



December 2021

# NUCLEAR WASTE DISPOSAL

Actions Needed to  
Enable DOE Decision  
That Could Save Tens  
of Billions of Dollars



A Century of Non-Partisan Fact-Based Work

# GAO@100 Highlights

Highlights of [GAO-22-104365](#), a report to congressional addressees.

## Why GAO Did This Study

DOE oversees the treatment and disposal of 54 million gallons of nuclear and hazardous waste at the Hanford site in Washington State. Hanford's tank waste is currently managed as HLW; however, more than 90 percent of the waste's volume has low levels of radioactivity. DOE plans to vitrify a portion of Hanford's LAW, but it has not made a decision on how to treat and dispose of the roughly 40 percent referred to as supplemental LAW. In May 2017, GAO found that grouting supplemental LAW could save tens of billions of dollars and reduce certain risks compared to vitrification. However, little is known about disposal options for grouted LAW.

GAO examined (1) what potential disposal options exist for grouted supplemental LAW, (2) what is known about the costs and environmental risks of potential disposal facilities and the extent to which DOE has assessed them, and (3) the challenges DOE faces in selecting a disposal method. GAO reviewed technical reports on DOE's waste disposal strategies at Hanford, compared DOE's approach to best practices, and interviewed DOE officials and disposal facility representatives.

## What GAO Recommends

Congress should consider clarifying two issues, including DOE's authority to manage and dispose of the tank waste as other than HLW, consistent with existing regulatory authorities. GAO also recommends that DOE expand the potential disposal options it assesses to include all facilities that could receive grouted supplemental LAW. DOE concurred with GAO's recommendation.

View [GAO-22-104365](#). For more information, contact Nathan Anderson, 202-512-3841, [andersonn@gao.gov](mailto:andersonn@gao.gov)

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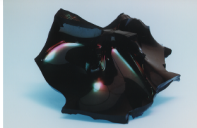
### Actions Needed to Enable DOE Decision That Could Save Tens of Billions of Dollars

## What GAO Found

Several potential options exist for disposing of grouted supplemental low-activity waste (LAW) from the Department of Energy's (DOE) Hanford site. (Grout immobilizes waste in a concrete-like mixture.) Specifically, two commercial and two federal facilities present minimal technical challenges to accepting grouted LAW. The commercial facilities—Clive Radioactive Waste Disposal Facility in Utah and Waste Control Specialists in Texas—are licensed to receive similar waste. The federal facilities—Hanford's Integrated Disposal Facility and the Nevada National Security Site—face regulatory constraints and other challenges to disposing of grouted supplemental LAW.

Disposal costs and health and environmental risks vary among the four potential disposal facilities, but disposing of Hanford's supplemental LAW as grouted waste could cost billions less than disposing of it as vitrified waste, which is DOE's current plan. (Vitrification immobilizes the waste in glass.) DOE estimated that vitrification and disposal of the waste would cost between \$21 billion and \$37 billion. GAO estimated grouting and disposal would cost between \$11 billion and \$13 billion (see figure) and may be faster. DOE has begun exploring how to dispose of grouted Hanford waste, but it has not analyzed a range of options as GAO and DOE best practices recommend. As a result, DOE is likely missing opportunities to reduce risks, expedite treatment, and save tens of billions of dollars.

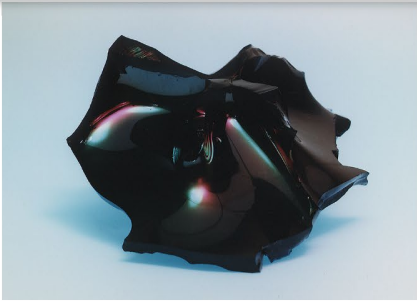
**Figure: Estimated Total Costs for Treatment and Disposal of Vitrified and Grouted Supplemental Low-Activity Waste**

|               | DOE's current baseline approach                                                     | Alternative approach                                                                                                      |
|---------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
|               |  |                                      |
| Waste form    | Glass                                                                               | Grout                                                                                                                     |
| Disposal site | Hanford Integrated Disposal Facility, Washington                                    | Several options, including two federal facilities in Washington or Nevada and two commercial facilities in Texas and Utah |
| Total cost    | \$21 - \$37 billion                                                                 | \$11 - \$13 billion                                                                                                       |

Sources: GAO analysis of Department of Energy (DOE) and disposal site documents, photos: DOE, mdbildes/stock.adobe.com. | GAO-22-104365

DOE faces legal challenges in selecting a disposal site if it grouts supplemental LAW. For example, before DOE can consider alternatives to vitrification, it must show it can manage Hanford's tank waste as a waste type other than high-level waste (HLW) because it is currently required to vitrify at least a portion of the HLW. DOE is testing alternative treatment and disposal options, but DOE officials told GAO that if they continue with the testing, they expect the effort to be the subject of litigation. Clarifying DOE's authority to manage Hanford's supplemental LAW as low-level waste and transport it outside Washington State for disposal could help save tens of billions of dollars by allowing DOE to pursue less expensive disposal options.

**Figure 4: Estimated Total Costs for Treatment and Disposal of Grouted Supplemental Low-Activity Waste, Compared with Vitrification**

|               | DOE's current baseline approach                                                   | Alternative approach                                                                                                      |
|---------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
|               |  |                                        |
| Waste form    | Glass                                                                             | Grout                                                                                                                     |
| Disposal site | Hanford Integrated Disposal Facility, Washington                                  | Several options, including two federal facilities in Washington or Nevada and two commercial facilities in Texas and Utah |
| Total cost    | \$21 - \$37 billion                                                               | \$11 - \$13 billion                                                                                                       |

Sources: GAO analysis of Department of Energy (DOE) and disposal site documents, photos: DOE, mdbildes/stock.adobe.com. | GAO-22-104365

Note: DOE includes vitrification as the current baseline disposal path for Hanford's supplemental LAW in its planning documents, but it has not made a formal decision to vitrify or grout Hanford's supplemental LAW. Total costs in this graphic include the treatment process (vitrification or grouting), as well as our estimated costs associated with disposal (pretreatment, transportation, and permanent disposal costs).

To estimate the total disposal costs for each facility, we identified the following major categories of disposal costs: pretreatment, transportation, and permanent disposal.<sup>35</sup> Table 1 shows the estimated costs associated with each major category of disposal costs for grouted supplemental LAW from Hanford.<sup>36</sup>

<sup>35</sup>We included pretreatment in our disposal calculations because pretreatment costs vary among the selected disposal facilities.

<sup>36</sup>The estimates in this section are based on the same amount of grouted waste (all of the Hanford supplemental LAW) and on the best information available to us from various DOE documents and interviews with DOE officials and disposal facility representatives. To the extent possible, we corroborated estimated costs with them.

**Table 1: Estimated Costs for Disposal of All Grouted Supplemental Low-Activity Waste (LAW) at Selected Facilities**

In billions of dollars

| Phases of disposal process                      | Integrated Disposal Facility, Hanford Site, near Richland, WA | Waste Control Specialists (WCS), Federal Waste Facility, near Andrews, TX | Clive Radioactive Waste Disposal Facility, near Clive, UT | Radioactive Waste Management Complex, Nevada National Security Site (NNSS), near Mercury, NV |
|-------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Pretreatment                                    | \$1.3                                                         | \$1.4                                                                     | \$1.5 <sup>a</sup>                                        | \$1.4 <sup>b</sup>                                                                           |
| Transportation                                  | 0.04                                                          | 0.2                                                                       | 0.1                                                       | 0.3 <sup>c</sup>                                                                             |
| Permanent disposal <sup>d</sup>                 | 1.0                                                           | 2.7 <sup>e</sup>                                                          | 0.7 <sup>e,f</sup>                                        | 0.5 <sup>f,g</sup>                                                                           |
| <b>Disposal process total costs<sup>h</sup></b> | <b>\$2.4</b>                                                  | <b>\$4.3</b>                                                              | <b>\$2.3</b>                                              | <b>\$2.2</b>                                                                                 |

Source: GAO analysis of Department of Energy (DOE) and disposal facility documents and interviews with officials from DOE and disposal facilities. | GAO-22-104365

Note: The Hanford Site has 49 million gallons of LAW, and about 20 million gallons of which is considered to be supplemental LAW. Under the Hanford System Plan, the projected volume of supplemental LAW will increase due to the need to add water while removing the waste from the tanks to transfer and pretreat it. As a result, there is expected to be about 52 million gallons of supplemental LAW. The treatment process also necessarily increases the volume of the waste treated because water and other materials are added during the process. According to the Hanford System Plan, the grouting process would create roughly 81 million gallons (11 million cubic feet) for disposal. Additionally, all costs and cost estimates in this table are presented in 2020 dollars.

<sup>a</sup>According to EnergySolutions representatives, the figure they estimated for the necessary pretreatment process to meet their waste acceptance criteria does not include labor costs. To account for this, we created a proxy pretreatment labor cost using the costs estimated by the Federally Funded Research and Development Center (FFRDC) for WCS, and we added it to their estimated pretreatment cost.

<sup>b</sup>NNSS officials could not provide an estimate of the costs to pretreat Hanford's supplemental LAW to meet their waste acceptance criteria. As a proxy, we used the pretreatment costs calculated by FFRDC for WCS.

<sup>c</sup>The estimate is based on a comparable rate given to us by NNSS.

<sup>d</sup>Permanent disposal costs are what disposal facilities charge to receive the waste and place it in the disposal cell. Long-term maintenance costs are not included in table 1. According to DOE documentation, Hanford's total site-wide long-term surveillance and maintenance costs for 30 years following site closure will be over \$3.5 billion, in 2020 dollars; Hanford does not break down the costs specifically for the Integrated Disposal Facility. According to DOE officials, NNSS's total long-term surveillance and maintenance costs for their waste disposal facilities for 75 years following site closure will be about \$440 million, in 2020 dollars. According to DOE officials, part of the waste disposal fee at commercial sites includes closure and post closure care costs.

<sup>e</sup>The estimate is based on Indefinite Delivery, Indefinite Quantity contract rates. According to representatives from WCS, once a specific contract is negotiated, these values could be lower.

<sup>f</sup>This facility currently lacks sufficient space to dispose of the entire volume of Hanford's grouted supplemental LAW. If DOE selected this facility as the sole disposal location, additional disposal cells would need to be constructed. We estimated the cost for construction based on the cost to expand other disposal facilities from our 2010 report on DOE cleanup costs. See GAO, *Recovery Act: Most DOE Cleanup Projects Appear to Be Meeting Cost and Schedule Targets, but Assessing Impact of Spending Remains a Challenge*, [GAO-10-784](#) (Washington, D.C.: July 29, 2010).

**Table 2: Department of Energy (DOE) Processes to Classify and Manage Waste as a Waste Type Other Than High-Level Waste (HLW) and Their Limitations**

| Process                                                                                             | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Limitations                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Waste incidental to reprocessing evaluation process under DOE Manual 435.1-1</b>                 | Under DOE Manual 435.1-1, DOE may determine that waste is incidental to reprocessing and, therefore, manage the waste as low-level radioactive waste if it (1) has been processed such that key radionuclides have been removed to the maximum extent technically and economically practicable, (2) will meet safety requirements comparable to the performance objectives established in Nuclear Regulatory Commission (NRC) regulations for the low-level waste disposal facilities, and (3) will be in a solid form that does not exceed NRC concentration limits for Class C low-level radioactive waste.                                                                                                                                                                                                                                                                                                             | The validity of Manual 435.1-1 and the associated order were challenged in a 2002 lawsuit. DOE could be open to further legal challenges if it attempts to use Manual 435.1-1 to manage tank waste as low-level radioactive waste at Hanford. <sup>a</sup> |
| <b>Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005</b> | Section 3116 of the National Defense Authorization Act for Fiscal Year 2005 authorized the Secretary of Energy, in consultation with NRC, to determine that certain waste from reprocessing is not HLW if it (1) does not require disposal in a deep geologic repository, (2) has had highly radioactive radionuclides removed to the maximum extent practical, and (3)(a) does not exceed radioactive concentration limits for low-level radioactive waste, and will be disposed of in accordance with NRC performance objectives for low-level radioactive waste disposal and pursuant to a state-approved closure plan or permit, or (b) exceeds Class C concentration limits but will be disposed of in accordance with NRC performance objectives for low-level radioactive waste disposal, and pursuant to a state-approved closure plan or permit and pursuant to plans developed by DOE in consultation with NRC. | Section 3116 only applies to waste in South Carolina and Idaho; it does not apply to the Hanford Site.<br><br>Section 3116 does not apply to waste being transported out of state from South Carolina or Idaho.                                            |
| <b>HLW interpretation</b>                                                                           | In June 2019, DOE issued its interpretation of the statutory term "high-level waste." DOE subsequently incorporated this definition into Manual 435.1-1 in January 2021. Under the HLW interpretation, DOE will manage tank waste as something other than HLW if it (1) does not exceed concentration limits for Class C low-level radioactive waste as set out in section 61.55 of title 10, Code of Federal Regulations and meets the performance objectives of a disposal facility; or (2) does not require disposal in a deep geologic repository and meets the performance objectives of a disposal facility as demonstrated through a performance assessment conducted in accordance with applicable requirements.                                                                                                                                                                                                  | The National Defense Authorization Acts for fiscal years 2020 and 2021 prohibited DOE from spending funds from those years at the Hanford Site to apply this HLW interpretation in fiscal years 2020 and 2021.                                             |

Source: GAO analysis of laws and regulations. | GAO-22-104365

<sup>a</sup>A federal district court held that the relevant provisions of the Order and Manual were inconsistent with the Nuclear Waste Policy Act, *Nat. Res. Def. Council v. Abraham*, 271 F. Supp. 2d 1260 (D. Idaho 2003). However, a federal appeals court reversed that decision on procedural grounds in October 2004 and ordered dismissal of the suit without ruling on the underlying claim. *Nat. Res. Def. Council v. Abraham*, 388 F.3d 701 (9th Cir. 2004). DOE successfully used the waste incidental to reprocessing process under Manual 435.1-1 to determine that certain wastes associated with the West Valley Demonstration Project in New York and 3 gallons of Hanford tank waste could be managed as low-level radioactive waste.

whether the associated treatment standards also change or if the original treatment requirements must still be met. Specifically, RCRA disposal regulations are silent on whether vitrification is required for mixed low-level waste that was previously managed as mixed HLW—as in the case of supplemental LAW.<sup>74</sup> Table 3 provides a summary of waste treatment requirements by waste type under RCRA.<sup>75</sup>

**Table 3: Waste Treatment Requirements by Waste Type under the Resource Conservation and Recovery Act (RCRA)**

| Waste type                                                   | Treatment standard under RCRA regulations                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mixed high-level waste                                       | <i>Vitrification.</i> Radioactive high-level wastes generated during the reprocessing of fuel rods that exhibit specified hazardous waste characteristics must be vitrified in compliance with all applicable radioactive protection requirements under control of the Nuclear Regulatory Commission before the waste can be land-disposed.                                                                                             |
| Mixed low-level waste                                        | <i>There is no general treatment standard.</i> RCRA regulations specify treatment standards for a few hazardous wastes that are radioactive, but there is no general standard for low-level mixed waste. Other mixed waste must generally be physically, chemically, or thermally treated to substantially diminish its toxicity or to reduce the mobility of the hazardous constituents according to waste-specific regulatory levels. |
| Mixed low-level waste previously managed as high-level waste | <i>RCRA does not specify the treatment standard.</i> It is unclear whether the vitrification requirements for high-level waste remain with the waste even after it is reclassified as mixed low-level waste or if the mixed low-level waste requirements that allow other types of treatment prevail.                                                                                                                                   |

Source: GAO analysis of RCRA and the Environmental Protection Agency’s RCRA regulations. | GAO-22-104365

Officials from DOE and Ecology differ on the extent to which RCRA’s land disposal requirements apply to supplemental LAW.

DOE’s Views on Its Authorities

DOE officials told us that DOE has the authority under the Atomic Energy Act of 1954 to manage the radioactive component of tank

<sup>74</sup>The state of South Carolina elected to manage DOE’s tank waste treatment facilities at the Savannah River Site as wastewater treatment units under the Clean Water Act, an option that RCRA regulations authorize under certain conditions. See 40 C.F.R. §§ 260.10, 264.1(g)(6). As we found in 2017, according to officials from the Savannah River Site, DOE chose to grout LAW at the Savannah River Site because of the state’s desire to address environmental risks sooner than it could using other methods. We also found that DOE does not have LAW at its Idaho Site because it did not separate out a lower activity portion from the site’s HLW. See [GAO-17-306](#).

<sup>75</sup>According to Ecology, Hanford tank waste has been designated as “extremely hazardous waste” and thus cannot be disposed in Washington State unless all reasonable methods of treatment detoxification, neutralization, or other waste management methodologies designed to mitigate hazards associated with these wastes have been employed.

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## Matters for Congressional Consideration

We are making the following two matters for congressional consideration.

- To enhance DOE's ability to make risk-informed decisions for the treatment of Hanford supplemental LAW, Congress should consider clarifying, in a manner that does not impair the regulatory authorities of EPA and any state, DOE's authority to determine, in consultation with NRC, whether portions of the tank waste that can be managed as a waste type other than HLW and can be disposed of outside the state of Washington. (Matter for Consideration 1)
- In support of the Test Bed Initiative and in a manner that does not impair any state's authority to determine whether to accept waste for disposal, Congress should consider (i) authorizing DOE to classify the volumes of waste corresponding to the second phase of the Test Bed Initiative for out-of-state disposal as something other than HLW and (ii) specifying that RCRA's HLW vitrification standard does not apply to this volume of waste. (Matter for Consideration 2)

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## Recommendation for Executive Action

- The Secretary of Energy should direct the Assistant Secretary for Environmental Management to expand future analyses of potential disposal options to include all federal and commercial facilities that could potentially receive grouted supplemental LAW from Hanford. (Recommendation 1)

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## Agency Comments and Our Evaluation

We provided a draft of this report to DOE for review and comment. We also provided relevant portions of the report—specifically the background and the third objective examining the challenges that DOE faces in selecting a disposal method option for Hanford's supplemental LAW—to EPA and Ecology for review and comment.

In its comments, reproduced in appendix III, DOE concurred with our recommendation and stated that actions to implement it are in progress. Specifically, DOE noted that it will consider disposal options analyzed by the FFRDC in coordination with the National Academies under Section 3125 of the National Defense Authorization Act for Fiscal Year 2021. DOE also stated that if it decides to pursue treatment of supplemental LAW from Hanford using grout technology, it will evaluate reasonable disposal alternatives in accordance with