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Enhanced Attenuation and Long Term Monitoring of Groundwater Plumes:

Examples from the DOE Savannah River Site

Carol Eddy-Dilek and Miles Denham
Savannah River National Laboratory

March 16, 2017



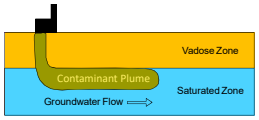
Remediation of Contaminated Groundwater

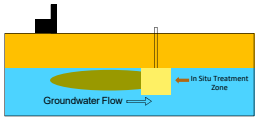
- Source Terms at DOE sites tend to be more concentrated /complex but our experiences may provide valuable lessons to NRC
  - Enhanced Attenuation (EA): Addition of low cost amendments to remove low levels of contamination from groundwater and/or hydraulic control to slow contaminant movement
  - Leaves contamination stabilized in the subsurface
- Long Term Monitoring of residual contamination
  - Shift emphasis of monitoring to controlling variables rather than contaminant concentrations – leads to proactive decisions and lower costs
- Strategic design can significantly expedite site closure
  - Expedite Regulatory/Stakeholder acceptance

Attenuation-Based Remedies

Monitored Natural Attenuation (MNA):
Let natural processes do the work and monitor progress

Enhanced Attenuation (EA):
Engineered remedy that increases attenuation capacity of aquifer





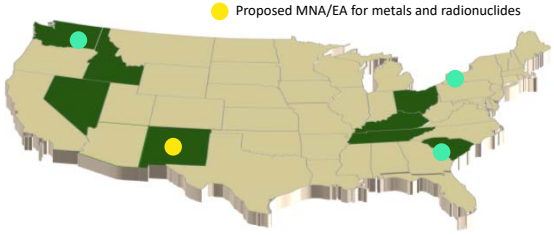
Attenuation-based remedies leave contaminants in subsurface

- Require a high burden of proof that contaminants will not re-mobilize and become a threat again
- Strategic design helps meet the burden of proof

Scope of DOE Groundwater and Soil Problem

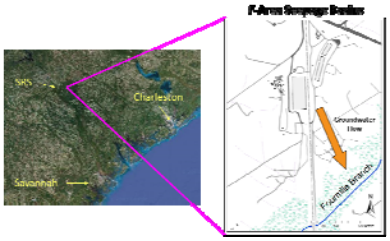
Nearly 1,800 million m^3 of groundwater and 40 million cubic m^3 of soil

- Ongoing MNA/EA for metals or radionuclides
- Proposed MNA/EA for metals and radionuclides



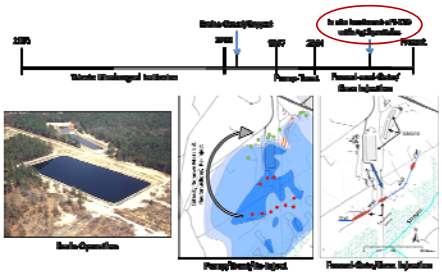
Contaminants: Organic (mostly solvents), many radionuclides (mostly tritium and fission products)

Example: F-Area Seepage Basins, Savannah River Site



- 7 billion liters of acidic low level radioactive waste disposed in 3 unlined basins
- Over 35 year time period
- Contaminant plume is approximately 1 square kilometer in footprint
  - Contaminants of concern – tritium, ^{90}Sr, uranium, ^{129}I

History of the F-area Groundwater Treatment Strategy



- Subsurface barrier reduces tritium flux to stream
- Alkaline solution periodically injected into gates to enhance sorption of U and ^{90}Sr
- In situ use of silver chloride to treat ^{129}I

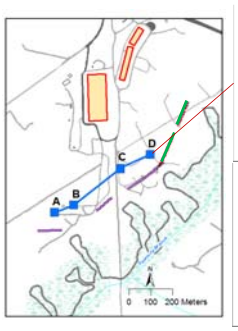
Innovative EA technologies developed with SRNL allowed shut-down of pump-and-treat system

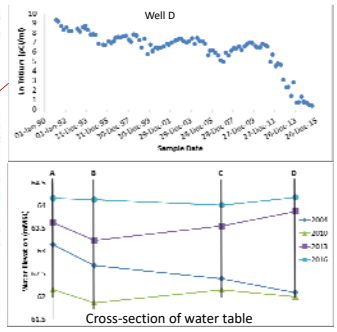
- **Saved $280M in lifecycle cost**
- **Eliminated creation of solid radioactive waste**

Proposed New LTM Paradigm

- Based only partially on groundwater sampling and analysis
  - Cannot eliminate concentration measurements – reduce locations and frequency
- Instead measure contaminant controlling processes
  - Boundary Conditions -- Overall physical and hydrological driving forces such as water level, evapotranspiration, stream flow
  - Controlling Variables -- Key geochemical controls on migration in the groundwater system such as pH, redox, ORP, specific conductivity etc.
- Cheaper, easier methods for measurement
  - Pressure transducers for water levels, sensors (pH, redox, salinity), rainfall, stream gage
- Provide early warning to changes in contaminant behavior
  - Leads to proactive rather than reactive decisions
- Numerical modeling used to understand plume behavior under different scenarios

An Example of Physical Processes Control on Contaminant Movement





Cross-section of water table