History of Vitrification at Hanford

Oregon Hanford Cleanup Board

Tamástslikt Cultural Institute

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Basics

• Many attempts at Vitrification
• Many diversions
• Many failures
• Principle problem -> cheaper, better, faster…. – it never is
• Secondary problems -> lack of full understanding – technical & financial

Washington State Department Chronology of Hanford Tank Waste Treatment
“Trail of False Starts”

Stakeholder Workshop
October 26, 2000
History of Hanford Tank Waste Treatment Project 1989-2010

Plan #1 - 1989
Hanford Waste Vitrification Project for Double-Shell Tank Waste

Plan #2 - 1993
New technical strategy to retrieve and vitrify all waste

Plan #3 - 1996
Privatization Concept adopted for tank waste treatment

Plan #4 - 2000
Bechtel selected as new Waste Treatment Plant (WTP) contractor

Plan #4 - delay
WTP Construction Schedule Slip

Schedule Slip in 2003
Schedule Slip in 2005
Schedule Slip in 2007

2007 Old Hot Start
2011 Full-Scale Operation Plan
2019 Hot Operations

Terminated
Terminated
Terminated

10 Years with 3 major delays adds 12 years to hot operations
Waste Treatment

Major attempts to build processing facilities

- Circa 1952 - facility to turn Hanford wastes into granular solids (Calcine)
- 1989 HWVP – Hanford Waste Vitrification Plant and Grout - (DSTs only)
  - Pilot plant for first 18% and follow-on for the rest
- 1993/4 TWRS – Tank Waste Remediation System Rebaselining
- 1995/6 WTP – First try at building the Waste Treatment Plant
- 1995 Privatization – Rebidding for two competing plants
- 2000 WTP II – The first major construction
Waste Treatment

Major diversions:

• 1976-1988 Basalt Waste Isolation Project
• 2000-Now Alternate Waste Forms & Supplemental Treatment, & others
  – Cast Stone a.k.a. Grout, Steam Reforming, Bulk Vitrification
• 2002-2008 Bulk Vitrification

• 2000-Now
  – Lithium hydroxide dissolution, Iron Phosphate glass, CH-TRU tanks
• 2009-10 & 2012-2016
  – Legal Actions by the States of Washington and Oregon
• 2012 Secretarial Expert Panel on WTP technical issues
• 2012-2013 Secretarial Framework
• 2016 Vitrification Grand Challenge
1940s - Three approaches

- Store waste in tanks
- Concentrate waste in tanks
- Dispose of waste to the ground
  - "Major cost savings over tank storage"

HW-58329, Seven Year Waste Program, Dec. 15, 1958
Radionuclides in the ground
1950s - First efforts

- Calcination studied
  - Many types
- Vitrification
- Other methods
  - Drying
  - Steam reforming
- Greatly reduced ground disposal
  - Use vadose zone as protection
- Calcining the wastes was assessed as being too costly
  ~ $50 million
- Continued tank storage was selected

![Waste Disposal Research and Development Cost Graph](chart.png)
1978 National Research Council

• National Research Council issues
  “A Technical Review” on the “Radioactive Wastes at the Hanford Reservation”

• Proposed three options
  – Bury the waste in basalt several hundred meters below Hanford
  – Bury the waste in basalt at the end of a tunnel in the Rattlesnake Hills.
  – Convert the waste to a stable solid, put it back in tanks and cover with an impermeable cap
1980 Waste Management Supplement

Construct 7 new DSTs at Hanford
- 8 actually constructed in the AP tank farm

1. use higher strength carbon steel
2. provide adequate corrosion allowance
3. stress relieve primary tank after fabrication
4. increased dome strength
5. use more comprehensive non-destructive examination of tanks
6. decided against using cathodic protection
1983 DOE commitment

Complete all cleanup in 30 years

⇒ 2013!
• Five alternatives considered
  – Deep Geologic Disposal
  – In-Place Stabilization and Disposal
  – Reference (Combination Disposal)
  – Preferred Alternative
  – No Disposal Action
Preferred Alternative –
- Vitrify essentially all (by activity) present and future high-level waste in double-shell tanks -> send to a commercial deep geologic repository
- Dispose of low-activity HLW fraction in grout in near-surface RCRA vaults covered by a protective barrier and marker system.
- Send Strontium and Cesium capsules to a commercial geologic repository
- Dispose of retrievably stored and future TRU wastes in WIPP
- Dispose of pre-70 TRU waste & 618-11 TRU waste in WIPP
- Decisions on disposal of all other wastes are deferred
- Protective barriers are installed over tank residuals and grout vaults.
- A marker system is installed
BOROSILICATE GLASS - THE "PREFERRED" HIGH-LEVEL RADIOACTIVE WASTE FORM

- Early AEC studies on clay-waste mixtures yielded glass-like waste forms (1300 °C process temperatures)
- U.S., British, French research focused on borosilicate glass for process ability (1150 °C)

- '55
- '60's
- '70
- '82
- '84
- '87
- '90

- WSEP - DOE Radioactive Pilot Plant R&D:
  - Phosphate glass
  - Borosilicate glass
- West Valley selection of glass
- Hench Panel confirms DWPF selection of borosilicate glass
- HWVP EIS selects glass
- EPA rulemaking lists glass as "preferred" waste form

April 1988 joint Governors request

CONCEPTUAL PLAN FOR HANFORD CLEAN-UP AND DISPOSAL

WASTE

- HIGH LEVEL WASTE IN TANKS
- LOW LEVEL WASTE LIQUIDS
- HAZARDOUS CHEMICAL WASTE*
- LOW LEVEL WASTE SOLIDS
- TRU CONTAMINATED SOIL
- PRE-1970 TRU IN TRENCHES
- POST-1970 TRU IN STORAGE

WHAT NEEDS TO HAPPEN

- B-PLANT begin pre-treatment in 1990
- CHARACTERIZATION RCPRA & CERCLA permitting
- CHARACTERIZATION chemical & radiological to begin in 1989
- TRU PACKAGING FACILITY (WRAP)

DISPOSAL

- VITRIFICATION PLANT begin operations in 1996
- GROUT FACILITY begin operations in 1990
- IN-PLACE STABILIZATION
- TRANSPORTATION SAFETY PROGRAM
- HIGH LEVEL WASTE REPOSITORY operational by 2003
- ON-SITE CONCRETE VAULTS operational 1990
- WIPP New Mexico begin operations 1989
- SHALLOW LAND BURIAL

*All tank and TRU waste is chemically hazardous as well.
1988 Record of Decision on Disposal

- In 1988 DOE issued its record of decision on disposal of high-level waste implementing the EIS
- Begin grouting in 1988
- Build and operate the HWVP
- Complete all grouting and vitrification of DST waste in 2016
- Develop and complete technical evaluations for the SST waste ~2015
Double Shell Tank Waste
Hanford Waste Vitrification Plant
Grout Treatment Facility

DOE/RL 88-13
Single Shell Tanks

- Retrieve
- Waste
- Emptied Tanks
- Decision: Retrieve or Leave In Place
- Leave
- Waste Preparation
- Dome Filling
- Grout LLW
- Waste Treatment HLW
- Glass Canisters
- Vault
- Geologic Repository
- Barrier/Marker Placement

DOE\RL 88-13
Protective Barrier System

- 13 ft Aboveground Warning Marker
- About 40 ft From Tanks Nearest to Barrier Edge
- 5 ft Fine Soil Revegetated
- 1 ft Rock/Gravel
- 12 ft Coarse Rock
- Native Soil and Gravel
- Single-Shell Tanks Backfilled With Gravel
- Nuclear Waste (For In-Place Stabilization Alternative)
- About 140 to 230 ft to Groundwater Level
- Three Layers of Subsurface Warning Markers

DOE/RL 88-13

Oregon Department of Energy
Hanford Waste Vitrification Plant

- **West Valley Demonstration Project** – 1983 – 2002
  - 1983 glass selected, 1984 first test pour, 1996 start, 2002 completion
  - 275 10 foot high stainless steel canisters await disposal in deep repository

- **Savannah River Site - Defense Waste Processing Facility** – 1987 – Now
  - 1982 glass selected, 1996 start
  - January 25, 2016 – poured 2,000th canister
Hanford Waste Vitrification Plant

• 1989 Hanford Site – Tri-Party Agreement, Hanford Waste Vitrification Plant
  – 1987 glass selected, operations planned in December 1999
  – November 1989 DOE awards a $550 million construction contract to begin building the High-Level Waste Vitrification Plant (HWVP)
    • TPA calls for HWVP construction to begin in July 1991
      – 10% of waste volume, 90% radioactive curies
    • Only covers Double Shell Tank waste
    • Pretreatment in B Plant
    • HLW to be vitrified
    • SSTs deferred pending technical analysis and decisions
    • Low-Activity Waste (LAW) to be grouted
      – 90% of waste volume, 10% of radioactive curies
    • 14 grout vaults for LAW grout to be constructed in 1994
1990

- DOE determines that single-shell tank waste is as hazardous as double-shell tank waste
  - All tank waste will now be treated through the HWVP and grout programs
- September
  - DOE informs Washington State that tank safety issues may delay the vitrification plant
1991

• Major hazards are recognized in many tanks
• January
  – Wyden “watch list” created covering 56 SSTs and DSTs
  – Flammability, criticality, hydrogen, organic chemicals, explosive and other hazards
  – Last watch list tank issues resolved in 2001
• May
  – Secretary Watkins delays start of HWVP construction to April 1992
  – Redesign to handle all SST and DST wastes
  – Planned operation in December 1999
  – TPA milestones adjusted
• December
  – DOE drops consideration of using B Plant for pretreatment under pressure from the State as it would not meet regulatory requirements
Late 1992 - Grout

• **Grout problems**
  – Serious technical problems
  – Pipes clogged and leaked
  – Grout found incapable of retaining Technetium
  – Costs rose to exceed vitrification

• **Grout dies**
  – Grout program ends due to high cost, technical incapability, technical difficulties and extensive stakeholder opposition
1993

• HWVP plans begin to stall
• First 5 year plan proposal released
  – Propose delaying vitrification start to 2020
• March – GAO endorses delays in the vitrification plant due to major technical issues
• Secretary O’Leary meets with Governor Lowery to assure him that DOE stands by their plans
• Later in March, the Tri-Parties agree to a six month delay
• May – Hanford Tank Waste Task Force begins meeting
  – They meet four times – May to December
  – They expand on and reinforce the cleanup principles recommended by the Future Site Uses Working Group and identify specific values related to tank waste treatment
1993 TWRs Rebaselining

• DOE formally proposes changes to the TPA
• Tank Waste Remediation System Rebaselining
  – Studied a wide array of waste forms
• TPA renegotiation – excellent public involvement in five cities (Spokane, Seattle, Richland, Hood River, Portland)
  → Vitrify all HLW – DSTs and SSTs
  → Focus on cleanup along the river to show progress
• October – new TPA milestones are agreed to
  – Delay construction of the HLW vitrification plant
  – Add a low-activity waste vitrification plant to replace the grout program
  – Extend cleanup by 10 years
  – New target for mission completion 2028
Jan 1994 - TWRS EIS

- Retrieve present and future waste from all DSTs and SSTs
- Separate the waste into HLW and LAW streams to the extent required to meet onsite disposal requirements for LAW and to maintain an acceptable volume of HLW for offsite disposal
- Vitrify the LAW and dispose of it onsite in a near-surface disposal facility in a retrievable form
- Vitrify the HLW and store it onsite at a designated storage facility for future disposal at the potential geologic repository
- 1994 Safe Interim Storage EIS used to decide to remove all pumpable liquids from the SSTs
Tank Waste Technical Options Report

Figure 2.4: Separations, Treatment, and Disposal Costs Versus Separations Technology Option

Cost - $ Billions

- Disposal
- Expense
- Capital

- In-tank Sludge Wash A
- In-tank Sludge Wash B
- Sludge Wash A
- Sludge Wash B
- Sludge Wash C
- Sludge Wash D
- Solvent Extraction A
- Solvent Extraction B
- Solvent Extraction C
- Solvent Extraction D
- Clean
- None, no LLW

Grout LLW, 1.40 m3 Canister
Grout LLW, 0.62 m3 Canister
11 m3 Cask
1994

- Vitrification now planned as a two stage process
  - Vitrification pilot plant to process 18% of the waste
  - Followed by construction of a second facility to vitrify the rest

- Concerns that once the first plant was constructed money would not be available for the second plant

- Privatization proposed instead
• **September 1995** Secretary Hazel O’Leary announces a new approach – privatization

• ...a new approach to more cost-effective cleanup of the Cold War legacy ...

• Under this “privatized” arrangement, the contractor finances, designs, builds, and operates its own facility to provide the cleanup services and receives payment from the DOE for fixed-price products
TWRS - Privatization

• 14 companies initially expressed interest
• **November 1995** - Draft Request for Proposals issued
• DOE estimates $40 billion to treat all of the tank waste

• **January 1998** - two bids resulted
  – British Nuclear Fuels, Limited wholly owned subsidiary BNFL, Inc.
  – Lockheed Martin

• DOE report to Congress
  – Delayed startup and increased costs
  – Much longer facility lives – 30 years rather than 5 to 7
  – Estimated cost $6.9 billion (1997 $)
  – Vitrification to begin in 2006-2007
  – Waste from 11 tanks to be vitrified by 2018
1998 Privatization

- The HAB requested & DOE provided 8 criteria to judge success of privatization
  - Privatization ultimately failed all eight criteria
  - Privatization using two competing contractors died when the Lockheed Martin’s proposal was assessed as technically not viable

- DOE shifted to privatization using a single contractor
- Despite concerns Washington Department of Ecology supported the contract

- August 1998 - BNFL, Inc. created and selected for a single vitrification complex using a cost plus contract
  - 24-33 month period to reach 30% design, obtain permits and financing
- GAO reports that the BNFL contract carried substantial risk
  - Concerns that their vitrification technology would not work at Hanford
TWRS - Privatization

• Phase I, running through 2011, will treat and immobilize 13% of the tank waste

• Phase I - BNFL Inc. will:
  – In Part A ... develop the technical, financial, and regulatory bases to implement Part B under a fixed-price contract.
  – In Part B ... design, build, and operate a treatment facility using proven technologies, operating practices, and safety principles developed by BNFL over the past 45 years

• Phase II, starting in 2008, to recover and immobilize the remainder by 2024 in a follow on or expanded treatment plant
Privatization

• **2000** - Ecology Director Tom Fitzsimmons issued a final determination setting milestones and enforcement penalties for building the tank waste treatment facilities, after 18 months of failed negotiations

• DOE agreed to
  – Contract with BNFL by August 31, 2000
  – Construction to begin by July 31, 2001
  – Operational testing of vitrification facilities to begin by Dec 31, 2009
  – 10% of tank waste to be vitrified by December 31, 2018

• DOE Inspector General assessed the 2028 deadline to treat all tank as unrealistic
2000 Privatization

- Washington Legislature passed a bill to exempt Hanford’s tank waste treatment from local property taxes saving about $1 billion
- **April** – BNFL submits their cost estimate
  - $15.2 billion entirely with private financing
  - Confident that construction and operating costs would be about $6 billion
  - $9.2 billion would be financing costs
- Secretary Richardson proclaimed the price unacceptably high and unfundable
- **May** – Sec’y Richardson announced he would terminate the contract
- DOE to seek new bidders and award a new contract by the end of the year to complete design and to construct the facilities
- DOE Deputy Secretary Glauthier judged BNFL’s design work sound and Bechtel (a BNFL partner) would continue the design
- DOE judged that privatization had failed
- BNFL, Inc. had reached about 30% completion on the design of the facilities
2000 Recovery

- Secretary Richardson, Governor Locke and Attorney General Gregoire worked to keep the program moving
- Richardson agreed to immediately amend the Consent Decree to require DOE to meet milestones to replace BNFL
- DOE agreed to award a new contract by January 15, 2001
- **June** – DOE issued a notice to terminate the contract with BNFL
- DOE-ORP modified its contract with CH2M-Hill to take over design from BNFL after complaints that Bechtel would have an unfair advantage
- DOE issued its fair cost estimate for tank waste treatment - $9.512 billion
  - Hard costs for design and construction - $3.653 billion
  - Private financing - $5.859 billion
2000 Rebid

• TWRS P document
  – DOE’s regulatory group tracked design issues during privatization
  – The rebid facility was required to use the 30% design completed so far
  – The issues tracked in TWRS-P were not included or addressed

• August – DOE released its final Request for Proposals
  – Delay construction to 2002, maintain start of hot operations in 2007

• December – DOE awarded 10 year $4 billion contract
  – Bechtel Hanford group and Washington Closure

• Construction begins in 2001
2001

• DOE extended the CH2M-Hill contract to manage tank farms
• Washington Closure (responsible for the design, construction and operation on the team for the WTP) filed Chapter 11 bankruptcy
• Ecology rejected DOE request to delay TPA milestones related to WTP
  – Announced intent to begin fines if the July 31 start of construction deadline is missed, beginning August 1
  – DOE appealed
• DOE Manager Harry Boston:
  – DOE exploring alternatives to vitrifying all of Hanford’s tank wastes
  – hope to save tens of billions of dollars, and completing decades ahead of schedule
  – initial vitrification plant able to treat more waste than originally envisioned, possibly eliminating the need for an additional, larger plant
  – increasing the ORP budget from $1 billion per year to the $3-4 billion per year needed to complete both plants undoable
  – many tanks contain very little waste and could perhaps be left in place as is
November 19 – Assistant Secretary Jessie Roberson outlines plan to
- Reduce cost and schedule by not vitrifying 75% of the waste
- Develop two non-vitrification technologies

Alternate Waste Forms

Bulk Vitrification
Bulk Vitrification (aka dumpster vit)

- The idea was that a cheaper, better, faster form of vitrification could be accomplished using electrodes to melt waste and glass in dumpsters.
Bulk Vitrification

• Emphasis on wastes in selected Single Shell Tanks (SSTs)
• October 2002, CH2MHiIl issues a request for proposal
  – process development testing, engineering and data package for a non-radioactive (cold) pilot bulk vitrification process, and pre-conceptual engineering of a production bulk vitrification system
• Claims:
  – “New”, “low cost” approach
  – Pretreatment and bulk vitrification process technologies successfully deployed to remediate both radioactive and chemically hazardous wastes at nuclear power plants, DOE sites, and commercial waste sites in the US and abroad
  – Integrated systems approach
• Bulk vitrification project officially began in June 2004
• Bulk vitrification project unofficially died in ~ 2008

2002 to present

- **2002-2004** – Numerous reassessments, engineering issues, delays
- **2005** – PNNL Seismic report begun in 1999 show much greater seismic risk
  - Results in a two year pause for redesign (upper floors and equipment)
- Design and construction resumes
- Costs rise and a large number of technical issues become prominent
- Two lawsuits by Washington and Oregon
- Engineering and Design Issues reported for the HLW and ILAW plants
- Defense Nuclear Safety Board recommendations on technical issues and safety culture
WTP project schedule slips

• Original  Hot operations in 2007
• 2003       Hot operations in 2011
• 2005       Hot operations in 2017
• 2007       Hot operations in 2019
• 2012       Proposed hot operations in 2022
• Treatment scheduled to take 25 years (complete by 2047)
• 2016       Full hot operations in 2036
Dirk’s laws of Hanford

• *Grout is dead!* Long live grout!
• *Cheaper, better, faster* is almost never any of these
• *Saving money* is really really expensive (and time consuming), especially at the start
• *Magic bullets* aren’t!
  – Corollary: *Cheap fixes aren’t either!*
  – Corollary: Neither are ‘temporary’ solutions, or ‘quick’ fixes!
• *Really neat ideas* never are
  – Corollary: They tend to be really expensive, time consuming, and immensely profitable
• There is never enough time or money to do the job right
  – Corollary: There is ample of both to do it over and over and over...
• *Temporary is temporary* ➔ Until it becomes permanent
  – Corollary: Everything is “temporary” at Hanford
• Whenever things get hard ➔ start over
  – Corollary: *Things always* get hard
Questions