Post-Treatment NAPL Source Zone Residuals
- ◆ ER-0715: DNAPL Removal from Fractured Rock Using Thermal Conductive Heating
- ◆ ER-0716: Improving Effectiveness of Bioremediation at DNAPL Source Zone Sites Applying Partitioning Electron Donors
- ◆ ER-0719: Combining Low-Energy Electrical Resistance Heating with Biotic and Abiotic Reactions for Treatment of Chlorinated Solvent DNAPL Source Areas

Future Coordination Plans

- ◆ DNAPL Side Meeting at SERDP/ESTCP Symposium (December 2007)
 - ◆ Training Workshop on DNAPL FAQs and Decision Guide (December 2007)
 - ◆ Publication of book summarizing DNAPL research and demonstrations (~2009)
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