EPA Session 2 (1C.30S):
Evolution of Optimization and other Key Trends in Cleanups: A Superfund Perspective

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US EPA Superfund Program
Washington, DC

AquaConSoil
Copenhagen, Denmark
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Agenda

♦ Historical trends in remediation technologies and an overview of technical developments

♦ Optimizing remedies in Superfund: Approaches and findings

♦ High Resolution Site Characterizations: The basics

♦ Insights on progress in Superfund groundwater remedies and recent guidance

♦ Greener cleanups are helping us achieve protectiveness at site cleanups at lower cost and environmental footprint
Trends in Technologies and Developments in Superfund
Early Cleanups in Superfund

♦ Superfund Law Enacted in 1980 in response to a need to protect citizens from the dangers posed by abandoned or uncontrolled hazardous waste sites

♦ Superfund was a powerful law that resulted in immediate action at many priority sites

♦ The challenge was new, and the need for action prevailed. Technical solutions were few and we applied what we knew

Superfund Remedies: Early Years (1982-1985)

<table>
<thead>
<tr>
<th></th>
<th>Containment</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Remedies</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>Pump &amp; Treat</td>
<td></td>
<td>In-Situ Treatment</td>
</tr>
<tr>
<td>Groundwater remedies</td>
<td>90%</td>
<td>3%</td>
</tr>
</tbody>
</table>
EPA Contaminated Site Programs: We Still a Lot of Remediation Work to Do

♦ We have made great progress cleaning up contaminated sites but...

♦ National Academies of Sciences estimates 126,000 sites across US still have contaminated groundwater, and their closure expected to cost at least $110 billion to $127 billion

♦ We continue to invest over $8 billion a year in remediation (USEPA, EBJ)

♦ We have opportunity to take lessons learned over the past decades, and apply innovations and best management practices to future sites

Estimated Number of Contaminated Sites (USEPA 2004) (United States, Cleanup horizon: 2004 – 33)

Total Sites = 294,000

Remediation: The “Big Picture” - Remedy Types at National Priority List Sites

- Superfund law established preference for treatment and permanent remedies
- In early years that was a challenge; we did not have many alternatives to contain, burn, or pump and treat remedies
- Over time Superfund program has succeeded in implementing treatment remedies at over 70% of NPL sites
- At many sites we are treating both soil and groundwater contamination

Total number of sites with remedies = 1,468, 1982-2011
Superfund Remedies for Sources\(^1\) (2009–2011)

- Remedies often selected and applied in combination
- For example, over 30% of treatment remedies were selected with other types of remedies
- We now have a rich mix of remedies available and mature consulting and engineering sector to implement them

1. “Sources”, include soil, sediment, solid waste, NAPL

\*a: ENR/MNR & ICs/Other (2) 1%
\*b: ENR/MNR, Containment & ICs/Other (2) 1%
About 45% of treatment remedies for source control are currently in situ (in place)

We are seeing fewer developments in new technologies, and more innovation in design, construction and operation of commercial technologies

More aggressive remedies used to tackle source areas (such as in situ thermal treatment, chemical oxidation)

Often coupled with groundwater remedies, treatment and non-treatment

<table>
<thead>
<tr>
<th>Technology</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Vapor Extraction</td>
<td>25</td>
<td>14%</td>
</tr>
<tr>
<td>Chemical Treatment</td>
<td>17</td>
<td>10%</td>
</tr>
<tr>
<td>Solidification/Stabilization</td>
<td>11</td>
<td>6%</td>
</tr>
<tr>
<td>Multi-Phase Extraction</td>
<td>9</td>
<td>5%</td>
</tr>
<tr>
<td>In Situ Thermal Treatment</td>
<td>7</td>
<td>4%</td>
</tr>
<tr>
<td>Bioremediation</td>
<td>5</td>
<td>3%</td>
</tr>
<tr>
<td>Subaqueous Reactive Cap</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Flushing</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Fracturing</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Phytoremediation</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total In Situ</strong></td>
<td><strong>79</strong></td>
<td><strong>45%</strong></td>
</tr>
</tbody>
</table>
Trends in Superfund Groundwater Remedies Selection (1986–11) Total Groundwater Decision Documents = 1,912
Groundwater Remedy Types Recently Selected in Superfund

- Groundwater pump and treat still common, but we see more in situ treatment remedies
- Monitored natural attenuation is used either alone or in combination
- Concept of “adaptive management” gaining ground: Actively monitoring operating systems to determine optimal transition time and place between remedy components

<table>
<thead>
<tr>
<th>Remedy Type and Technologies</th>
<th>Total (FY09–11)</th>
<th>Percent (FY09–11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater Pump and Treat</td>
<td>44</td>
<td>12%</td>
</tr>
<tr>
<td>In Situ Treatment of Groundwater</td>
<td>78</td>
<td>21%</td>
</tr>
<tr>
<td>Bioremediation</td>
<td>49</td>
<td>13%</td>
</tr>
<tr>
<td>Chemical Treatment</td>
<td>27</td>
<td>7%</td>
</tr>
<tr>
<td>Air Sparging</td>
<td>14</td>
<td>4%</td>
</tr>
<tr>
<td>Permeable Reactive Barrier</td>
<td>8</td>
<td>2%</td>
</tr>
<tr>
<td>In-Well Air Stripping</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Multi-Phase Extraction</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>MNA of Groundwater</td>
<td>56</td>
<td>15%</td>
</tr>
<tr>
<td>Groundwater Containment (VEB)</td>
<td>6</td>
<td>2%</td>
</tr>
<tr>
<td>Engineered (Constructed) Wetland</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>Other Groundwater</td>
<td>177</td>
<td>49%</td>
</tr>
<tr>
<td>Institutional Controls</td>
<td>173</td>
<td>48%</td>
</tr>
<tr>
<td>Alternative Water Supply</td>
<td>13</td>
<td>4%</td>
</tr>
<tr>
<td>Engineering Controls</td>
<td>2</td>
<td>1%</td>
</tr>
</tbody>
</table>
In Situ Groundwater Treatment: Increasing Use in Superfund

Total number of groundwater decision documents = 1,912
Use of improved field sampling and analytical technologies yield abundant, reliable, and relatively inexpensive field data.

Traditional cycle of demobilizing to update the conceptual site model negates benefits of real-time information.

A dynamic work strategy (DWS) is needed to identify and eliminate data gaps and test the CSM, in the field.

So we now begin with systematic planning to develop baseline CSM, identify data gaps, and develop DWS.
Developments Beyond New Remediation Technologies

- Integrating field sampling and analytical technologies to address uncertainty and inform active remedy operation decisions
- Improving our understanding of in situ processes to better design, operate, and monitor remedy performance
- High resolution site characterization - a necessary tool for more effective in situ remedies, enabling adaptive management and reducing remedy footprints
- Optimizing remedies in long-term operation phase
- Green remediation in EPA’s programs
Managing Superfund in a Changing Landscape

♦ Decreasing budgets: $105 million reduction in Superfund annual remedial budget, and loss of 70 FTE, since 2011

♦ Program and Agency Priorities include:
  » Working Toward a Sustainable Future
  » Embracing EPA as a High-Performing Organization

♦ Administrator interest in statutory/regulatory/policy ideas that would leverage capabilities, demonstrate progress sooner, and make more efficient use of Superfund resources to maintain program accomplishments

♦ Maintain core mission functions with lower environmental footprints
Recent Technical and Policy Trends in Superfund Groundwater Remedies
(Underlying Chart = Superfund Groundwater Remedy Selections)

Focus on Optimization (GW) & Triad Soil
Focus on High Res Site Characterization
Focus on Green Remediation
Focus on In Situ Treatment

EPA
Remedy Optimization in EPA’s Superfund Program
Optimization: Revisiting long-term remedies
Analysis of 52 of 150 optimized sites in Superfund

- Cost savings
  - 83% cost savings opportunities
  - 52% cost savings opportunities > $1 million

- Improved protectiveness
  - 19% eliminate or confirm no ecological exposures
  - 33% eliminate or confirm no human exposures
  - 62% improve or confirm control of plume migration

Similarly positive findings for the other 98 optimized sites...

and >$350M in potential cost savings/avoidance for all 150 sites.

**More than 40% of sites evaluated recommended additional characterization.

Combined with trends toward increased use of *in situ* remedies - indicates need for high-resolution site characterization.

83% of sites had cost savings opportunities
33% eliminate or confirm no human exposures
Systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness and cost efficiency, and to facilitate progress toward site completion.
From Discovery to Completion

Optimization Stages

- Site Discovery
- Investigation Stage
  - Site Assessment
  - Remedial Investigation
  - Feasibility Study
- Design Stage
  - Remedial Design
  - Remedial Action
- Remedy Stage
  - Long-term Response Action
- Long-term Monitoring Optimization Stage

Key Optimization Components

- Conceptual Site Model
- Exit Strategy
- Remediation Components
- Monitoring
- Green Remediation
- Data Management
- Triad Approach

Operation & Maintenance
Optimization During The Investigation Stage

♦ Historical information and data
  » Geology / hydrogeology / chemistry / operations
  » Data quality / usability / net information value
  » 3-D visualization and analysis

♦ CSM status / alignment with project life cycle needs
  » Plume delineation; plume core & migration pathways
  » Source identification

♦ Technologies previously applied / may apply in future
  » Analytical, sampling and measurement tools

♦ Key stakeholder needs

♦ Exit strategy considerations
Frequent Review Findings & Recommendations

◆ Data
  » Numerous prior data collection efforts, data not leveraged
  » Low data density = high spatial uncertainty
  » Non-existent or inadequate CSM

◆ Strategy & Technologies
  » Static vs. dynamic work strategies
  » High cost, conventional methods
  » Scale of measurement ≠ heterogeneity

◆ Decision ability
  » End data users not adequately considered
  » Plan for and collect collaborative data to support risk assessment, remedy selection and design

» Improve CSM
» Use HRSC approaches
» Develop collaborative data sets
» Design investigation around CSM gaps
» Apply systematic project planning
» Scale of measurement = heterogeneity
» Plan for and collect collaborative data to support risk assessment, remedy selection and design
Optimization - The Design and Construction Stages

Why Optimize

♦ Concerns regarding protectiveness or cost
♦ Concerns regarding current CSM
♦ Differences in opinion among members of site team
♦ Concerns or uncertainty regarding key conclusions or findings from site consultant
♦ Unexpected monitoring results

Sources of Information

♦ Remedial Investigation and Feasibility Study Reports
♦ Decision documents
♦ Design submittals (including tech memos)
♦ Pilot test results
♦ Work plans for future work
♦ Implementation reports (such as construction, start-up, performance monitoring)
♦ And many other potential documents as appropriate
Alternative approaches or technologies are available for implementing selected remedy

» Example 1 – Carefully designed permanent injection wells instead of direct-push injections

» Example 2 – Pre-fabricated system instead of on-site building

» Example 3 – Treatment and reinjection instead of discharge to POTW

» Example 4 – Use of extracted groundwater instead of potable water for reagent blending, injection, and circulation
Frequent Optimization Recommendations

- Refinements to CSM through additional monitoring or testing
- Suggestions for improving numerical model
- Suggestions for reducing/streamlining costs and cost estimates
- Phase remedial components so later components benefit from results of earlier phases
- Consider specific alternative approaches or technologies
Optimization: Long-term remedies

Why Optimize

♦ Remedy not achieving goals in time-frame
♦ Cost issues
♦ Questions of long-term protectiveness
♦ Property re-development or transfer to state – expedited time frame
♦ Energy, efficiency and effort
♦ Exit strategies

What we review

♦ CSM – all of it
  » Original CSM at time of design
  » Changes to CSM since design
♦ Remedies
  » Remedial Objectives
  » Original Remedial Design
  » Identify Performance Criteria
  » Performance data -- Correlate treatment performance with cost

Goal: Improve Protectiveness, Efficiency (cost, carbon, effort) and Time to completion.
What is Frequently Reviewed

- Changes in COC concentrations
- Rate of mass removal
- Effluent discharge
- Evaluate costs/ effort/ carbon/
- Containment
- Monitoring network
What is Frequently Reviewed

♦ Extraction and monitoring well locations
♦ Amendment injection amount/location
♦ Groundwater extraction performance
♦ Re-injection, release, reuse
♦ Air stripping – GAC – ion exchange
♦ Chemical feed and storage

♦ Conditions since end of active remedy
Frequent Optimization Findings & Recommendations

Findings

♦ Improve CSM
  » Sources
  » Low and high permeability zones
  » NAPL

♦ Data management
  » Tracking and reporting performance
  » Spatial data
  » Historic data (paper → electronic)

Recommendations

♦ Remedy system components
  » Operational improvements
  » Update current system
  » Monitoring optimization (LTMO)

♦ Change Remedy Strategy
  » P&T to MNA

♦ Exit strategy
  » How close are we to cleanup?
  » What data do we need to show attainment?
High Resolution Site Characterization: The Basics
A subsurface investigation appropriate to the scale of heterogeneities in the subsurface which control contaminant distribution, transport and fate, and that provides degree of detail needed to understand:

- Exposure pathways
- Processes affecting the fate of contaminants
- Contaminant mass distribution and flux by phase and by media (mobile and immobile)
- How remedial measures will affect the problem
Key Priorities of HRSC

♦ HRSC Addresses Scale First
  » If measurements are made at the wrong scale it is very hard to understand what is being measured no matter how many measurements are made.

♦ HRSC Addresses Measurement Spacing, Density and Placement Second
  » Measurements made at the right scale will not help unless a sufficient number of measurements are made at the right spacing and in the right places.

♦ Collaborative data – “multiple lines of evidence”

♦ Clearer picture of subsurface heterogeneities

  Porosity          Geochemistry          Capillary pressure
  Hydraulic Conductivity          Hydraulic Head/Hydraulic Gradient
HRSC: Improved site characterization and remedy design, operation and performance tracking
Cost of Remedies vs. Cost of Characterization

♦ Remedies based on a flawed CSM may not perform as expected, increasing the time it takes to achieve remedial action objectives and the overall cost

♦ HRSC makes the investment upfront to obtain a more complete and realistic CSM

♦ Pay a little more now to avoid paying a lot more later

» Until the CSM reflects reality, investigation and cleanup will be costly – pay the costs upfront and get the CSM right the first time in order to avoid paying more later - conceptually…

♦ +50% Characterization, design, monitoring  +$150,000

♦ -10% remedy operation & closure  - $1,000,000
HRSC Summary

- HRSC uses transects of vertical profiles to overcome challenges of subsurface heterogeneity
  - Improved tools allow this approach for shallow and deep unconsolidated environments
  - Monitoring wells are not optimal characterization tools because they are making measurements at too large of a scale

- HRSC results provide the detailed information necessary to design and implement targeted in situ and ex situ remedies
  - HRSC can find the 75% to 95% of contaminant mass discharging in 5 to 25% of an unconsolidated aquifer, allowing the selected remedial action to target those zones

- HRSC is applicable to the characterization of shallow and deep unconsolidated environments and fractured bedrock environments
Analysis of Superfund Groundwater Cleanups
Groundwater Remedial Action Objectives (RAOs) and Cleanup Levels*

♦ Numeric cleanup levels (restoration RAO)
  » Federal or state drinking water Maximum Contaminant Levels (MCLs)
  » Risk-based contaminant concentrations

♦ Containment of plume (nonrestoration RAO)
  » Prevent migration (horizontal & vertical)
  » Protect surface water bodies
  » Protect drinking water wells

### GW Contaminants Addressed

<table>
<thead>
<tr>
<th>Contaminant Group*</th>
<th>Number of Sites/OUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated VOCs (e.g., TCE)</td>
<td>31 sites/OUs</td>
</tr>
<tr>
<td>Metals (e.g., Cr+6, As, Cd)</td>
<td>21 sites/OUs</td>
</tr>
<tr>
<td>Nonchlorinated VOCs (e.g., BTEX)</td>
<td>12 sites/OUs</td>
</tr>
<tr>
<td>PCBs, Pesticides, Dioxins and/or Furans</td>
<td>11 sites/OUs</td>
</tr>
<tr>
<td>PAHs, SVOCs, and/or CSVOCs (e.g., creosote, pentachlorophenol)</td>
<td>11 sites/OUs</td>
</tr>
</tbody>
</table>

*28 of 43 GW sites (65%) had more than one contaminant group
*13 sites had observed or suspected dense nonaqueous phase liquids (DNAPLs)
Out of 34 projects with restoration goals:

♦ 18 met restoration RAOs
  » All have reduced contaminant concentrations by 2 to 4 orders-of-magnitude

♦ 16 restoration sites made significant progress
  » 6 within 10 ppb of cleanup level
  » 3 of these have only 1 well that exceeds cleanup levels
  » Half have reduced contaminant concentrations by 2 orders-of-magnitude

♦ All 9 nonrestoration GW sites met RAOs
Examples of GW Remedy Performance

- **Norton AFB, CA**, reduced TCE from 4,630 ppb to below MCL (5 ppb)
- **Gold Coast Oil, FL** remedy reduced PCE from 48,000 ppb to <3 ppb (EPA MCL 5 ppb)
- **Western Processing, WA** remedy reduced DCE conc. of 10,000 ppb in offsite plume to ND (EPA MCL 70 ppb)
- **Island Chemical, VI** remedy reduced total toluene/ethylbenzene/xylene conc. from 176,000 ppb to 13 ppb (all individual contaminant conc. below EPA MCLs)
In general, multiple treatment methods often combined to address:

- different media,
- different contaminants in the same media, or
- different contaminant concentrations

GW remediation often preceded by or combined with source control remedies (e.g., excavation & removal, capping, vertical engineered barriers)

GW restoration achieved with only P&T at some sites

Remedy optimization or changes often occurred
Remedy Findings Related to Hydrogeologic Complexity

♦ Range of hydrogeology (from homogeneous to fractured)

♦ Traditional technologies (such as P&T, SVE, air sparging) effective at sites with dissolved phase plumes (e.g., cVOCs) in permeable homogeneous & layered/interbedded aquifers

♦ Other supplemental technologies (such as ISCO and in situ thermal treatment) necessary for sites with non-VOC contaminants in same subsurface environments
Sites with more homogeneous and permeable subsurface, smaller plumes and lower initial concentrations usually required less time to meet GW RAOs/cleanup levels

- Homogeneous – 4 to 6 years (3 sites)
- Heterogeneous – 9 years (1 site)
- Layered/Interbedded – 6 to 24 years (6 sites)
- Fractured – 10 years (1 site)
New Suite of Groundwater Guidance

- *Groundwater Remedy Completion Strategy* (May 2014)

- *Guidance for Evaluating Completion of Groundwater Restoration Remedial Actions* (Nov. 2013)


- *Groundwater Statistics Tool* (August 2014)
Groundwater Remedy Completion Strategy
(May 2014, OSWER 9200.2-144)

♦ Recommends step-wise planning and decision-making processes for evaluating groundwater remedy operation and progress toward achieving groundwater RAOs and cleanup levels

♦ Process to focus resources toward effective and efficient completion of groundwater remedies
  » Understand current site conditions
  » Design site-specific remedy evaluations
  » Develop performance metrics and collect monitoring data
  » Conduct remedy evaluations using site-specific metrics
  » Make management decisions
Example Groundwater Remedy Completion Strategy

**Assumes a current conceptual site model**

- Define Evaluation Questions
  - Is groundwater extraction rate adequate?
  - Are contaminant concentrations decreasing?
  - Have cleanup levels been achieved?

- Define Metrics and Monitor
  - Extraction Rate
  - Capture Zone
  - Contaminant Concentration Trends
  - Contaminant Concentrations

- Conduct Remedy Evaluations
  - Are remedy operation and progress adequate?
  - Have RAOs and cleanup levels been attained?

= Make Management Decisions
The recommended strategy does NOT...

♦ Alter Agency approach for setting RAOs or cleanup levels

♦ Change existing guidance or policy on remedy selection

♦ Address groundwater classifications or use designations

♦ Request that states or tribes alter existing groundwater classification or use designations
♦ Recommends evaluating contaminant of concern (COC) concentration levels on a well-by-well basis

♦ Well-specific conclusions used with conceptual site model to demonstrate that:

  » Groundwater has met and
  » Will continue to meet cleanup levels for all COCs in the future
Groundwater Statistical Tool
(August 2014, OSWER 9283.1-46)

♦ Supports EPA’s recommended approach for evaluating groundwater restoration actions

♦ Tool uses statistics to evaluate completion of a groundwater remediation action at a specific well for a specific contaminant
  » Remediation Monitoring Phase
  » Attainment Monitoring Phase

♦ May also be used to evaluate data trends during cleanup
Superfund has successfully cleaned up hard-to-remediate GW sites to achieve RAOs/cleanup levels in many different settings.

Superfund has used multiple remediation approaches, especially for challenging sites.

Remedy optimization and changes have resulted in cleanups.

Superfund has used and achieved nonrestoration RAOs.

Superfund striving to focus resources on information and decisions needed to effectively complete groundwater remedies.
Greener Cleanups & Sustainability in Superfund Cleanups: Completing the Sustainability
Sustainability in Superfund Site Remediation

♦ Social:
  » Engaging communities in site cleanup decisions
  » Turning contaminated sites into community assets

♦ Economic:
  » Redevelopment in blighted areas (aligns with smart growth goals)
  » Fostering employment opportunities in communities where sites are cleaned up
  » Rising property values in communities
  » Remediation in the U.S.: A $7 billion/year economic engine

♦ Environmental:
  » Protecting Human Health and the Environment
  » Liberating contaminated sites for reuse (1 remediated acre redeveloped = 4 acres of green field development)

♦ Challenge: A smaller environmental footprint cleaning up sites
Challenge: Lowering the Environmental Footprint of Site Cleanup Projects

Green Remediation

The practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions.

*as defined by US EPA, a.k.a. greening response actions, greener cleanups, etc.
Addressing the Environmental Leg of Sustainability: Core Elements of Green Remediation

“Minimize, Reuse, and Recycle…”

“Conserve, Protect, and Restore…”

“Reduction, Efficiency, and Renewables…”

“Protect Air Quality, Reduce Greenhouse Gases…”

“Improve Quality, Decrease Quantity of Use…”
Implementation of GR in EPA Contaminated Site Programs

♦ Define internal policies, strategies and program action plans:
  » Cross-Agency Principles for all cleanup programs
  » Superfund green remediation strategy & 40 action items
  » Update contracting language to reflect new practices

♦ Develop technical guidance for practitioners
  » Best management practice fact sheets (13 to date)
  » Environmental footprint evaluation methodology

♦ Leverage voluntary market driven options
  » ASTM Standard Guide for Greener Cleanups
The Role of the ASTM Guide in Greener Cleanups

→ **ASTM Standard Guide for Greener Cleanups (E2893):**
  - Codifies best practices and defines a process for reducing environmental footprint
  - Includes over 160 BMPs and outlines process for straight BMP application or use of quantification
  - Useful protocol for contracting purposes
  - Results in a transparent documented process that is reported publicly

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**Green Remediation Goals in Cleanup Project (Client request, Contractual Requirement, Regulatory requirement, etc)**

- Small cleanup project, or standard cleanup approach
- Large complex projects
- Quantify footprint, prioritize reduction targets
- Select and apply specific best management practices
Options for Implementing Green Remediation

- **Direct Use of Best Management Practices (BMPs)**
  - Excavation and Surface Restoration
  - Site Investigation
  - Pump and Treat Technologies
  - Bioremediation
  - Soil Vapor Extraction & Air Sparging
  - Clean Fuel & Emission Technologies for Site Cleanup
  - Integrating Renewable Energy into Site Cleanup
  - Sites with Leaking Underground Storage Tank Systems
  - Landfill Cover Systems & Energy Production
  - Mining Sites
  - Implementing In Situ Thermal Technologies
  - Overview of EPA's Methodology to Address the Environmental Footprint of Site Cleanup

- **For Complex Projects – Apply Footprint Methodology**

[www.cluin.org/greenremediation/](http://www.cluin.org/greenremediation/)
Standard Guide for Greener Cleanups: Integrating Greener Cleanup Goals at Sites

♦ Provide clear definitions, methods and expectations for all stakeholders

♦ Leverage private sector resources

♦ Harness corporate responsibility

♦ Incorporate new approaches

♦ Build upon state and local incentives

♦ Minimize green-washing
What the Standard Guide Does

♦ Codify best practices
♦ Define a process for reducing environmental footprint
♦ Provide a protocol for contracting purposes
♦ Provides “brand recognition” for greener cleanups
♦ Results in a transparent documented process that is reported publically
Summary: Leveraging innovation efficient remedies with a lower environmental footprint

♦ Cost effectiveness and large reductions in environmental footprints come from...
  » Accurate CSM
  » Well-characterized source areas and contaminant plumes
  » Optimal remedial strategy
  » Adaptive management
  » Streamlined performance monitoring

♦ Further environmental footprint reductions are achieved applying green remediation best management practices

♦ As a result, we sustainably protect human health and the environment prepare sites for reuse
We have made significant progress in pollution prevention and remediating legacy contaminated sites, but we still have work to do.

Remediation sector is benefiting from years of investments and technology developments. Once “innovative approaches” are now mainstream.

Several evolving concepts are helping us achieve protectiveness at lower cost and environmental footprint.

EPA seeks to further reduce the environmental footprint of cleanups, while integrating community interests, and supporting economic growth.
Thank You!

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EPA Office of Superfund Remediation and Technology Innovation  
US EPA, Washington DC  
Presentation available at - http://cluin.org/global
EPA Information and Resources

Superfund Remedies Report:
http://www.epa.gov/superfund/remedytech/srr/

Key EPA Superfund Groundwater Policies:
http://www.epa.gov/superfund/health/conmedia/gwdocs/

Groundwater Remedial Action Completion Guidance(s):
http://epa.gov/superfund/health/conmedia/gwdocs/remedial.htm

Remedy Optimization:
http://www.cluin.org/optimization/

Green Remediation:
http://cluin.org/greenremediation

High Resolution Site Characterization:
http://cluin.org/hrsc
Federal and State Links to Optimization Resources

♦ EPA’s Remedy Optimization
  » www.epa.gov/superfund/cleanup/postconstruction/optimize.htm

♦ CLU-IN Optimization
  » www.cluin.org/optimization

♦ U.S. Army Corps of Engineers

♦ U.S. Army Environmental Command
  » www.aec.army.mil/usaec/cleanup

♦ U.S. Air Force Center for Engineering and the Environment

♦ U.S. Naval Facilities Engineering Command
  » www.ert2.org/T2Opt/

♦ Federal Remediation Technologies Roundtable
  » www.frtr.gov/optimization/

♦ Interstate Technology Regulatory Council
  » www.itrcweb.org/teampublic_RPO.asp