HANFORD CHALLENGE

Charles D. Ferguson, Ph.D.
Board Director
Nuclear and Radiation Studies Board
Division on Earth and Life Studies
The National Academies of Sciences, Engineering, and Medicine
500 Fifth Street, NW
Washington, DC 20001

October 25, 2019

RE: Comments of Hanford Challenge on the Supplemental Treatment of Low-Activity Waste at Hanford

Dear Mr. Ferguson,

Thank you for the opportunity to provide comments on the *Review of the Final Draft Analysis of Supplemental Treatment Approaches of Low-Activity Waste at the Hanford Nuclear Reservation: Review #3* (2019) (NAS Review), and on the Federally Funded Research and Development Center (FFRDC) report itself *Report of Analysis of Approaches to Supplemental Treatment of Low-Activity Waste at the Hanford Nuclear Reservation* (FFRDC report), prepared under the auspices of the DOE's Savannah River National Laboratory. We appreciate the iterative process and opportunities for public comment that have accompanied the review of the FFRDC reports.

Trouble has plagued the path to Hanford's tank waste removal, treatment and disposal since efforts towards vitrification began. Attempts to find a cheaper, faster alternative to immobilizing tank waste in glass have been ongoing throughout this timeline, and have become increasingly desirable as the Waste Treatment Plant technical challenges continue to escalate cost and justify delay.

The trajectory of tank waste treatment at Hanford has come into question more sharply in recent years with various efforts underway to make it easier to reclassify high-level waste as low-activity waste, which would allow for more waste to be left behind in tanks and in the ground. We want to be clear that Hanford Challenge considers Hanford's tank waste to be high-level waste as defined by the Nuclear Waste Policy Act. We are concerned that the desire to demonstrate progress in a cleanup that presents unprecedented technical challenges, chronic mismanagement that has led to predictable cost overruns and delays, and end-dates beyond the lifespans of many who are tackling these challenges tilts decision making towards faster, cheaper solutions at the expense of environmental protectiveness and human health and safety.

Supplemental treatment for the portion of Hanford's tank waste that the Waste Treatment Plant would be unable to immobilize in glass has been the primary focal point of reports, reviews, and significant effort to find alternatives to vitrification, and have all ended with the conclusion that nothing proposed is "as good as glass."

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The FFRDC report and NAS review focus on options for the future treatment, storage and disposal of an estimated 54 million gallons of Low-Activity Waste (LAW), including existing waste and waste generated during the operation of the WTP. Unless this waste undergoes additional treatment, it will contain dangerous long-lived radionuclides, notably technetium-99, with a half-life of 211,000 years and iodine-129, with a half-life of 15 million years. The sheer volume of this waste and the presence of these long-lived radionuclides require that the decision about what form this waste will take and where it will be disposed must be made with the best available data and a rigorous and scientifically defensible analysis.

Hanford Challenge is deeply concerned with the conclusion of the FFRDC report that grout is the preferred option for Hanford's SLAW form and that grouted SLAW could be safely disposed at Hanford's Integrated Disposal Facility. Hanford Challenge firmly believes that waste containing long-lived radioactive toxins that will take millions of years to decay should not be buried at Hanford above an aquifer that feeds into the Columbia River, where it poses a threat of irreversible harm over an extraordinarily long timeline.

Additionally, we believe that cost savings should not be the dominating factor that drives cleanup decisions at Hanford and can often be deceptive. Fundamentally, the projected short-term cost benefit of saving an alluring estimated $18-22 billion using grout instead of vitrification should not overwhelm the sound scientific basis for vitrification as a disposal medium for long-term isolation of long-lived radioisotopes. Cost is a real factor, but must not be the dominating factor when making recommendations for decision makers about the best path forward. Caution is advisable when considering this data point as well, considering Hanford's long history of grossly miscalculated cost estimates and cost overruns, of which the Waste Treatment Plant is a case in point. For example, if further research shows that the getters are not guaranteed to confine technetium-99 and iodine-129 in the grout form and pretreatment is required to remove these long-lived radionuclides prior to putting it in grout form, those cost savings could quickly disappear.

Unfortunately, US policy has enthusiastically embraced spending on nuclear weapons without fully accepting the true economic calculation of safe disposal of nuclear waste, protection of irreplaceable environmental resources and human health. According to the Brookings Institute[1], the nation spent an estimated $5 trillion ($9 trillion in today's dollars) to develop/deploy nuclear weapons, and is poised to spend another $1.7 trillion in the next ten years on nuclear weapons.

Truly protecting the environment and human health and safety needs to be the primary focus of decisions about Hanford's tank waste, not cost. As a country we are expecting to spend 24x more on weapons over the next ten years than we are on cleanup[2]. We should be equally concerned with protecting the environment from irreparable harm from the radioactive and chemical toxins generated in pursuit of those weapons, but this is not the case, yet. To put a fine point on it, we spend freely on weapons under the rhetoric of protecting our people, without investing a proportionate amount of resources to clean up the nuclear weapons waste that will hurt those same people if not properly isolated and immobilized.

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[1] Schwartz, S., Brookings Institute, *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940*, June 1, 1998, see https://www.brookings.edu/book/atomic-audit/

[2] Assuming $70 billion in cleanup spending nationwide, over the next ten years.

We are concerned with the enthusiasm both reports have generated within the Department of Energy for using grout for Hanford's Supplemental Low-Activity Waste (SLAW), despite the need for further research and development to prove that the projected cost savings and best-case scenarios for retention of long-lived radionuclides are scientifically defensible.

We believe that the findings in the NAS Review and FFRDC report may be used to pave the way for using grout at Hanford for more than just the supplemental treatment of Hanford's low-activity waste. We echo the Oregon Department of Energy's concerns from their August 14, 2019 comments that more work is needed to overcome the inadequate time and resources voiced by the FFRDC report's authors in preparing their findings. It seems premature to declare that there is a clear scientifically defensible path forward for grout, or commit to grout under the assumption that further study and research will confirm the best-case scenarios. Additionally, Hanford has a history of prematurely committing to projects that claim to be faster, cheaper, and scientifically sound yet repeatedly fail to deliver on their promises and result in extreme cost overruns, delays, and potentially insurmountable technical challenges.

Supplemental LAW is one of many decisions yet to be made at Hanford and must be examined in the context of how much total waste DOE plans to leave on the Hanford Site. Hanford Challenge has opposed plans to abandon high-level nuclear waste in concrete as part of Hanford's C-Farm Waste Incidental to Reprocessing process which would result in over 70,000 gallons of high-level waste remaining in Hanford's C-Farm tanks. As each piece of the cleanup puzzle comes together, cumulative impacts must be considered to ensure cleanup plans are protective of future generations.

A summary of our technical concerns include:

- The grout form proposed by the FFRDC report is itself toxic and a potential threat to the environment.
- The long-term integrity of grout is untested. Even acceptable short-term performance is not guaranteed.
- Grouting will not effectively bind residual high-level waste components such as iodine-129 and technetium-99.
- Hanford's climatic and soil environments are particularly harsh for grout monoliths.
- Grout performance and the rate of groundwater flow through the grout monolith, is critically dependent on near-perfect, fracture-free, installation.
- Reasonably foreseeable future land uses that could affect groundwater hydraulic gradients and exposure scenarios are not addressed in the FFRDC report.
- Future use scenarios assume continuous institutional controls over the entire life of the project, including unrealistic restrictions on land uses. For example, the scenarios all assume no anthropogenic disturbance of a scale greater than drilling.
- Climactic scenarios exclude dam failures, Columbia River flooding, concentrated rainfall events, glacial flooding/damming and climate change-induced alterations in evapo-transpiration/rainfall, all of which are plausible and even predictable events for this region.

In conclusion, Hanford Challenge opposes the use of grout at Hanford for purposes of immobilizing long-lived nuclear wastes, and urges the National Academy of Sciences to resist the allure of short-term cost-savings as a trade-off for long-term protection of the environment and human health.

Our technical comments follow, some of which are extracted from an engineering analysis prepared by Dr. Marco Kaltofen, Ph.D., whose full comments[3] (prepared in response to the DOE's proposal to grout untreated high-level waste at Hanford's C Tank Farms) are attached.

Sincerely,

Tom Carpenter, Executive Director
Hanford Challenge
October 25, 2019

Marco Kaltofen, PhD., PE (Civil, MA)
Associate Research Engineer
Worcester Polytechnic Institute
October 25, 2019

[3] Kaltofen, M, *Comments on Draft Waste Incidental to Reprocessing Evaluation for Closure of Waste Management Area C at the Hanford Site*, October 29, 2018, submitted as part of the Comment of Hanford Challenge and NRDC.

Hanford Challenge Technical Comments

Proposed Grout Form is Toxic: The grout form being proposed for Hanford as the encasement for nuclear waste is itself a hazardous waste product that in and of itself poses a threat to the environment.

- The FFRDC report models grout at Hanford on Savannah River's Salt Stone grout, which, they rename Cast Stone for purposes of Hanford grout. The formula they publish is:
  - "Cast Stone consists of a dry mix containing ordinary Portland cement (8 weight %), blast furnace slag (47 wt%), and class F fly ash (45 wt%), typically mixed in a water:dry-mix ratio of 0.4–0.6." FFRDC Report, p. 40.

- Coal ash, the toxic remains of coal burning in power plants, is full of chemicals that cause cancer, developmental disorders and reproductive problems. It poisons our water and kills fish and wildlife.[4]

- Fly ash contains arsenic, lead and other contaminants that can pose threats to the environment through air and water.

- Physicians for Social Responsibility has the following to say about coal fly ash:
  - "Why is it dangerous? Depending on where the coal was mined, coal ash typically contains heavy metals including arsenic, lead, mercury, cadmium, chromium and selenium, as well as aluminum, antimony, barium, beryllium, boron, chlorine, cobalt, manganese, molybdenum, nickel, thallium, vanadium, and zinc.
  - How dangerous is coal ash to humans? The Environmental Protection Agency (EPA) has found that living next to a coal ash disposal site can increase your risk of cancer or other diseases. If you live near an unlined wet ash pond (surface impoundment) and you get your drinking water from a well, you may have as much as a 1 in 50 chance of getting cancer from drinking arsenic-contaminated water. If eaten, drunk or inhaled, these toxicants can cause cancer and nervous system impacts such as cognitive deficits, developmental delays and behavioral problems. They can also cause heart damage, lung disease, respiratory distress, kidney disease, reproductive problems, gastrointestinal illness, birth defects, and impaired bone growth in children.
  - Is coal ash a big problem? The EPA estimates that 140 million tons of coal ash are generated annually. Arsenic is one of the most common, and most dangerous, pollutants from coal ash. The EPA also found that living near ash ponds increases the risk of damage from cadmium, lead, and other toxic metals." (from, Coal Ash: Hazardous to Human Health, Physicians for Social Responsibility Fact Sheet5)
- The Material Safety Data Sheet[6] for blast furnace slag states:

[4] https://earthjustice.org/advocacy-campaigns/coal-ash

[5] https://www.psr.org/wp-content/uploads/2018/05/coal-ash-hazardous-to-human-health.pdf

[6] http://skywaycement.com/wp-content/uploads/2017/03/SAFETY-DATA-SHEET-Ground-Granulated-Blast-Furnace-Slag-8-6-2015.pdf

- o “The majority of components in Granulated Blast Furnace Slag are various glassy Metallic Silicates (Iron, Calcium, Magnesium, Aluminum, and Titanium Silicates), including: Dicalcium Silicate (Ca_2SiO_4) 14284-23-2, Merwinite ($Ca_3MgSi_2O_8$) 13813-64-4, and Gehlenite ($Ca_2Al_2SiO_7$) 1302-56-3. It may contain trace quantities of other hazardous materials, including crystalline silica. Crystalline silica has been classified by IARC and NTP is considered a carcinogen by OSHA.”

Concerns Related to Long-Term Disposal of Grout at Hanford:
The following specific comments are excerpted from Hanford Challenges comments on the Draft C-Farm Waste Incidental to Reprocessing Evaluation prepared by the Department of Energy. We have similar concerns with plans to dispose of grouted SLAW at the Integrated Disposal Facility and request that you consider these comments on the following issues:

- longevity of grout monoliths,
- inadequacy of evaluated time frame,
- surface disposal pathway to groundwater and Columbia River,
- concentration of isotopes leached from grout,
- soil chemistry,
- groundwater modeling inadequate to consider wide range of hydraulic conductivity values (homogeneous groundwater modeling vs. multi-layer heterogeneous groundwater modeling,)
- low estimated hydraulic gradient does not consider Hanford’s history of higher hydraulic gradient values (unexpected rainfall, flooding, etc.),
- future land use impacts,
- pH and redox conditions in grout,
- impacts from chemical compounds in waste,
- potential for chemical-induced failure to set,
- presence of iodine-129 and technetium-99 in grouted waste,
- cumulative impacts from other long-lived radionuclies disposed on the Hanford Site.

<u>Technical Comment Excerpts from C-Farm WIR Comments that Apply to Grouted SLAW:</u>

- **Grout Monolith Longevity:** Grout has never been tested under realistic conditions. In the Draft C-Farm Waste Incidental to Reprocessing documents, the Department of Energy (DOE) suggests that grout proposed for C-Farm is required to protect the environment from residual HLW for 1,000 years (the “compliance period” vs. the sensitivity/uncertainty period of 10,000 years). The 1,000-year time frame is of course, highly abbreviated compared to other analyses of waste migration performed at Hanford.

- **Inadequacy of Evaluated Time Frame**: DOE, in an act of self-regulation, created this specific time period in a DOE “order”. This shortened period of 1,000 years does not meet the requirements of 40 CFR 191, which specifies a required period of 10,000 years (NRC 1995). The 2012 TC & WM EIS carries the grout leachate model past the year 4,000 mark, when Columbia River activity levels for technetium-99 and iodine-129 would be reaching their equilibrium maxima. Current models developed from empirical laboratory grout simulations cannot provide this kind of assurance for either 1,000 years or 10,000 years. A 1995 PNL grout test at Hanford noted that (PNL 1995),

- "The semi-infinite solid diffusion model was selected as the most representative model for describing leaching of grouts. The use of this model with empirically derived leach constants yields conservative predictions of waste release rates, provided no significant changes occur in the grout leach processes over long time periods."

- **Surface Disposal Pathway to Groundwater**: Leaving HLW near the surface of the ground at Hanford creates some unavoidable conflicts with the local environment. Shallow-buried materials lie in the portion of the soil where any groundwater percolates downward over time into the deeper, fully saturated, aquifer. This creates an obvious transport mechanism for any leached isotopes, including transuranic (heavier than uranium) isotopes of plutonium, americium and neptunium, that will eventually reach the Columbia River or potentially some other future groundwater user. Most Americans rely at least in part on groundwater for drinking or agriculture.

- **Concentrations of Isotopes Leached from Grout:** Hanford's semiarid climate also creates conditions where any isotopes leached from grout will arrive at the sediment interface at their maximum concentration. This means that the initial concentration of leached radioactive transuranic isotopes (TRU) in the unsaturated soil will be limited only by its solubility in water. Radioactivity dissolved in groundwater will always begin at the highest theoretical activity, with very little dilution through the unsaturated zone (PNL 1995 p. 2.3). This condition creates a "solubility-controlled" release model, where the source concentration at the tank farm does not decline over time; this is not advantageous.

- **Soil Chemistry Concerns**: The chemistry of Hanford's soils also creates conditions where, given the pH (acidity) and redox potential (ability to oxidize, e.g. rust in the case of iron) of soils in the vadose zone, groundwater contaminants transported through the unsaturated zone in the upper soils will not be chemically fixed. The soil retardation effect on contaminants is small to nonexistent. In certain climates pH and redox dependent processes can slow the transport of contaminants, but these processes are nearly absent at Hanford (Ibid). This creates a conservative (no chemical losses) diffusion process, where groundwater contaminant concentration is only reduced by dilution as the groundwater encounters fresh uncontaminated sediment, groundwater or Columbia River water.

- **Groundwater Models Inadequate to Consider Wide Range of Hydraulic Conductivity Values**: The use of homogeneous groundwater models instead of multilayer heterogeneous modeling is insufficient to provide a realistic assessment of the time to breakthrough of residual tank wastes into the Columbia River. As noted in the draft C-Farm WIR evaluation documents, "Hydraulic conductivity values reported for the aquifer in this area vary considerably, ranging from 0.04 (silt lenses within the sandy gravel) to 6,900 m/day." This is an unusually wide range of hydraulic conductivity values, and it demonstrates the heterogeneous nature of the aquifer. No known homogeneous hydrogeologic model can accommodate such a wide range of hydraulic conductivities. Given that HLW is already in the vadose zone and moving into the Columbia River, a more realistic multilayer heterogeneous groundwater model is required.

- **Low Estimated Hydraulic Gradient Does Not Consider Hanford's History of Higher Hydraulic Gradient Values:** The estimated hydraulic gradient, the driving force behind groundwater flow velocity, is a relatively low 1.0 × 10-5 to 2.0 × 10-5 m/min, but this gradient has varied greatly in Hanford's history (US DOE 2018), especially when waste waters were disposed of directly into the vadose zone. Any unexpected rainfall, flood event, wastewater discharge or even dam or flood control structure release would dramatically raise the hydraulic gradient and reduce the elevation difference between abandoned tank waste and the water table. Combined with the high hydraulic conductivities, a disastrous release of contaminants could move into the Columbia River.

- **Future Land Use Impacts**: Notably, reasonably-foreseeable future land uses like irrigated agriculture would introduce water to the area, increasing the hydraulic gradient, and again potentially causing mounding of groundwater.

- **pH and Redox Conditions in Grout**: The pH and redox conditions in the grout itself are a different issue than for soils. The grout containers must provide near- and long-term high pH and chemically reducing capabilities to maintain the radionuclides and toxic heavy metals, such as technetium and neptunium, in their least mobile chemical forms, i.e., the lower-oxidation state or reduced form (Buice et al., 2005).

- **Impacts from Chemical Compounds in Tank Waste**: Hanford's HLWs also contain nonradioactive but potentially reactive chemical compounds. These chemical compounds have created important health and safety issues for Hanford Tank Farm workers. (Reference: Hanford Chemical Vapors: Worker Concerns and Exposure Evaluation, CH2M-32068-FP Revision 0, Dec. 2006) It is not clear how these chemical constituents, including liquid organic materials and ammonia, would impact the formation of high-quality cured grouts. This lack of clarity is a result of insufficiency of the evidence base about the conditions under which grouts might fail to set, given the complex chemistry and radiochemistry of tank wastes.

- **Potential for Chemical-Induced Failure to Set**: There is no evidence-based method for even estimating the potential failure rate of grouting based on failure to set due to waste chemistry. It is not feasible to pilot test a grouting treatment process facility that realistically simulates disposition of materials formerly classified as HLW. The actual chemistry of this processing is not known. Examples of chemical-induced failure to set include:

    - "We have used a composition for Type 1 Portland cement to represent the 63 tons of cement that was added to BY-105 in 1972. This cement was added in an attempt to sequester the residual fluids within BY-105 tank, which was a suspected leaker. Evidently, the cement did not set in the high-caustic, high salt liquid and no further additions of cement were made to this or any other tank. Type 1 Portland cement is 46 wt% [weight percent] Ca, 10 wt% Si, with the balance being oxygen, Al, Fe, Ca, Mg, sulfate, and water. Since the basic constituent of cement is calcium silicate, we are able to adapt it to our composition vectors. We assume that the cement was added with a specific volume of 0.13 kgal/ton, for a total amount of 8 kgal added to BY-105. As far as we know, this is the only addition of cement to any tank at Hanford."

Diatomaceous earth in Hanford Tank 104-U (capacity, 530,000 gallons).

Diatomaceous earth was dumped in to Tank 104-U, (1971) BX-102 (1971), SX-113 (1972), TX-116 (1970), TX-117 (1970), and TY-106 (1972). They contain ~2.51 MCi.

Hundreds of tons of Portland cement were dumped in 241-BY-105. The cement did not set in the high-caustic, high-salt liquid and no further additions of cement were made to this or any other tank. This tank contains ~575,000 Ci.

Courtesy of Robert Alvarez.

- Reference: Stephen F. Agnew (1996) LANL, Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4.

- **Presence of Iodine-129 and Technetium-99 in Grouted Waste**: Prior US DOE documents (such as the 2012 Final Hanford Tank Closure and Waste Management Environmental Impact Statement, TC & WM EIS) note that the eventual long-term equilibrium activity of iodine-129 and technetium-99 in the Columbia River is a function of the percent removal of HLW from the tank farms (Sec. 3, DOE responses to public comments, TC & WM EIS).

- **Cumulative Impacts from Other Long-Lived Radionuclides Disposed at Hanford**: The plans to abandon tank residuals containing these isotopes fails to consider that nuclides such as technetium-99 and iodine-129 exist at other waste sites on the Hanford Plateau. For example naval wastes disposed of at Hanford contain both nuclides, including 2.8 Curies of technetium-99 and a poorly characterized (but smaller) amount of iodine-129 (3/5/2010 letter from T. Mueller, Naval Systems Command to US DOE ORP).