National Academies of Science – Supplemental LAW Options

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Oregon Hanford Cleanup Board
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Tank mission “product”

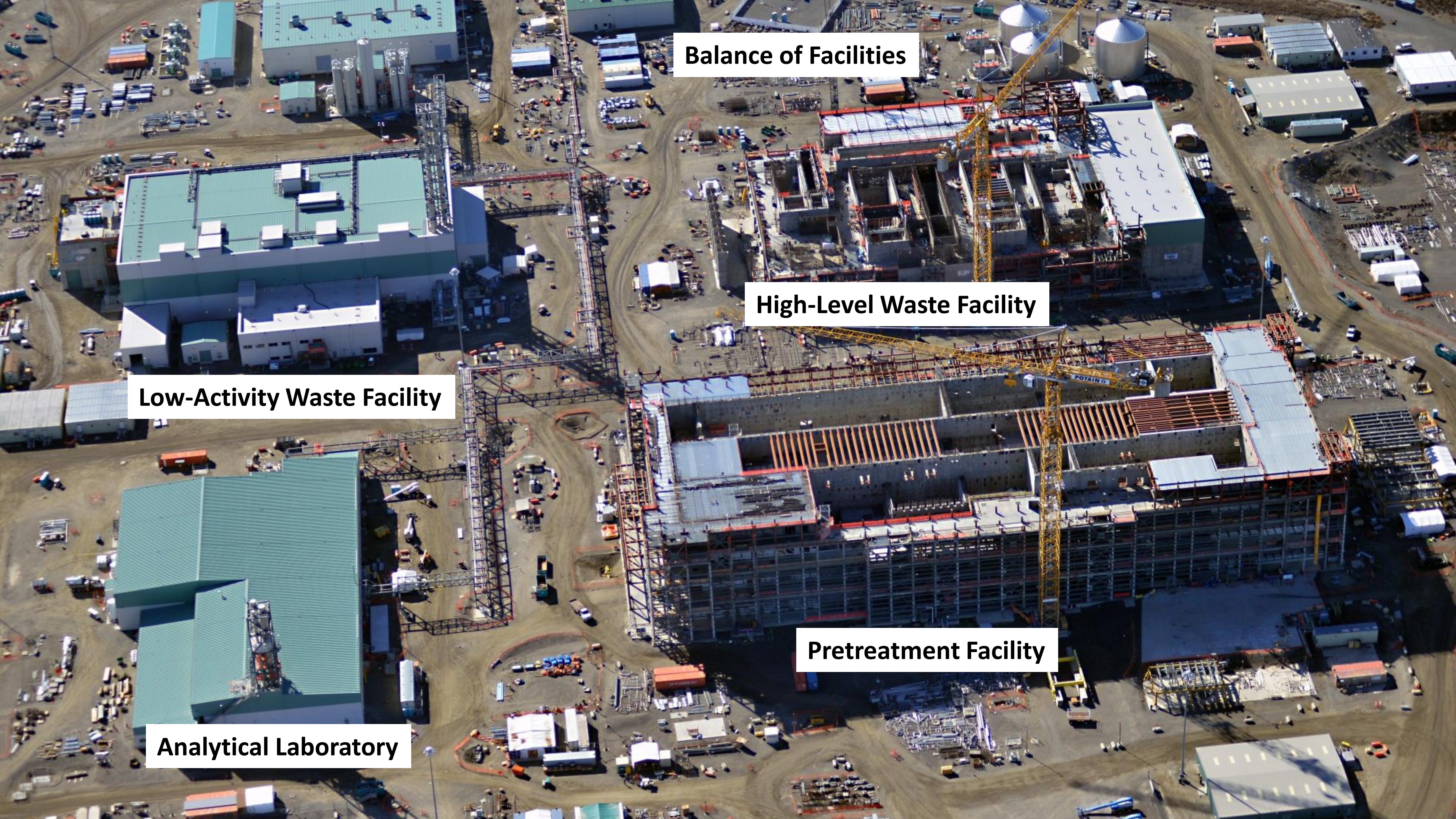
High-level waste canisters

- 6,600 pounds of glass each
- ~ 7,200 to 27,800 canisters
- Temporarily stored at Hanford until National Repository opened

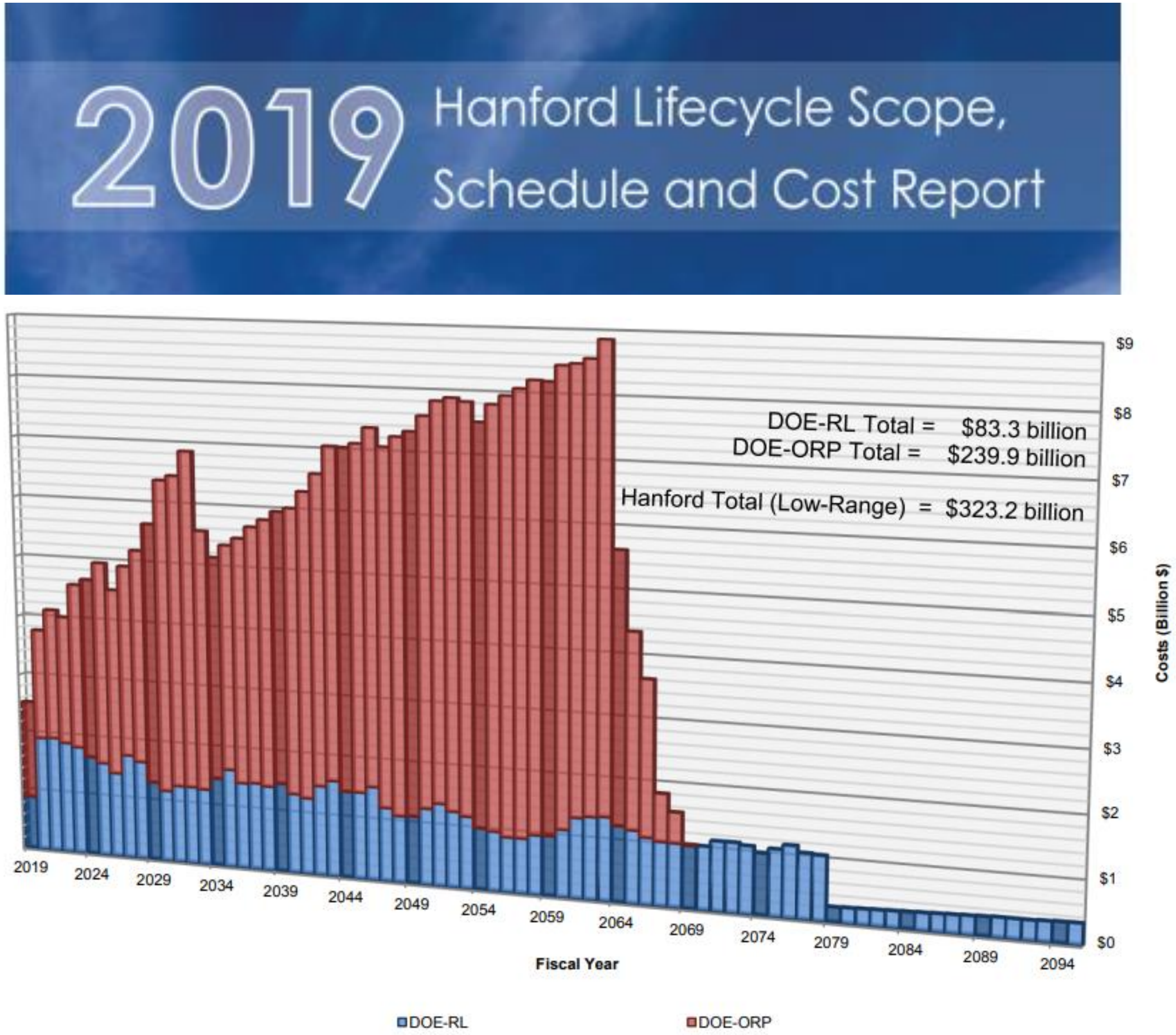
Low-activity waste canisters

- 13,000 pounds of glass each
- ~ 58,000 to 96,000 canisters
- Disposed on Hanford Site
- Current LAW Vitrification facility only sized to handle ~50% of this waste volume.

Source: System Plan 8


Balance of Facilities
High-Level Waste Facility
Low-Activity Waste Facility
Pretreatment Facility
Analytical Laboratory

Current cleanup path under threat



$323.2 billion to $677 billion*

cleanup complete 2078 to 2102

Purpose & Scope of the National Academies of Sciences (NAS) Study

- Initiated by the 2017 National Defense Authorization Act
- "The Secretary of Energy shall enter into an arrangement with a federally funded research and development center (**FFRDC**) to conduct an analysis of approaches for treating the portion of low-activity waste at the Hanford Nuclear Reservation."
- (1) An analysis of, at a minimum, the following approaches for treating the low-activity waste described in subsection (a):

  (A) Further processing of the low-activity waste to <u>remove long-lived radioactive constituents</u>, particularly technetium-99 and iodine-129, for immobilization with high-level waste.

  (B) <u>Vitrification, grouting, and steam reforming</u>, and other alternative approaches identified by the Department of Energy for immobilizing the low-activity waste.

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Purpose & Scope of the NAS Study

(2) An analysis of the following:

(A) The **risks** of the approaches relating to treatment and final disposition.

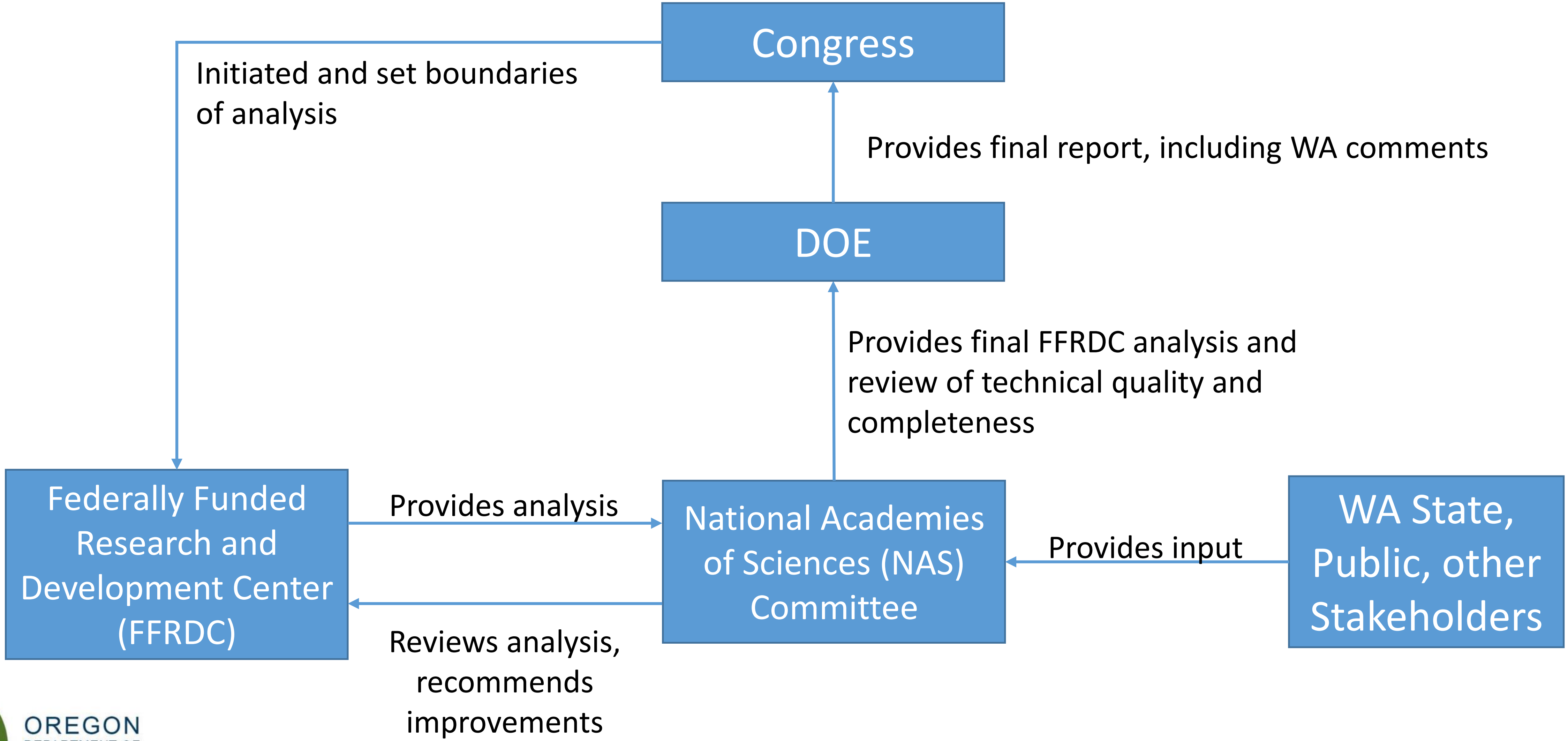
(B) The **benefits and costs** of such approaches.

(C) Anticipated **schedules** for such approaches, including the time needed to complete necessary construction and to begin treatment operations.

(D) **Compliance of approaches with applicable technical standards** associated with and contained in regulations pursuant to CERCLA, RCRA, Clean Water Act, and Clean Air Act.

(E) Any **obstacles** that would inhibit the ability of the Department of Energy to pursue such approaches.

Simplified Study Process



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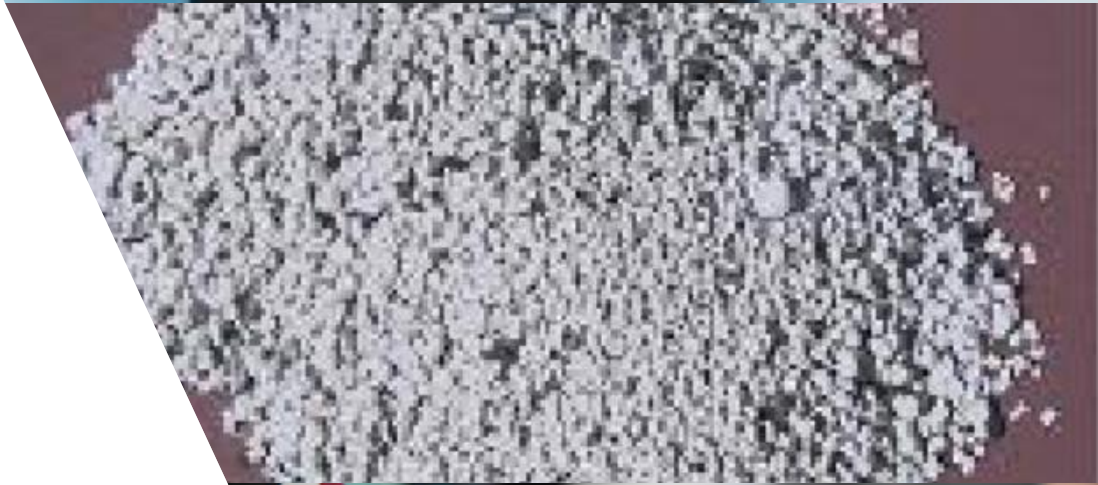
Major Options Considered

- Vitrification
- Fluidized Bed Steam Reforming
- Grout
    - Onsite disposal (Hanford Integrated Disposal Facility)
    - Offsite disposal (Waste Control Specialists Low Level Waste Facility in Texas)
- Pretreatment to remove organics, technetium-99, and/or iodine-129



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New Information Since the 2012 Tank Waste EIS

- Cost information from constructing the Hanford LAW facility
- Cost information from experience constructing/operating the Savannah River Saltstone (grout) disposal facility
- New high performance grout waste form performance data (laboratory results)
- Waste Control Specialists in Texas opened as a commercial Low Level Waste Disposal Facility

Saltstone Grout Facility at Savannah River

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Hanford Integrated Disposal Facility

Saltstone Disposal Units at Savannah River

Waste Control Specialists, Texas

- Facility underlain by 600 ft of nearly impermeable redbed clays
- WCS facilities not over or adjacent to a drinking water aquifer
- ! WCS has high limits for Technetium or Iodine
- DOE signed agreement to take ownership of Federal Waste Cell after closure
- Offsite disposal of Hanford Supplemental LAW estimated to take 26 railcars per month for 28 years

Figure 5-2 A Waste Control Specialists Disposal Cell and Wastes Being Placed in Modular Concrete Canisters (note workers for scale)

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General Findings

- The FFRDC believes that grout can meet performance objectives for onsite or offsite disposal, without removing Tc-99 or I-129.
- Additional R&D is needed before implementing grout for Hanford.
- Compared against vitrification, grout is less complicated (room temperature process).
- Compared against vitrification, grout produces less secondary waste (i.e., glass offgas effluents, which would be grouted anyway).
- Grout requires more disposal space than glass, but sufficient capacity is available.
- Grout is estimated to be significantly cheaper than glass.
- A near-term decision is needed for Supplemental LAW, but there is inadequate funding no matter the option chosen.

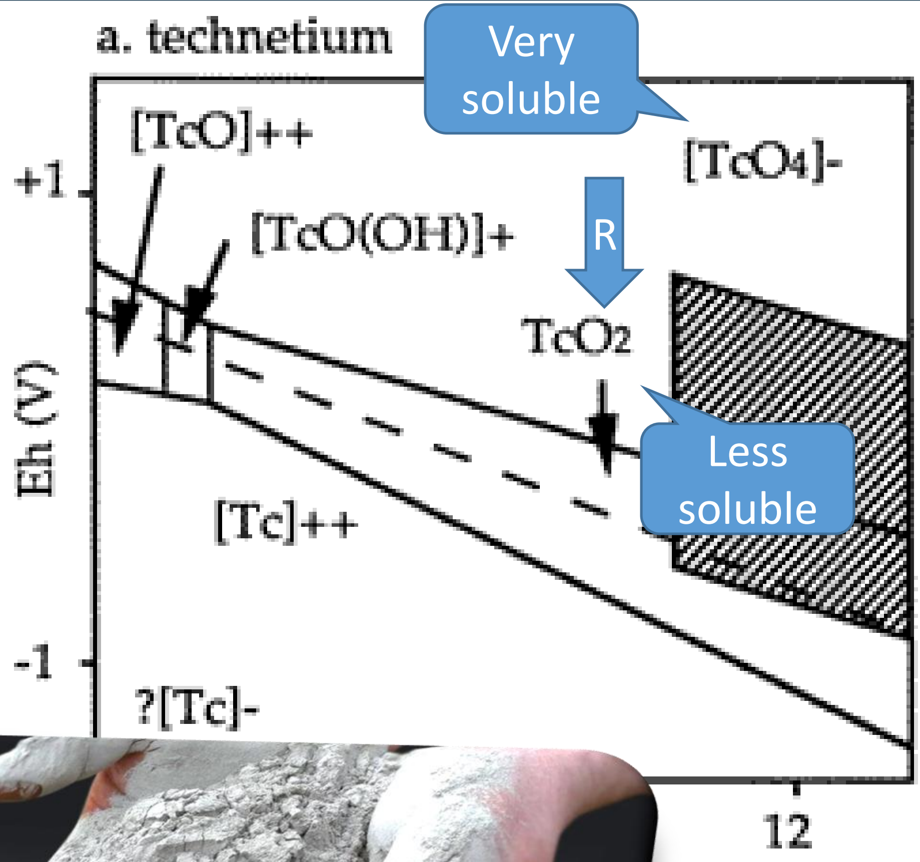
Treatment Technology Comparisons

IMMOBILIZATION TECHNOLOGY	RISKS/ OBSTACLES	BENEFITS	COSTS	SCHEDULES	ONSITE REGULATORY COMPLIANCE	OUT-OF-STATE REGULATORY COMPLIANCE
VITRIFICATION	• Most complex process • Most dependent on integrated facility performance ○ Highest throughput risk ○ Most impacted by feed rate variability ○ Lowest single-pass retention • Highest volume and curies secondary waste	• Most technically mature for SLAW feed • High temperature LDR organic/ nitrate destruction • Lowest volume primary waste	Highest: ~$20 to ~$36B	10-15 years	• Primary wasteform meets DOE Technical Performance Criteria (TPC) • Primary wasteform meets state permit requirements • May require mitigation for Iodine-129 in secondary waste	• Primary wasteform not evaluated • Secondary wastes meet WAC requirements
GROUTING	• LDR organics likely to require mitigation measures such as waste pretreatment or System Plan feed adjustments • May require Tc treatment for onsite disposal • Highest volume primary waste	• Least complex process • Least dependent on integrated facility performance ○ Lowest throughput risk ○ Greatest stop/start flexibility • Room-temperature process • Lowest volume and curies secondary waste	Lowest: ~$2B to ~$8B	8–13 years	• Primary wasteform likely to meet DOE TPC • Further validation of acceptable wasteform performance needed • May require mitigation for I-129	• Meets WAC (assuming LDR organics addressed) and transportation requirements
STEAM REFORMING	• Least technically mature for SLAW feed • Complex process • Requires rigorous process monitoring and control of fluidized bed and solids handling systems	• Lowest cost high temperature LDR organic/ nitrate destruction • Little waste volume increase during treatment • No liquid secondary waste	Middle-range: ~$6B to ~$17B	10-15 Years	• Monolithic primary wasteform likely to meet DOE TPC • Primary wasteform likely to meet state permit requirements • Further validation of acceptable wasteform performance needed • May require mitigation for I-129 in secondary waste	• Meets WAC and transportation requirements

Source: FFRDC latest draft report

What’s so special about new grout?

- Cast Stone (grout) is the same formulation now as was assumed in the 2012 Tanks EIS.
  - EIS: 8.2% Portland Cement, 44.9% fly ash, 46.9 blast furnace slag.
  - BUT! The EIS used leaching data based on grout without blast furnace slag.
- Blast furnace slag is a strong reductant.
- In its chemically reduced state, Technetium becomes insoluble and is capable of binding to suspended solids and sediment (i.e., becomes less mobile)
- Reduced environments do not slow down iodine – in fact they may speed it up!



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FFRDC Waste Form Performance Evaluation

- 2017 Hanford Integrated Disposal Facility – Base case analysis for the FFRDC Performance Evaluation:
  - LAW glass (first half only)
  - Solid secondary waste and liquid secondary waste from vitrification processing

- NAS additional study-specific Performance Evaluation cases:
  - 1st half LAW and Supplemental (2nd half) LAW glass
  - Supplemental LAW grout case
  - Supplemental LAW steam reforming case
  - Secondary solid and liquid wastes associated with all 3 primary waste forms (glass, grout, steam reforming)

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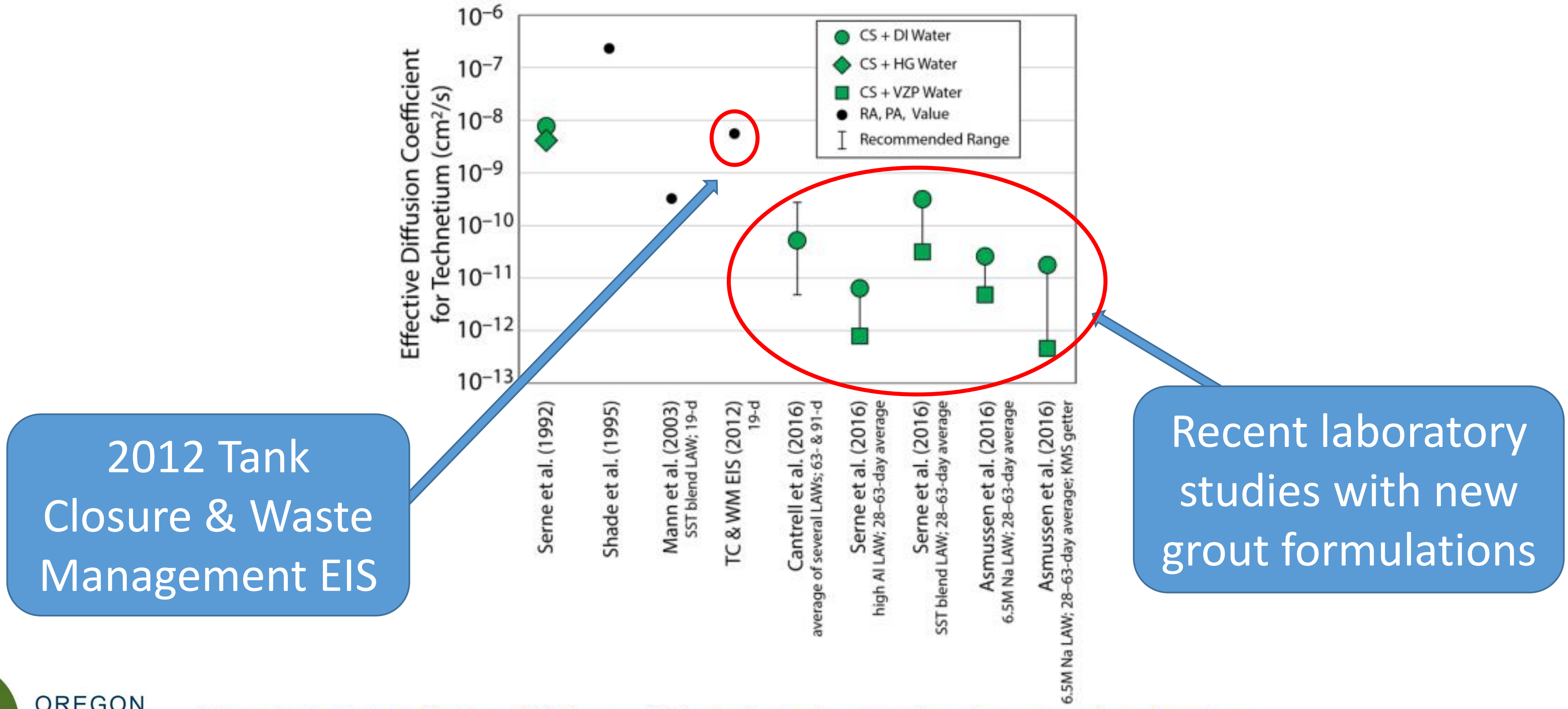
Sensitivity Cases

- Three sensitivity cases (waste release rate) for each waste form
  - **Low performing** – based on range from laboratory testing
  - **High performing** – based on range from laboratory testing
  - **Projected best case** – based on the highest performance from laboratory testing (includes “getters” and likely requires additional study to assure results can be consistently obtained)

Grout performance changes



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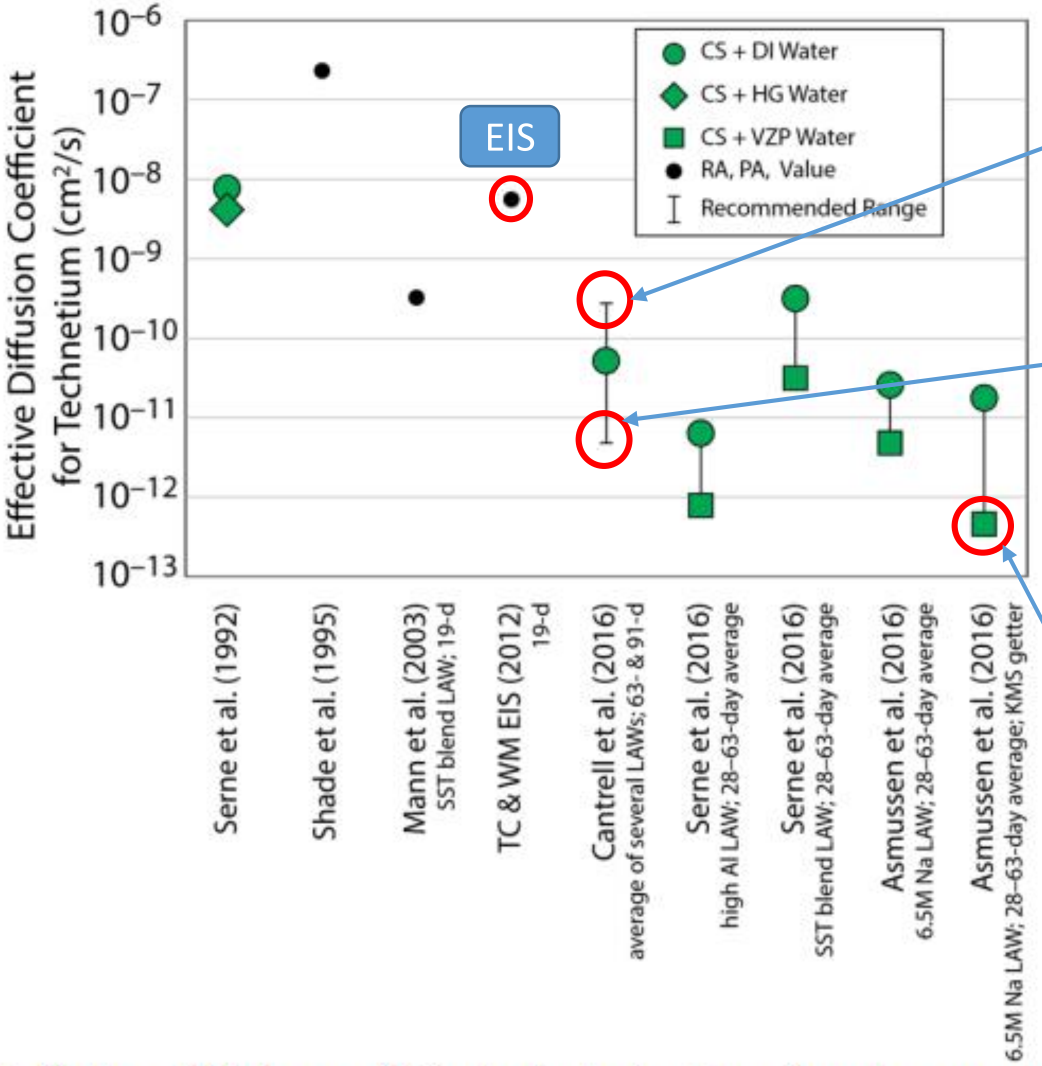
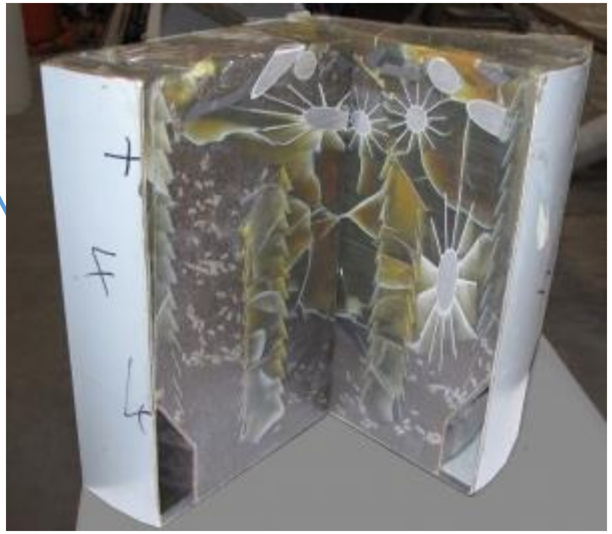
Source: NAS May 2019 meeting, FFRDC presentation

Grout performance changes



"Low" performing grout

"High" performing grout



Source: NAS May 2019 meeting, FFRDC presentation

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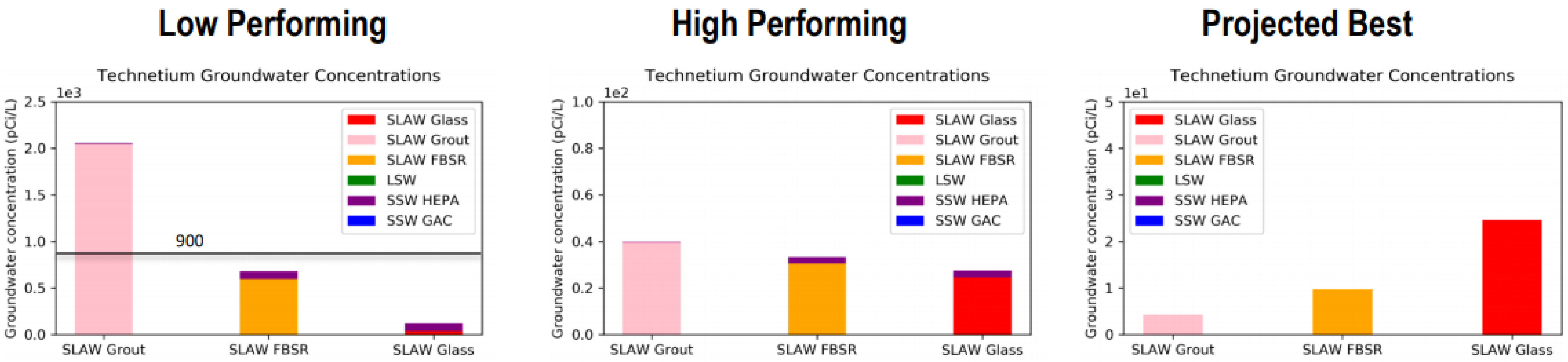
Projected Peak Groundwater Concentrations for All Cases

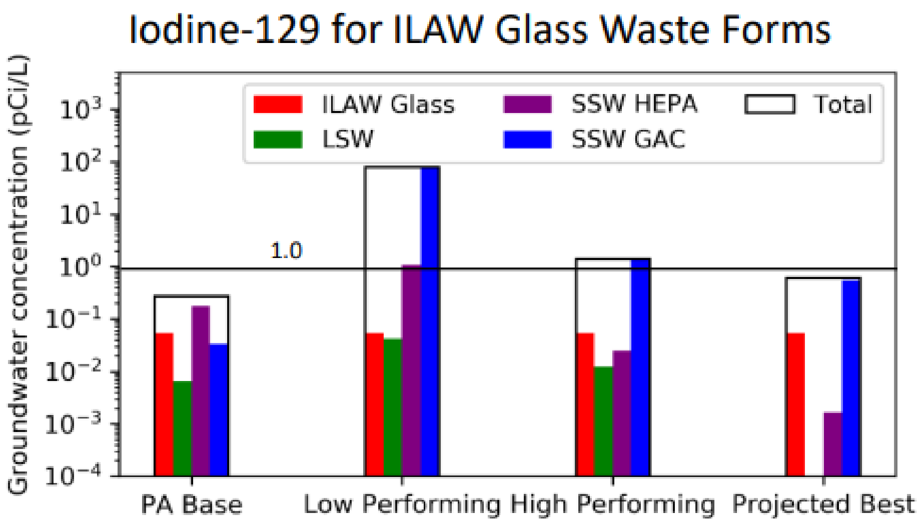
- Tc-99

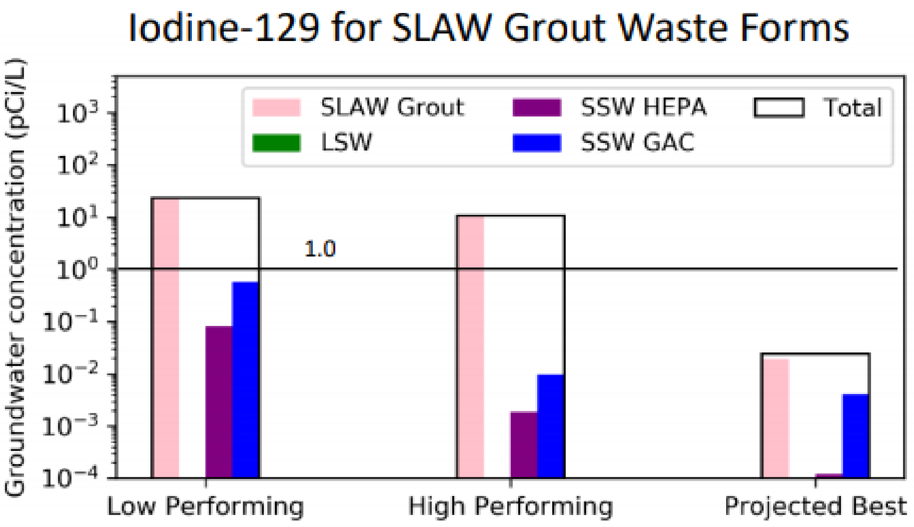


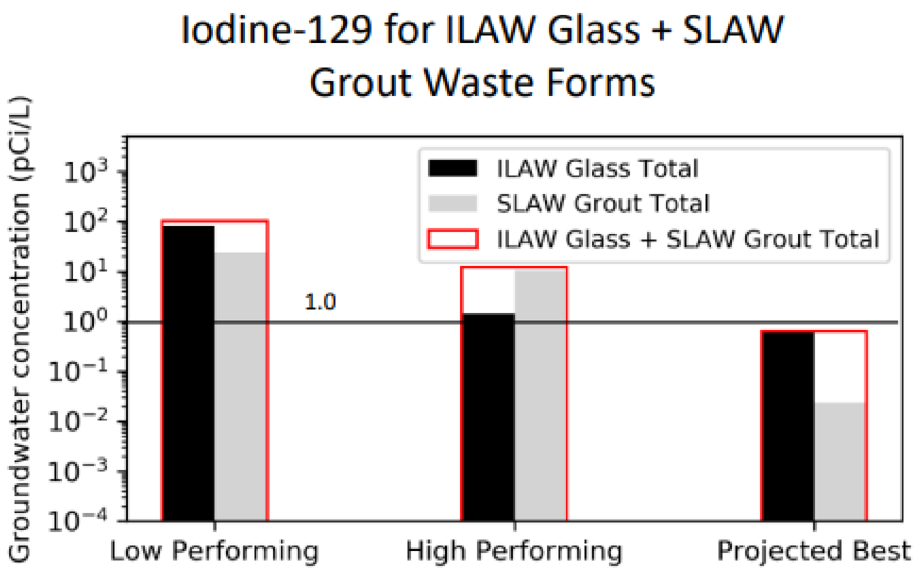
Translation:
Grout at Hanford is protective of groundwater for Tc-99 under "High Performing" and "Projected Best" case performance.

Source: NAS May 2019 meeting, FFRDC presentation

Performance Evaluation Results – Cumulative Groundwater Impacts







Translation:
Grout at Hanford is only protective of groundwater for Iodine-129 under the "Projected Best" case grout performance.

Source: NAS May 2019 meeting, FFRDC presentation

Results of an "expert elicitation" Analytical Hierarchy Process decision-making exercise, included in the July 2018 FFRDC draft.

Table F-1. Ranking of Approaches for Supplemental Treatment of Low-Activity Waste

Options Evaluated	Score (1 – 100)
2g2 - Grout with LDR pretreatment; Primary to WCS	87
2f - Grout with LDR and Sr pretreatment to HLVit, Primary to WCS	85
3b - Steam reforming to WCS, Secondary to WCS	77
1c - Vit to IDF, Secondary to WCS	67
2d - Grout with LDR pretreatment, Primary & secondary to IDF	67
2 - Grout - Base Case	65
1g - Bulk vit in large container to IDF, Secondary to WCS	63
2e2 - Grout with LDR and Tc & I pretreatment to WCS, Primary & secondary to IDF	63
2e1 - Grout with LDR and Tc & I pretreatment to HLVit, Primary & secondary to IDF	62
1 - Vitrification - Base Case	56
1d - Bulk vitrification	55
3 - Steam reforming - Base Case	53

Academies' review: "*In brief, the committee believes the team's draft report provides too little information in meaningful comparative formats useful to support decision-makers' evaluations, while its use of its AHP results* ***would supplant (or at least anticipate) the decision-makers' evaluation by performing one of its own***."

Source: NAS July 2018 meeting, FFRDC presentation

Uncertainties/Issues

Are the new grout performance numbers reliable?

- The mechanism for the improved performance is not fully understood.
- Are lab results applicable to field implementation?
- How will variations in waste chemical composition affect grout setting/performance?
- Would “getters” actually work as predicted over time?

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Uncertainties/Issues

- Grout degrades over time. Does it matter?
  - Moisture in cracks will undo the "reducing" chemical environment that holds Tc-99.
  - Studies have shown this effect to spread ~5cm radius from each crack.
  - NRC-funded studies of grouted waste forms demonstrate multiple grout cracks over relatively short timespans.
  - The IDF Performance Assessment assumes that the disposal facility will stay relatively dry.
  - The NAS working group therefore concludes that despite predicted cracking, the effect on radionuclide release will be minimal.
  - Has the IDF Performance Assessment adequately considered uncertainty? We don't know, because it isn't public yet.

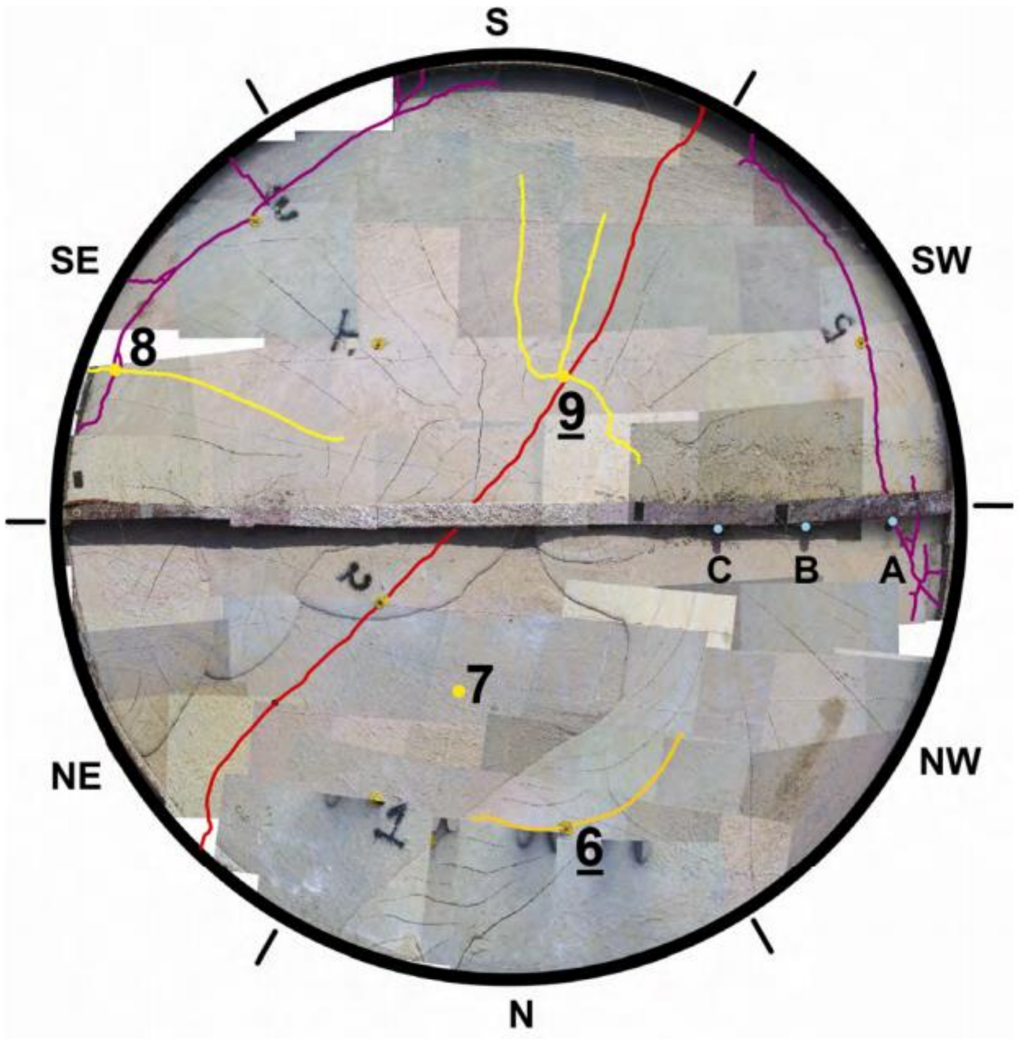

Figure 3-1. Photomosaic of the 6.1-m [20-ft]-Diameter Intermediate-Scale Grout Monolith Surface Cracks, Embedded Pipes A–C, and Coreholes 1–9 (Adapted From Dinwiddie, et al., 2011, Figure 4-2). Corehole-Intersecting Surface Cracks Are Colored According to Set Categories Defined by Dinwiddie, et al. (2011).

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Uncertainties/Issues

How critical is Supplemental LAW really?

- The NAS working group says that according to System Plan 8, we needed to start Supplemental LAW construction yesterday.
- But, System Plan 8 is built on assumptions.
- DOE's Glass Scientist predicts future LAW melters will be more efficient.
  - 15 metric tons/day → 50 MTD if we remove unnecessary refractory liner.
  - Increasing crystallization tolerance in glass from 1% to 1.5% would reduce the mission by 20%
  - A system model from the contractor in 2013 predicted no need for Supplemental LAW if a 3rd melter is added to the existing LAW facility.
  - A new 2020 glass formulation model predicts no need for Supplemental LAW.
  - How optimistic are we?

Complicating Factors

- The scope of the study is limited to the waste treatment system on the date of study initiation in 2017.
- Many new initiatives brewing could change the overall amount of Low Activity Waste produced.
  - Test Bed Initiative (at-tank cesium separation and grouting for disposal in Texas).
  - Direct-Feed HLW (i.e., limit or don't finish the Pretreatment Facility).
  - New high-level waste definition (could change 90/10% split between HLW and LAW or allow in-place closure of tanks without waste retrieval).
- A large supplemental waste facility (e.g., glass or grout) could take waste away from the first LAW vitrification facility.
- Potential gains from glass process improvement.

What could this mean for cleanup?

- Could offsite disposal as grout offer a cheaper, less complicated solution for some tank waste?
- Washington State has held firm that tank waste disposed at Hanford must be "as good as glass". Will the NAS report allow grout to meet this standard?
- If grout is good for half of the Low-Activity Waste, why not all?
- What could be the future of the existing LAW glass plant?
  - Keep it running?
  - Convert it to HLW glass-making?
  - DOE remains committed to DFLAW by 2023, then we'll see.

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Next Steps

- Oregon is working on a letter to the National Academies with our review of the FFRDC analysis.
- Next public meeting to occur in November in Richland, WA.
- Final report to Congress expected in Spring 2020.

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If you want to learn more…

Google “NAS Supplemental LAW Hanford” to watch all the public meetings, read the reports, and hear the deliberations.

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