



U.S. DEPARTMENT OF
ENERGY

OFFICE OF
**ENVIRONMENTAL
MANAGEMENT**

Innovative Risk Management Techniques in Environmental Remediation

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Facilities Disposition and Site Remediation Committee

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- **Overview 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

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

- **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



M Area Historical Timeline

M-Area
Metal-Working Facilities



M-1 Air-Stripper



Soil Vapor
Extraction Unit



BaroBall



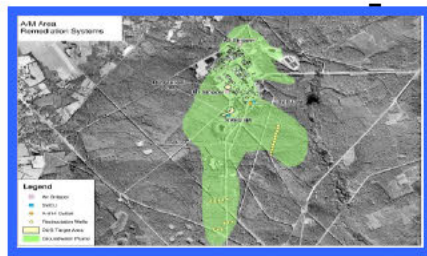
Phytoremediation
Southern Sector of A/M Area



RCRA Permit
Issued by
SCDHEC

Area
Completion
Strategy MOA

Airlift Recirculation Wells



M Settling
Basin



Lost Lake



Sludge Removal



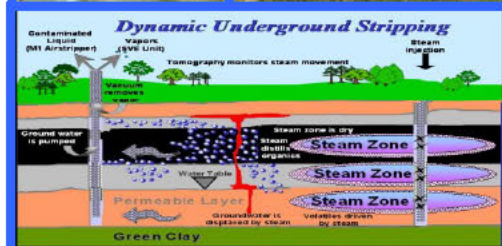
Capping



Dynamic Underground
Stripping Phase 1

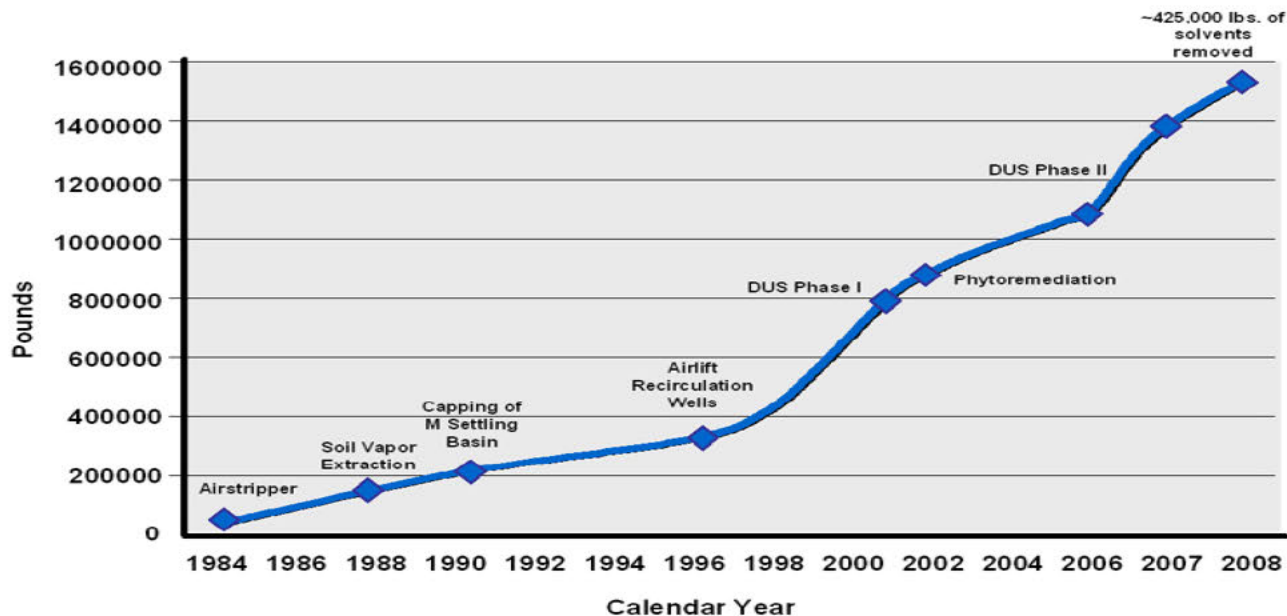


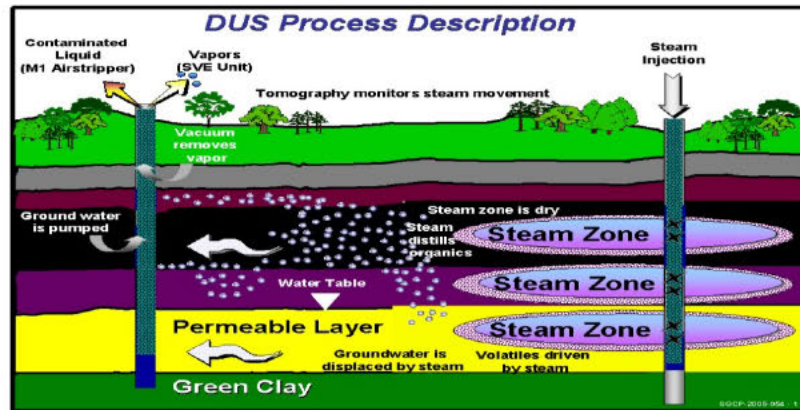
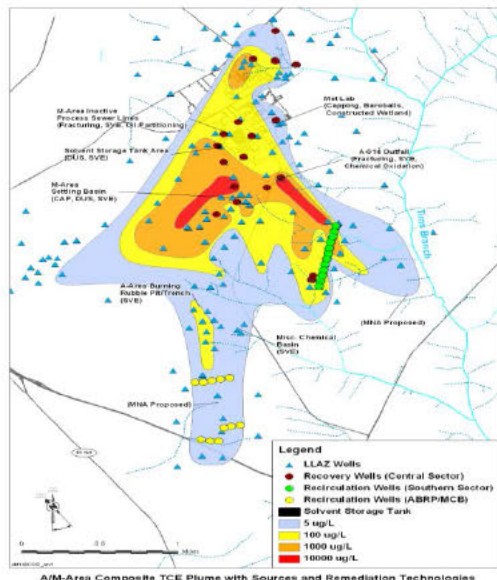
Dynamic Underground
Stripping Phase 2



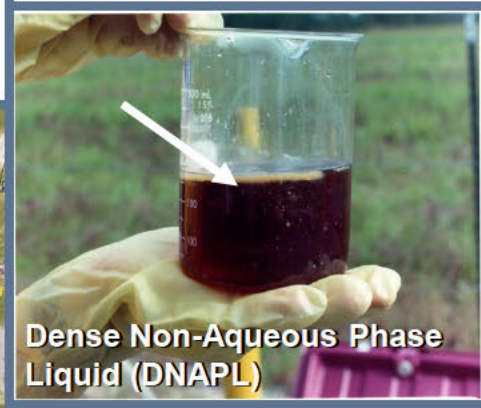


M Area VOC Removal





Dynamic Underground Stripping



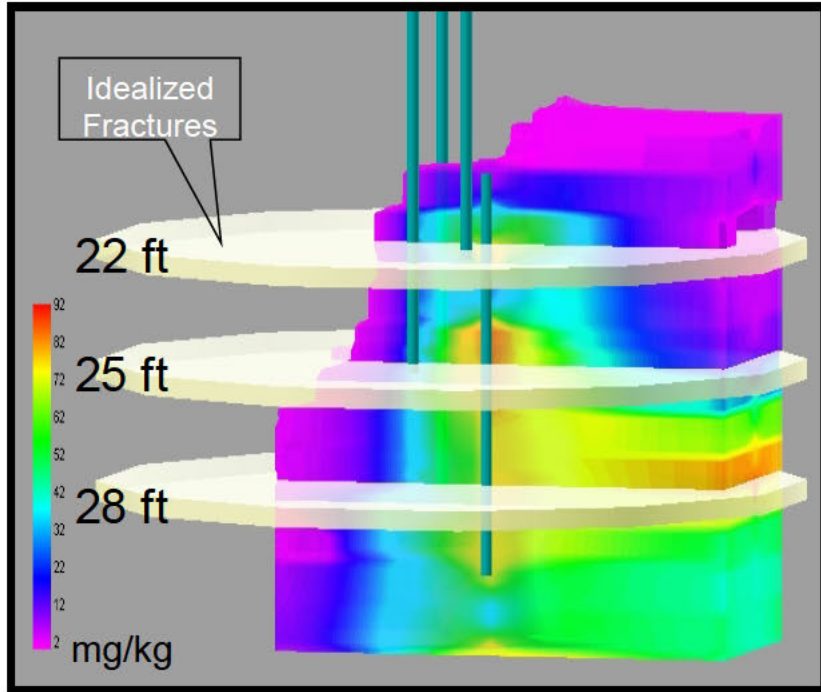
Technologies borrowed from the Oil Industry

- **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*



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

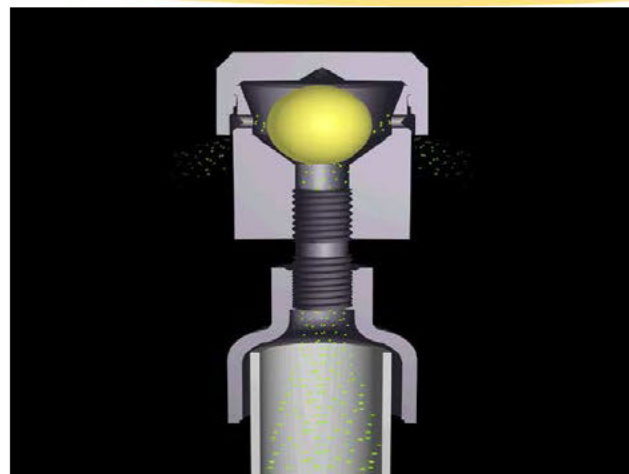
Remediation Technologies Developed at SRS

- **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)



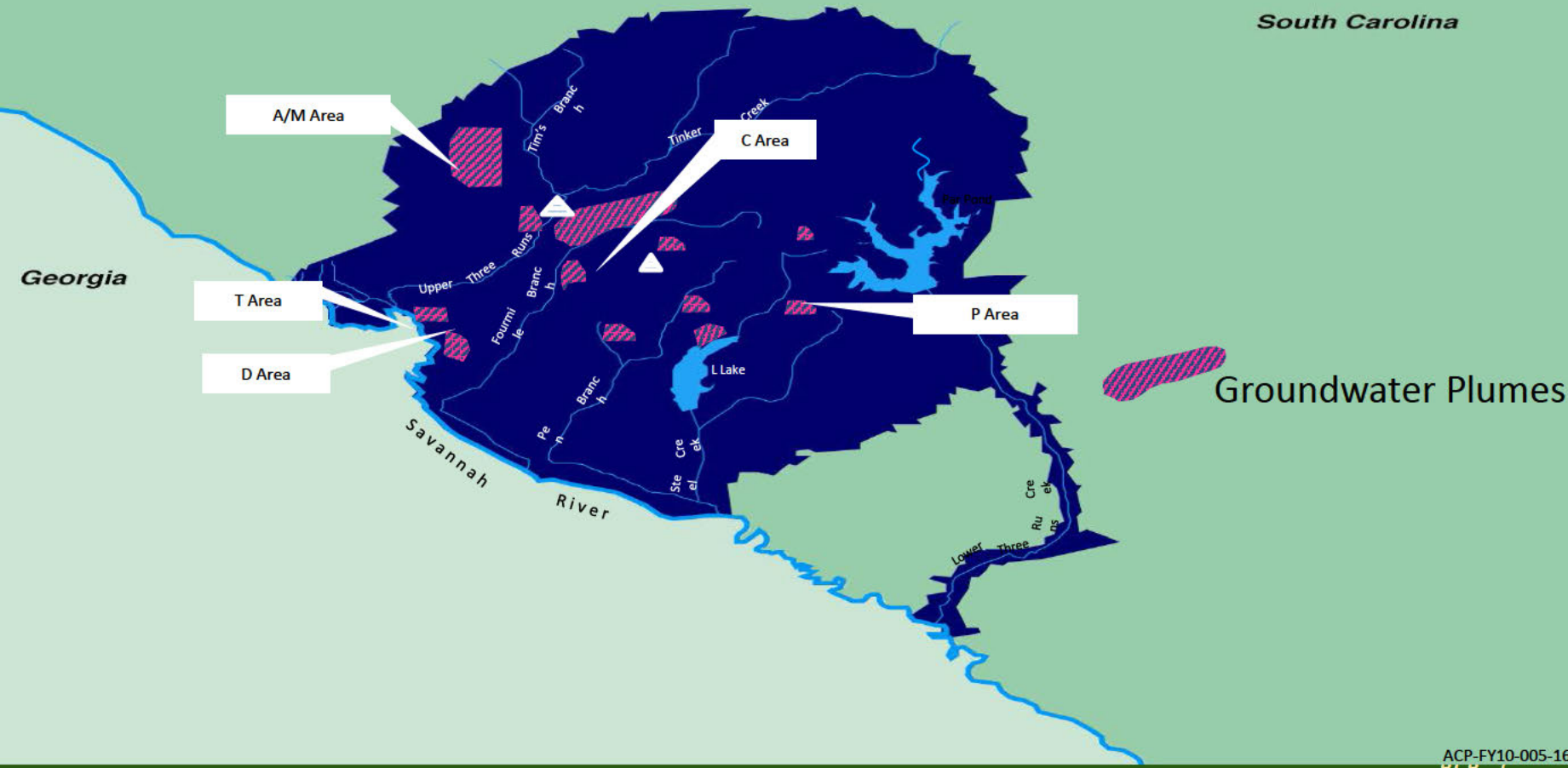
When the subsurface pressure is higher than at ground surface, contaminants naturally move upward through venting wells.

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

South Carolina



Savannah River Site

Edible Oil Injection at T Area



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

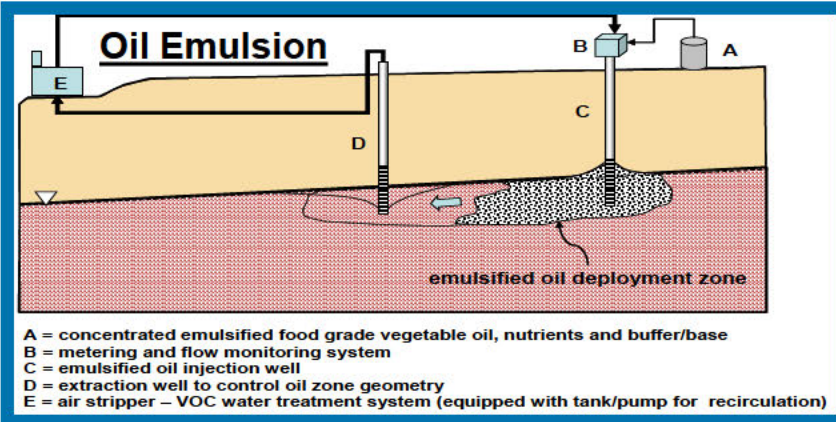
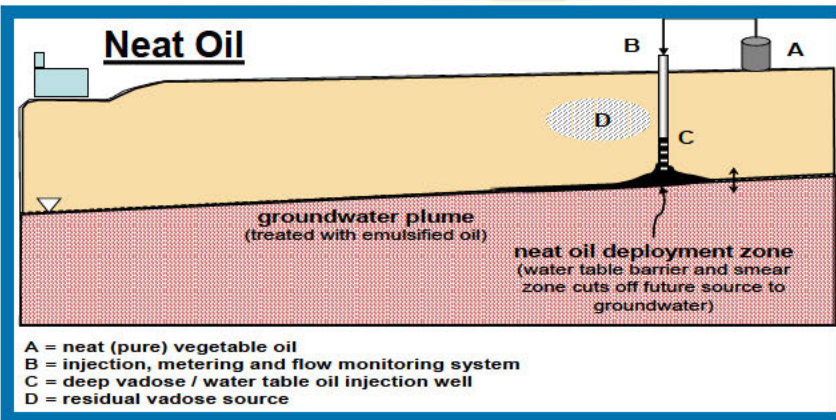
Edible Oil Injection at T Area

Performing Injection



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



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Savannah River Site *Phyto-Remediation Project*



Phyto-remediation with collection pond and irrigation



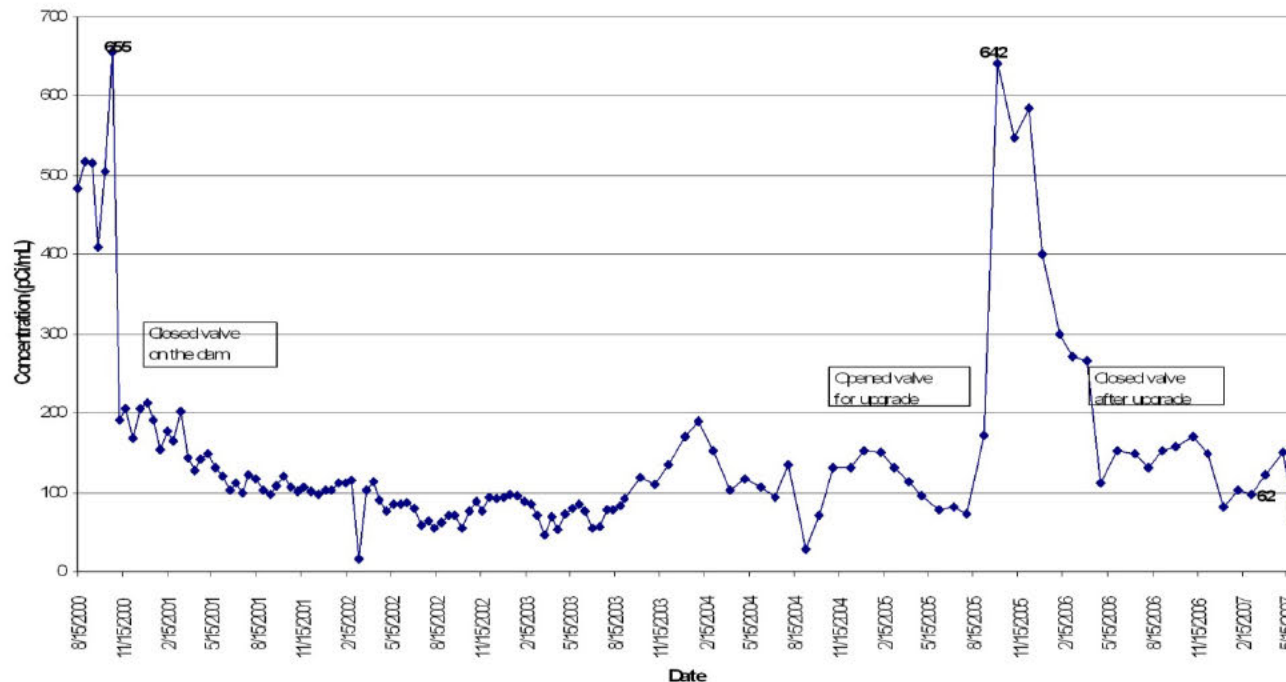
Pond Created with Sheetpile



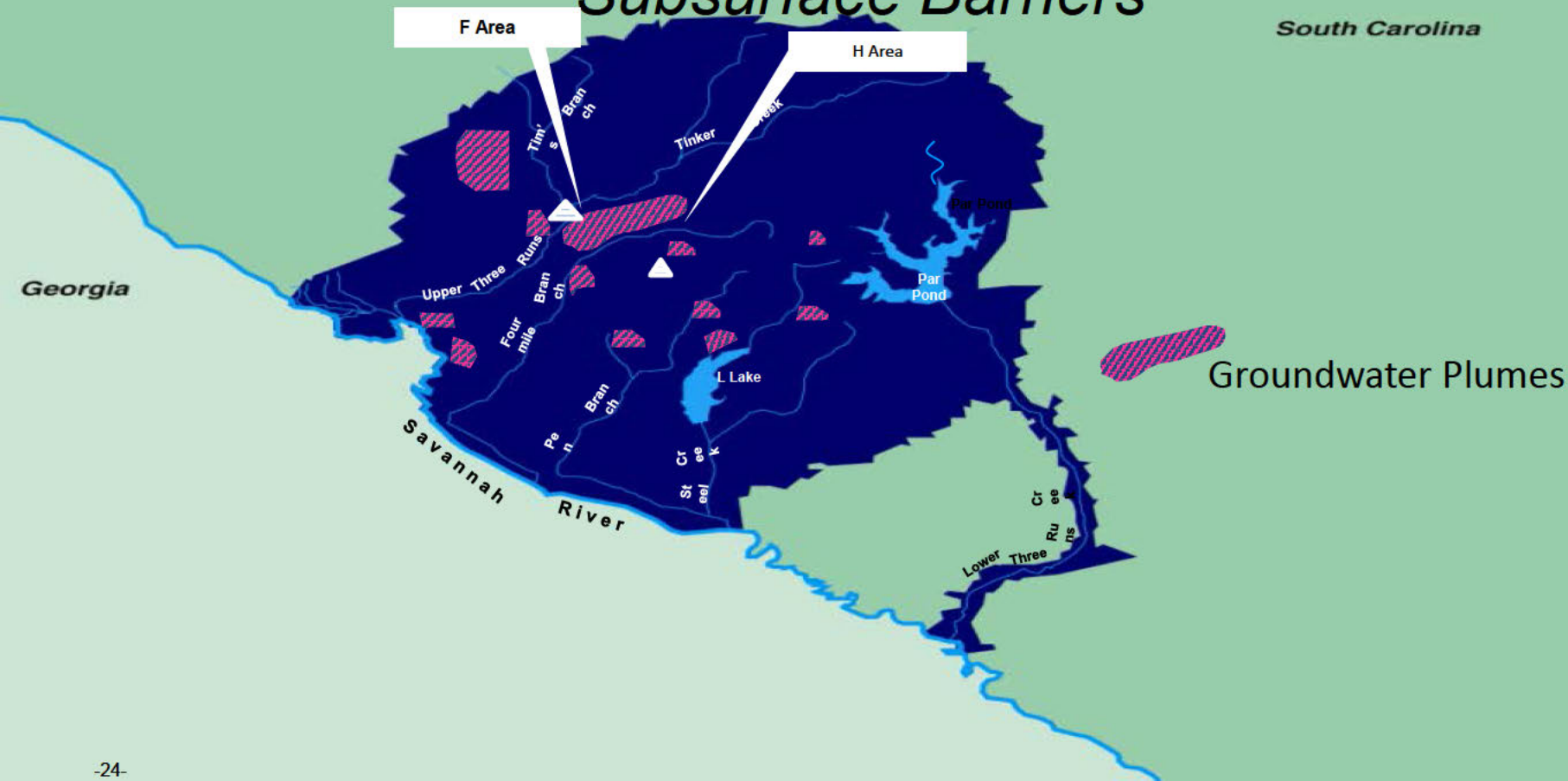
- Tritium contaminated groundwater is intercepted before discharging to stream.
- The water is used to irrigate pine forests.

Tritium in Fourmile Branch

Changes in Tritium Concentration in Fourmile Branch



Savannah River Site *Subsurface Barriers*



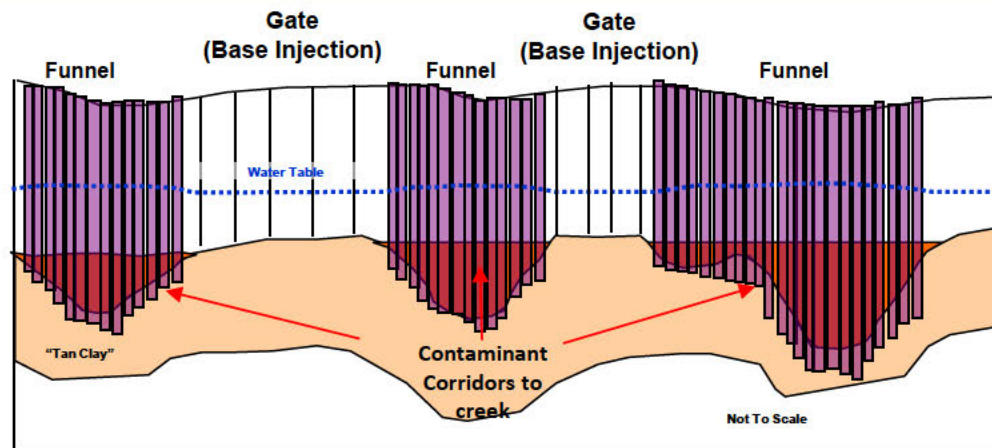
In-Situ Soil Mixing Barrier Wall

- **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

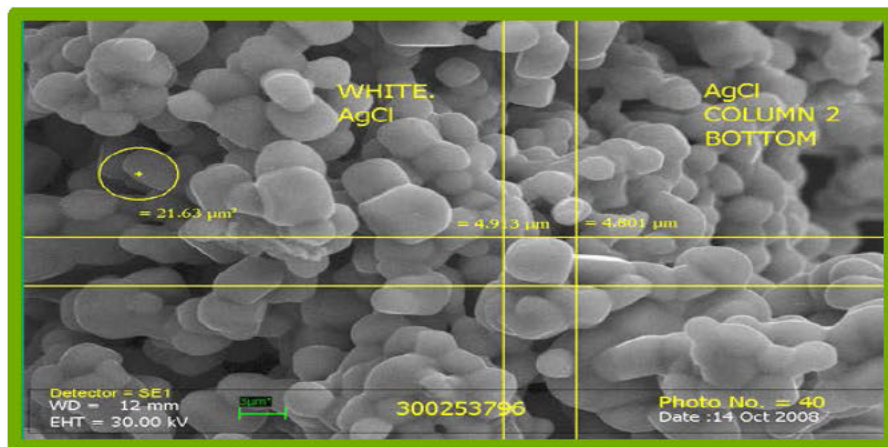


F Area Groundwater Cleanup Strategy

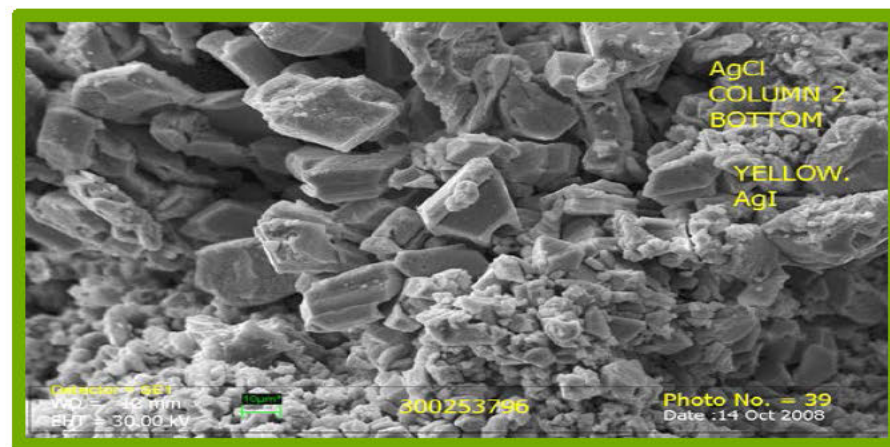
Iodine Capture with Silver Chloride Injection

- **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)**

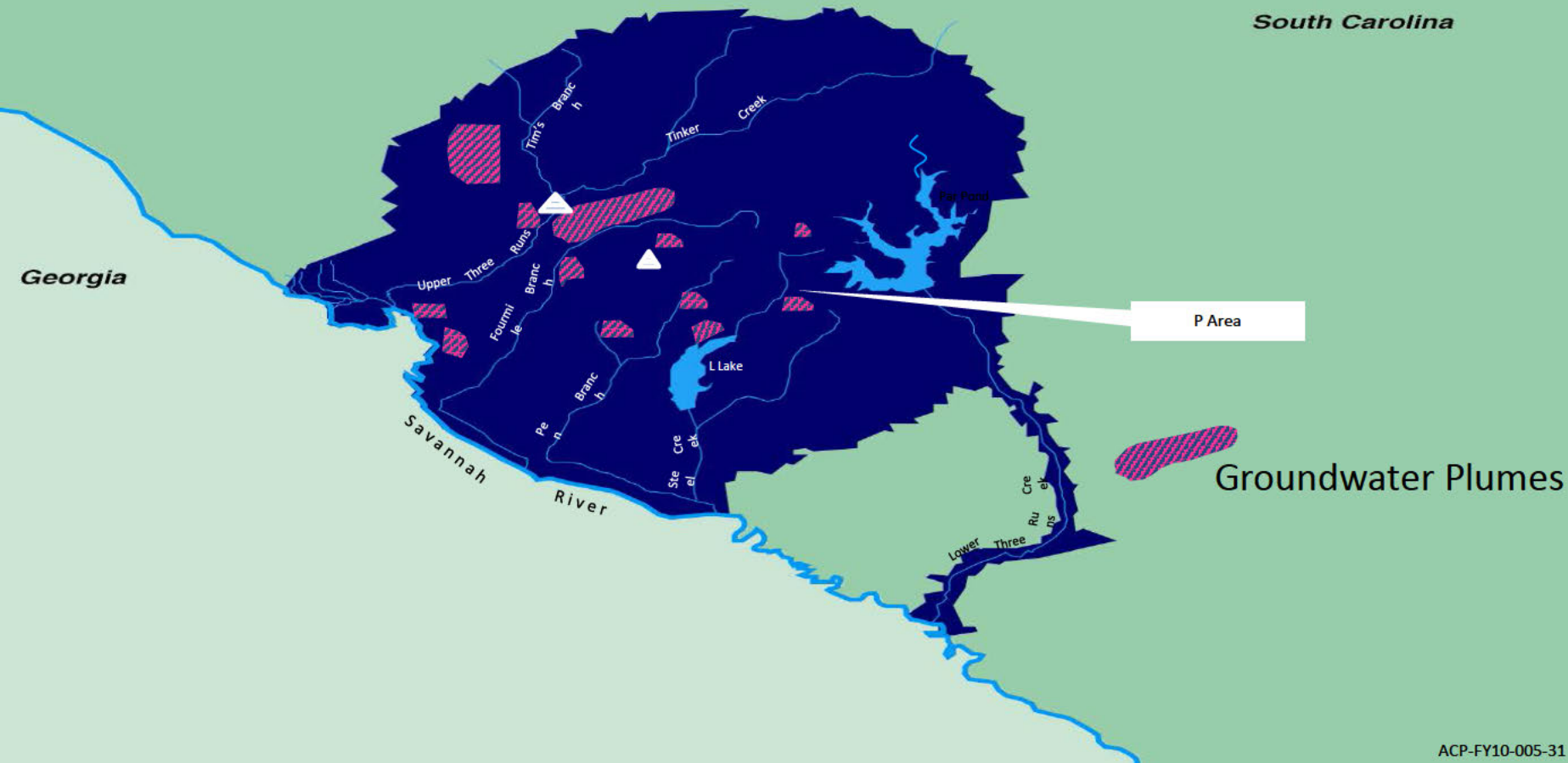
Silver Chloride Injection F Area



Savannah River Site

Bio-remediation using MicroCED at P Area

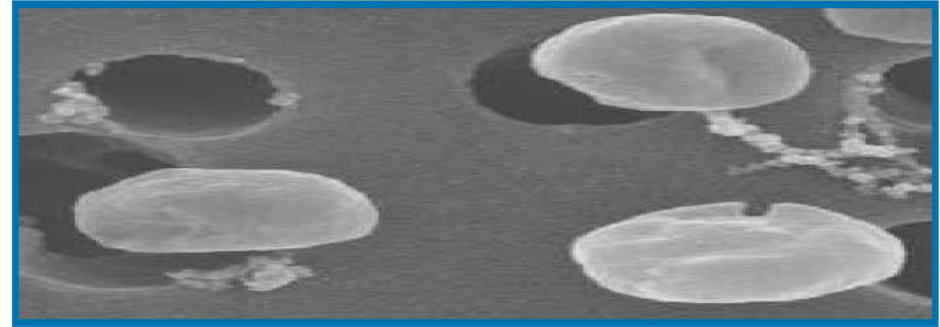
South Carolina



MicroCED at P-Area

Micro-biological-based Chlorinated Ethene Destruction (MicroCED)

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

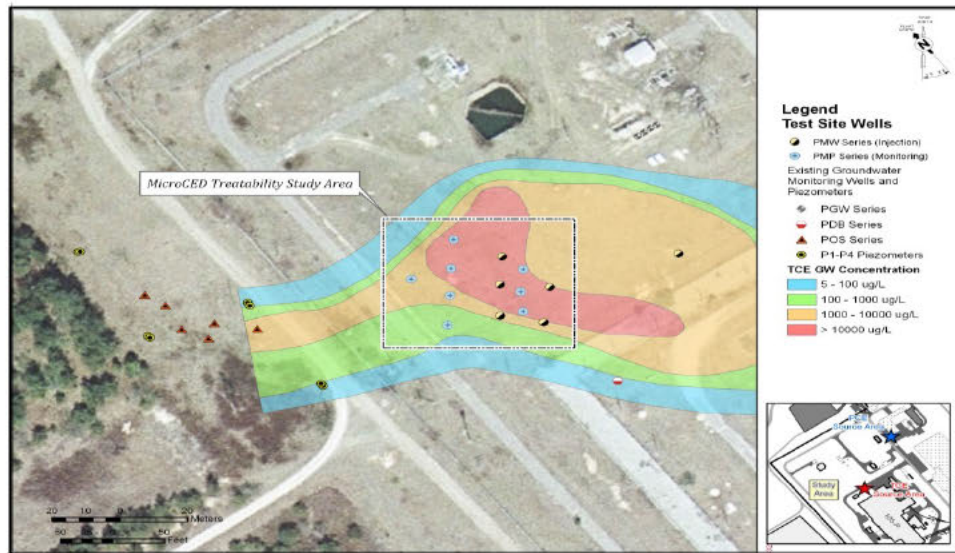


Microscopic picture of MicroCED



MicroCED growth canister.

Bio-remediation at P Area using MicroCED



- **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

- **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



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



Questions?