U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Innovative Risk Management Techniques in Environmental Remediation

Cathy Lewis

EC&ACP Engineering,
Remediation Support
Savannah River Nuclear Solutions

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Purpose

- Fulfill a 2015 Facilities Disposition & Site Remediation Committee Work Plan topic
- Provide an overview of the evolution of technologies and techniques used for Environmental Remediation at SRS.
  - ◇ Traditional technologies used in early phases
  - ◇ Developed new technologies
  - ◇ Adapted existing technologies from other industries for environmental clean up at SRS
  - ◇ Transition from Active to Passive Technologies

Acronyms

- ER – Environmental Restoration
- SRS – Savannah River Site
- VOCs – Volatile Organic Compounds
- SVE – Soil Vapor Extraction
- SRNL – Savannah River National Laboratory

History of Technology Deployment

- Beginning in the mid-1990s, SRS began intensively developing and executing new and innovative technologies for use in the Environmental Restoration (ER) program.
- Overall, more than 110 new characterization and remediation technologies have been deployed, some examples of which will be discussed during this presentation.

Savannah River Site
M Area History

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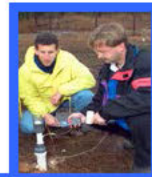
M Area Historical Timeline

M-Area Metal-Working Facilities

M-1Air-Stripper

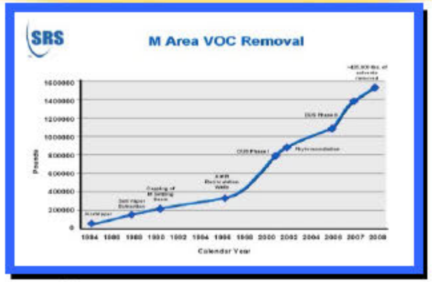
Soil Vapor Extraction Unit

BaroBall



Airlift Recirculation Wells

Phytoremediation Southern Sector of A/M Area



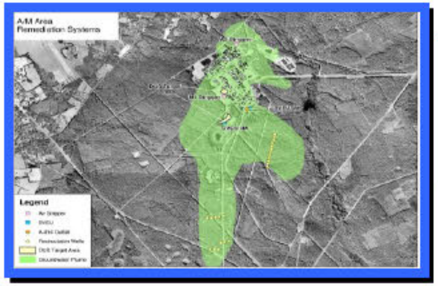
RCRA Permit Issued by SCDHEC

Area Completion Strategy MOA

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

Dynamic Underground Stripping Phase 1

Dynamic Underground Stripping Phase 2



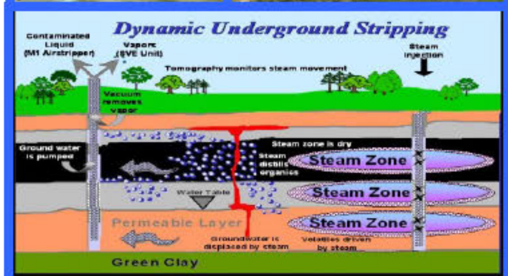
A/M Area Plume - 1500 Acres

M Settling Basin

Lost Lake

Sludge Removal

Capping



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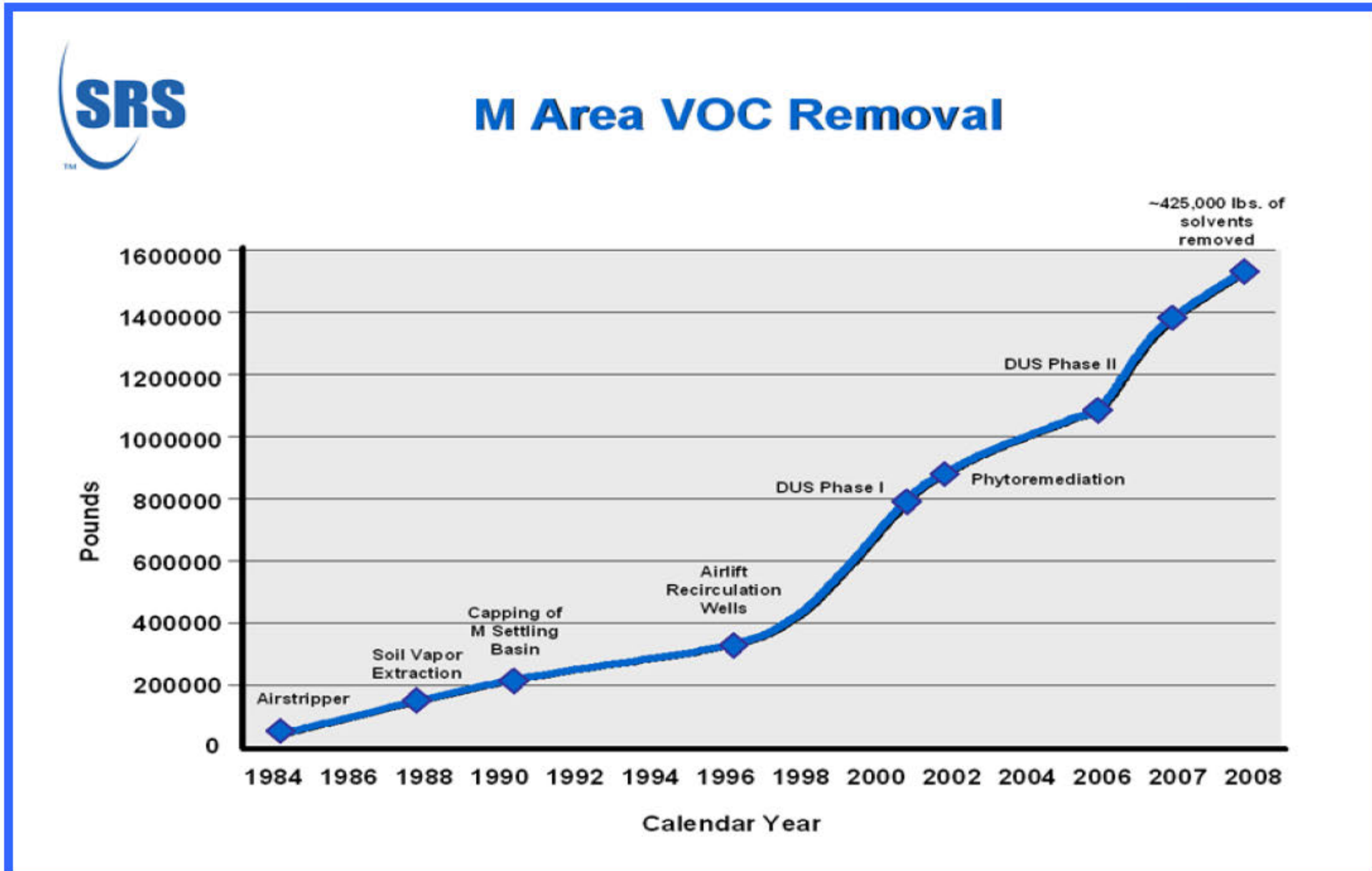
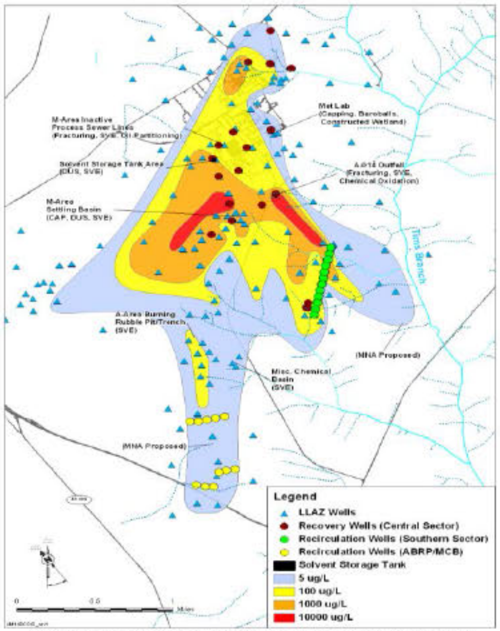
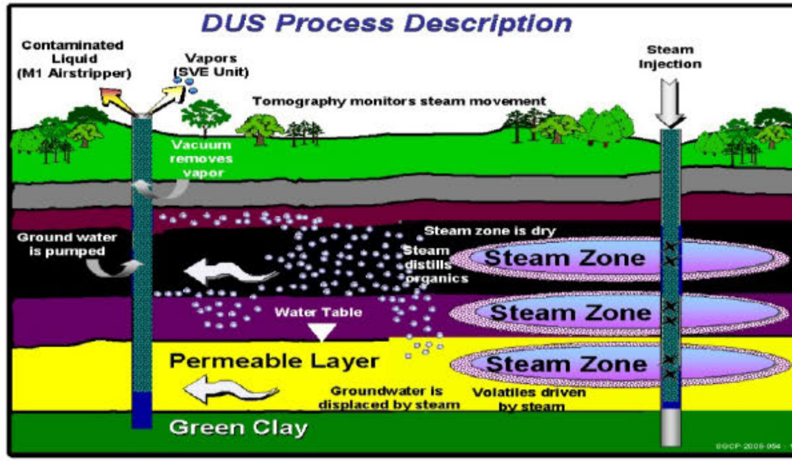

M Area VOC Removal
~425,000 lbs. of solvents removed
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
Pounds
Airstripper
Soil Vapor Extraction
Capping of M Settling Basin
Airlift Recirculation Wells
DUS Phase I
Phytoremediation
DUS Phase II
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2007
2008
Calendar Year

Dynamic Underground Stripping



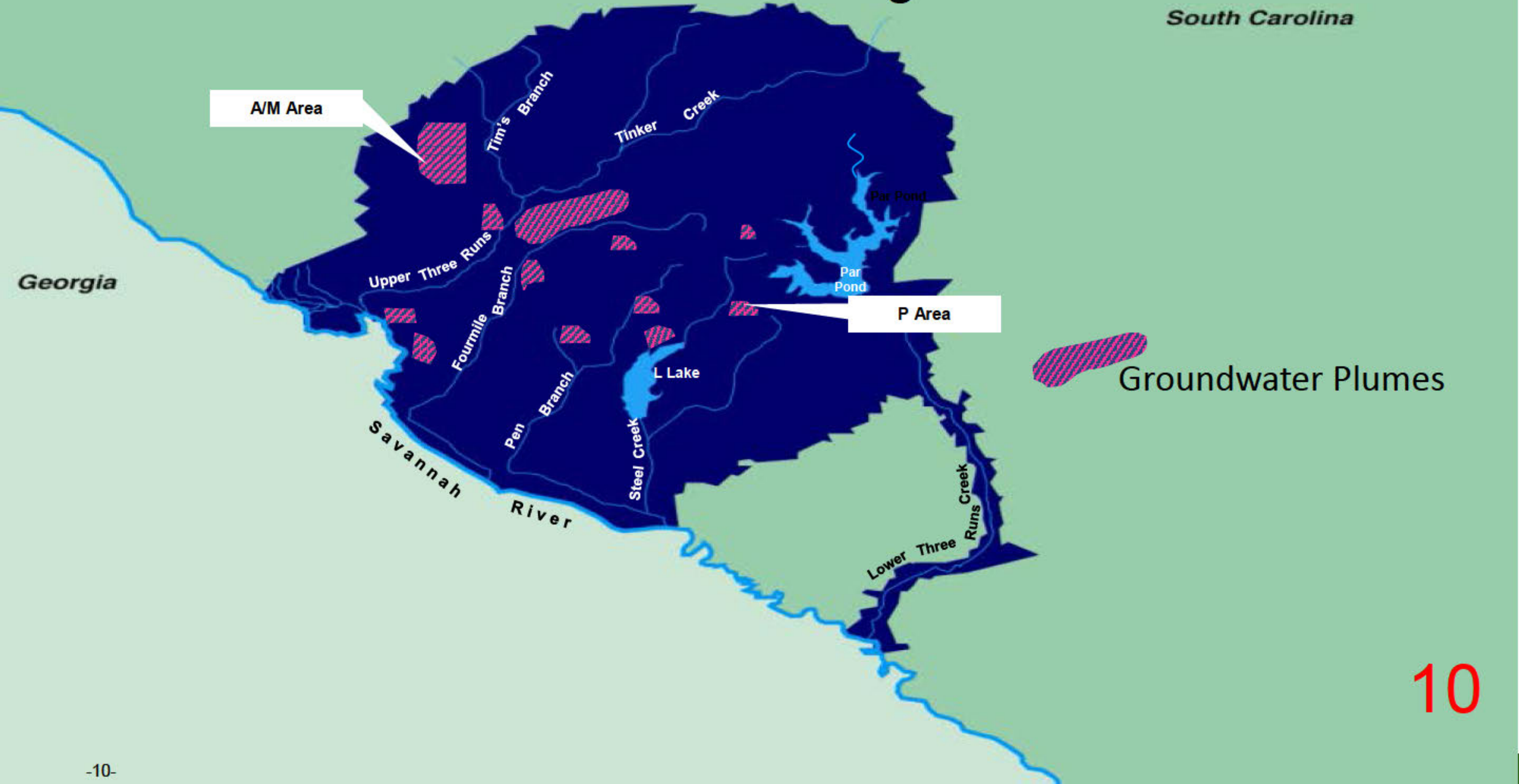
A/M-Area Composite TCE Plume with Sources and Remediation Technologies



Technologies borrowed from the Oil Industry

- Steaming
  - ◇ M Area Dynamic Underground Stripping (DUS)
- Subsurface Fracturing
  - ◇ M Area Process Sewer Lines (MAPSL)
  - ◇ A-14 Outfall in M Area
  - ◇ P Area Vadose Zone Source Area

Savannah River Site
Fracturing



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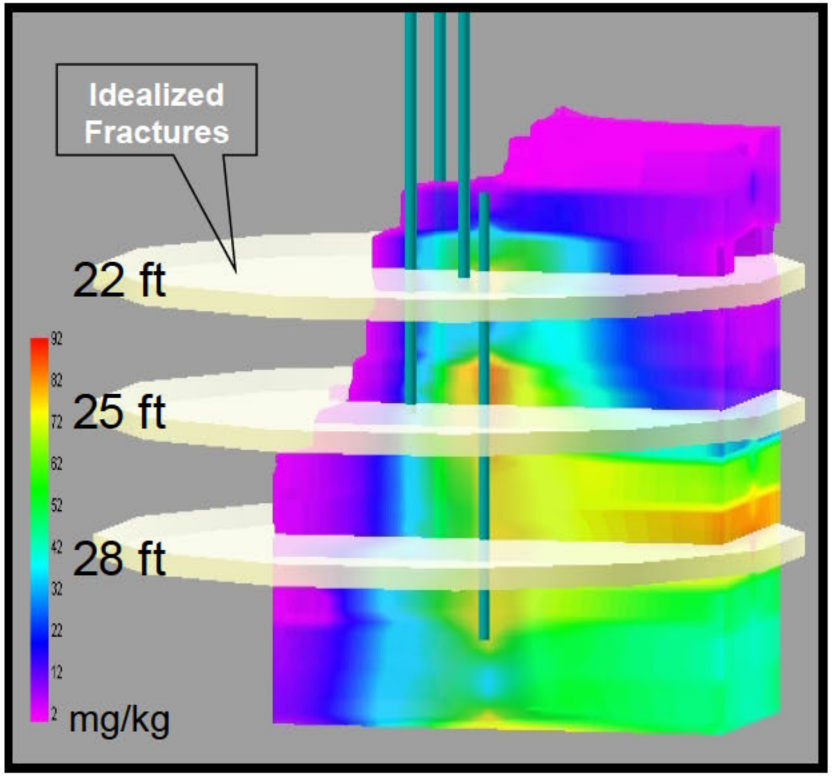
Soil Hydraulic Fracturing



- 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

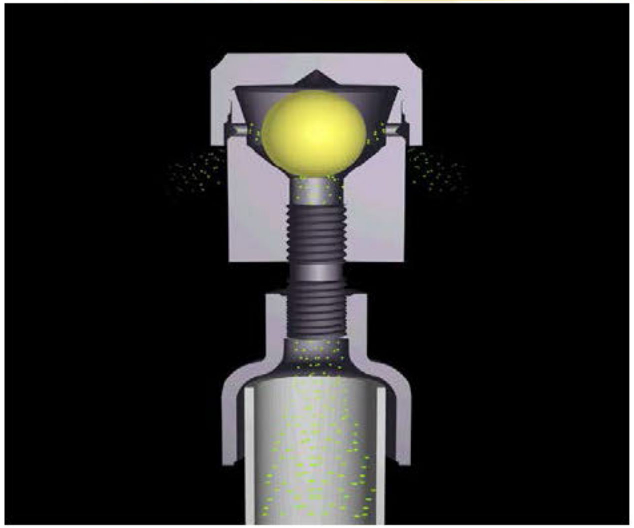
Mixed guar/sand slurry loading into the pumping hopper

Remediation Technologies Developed at SRS

- Some examples of technologies that were developed at SRS, or modified by SRS, to meet the site-specific needs:
  - ◇ Soil Vapor Extraction by Solar Microblowers
  - ◇ Barometric Pumping (Baroballs™)
  - ◇ Edible Oil Injection
  - ◇ Phyto-remediation
  - ◇ In-Situ Soil Mixing Subsurface Barrier
  - ◇ Silver Chloride Injection
  - ◇ Bio-remediaiton using Micro-CED

Soil Vapor Extraction with Solar Powered Micro-blowers

Soil Vapor Extraction with Barometric Pumping (Baroballs)

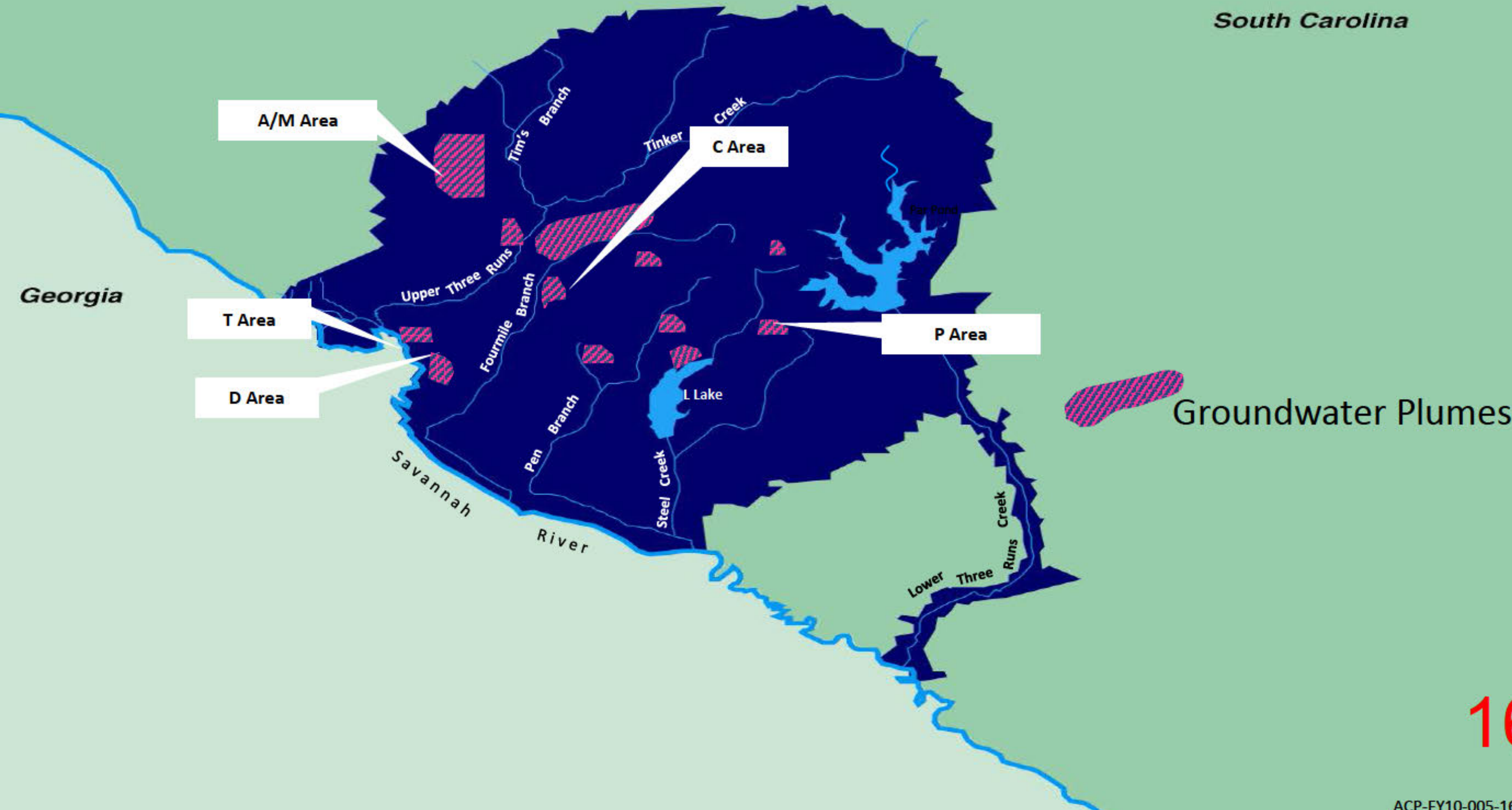


When the subsurface pressure is higher than at ground surface, contaminants naturally move upward through venting wells.

When the above ground pressure is greater, air is prevented from traveling down by a simple plastic sphere.

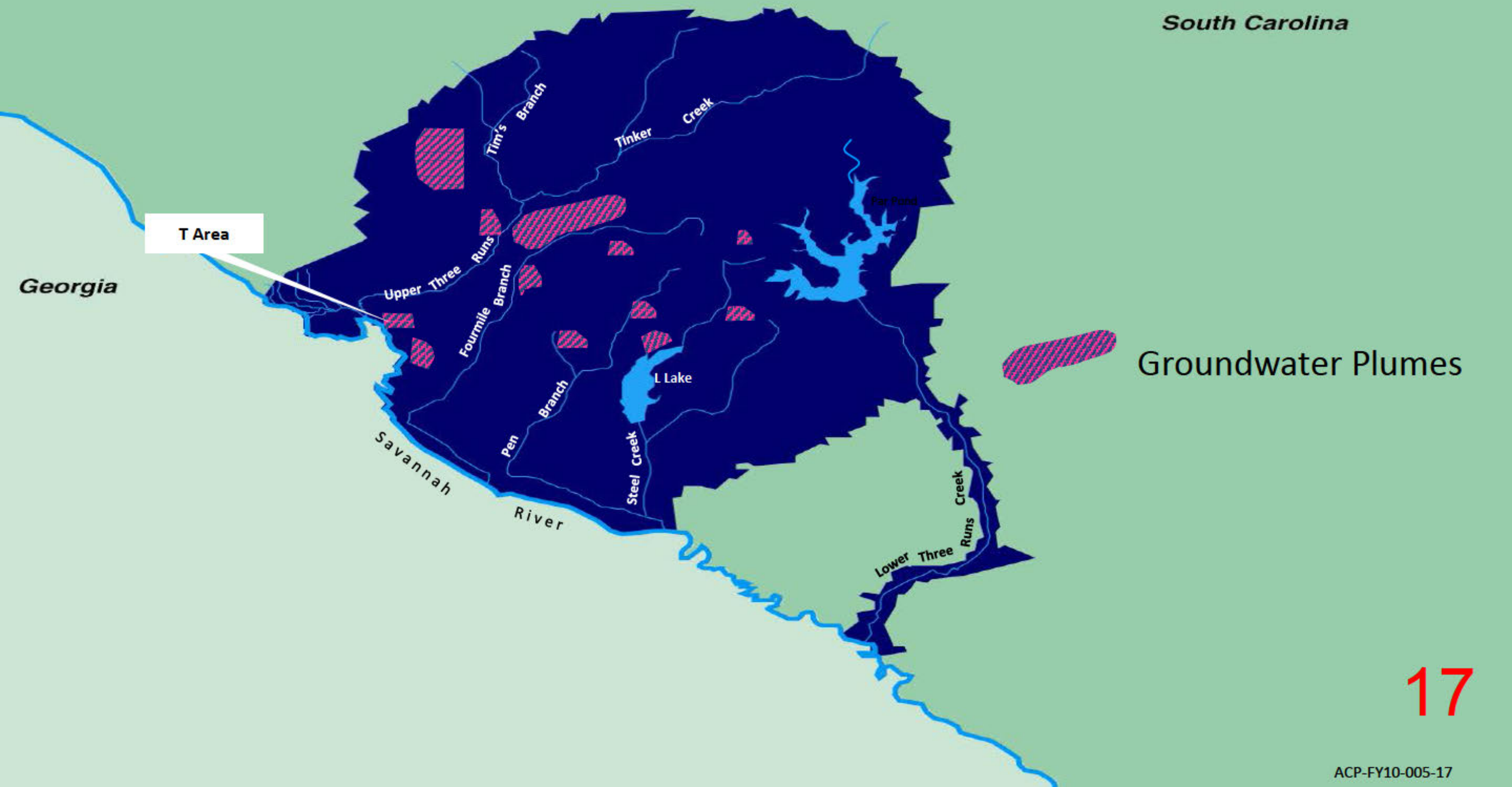
Savannah River Site

Micro-blowers and Baroballs



Savannah River Site

Edible Oil Injection at T Area



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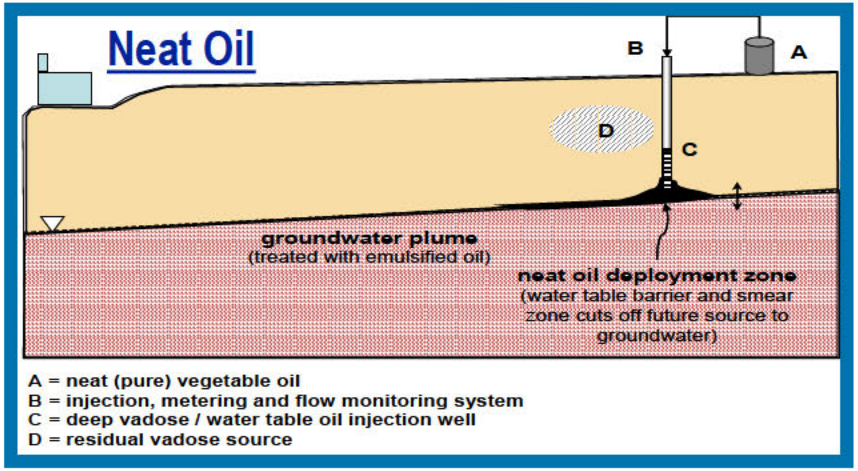
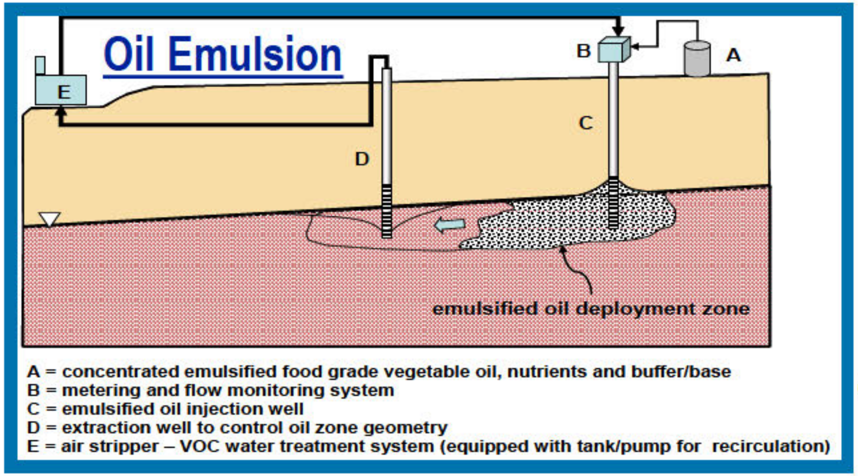
T Area Active to Passive Transition

- T Area groundwater clean up of VOCs was initially by traditional remediation technologies
  - ◇ Pump and treat with air stripping
  - ◇ Soil Vapor Extraction (traditional SVE)

- Transitioned to
  - ◇ Edible Oil Injection
  - ◇ SVE by Microblowers

Edible Oil Injection at T Area



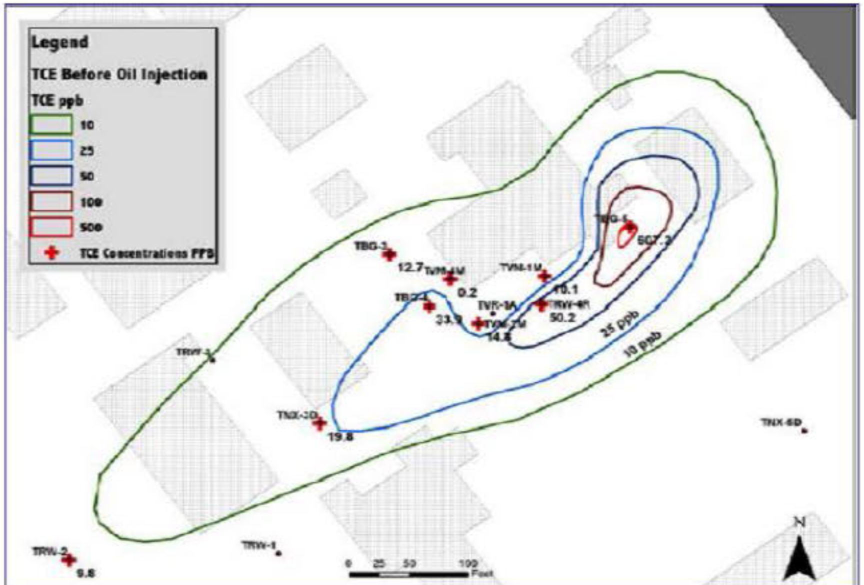


Edible Oil injection techniques to sequester and biologically destroy the VOCs

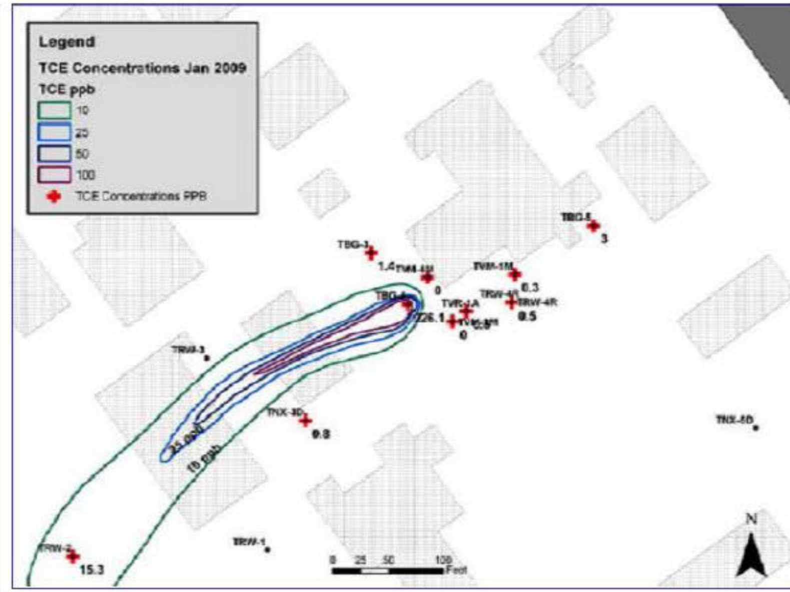
- Inject Neat Edible Oil to sequester VOCs (vadose zone source)
- Inject Edible Oil emulsion (food source) to promote microbial activity (reductive dechlorination)
- Obvious results in less than six months

Edible Oil Injection at T Area

T Area Edible Oil (Before and After)

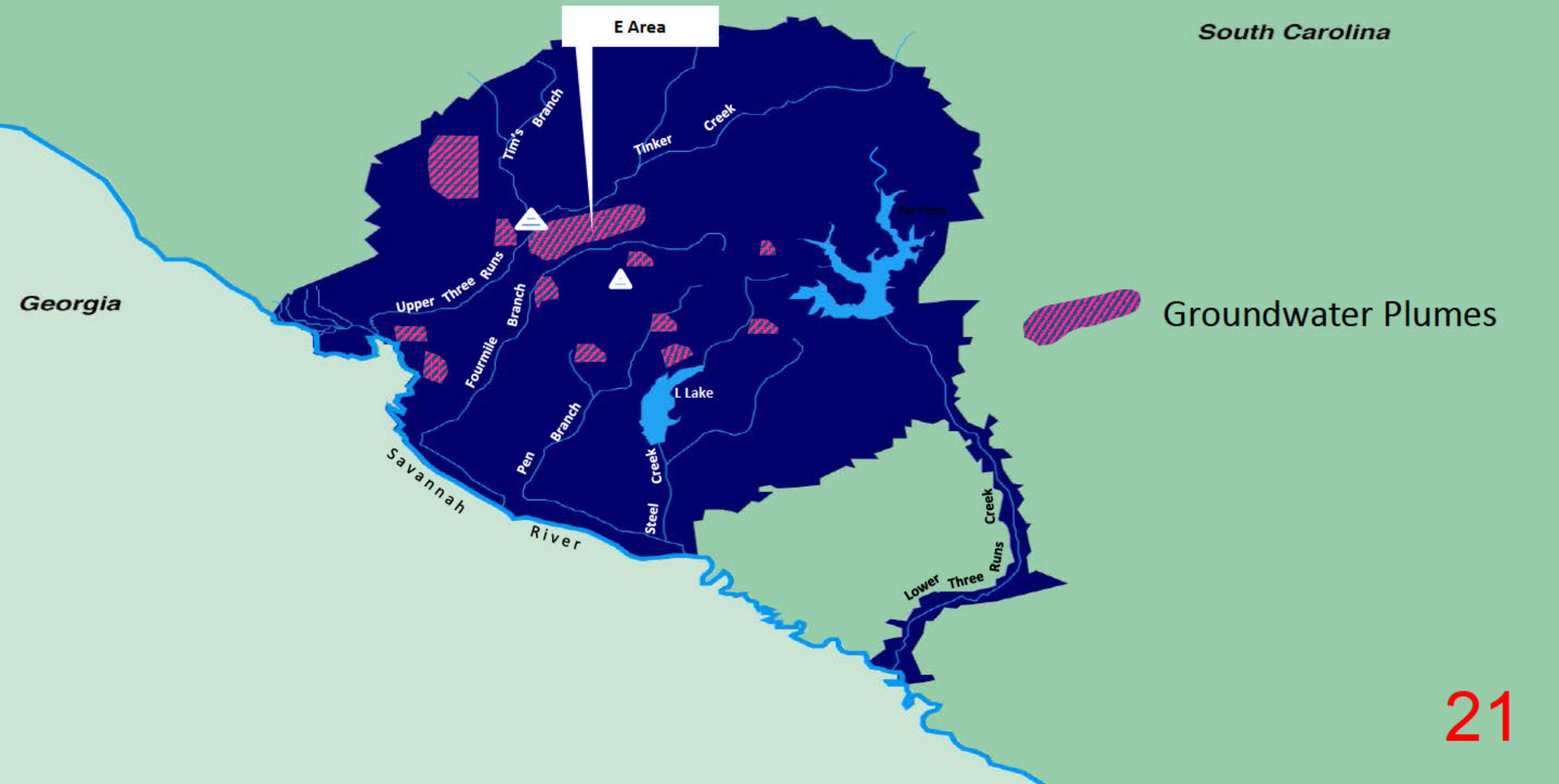


Plume before oil injection.



Plume after oil injection.

Savannah River Site
Phyto-Remediation Project



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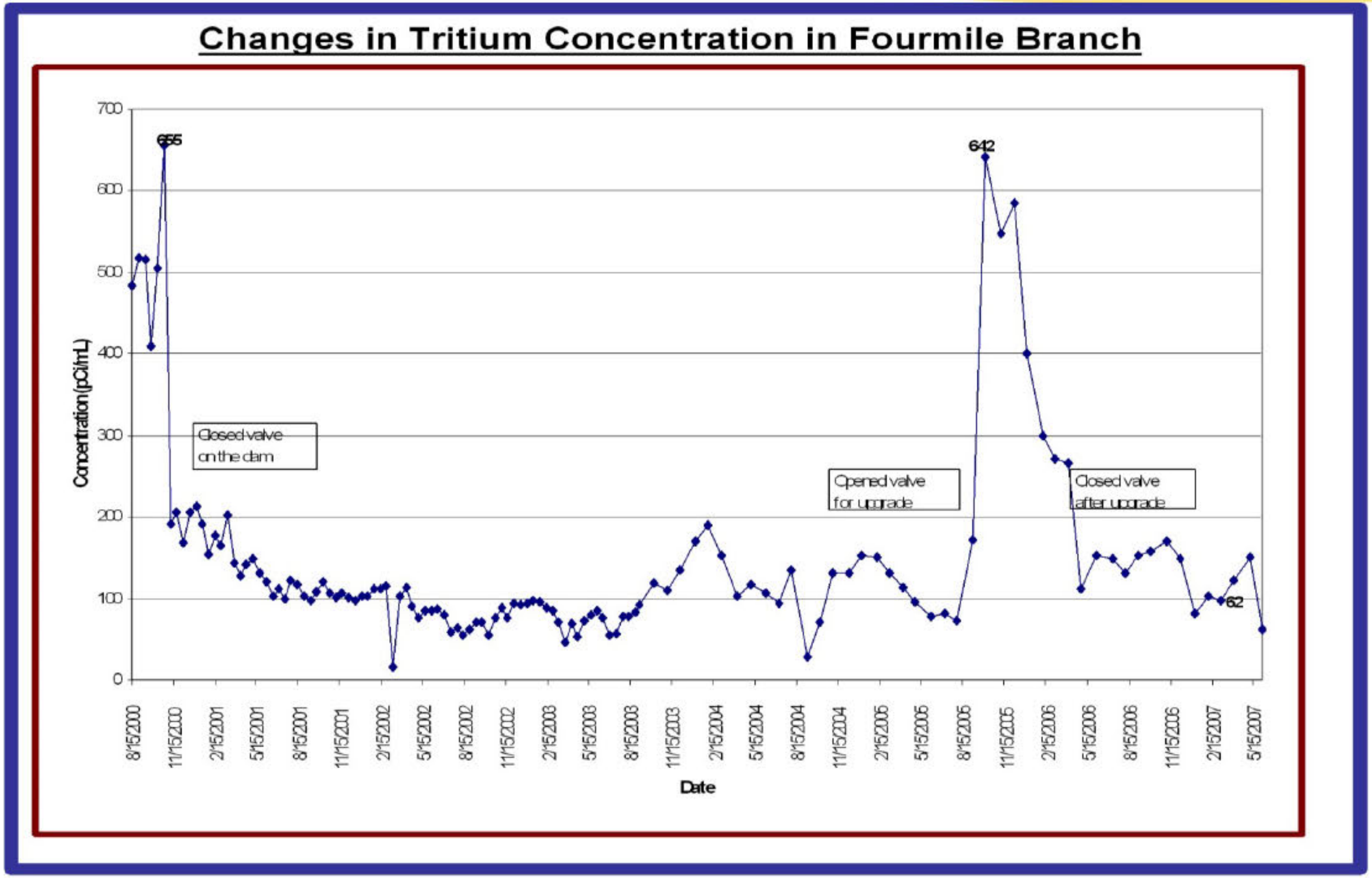
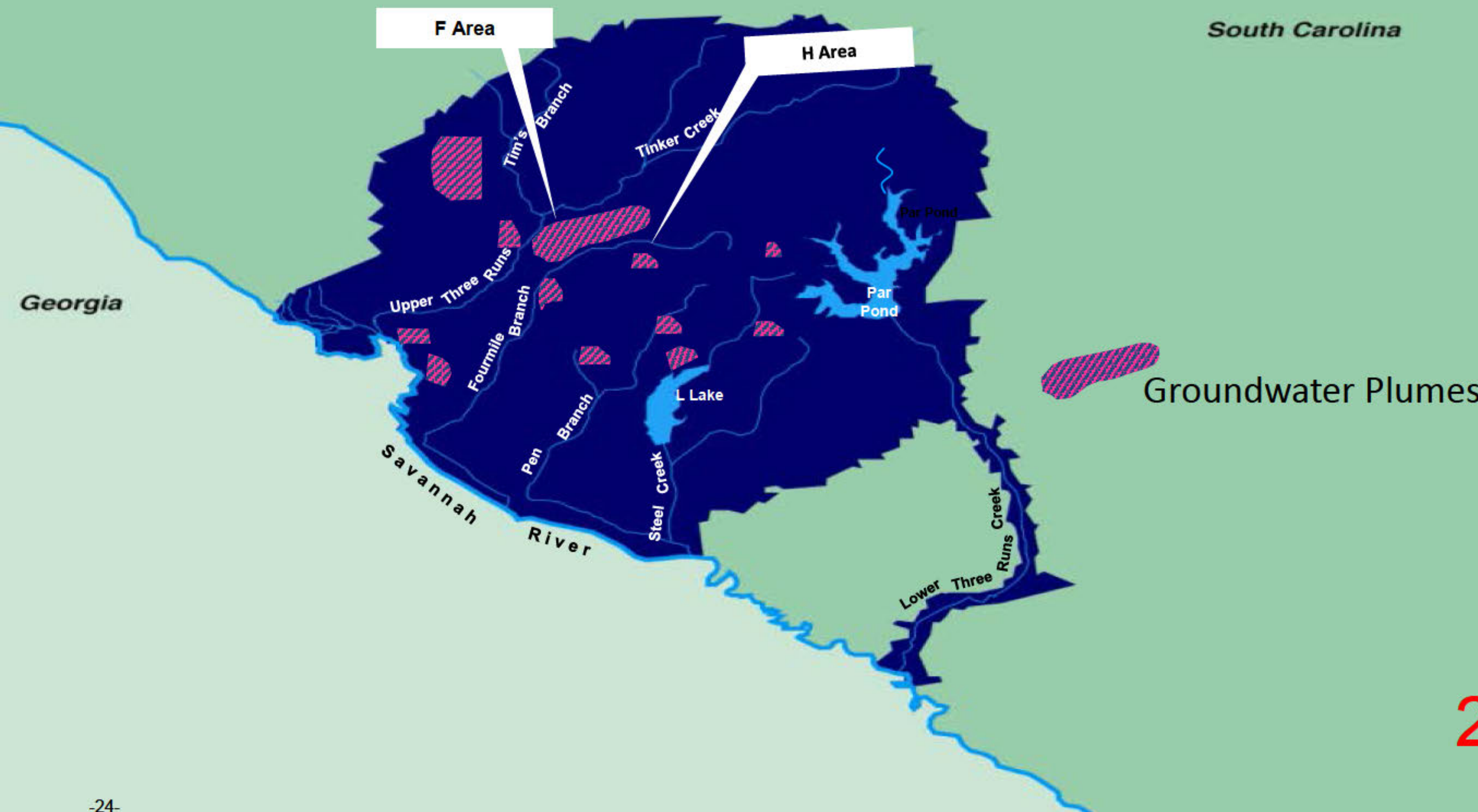
Phyto-remediation with collection pond and irrigation

- Tritium contaminated groundwater is intercepted before discharging to stream.
- The water is used to irrigate pine forests.

Tritium in Fourmile Branch



Savannah River Site
Subsurface Barriers

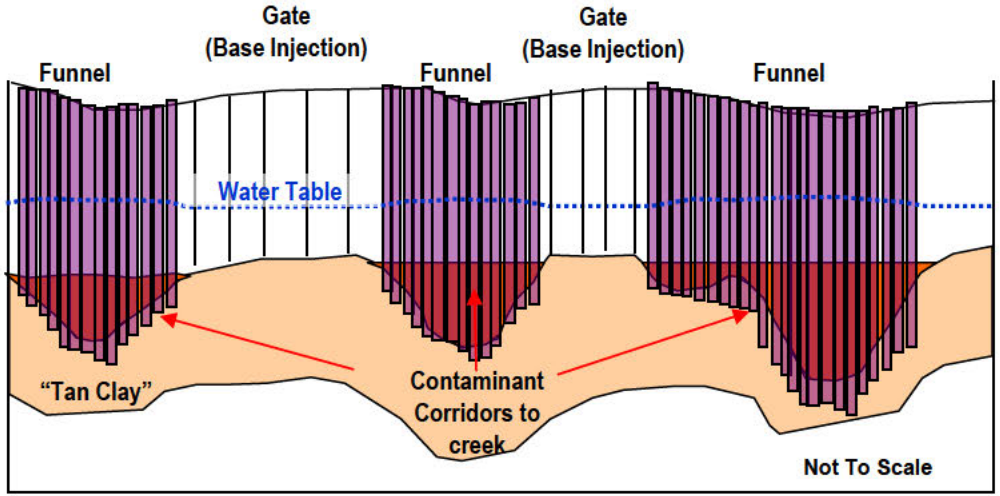


In-Situ Soil Mixing Barrier Wall

- The barrier wall technique was installed in F- and H-Areas on SRS as a means of locally controlling the flow of contaminated groundwater.
  - ◇ Deep soil mixing was used to mix an inert, low permeability grout into existing soils to form a series of low permeability barrier walls.
  - ◇ The walls redirect the flow of the groundwater, and the longer travel time allows for increased radioactive decay, and the slowed release rate reduces the concentration of tritium in nearby streams.

In-Situ Soil Mixing Subsurface Barrier

Subsurface Barriers form Funnel and Gate System in F Area

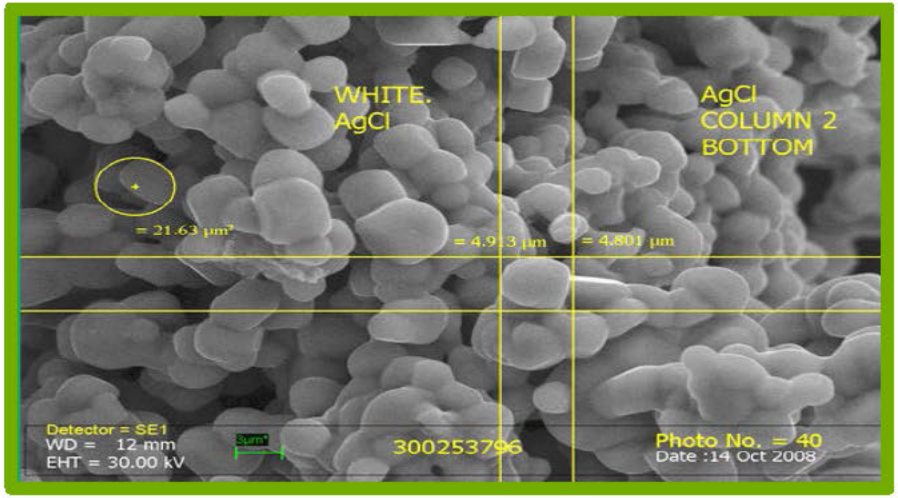


F Area Groundwater Cleanup Strategy

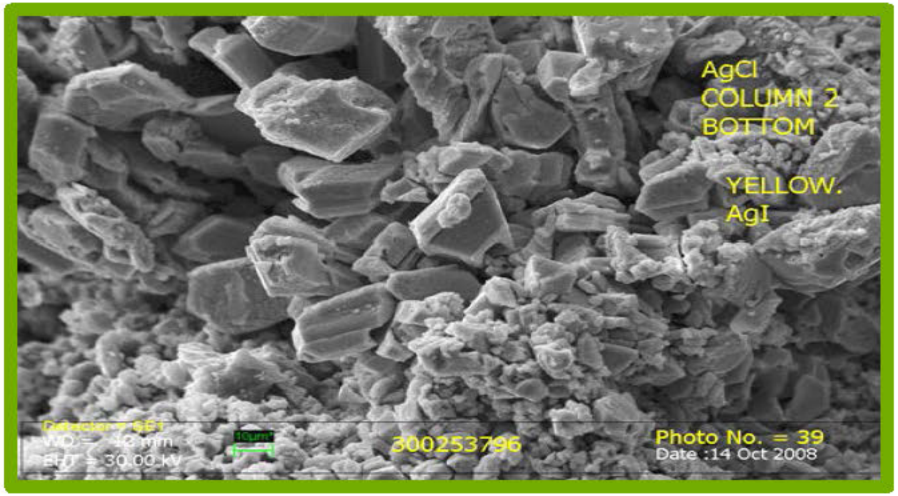
Iodine Capture with Silver Chloride Injection

- SRNL invented the use of silver-bearing materials to capture radioactive Iodine-129 (I-129) by injecting silver chloride along a groundwater flow path.
  - ◇ I-129 can be captured with silver chloride to form silver iodide which has a very low solubility, causing the I-129 to remain in the sub-surface, not moving with the groundwater
  - ◇ The technology was deployed in F-Area in 2011, and the sample results to date show that the concentration of I-129 has been reduced by 40%.

Silver Chloride



Silver Chloride Before Capture of Iodine



**Silver Chloride in a Soil Matrix
After Capture of Iodine
(Crystal Structure Change)**

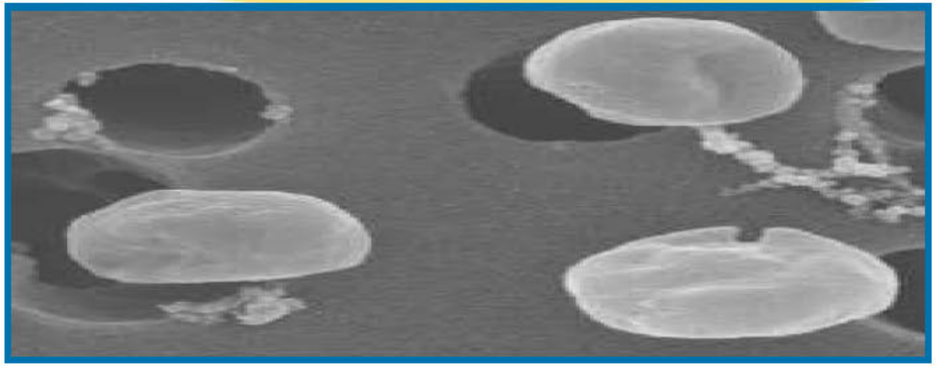
Silver Chloride Injection F Area

Savannah River Site

Bio-remediation using MicroCED at P Area

MicroCED at P-Area

Micro-biological-based Chlorinated Ethene Destruction (MicroCED)

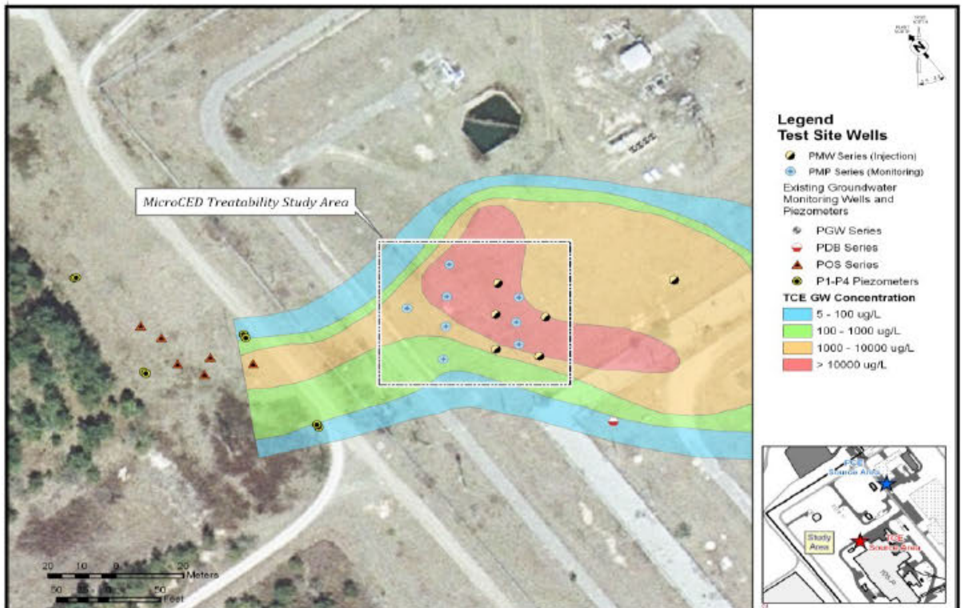


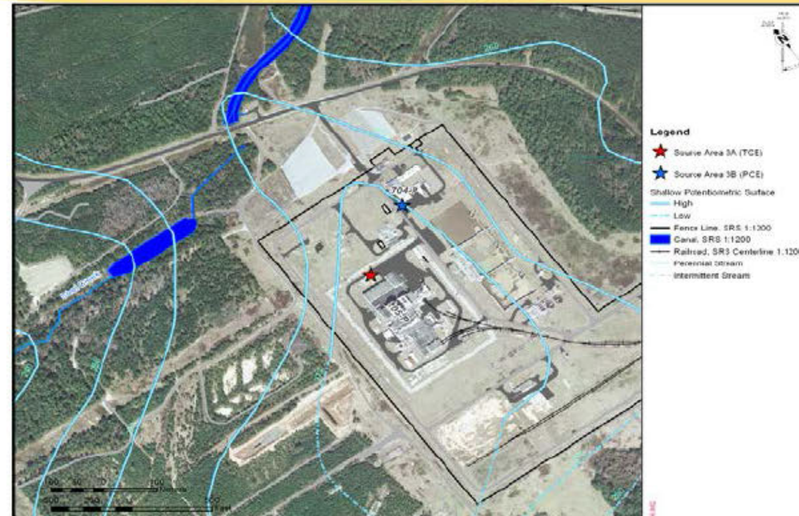
Microscopic picture of MicroCED

- Indigenous bacteria discovered at SRS
- Bacterial activity can result in complete degradation of VOCs

MicroCED growth canister.

Bio-remediation at P Area using MicroCED





Technology Deployment at SRS

- Some benefits of SRS's long history of developing and implementing alternative technologies:
  - Gaining regulator support for use of innovative technologies
  - Able to evaluate technology effectiveness in the field
  - Technologies developed specifically for SRS
  - Technologies "borrowed" from industry, and adapted to SRS's needs
  - Using SRS as "proving ground" for future implementation
  - Sharing technologies with regulators, industry, and other federal facilities

Technology Success

- Robust source control measures can offer return on investment
- Simple basic solutions work well (baroballs, microblowers)
- Working with nature works well (bio-, phyto-remediation)
- Long history of successful innovative technology implementation at SRS (WSRC-RP-99-4015) on the SRS web site

http://irmsrv02.srs.gov/general/programs/soil/gen/sgcp_tech_descriptions.pdf

Looking to the Future

- Transitioning from active to passive cleanup
  - ◇ Enhanced Natural and passive technologies
  - ◇ Efficient long-term monitoring
- Green Remediation
  - ◇ Minimize energy usage
  - ◇ Minimize waste generation
  - ◇ Minimize carbon emissions
  - ◇ Minimize impact to natural environment / resources

Summary

- SRS continues to explore applications of new technologies
  - ◇ Reach remedial goals less expensively
  - ◇ Reach remedial goals more quickly
  - ◇ Passive technologies
  - ◇ Green technologies

Active → Passive → Natural

Questions

Questions?