Tank Waste Retrieval Operations at Oak Ridge National Laboratory

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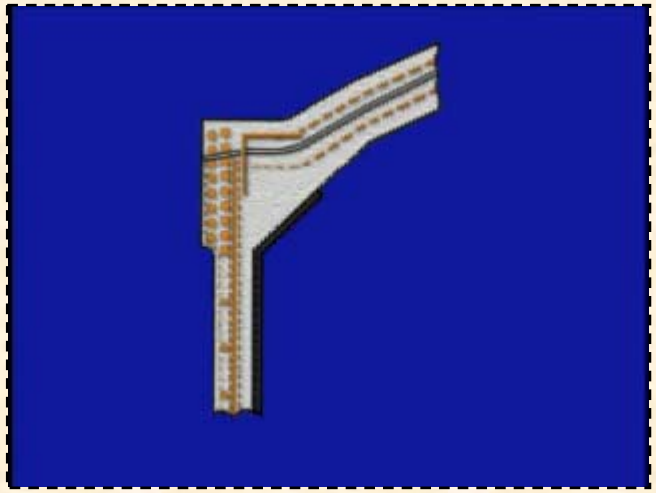
ORNL Tank Waste Retrieval

- Purpose: Consolidation of waste from the active and inactive storage tanks to a single active waste storage tank system
  - Inactive Tanks
    - 12 Gunite and Associated Tanks (GAAT)
    - 5 Old Hydrofracture Facility Tanks
    - Multiple Federal Facilities Agreement Tanks
  - Active Tanks
    - 5 Bethel Valley Evaporator Service Tanks (BVESTs)
    - 8 Melton Valley Storage Tanks (MVSTs)
    - 6 Melton Valley Capacity Increase Tanks

Waste Consolidation Tanks

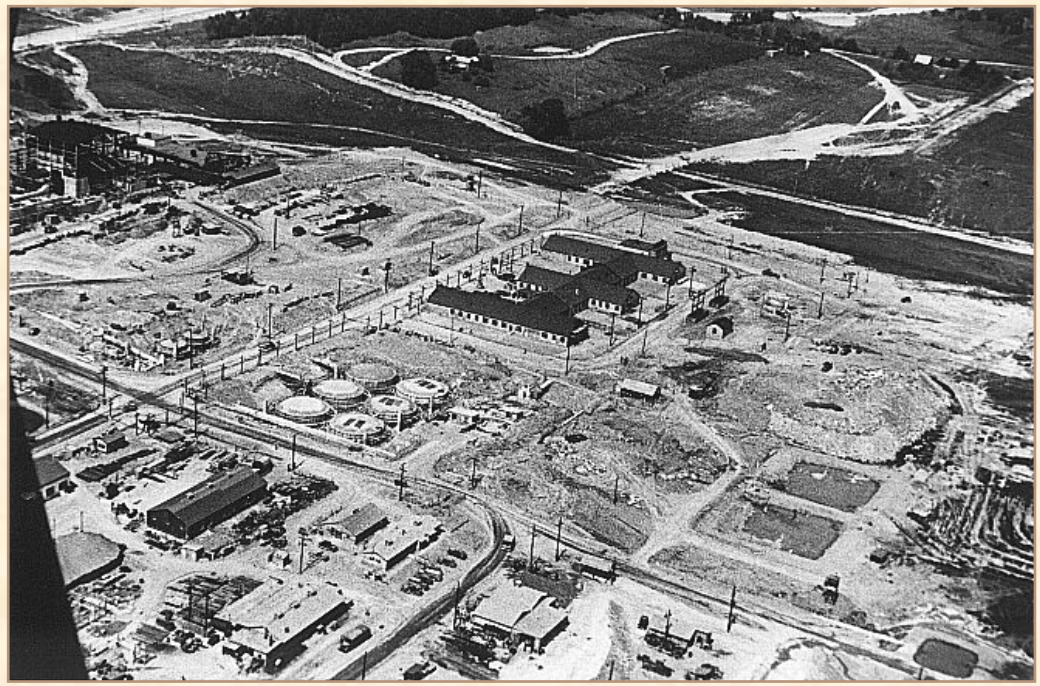
Gunite Tank History



- In 1943, twelve underground storage tanks were constructed of ”gunite" – a sand and portland cement mixture sprayed over a wire mesh and reinforcing rod frame
- The tanks were used to store wastes from “pilot-scale” separation operations and research missions
- The tanks were removed from service in the early 1970s
- Most (~90%, >300,000 gal) of the accumulated sludge waste was removed from the gunite tanks during an 18-month campaign from 1982 through 1984

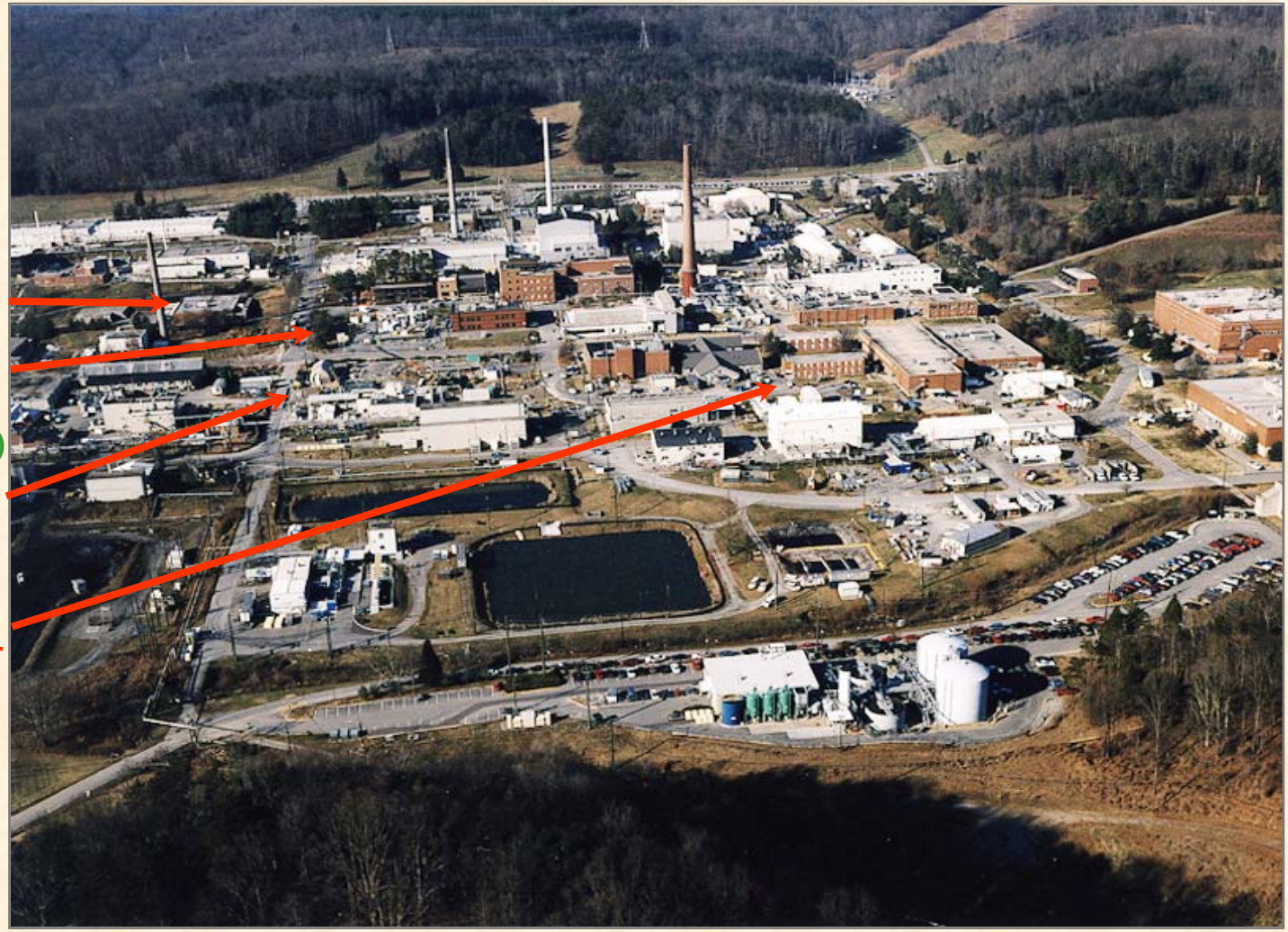
Gunite Tanks Project Goal

To remove the remaining transuranic sludge and supernatant waste from the 55-year-old gunite tanks located in the main plant area of Oak Ridge National Laboratory



ORNL during construction—1943

The Gunite Tanks Are Located in Central ORNL



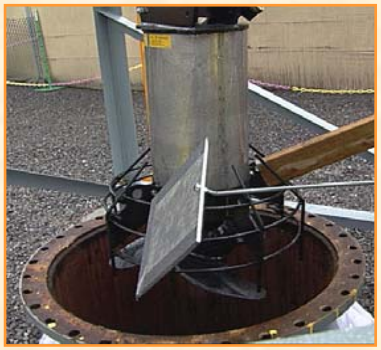
Gunite Tanks Project Status

- January 2001 – Completed waste removal operations in the 9 largest gunite tanks
  - Removed 439,000 gallons (>98%) of waste (sludge and supernatant) containing 82,000 curies (>95%)
  - Successfully transferred sludge to the MVSTs
  - Completed waste retrieval operations ~5.5 years ahead of the baseline schedule
    - Savings of over $120 million
- Site demobilization is complete
  - Contaminated material has been containerized for disposal
  - The retrieval systems have been either reused or containerized for disposal

Common Steps in Waste Retrieval Operations

All waste retrieval operations include 4 main steps

- **Sampling, Characterization, and Modification**
- **Waste Mixing**
- **Retrieval and Wall Cleaning**
- **Waste Conditioning and Transfer**



Specialized tools and equipment are used to perform key operations during each step – the GAAT Remediation Project exemplifies these steps

The GAAT Remediation Project Deployed Approximately 40 Technologies

Sampling, Characterization, and Modification

- Floating Boom In-Tank Camera & Sampling Device
- Ponar Sampling Tool
- Sludge Mapping Tool
- Topographical Mapping System
- Large-Diameter Coring Saw for Tank Riser Installation
- Remote Video Cameras & Lighting
  - Multiplexed Pan & Tilt Controller for Multiple Cameras
- Gunite Isotope Mapping Tool
- Characterization End-Effector
- Feeler Gauge
- Hydraulic Shears
- Pipe-Cutting Saw
- Pipe-Plugging Tool
- Wall-Coring Tool
- Wall-Scraping Tool

Waste Mixing

- Flygt Mixers
- Pulsair Mixers
- Russian Pulsating Mixer Pump

Retrieval and Wall Cleaning

- Modified Light-Duty Utility Arm
- Houdini I Remotely Operated Vehicle
- Houdini II Remotely Operated Vehicle
- Decontamination Spray Ring
- Waste Dislodging & Conveyance System
  - Confined Sluicing End-Effector
  - Hose Management Arm
  - Axial-Flow Jet Pump
  - Flow Monitor & Sampling Device
- Gunite-Scarifying End-Effector
- High-Pressure Pump for Wall Scarifying
- Gripper End-Effector Hydraulic Pump
- Linear Scarifying End-Effector

Waste Conditioning and Transfer

- Waste Removal & Transfer System
- Sludge Conditioning System
  - Primary Conditioning System Module
    - In-Line Sampler
    - Size Classifier
  - Discflo Pump
  - Solids Monitoring Test Loop
    - Particle Size Analyzer
    - Ultrasonic Suspended Solids Monitor
    - Coriolis Density Meter

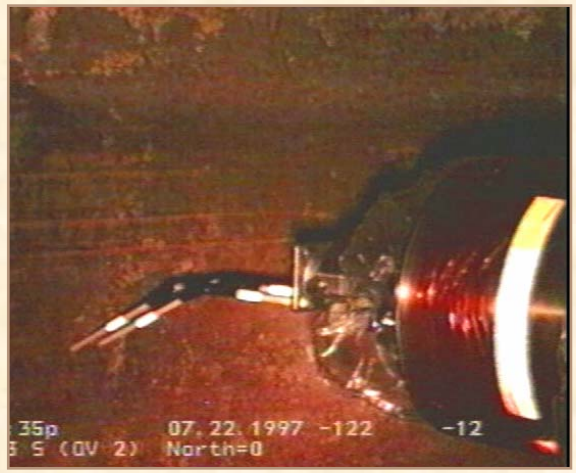
Key Systems Used in Most Operations

- **Remote camera and lighting** – Served as the eyes of the equipment operators
- **MLDUA** – 8 degree-of-freedom robotic arm used to deploy tank characterization equipment, tank modification tools, and waste retrieval and wall-cleaning end-effectors
  - Gripper end-effector
  - Two cameras
  - 15-ft reach and 200-lb payload capacity
  - Operated remotely or via preprogrammed sequences
- **Houdini ROV** – 1000-lb tethered collapsible vehicle with a 4 x 5 ft expanded footprint that provided versatility during in-tank operations to deploy various tools and end-effectors
  - Track driven via hydraulic motors
  - 6 degree-of-freedom robotic arm and gripper end-effector with a payload capacity of 240 lb
  - On-board cameras
  - Plow blade for breaking up and pushing sludge
- **Waste Dislodging and Conveyance System** – Provided the capability to dislodge and retrieve waste, manage the in-tank hoses and lines, and deploy various tooling
  - Confined Sluicing End-Effector with rotating cutting jets
  - Jet pump vacuum source
  - Hose Management Arm

The Gunite Tanks Remediation Project
South Tank Farm Operations

Sampling, Characterization and Modification

- **Remote Cameras**
  - *Tank inspections and operations surveillance*
- **Modified Light-Duty Utility Arm (MLDUA)**
  - *Deployed and operated tools in tank*
- **Houdini Remotely Operated Vehicle**
  - *Deployed and operated tools in tank*
- **Sampling Tools**
  - *Samples were taken from various locations*
- **Wall-Coring Tool**
  - *Analysis of wall cores determined the depth and amount of contamination in the tank walls*
- **Hydraulic Shears**
  - *Removed obstructions in tank*
- **Pipe-Plugging/Cutting Tool**
  - *Plugged interior tank pipes to improve tank vacuum and efficiency of air filtration system*
- **Feeler Gauge**
  - *Determined depth of wall degradation*



Sampling

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UT-BATTELLE

Tank Characterization

A coring tool was used to remove core samples from the tank wall

Analysis of wall cores indicated the depth and amount of wall contamination

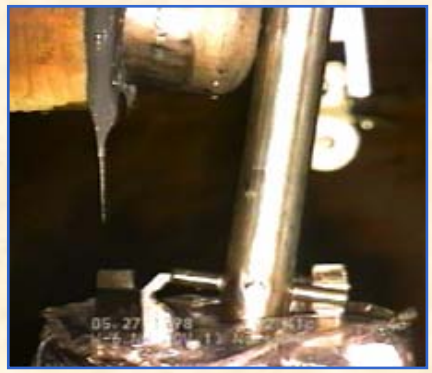
Tank Characterization

The MLDUA-deployed Characterization End-Effector provided radiation readings of the tank interior and walls

Tank Modification

Remotely deployed saws and hydraulic shears were used to remove interior tank obstructions (piping)

Pipe-plugging tool was used to plug interior pipes to improve vacuum



Heel Retrieval and Wall Cleaning

- **Modified Light-Duty Utility Arm**
  - *Deployed tools in tank*
- **Houdini Remotely Operated Vehicle**
  - *Deployed tools in tank*
  - *Plowed and cut sludge*
- **Confined Sluicing End-Effector**
  - *Sludge/Supernatant mining and waste retrieval*
  - *Cleaned tank walls*
- **Gunite-Scarifying End-Effector**
  - *Cleaned tank walls*
- **Hose Management Arm (HMA)**
  - *Supported and deployed end-effectors and hoses*
- **Axial-Flow Jet Pump**
  - *Conveyed waste out of tank*
- **Flow Monitor and Sampling Device**
  - *Monitored waste flow and allowed collection of waste slurry samples*

Heel Retrieval—Dewatering

The Confined Sluicing End-Effector (CSEE) was used in conjunction with the MLDUA and HMA to remove liquid waste in preparation for sludge mining

Heel Retrieval—Sludge Mining

High-pressure water (10 ksi) and rotating (0–500 rpm) cutting jets were used to dislodge the sludge

The jet pump removed sludge through a Flow Monitor and Sampling Device to a waste consolidation tank via a 2-in.-diam hose connected to the Hose Management Arm

Heel Retrieval—Sludge Mining

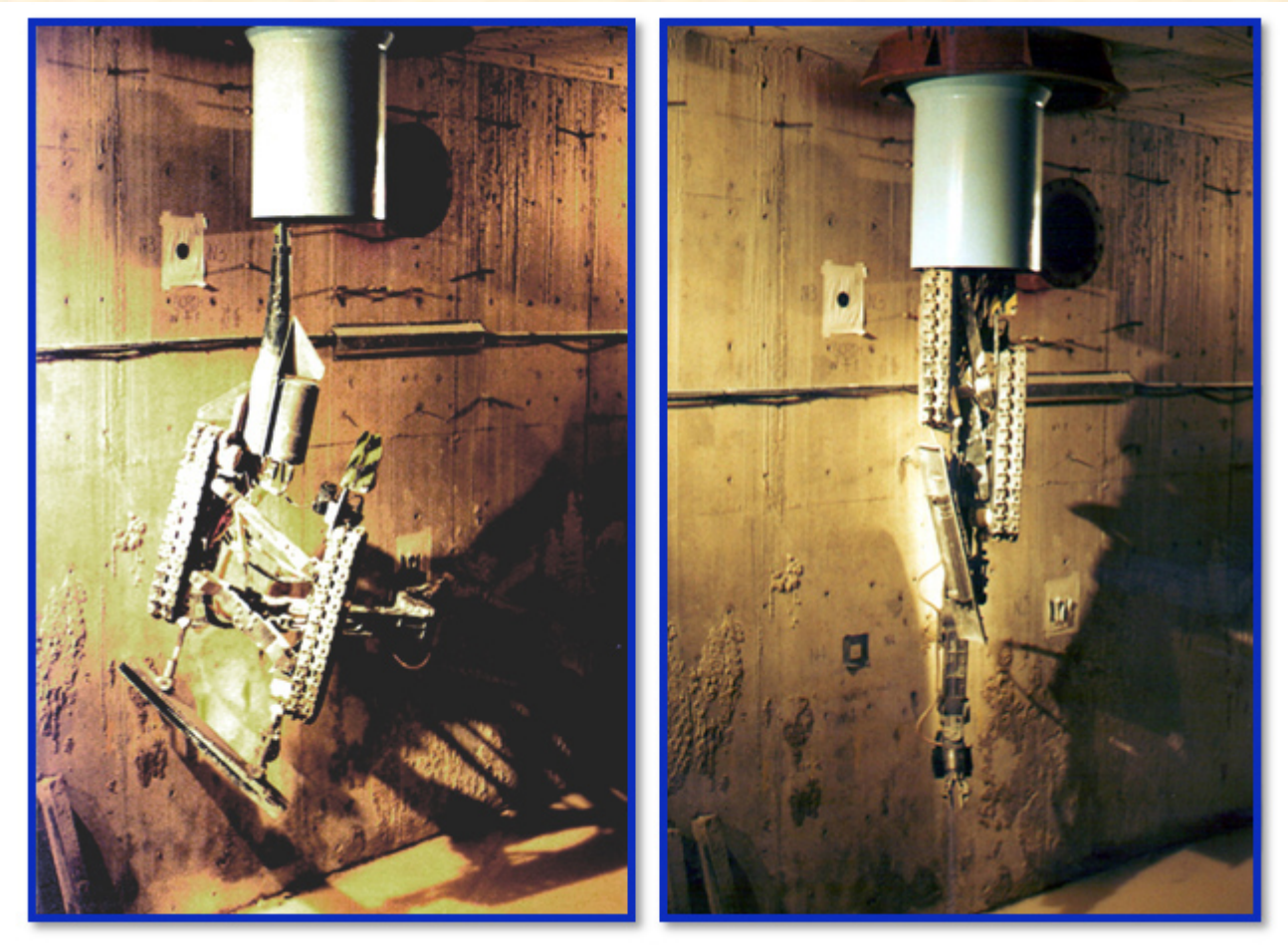
The Houdini was used to plow sludge toward the CSEE to improve sludge-mining operations

Typically, less than 1 in. of sludge remained in the tanks after sludge mining

Wall Cleaning

The Gunite-Scarifying End-Effector was used in conjunction with the MLDUA to remove contamination from the tank walls

Houdini Remotely Operated Vehicle: Insertion into Tank



MLDUA and Decontamination Spray Rings (DSRs)

DSRs provided gross decontamination using 200- to 2100-psi rinse water

Waste Mixing

- Pulsair Mixers
  - *These devices used a 13 pulse-plate mixing system to mix the waste and keep the sludge suspended in the consolidation tank*
- Flygt Mixers
  - *Two 15-hp mixers were used to mix and suspend sludge for transfer out of tanks W-5 and W-9*

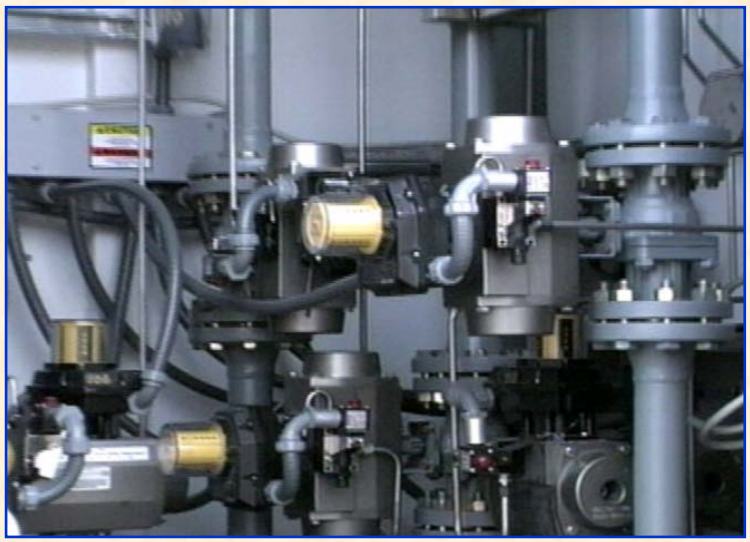
Waste Mixing

- Russian Pulsating Mixer Pump
  - *Mobilized waste and kept sludge suspended in tank TH-4*

  - *82.5% of sludge volume and initial radioactivity were removed*

Waste Conditioning and Transfer

- Primary Conditioning Module
  - *Particle size classification to meet Waste Acceptance Criteria*
- Slurry Monitoring Module
  - *Monitored waste characteristics to ensure uniform consistency*
- Discflo Pump
  - *Provided consistent pressure and flow during waste transfers*



Lessons Learned from the GAAT Remediation Project

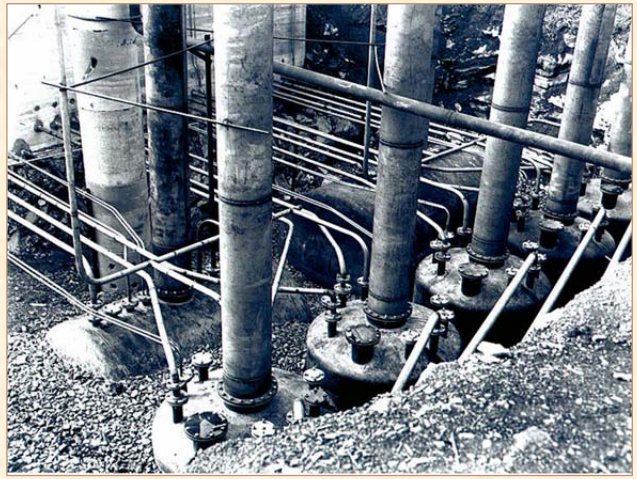
- Know the environment but expect something worse
- Develop systems/tools that have
  - Complementary capabilities
  - Redundant capabilities
- Understand the nature of prototypic systems
- Cold test everything
- No substitute exists for quality
- Maintenance issues are key to success. Design for
  - High reliability
  - Ease of maintenance
  - Replacement vs repair
  - “Maintenance-friendly” containment

Old Hydrofracture Facility

- Five horizontal cylindrical tanks, 8- to 10.5-ft diam and 23 to 44 ft long, constructed of carbon steel
- Initially contained about 53,000 gallons of radioactive waste from hydrofracture operations
- Submersible pumps were used in conjunction with a Bore-hole miner with an articulated extendable nozzle to mobilize and retrieve >98% of the wastes from these tanks
- Completed closure of the tanks in FY 2000 by grouting in place

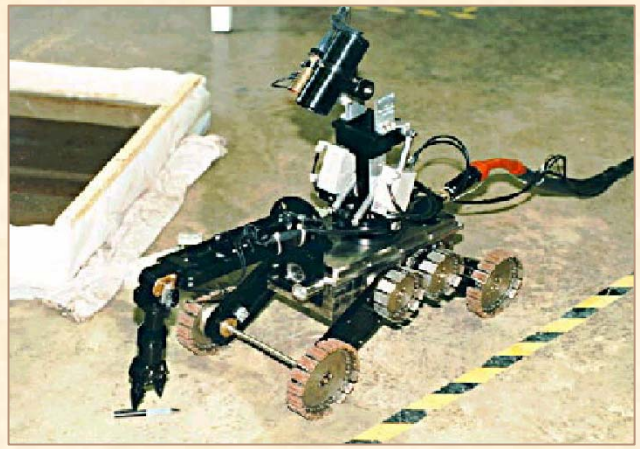
Federal Facilities Agreement (FFA) Tanks

- Many of the FFA tanks were emptied and then filled with grout
- The Scarab III ROV was deployed in tank T-14 for sludge sampling
  - Small mobile platform
  - Lightweight manipulator
  - On-board cameras and lights
- A mobile AEA power fluidic pump and a hurricane nozzle retrieval system were deployed in FFA tank 3003A



Numerous inactive Federal Facility Agreement tanks

Mobile AEA power fluidic pump at tank 3003A



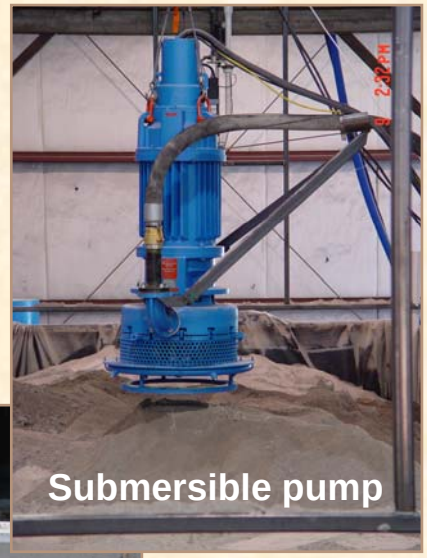
Scarab III Remotely Operated Vehicle

Active Low-Level-Waste Tanks

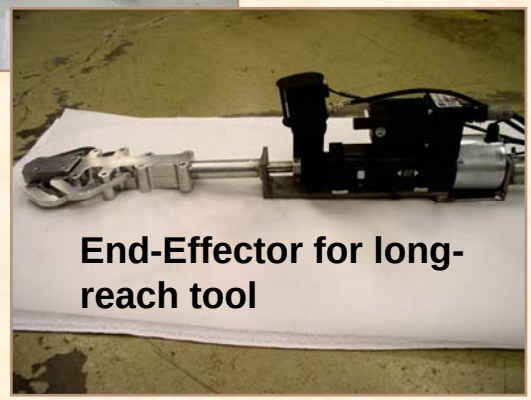
- AEA pulse-jet fluidic mixer systems were deployed at the BVESTs to mobilize ~40,000 gallon (>97%) of sludge for transfer to the MVSTs
- Existing piping and in-tank nozzles were used with the AEA system in three of the BVESTs
- An AEA mixing system was also included in the design of the Melton Valley Capacity Increase Tanks
- Principle of operation:
  - Vacuum used to pull slurry into pulse chamber
  - Pressurized air used to expel slurry from pulse chamber to mobilize sludge

Fernald Silos 1 and 2 Waste Retrieval Plans

- Concrete silos, 80-ft diam and 36 ft tall at center of the dome
- Contain almost 10,000 tons of sand-like radium-bearing waste
- Accelerated Waste Retrieval Program will use articulated sluicing nozzles and a submersible pump for bulk waste retrieval
- Heel retrieval using modified submersible pump in conjunction with a remotely operated vehicle and long-reach tools as needed for debris removal


Submersible pump


Remotely operated vehicle


End-Effector for long-reach tool