Supplemental Treatment Hanford Immobilized Low Activity Waste Discussion

National Academies of Sciences, Engineering, and Medicine

Alex Smith

Washington State Department of Ecology

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DEPARTMENT OF ECOLOGY
State of Washington

Outline

- Performance Standard for Immobilized Low Activity Waste at Hanford
- Background
  - Hanford and its Tank Waste
  - History of Plans for Tank Waste Treatment
  - History of Plans for Low Activity Waste Treatment (including “supplemental treatment”)
  - Immobilized Low Activity Waste Performance Standard and “As Good as Glass”
  - Conclusion

Hanford Low Activity Waste (LAW) Immobilization Standard is Vitrification

This standard is because the immobilized LAW will be disposed of in the near surface at Hanford. The standard is reflected in:

- Waste Treatment Plant (WTP) flow sheet and design
- Pretreatment requirements
- RCRA requirements
- Nuclear Regulatory Commission approval of this LAW disposal pathway

Hanford Low Activity Waste (LAW) Immobilization Standard is Vitrification

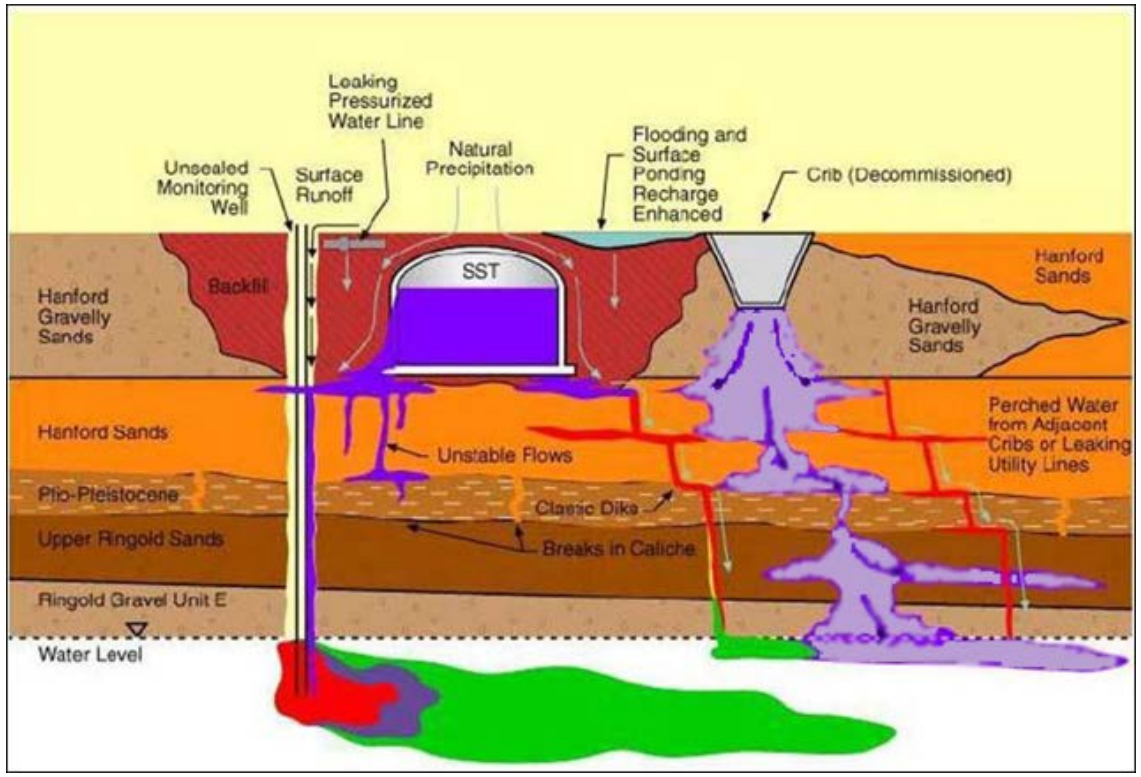
- ***Long history***: Over time studies, new approaches, and commitments have maintained that vitrification (glass) is the appropriate standard.

- The decision for LAW vitrification is based on minimizing risks that near surface disposal of Immobilized Low Activity Waste (ILAW) at Hanford poses to human communities and the environment in the Pacific Northwest.

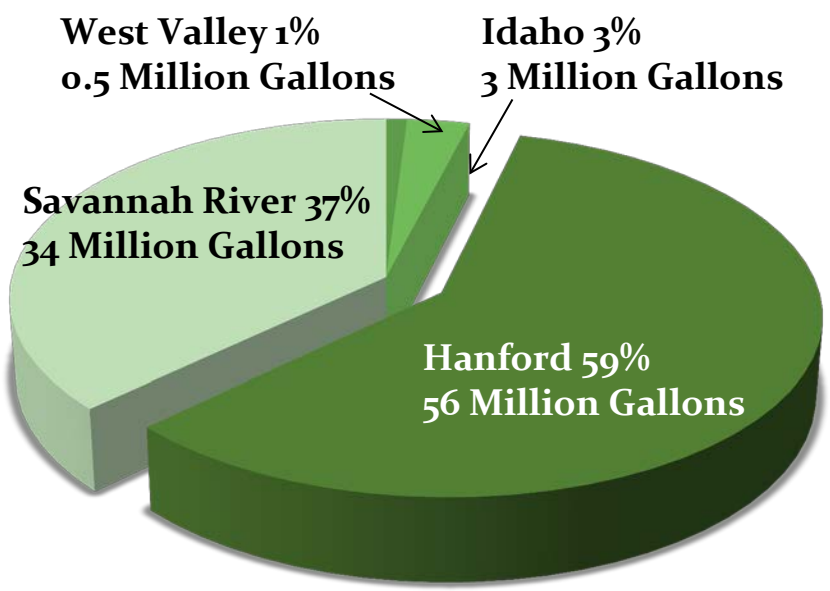
Background

Hanford is The Largest Federal Cleanup Site in the United States

- 72 square miles of groundwater contaminated above drinking water standards.
- 177 underground storage tanks containing 56 million gallons of High Level Nuclear Waste stored in underground tanks.
- Tanks have leaked over 1 million gallons.
- 440 billion gallons of contaminated waste discharged to the Hanford soils.
- Immobilized LAW decisions need to be evaluated against the backdrop of the existing contamination.

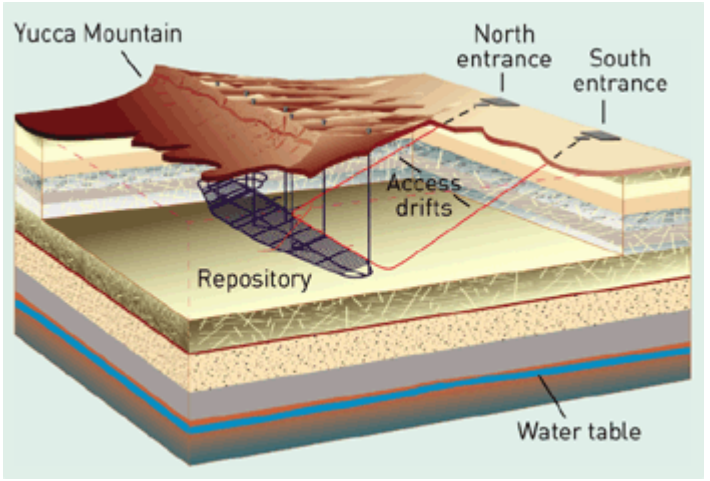


High Level Radioactive Tank Waste



All the tank waste (HLW) should go to deep geologic repository

- **Where the geology protects human health**



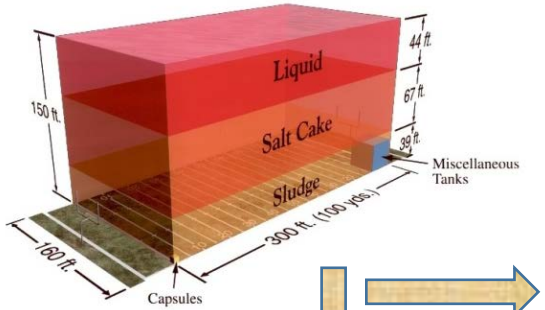
Low Activity Waste (LAW) – vitrification is the long agreed to waste form for on-Site disposal

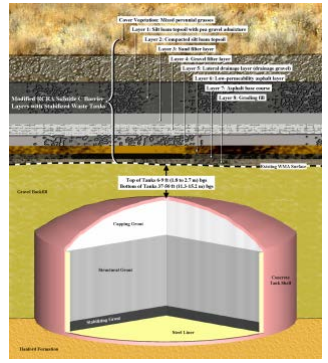
If, and only if, key factors are met, can some of the waste be disposed in a near-surface environment

- **Where waste form and radionuclide removal protects human health**

Full Operational WTP Flow Sheet Starting in 2033

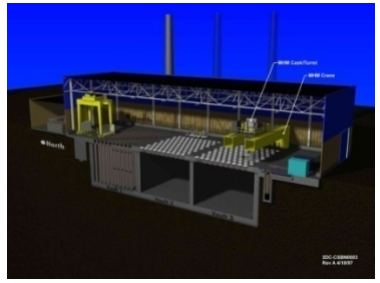
Tank Waste
56 million gallons
195 MCi
190,000 tons of chemical





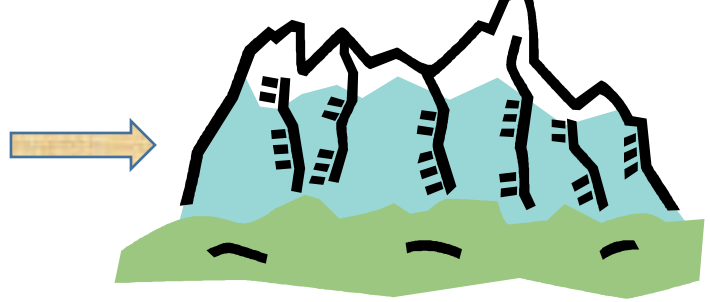
Closed Tanks and Residuals
3.2 MCi in tank residuals

Immobilized High Level Waste
36,000-48,000 metric tons of glass
10% of the volume
179-184 MCi
12,000-16,000 canisters (2’ by 14.5’)
95-97 % of radionuclides



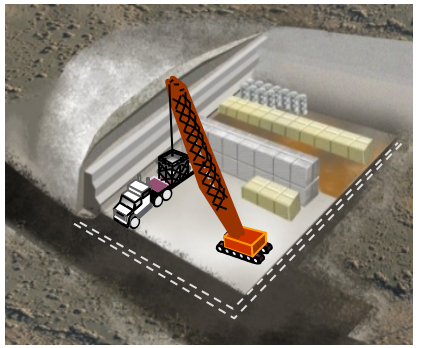
On Site Interim Canister Storage

Immobilized Low Activity Waste
380,000-620,000 metric tons of glass
90% of the volume
5-10 MCi
60,000-100,000 canisters (4’ by 7.5’)
3-5 % of radionuclides

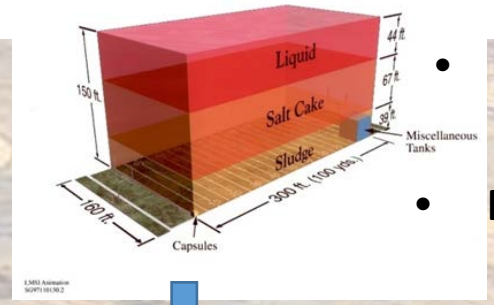


Deep Geologic Repository

On Site Landfill Disposal



Direct Feed Low Activity Waste Treatment Starting in 2023



- 1/3 of the Tank Waste is Liquid Feed for Direct Feed
- Remaining Direct Feed from Salt Cake

On Site Landfill Disposal

Treat 10 years Immobilized Low Activity Waste

21 metric tons per day of glass waste

242-A Tank Waste Evaporator

200 East Tank Farms

Effluent Treatment Facility

AP Tank Farm

Low-Activity Waste Pretreatment System

Analytical Laboratory

Low-Activity Waste Vitrification Facility

LAW Effluent Management Facility

Waste Treatment Plant

WASTE FEED | LIQUID EFFLUENT | GLASS CONTAINERS

At Hanford, "Supplemental Treatment" Has Meant Different Things

- A Second LAW treatment facility that augments the Low Activity Waste (LAW) Vitrification Facility may be needed to treat all the low activity waste that is produced when WTP Pretreatment facility is running.
  - Original mass balance estimates indicated that a Second LAW Treatment system would be needed to treat the volume (50 to 65%) of LAW beyond what the planned LAW Vitrification Facility has the capacity to treat.
- Alternative ways to treat or package the tank waste retrieved directly from the tanks.

We assume the Committee is looking at the first.

Hanford History of Low Activity Waste

- Washington State has a role in defining the nature of the final waste form.
  - Approximately 90% of tank waste volume is to be disposed in a near surface landfill in soils at Hanford, above groundwater that flows to the Columbia River.
- DOE previously made commitments to Washington State that Low Activity Waste disposed at Hanford would be vitrified:
  - In exchange for Washington's agreement to delay the Hanford Vitrification Facility in the 1990s, so that Savannah River's vitrification facility could be constructed ahead of Hanford's.
  - Based on significant performance issues identified for previously proposed grout vaults that concerned Ecology and the public.
  - Based on a 1996 Environmental Impact Statement and Record of Decision in which DOE committed to pretreating the tank waste and vitrifying ***all*** the tank waste (both HLW and LAW).

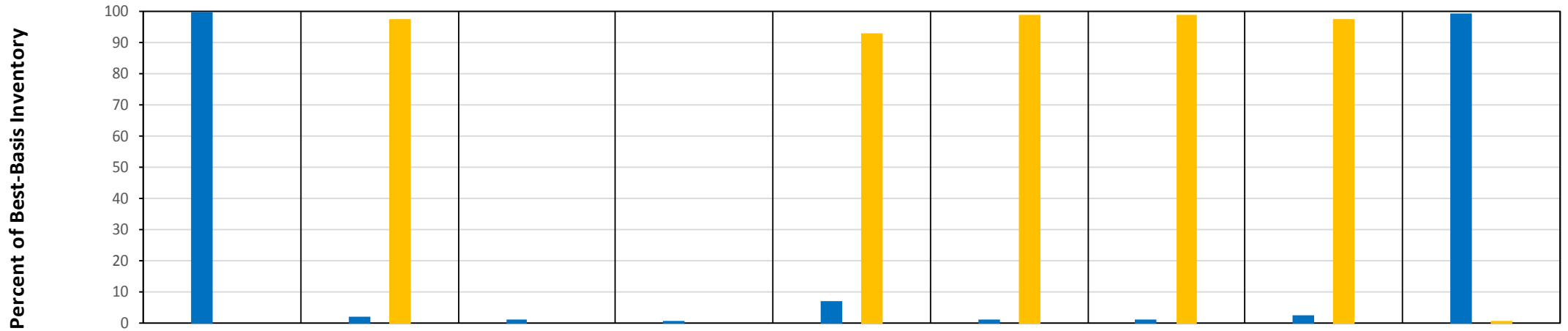
Hanford History of Low Activity Waste

- Since the early 1990s, the Tri-Party Agreement has reflected these commitments to vitrify both HLW and LAW
  - 2003-2006: A waste form that performed "as good as glass" was considered as an option for supplemental LAW treatment.
  - **Subsequently, however, no viable alternatives to vitrification were identified that provide adequate protection to the human health and the environment**
  - Tri-Party Agreement went back to identifying LAW Vitrification as the treatment method.

Hanford History of Low Activity Waste

- In 2002, Ecology issued a RCRA Permit for Waste Treatment Plant (WTP). The permit includes:
  - A Pretreatment Facility for radionuclide and chemical separations, a HLW Vitrification Facility, and a LAW Vitrification Facility.
  - HLVIT is the RCRA Land Disposal Restriction (LDR) treatment standard for high level radioactive waste with hazardous waste codes D002 and D004 through D011.
- Currently, Tri-Party Agreement and Consent Decree require the construction and operation of:
  - Pretreatment Facility, HLW Vitrification Facility, LAW Vitrification Facility and "Supplemental Vitrification Treatment".

Distribution of Key Constituents in Waste Forms



	Iodine-129	Cesium-137[a]	Carbon-14	Hydrogen-3	Uranium-233, -234, -235, -238	Neptunium-237	Plutonium-239, -240	Strontium-90[a]	Technetium-99
Best-Basis Inventory (curies)	4.82×10^{1}	4.85×10^{7}	3.12×10^{3}	1.21×10^{4}	9.38×10^{2}	1.41×10^{2}	8.41×10^{4}	5.05×10^{7}	2.97×10^{4}
% Disposal									
Onsite[b]	100.2	2.4	1.3	1.0	7.2	1.2	1.2	2.5	99.6
Offsite[c]	0.0	97.9	0.0	0.0	93.1	99.0	99.0	97.6	0.8
Total[d]	100.2	100.3	1.3	1.0	100.3	100.2	100.2	100.1	100.4

[a] This figure excludes the inventory and secondary waste generated by the treatment of the cesium and strontium capsules.

[b] Immobilized low-activity waste glass, tank residuals, retired low-activity waste melters, solids secondary waste, and Effluent Treatment Facility-generated secondary solid waste.

c Immobilized high-level radioactive waste glass.

d Totals may exceed 100 percent due to conservative estimates or rounded numbers. Carbon-14 and hydrogen-3 many not total 100 percent because portion of each are released to the offgas streams and stack or to the State-Approved Land Disposal Site.

LAW Performance Studies History

Key Factors in Assessing Risk Include:

- Previously disposed legacy waste has already impacted groundwater and will continue to contribute to the overall Site risk burden.
- Immobilized LAW is not the only waste form to use up the allowable remaining risk burden. (Secondary waste will use up a significant amount.)
- In general, landfill standards require that treated waste not impact groundwater at all.
  - In this case, Washington is allowing cumulative impacts to groundwater that stay below risk standards such as drinking water criteria.

LAW Performance Studies History

Other Studies re ILAW Performance:

- Hanford Waste Task Force (1993) concluded there were concerns with grout:
  - "[G]rout doesn't adequately protect public, workers, and environment"
  - "[R]eduction of waste volume was an issue for grout"
- DOE's waste form performance assessment (1995):
  - Identified three constituents that violate drinking water standards if grout is used: nitrate, iodine-129, and technetium-99.

LAW Performance Studies History

1996: TWRS EIS made the decision to retrieve the tank waste, separate it and vitrify both HLW and LAW portions.

2003-2006: Washington State and USDOE explored alternative supplemental treatment approaches for LAW to see if any performed "as good as glass."

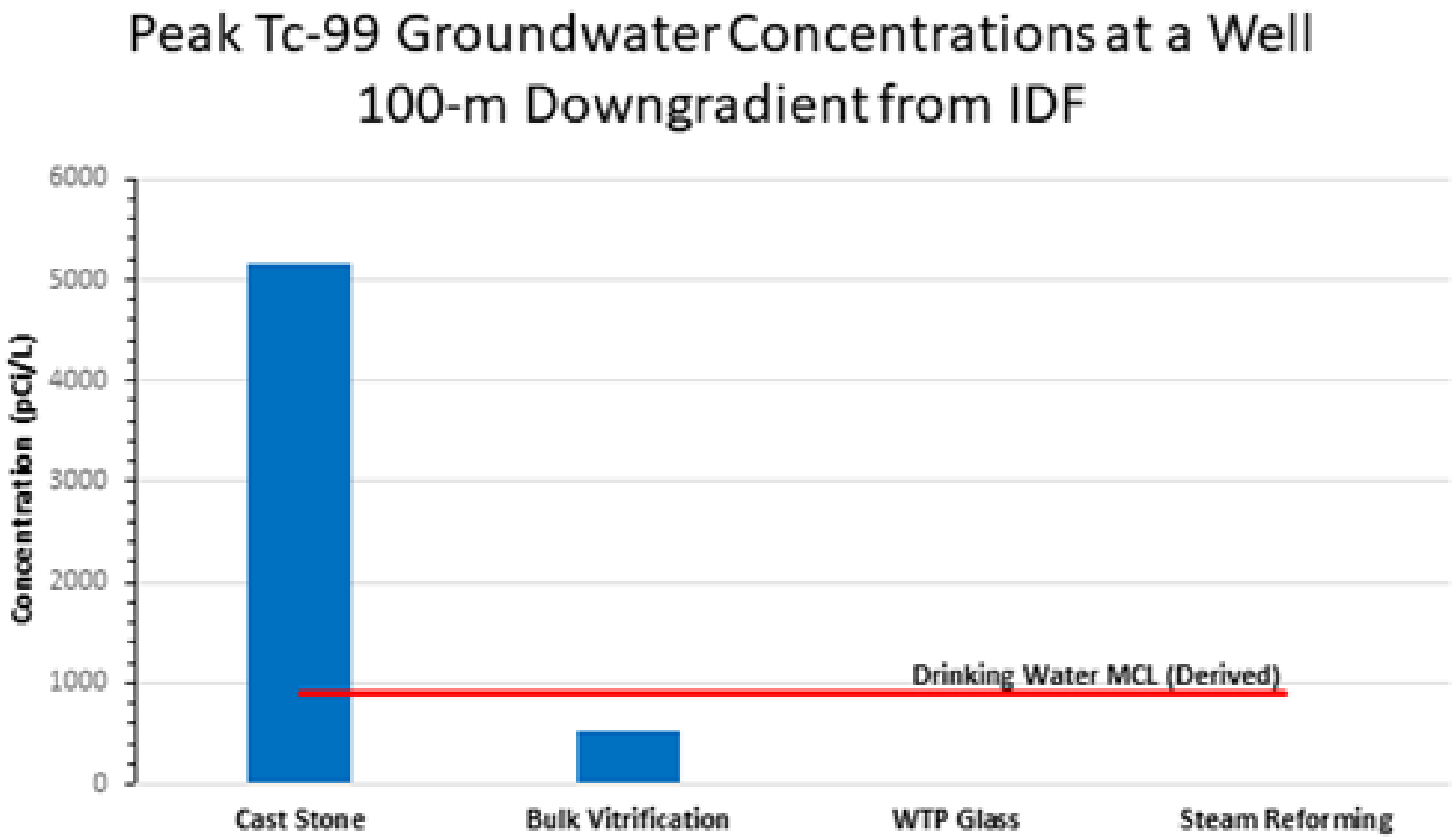
- USDOE's goal: Find approaches that were faster, less costly, and produced a waste form that was as "good as glass."
- Alternatives considered included WTP glass, Grout, Steam Reforming and Bulk Vitrification.
- Grout and Bulk Vitrification were not shown to perform in a manner that was protective of groundwater, and were therefore not as "good as glass."
- Grout additionally showed impacts to groundwater above standards.

LAW Performance Studies History

2012: Tank Closure Waste Management EIS

- Extensive analyses evaluated different Supplemental Treatment waste forms including WTP glass, grout, bulk vitrification and steam reforming.
- EIS analyses showed that vitrification was the most protective waste form and that other waste forms did not adequately limit the impacts to groundwater.
- EIS had to assume Tc-99 was removed or pretreated in order to even consider grout as an option.
    - Tc-99 removal is not part of the current pretreatment design.

2003-2006 Risk Assessments



Results for 2012 Tank Closure Waste Management EIS

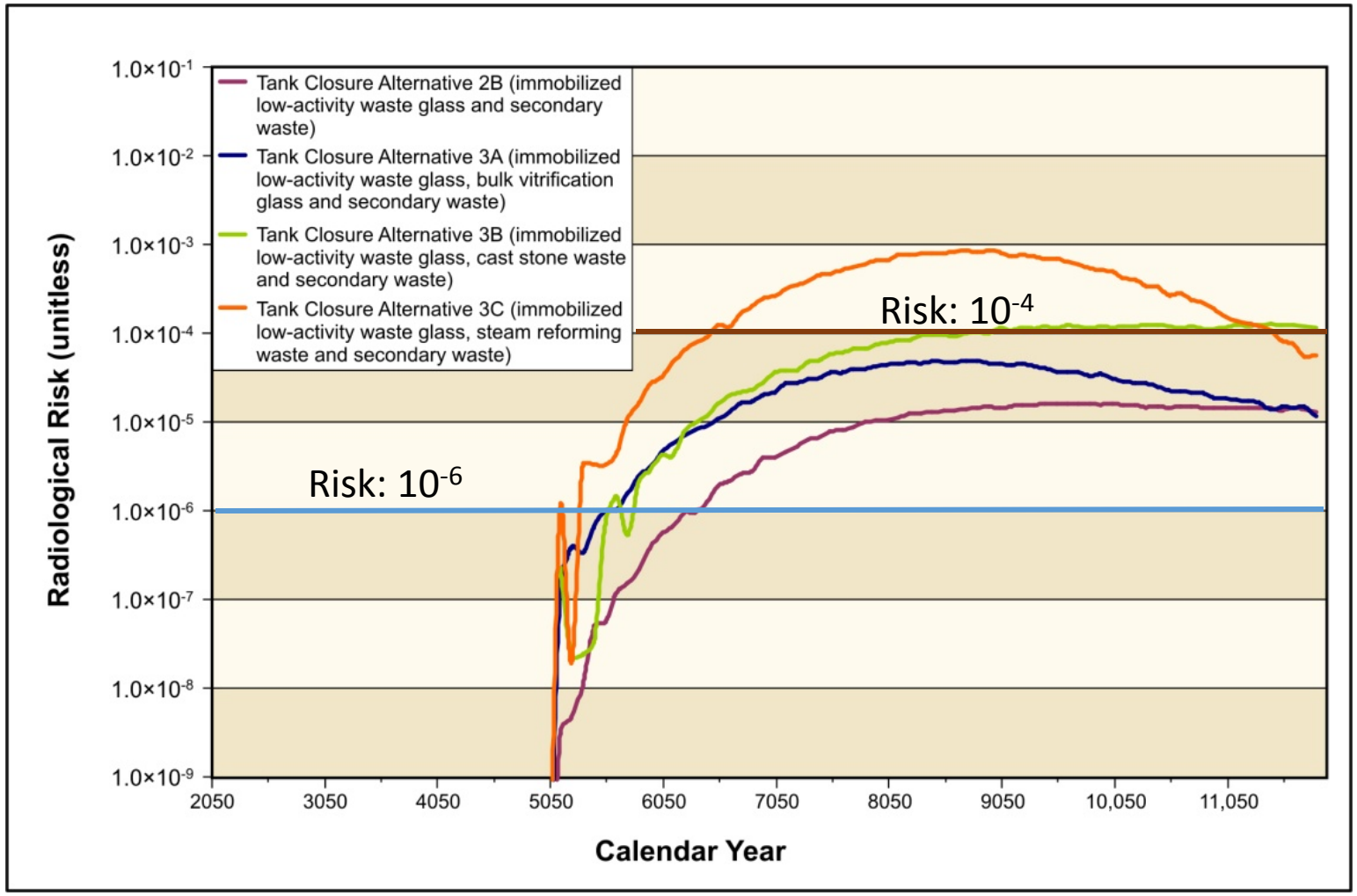
- TC&WM EIS showed that LAW grout as supplemental treatment is not as "good as glass" and not protective of groundwater.
- Constituents from grout reached groundwater in concentrations that **significantly exceed drinking water standards for technetium, nitrate, and chromium.**
  - Technetium, the peak groundwater concentration is almost **6 times greater** than the drinking water standard and **10 times greater** than the all-vitrification options.
  - Chromium, the peak groundwater concentration is **4 times greater** than the drinking water standard and **100 times greater** than the all-vitrification options.
  - Nitrate, the peak groundwater concentration is **1.1 times greater** than the drinking water standard and **3 times greater** than the all-vitrification options.
- EIS Alternatives that used all-Vitrification:
  - **Primary glass waste shows only limited impact to groundwater.**
  - **Secondary waste (grouted) shows impacts to groundwater and mitigation will b**e required.

Peak Groundwater Results on Various Waste Forms and Secondary Waste

	Glass	Glass and Bulk Vit	Glass and Cast Stone	Glass and Steam Reforming	Benchmark
iodine-129 (pCi/L)	1.4	1.7	0.7	10.7	1
technetium-99 (pCi/L)	471	1,604	5,022	29,171	900
chromium (mcg/L)	4	2	436	436	100
nitrate (mcg/L)	14,243	14,381	50,234	14,512	45,000

- Results are without offsite waste inventory and impacts.
- With the vitrification options most contamination concentrations come from secondary waste.

2012 Tank Closure and Waste Management EIS



For all glass options, most of the impacts come from secondary waste. Secondary waste causes significant groundwater impacts and needs robust mitigation to get below levels of concern.

Cost Estimates

- The costs of LAW vitrification appeared to be similar to those for grout on a grand scale.
- USDOE's *Assessment of Low-Activity Waste (LAW) Treatment and Disposal Scenarios for the River Protection Project* (2003)
  - Did not show a favorable grout waste treatment cost estimate.
- USDOE's *Hanford River Protection Project Low Activity Waste Treatment: A Business Case Evaluation*, examined the cost and viability of implementing cast stone, bulk vitrification, and steam reforming waste treatment (2007). The report stated:
  - That "cost differences between [the different treated waste forms] are unlikely to be the major factor in selecting a supplemental LAW technology."
  - All the technologies were cost neutral when compared to each other and to vitrified LAW.
  - Added time and cost that would be required to bring the supplemental technologies up to the technology readiness level of vitrified LAW.
- The 2009 *Draft* and 2012 *Final TC & WM EIS* indicate that the costs are relatively equivalent for vitrified LAW and grouted LAW approaches.

As Good As Glass

2003–2006: Evaluation of Supplemental Treatment Technologies

This effort resulted in several outcomes:

1. Defining what "as good as glass" means.
2. Examination of many technologies that could potentially be used to treat LAW.
3. Determination of Equivalent Treatment would be required for any non-Vitrification approach
4. Ultimately proving no options were protective or as good as glass

Good As Glass:

Roy Schepens, USDOE Office of River Protection Manager, defined the term "as good as glass" in a letter to Mike Wilson of Ecology (June 12, 2003):

> "The waste form resulting from treatment must meet the same qualifications of those imposed for the expected glass form produced by the Waste Treatment Plant (WTP). We expect all waste forms produced from any supplemental technology to:
>
> (1) perform over the specified time period as well as, or better than WTP vitrified waste;
>
> (2) be equally protective of the environment as WTP glass;
>
> (3) meet LDR [land disposal restrictions] requirements for hazardous waste constituents;
>
> (4) meet or exceed all appropriate performance requirements for glass, including those identified in the WTP contract, Immobilized Low Activity Waste (ILAW) Interface Control Documents, and ILAW Performance Assessment."

Basis for Disposing ILAW in Near Surface Landfill

Includes Basis for the WTP Pretreatment and LAW Vitrification Facility

Nuclear Waste Policy Act of 1982 addressed source and hazard. Section 2(12) of the NWPA defined HLW as

(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and,

(B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.

Current approach for Immobilized LAW

- Allows the High-Level Waste to be disposed in near surface facilities, instead of a deep geologic repository licensed by the Nuclear Regulatory Commission (NRC)
- A series of technical letters between DOE and the NRC in the 1980s and 1990s.

NRC established three criteria:

1. Tank wastes have been processed (or be further processed) to remove key radionuclides to maximum extent technically and economically practical.
2. Wastes will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C [low-level waste] as set out in 10 CFR Part 61.
3. Wastes are to be managed so that safety requirements comparable to the performance objectives set out in 10 CFR Part 61 Subpart C are satisfied.

Basis for Disposing ILAW in Near Surface Landfill

Includes Basis for the WTP Pretreatment and LAW Vitrification Facility

1997 NRC letter to USDOE:

- Provided an integral part in determining the criteria and methods to be used for separation.
- Issued a Waste Incidental to Reprocessing (WIR) determination for a portion of Hanford tank waste.
- NRC judged that three proposed separations technologies were technically and economically practicable.
  - Simple solids-liquid separation on each batch of tank waste
  - Removal of transuranic waste from selected tanks
  - Single-cycle ion exchange removal of cesium-137 from certain waste
- And that the three technologies along with **vitrification** and specific disposal location performance assessment met the three 1993 NRC criteria.
- Leaving 8.5 MCi of activity remaining in Immobilized Low Activity Waste, which is equal to about 2% of total of 422 MCi of the original inventory in the tanks.

LAW Glass Has Long Been the Technical Basis

- WIR for LAW is built on the waste form being glass. Any differences would require a new WIR and changes to the WTP flowsheet
- Washington State's acceptance of Immobilized LAW staying in Northwest is based on vitrification
- WTP current design, of the LAW Vitrification Facility, and the Pretreatment Facility is dependent on LAW glass.
  - Tc-99 and I-129 are NOT removed from LAW feed and sent to HLW feed.
  - Originally, there was a Tc-99 removal system planned in Pretreatment Facility to move Tc-99 from LAW feed to the HLW feed.
  - Based on the glass performance and capture of Tc-99 in glass, the Tc-99 pretreatment system was deleted from the design and actual foot print was altered.

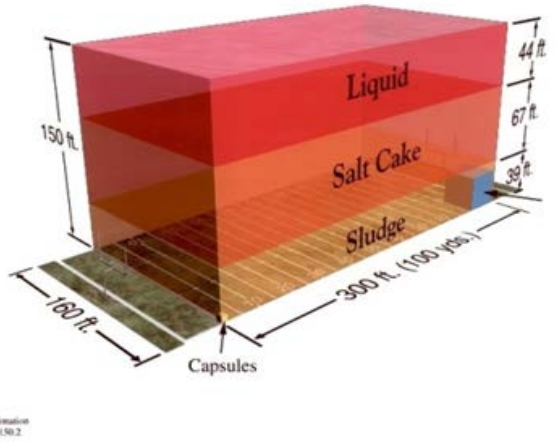
LAW Vit Melter

Alternatives Over Time

- Through past decades there have been several attempts (cycles) to prove out better, faster, and cheaper approaches to Immobilized LAW.
- Recently this cycle has begun again. There are assertions that some previous performance data needs to be revisited.
- Ecology perspectives on the most recent assertions:
  - They lack scientific data presented in a form of comparative analysis to the 2012 EIS.
  - They lack cost data presented in a form of comparative analysis to the 2012 EIS.
  - They have not identified any scientific studies beyond “bench scale” or “experimental” to show that a “new generation of” grout is as protective as glass.

Will There Be A Need for Supplemental Treatment?

- **Where does LAW waste feed come from?**
  - From supernate (1/3 of tank volume) that is pretreated to remove cesium and filtered for solids.
  - From dissolved salt cake (1/3 of tank volume) that is pretreated to remove cesium and filtered solids.
  - From washing the sludge and segregating the chemicals to the low activity waste side.



- **Direct Feed LAW Vitrification (DFLAW),** operating at least a decade before WTP, will reduce the total volume of supplemental low activity waste to be treated.
  - Decade of DFLAW will treat most of the supernate, all the dissolved salt cake from A/AX single shell tank farms and some salt cake from S/SX single shell tank farm.

Will There Be A Need for Supplemental Treatment?

- Improved glass loading in both high level and low activity glass will reduce the treatment capacity needs.
- A supplemental treatment system for LAW is only needed when WTP Pretreatment facility is operational and producing excess low activity effluent from the sludge washing.
  - If Pretreatment facility is never operational, then supplemental treatment facility won't be needed at all.
  - When Pretreatment Facility is operational, the size or capacity need for supplemental treatment is now in question based on the factors discussed above.

Direct Feed LAW Treatment

- Ecology fully supports Direct Feed Low Activity Waste approach and the need to be turning tank waste into glass in the near term by 2023.
- DOE's highest priority should be accomplishing DFLAW task.
- September 2017 the LAW facility was:
  - 64% complete overall
  - Engineering design 86% complete
  - Construction 87% complete
  - Startup/commissioning 12% complete

- DOE's second highest priority should be resolving the technical issues with High Level Vitrification and Pretreatment facilities. Operations by 2033.
  - Without success in this arena, there won't be a treatment path for the high-level feed.
- When those efforts are fully realized, then time and money can be spent on supplemental treatment *if* it is still needed at that point.

The Solution – Treat the Tank Waste Through Vitrification

2018