A/M Area Groundwater Cleanup
Status Update

A Presentation to the
Citizens Advisory Board

Chris Bergren
Project Manager
Savannah River Nuclear Solutions
Upper Three Runs and Reactors

January 26, 2009
<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE</td>
<td>Department of Energy</td>
</tr>
<tr>
<td>DUS</td>
<td>Dynamic Underground Stripping</td>
</tr>
<tr>
<td>ERT</td>
<td>Electrical Resistance Tomography</td>
</tr>
<tr>
<td>RCRA</td>
<td>Resource Conservation and Recovery Act Permit</td>
</tr>
<tr>
<td>SCDHEC</td>
<td>South Carolina Department of Health &amp; Environmental Control</td>
</tr>
<tr>
<td>SVE</td>
<td>Soil Vapor Extraction</td>
</tr>
<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
</tr>
<tr>
<td>VOS</td>
<td>Vadose Oil Substrate</td>
</tr>
</tbody>
</table>
Agenda

• A/M Area Remediation History
• Cleanup Progress
• A/M Groundwater Remediation Framework
• Technology Application – examples
• New Technologies
• Path Forward
Purpose

- Provide an update on the A/M-Area Groundwater remediation to the Citizens Advisory Board
Remediation History of A/M Area

- 3.5 million pounds of solvents released to multiple sources that seeped into soils and groundwater (1950s to 1980s)
  - Large contaminated groundwater plume approximately 1500 acres
  - Contained to SRS; no offsite contamination
- Cleanup is conducted under South Carolina Department of Health & Environmental Control (SCDHEC) Resource Conservation and Recovery Act Permit (RCRA) - issued in 1987
- Multiple treatment technologies in use, include:
  - Airstripping
  - Soil vapor extraction
  - Recirculation wells
  - Dynamic Underground Stripping
  - Baroballs
  - Microblowers
Remediation History of A/M Area
(continued)

• Groundwater remediation efforts refocused over time:
  – Early: Plume control
  – Today: Source removal

• Over 4.8 billion gallons of groundwater treated; 1.4 million pounds of solvents removed from the subsurface since 1983
M Area Historical Timeline

- M-Area Metal-Working Facilities
- M-1 Air-Stripper
- Soil Vapor Extraction Unit
- BaroBall
- Phytoremediation Southern Sector of A/M Area
- M Settling Basin
- Lost Lake
- Sludge Removal
- Capping
- A/M Area Plume - 1500 Acres

Timeline:
- 1954 - 1988
- 1983
- 1987
- 1990
- 1996
- 2000
- 2002
- 2003
- 2005
- 2007
- 2008

Key Events:
- RCRA Permit Issued by SCDHEC
- Airlift Recirculation Wells
- Area Completion Strategy MOA
- Dynamic Underground Stripping Phase 1
- Dynamic Underground Stripping Phase 2

Legend:
- Green: Water
- Yellow: Contaminated Soil
- Red: Impact Zone
- Blue: Treatment Area

A/M Area VOC Removal
A / M Groundwater Remediation Framework

- Protect groundwater from further degradation
- Reduce plume migration minimizing impacts to:
  - Surface water
  - Deeper groundwater
  - Ecological community
- Focus on source remediation, including vadose zone
  - Significant reductions in time to reach cleanup goals
- Optimize groundwater projects to improve remediation effectiveness
A / M Groundwater Remediation Framework
(continued)

- Develop and implement alternative remediation technologies
  - Transition from active remediation systems to passive processes as contaminant concentrations decrease

- Monitor effectiveness of remediation systems to determine if necessary changes or enhancements are needed or possible

- Optimize groundwater monitoring to reduce long-term costs

- Conduct all groundwater activities with regulatory involvement and approvals
Remediation Strategy

Treating a Contaminated Site

Waste Site

Source Zone
Highly Aggressive Technologies:
- Excavation
- Heating (Dynamic Underground-Stripping or Electrical Resistance Heating)
- In situ chemical oxidation
- Active Soil Vapor Extraction

Primary Groundwater / Vadose Zone Plume

Less Aggressive Active Technologies:
- Air stripping
- Recirculation wells
- Hydraulic barrier / Phyto-irrigation
- Base injection

Low Energy Technologies:
- Phytoremediation
- Passive Soil Vapor Extraction (baroballs)
- Monitored Natural Attenuation

Enhanced Attenuation alternatives can apply to all zones to supplement Monitored Natural Attenuation (MNA):
- Capping, Oil Partitioning
- Permeable Biotreatment Wall
- Constructed Wetland

Highlighted technologies above represent those being utilized at A/M Area.
Technology Application - Examples

• Source Remediation
  – Dynamic Underground Stripping

• Passive Systems
  – Baroballs
  – Microblowers
Dynamic Underground Stripping at the M Area Settling Basin

- Utilizes steam to heat / vaporize solvent contaminants
- 12,000,000 cubic feet targeted over three acres, to depths of 160 feet
- Over 425,000 pounds of solvents removed to date
- Significant reduction in time to reach cleanup goals (75 times faster than pump and treat)

Originally used by the petroleum industry for secondary oil and gas recovery
Dynamic Underground Stripping
(continued)

- Steam is injected into subsurface
- VOCs captured by extraction wells and brought to the surface
- Utilize horizontal and angled wells to access contaminants
- Subsurface probes monitor heating progress
- Greatly accelerates groundwater cleanup
Dynamic Underground Stripping

Contaminated Liquid (M1 Airstripper)

Vapors (SVE Unit)

Vacuum removes vapor

Tomography monitors steam movement

Ground water is pumped

Steam zone is dry

Steam distills organics

Steam Zone

Permeable Layer

Groundwater is displaced by steam

Volatiles driven by steam

Steam Zone

Steam Zone

Green Clay
Baro Ball
Microblower
New Technologies

- Soil Fracturing to enhance Soil Vapor Extraction (SVE)
- Edible Oil Induced Partitioning and Degradation in the Vadose Zone (passive replacement of SVE)
Soil Hydraulic Fracturing

• Deployed in 2008
• High pressure “notching” of formation initiates fracture (vadose zone)
• Inject sand, water, and guar slurry into formation
• Creates horizontal fractures with radius approximately 10 ft.; fractures can be made at any depth
• SVE flow rates increased by an order of magnitude
Fracturing

Soil notching using a high pressure jet – initiates fractures horizontally

Mixed guar/sand slurry loading into the pumping hopper
Proposed Vadose Oil Substrate (VOS) Field Test (Injection Location)

• VOS (patent pending) is a mixture of edible oil and water with nutrients, buffers and microbes
• Designed to be easily injected in the vadose zone
• VOS sequesters the solvents by diffusion and partitioning and creates an efficient bioreactor for degradation for long-term enhanced attenuation and flux reduction
Path Forward

- Continue to explore application of new technologies
- Aggressively pursue remedial optimization
- Continued monitoring to ensure protectiveness of human health and environment is maintained