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

Typical Sludge Characteristics

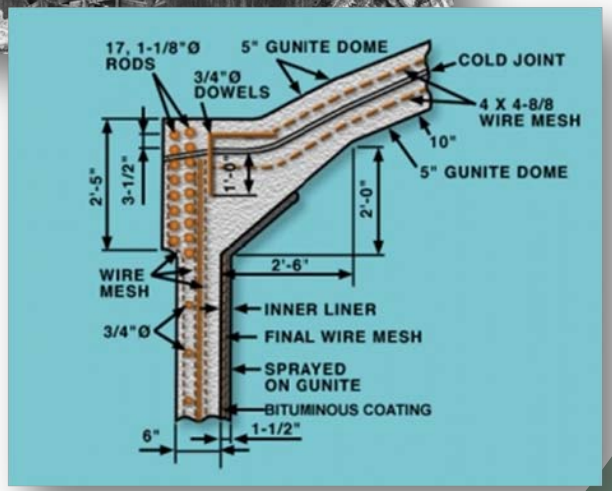
	Range	Average	Wt %
Density (g/mL)	1.169 – 1.675	1.343	
Water (wt%)	52.9 – 72.7	59.1	59.1
pH	8.7 – 12.0	10.1	
TOC (mg/kg)	2,300 – 13,400	7613	0.76
Ca (mg/kg)	23,400 – 73,700	49,825	4.98
Na (mg/kg)	23,700 – 48,000	39,225	3.92
U (mg/kg)	18,000 – 41,900	29,100	2.91
NO_3 (mg/kg)	73,500 – 233,000	135,400	13.54
^{137}Cs (Ci/gal)	0.0639 – 0.235	0.0989	
^{90}Sr (Ci/gal)	0.0988 – 0.51	0.272	
G Beta (Ci/gal)	0.507 – 1.27	0.731	
G Alpha (Ci/gal)	0.00668 – 0.027	0.0136	

Waste Transfer Line

- **2 in. diameter SCH 40 Stainless steel pipe**
  - **Double contained within 3 in. diam. SCH 40 pipe**
- **Multiple elevation changes (~51 ft) between Bethel Valley Evaporator Service Tanks and Melton Valley Storage Tanks**
- **Over 1 mile long**
- **Moyno progressive cavity transfer pump or Discflo centrifugal transfer pump**
- **Waste Acceptance Criteria**
  - **suspended solids <5 wt %**
  - **maximum particle of 100 μm**

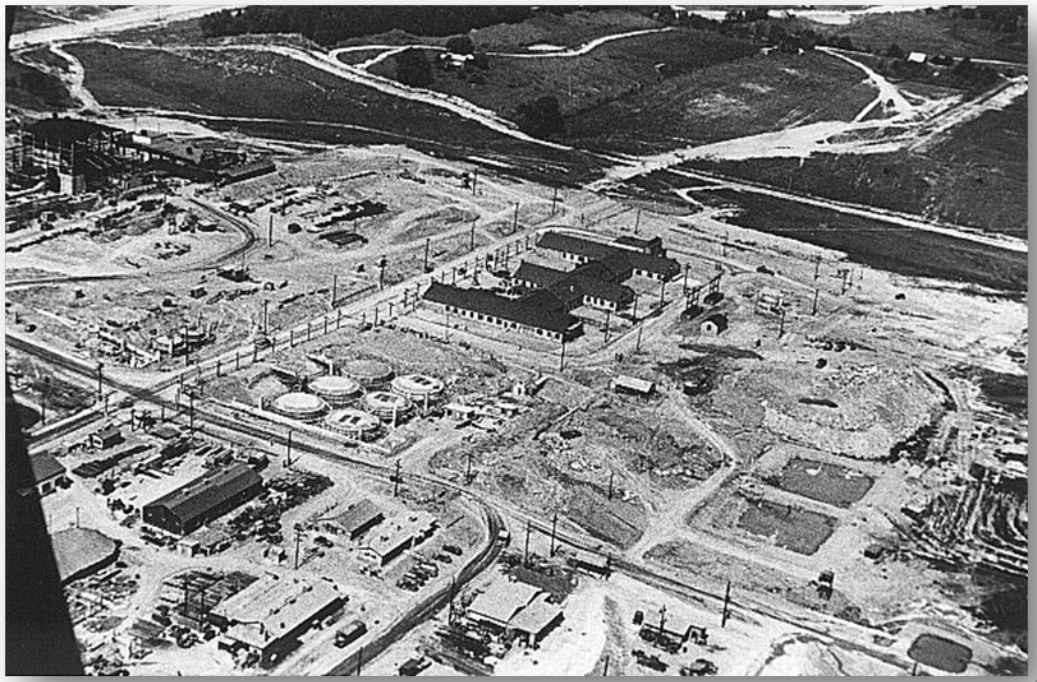
Gunite Tanks History

- 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 1970’s.
- Most (~90%) of the accumulated sludge and liquid waste was removed during an 18 month campaign from 1982 through 1984.



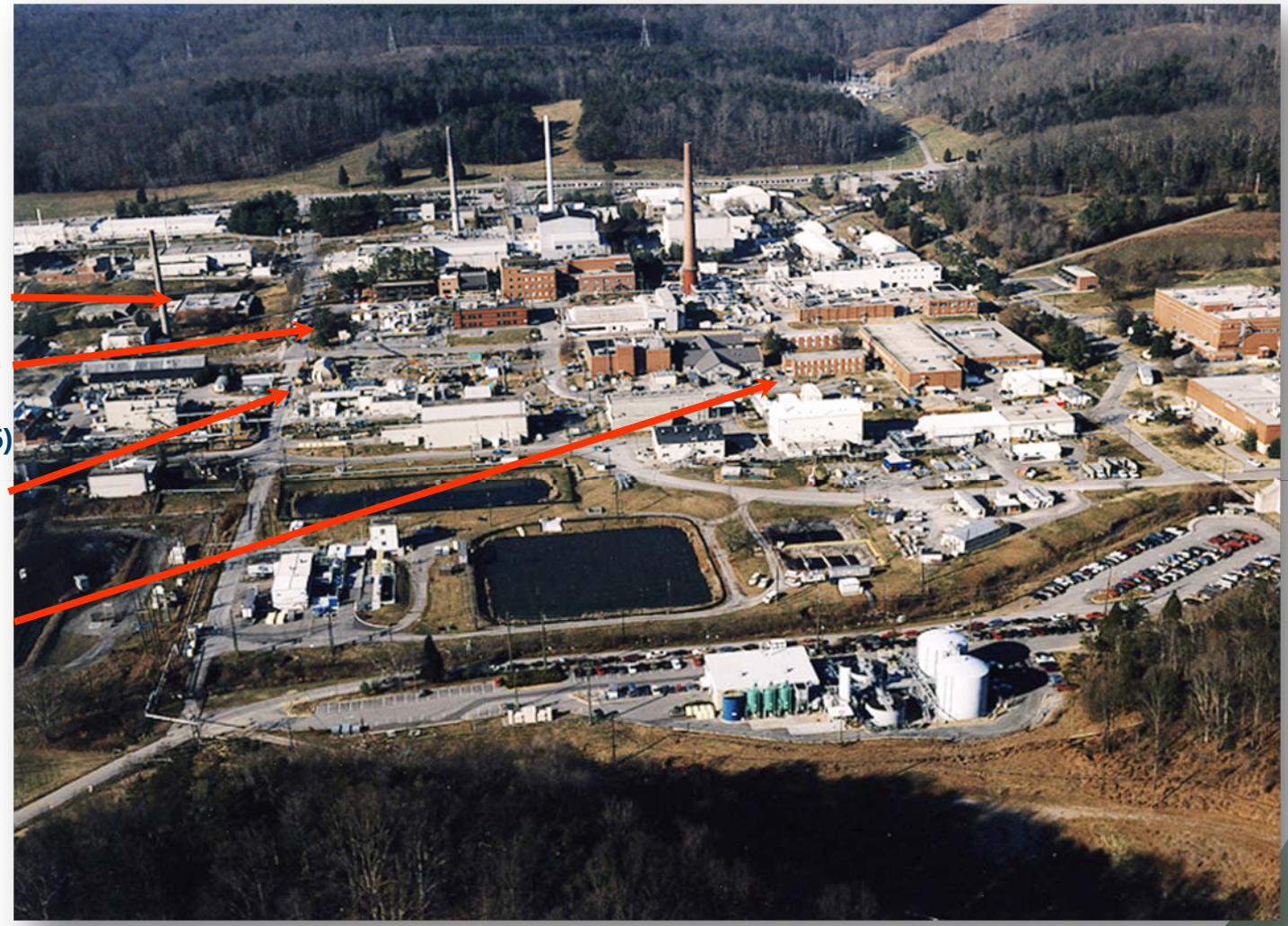
Gunite Tanks Project Goal

- Remove the remaining transuranic sludge (~94,000 gal) and supernatant waste from the 55-year old gunite tanks located in the main plant area of Oak Ridge National Laboratory
- Consolidate the waste in the permitted Melton Valley Storage Tanks
- Address final closure



ORNL during construction - 1943

The Gunite Tanks are Located in Central ORNL



Gunite Tanks Status

- January 2001 – Completed waste removal operations in the nine largest gunite tanks
  - Removed 439,000 gallons of waste (sludge and supernate) containing 82,000 curies
  - Sludge successfully transferred to the Melton Valley Storage Tanks
  - Completed waste retrieval operations ~5.5 years ahead of the original baseline schedule
    - Savings of over $120 Million
- Site demobilization completed
  - Secondary waste has been containerized for disposal and equipment either reused or disposed
  - Tanks have been filled with grout
  - Site is now a parking lot

The GAAT Remediation 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

Sludge Heel 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

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

* Refer to Lewis, B.E, et al., *The Gunite and Associated Tanks Remediation Project Tank Waste Retrieval Performance and Lessons Learned*, ORNL/TM-2001/142/V1, Sept. 2003, for additional information.

The Gunite Tanks Remediation Project
South Tank Farm Operations

Key Systems

- **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

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 (GSEE) was used in conjunction with the MLDUA to remove contamination from the tank walls

Water pressure up to 22,000 psi was used with the GSEE

Waste Mixing

- Pulsair Mixers
  - These devices used a 13 pulse-plate mixing system to mix the waste and keep the solids 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

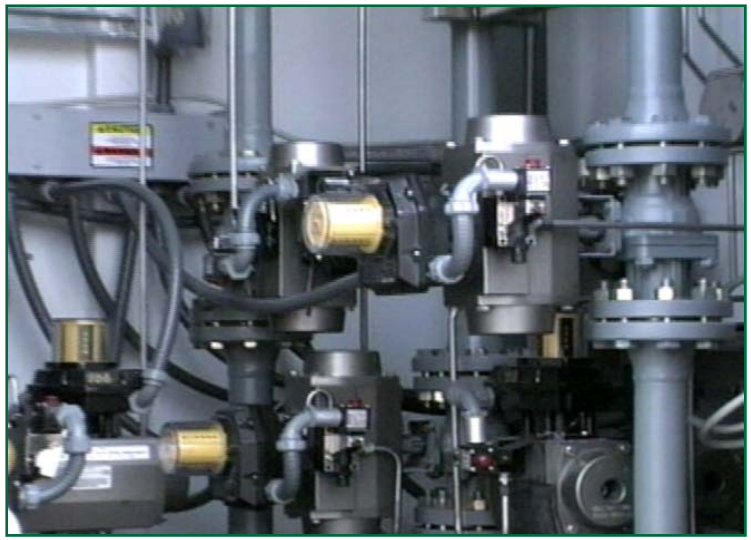
Waste Mixing

- 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

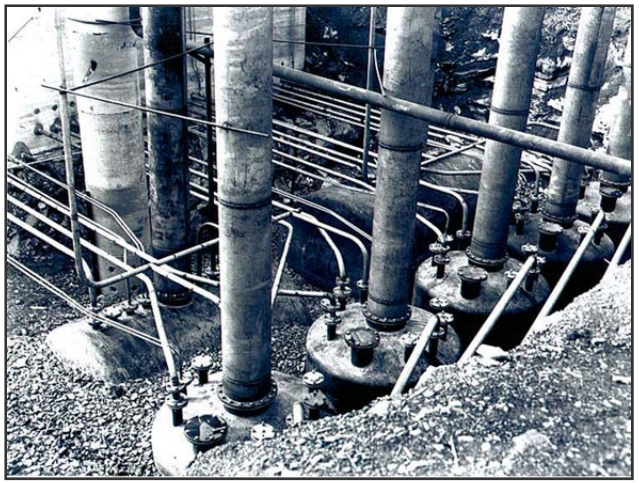


Old Hydrofracture Facility

- 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

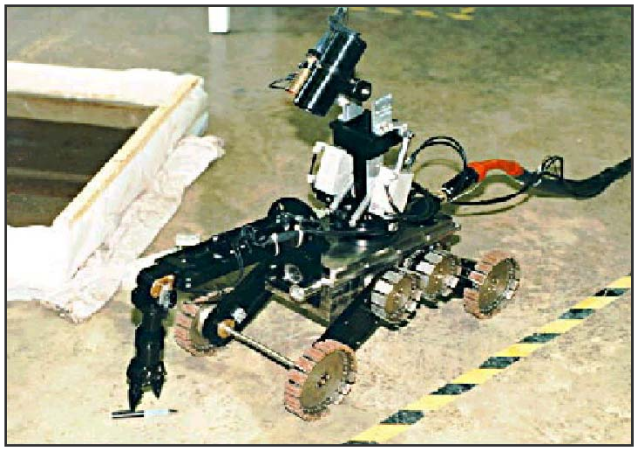
FFA Tanks

- Many of the FFA (Federal Facilities Agreement) 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

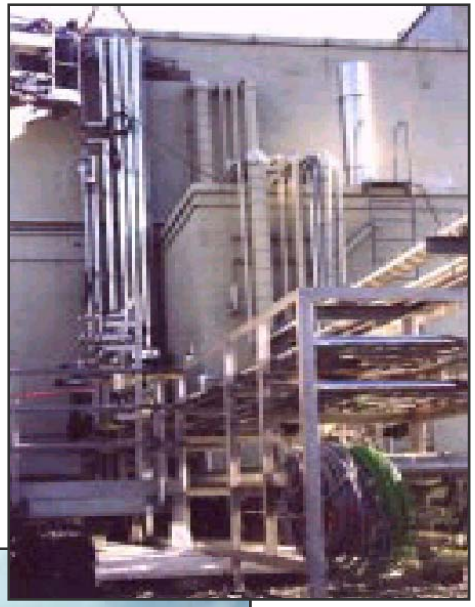
Mobile AEA power fluidic pump at tank 3003A

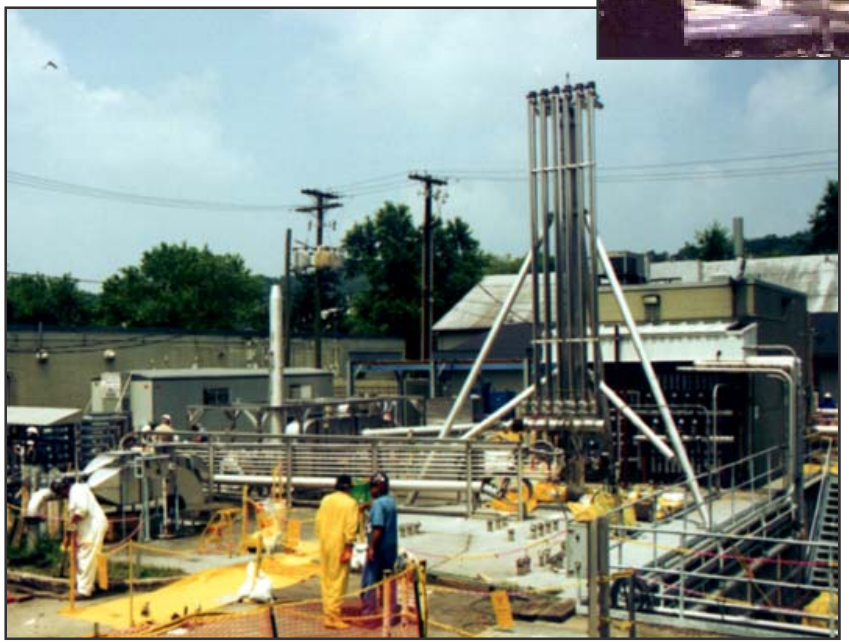


Scarab III Remotely Operated Vehicle

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
  - Five 50,000 gal horizontal stainless steel tanks
- 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





Advice

- **Equipment**
  - Consider ergonomics for repetitive manual operations
  - Use high quality components and parts
  - Understand the nature of prototypic systems
    - Expect some valve and line failures in initial prototypes
  - Ensure fastener integrity and robustness
  - Maintenance issues are key to success. Design for:
    - High reliability
    - Ease of maintenance
    - Replacement vs. repair
    - Maintenance friendly containment
  - Practice preventative maintenance and inspections to identify problems and extend operating life
  - Understand equipment limitations
- **Environment**
  - Know the environment but expect something worse – Waste material variability will likely be greater than initially expected
  - Work schedules during hot operations should be structured around weather considerations

Advice (cont.)

- **Operators**
  - Cross training on various systems may be required to optimize staff utilization
- **Ensure that system components are thoroughly tested under a broad range of conditions**
  - If possible cold test everything
- **Control system**
  - Control system interfaces should be designed with consideration for the talents, abilities, and background of the personnel who will be operating the equipment
  - User-friendly straightforward equipment interfaces should be used
  - Operator input should be used during the design to ensure ownership and acceptance of the equipment in the field