U.S. DEPARTMENT OF ENERGY

20 Years of Progress in Processing Nuclear Waste

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Introduction to Nuclear Fuel Cycle Separations
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Introduction

- The Office of Environmental Management (EM) provides environmental remediation cleanup progress today, along with potential energy solutions for the future.

- Although much progress has been made, EM is still facing management challenges and site remediation efforts that will require the ability to continue to make technological leaps forward.

- Solving these challenges is inherently dependent upon understanding the underlying chemistry and how to separate or immobilize radionuclides.

- With completion dates extending past 2050, EM will continue to need a cadre of managers, engineers, and scientists who will be able to make informed decisions based on the best engineering and scientific understanding of the cleanup issues.

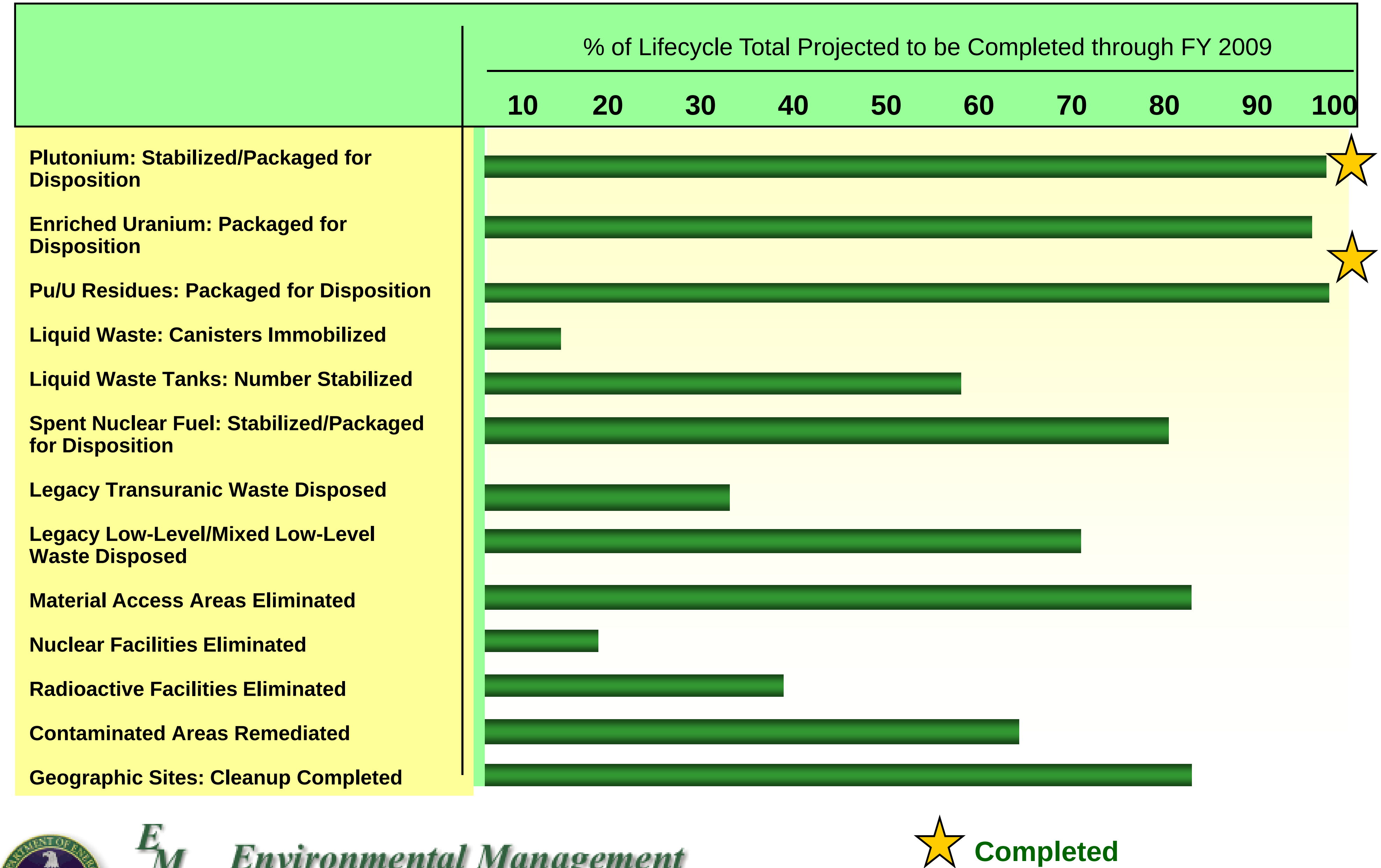
20 Years of Progress – Summary

- **The Department's Responsibility**
  - **Cleanup of radioactive waste and contamination generated by nuclear energy research and weapons production**
  - **Protection of groundwater and soil**
  - **Decontaminate and decommission contaminated surplus facilities**
  - **Reduction of risk to the nation's citizens**

- **2009 Marks 20 Years of Our Cleanup Effort**
  - **Demonstrated progress in cleanup**
  - **Technological breakthroughs**

- **Our Future**
  - **Continuing nuclear waste challenges to solve**
  - **Continuing to reduce risk while maximizing regulatory compliance**
  - **Implications for the world's energy future**

Bringing us closer to our destination . . .



But Significant Cleanup Challenges Lie Ahead

Retrieving 3000+ million liters of liquid radioactive waste . . .

. . .Safely storing it in 200+ underground tanks . . . and

. . .Solidifying it for safe disposal

Cleaning up 240 sq. km. of contaminated groundwater

Maintaining a stable and skilled workforce

Developing technologies – vitrified waste from Savannah River, South Carolina

Key Challenge to Provide Scientific Understanding of Complex Mixtures

- **Highly radioactive waste with widely varying half-lives, i.e., cesium-137 and strontium-90 (about 30 years) to technectium-99 and iodine-129 (211,000 years and 15,700,000 years, respectively)**

- **Non-homogenous mixtures of waste**
  - **Contain various constituents that effect the waste chemistry, e.g., aluminum, sodium, sulfur, and chromium**
  - **Have varying physical properties, i.e., densities, viscosity, water content**

- **Various contaminated media:**
  - **Need to understand how to immobilize contaminates in soils**
  - **Need to understand how to separate contaminates in groundwater or reduce bioavailability of contaminates to reduce exposure pathway**
  - **Need to understand how to best separate contaminated surfaces for decontaminating building materials such as concrete, piping, equipment to reduce .**

Challenges for Technological Advancement

- Reduce risk while maximizing regulatory compliance
- Improve existing technologies to take advantage of advances in science and engineering
- Develop new technologies to resolve technical barriers and are acceptable to regulations and other stakeholders
- Identify insertion points for technology advances or new technologies to maintain momentum of cleanup progress while maintaining regulatory compliance

Our Mission – Every Project as Successful as This

1960s: Plutonium Manufacturing
Rocky Flats, Colorado

Cleanup

Rocky Flats today:
National Wildlife Refuge

High-Level Waste

Tank Construction, Savannah River, South Carolina, 1963

Waste Treatment Plant Construction, Hanford, Washington, 2008

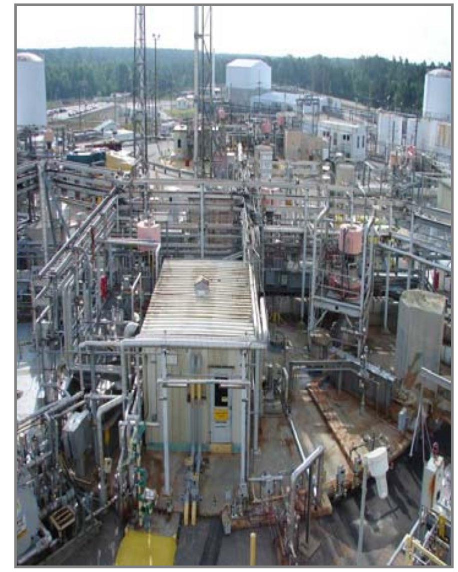
- **Waste Disposition: Waste is non-homogenous, requiring different processing:**
  - **Waste Treatment Plant (Washington State)**
  - **Defense Waste Processing/Salt Waste Processing Facilities (South Carolina)**
  - **Sodium Bearing Waste Plant (Idaho)**
  - **West Valley Vitrification Plant (New York)**
- **Tank Closure: Empty tanks filled with grout to stabilize contents and structure**

Global Energy Benefit: Demonstrating the management of waste generated by the nuclear fuel cycle

Challenge – High-Level Waste

Single-shell tanks under construction in 1944 at Hanford

Consistency and chemistry of tank contents varies greatly



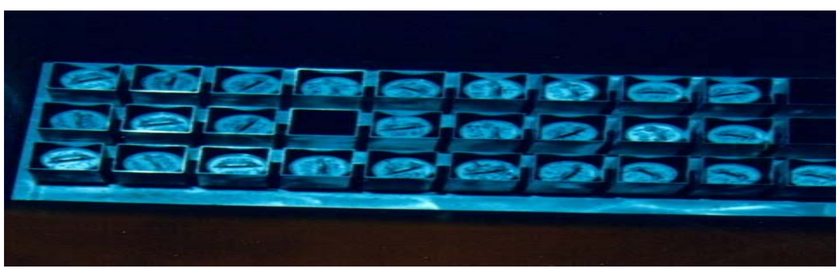
Fluidized Bed Steam Reforming Treatment at Savannah River

- **Storage: Tanks capacity is limited, and have exceeded their design life.**
- **Retrieval: Retrieval and monitoring operations are costly, inefficient, and limited by complicated tank design and previous leakage.**
- **Closure: More cost-effective and efficient closure methods are needed.**
- **Waste Pretreatment: Low- and high-level wastes must be effectively separated, which requires better understanding of contents chemistry.**

Spent Nuclear Fuel

The Department's manages more than 2,400 metric tons of spent nuclear fuel, including foreign research reactor fuel of U.S. origin.

Receipt and Storage of spent nuclear fuel at U.S. DOE facilities



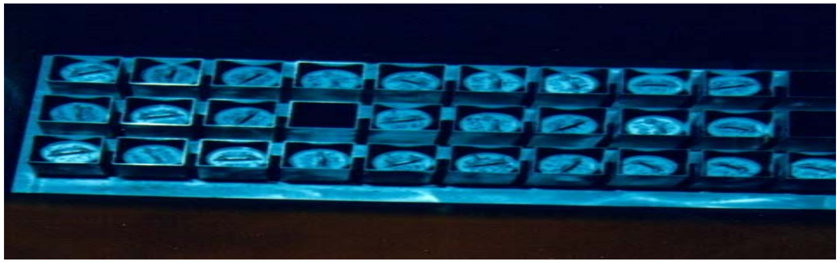
Spent Nuclear Fuel

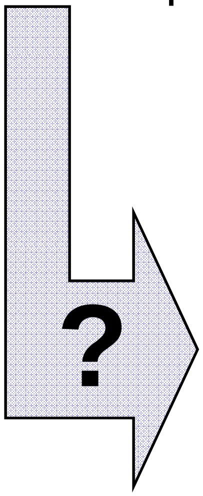
DOE has developed:

- **Best-in-class wet storage practices for spent reactor fuel**
- **Dry storage methodologies for damaged spent fuel**
- **Water cleanup systems that support spent fuel recovery and basin decommissioning**

Global Energy Benefit: Supports global non-proliferation

Challenge – Spent Nuclear Fuel


Spent Nuclear Fuel in Wet Storage




Yucca Mountain, NV

Challenges:

- Vulnerable fuel types may continue to deteriorate, which may impact repository acceptance.
- Developing decladding techniques to handle aluminum-clad fuel

Strategy:

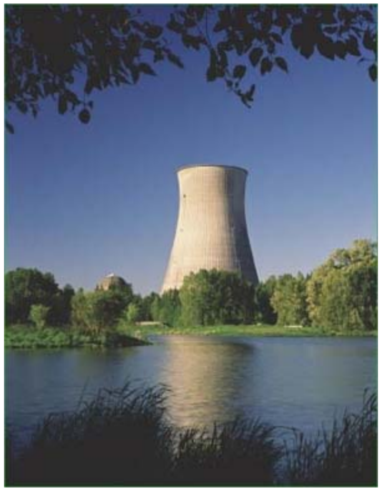
- Improve monitoring of fuel condition and wet storage basin integrity.
- Develop neutron-absorbing materials for use inside long-term disposal packages.

Timing of spent nuclear fuel disposition is subject to compliance agreements and the opening of the repository.

Special Nuclear Materials

- **The Department manages more than 30 metric tons of excess special nuclear materials such as plutonium, enriched uranium, and U-233.**
- **Surplus plutonium will be fabricated into mixed oxide (MOX) fuel for commercial nuclear power, or dissolved and vitrified**
- **Highly enriched uranium is being downblended to low enrichment for use as commercial reactor fuel**

MOX Fuel Fabrication Facility,
Savannah River. South Carolina



***Global Energy Benefits:* Non-proliferation, and former weapons material becomes feedstock for commercial nuclear power**

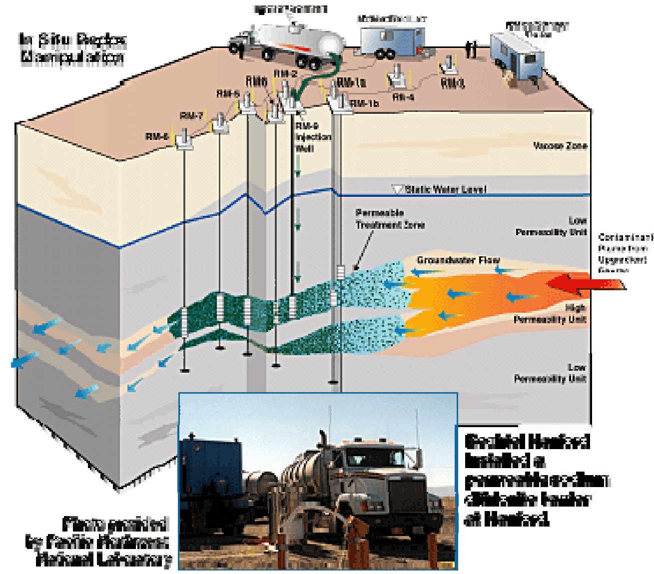
Challenge – Special Nuclear Materials



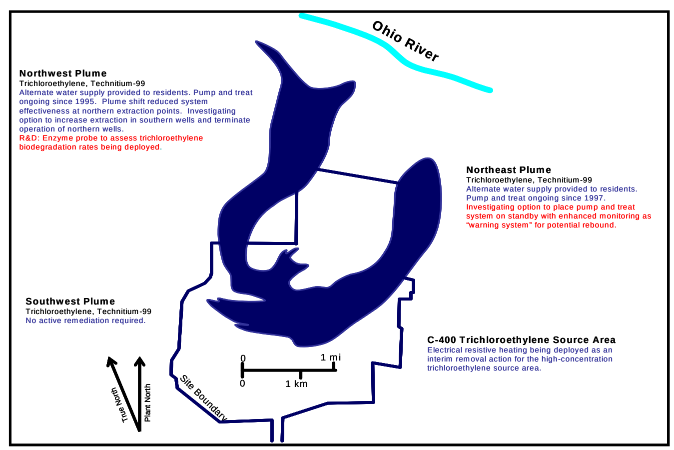

- **Improved inventory and characterization data are needed**
  - **Need more comprehensive inventory analysis – some materials are non-MOXable**
  - **Need to improve understanding of material behavior**
- **Enhanced conditioning, packaging, and transportation technologies/methodologies are needed**
  - **Not a “one size fits all” approach**
  - **Portable/mobile conditioning vs use of existing facilities**
  - **Facility and infrastructure optimization too support needs**

Groundwater and Soil

- Stabilized more than 100 groundwater plumes
- Developed pump-and-treat, and passive permeable barrier remedies for contaminants such as chromium and strontium-90
- Implementing permanent, cost-effective technologies to remove and/or immobilize rads, metals, and chlorinated organics
- Implementing state of the art approaches and technologies in the design, construction, operation & maintenance of landfills

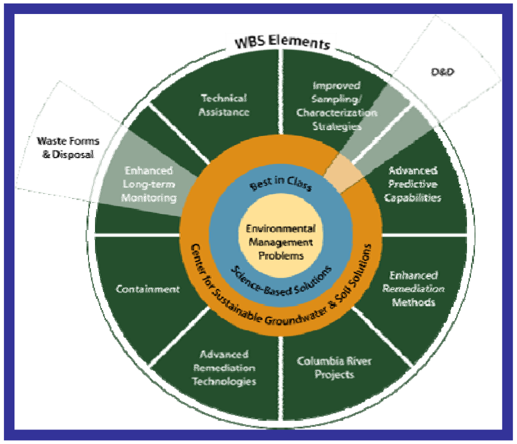


Passive Barrier treatment of hexavalent chromium near Columbia River, Hanford, WA

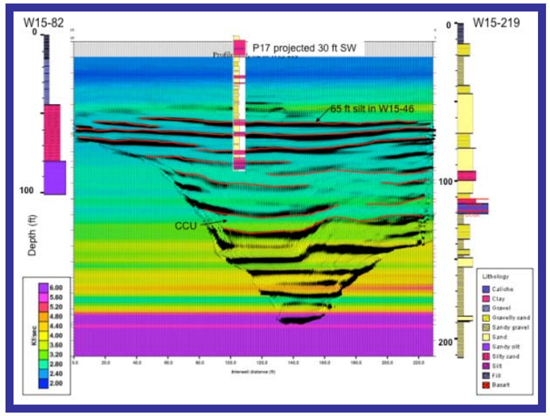


Paducah, KY plume contaminated with Technetium-99 treated since 1997

Challenges – Groundwater and Soil



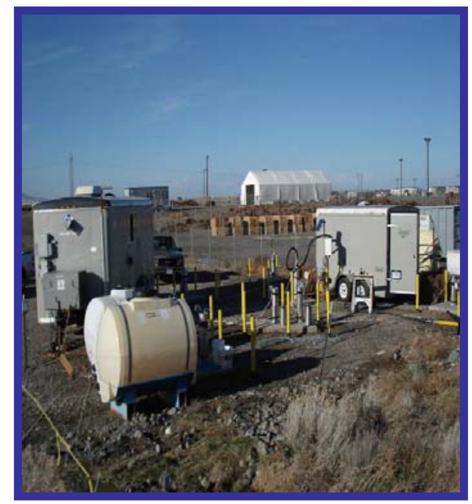
Integrated technical strategy to address challenges.



Use of Geophysical Methods to identify the spatial distribution of subsurface contamination.

Mercury contamination in the surface (East Popular Creek) and subsurface water and soil at Y-12 (Oak Ridge, TN).

- **2 Billion m^3 contaminated Groundwater & Soil at over 60 sites in 22 states**
  - 300 remedies in place but current tools only partially effective (pump & treat)
- **Next generation tools to aid characterization, remediation and predictive capabilities**
  - Geophysical methods for characterization and long term monitoring
  - Next generation predictive modeling tools
  - In-situ deep vadose zone & groundwater treatment technologies
  - Attenuation based remedies
- **Massive Mercury Remediation at Oak Ridge**
- **In-situ Electrical Resistance Heating in High GW Velocity at Paducah**
- **Monitored Natural/Enhanced Attenuation approaches**
- **Implementation of Technical Impracticability (TI) Waivers**
- **Long-Term stewardship and monitoring**
- **New Paradigms for Landfill Design, Operation & Maintenance**



In-situ and deep vadose treatment of uranium contamination at the 300 Area Hanford (Richland, WA).

In Conclusion

U.S. Department of Energy nuclear waste management provides pollution cleanup today and energy solutions for tomorrow

Our record proves that safe, effective nuclear waste management is possible:

- **We have effectively reduced risk to the environment and the community**
- **Each year, our knowledge and skill base grows**

Our work provides global benefits beyond nuclear cleanup:

- **Advancing nuclear power during a stagnant time for the nuclear industry**
- **Enhancing global security and nuclear non-proliferation**

Enormous challenges lie ahead:

- **The ability to continue to make technological leaps forward**
- **The willpower of societies to continue to pursue difficult, expensive work**