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Report to Congressional Addressees

December 2021

NUCLEAR WASTE DISPOSAL

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

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GAO-22-104365

GAO@100 Highlights

Highlights of GAO-22-104365, a report to congressional addressees.

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NUCLEAR WASTE DISPOSAL

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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.

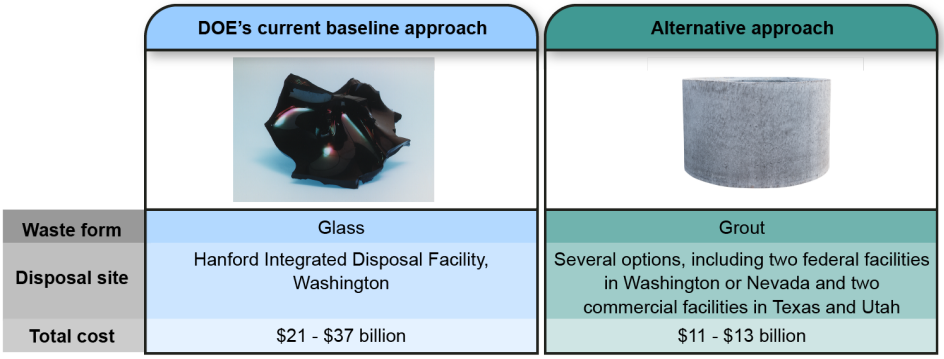
View GAO-22-104365. For more information, contact Nathan Anderson, 202-512-3841, andersonn@gao.gov

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



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.

Contents

Figures

Abbreviations

DOE	Department of Energy
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
FFRDC	Federally Funded Research and Development Center
HLW	high-level waste
IDF	Integrated Disposal Facility
LAW	low-activity waste
National Academies	National Academies of Sciences, Engineering, and Medicine
NNSS	Nevada National Security Site
NRC	Nuclear Regulatory Commission
RCRA	Resource Conservation and Recovery Act of 1976
TPA	Tri-Party Agreement
WCS	Waste Control Specialists LLC
WIPP	Waste Isolation Pilot Plant
WTP	Waste Treatment and Immobilization Plant

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441 G St. N.W.
Washington, DC 20548

December 9, 2021

Congressional Addressees

The Hanford Site in Washington State is home to one of the largest environmental cleanup projects in the world. After decades of research and production of weapons-grade nuclear materials at the 586-square-mile campus ceased in the late 1980s, the Department of Energy (DOE) began cleanup of the remaining hazardous and radioactive waste. At Hanford, this waste includes 54 million gallons stored in 160 large underground waste storage tanks that must be retrieved and treated—or immobilized—before disposal, according to legal requirements and agreements made with federal and state environmental regulators.[1] In January 2019, DOE estimated that completing cleanup of the entire Hanford Site would cost between $323 billion and $677 billion and take decades.[2]

As a matter of policy, DOE manages Hanford's tank waste as "high-level radioactive waste" (HLW) unless and until it is classified as another waste type. "Low-activity waste" (LAW) is DOE's term for the portion of this tank waste with low levels of radioactivity.[3] Before treating the tank waste, DOE plans to separate it into two streams: the high-activity portion, which DOE estimates will contain more than 90 percent of the radioactivity but less than 10 percent of the volume; and the low-activity portion, which will contain less than 10 percent of the radioactivity and more than 90 percent

[1]There are 177 underground waste storage tanks on site that historically have held the waste. According to DOE officials, the waste has been retrieved from 17 of these tanks.

[2]DOE's estimate of these costs is in escalated dollars. Department of Energy, *2019 Hanford Lifecycle Scope, Schedule and Cost Report* (Richland, WA: January 2019). In total across the complex, according to our prior work, DOE has spent more than $170 billion since it began its cleanup program in 1989. In DOE's fiscal year 2020 financial report, DOE's overall environmental liability was $512 billion in 2020 dollars, of which its Office of Environmental Management, which oversees nuclear waste cleanup, had an environmental liability estimate of $406 billion. The Hanford Site in Washington State accounted for $271 billion (over 50 percent) of this liability. See Department of Energy, *Agency Financial Report: Fiscal Year 2020*, DOE/CF-0170 (Washington, D.C.: Nov. 16, 2020).

[3]LAW is primarily the liquid portion of the tank waste that remains after as much radioactive material as is technically and economically practical has been removed. DOE uses the term LAW to mean the waste that, when solidified and properly classified as low-level radioactive waste, may be disposed of as low-level radioactive waste in a near-surface facility.

of the volume. DOE plans to vitrify some of the Hanford tank waste—a process in which the waste is immobilized in glass—prior to disposal.

DOE's current system plan for treating Hanford's tank waste is to use the Waste Treatment and Immobilization Plant (WTP) at Hanford to vitrify the waste.[4] The WTP, which has been under construction since 2000, consists of multiple facilities, including a key pretreatment facility intended to separate the waste into high-activity and low-activity waste streams and two facilities to vitrify these waste streams.[5] DOE plans to dispose of the vitrified LAW on site. However, the WTP is currently designed to treat only about 60 percent of Hanford's LAW. DOE has not yet determined how it will treat the remaining portion of the LAW, known as supplemental LAW. This decision is one of many that DOE and Washington State are negotiating.

DOE's Hanford System Plan assumes that DOE will vitrify all of the supplemental LAW and dispose of it on site. This plan would involve building a second LAW vitrification facility and supporting facilities. DOE has information about the cost to construct and operate some facilities.[6] However, alternative approaches exist and, in recent years, DOE and we have reported on potential cost and schedule savings associated with such approaches for treating Hanford's supplemental LAW.

- In 2017 we reported that experts believed that much of Hanford's supplemental LAW could be safely grouted—i.e., immobilized in a concrete mixture—and doing so could save tens of billions of dollars

[4]DOE's current plan for Hanford's waste, known as the River Protection Project System Plan, provides an evaluation of scenarios including underlying assumptions, selected and defined by DOE and the Washington State Department of Ecology (Ecology), for the disposition of all Hanford tank waste. In this report, we refer to it as the Hanford System Plan. Department of Energy, *River Protection Project System Plan*, ORP-11242 rev. 9 (Richland, WA: November 2020).

[5]DOE chose vitrification for this portion of the waste in the 1990s with input from Washington State because studies at that time indicated that vitrification would be the most effective treatment approach for the conditions at Hanford.

[6]DOE has not yet selected an approach to treat the supplemental LAW at Hanford and, therefore, does not have an estimate for the costs to complete LAW treatment. However, DOE's current life-cycle estimate assumes that DOE will build and operate a second LAW vitrification facility with the same technical assumptions as the first one.

compared with vitrifying all of the supplemental LAW.[7] We recommended that DOE develop updated information on the cost and effectiveness of disposing of supplemental LAW, including at alternate disposal facilities.[8]

- In 2017, a Federally Funded Research and Development Center (FFRDC) team—DOE's Savannah River National Laboratory—conducted a review of options for treating the Hanford supplemental LAW.[9] The team reported in October 2019 that DOE's current approach of vitrifying the Hanford supplemental LAW would take 10 to 15 years to implement and cost $20 billion to $36 billion, while grouting the supplemental LAW would take 8 to 13 years to implement and cost $2 billion to $8 billion.[10] The National Academies of Sciences, Engineering, and Medicine (National Academies) conducted four independent peer reviews of the FFRDC report during the drafting process.[11]
- DOE's update to its Hanford System Plan in October 2020 reported that grouting the supplemental LAW could cost $20 billion less than vitrifying it, and doing so would keep the annual funding requirements for the Hanford cleanup below $2 billion, the approximate amount that the Hanford Site has received annually over the last decade.[12]

[7]GAO, *Nuclear Waste: Opportunities Exist to Reduce Risks and Costs by Evaluating Different Waste Treatment Approaches at Hanford*, GAO-17-306 (Washington, D.C.: May 3, 2017).

[8]DOE implemented this recommendation by conducting a review of options for treating the Hanford supplemental LAW in 2017 (see next bullet).

[9]Section 3134 of the National Defense Authorization Act for Fiscal Year 2017 mandated that a FFRDC team conduct an analysis of technologies for treating and solidifying the Hanford supplemental LAW. The FFRDC team was composed of technical experts from various DOE national laboratories. The mandate also required a concurrent review of the FFRDC analysis by a committee of technical experts selected by the National Academies of Sciences, Engineering, and Medicine (National Academies).

[10]Costs are in 2018 dollars. Savannah River National Laboratory, *Report of Analysis of Approaches to Supplemental Treatment of Low-Activity Waste at the Hanford Nuclear Reservation*, SRNL-RP-2018-00687 (Aiken, SC: October 2019).

[11]The National Defense Authorization Act for Fiscal Year 2021 requires DOE to commission a further study of alternatives for addressing Hanford's supplemental LAW. This study, to be conducted by an FFRDC and reviewed by the National Academies, began in July 2021 with an initial public meeting.

[12]ORP-11242 rev. 9.

- In December 2020, DOE submitted a report to Congress estimating that classifying some of the Hanford tank waste as other than HLW and grouting the supplemental LAW could help reduce the cost of cleanup for the entire site by $73 billion to $210 billion and it could shorten the tank waste mission by at least a decade.[13]

While cost and schedule savings information is available for treating supplemental LAW using grout, less is known about disposal options for grouted supplemental LAW.

We conducted this work under the authority of the Comptroller General. Our work examines (1) potential facilities for the disposal of grouted supplemental LAW from the Hanford Site and the regulatory and technical challenges DOE faces at each facility; (2) the costs and environmental risks associated with disposal of grouted supplemental LAW at selected facilities; and (3) the challenges DOE faces in selecting a disposal option for Hanford's supplemental LAW.

To address all three objectives, we reviewed information on DOE's waste disposal strategies at Hanford and the characteristics of selected disposal facilities. Specifically, we reviewed DOE reports and information on the disposal facilities' histories, characteristics, criteria, schedules, and cost estimates. The facilities we selected for inclusion in this review were those identified in reports by DOE or the National Academies as potential disposal sites for grouted supplemental LAW (we discuss excluded sites below). For each objective, we also took the following steps:

- To examine potential disposal facilities and the regulatory and technical challenges DOE faces at each facility, we reviewed documents from DOE and selected sites and interviewed officials at DOE headquarters and at the selected sites about those challenges DOE faces at each facility. We also interviewed officials from the Washington State Department of Ecology (Ecology), the Utah Department of Environmental Quality, the Nevada Division of Environmental Protection, and the Texas Commission on Environmental Quality—the state agencies that help regulate the disposal sites we selected for our review.

[13]Department of Energy, *Evaluation of Potential Opportunities to Classify Certain Defense Nuclear Waste from Reprocessing as Other than High-Level Radioactive Waste* (Washington, D.C.: December 2020).

- To examine the costs and environmental risks associated with the disposal of grouted supplemental LAW at selected facilities, we reviewed and analyzed DOE documentation to identify the steps of the disposal process and costs and risks associated with each step. In addition to the steps we identified, we determined through our analysis that pretreatment may also contribute to disposal costs. We also interviewed DOE officials and facility officials about the costs of disposal and environmental risks at each facility.

  We only examined the costs associated with disposal of grouted supplemental LAW because much is already known about treatment and disposal costs associated with vitrification. We analyzed available information about estimated disposal costs for Hanford's grouted supplemental LAW at each selected facility. Because precise information on the costs of the disposal process was not available, we used the best available information to provide a rough order-of-magnitude estimate in 2020 dollars. We believe that the information presented in our report provides an approximate order-of-magnitude comparison and is sufficiently reliable to identify differences in disposal costs among the selected facilities.

  We also reviewed information from DOE's Hanford System Plan. We interviewed officials from DOE and Ecology regarding their views on the challenges that DOE faces in selecting a disposal option for Hanford's supplemental LAW. We compared DOE's decision-making against our risk-informed decision-making framework and DOE's analysis of alternatives guidance.[14]

- To examine the challenges DOE faces in selecting a disposal option for Hanford's supplemental LAW, we reviewed applicable legal and regulatory requirements and guidance documents governing the cleanup of hazardous and radioactive wastes. We also interviewed officials from DOE, Environmental Protection Agency (EPA), and Ecology regarding their views on the challenges that DOE faces in selecting a disposal option for Hanford's supplemental LAW. Additional details on our objectives, scope, and methodology can be found in appendix I.

[14]GAO, *Environmental Liabilities: DOE Would Benefit from Incorporating Risk-Informed Decision-Making into Its Cleanup Policy*, GAO-19-339 (Washington, D.C.: Sept. 18, 2019); and Department of Energy, *Analysis of Alternatives Guide*, DOE G 413.3-22 (Washington, D.C.: June 6, 2018).

We conducted this performance audit from July 2020 to December 2021 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Composition of Hanford's Tank Waste

Established in 1943, the Hanford Site produced plutonium for the world's first nuclear device and continued to produce nuclear materials for decades, generating millions of gallons of radioactive and hazardous chemical waste in the process. Some of this waste was deposited directly into the soil, some liquids were evaporated, and some waste was stored in 177 large underground tanks clustered together in 18 locations called tank farms. The waste has been retrieved from 17 of these tanks. The remaining 160 tanks are still in use—most operating decades past their original design life—and contain about 54 million gallons of waste. DOE estimates that 69 of these tanks might have collectively leaked more than 1 million gallons of waste into the ground.

Hanford's tanks contain a complex mix of radioactive and hazardous components (such waste is called mixed waste) in both liquid and solid forms.[15] For example,

[15]Specifically, the term "mixed waste" means waste that contains both (1) hazardous waste subject to the Resource Conservation and Recovery Act (RCRA) or authorized state programs that operate in lieu of the federal program; and (2) radioactive source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954. Hanford's tank waste also includes various metals. Low-level radioactive waste mixed with hazardous chemicals (as is the case with Hanford's waste) is often referred to as "mixed low-level waste." In this report, we use the general term "low-level radioactive waste" to refer to both types except in those instances where we determine that the distinction is important to make.

Low-Level Radioactive Waste

Most of the waste managed by the Department of Energy's (DOE) cleanup activities is characterized as low-level radioactive waste. Low-level radioactive waste is also generated through commercial activities, such as nuclear power plant operations, and it varies from lightly contaminated soils and building materials to highly irradiated nuclear reactor components.

The Low-Level Radioactive Waste Policy Amendments Act of 1985 defines low-level radioactive waste as radioactive material that (1) is not high-level waste, spent nuclear fuel, or byproduct material; and (2) the Nuclear Regulatory Commission (NRC) classifies as low-level radioactive waste. DOE disposes of low-level radioactive waste at its own sites as well as at some commercial facilities in accordance with its guidelines. NRC classifies low-level radioactive waste according to its radiological hazard for disposal in licensed facilities. The classes include Class A, B, and C, with Class A being the least hazardous (and accounting for more than 90 percent of the low-level radioactive waste) and Class C waste being the most hazardous. As the waste class and hazard increase, NRC regulations require progressively greater controls, such as intrusion prevention measures, to protect human health and the environment. (See 10 C.F.R. § 61.55, "Waste Classification.") DOE does not use the NRC classification system for low-level radioactive waste disposed of at DOE facilities, but it instead relies on site-specific performance assessments and waste acceptance criteria.

Source: GAO. | GAO-22-104365

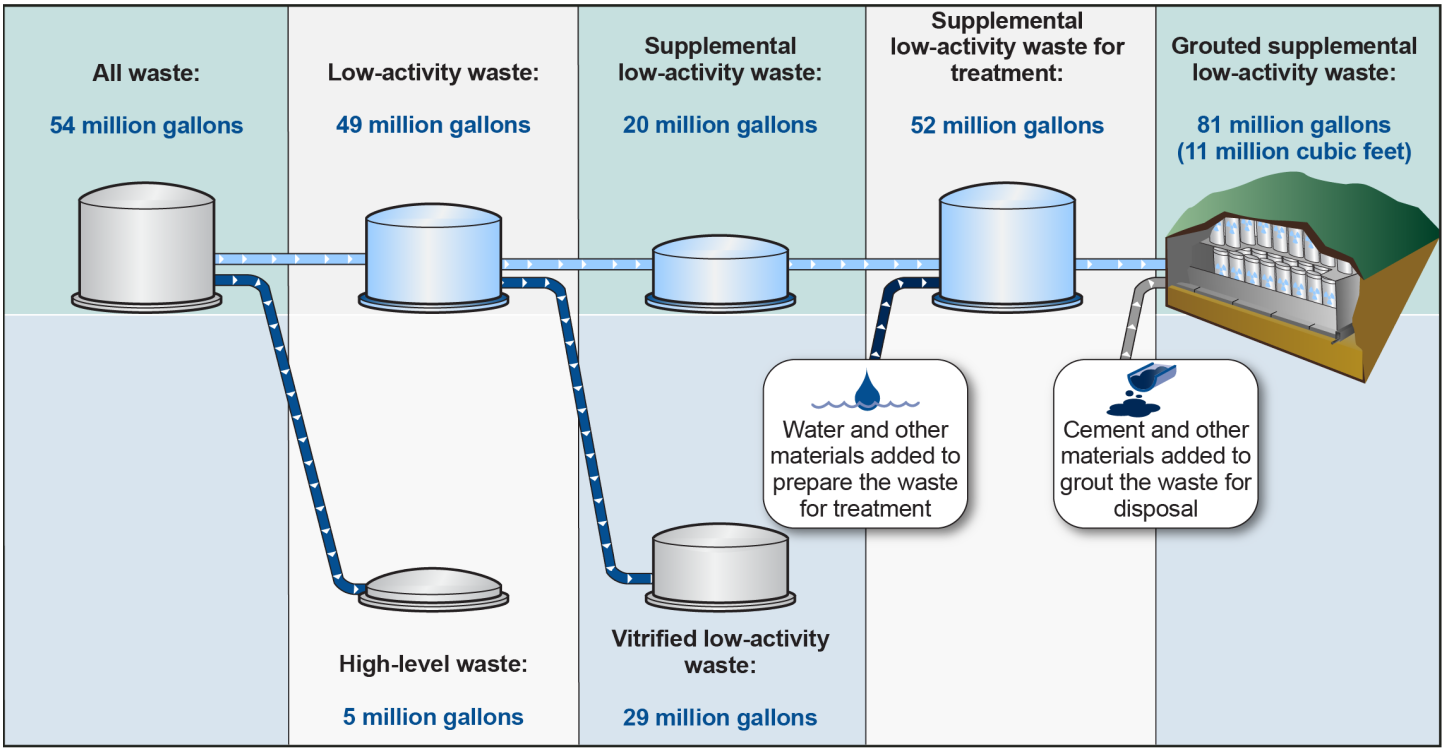
- **Radioactive component.** About 46 different radioactive constituents—byproducts of chemically separating plutonium from uranium for use in nuclear weapons—account for the majority of the radioactivity in the Hanford Site's tanks. The atoms of a radioactive constituent decay over time emitting their radiation. Some of these constituents decay to a stable (or non-radioactive) form in a relatively short time, while others remain radioactive for millions of years. The rate of radioactive decay is measured in half-lives—that is, the time required for half the unstable atoms in a radioactive material to decay. The vast majority (98 percent) of the radioactivity of the tank waste comes from two constituents, strontium-90 and cesium-137, which have half-lives of about 29 years and 30 years, respectively. The remaining radioactive constituents, which account for about 2 percent of the waste's total radioactivity, have much longer half-lives. For example, the half-life of technetium-99 is 213,000 years, and that of iodine-129 is 15.7 million years.
- **Hazardous chemical component**. The tanks also contain large volumes of hazardous chemical waste. Altogether, about 240,000 tons of hazardous chemicals were added to Hanford's tanks from the 1940s through the mid-1980s. A majority of these chemicals were added to neutralize acids in the waste. Other chemicals, such as solvents and several organic compounds, were added during various waste extraction operations to help recover selected radioactive constituents (uranium, cesium, and strontium) for reuse. Depending on dose and concentration, these hazardous chemicals are dangerous to human health and can remain so for thousands of years.

Most of the waste in the tanks at Hanford will ultimately be disposed of as LAW. Specifically, as we have previously reported and as figure 1 illustrates, about 49 million gallons of the tank waste consists of LAW.[16] According to the Hanford System Plan, 41 percent of that waste (about 20 million gallons) would be supplemental LAW, and the volume of supplemental LAW would increase to 52 million gallons due to the need to add water while removing the waste from the tanks, transferring the waste, and pretreating it. The treatment process will further increase the volume of the waste treated because water and other materials, such as cement, are added during the process. According to the Hanford System Plan, if the supplemental LAW were grouted, the grouting process would

[16]GAO-17-306.

create roughly 81 million gallons (11 million cubic feet) of grouted waste for disposal.

Figure 1: Low-Activity Waste Volume Changes during Treatment



Source: GAO. | GAO-22-104365

The LAW can be characterized as a “mixed” radioactive waste because it contains both radioactive and hazardous components. Compared to the high-activity waste stream, the radioactivity of the LAW and supplemental LAW is low. However, although the radioactivity is relatively low, some of the supplemental LAW may contain radionuclides that are long-lived and mobile in the environment, such as technetium-99 and iodine-129.

Hanford’s Waste Treatment Process

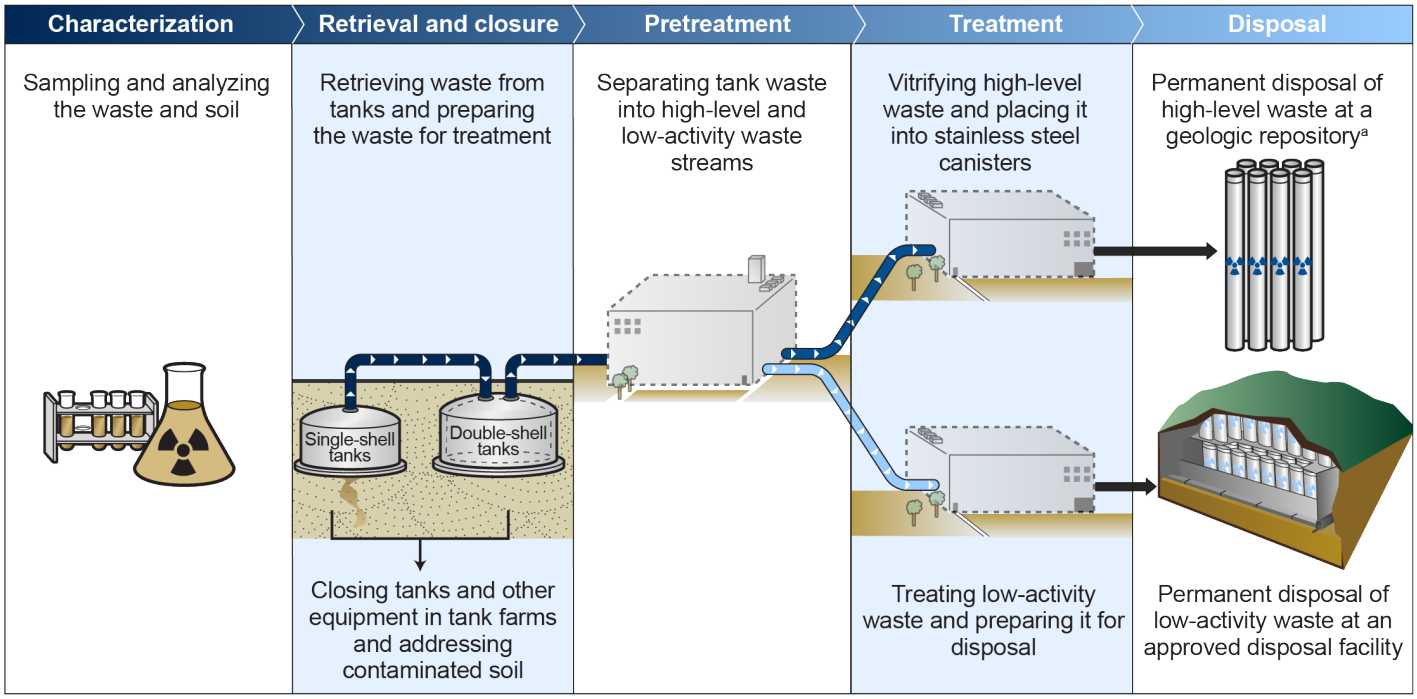
The tank waste cleanup mission generally consists of five phases:

1. “Characterization” of the waste through sampling and analysis to determine the specific physical, radiological, and chemical components of the wastes in each tank.

2. Retrieving waste from the underground tanks and closing the tanks and tank farms.
3. Separating the wastes into high-activity and low-activity streams as part of a process called pretreatment.
4. Treating the waste to immobilize the constituents.
5. Disposing of the waste.

This report focuses on the disposal phase of the waste cleanup mission (see fig. 2).

Figure 2: Phases of the Tank Waste Cleanup Mission at Hanford



Source: GAO analysis of Department of Energy documents. | GAO-22-104365

[a]A geologic repository for permanent disposal of high-level waste has not yet been designated.

The WTP project, currently being designed and constructed to treat Hanford's tank waste, has faced technical challenges, cost overruns, and schedule delays. In 2012, DOE stopped construction of the pretreatment facility until technical challenges could be resolved. In 2018, the U.S. Army Corps of Engineers reported that at current annual funding levels,

completing the pretreatment facility by 2031, as required by an agreement with the state of Washington, likely would not be possible.[17] In May 2020, we reported that DOE was analyzing how alternate options for the pretreatment of waste could affect how the HLW treatment facility is used.[18] According to DOE officials, DOE is nearing completion of the LAW vitrification facility and the ancillary facilities and systems needed to pretreat and transport the waste to it. DOE plans to begin vitrifying about 60 percent of the LAW (the portion of the waste that is not considered to be supplemental LAW) by December 2023.

DOE has taken some steps to explore alternative options to vitrification for treating Hanford's supplemental LAW. Specifically, according to DOE documents, DOE successfully completed a laboratory scale test of an approach—known as the Test Bed Initiative—in December 2017 to demonstrate the feasibility of grouting, transporting, and disposing of 3 gallons of Hanford's LAW at a licensed commercial low-level radioactive waste disposal site in Andrews, Texas. In November 2018, DOE sought to expand the project to demonstrate the feasibility of grouting, transporting, and disposing of 2,000 gallons of Hanford's LAW at the same site in Texas. However, in spring 2019, DOE withdrew its Washington State permit application for the Test Bed Initiative. According to DOE officials, Ecology—which regulates solid, hazardous, and nuclear waste—proposed permit conditions that were unacceptable to DOE and later offered that DOE and Ecology engage in negotiations to develop a "holistic and realistic" approach to the retrieval and treatment of Hanford's tank waste. Congressional appropriations committees directed that DOE could spend up to $10 million to continue the Test Bed Initiative in fiscal year 2020. DOE officials said they plan to apply for a new permit to resume the project in 2022.[19]

[17]U.S. Army Corps of Engineers, *Parametric Evaluations of the Waste Treatment and Immobilization Plant* (Washington, D.C.: July 10, 2018).

[18]GAO, *Hanford Waste Treatment Plant: DOE Is Pursuing Pretreatment Alternatives, but Its Strategy Is Unclear While Costs Continue to Rise,* GAO-20-363 (Washington, D.C.: May 12, 2020).

[19]In August 2021, DOE submitted a draft environmental assessment for this project, which analyzed, in detail, four action alternatives for the treatment and disposal of this waste at off-site commercial facilities, including Waste Control Specialists LLC (WCS) in Texas and EnergySolutions in Utah.

Regulatory Framework Governing Hanford's Tank Waste

The treatment and disposal of Hanford's tank waste is governed by a number of federal laws—some of which establish state responsibilities—regulations, DOE Orders, and cleanup agreements among DOE, the EPA, and Washington State.

- **Atomic Energy Act of 1954, as amended**, authorizes DOE to regulate the radioactive component of mixed high-level waste (HLW).
- **Resource Conservation and Recovery Act of 1976 (RCRA), as amended**, governs the treatment, storage, and disposal of the hazardous waste component of mixed waste. EPA has authorized Ecology to administer its own hazardous-waste regulatory program in lieu of the federal program.[20]
- **Nuclear Waste Policy Act of 1982, as amended,** establishes procedures for the evaluation, selection, and approval of deep geologic repositories for the disposal of spent nuclear fuel and HLW. It also provides the definition of HLW.
- **DOE Order 435.1 and Manual 435.1-1**, issued in July 1999 and subsequently revised, set forth procedures for the management of DOE's radioactive wastes in a manner that is protective of worker and public health and safety as well as the environment.[21] Under the manual associated with this order, DOE has two processes for determining that waste can be managed as non-HLW, which is less expensive to manage than HLW. (These processes are described in greater detail below.)
- **Hanford Federal Facility Agreement and Consent Order of 1989 (or Tri-Party Agreement) (TPA)** is an agreement among DOE, EPA, and Ecology that lays out, among other things, a process and a series

[20]Under RCRA, EPA may authorize a state to implement its own hazardous waste management program in lieu of the respective federal program, so long as the state program is equivalent to and at least as stringent as the federal program. State programs may be more stringent than the federal program and may have provisions that are broader in scope than the federal program. EPA has authorized Washington to administer its own hazardous waste programs.

[21]Department of Energy, *Radioactive Waste Management*, Order 435.1 (Washington, D.C.: Jan. 11, 2021); and Department of Energy, *Radioactive Waste Management Manual*, Manual 435.1-1 (Washington, D.C.: Jan. 11, 2021).

of legally enforceable milestones for selecting a technology and constructing facilities to treat the supplemental LAW.[22]

- **Consent decree of 2010, as amended**, was established as a result of litigation brought against DOE by Ecology for missing certain TPA milestones. This judicially enforceable consent decree establishes, among other things, specific cleanup milestones for retrieval of waste from certain specified tanks.

Several Facilities Could Accept Hanford's Grouted Waste with Few Technical Challenges, but Regulatory Constraints Exist

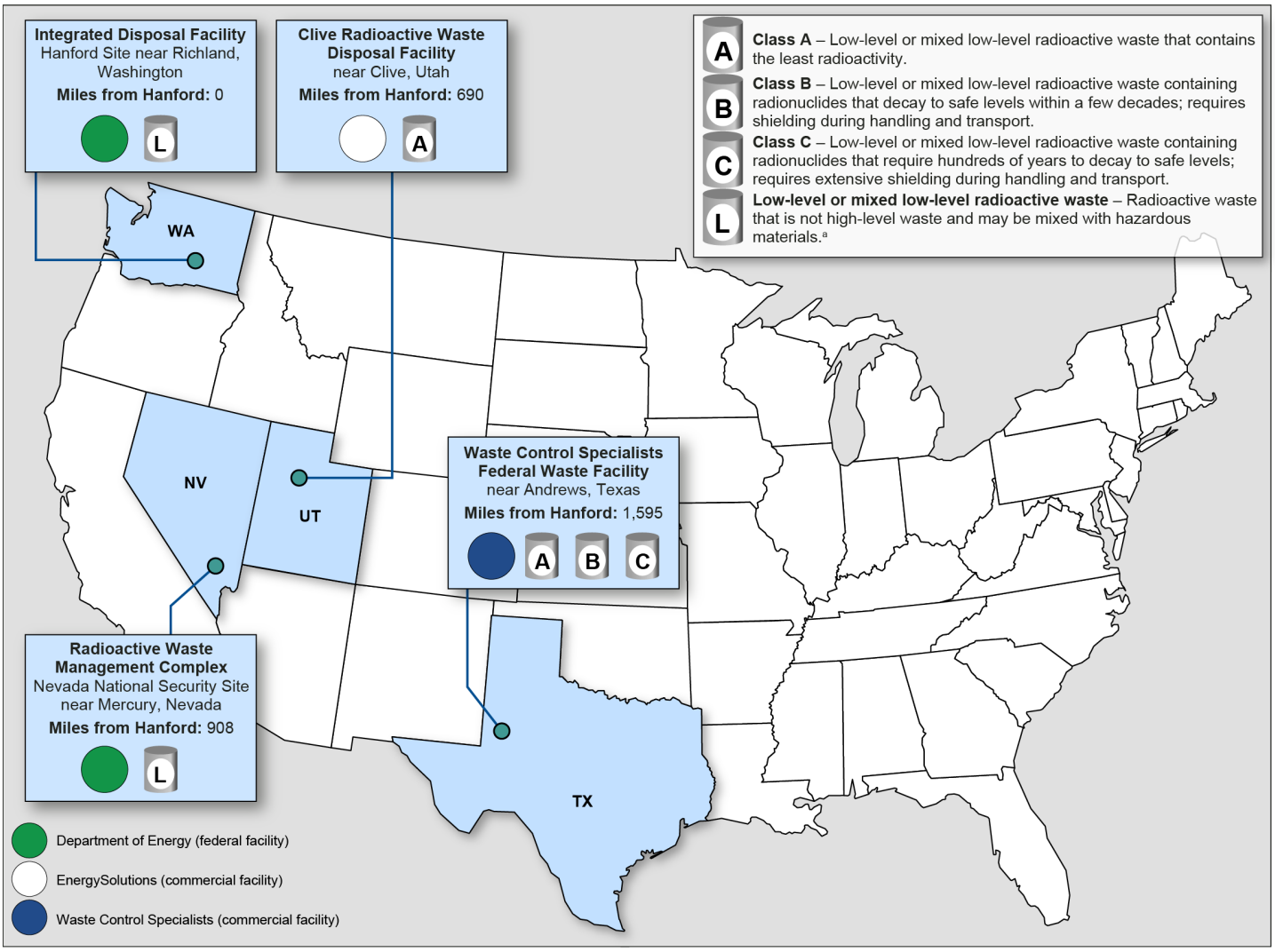
Two federal and two commercial waste disposal facilities could receive grouted supplemental LAW for permanent disposal. Technical challenges to disposing of the waste are minimal, but DOE faces regulatory constraints and other challenges to disposing of the waste at the two federal facilities. Although other potential off-site disposal facilities exist, because of either current law or DOE practice, these facilities are currently not viable options for disposing of Hanford's grouted supplemental LAW.

Two Federal and Two Commercial Disposal Facilities Could Accept Grouted Low-Level Radioactive Waste with Few Technical Challenges

Two federal waste disposal facilities and two commercial facilities appear to be able to accept grouted low-level radioactive waste from the Hanford Site without technical impediments (see fig. 3).

[22]One purpose of the Tri-Party Agreement is to ensure that the environmental effects associated with past and present activities at the Hanford Site are thoroughly investigated and appropriate response actions are taken as necessary to protect the public health, welfare, and the environment. Another is to promote an orderly, effective investigation and cleanup of contamination at the Hanford Site and to avoid litigation between the parties.

Figure 3: Map of Potential Disposal Sites for Grouted Supplemental Low-Activity Waste from Hanford



Sources: Department of Energy and Map Resources (map). | GAO-22-104365

Note: The Department of Energy (DOE) has not selected a treatment technology or a disposal site for supplemental LAW. Should DOE decide to grout the supplemental LAW, DOE officials stated that any disposal site selection would be based on careful analysis, including evaluating disposal facility waste acceptance criteria and impacts on performance objectives of the disposal facility. According to DOE, the licensee or permittee for the disposal facility may also be required to obtain appropriate regulatory authorizations to accept the waste. Although we have included it in our analysis, DOE officials stated that the Nevada National Security Site is not being considered as a disposal site for Hanford supplemental LAW.

[a]The waste classifications (A, B, and C) are designations used by the Nuclear Regulatory Commission for low-level radioactive waste disposed of at commercial sites. DOE does not use the same classifications for low-level radioactive waste disposed at DOE facilities.

Federal Facilities

The two federal facilities that appear to be able to accept Hanford's low-level grouted waste are the Integrated Disposal Facility (IDF) in Washington State and the Radioactive Waste Management Complex in Nevada.

- **IDF.** Located on the Hanford Site, DOE's IDF was designed and built to provide a disposal facility for the vitrified LAW from the WTP, as well as other related secondary wastes. The IDF is nearly 1,500 feet wide, 765 feet long, and 45 feet deep, with a capacity to hold over 32 million cubic feet of treated waste. As stated earlier, supplemental LAW, if grouted, would take up 11 million cubic feet. The first phase of construction of two disposal areas—referred to as disposal cells—in the IDF is complete, and the facility has final DOE authorization and RCRA permitting from the state of Washington for the cells to receive treated waste. According to DOE officials, the facility could be expanded to provide additional capacity. In 2017, we reported that, according to experts, Hanford is a favorable place for the long-term disposal of LAW with either vitrification or grout because of its arid climate and low rainwater soil infiltration rates.[23]
- **Radioactive Waste Management Complex.** This facility is located at the Nevada National Security Site (NNSS), in Nye County, Nevada, about 65 miles northwest of the city of Las Vegas. The site is used for disposal of low-level radioactive waste generated by environmental cleanup activities at NNSS and other DOE sites, as well as NNSS and Department of Defense sites historically involved with nuclear weapons research, development, and testing. The site has eight active disposal cells, one of which is permitted to receive mixed low-level radioactive waste, with a total available capacity of nearly 6.4 million cubic feet of treated waste, according to DOE officials. NNSS accepts approximately 1 to 1.5 million cubic feet of low-level radioactive waste per year—some of it immobilized in grout—from more than 25 different DOE facilities.[24] Although we have included it in our analysis—and others, including the Consortium for Risk Evaluation with Stakeholder Participation, have recommended that NNSS be considered as a potential disposal site for the waste—DOE officials stated that the NNSS is not being considered as a disposal site for Hanford supplemental LAW for reasons discussed below.

[23]GAO-17-306.

[24]According to DOE officials, approximately 100,000 cubic feet of this waste is mixed low-level waste.

Commercial Facilities

The two commercial facilities that appear to be able to accept Hanford's grouted LAW are the Clive Radioactive Waste Disposal Facility in Utah and the Waste Control Specialists (WCS) Facility in Texas.

- **Clive Radioactive Waste Disposal Facility**. The Clive facility is in the west desert of Utah, about 75 miles west of Salt Lake City. The Clive facility is commercially operated by EnergySolutions and licensed by the state of Utah to dispose of Class A low-level radioactive waste. Historically, waste from various sites around the country, including DOE sites such as Hanford and Savannah River, has been shipped to the Clive facility for disposal, according to Clive representatives. The Clive facility has the capacity to dispose of over 115 million cubic feet of waste, including, according to Clive representatives, nearly 10 million cubic feet for mixed waste.
- **Waste Control Specialists Facility.** This disposal facility is on a 1,338-acre parcel of land 35 miles west of Andrews, Texas, and 5 miles east of Eunice, New Mexico. The facility is commercially operated by Waste Control Specialists LLC and is licensed and has facilities to handle the treatment, storage, and disposal of all classes of low-level radioactive waste. According to WCS representatives, as much as 2,000 tons of waste from around the country are routinely handled each day for disposal at the WCS facility. The portion of the facility dedicated to federal waste will have the capacity to permanently dispose of up to 26 million cubic feet of waste. WCS controls several thousand additional acres around the licensed site.

The Four Facilities Present Minimal Technical Challenges, but DOE Faces Constraints at the Two Federal Facilities

Disposing of grouted supplemental LAW at the four selected disposal facilities appears to present minimal technical challenges. This is because DOE has demonstrated the technology and capability to (1) pretreat and separate out low-level radioactive waste from the tank waste, (2) grout low-level tank waste, (3) ship grouted low-level tank waste long distances for disposal, and (4) dispose of grouted low-level tank waste.

- **Pre-treating tank waste.** In December 2017, DOE completed a laboratory scale test of a process to pretreat Hanford's tank waste in preparation for grouting and shipping to WCS. This test, referred to as the Test Bed Initiative, employed a pretreatment technology to remove solids and cesium (a highly radioactive radionuclide) from the tank waste. During the test, DOE pretreated 3 gallons of Hanford tank waste, and DOE determined that the resulting waste was low-level

radioactive waste.[25] The pretreated and grouted waste met the low-level radioactive waste acceptance criteria at the WCS disposal facility in Texas.[26] DOE officials stated that the 3 gallon test resulted in waste that was within Class A limits. Nonetheless, it is unclear whether this pretreated waste would meet the acceptance criteria at the two federal sites (see below for a discussion on regulatory challenges).

- **Grouting pre-treated tank waste.** DOE routinely grouts government-owned low-level radioactive waste at cleanup sites around the country. For example, according to DOE officials, since 1990 when disposal operations began at the Savannah River Site, DOE has grouted and disposed of nearly 18 million gallons of tank waste from that site. It has also successfully demonstrated grouting of Hanford LAW. In 2017, DOE used the commercially operated Perma-Fix Environmental Services Northwest facility near the Hanford Site to grout the 3 gallons of pretreated Hanford tank waste as part of the Test Bed Initiative. A 2013 DOE study found that grouted waste met the land disposal standards for hazardous constituents and met the anticipated waste acceptance criteria for on-site disposal at Hanford.[27]
- **Shipping of grouted waste.** DOE has overseen the shipment of thousands of barrels of grouted, low-level radioactive waste from various sites around the country. For example, according to DOE officials, from 2006 through 2007, DOE shipped (via a combination of railway and highway) nearly 20,000 drums of grouted tank waste from the West Valley Demonstration Project in New York to Nevada for disposal. In addition, in 2017, it shipped the 3 gallons of grouted Hanford tank waste for disposal at WCS in Texas.[28]
- **Disposing of grouted waste.** DOE has also disposed of millions of gallons of grouted tank waste over the years. As noted above, it has

[25]DOE is nearing completion of construction at Hanford of a pretreatment approach, which relies on a similar pretreatment technology used for this laboratory test called tank-side cesium removal.

[26]Each facility has waste acceptance criteria, or technical and administrative requirements that a waste must meet in order for it to be accepted at a storage, treatment, or disposal facility.

[27]Department of Energy, *Supplemental Immobilization of Hanford Low-Activity Waste: Cast Stone Screening Tests*, PNNL-22747, SRNL-STI-2013-00465 (Aiken, SC and Richland, WA: September 2013).

[28]In September 2020 using similar technology, DOE completed the shipment of 8 gallons of tank waste from Savannah River Site in South Carolina to WCS to be grouted and disposed.

grouted tank waste from the West Valley Demonstration Project, which resulted in about 1.7 million gallons of tank waste that was grouted, shipped to, and disposed of at the NNSS. In addition, DOE reported that the department has disposed of about 38 million gallons of grouted waste (referred to as saltstone) in large concrete vaults at the Savannah River Site.

However, DOE faces regulatory constraints and other challenges to disposing of grouted supplemental LAW from Hanford at the two federal sites. Both sites are in states that have been historically opposed to permitting disposal of this type and form of waste.

- **IDF in Washington.** Washington State officials have approved a permit for disposal of vitrified LAW at the IDF, but according to DOE officials, this permit would not apply to grouted supplemental LAW. To dispose of such grouted waste in the IDF, DOE would have to obtain a modified permit from Washington State, according to DOE officials. However, Ecology officials have rejected the proposition that the supplemental LAW be grouted. According to Washington state officials, the TPA requires DOE to vitrify the tank waste or immobilize it with a technology that is "as good as glass" if it will be disposed on-site at Hanford.[29]
- **Radioactive Waste Management Complex in Nevada.** Disposing of the Hanford supplemental LAW at NNSS faces several regulatory and political hurdles. First, according to DOE officials, the permit governing the disposal of low-level radioactive waste at NNSS would need state authorization for a significant increase in the amount of waste coming to the site for disposal. Second, in a November 2018 letter to a Senator from Nevada, the then Secretary of Energy said that DOE did not intend to dispose of any reclassified waste from Hanford's Office of River Protection—which includes Hanford's tank waste—in the state of Nevada. Third, officials at NNSS said that because of limited space in the disposal cells, any new waste disposal could displace existing commitments and may require state approval to build additional disposal cells on site. According to NNSS officials, these barriers present a challenge, given that in the past the state of Nevada has opposed efforts to bring additional waste into the state. For these reasons, DOE officials said NNSS is not being considered

[29]This term is not defined in law, regulation, or agreement, but it is used by Washington State officials to convey their view that all tank waste should be vitrified or treated in a way that is equivalent to vitrification.

as a disposal facility for the Hanford supplemental LAW.

In contrast, state regulators in Texas and Utah told us that if the waste entering their states for disposal in a commercial low-level radioactive waste facility meets the facility's established waste acceptance criteria, it would be accepted and could be disposed of at the WCS or Clive facilities.

Other Disposal Facilities Exist, but Currently Are Not Viable Options

The Waste Isolation Pilot Plant (WIPP) in New Mexico

WIPP can only receive transuranic waste (which is waste contaminated with elements that have an atomic number greater than uranium), consistent with the WIPP Land Withdrawal Act.[30] Modifications to the WIPP Hazardous Waste Facility Permit from the state of New Mexico would be necessary to dispose of grouted supplemental low-activity waste from Hanford at WIPP. The Hanford System Plan indicates that waste from 11 of the Hanford tanks may contain transuranic waste, and the preferred destination for disposal of that waste is WIPP. However, as we reported in November 2020, WIPP faces statutory and physical space limitations that may prevent the waste from these 11 tanks from being accepted for disposal. In addition, WIPP's permit with the state of New Mexico prohibits disposal at WIPP of waste from certain tanks at Hanford. For more details, see GAO, *Nuclear Waste Disposal: Better Planning Needed to Avoid Potential Disruptions at Waste Isolation Pilot Plant*, GAO-21-48 (Washington, D.C.: Nov. 19, 2020).

Source: GAO. | GAO-22-104365

In addition to the four facilities that we examined for this review, several other facilities around the country receive low-level radioactive waste for disposal. Specifically, according a report by the National Academies, four additional DOE facilities accept low-level radioactive waste, but only when generated on-site.[31] These facilities are the Idaho National Laboratory; Los Alamos National Laboratory, New Mexico; Oak Ridge Reservation, Tennessee; and Savannah River Site, South Carolina.

Two additional commercial facilities dispose of low-level radioactive waste, but because of either current law or DOE practice, these facilities are currently not viable options for disposal of grouted supplemental LAW from Hanford. Specifically,

- **Barnwell Disposal Facility.** This facility, in Barnwell, South Carolina, is owned by the state of South Carolina and operated by EnergySolutions. The Barnwell facility is a low-level radioactive waste disposal facility for waste generated in states that are part of the Atlantic Compact, which comprises South Carolina, Connecticut, and New Jersey. Under South Carolina law, the Barnwell facility currently can receive waste only from these three states.
- **US Ecology Washington Facility.** This facility, near Richland, Washington, is operated by US Ecology, Inc., as the disposal facility for regional compacts to receive low-level radioactive waste from several western states, including Washington. However, DOE officials said that, as a matter of practice, DOE does not view the US Ecology facility as an option to receive Hanford's supplemental LAW because the facilities on the Hanford Site,

[30]"Transuranic" is used to describe elements that have atomic numbers greater than that of uranium. Transuranic waste is defined in the Waste Isolation Pilot Plant Land Withdrawal Act as waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for (A) high-level radioactive waste; (B) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency, does not need the degree of isolation required by the disposal regulations; or (C) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations. Pub L. No. 102-579, § 2(20), 106 Stat. 4777, 4779 (1992).

[31]National Academies of Sciences, Engineering, and Medicine, *Low-Level Radioactive Waste Management and Disposition: Proceedings of a Workshop* (Washington, D.C.: The National Academies Press, 2017). According to DOE officials, some low-level radioactive waste from U.S. Navy shipyards is currently accepted at the Savannah River Site.

such as the IDF, were built and funded for on-site disposal of low-level radioactive waste.

Disposal Costs and Risks Vary among the Potential Facilities, but Grout Disposal Is Likely Billions Less than Vitrification

The costs, as well as the potential health and environmental risks, related to disposal of grouted supplemental LAW vary for each facility, but each disposal option for grouted supplemental LAW likely would cost billions of dollars less than DOE's current baseline approach to vitrify supplemental LAW and dispose of it at the IDF. DOE has begun exploring options for disposal of Hanford's supplemental LAW, but it has not followed leading practices for risk-informed decision-making in doing so.

Each Grout Disposal Option Is Estimated to Cost Billions Less than Vitrification

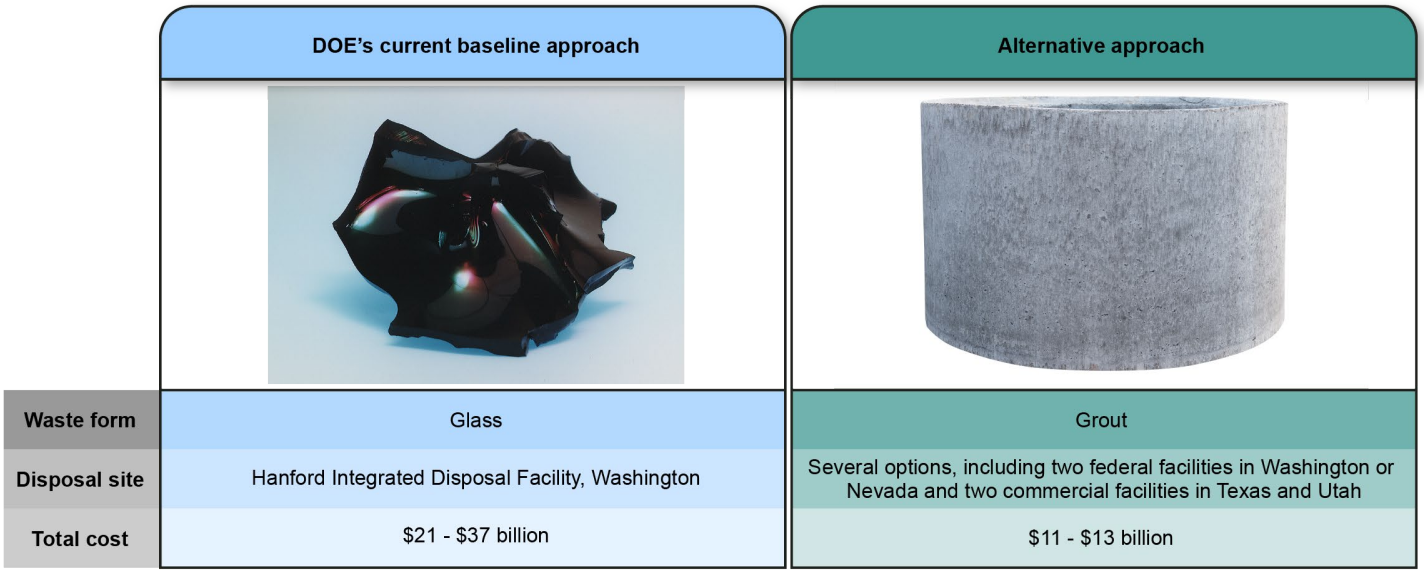
The total estimated costs associated with each grout treatment and disposal option we identified are substantially lower than the total estimated costs associated with DOE's current baseline approach to vitrify supplemental LAW and dispose of it at the IDF. A 2019 FFRDC report estimated the total cost of vitrifying and disposing of Hanford's supplemental LAW at between $21 billion and $37 billion (according to DOE officials, separate cost estimates for vitrification and disposal are not available).[32] In comparison, we estimate the total costs for grouting and disposing of Hanford's supplemental LAW could range from $11 billion to $13 billion (see fig. 4).[33] Specifically, based on our 2017 analysis of treatment costs, we estimated the total cost of grouting the 52 million gallons of supplemental LAW to be about $8.6 billion. As discussed below, our current estimate of the cost to dispose of the grouted waste is between $2.2 and $4.3 billion.[34]

[32]According to its report, the FFRDC completed a Rough Order of Magnitude Class 5 Planning Estimate for research and development; design; construction; and life cycle costs, including transportation and disposal. Class 5 estimates have the least project definition available (from 0 to 2 percent) and, therefore, have very wide ranges. See SRNL-RP-2018-00687.

[33]Costs are presented in 2020 dollars.

[34]In our 2017 report, we estimated that grouting LAW at the Savannah River Site—including the costs of constructing and operating a grout facility—could cost $153 per gallon, in 2015 dollars. We based our analysis on the assumption that DOE will have 52 million gallons of supplemental LAW—due to the need to add water while removing the waste from the tanks, transferring it, and pretreating it. See GAO-17-306. For more details on our methodology, see appendix I.

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



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.[35] Table 1 shows the estimated costs associated with each major category of disposal costs for grouted supplemental LAW from Hanford.[36]

[35]We included pretreatment in our disposal calculations because pretreatment costs vary among the selected disposal facilities.

[36]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[a]	$1.4[b]
Transportation	0.04	0.2	0.1	0.3[c]
Permanent disposal[d]	1.0	2.7[e]	0.7[e,f]	0.5[f,g]
Disposal process total costs[h]	**$2.4**	**$4.3**	**$2.3**	**$2.2**

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.

[a]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.

[b]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.

[c]The estimate is based on a comparable rate given to us by NNSS.

[d]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.

[e]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.

[f]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).

[g]NNSS officials told us that the facility charges an administrative fee associated with generating site certification costs. NNSS could not provide exact numbers, but officials informed us that the Waste Isolation Pilot Plant has a similar process, which we used as a proxy for this estimate.

[h]Numbers may not sum to totals because of rounding.

Pretreatment. Each facility has its own waste acceptance criteria, which limit the types of waste the facility can accept. To meet the waste acceptance criteria for the disposal facilities, Hanford's supplemental LAW would need to be pretreated to remove some constituents—such as strontium-90 or organic material—before grouting, depending on the requirements of the disposal facility.[37] These pretreatment needs could significantly affect the cost of disposal, and we estimated that pretreatment costs for the waste to be disposed of at the facilities we evaluated could range from $1.3 to $1.5 billion, depending on the facility.[38]

However, the pretreatment costs could vary depending on the site and technology selected. For example, in its 2019 report, the FFRDC stated that Clive was originally considered as a disposal option for the purposes of their analysis because the cost savings in disposal fees would be roughly $1.5 billion in 2018 dollars, compared to other low-level radioactive waste disposal sites, if the waste could be pretreated to reach Clive's required levels of radioactivity. The FFRDC report stated that they removed the Clive facility from their study because Clive can only accept Class A waste—waste with low levels of radioactivity.[39] At the time, the FFRDC team determined that they would not include the Clive facility in their analysis of potential disposal options for the Hanford supplemental LAW because of uncertainty about pretreatment technology and potentially high

[37]According to a 2002 DOE report, approximately 20 percent of the tank waste at Hanford contains soluble organic compounds. Department of Energy, *Recommendation for Supplemental Technologies for Potential Mission Acceleration*, RPP-11261, rev. 0 (Richland, WA: July 26, 2002). A January 2021 report by DOE found that most of the organic compounds in the waste could be effectively removed by evaporation without additional pretreatment. Savannah River National Laboratory, *Hanford Supplemental Low Activity Waste Simulant Evaporation Testing for Removal of* Organics, SRNL-STI-2020-00582, rev. 0 (Aiken, SC: January 2021).

[38]See table 1 for more information. Hanford's low-end estimate of pretreatment costs is $1.3 billion, while EnergySolutions estimate of pretreatment costs is $1.5 billion.

[39]See SRNL-RP-2018-00687. DOE also stated that the size of the mixed low-level waste disposal cell at Clive was a key factor in their decision to exclude it from consideration.

pretreatment costs associated with preparing the waste to go to Clive.[40] However, EnergySolutions representatives told us their facility now has the ability to pretreat the waste, and the cost estimate they provided us would make the Clive facility competitive with the other facilities for overall costs.

Transportation. Transportation includes packaging the waste and transporting it to the disposal facility. While each facility has some requirements for packaging, they all can accept a variety of containers for waste.[41] Hanford officials stated that the IDF can accept various types of packaging. NNSS has additional requirements for packaging strength because the facility stacks the waste in the disposal cell. EnergySolutions and WCS representatives said that their facilities can accept any packaging that meets Department of Transportation packaging requirements for waste.[42]

The two primary modes of transporting waste are truck or rail, and rail is cheaper. The costs for transportation to the IDF are the least expensive because the waste would remain on site, but truck transportation is required to move waste across the facility. In addition to the costs for transportation itself, Hanford's infrastructure would need repairs or new infrastructure to enable shipment of the waste off-site by truck or by rail, so we included these costs in the transportation estimate for each facility, as appropriate. NNSS does not have rail access, so truck transportation would be required if that facility were

[40]According the 2019 FFRDC report, "almost all the grouted [waste] would be classified as Class A, if 99% of the Sr-90 could be removed prior to immobilization. With a total volume of 367,900 m3 (as grout) and a cost differential of ~$4,000 per m3 between Class A and Class B/C, the cost savings in disposal fees would be roughly $1.5 B. Additionally the Clive disposal facility in Utah could be considered, if the grouted or steam reformed [waste] classifies as Class A [mixed] LLW. The Clive facility is closer to Hanford (lower transportation costs), and the Clive facility would probably offer a competitive disposal fee for disposal of the Class A [mixed] LLW." See SRNL-RP-2018-00687.

[41]Packaging is a small portion—less than 2 percent—of the overall costs of disposal. We asked each facility for an estimate of packaging costs. Officials from Hanford stated that the packaging selected in the FFRDC report would be appropriate to use in our estimate. Representatives from WCS and EnergySolutions did not provide packaging estimates for their facilities, so we used the packaging selected in the FFRDC report as a proxy. DOE provided us with an estimate for packaging for NNSS, based on similar waste they have received.

[42]According to the Nuclear Regulatory Commission (NRC), NRC and the Department of Transportation share responsibility for the control of radioactive material transport, and, in general, Department of Transportation regulations are more detailed.

to be considered for disposal of Hanford's supplemental LAW. According to facility representatives, both the Clive and WCS facilities are accessible by rail. Because rail transportation is cheaper than truck, Clive and WCS have lower estimated transportation costs than NNSS. Additionally, because WCS is a greater distance than Clive from Hanford (1595 miles versus 690 miles via public highway, respectively), the transportation costs to WCS are proportionally greater than the transportation costs to Clive.

Permanent disposal. Disposal facilities vary widely in the costs they charge to receive the waste and place it in the disposal cell. Officials at the two federal facilities told us they calculate disposal operations costs on an annual basis.[43] The two commercial facilities' disposal costs are based on contract rates, which include costs associated with the long-term maintenance of the facilities, according to DOE officials.[44] For this analysis, we used the publicly available Indefinite Delivery, Indefinite Quantity contract rates for the selected commercial facilities. A representative from WCS told us that when a disposal decision is made, a more definite contract can be negotiated that could have lower rates. However, the representatives at WCS and EnergySolutions could not provide us with an estimate of what those lower rates might be and stated that the Indefinite Delivery, Indefinite Quantity contract rates are the best available information.

Long-term maintenance. Nuclear Regulatory Commission (NRC) rules and state laws require that the two commercial facilities (WCS and Clive) provide funds from their permanent disposal fees to cover the long-term surveillance and stewardship costs of their facilities.[45] In the case of the Clive facility, the state of Utah will use these funds to

[43]NNSS also requires a certification process from the generating sites before it will accept their waste. This certification process includes an audit of the generating site and takes a minimum of 6 months. NNSS officials were not able to provide us with a cost for this process, but they stated that WIPP has a similar certification process, which we used as a proxy. According to WIPP officials, this process could cost from $10 million to $20 million, and we used the higher of these values in our estimate.

[44]The selected federal facilities do not include long-term maintenance costs in their storage fees.

[45]According to facility representatives, the commercial facilities (WCS and Clive) have designated federal cells—disposal areas that only contain federal waste—though the cells at Clive are not currently permitted to receive mixed low-level waste. The long-term surveillance and maintenance of the federal cells are covered by the facilities' funds, according to facility representatives.

take over stewardship of the majority of the facility after the facility is closed, according to EnergySolutions representatives.[46] The state of Texas also requires WCS to provide bonds for facility closure, post-closure, and corrective actions, according to an official from the Texas Commission on Environmental Quality.[47] However, neither federal facility (IDF nor NNSS) has any such built-in mechanism for funding the long-term maintenance of the facilities, according to DOE officials. Because DOE does not currently plan to grout Hanford's supplemental LAW, it is unknown how disposing of it at the federal facilities would change their long-term surveillance and maintenance costs.

Health and Environmental Risks of Disposal of Grouted Low-level Radioactive Waste Vary for Each Facility

We identified several risks associated with different aspects of the waste disposal process—waste packaging and transportation, acceptance, and disposal operations (see fig. 5). From our analysis of DOE documents, we determined that waste packaging and transportation have potential risks of accidents and exposure, waste acceptance has potential risks of the waste being rejected and sent to another facility, and disposal has potential risks of radioactive material leaching inadvertently into the facility or into the environment. DOE officials stated that these risks are mitigated by the established regulatory framework for transporting waste and the siting, design, construction, and operation of these facilities. Our analysis below describes some of the risks at each facility that decision-makers may consider; we did not conduct a formal risk assessment.

[46]The State of Utah is an "agreement state" with NRC with respect to NRC's low-level radioactive waste program. This means that, among other things, Utah's program for low level radioactive waste disposal requires compliance with standards for the protection of the public health, safety, and the environment from hazards associated with such material that are equivalent to the extent practicable, or more stringent than, standards adopted and enforced by NRC for the same purpose, including certain requirements and standards promulgated by NRC and EPA. Further, the *Utah Radiation Control Act Section 19-3-106.2* extends the financial assurance beyond the NRC requirements, creating a perpetual care fund pursuant to this section to provide the state with access to funding to care for the commercial portions of the Clive facility perpetually.

[47]According to Texas officials, these requirements include Tex. Health & Safety Code Ann. § 401.303(a), 30 Tex. Admin. Code § 336.736, and 30 Tex. Admin. Code Ch. 37, Subchapters B, C, D, and T.

Figure 5: Disposal Process of Grouted Supplemental Low-Activity Waste with Environmental Risks at Each Stage

Sources: GAO analysis of Department of Energy (DOE) documents. Photos: DOE, and boygek/stock.adobe.com. | GAO-22-104365

To better understand these risks, we evaluated the following four factors: waste packaging and transportation, facility environment, facility construction, and waste acceptance.[48]

Waste packaging and transportation. According to a 2006 report by the National Academies, risks associated with transportation include radiation exposure from the packages in normal transportation, accidental exposure if the waste is dispersed—such as in a truck crash or train derailment—and non-exposure effects such as increases in air pollution and accidents.[49] This report stated that the risks differ for rail and truck transportation, and that these risks are well understood and generally low, with the possible exception of releases in extreme accidents of low likelihood. In this report, which

[48]To describe the environmental risks associated with the disposal of grouted supplemental LAW at selected facilities, we reviewed DOE documentation regarding the risks associated with each step of the disposal process.

[49]National Academies of Sciences, Engineering, and Medicine, *Going the Distance?: The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States,* (Washington, D.C.: The National Academies Press, 2006).

evaluated DOE's plans to ship large quantities of HLW and spent nuclear fuel, the National Academies stated that they strongly endorse DOE's decisions to ship waste by rail and encouraged DOE to reduce cross-country truck shipments of waste. The National Academies found that rail has clear safety, operational, and policy advantages over highway transport for large quantity shipping programs. For example, rail reduces the total number of shipments, which in turn reduces the potential for routine radiological exposures, conventional traffic accidents, and severe accidents. The National Academies also preferred rail to truck in instances where rail infrastructure would need to be built to reach a disposal facility.[50] The transportation risks at each specific facility follow:

- **IDF.** According to DOE documentation, on-site disposal at IDF reduces transportation risk to the distance travelled across the facility. IDF uses trucks to move waste across the facility.
- **NNSS.** According to DOE documentation, NNSS does not have rail access and only accepts waste by truck. NNSS is 908 miles by highway from Hanford.
- **Commercial facilities.** According to WCS and EnergySolutions representatives, the WCS and Clive facilities can accept rail shipments, though WCS would require much further shipping distances than Clive (1595 miles versus 690 miles by highway, respectively).

DOE officials stated that packaging and transportation regulations mitigate these risks to ensure safe transport of radioactive materials, and that in 2020, DOE safely transported 3,200 hazardous material shipments over 6 million miles, with no U.S. Department of Transportation recordable accidents.

Facility environment. Each facility has unique geological and hydrological characteristics, which could contribute to environmental risks. According to our prior work, if contaminants are released into

[50]Our analysis only considers the transportation of treated supplemental LAW. Transportation of untreated supplemental LAW is outside the scope of our review because all four disposal options assume that the waste would be grouted prior to transportation to a disposal facility.

the soil, they may make their way into nearby groundwater.[51] Contamination of drinking water can pose human health risks to populations that depend on that water.[52] The facility geology and hydrology risks at each specific facility follow:

- **IDF.** According to DOE documentation, the groundwater at the IDF is about 400 feet below the surface, which combines with the aridity of the facility to reduce the risk of contamination. However, the facility is roughly 10 miles from the Columbia River and has potential risks of waste leaching into the river over hundreds of years. The Columbia River Basin has environmental, cultural, and economic significance, and its health is critical to the survival of hundreds of fish and wildlife species and to the well-being and livelihoods of the approximately 8 million people who inhabit and work in the Basin. In 2017, we reported that, according to experts, there is a very low risk that waste treated with either grout or vitrification would contaminate the groundwater at a modern disposal facility, such as the IDF.[53]
- **NNSS.** According to DOE documentation, NNSS has the deepest water table of the facilities we analyzed, at 700 feet or more below the facility. According to DOE documentation and officials, the facility has some potable—or drinkable—water wells but is not accessible to the public. DOE officials stated that NNSS is in an arid environment, and the disposal site has no impact on the groundwater.
- **Clive facility.** According to EnergySolutions representatives, the Clive facility is located above a water table that is closer to the surface (approximately 30 feet). However, the water is saline and non-potable, which reduces the risk of exposure if waste were to enter the water table, and the facility has no surface water and any rainwater quickly evaporates.

[51]GAO, *Hanford Cleanup: DOE's Efforts to Close Tank Farms Would Benefit from Clearer Legal Authorities and Communication,* GAO-21-73 (Washington, D.C.: Jan. 7, 2021).

[52]In our 2017 report, some experts stated that the engineering of the disposal facility plays a role in minimizing risks, and engineered barriers—such as adding a cap to prevent water infiltration into the disposal facility—could help to limit the possible spread of some contaminants from grouted waste forms for up to the 1,000-year period of performance. See GAO-17-306.

[53]GAO-17-306.

- **WCS facility.** The WCS facility has deeper groundwater than the IDF—the groundwater is separated from the facility above it by 600-foot thick clay beds, which serves as a natural barrier to prevent contaminants from reaching groundwater, according to the 2019 FFRDC report.[54] While a geologic formation contains potable groundwater within 2 miles of the facility, according to DOE documentation, this formation does not contain water beneath the facility. This groundwater is the primary source of drinking water for the Southern High Plains, a 174,000 square-mile area from South Dakota to Texas.[55]

DOE officials stated that all facilities are licensed or permitted to accept radiological waste in accordance with their waste acceptance criteria, which ensures that public health and safety requirements are met.

Facility construction. We have previously reported that engineered barriers can supplement natural geological barriers at waste disposal facilities.[56] Engineered barriers are structures intended to improve the disposal facility's ability to retain waste, such as using a liner in the disposal cell or adding a cap to prevent water infiltration into the disposal facility. The selected facilities have differences in the construction of their barriers that may affect environmental risks. The facility construction risks at each specific facility follow:

- **IDF.** According to DOE documentation and officials, the IDF is constructed with a system of liners, and waste will be placed below ground level with the engineered barrier extending five to 15 meters above the waste. However, while construction on the IDF is complete, permitting is still in progress, and the engineered barrier that will cover the waste is still being designed.
- **NNSS.** According to NNSS documentation and officials, the disposal cells at the Radioactive Waste Management Complex at NNSS are constructed with multilayer liners on which the waste is

[54]SRNL-RP-2018-00687.

[55]United States Department of Agriculture, *Ogallala Aquifer Initiative: 2018 Final Progress Report.*

[56]GAO, *Nuclear Waste: Foreign Countries' Approach to High-Level Waste Storage and Disposal*, GAO/RCED-94-172 (Washington, D.C.: Aug. 14, 1994).

placed and then covered with several feet of soil. According to NNSS documentation, the cell will be capped with four feet of native soil.

- **Clive facility.** According to EnergySolutions representatives, the disposal cells are constructed with liners made of the local clay, supplemented with a polyethylene liner in the cell for mixed low-level radioactive waste.[57] The water table at the facility is 30 feet below the surface. The cells extend 12 feet below the surface, and the completed cells extend 38 feet above the surface of the surrounding countryside. The caps for the cells will include compacted clay to prevent water intrusion and a layer of rock to prevent erosion and keep animals from intruding.
- **WCS facility.** According to DOE documentation, the cells at WCS are constructed with thick multilayer liners, and the waste can be placed deeply enough underground to allow the cells to be capped at ground level. The cell will be capped with a minimum 25-foot thick multilayer barrier.

DOE officials stated that all the facilities meet applicable regulatory requirements, including facility design and construction, and all waste must meet waste acceptance criteria.

Waste acceptance. Each facility has different waste acceptance criteria, which determine what types of waste the facility can accept for disposal, including concentrations of specific radionuclides.[58] For example, Hanford's supplemental LAW is known to contain technetium-99 and iodine-129, which have long half-lives. The half-life of technetium-99 is 213,000 years, and that of iodine-129 is 15.7 million years.

Since DOE has not made a decision for how the waste will be treated, the final form of Hanford's waste is still unknown, and the final concentrations of these constituents in the final grouted waste is also unknown. Selecting a disposal facility with more restrictive waste acceptance criteria could introduce the risk that a chosen facility may

[57]As described earlier, mixed waste is waste that has a hazardous component regulated under RCRA and a radioactive component regulated under the Atomic Energy Act.

[58]Concentrations of radionuclides are measured in curies per cubic meter (Ci/m^3). For example, we estimate the average amount of naturally occurring uranium in U.S. concrete is 8.7 picocuries per cubic meter. A picocurie is 10^{-12} of a curie (0.000000000001 Ci).

not be able to accept Hanford's grouted waste, and DOE would have to select a different facility.[59] This could create environmental risk and increased costs because DOE would need to place the grouted waste in interim storage until decision-makers select a different disposal option and then transport it to the newly chosen facility. The waste compliance risks at each specific facility follow:

- **Federal facilities.** According to DOE documentation, IDF's and NNSS's waste acceptance criteria are based on performance assessments done for each site and establish limits on the concentrations of certain isotopes, such as iodine-129 and technetium-99, that they can accept.[60]
- **Clive facility.** The Clive facility is licensed to accept Class A low-level radioactive waste—NRC's designation for waste containing the least concentrations of radioactivity. For example, of the selected facilities, the Clive facility has the lowest allowable concentration limits of isotopes iodine-129 and technetium-99. According to our calculations based on the waste acceptance criteria at these facilities, Clive's limits for these isotopes are at least dozens of times less than those allowed at the two federal facilities.[61]
- **WCS facility.** According to WCS documentation, WCS's waste acceptance criteria permit the disposal of Class C low-level radioactive waste. This waste contains radionuclides that require hundreds of years to decay to safe levels. While WCS's waste acceptance criteria have no limits for iodine-129 and technetium-99, WCS only accepts low-level radioactive waste that is Class C or below.

[59]The FFRDC report identified a number of challenges facing technology and disposal facility evaluation and selection. These included compliance of the wasteform with disposal criteria. The FFRDC report stated that additional studies and technology maturation may be needed to demonstrate its acceptable wasteform performance for Hanford's supplemental LAW. See SRNL-RP-2018-00687.

[60]IDF's waste acceptance criteria allow for concentrations of isotopes iodine-129 and technetium-99 of 0.1 Ci/m^3 and 0.9 Ci/m^3, respectively. NNSS's waste acceptance criteria allow for concentrations of isotopes iodine-129 and technetium-99 of 0.1 Ci/m^3 and 0.1 Ci/m^3, respectively.

[61]The Clive facility's waste acceptance criteria limit concentrations of isotopes iodine-129 and technetium-99 to 0.00005 Ci/m^3 and 0.004 Ci/m^3, respectively.

DOE Has Begun Exploring Options for Disposal of Hanford's Supplemental LAW but Has Not Followed Leading Practices for Risk-Informed Decision-Making

DOE has started to explore options for disposal of Hanford's supplemental LAW, but it has limited information about the costs and regulatory challenges associated with various options, which is inconsistent with leading practices for risk-informed decision-making. Specifically, DOE has only considered one alternative disposal facility in addition to its current baseline approach to dispose of the supplemental LAW in the IDF at Hanford. The 2017 FFRDC review, which largely focused on treatment alternatives, only considered one off-site disposal option: the WCS Federal Waste Facility in Texas.[62] Furthermore, DOE's 2017 laboratory scale test for sending grouted waste off-site for disposal was limited to the WCS facility.

However, leading practices for risk-informed decision-making and DOE guidance call for analyzing a wide range of alternatives before selecting a cleanup solution. For example, in 2019 we outlined a framework for risk-informed decision-making that includes identifying options in the design phase of the decision-making process and narrowing those options during the analysis and decision phases.[63] The framework states that, for a risk-informed cleanup decision, the identified options should be broad enough to be expected to offer distinct differences with respect to human health and environmental risks and cost.[64] Similarly, DOE's guide for analyzing alternatives calls for conducting analyses without a predetermined solution.[65] Specifically, the guide says that the analysis of alternatives process informs the decision-making process rather than reflecting the validation of a predetermined solution and should therefore represent an unbiased inquiry into the costs, benefits, and capabilities of all alternatives. According to the guide, without this, the results of the analysis may be distorted and the validity of the results may be affected.

[62]SRNL-RP-2018-00687.

[63]GAO-19-339.

[64]In addition, the framework states that regulatory or statutory constraints, such as federal or state cleanup requirements, may not be fixed because an agency can seek waivers or statutory changes. We reported that, according to experts, agencies should consider opportunities to negotiate or pursue waivers or changes to these types of constraints where appropriate, so the decision-making process stays as open as possible to creative solutions.

[65]Department of Energy, *Analysis of Alternatives Guide*.

DOE officials and the FFRDC team told us that they did not consider a wider range of other disposal facilities because of uncertainty about pretreatment costs, current DOE policy, or states' historical opposition. For example, they did not include the Clive facility because it is only licensed to receive Class A low-level radioactive waste (the least radioactive). Further, the FFRDC team who reviewed the alternatives did not ultimately include the Clive facility in its analysis of potential disposal options for the Hanford supplemental LAW because of uncertainty about pretreatment technology and potentially high pretreatment costs associated with preparing the waste to go to Clive. However, as we noted above, in 2017 DOE pretreated 3 gallons of Hanford tank waste for shipment to WCS as part of a demonstration project and, according DOE officials, the pretreatment demonstration resulted in waste that was within Class A limits. DOE officials added that they did not consider the Radioactive Waste Management Complex at NNSS as an option because (1) DOE policy currently is to avoid sending Hanford waste to NNSS, (2) the state of Nevada has historically opposed being the only location for disposal of low-level radioactive waste from DOE sites, and (3) the disposal facility at NNSS lacks the physical capacity for both the Hanford waste and waste currently designated to come to the facility. Accordingly, because DOE considered a limited set of disposal options, it does not have details about the costs or the technical and regulatory challenges associated with disposing of grouted supplemental LAW at other federal and commercial facilities.

DOE officials also told us they are waiting for three ongoing activities to conclude before they begin considering additional options for treating and disposing of the supplemental LAW. These activities are (1) the conclusion of the most recent FFRDC study that DOE commissioned in 2021, (2) DOE's negotiations with Washington State on a wide range of cleanup milestones affecting the Hanford Site, and (3) an ongoing analysis DOE is pursuing of alternatives for HLW pretreatment in connection with the WTP.[66] However, without more

[66]In September 2019, DOE informed Ecology that a serious risk had arisen that DOE might be unable to meet certain Amended Consent Decree milestones related to, among other things, the construction of the pretreatment facility. In the same month, DOE agreed to participate in "holistic negotiations" to identify a new path forward for treating and disposing of Hanford's tank waste. As part of this agreement, the parties involved—DOE, Ecology, and EPA—have used the services of a mediator to assist with negotiations. In October 2018, facing continuing technical challenges and delays on its pretreatment facility at the WTP, DOE began analyzing alternatives for pretreating HLW. As of September 2021, these two efforts were still ongoing.

information about the costs, environmental risks, and technical and regulatory challenges associated with various disposal facilities, DOE and Washington State officials are limited in their ability to negotiate treatment and disposal options for Hanford's tank waste. Specifically, Ecology officials told us they need assurance that disposal facilities outside the state will commit to receiving the grouted supplemental LAW before the state could agree to an alternative treatment approach.

Without following our framework for risk-informed decision-making—such as ensuring that the potential disposal options include all federal and commercial facilities that could potentially accept grouted supplemental LAW from Hanford—and its own best practices for analyzing alternatives, DOE may be missing opportunities to pursue alternate treatment and disposal options that could save billions of dollars.

DOE Faces Legal Uncertainty in Selecting a Disposal Option and Is Behind Schedule in Doing So

DOE faces legal and regulatory challenges in attempting to consider disposal options for its supplemental LAW. Each of DOE's options for classifying and managing the supplemental LAW as anything other than HLW faces limitations. Further, even if DOE is able to classify and manage its supplemental LAW as low-level radioactive waste, it may encounter legal challenges under RCRA by trying to use methods other than vitrification to treat the waste and preparing it for disposal. In addition, DOE has not yet taken certain steps that would enable it to make a decision in time to meet its treatment milestones and schedule. For instance, DOE has not yet made a decision on a treatment approach for the supplemental LAW but DOE's current baseline system plan calls for design and construction of treatment facilities to begin in 2025.

DOE's Options for Managing the Supplemental LAW as a Type Other than HLW Face Legal and Regulatory Challenges

Before DOE can consider alternate options to vitrification for treating and disposing of Hanford's supplemental LAW, it has to show it can classify and manage this waste as a type other than HLW for two reasons. First, under EPA regulations also adopted by Ecology to implement RCRA, high-level mixed waste generated during the reprocessing of nuclear weapons material must be vitrified prior to disposal. Second, the waste acceptance criteria at the potential disposal facilities we identified currently only permit disposal of low-level radioactive waste and do not permit disposal of HLW.

Generally, DOE has three processes it could use to determine that certain waste from reprocessing is not HLW: (1) the waste incidental

to reprocessing evaluation process as outlined in DOE Manual 435.1-1, (2) Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005,[67] and (3) DOE's HLW interpretation, as articulated in its June 2019 notice and as later incorporated in DOE Manual 435.1-1. Once a determination is made, such waste can then be managed as either transuranic (which is waste contaminated with elements that have an atomic number greater than uranium) or low-level radioactive waste.[68]

However, each of these processes has certain limitations that may prevent DOE from applying them to the treatment and disposal of Hanford's supplemental LAW, including for disposal options outside the state of Washington. For example, DOE could face legal challenges if it uses the process set out in Manual 435.1-1 for evaluating Hanford's supplemental LAW. In addition, Section 3116 is limited to waste in Idaho and South Carolina and does not apply to Hanford or to the disposal of waste out of state. Finally, DOE's HLW interpretation is prohibited by the National Defense Authorization Acts of fiscal years 2020 and 2021 from being applied at the Hanford Site in fiscal years 2020 and 2021.[69] Table 2 summarizes each of these three processes and the key limitations for the disposal of grouted supplemental LAW. See appendix II for additional information about the three processes.

[67]Pub. L. No. 108-375, § 3116, 118 Stat. 1811, 2162–64 (2004).

[68]The definition of "transuranic waste" in DOE Manual 435.1-1 matches that in the WIPP Land Withdrawal Act of 1992, as detailed above.

[69]The National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, § 3121, 133 Stat. 1198, 1953 (2019); The William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021", Pub. L. No. 116-283, § 3124, 134 Stat. 3388 (2021).

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
Waste incidental to reprocessing evaluation process under DOE Manual 435.1-1	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.[a]
Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005	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. Section 3116 does not apply to waste being transported out of state from South Carolina or Idaho.
HLW interpretation	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

[a]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.

Because of significant limitations with using any of these three processes, DOE may be restricted in its ability to grout supplemental LAW or dispose of it outside of the State of Washington unless it succeeds in managing some tank waste as low-level radioactive waste. DOE officials have repeatedly said that, when making treatment and disposal decisions, DOE has the authority under current law to classify the waste as other than HLW. However, as we found in May 2017, legislation specifically authorizing DOE to manage some of Hanford's waste as low-level radioactive waste, similar to section 3116 of the National Defense Authorization Act for Fiscal Year 2005, could insulate DOE from legal challenges to its authority to make treatment decisions based on the actual radioactivity of the waste.[70] Such legislation could allow DOE to consider potentially less costly and less complicated treatment approaches or alternate disposal options for Hanford's supplemental LAW, such as grouting and disposal at one of the four potential facilities we identified. Furthermore, Section 3116 currently applies only to Idaho and South Carolina and does not allow for waste being managed as something other than HLW to be shipped out of state, and so it would not address the obstacles discussed here absent modification by Congress. Legislation that gives DOE specific authority to manage Hanford's supplemental LAW as low-level radioactive waste and to transport it outside the State of Washington for disposal could help DOE save tens of billions of dollars and complete its waste treatment sooner by enabling it to treat and dispose of the supplemental LAW as low-level radioactive waste at off-site disposal facilities.

DOE May Encounter Legal Challenges Even If It Manages the Waste as Low-Level Radioactive Waste

Even if DOE is able to classify and manage its supplemental LAW as low-level waste, it may encounter legal challenges under RCRA if it tries to use methods other than vitrification to treat the waste and prepare it for disposal. These potential legal challenges stem from the lack of clarity over the extent of DOE's authorities and Ecology's requirements. According to DOE officials, DOE determined in the late 1980s that Hanford's tank waste possessed several hazardous waste

[70]GAO-17-306. We also previously recommended such legislation in 2009 and 2003. See GAO, *Nuclear Waste: Uncertainties and Questions about Costs and Risks Persist with DOE's Tank Waste Cleanup Strategy at Hanford*, GAO-09-913 (Washington, D.C.: Sept. 30, 2009); and GAO, *Nuclear Waste: Challenges to Achieving Potential Savings in DOE's High-Level Waste Cleanup Program*, GAO-03-593 (Washington, D.C.: June 17, 2003).

characteristics.[71] Under RCRA's land disposal requirements, when hazardous waste constituents with these waste characteristics are mixed with HLW generated during the reprocessing of fuel rods—called mixed HLW—the waste is required to be immobilized to meet the treatment standard of vitrification before disposal.[72] Conversely, RCRA regulations do not require low-level waste with these hazardous characteristics—called mixed low-level waste—to be vitrified; instead, mixed low-level waste is required to be treated in a way that reduces the mobility of the hazardous constituents and that meets the requirements of the disposal facility.[73]

However, in cases where waste is classified as something other than HLW, such as mixed low-level waste, it is unclear under RCRA

[71]These include characteristic hazardous wastes regulated under RCRA, mixed with radioactive wastes regulated under the Atomic Energy Act and the Nuclear Waste Policy Act. Characteristic hazardous wastes are those wastes that exhibit any of the characteristics specified in EPA's 40 C.F.R. Part 261 Subpart C regulations—including, for example, those with characteristics of corrosivity or ignitability, as well as metals and other compounds exhibiting toxicity. DOE also determined that the tank wastes include other constituents that are listed hazardous wastes regulated under RCRA. Listed hazardous wastes are those specified in EPA's 40 C.F.R. Part 261 Subpart D regulations, and they include, for example, certain solvents or industrial process wastes.

[72]Specifically, in Washington, these wastes are regulated under Ecology's dangerous waste program, as authorized by EPA to operate in lieu of the federal RCRA program. Nevertheless, this report discusses the relevant treatment standards under EPA's RCRA land disposal regulations both because the report addresses out-of-state disposal options and because EPA's land disposal treatment standards are incorporated by reference in Ecology's dangerous waste regulations, with some additional requirements for and restrictions on in-state disposal of state-defined "extremely hazardous waste." The hazardous component of mixed waste is subject to applicable RCRA requirements, which include compliance with land disposal restrictions. This means that generated waste must be treated to specific regulatory levels or according to specified methods of treatment prior to land disposal. Treatment either substantially decreases the toxicity of the mixed waste, or it reduces the likelihood that hazardous constituents (e.g., metals) will migrate from the mixed waste and contaminate the environment. Under RCRA's land disposal requirements program, certain mixed wastes have specific treatment standards. For example, radioactive HLWs 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 NRC before the waste can be land-disposed. 40 C.F.R. §§ 268.40, 268.42(a).

[73]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. This waste may then be disposed of in a near-surface landfill, which must meet requirements established under RCRA, including that it have a double liner and a leachate collection system, which collects any liquids that leach from the disposal unit.

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.[74] Table 3 provides a summary of waste treatment requirements by waste type under RCRA.[75]

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	*Vitrification.* 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	*There is no general treatment standard.* 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	*RCRA does not specify the treatment standard.* 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

[74]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.

[75]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.

waste, including the authority to determine if the waste is no longer considered to be HLW based on the radioactivity of the waste.[76] DOE officials believe that waste determined to be low-level waste based on the radioactivity of the waste should be subject to the same RCRA requirements as mixed low-level waste, which does not require vitrification. In December 2017, in order to demonstrate the feasibility of grouting and disposing of Hanford LAW at WCS, DOE used Manual 435.1-1 to classify the waste as low-level radioactive waste. DOE successfully completed this demonstration project, part of the Test Bed Initiative. However, Ecology officials have recently stated to DOE and its contractors on multiple occasions that classifying some of the tank waste as low-level radioactive waste does not necessarily remove the RCRA vitrification treatment standard from the waste. DOE withdrew their permit to conduct a second phase of the Test Bed Initiative in part to better understand this issue.

Ecology's Views on Its Requirements

According to Ecology officials, RCRA regulations require mixed low activity waste that has been reclassified from mixed HLW to be vitrified because the applicable land disposal treatment standards remain attached to the waste until the applicable treatment standards, or alternative standards established through a treatability variance, have been met. Furthermore, Ecology officials told us that if DOE were to go through a process—such as through DOE Order 435.1—to determine that the waste is waste incidental to reprocessing, this designation would only apply to the waste for purposes of compliance with the Atomic Energy Act and the Nuclear Waste Policy Act, not for purposes of compliance with RCRA or Washington State's hazardous waste management laws. In July 2020 correspondence from Ecology to DOE, Ecology officials stated that the HLW vitrification treatment standard applies to the waste within the tank that DOE used for the Test Bed Initiative, and it could not be removed until the waste is treated to the HLW treatment standard or a variance is issued.

Ecology officials told us that DOE has existing regulatory pathways to treat mixed HLW, including with treatment methods other than vitrification. Specifically, Ecology officials stated that DOE could seek a treatability variance from the appropriate regulatory authority for an off-site disposal location, which would establish an alternative

[76] 42 U.S.C. §§ 2011 et. seq.

treatment standard.[77] Alternatively, DOE could petition for a "no migration variance" from the EPA, in which DOE would have to demonstrate to a reasonable degree of certainty that there would be no migration of hazardous constituents from the disposal facility for as long as the waste remains hazardous. RCRA regulations also provide for a determination of equivalent treatment to authorize a treatment method other than the one provided for in the disposal regulations, if the equivalent treatment can be shown to achieve a measure of performance equivalent to the specified treatment standard.[78] Ecology officials noted that although DOE could theoretically pursue a determination of equivalent treatment, in their view, grout is not equivalent to vitrification in its ability to immobilize certain radioactive and hazardous constituents of concern.

Congressional Action Could Facilitate the Path Forward

DOE and Ecology do not agree on a path forward or how RCRA could impact DOE's ability to evaluate alternate disposal pathways; however, both parties agree that it would be beneficial for DOE to conduct the second phase of the Test Bed Initiative. Although Ecology officials described several options under existing regulatory pathways, DOE officials told us that such options do not apply to waste that is no longer considered to be HLW, as in the case of supplemental LAW. DOE officials told us that, according to their perspective, after DOE determines the waste can be managed as mixed low-level waste, this should be considered a new "point of waste generation"—which refers to the point at which waste is determined to hold hazardous characteristics. The waste then should be immobilized according to the same requirements of mixed low-level waste, which would therefore allow DOE to grout the waste as long as it meets the waste acceptance criteria of the chosen disposal facility.

EPA officials told us they do not have an official position on how RCRA applies to supplemental LAW because authorized states are entitled to implement their hazardous waste programs as they deem

[77]Under RCRA regulations, the treatment standard (i.e., a required method of treatment) for mixed HLW is vitrification, unless a site-specific treatability variance is obtained prior to land disposal. EPA or an authorized state, such as Washington, may grant a treatment variance where the following are shown: it is either physically impossible or inappropriate to apply the specified treatment standard; and compliance with any given treatment variance is sufficient to minimize threats to human health and the environment posed by disposal of the waste.

[78]40 C.F.R. § 268.42(b). EPA regulations also require the alternative treatment method to comply with federal, state, and local requirements; and protect human health and the environment.

most appropriate for their state, with EPA's role limited to overseeing implementation to ensure those programs are consistent with, and at least as stringent as, RCRA. EPA officials further explained that because authorized states' regulations operate "in lieu of"‘ RCRA, EPA elected not to hypothesize on how RCRA would apply in Washington State.

Both DOE and Ecology officials have said that it would be beneficial to continue the second phase of the Test Bed Initiative to obtain additional information about the feasibility of off-site disposal for grouted supplemental LAW. For example, Ecology officials told us that continuing with the Test Bed Initiative would allow DOE to further explore regulatory options for disposing of grouted tank waste, such as through a variance or no migration petition. They also noted that they are reluctant to agree to authorize grouting of tank waste without assurance that another state would be able and willing to accept the grouted waste for permanent disposal. Without this assurance, the waste may become an "orphan waste" with no place for disposal. Consequently, it would be stuck at Hanford without state approval to be disposed of at Hanford.

DOE officials told us that if they continue with the second phase of the Test Bed Initiative without clear legal authority, this RCRA issue could be litigated in courts, which could add several years to their ability to begin the demonstration project. If Congress clarifies that DOE can continue with the second phase of the Test Bed Initiative without application of the RCRA vitrification treatment standard for mixed HLW, DOE and Ecology could obtain valuable information about the regulatory pathways, costs, and technical feasibility of off-site disposal of grouted supplemental LAW. Furthermore, if Congress (1) authorizes DOE to classify the volume of wastes corresponding solely to the second phase of the Test Bed Initiative as something other than HLW and (2) specifies that RCRA's HLW vitrification standard does not apply to this volume of waste, Ecology may be able to avoid prematurely making a final determination of how RCRA applies under these circumstances. This could avoid setting an unintended precedent that could impact future treatment and disposal decisions. However, without clarification from Congress that provides a clear legal pathway for the second phase of the Test Bed Initiative, both DOE and Ecology may be limited in the extent to which they can explore the viability of alternate treatment and disposal options. Further, DOE may encounter additional delays in making a decision about how it will treat and dispose of supplemental LAW.

DOE Faces Urgency in Selecting a Treatment and Disposal Option for Hanford's Supplemental LAW

Recently missed and quickly approaching cleanup milestones and design and construction deadlines, along with rising costs to maintain aging waste tanks, contribute to the urgency DOE faces to making supplemental LAW treatment and disposal decisions. Specifically, four main factors contribute to this urgency:

- DOE already missed a key TPA deadline related to supplemental LAW treatment. In particular, the TPA currently requires DOE to have decided on a supplemental LAW treatment technology by April 30, 2015, but DOE has not done so. In recent years, DOE and Washington State have disputed this milestone, and Ecology officials said in 2020 that this milestone dispute is part of proposed topics for ongoing mediated negotiations between the state, DOE, and EPA.
- The amount of time for construction and startup of a supplemental LAW treatment facility requires decisions soon to allow completion by planned dates. For example, DOE's current baseline system plan calls for design and construction of supplemental LAW treatment facilities to begin in 2025 and operations to begin in 2034.[79] The 2019 FFRDC report stated that, assuming a typical capital project timeline, there is urgency to make decisions for the supplemental LAW treatment technology in order to meet that schedule for construction and operations.
- In May 2017, we reported that, according to experts, DOE would benefit from treating at least a portion of its supplemental LAW with grout because it would allow DOE to complete waste treatment sooner and with less costly methods, reducing both short-term risks and long-term costs.[80] From fiscal year 2017 through 2019, DOE spent more than $400 million per year to maintain the waste in the tanks.
- We found in January 2021 that DOE may soon run out of tank space.[81] Specifically, in internal project management documents, DOE identified insufficient tank space as the top risk to its cleanup mission. It also estimated there was a 95 percent chance it would run out of double-shell tank space, as it continues moving waste

[79]ORP-11242 rev. 9.

[80]GAO-17-306.

[81]GAO-21-73.

out of aging and leaking single-shell tanks.

Delaying decisions on treatment and disposal could lead to further long-term costs for tank maintenance. In addition, by beginning supplemental LAW treatment sooner, DOE may be able to remove waste from the double-shell tanks sooner, thereby freeing up additional tank space.

Conclusions

In recent years, DOE has taken a number of steps to examine alternative approaches for treating Hanford's tank waste that could save billions of dollars. Other entities—including an FFRDC and the National Academies—also examined different approaches and determined that grouting certain portions of the tank waste may be cheaper and faster than vitrification. DOE's consideration of alternative disposal options that better reflect the relatively low risks that supplemental LAW poses is impeded by decisions made decades ago that prohibit consideration of treatment approaches that are commonly used for waste with low levels of radioactivity. Legislation that gives DOE specific authority to manage Hanford's supplemental LAW as low-level radioactive waste, where applicable, and transport it outside the state of Washington for disposal could help DOE reduce risks posed by leaking tanks, expedite tank waste treatment, and save billions of dollars. Moreover, legislation that (1) authorizes DOE to classify the wastes corresponding to the second phase of the Test Bed Initiative as something other than HLW and (2) specifies that RCRA's HLW treatment standard does not apply to this volume of waste could help both DOE and Ecology obtain critical information needed to inform decisions about the feasibility of grouting supplemental LAW.

Even if such authority were given, DOE has an incomplete understanding of its options because it has only considered one alternative facility to the IDF at Hanford for disposing of Hanford's supplemental LAW. Because DOE has not followed our framework for risk-informed decision-making, DOE and Washington State are limited in their ability to negotiate treatment and disposal options for portions of Hanford's tank waste. It also may be missing opportunities to reduce risks posed by leaking tanks, expedite tank waste treatment, and save tens of billions of dollars.

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)

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)

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

regulatory and other applicable requirements. We also received technical comments from DOE, which we incorporated as appropriate.

Regarding the first Matter for Congressional Consideration, DOE and Ecology stated that additional clarification from Congress is not required for DOE to classify Hanford's tank waste as non-HLW, whereas EPA did not offer comments specific to the first matter. EPA's comments are reproduced in appendix IV, and Ecology's comments are reproduced in appendix V. In its comments, DOE summarized its existing authorities, including DOE Order 435.1*, Radioactive Waste Management,* and DOE Manual 435.1-1, *Radioactive Waste Management Manual*, which were issued pursuant to DOE's existing authority under the Atomic Energy Act of 1954, as amended. The Order and Manual set forth mechanisms by which DOE may determine that certain reprocessing waste is waste incidental to reprocessing, which is non-HLW that can be classified on the basis of its radiological risk.

We are aware of these authorities and describe them in detail in our report. We are also aware of DOE's history using these authorities for reclassifying tank waste. This history and the possibility of legal and other challenges highlight the need for additional clarification. We made similar recommendations or Matters for Congressional Consideration in 2003, 2009, 2017, and 2021.[82] For example, in June 2003, we recommended that DOE pursue legislative clarification because of a legal challenge that threatened DOE's ability to proceed with its strategy for treating and disposing of radioactive tank waste that had been managed as HLW. The legal challenge could have prevented DOE from proceeding with its plan at its Savannah River Site in South Carolina to treat and dispose of LAW less expensively (i.e., by using grout) than waste with higher concentrations of radioactivity. DOE estimated at that time that pursuing an alternative treatment and disposal strategy—namely, by vitrifying the LAW—at the Savannah River Site would increase waste treatment disposal costs by $55 billion to $60 billion (constant 2003 dollars). Following our recommendation, DOE sought and obtained clarification of its authority from Congress. In October 2004, Congress passed and the President signed into law the National Defense Authorization Act for Fiscal Year 2005, which contained a provision that, among other things, authorizes DOE to determine that certain waste from

[82]GAO-21-73, GAO-17-306, GAO-09-913, and GAO-03-593.

reprocessing in South Carolina (including SRS) is not HLW if it meets certain criteria. DOE used this authorization to follow its planned treatment and disposal strategy at its Savannah River Site of using grout for low-level waste, thus avoiding a cost increase of $55 billion to 60 billion (2003 dollars).[83] However, as discussed above, this provision does not apply to Hanford, thus the risk faced by DOE at the Savannah River Site in 2003 remains a risk for DOE at Hanford today.

Regarding the second Matter for Congressional Consideration, DOE, EPA, and Ecology all stated that the Matter was not needed, but for different reasons. It is these differences that underscore the need for clarity from Congress if the second phase of the Test Bed Initiative is to continue without significant interruption. Central to Ecology's and EPA's position is their assertion that DOE could proceed with grouting this volume of LAW for out-of-state disposal if DOE applies for a variance from the HLW vitrification treatment standard and meets associated requirements. Ecology and EPA state that RCRA contains multiple, viable mechanisms that allow DOE to avoid the HLW vitrification treatment standard for waste planned for use in the second phase of the Test Bed Initiative. As we describe in our report, Ecology told us during the audit that three viable mechanisms exist: a treatability variance, determination of equivalency, and "no migration" petition. However, it is unclear whether these three mechanisms are truly viable. For example, Ecology has stated that they do not view grouting as equivalently protective as vitrification, which is a serious obstacle to one of the three options. In addition, Ecology has raised the concern of orphan waste—that is, a situation where the disposal state rejects the treated waste from entering the state—as a reason why they may object to any solution other than vitrification. In response to Ecology's concerns, we have clarified the Matter to note that any legislation introduced by Congress should not impair any state's authority to determine whether to accept this waste for disposal.

In contrast to Ecology's position that viable mechanisms exist for DOE to try to obtain approval for an alternative to RCRA's HLW vitrification standard, DOE has told us that after it determines the waste can be managed as mixed low-level waste, this waste should be immobilized according to the same requirements of mixed low-level waste. In DOE's view, if the agency were to classify the waste as low-level

[83]Pub. L. No. 108-375, § 3116, 118 Stat. 1811, 2162–64 (2004).

waste, it would result in a new point of generation under RCRA, meaning RCRA's HLW vitrification requirement would no longer apply and DOE would only need to demonstrate compliance with low-level waste standards. DOE officials told us that disagreement over this subject will likely be litigated, which would in turn cause delays in conducting the second phase of the Test Bed Initiative. It is on this area of disagreement among DOE, EPA, and Ecology that our second Matter for Congressional Consideration hinges. Without near-term direction from Congress that the vitrification treatment standard shall not apply to the waste under the second phase of the Test Bed Initiative, both DOE and Ecology may be limited in the extent to which they can explore the feasibility of alternate treatment and disposal options. If DOE is able to move forward with the second phase of the Test Bed Initiative, DOE, EPA, and Ecology may concurrently continue discussions about how to resolve disagreement about how RCRA applies to this situation for any future treatment and disposal decisions.

Ecology expressed concerns about other aspects of our report. Their concerns can be summarized as (1) GAO's process in conducing the audit, (2) the information GAO used, and (3) the future tank waste treatment mission at Hanford.

GAO's process in conducting the audit. Ecology stated that they are troubled by the process in which our report was drafted. They stated that GAO's efforts to seek input from Ecology and EPA on the core questions GAO sought to analyze came far too late in the process. Ecology added that GAO waited until August of this year—more than a year into its efforts—to seek input from regulators on the key aspects of what the GAO was reviewing. They further stated that even when that feedback was finally solicited, it is unclear whether we actually gave serious consideration to what either Ecology or EPA had to say.

We alerted Ecology officials to our audit in November 2020, soon after initiating the work. We then met with officials from Ecology at several points in this review, including in November 2020, March 2021, and August 2021. We discussed our results at a subsequent exit conference with Ecology in September 2021. DOE, EPA, and Ecology were each provided with a statement of facts in advance of the exit conferences. Information provided by all parties was examined and assessed for reliability. Potential findings with legal implications, such

as those related to the two Matters for Congressional Consideration, were examined for months by a team of GAO analysts and attorneys.

Information GAO used. Ecology stated that GAO seems driven towards a pre-determined outcome rather than toward a hard and honest look at existing regulatory options. They added that the draft report touts what it views as significant long-term cost savings to DOE from large-scale grouting and off-site disposal of Hanford tank wastes. Based on prior documentation provided to GAO, Ecology disputes that grouting will result in the significant cost savings DOE claims and that GAO simply repeats those claims in its draft report. Ecology believes that the final GAO report should reflect prior analyses showing that the question of whether grout will save large sums of money at Hanford is far from settled.

First, as stated, our report is focused on analyzing the alternatives DOE assessed for disposing of grouted supplemental LAW. We state that DOE already has information on the costs to vitrify all of the supplemental LAW and dispose of it on site. We note that alternative approaches exist, however, and in recent years we and others have reported on potential cost and schedule savings associated with such approaches for treating Hanford's supplemental LAW. While cost and schedule savings information is available for treating supplemental LAW using grout, less is known about disposal options for grouted supplemental LAW.

Second, the weight of evidence supports grout as a cost-effective treatment approach for LAW. This review stemmed from years of work by reputable scientific organizations showing that vitrifying LAW is not aligned with the risks the waste poses. As both grout and vitrification technologies matured at DOE sites over the last 30 years, new scientific information on the ability of grout and vitrification to immobilize radioactive and hazardous waste at the Hanford Site has also been developed. This new information, combined with the statements of many experts who participated in a meeting convened by the National Academies in 2016, has shed new light on the assumptions about grout performance at Hanford. These assumptions were used in the early 1990s to inform DOE's waste treatment approach for LAW and were reiterated in DOE's 2012 Environmental Impact Statement describing waste treatment options for supplemental LAW. The earlier assumptions about grout performance no longer appear to be accurate. The National Research Council has advised DOE to make risk-informed decisions when selecting waste

treatment approaches and disposal decisions.[84] Incorporating current scientific information on the performance of grout would help DOE ensure that it identifies potential treatment approaches that align the costs of treatment and disposal pathways with the relatively low long-term risk of LAW.

Moreover, according to experts who participated in a meeting convened by the National Academies' in 2016, both vitrification and grout could effectively treat Hanford's LAW and be protective of human health by, for example, limiting the risk of exposure over the long term. Many experts who participated in the meeting asserted that the risk posed to human health and the environment by both vitrified and grouted waste is small at a modern disposal site. A few experts noted that the long-term risks of vitrified and grouted LAW in a modern disposal site are so low that the difference in exposure risk between the two forms might not be measurable. One expert noted that a 2013 DOE report that studied grout formulations found that for the range of parameters studied, all 26 of the grout formulations tested met the land disposal standards for hazardous constituents and met the anticipated waste acceptance criteria for on-site disposal at Hanford. Notably, these experts' views are in the context of disposing of grouted supplemental LAW at Hanford, whereas the Matters for Congressional Consideration in our current review are for out-of-state disposal—an outcome that would avoid disposing of grouted or vitrified supplemental LAW on-site. In addition, the 2019 FFRDC report found that grouted tank waste, when properly pretreated, would likely meet technical and waste acceptance requirements.[85]

Third, the information Ecology provided to us on the costs of grouting is in conflict with recent studies that have found that the costs of grouting supplemental LAW could be tens of billions of dollars less expensive than vitrifying it. As we state in this report, several organizations have reported on the cost effectiveness of grout when compared to vitrification. For example, the FFRDC team found that DOE's current approach of vitrifying the Hanford supplemental LAW would take 10 to 15 years to implement and cost $20 billion to $36

[84]Committee on Risk-Based Approaches for Disposition of Transuranic and High-Level Radioactive Waste, National Research Council of the National Academies, *Risk and Decisions About Disposition of Transuranic and High-Level Radioactive Waste* (Washington, D.C.: National Academies Press, 2005).

[85]SRNL-RP-2018-00687.

billion, while grouting the supplemental LAW would take 8 to 13 years to implement and cost $2 billion to $8 billion.[86] The National Academies conducted four independent peer reviews of the FFRDC report during the drafting process.[87] In addition, we found in 2017 that the costs of grouting the Savannah River Site's LAW is tens of billions of dollars cheaper than the estimated costs of vitrifying Hanford's supplemental LAW.[88]

Future tank waste treatment mission at Hanford. Ecology stated that GAO inaccurately portrays the urgency of a supplemental LAW treatment decision. Ecology stated that GAO is incorrect that DOE has missed a Tri-Party Agreement deadline related to supplemental LAW. Ecology stated that this deadline has not been missed, pursuant to the Tri-Party Agreement, because it is the subject of an ongoing dispute resolution process and that the need for supplemental treatment needs to be timed with the startup of the Pretreatment System. According to Ecology, that system may not be ready until 2040 or 2050, by which time the Direct Feed LAW approach will have been vitrifying LAW and reducing the volume of waste over a period of 20 to 30 years.

As stated earlier, the weight of evidence supports grout as a treatment approach for immobilizing LAW in a manner that is better aligned than vitrification for the risks the waste poses. With more than $400 billion in estimated costs to clean up the nation's former weapons production sites, DOE must seek ways to address risks nation-wide under a limited budget. Reputable scientific organizations, such as the National Academies, have reported on the disconnect between the treatment approaches for LAW at Hanford and the risks that such

[86]Costs are in 2018 dollars. SRNL-RP-2018-00687.

[87]The William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 requires DOE to commission a further study of alternatives for addressing Hanford's supplemental LAW. Pub. L. No. 116-283, § 3125(a), 134 Stat. 3388, 4381 (2021).This study, to be conducted by an FFRDC and reviewed by the National Academies, began in July 2021 with an initial public meeting.

[88]GAO-17-306.

waste presents.[89] Our report assesses the extent to which DOE has explored options for the portions of the LAW—if eventually grouted—to be disposed of outside the State of Washington. Such treatment and disposal options are far less expensive than vitrifying the tank waste, and disposing of the waste out-of-state can help to reduce the amount of waste disposed of on-site, which is DOE's current plan.

Second, Ecology's statement that treatment approaches for this waste may not be needed until 2040 or 2050 seems at odds with their public statements about the need to address risks posed by leaking tanks. It also seems to create an unnecessary delay in treating supplemental LAW—the current Hanford System Plan called for design and construction of such facilities to begin by 2025. We found in January 2021 that DOE may soon run out of tank space, and DOE's project management documents estimate that there is a 95 percent chance that it will run out of double-shell tank space.[90] By beginning supplemental LAW treatment sooner, DOE may be able to remove waste from the double-shell tanks sooner, thereby freeing up additional tank space. A treatment approach for supplemental LAW that could operate in parallel to the Direct Feed LAW approach could reduce risks posed by leaking tanks faster and cheaper than a delay of several decades. Given the Savannah River Site's experience of saving billions of dollars by grouting its LAW rather than vitrifying it, DOE may have an opportunity to also save costs at Hanford while removing waste sooner from the aging Hanford tanks. As experts asserted in 2017, by taking a hybrid approach to LAW treatment at Hanford, DOE may be able to target different portions of the waste with different treatment methods based on the radioactive and hazardous constituents of the waste, thereby reducing both short-term risks and long-term costs.

[89]Committee on Risk-Based Approaches for Disposition of Transuranic and High-Level Radioactive Waste, National Research Council of the National Academies, *Risk and Decisions About Disposition of Transuranic and High-Level Radioactive Waste* (Washington, D.C.: National Academies Press, 2005). National Research Council of the National Academies, *Improving the Regulation and Management of Low-Activity Radioactive Wastes,* (Washington, D.C.: National Academies Press, 2006). Committee on Waste Forms Technology and Performance, National Research Council of the National Academies, *Waste Forms Technology and Performance: Final Report* (Washington, D.C.: National Academies Press, 2011). Omnibus Risk Review Committee, *A Review of the Use of Risk-Informed Management in the Cleanup Program for Former Defense Nuclear Sites* (August 2015).

[90]GAO-21-73.

Finally, we note that in Ecology's comment letter, Ecology asked GAO to include 10 pages of information on the regulatory environment at Hanford. We fully assessed this and other information Ecology provide to us over the course of our audit, and we include a summary of Ecology's views on the applicability of RCRA in our report. We view Ecology's supplemental information as technical comments, and therefore did not publish it.

We are sending copies of the report to the appropriate congressional committees, the Secretary of Energy, the Administrator of the Environmental Protection Agency, and other interested parties. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or andersonn@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made significant contributions to this report are listed in appendix VI.

Nathan J. Anderson
Director, Natural Resources and Environment

List of Addressees

The Honorable Jack Reed
Chairman
The Honorable James M. Inhofe
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Dianne Feinstein
Chair
The Honorable John Kennedy
Ranking Member
Subcommittee on Energy and Water Development
Committee on Appropriations
United States Senate

The Honorable Frank Pallone, Jr.
Chairman
The Honorable Cathy McMorris Rodgers
Republican Leader
Committee on Energy and Commerce
House of Representatives

The Honorable Diana DeGette
Chair
Subcommittee on Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

The Honorable Patty Murray
United States Senate

The Honorable Dan Newhouse
House of Representatives

Appendix I: Objectives, Scope, and Methodology

The objectives of our review were to examine (1) potential facilities for the disposal of grouted supplemental low-activity waste (LAW) from the Hanford Site and the regulatory and technical challenges the Department of Energy (DOE) faces at each facility; (2) the costs and environmental risks associated with disposal of grouted supplemental LAW at selected facilities; and (3) the challenges DOE faces in selecting a disposal option for Hanford's supplemental LAW.

We selected facilities for inclusion in this review that were identified as potential disposal facilities for grouted supplemental LAW by a Federally Funded Research and Development Center (FFRDC) or the National Academies of Sciences, Engineering, and Medicine (National Academies).[1] We focused on four potential disposal facilities: the Hanford Integrated Disposal Facility (IDF) in Washington State, Nevada National Security Site (NNSS) in Nevada, Waste Control Specialists (WCS) in Texas, and the EnergySolutions Clive (Clive) facility in Utah. Regarding our selection of these facilities, we included in our analysis (1) the IDF because the supplemental LAW is located on-site, and in 2017 we reported that, according to experts, grout could safely be disposed of there,[2] (2) the NNSS because it is a DOE facility licensed to accept out-of-state waste, and (3) WCS and Clive because both have contracts with the federal government and permission from their respective state regulators to accept out-of-state waste. We excluded from our analysis disposal facilities that cannot accept the waste for statutory reasons. For example, other DOE facilities cannot accept the waste for disposal because they are not permitted to accept out-of-state waste. In addition, we did not include the Waste Isolation Pilot Plant (WIPP) in New Mexico in our analysis

[1]Savannah River National Laboratory, *Report of Analysis of Approaches to Supplemental Treatment of Low-Activity Waste at the Hanford Nuclear Reservation*, SRNL-RP-2018-00687 (Aiken, SC: October 18, 2019); and National Academies of Sciences, Engineering, and Medicine (National Academies), *Final Review of the Study on Supplemental Treatment Approaches of Low-Activity Waste at the Hanford Nuclear Reservation: Review #4* (Washington, D.C.: The National Academies Press, 2020).

[2]GAO, *Nuclear Waste: Opportunities Exist to Reduce Risks and Costs by Evaluating Different Waste Treatment Approaches at Hanford*, GAO-17-306 (Washington, D.C.: May 3, 2017).

because, as we recently reported, WIPP faces statutory and physical space limitations.[3]

To inform and provide context to all three objectives, we gathered and reviewed DOE technical reports on Hanford's waste, as well as internal and external reports from DOE and the commercial facilities on the selected disposal facilities' regulatory status, construction, geology, climate, waste acceptance criteria, and disposal cost estimates. We reviewed key documents, including the 2019 FFRDC report, the National Academies peer reviews of the FFRDC report, Hanford System Plan 9, the 2019 DOE revision of its high-level waste (HLW) interpretation, and legal information including the Tri-Party Agreement (TPA) and Consent Decree.[4] We also reviewed our prior work, including GAO-17-306 and GAO-09-913.[5] For consistency in describing the volumes of waste and the capacities of the disposal facilities, we use gallons as the unit of measurement for liquid waste and cubic feet as the unit of measurement for solid waste, unless otherwise noted.

To examine potential facilities for the disposal of grouted supplemental LAW from the Hanford Site and the regulatory and technical challenges DOE faces at each facility, we reviewed documents including DOE technical reports related to federal disposal facilities, external reports from commercial disposal facilities, and information on the disposal facilities' histories and waste disposal schedules. In addition, we interviewed officials from DOE's Office of Environmental Management at DOE headquarters, as well as DOE officials at the two selected federal disposal facilities and representatives from the WCS and Clive disposal facilities regarding the regulatory and technical challenges at each facility. We also

[3]GAO, *Nuclear Waste Disposal: Better Planning Needed to Avoid Potential Disruptions at Waste Isolation Pilot Plant*, GAO-21-48 (Washington, D.C.: Nov. 19, 2020).

[4]SRNL-RP-2018-00687; National Academies, *Final Review of the Study on Supplemental Treatment Approaches of Low-Activity Waste at the Hanford Nuclear Reservation: Review #4*; Department of Energy, *River Protection Project System Plan*, ORP-11242 rev. 9 (Richland, WA: November 2020); and Department of Energy, *High-Level Radioactive Waste Interpretation Limited Change to DOE Manual 435.1–1, Radioactive Waste Management Manual and Administrative Change to DOE Order 435.1, Radioactive Waste Management*, 86 Fed. Reg. 5173 (Jan. 19, 2021).

[5]GAO-17-306 and GAO, *Nuclear Waste: Uncertainties and Questions about Costs and Risks Persist with DOE's Tank Waste Cleanup Strategy at Hanford*, GAO-09-913 (Washington, D.C.: Sept. 30, 2009).

interviewed officials from the Washington State Department of Ecology (Ecology), the Utah Department of Environmental Quality, the Nevada Division of Environmental Protection, and the Texas Commission on Environmental Quality, which are the state agencies that help regulate the selected disposal facilities.

To examine the costs associated with the disposal of grouted supplemental LAW at selected facilities, we analyzed DOE documents—including the 2019 FFRDC report—to identify the key steps of the disposal process: packaging, transportation, and permanent disposal. In addition to these steps, we also determined that pretreatment was a key step that may also contribute to the costs of disposal because it affects waste acceptance. For the two federal disposal facilities, we gathered and reviewed DOE technical reports and available reports on the disposal facilities' criteria and cost estimates—such as Hanford System Plan 9, the 2019 FFRDC report, and the NNSS 2021 Waste Allocation Cost Tables—and we interviewed agency officials about the costs of each step in the disposal process. For the two commercial disposal facilities, we reviewed documentation that each disposal facility provided—such as commercial facility contracts with DOE and other entities that ship comparable waste types—and interviewed representatives from both disposal facilities about the costs of each step in the disposal process. We examined disposal options only for grouted supplemental LAW since much is already known about the costs of disposal for vitrified supplemental LAW.

Below is a summary of the sources of information we used to estimate the costs of each step in the disposal process.

- **Pretreatment.** Pretreatment of waste to remove radionuclides is a key cost associated with waste acceptance. To estimate the costs of pretreatment at two facilities, the IDF and WCS, we used pretreatment cost estimates included in the FFRDC's 2019 report. Representatives from EnergySolutions provided us with an estimate of the cost per gallon to pretreat supplemental LAW to meet Class A disposal requirements, which would be necessary for disposal at the Clive facility under its current disposal license. However, they were not able to provide an estimate for labor costs for pretreatment. To estimate these labor costs with a conservative proxy, we used the highest estimate of labor costs for pretreatment included in the FFRDC's 2019 report. NNSS officials could not provide us with an estimate of the costs to

pretreat the supplemental LAW to meet NNSS's waste acceptance criteria, so we used the highest available Class C pretreatment cost estimate included in the FFRDC's 2019 report (specifically, their estimate for WCS) as a conservative proxy.[6]

- **Packaging and transportation**. To estimate the packaging costs for disposal at the IDF, we used the estimates in the FFRDC's 2019 report. To estimate the costs of transportation across the Hanford Site from the treatment facility to the IDF, we used estimates that DOE officials provided. For packaging and transportation for disposal at WCS, we used the estimate included in the 2019 FFRDC report. NNSS officials provided us with the actual costs of packaging and transportation from a commercial facility for a comparable shipment of waste to use as a proxy for packaging and transportation costs for their facility. EnergySolutions representatives could not provide us with packaging cost estimates for disposal at the Clive facility, but stated that the packaging estimate that the FFRDC used was comparable for their facility, so we used that as a proxy. EnergySolutions representatives also could not provide us with a transportation estimate for the Clive facility but stated that they could accept rail shipments, so we used the rail estimate that the FFRDC created for WCS as a proxy, scaled for the difference in distance between the facilities. We also included the estimated costs of repairs to Hanford's rail and road infrastructure that would be necessary for shipping waste by rail or truck to any of the four facilities, as DOE officials reported.
- **Permanent disposal.** To estimate permanent disposal costs at the IDF, we analyzed cost information included in the Hanford System Plan 9 and estimates that DOE officials provided. NNSS officials provided us with a cost per cubic foot estimate for the disposal costs at their facility. Because DOE officials told us that NNSS does not have sufficient space to dispose of all of Hanford's supplemental LAW, we added the estimated cost of expanding the NNSS facility. For this estimate, we used a proxy of the average cost to expand other disposal facilities, as reported in our prior work.[7] We also added the estimated cost of NNSS's waste certification process. DOE officials were not able to provide us

[6]Class C waste contains radionuclides that require hundreds of years to decay to safe levels.

[7]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).

with this estimate, so we used the estimated costs of the waste certification process at WIPP—which, according to WIPP and NNSS officials, uses a more rigorous waste certification process—as a proxy for the potential waste certification costs at NNSS. To estimate the cost of permanent disposal at Clive and WCS, we used the indefinite delivery/indefinite quantity contract costs for 2020 for mixed low-level radioactive waste.[8] Representatives from EnergySolutions and WCS stated that these are the best available cost estimates for their facilities.

To the extent possible, we took steps to corroborate estimated costs with available disposal facility documents, DOE reports, DOE officials, and commercial facility representatives, but the estimates we present are based only on available information and rough estimates that DOE and commercial facilities provided. Because precise information on the costs of disposal are unavailable, we used the best available information to provide a rough, order-of-magnitude estimate. We adjusted budget numbers for inflation and reported all figures in 2020 dollars, unless otherwise noted. If we found a range of estimated costs, we selected the high end of the range to include in our report to produce a more conservative estimate.

Because some of DOE's estimated costs were approximations or proxies from other sources, we conducted a sensitivity analysis by examining the estimated cost differences between the facilities under different scenarios. This helped us assess how, if at all, imprecise information could affect the results of this comparison. For example, we assessed how disposal costs would change if pretreatment costs were 50 percent greater than our estimates. In this scenario, DOE's estimated costs to grout the waste would increase, but the estimated costs of treating and disposing of supplemental LAW with grout would still be billions of dollars less than vitrification. We believe that the information presented in our report provides an approximate order-of-magnitude comparison and is sufficiently reliable to suggest that the costs of each disposal option for grouted supplemental LAW likely will cost billions less than DOE's current baseline approach to vitrify supplemental LAW and dispose of it at the IDF.

[8]Indefinite delivery/indefinite quantity contracts are used when the exact quantities and timing for products or services are not known at the time of award.

To describe the environmental risks associated with the disposal of grouted supplemental LAW at selected facilities, we reviewed DOE documentation to determine the risks associated with each step of the disposal process. We gathered and reviewed information on the characteristics of selected disposal facilities, including the waste acceptance criteria for each facility and DOE technical reports and internal and external reports. We also evaluated information on transportation risks, such as the National Academies 2006 report on transportation of spent nuclear fuel and HLW.[9] We interviewed DOE officials at the two selected federal disposal facilities and representatives from the WCS and EnergySolutions disposal facilities on the risks at each facility. We analyzed information collected to identify categories of risk for the stages of the disposal process (transportation, acceptance, and disposal) and to describe these categories of risks for each of the selected facilities.

To examine the extent to which DOE has assessed costs and risks with leading practices for risk-informed decision-making, we gathered and reviewed information on DOE's analysis of options for disposal of Hanford's waste, including the Test Bed Initiative and the 2019 FFRDC report. We also interviewed officials from DOE and Ecology to better understand DOE's decision-making process. We evaluated the extent to which DOE has taken a risk-informed approach to decision-making, in line with our risk-informed decision-making framework and DOE's analysis of alternatives guidance, which informs the decision-making process.[10]

To examine the challenges DOE faces in selecting a disposal option for Hanford's supplemental LAW, we gathered and reviewed information on DOE's time line for disposing of Hanford's supplemental LAW and the legal and regulatory challenges DOE faces in doing so. We also reviewed applicable legal and regulatory requirements and guidance documents governing the cleanup of hazardous and radioactive wastes, including the Atomic Energy Act of 1954, the Nuclear Waste Policy Act, the Resource Conservation and

[9]National Research Council, *Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States* (Washington, D.C.: The National Academies Press, 2006).

[10]GAO, *Environmental Liabilities: DOE Would Benefit from Incorporating Risk-Informed Decision-Making into Its Cleanup Policy*, GAO-19-339 (Washington, D.C.: Sept. 18, 2019); and Department of Energy, *Analysis of Alternatives Guide*, DOE G 413.3-22 (Washington, D.C.: June 6, 2018).

Recovery Act, DOE Order 435.1, DOE's HLW interpretation, Section 3116 of the National Defense Authorization Act for Fiscal Ronald W. Reagan Year 2005, and the TPA and Consent Decree. We also interviewed officials from DOE and the Ecology regarding their views on the challenges that DOE faces in selecting a disposal option for Hanford's supplemental LAW.

We conducted this performance audit from July 2020 to December 2021 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: High-Level Waste (HLW) Classification

The Department of Energy (DOE) has three processes for classifying and managing the waste as something other than high-level waste (HLW):

- **Waste incidental to reprocessing evaluation process under DOE Manual 435.1-1.** DOE Manual 435.1-1 provides that DOE can manage tank wastes as waste incidental to reprocessing if, among other things, the wastes (1) have been processed to remove radionuclides to the maximum extent practicable, (2) will be managed in a manner comparable to the performance objectives established in Nuclear Regulatory Commission (NRC) regulations for nuclear 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. However, we previously reported that DOE could be open to legal challenges if it attempts to use Manual 435.1-1 to manage Hanford's tank waste as low-level radioactive waste. For example, we reported in September 2009 that a 2002 lawsuit challenged the validity of Order 435.1 and the associated manual.[1] The federal district court held that the relevant provisions of the Order and manual were inconsistent with the Nuclear Waste Policy Act, but 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.[2] While the 2002 litigation was pending, DOE sought legislation clarifying its authority to manage portions of tank waste with low levels of radioactivity as low-level radioactive waste. In response, Congress passed Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 in October 2004. However, the legislation does not apply to Hanford. As we reported in September 2009, this conclusion could leave DOE open to further legal challenges if the department followed its reclassification process at Hanford.
- **Section 3116 of the National Defense Authorization Act for Fiscal Year 2005.** In 2002, while litigation was pending over the DOE's authority to use DOE Manual 435.1-1, DOE sought enactment of legislation clarifying its authority to manage portions

[1]GAO, *Nuclear Waste: Uncertainties and Questions about Costs and Risks Persist with DOE's Tank Waste Cleanup Strategy at Hanford*, GAO-09-913 (Washington, D.C.: Sept. 30, 2009); and GAO, *Nuclear Waste: Challenges to Achieving Potential Savings in DOE's High-Level Waste Cleanup Program*, GAO-03-593 (Washington, D.C.: June 17, 2003).

[2]Nat. Res. Def. Council v. Abraham, 271 F.Supp.2d 1260 (D. Idaho 2003), vacated as unripe 388 F.3d 701 (9th Cir. 2004).

of tank waste that have low levels of radioactivity as low-level radioactive waste. In response, in October 2004 Congress enacted Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005. Section 3116 authorizes the Secretary of Energy, in consultation with Nuclear Regulatory Commission, to determine that certain waste from reprocessing is not HLW if it meets specified conditions. These conditions include that the waste does not require disposal in a deep geologic repository and has had highly radioactive radionuclides removed to the maximum extent practical. However, Section 3116 only applies to waste stored at DOE facilities in Idaho and South Carolina that is not transported outside of either state.

- **HLW interpretation.** In June 2019, DOE issued a new interpretation of the statutory term "high-level waste." This change, which was formally incorporated into DOE's manual in January 2021, stipulates that DOE may determine waste to be "non-HLW" if the waste meets either of two criteria: (1) it 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) it 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. DOE completed its first application of the revised HLW interpretation in September 2020 by shipping a small quantity of recycled wastewater from the Savannah River Site to an off-site waste disposal facility in Texas. However, the National Defense Authorization Acts for fiscal years 2021 and 2020 prohibit DOE from spending its fiscal year funds on applying this high-level radioactive waste interpretation at Hanford.

Appendix III: Comments from the Department of Energy

Department of Energy
Washington, DC 20585
November 1, 2021

Mr. Nathan Anderson
Director, Natural Resources
and Environment
U.S. Government Accountability Office
Washington, D.C. 20548

Dear Mr. Anderson:

This letter provides the Department of Energy's (DOE) response to the U.S. Government Accountability Office (GAO) draft report, GAO-22-104365, *Nuclear Waste Disposal: Actions Needed to Enable DOE Decision that Could Save Tens of Billions of Dollars.*

DOE concurs with the Recommendation for Executive Action in the draft GAO report. The actions to fulfill the recommendation are already in progress as DOE continues to explore viable disposal options for supplemental low activity waste (LAW). Additional actions taken on the audit recommendation are described in the enclosures to this letter.

DOE emphasizes that it has considered, and continues to consider, all viable disposal options. Evaluation of "all federal and commercial facilities…" is not an efficient use of DOE funds and resources, as some disposal options are not viable for legal, technical, and/or policy reasons, e.g., the Nevada National Security Site (NNSS) is not viable due to permitted mixed low-level waste (MLLW) disposal capacity limitations and policy considerations. The Department's Technical Comments provide further detail on these points, as well as suggested corrections to the assumptions, facts, and statements in the draft report.

DOE does not believe additional clarification from Congress is required to classify Hanford reprocessing waste as non-high-level waste (HLW). To further explain, DOE Order 435.1, *Radioactive Waste Management*, and DOE Manual 435.1-1, *Radioacitve Waste Management Manual*, issued pursuant to DOE's existing authority under the Atomic Energy Act of 1954, as amended (AEA), set forth mechanisms by which DOE has determined, and will continue to determine, that certain reprocessing waste is waste incidental to reprocessing (WIR), which is non-HLW, that can be classified on the basis of its radiological risk. DOE Manual 435.1-1 provides that WIR determinations may be made pursuant to the evaluation method (determination waste meets criteria specified in DOE Manual 435.1-1) or the citation method (determination waste is contaminated job wastes including laboratory items, such as clothing, tools, and equipment). In 2017, DOE used the evaluation method to classify approximately three gallons of Hanford waste as low-level radioactive waste as part of the Test Bed Initiative (TBI) Laboratory Scale-Test. In addition, DOE Manual 435.1-1 provides for the use of DOE's HLW interpretation to classify reprocessing waste on the basis of criteria identified in the

interpretation (see the Supplemental Notice Concerning U.S. Department of Energy Interpretation of High-Level Radioactive Waste, 84 FR 26835 (June 10, 2019)). Although DOE currently is prohibited from applying the HLW interpretation to Hanford waste, the evaluation and citation WIR methods continue to apply to Hanford waste.

The draft GAO report also stated that Congress should consider (i) authorizing DOE to classify the volumes of waste corresponding to the TBI Demonstration for out-of-state waste disposal as something other than HLW and (ii) specifying that this waste is exempt from the Resource Conservation and Recovery Act (RCRA) vitrification standard for mixed HLW (HLVIT). As stated above, DOE believes that the authority to classify reprocessing waste as other than HLW already resides with DOE. Regarding the RCRA vitrification standard, it is DOE's position that HLVIT does not apply because, among other things, the production of pre-treated LAW would result from a new point of generation.

DOE continues to take actions to further the tank closure mission at Hanford in the most safe, timely, and cost effective manner possible.

Thank you for the opportunity to provide DOE's perspective on the draft report GAO-22-104365. If you have any questions, please contact me or Mr. John A. Mullis II, Acting Associate Principal Deputy Assistant Secretary for Regulatory and Policy Affairs, at (202) 586-5042.

Sincerely,

William I. White
Acting Assistant Secretary
for Environmental Management

Enclosures

Appendix IV: Comments from the U.S. Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV - 5 2021

DEPUTY ADMINISTRATOR

Mr. Nathan Anderson
Director, Natural Resources and Environment
U.S. Government Accountability Office
Washington, D.C. 20548

Dear Mr. Anderson:

On behalf of the U.S. Environmental Protection Agency, I would like to thank you for the opportunity to review and comment on a portion of the U.S. Government Accountability Office's draft report on waste disposal at the Hanford Site titled, *Nuclear Waste Disposal: Actions Needed to Enable DOE Decision that Could Save Tens of Billions of Dollars* (GAO-22-104365). While we have not had an opportunity to review the entire draft report, this letter provides the EPA's response to the portion of the draft report's findings, conclusions and recommendations that was shared with the agency.

The EPA supports the goal of the Test Bed Initiative to explore options for supplemental treatment of low activity waste that are cost-effective and protective of human health and the environment. However, the EPA is concerned with the GAO's recommended Matters for Congressional Consideration, in particular the matter that would create an exemption from a Resource Conservation and Recovery Act Land Disposal Restriction treatment standard. The EPA recommends the GAO instead encourage the Department of Energy to work with the EPA and the Washington State Department of Ecology, or other appropriate authorized state agency using existing statutory, regulatory and administrative tools. This approach would ensure that the Test Bed Initiative will be adequately evaluated, that interested parties will have a meaningful opportunity to participate, and that the Test Bed Initiative waste will be disposed of safely. Because a variance would also include alternate treatment requirements and could include other conditions, it would better ensure the safe disposal of the Test Bed Initiative waste.

The draft report includes two Matters for Congressional Consideration:

1. To enhance the 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 the 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.

2. In support of the Test Bed Initiative, Congress should consider (i) authorizing the 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 this waste is exempt from the RCRA HLW vitrification standard.

With respect to these two interrelated matters, the EPA agrees with the Washington State Department of Ecology that, from both a legal and policy perspective, congressional action is unnecessary with respect to the second matter and offers less assurance both of public engagement and protection of human health and the environment. A regulatory pathway exists under RCRA to support the Test Bed Initiative through a site-specific treatability variance, which would require public notice and a reasonable opportunity for public comment to implement. In addition, when considering a site-specific treatability variance petition, the implementing agency must establish an alternate treatment standard that ensures the statutory requirements of RCRA Section 3004(m) are satisfied at the point of disposal and may establish such other conditions as necessary to ensure that the alternate standard is appropriately applied. The GAO recommendation to create an exemption would not include these important steps in the regulatory process, providing less assurance of proper and safe disposal.

Additionally, in conducting an audit of the DOE, the GAO advocates creating a congressional exemption to RCRA without the same level of analysis of RCRA or the level of involvement from the regulatory agencies charged with implementing it. The EPA is also concerned that the GAO did not examine whether exempting the DOE from the LDR standards at the state regulated RCRA portion of the site would impact the ongoing CERCLA cleanup at Hanford that the EPA oversees, which is governed by the 1989 Tri Party Agreement signed by the DOE, the EPA and the state.

The EPA is committed to a robust and continued partnership with the Department of Energy, the Washington State Department of Ecology, Congress, and the GAO to ensure human health and the environment continue to be protected and prioritized as cleanup at the Hanford Site continues. If you have any questions regarding the contents of this letter or require any more information regarding Hanford or the Test Bed Initiative, you are very welcome to contact Tim Hamlin, director of the EPA's Region 10 Land, Chemicals and Redevelopment Division, at (206) 553-1563 or hamlin.tim@epa.gov.

Sincerely,

Janet G. McCabe

cc: Ms. Laura Watson
Director
Washington Department of Ecology

Appendix V: Comments from the Washington State Department of Ecology

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

October 29th, 2021

Nathan J. Anderson, Director
Natural Resources and Environment
United States Government Accountability Office
441 G Street NW
Washington DC 20548

Re: Government Accountability Office (GAO) "Nuclear Waste Disposal: Actions Needed to Enable DOE Decision that Could Save Tens of Billions of Dollar (GAO-22-104365)"

Dear Director Anderson:

Thank you for the opportunity to provide comment on the Government Accountability Office (GAO) partial draft report on waste disposal options at the Hanford Nuclear Facility (Hanford), *Nuclear Waste Disposal: actions Needed to Enable DOE Decision that Could Save Tens of Billions of Dollars* (GAO-22-104365).[1] In addition to this comment, Washington encloses a detailed analysis of the regulatory environment at Hanford, which should be included as a part of Washington's official comment on the draft report.

Washington has significant concerns about the process in which the draft report was executed, misstatements contained in the report, and the statutory exemptions recommended therein. We urge the GAO in the strongest possible terms to withdraw its recommendation to exempt Test Bed Initiative (TBI) Phase 2 wastes from regulatory requirements. Instead, the GAO should encourage USDOE to work with regulators on the existing regulatory path so that TBI can move forward under established standards that are both achievable and legally defensible.

A. The GAO Should Withdraw Its Recommendation That Congress Exempt TBI Waste

Washington fully supports the Test Bed Initiative pilot project (TBI), and the Department of Ecology has worked extensively with USDOE on each phase of TBI. Indeed, Ecology was ready to issue USDOE a permit for TBI in 2019, and at that time all parties were in agreement that there is a clear path forward for TBI under the existing regulatory environment. Despite this, USDOE withdrew its permit for TBI on the eve of public comment. As EPA has pointed out to you, TBI may have indeed already moved forward had USDOE simply continued on the path the parties previously agreed was appropriate. We therefore find it incomprehensible that the GAO recommends a congressional exemption for TBI rather than recommending USDOE work with regulators on the existing process.

See comment 1

First, creating a loophole in RCRA is not necessary to achieve the goals of TBI Phase 2. As both Ecology and EPA have repeatedly explained to the GAO, TBI can move forward under existing regulatory standards. USDOE has an existing process that allows it to reclassify High Level Waste as Waste Incidental to Reprocessing, thus eliminating the Atomic Energy Act and Nuclear Waste Policy

[1] Neither Ecology nor EPA have been provided a full draft of the report.

Act (AEA/NWPA) requirement that such wastes be disposed of in a deep geologic repository. In fact, USDOE already used this approach in phase one of TBI, and following that same approach in phases two and three of TBI is achievable. While Waste Incidental to Reprocessing determinations are made outside of the RCRA framework and do not extinguish applicable RCRA treatment standards, USDOE has multiple pathways under RCRA—including, but not limited to, seeking a site-specific treatability variance—to comply with applicable standards without vitrifying the waste. This pathway is viable, and the GAO's failure to fully analyze this alternative is puzzling and disappointing.

See comment 2

Second, the GAO's recommendation for a congressional exemption for TBI is particularly troubling because it would remove key safeguards to ensure protection of human health and the environment and shortcut public involvement. The Waste Incidental to Reprocessing process is designed to ensure that USDOE follows rigorous scientific methods in reclassifying wastes and that all of the Low Activity Waste that USDOE seeks to manage as Mixed Low Level Waste actually *is* Mixed Low Level Waste. RCRA also contains significant safeguards. RCRA's site-specific treatability variance requirements are designed to ensure that RCRA's overarching goal of protecting human health and the environment will still be met while providing common-sense flexibility for regulated entities. This process also ensures robust and meaningful opportunities for public input, including from the state(s) where wastes will ultimately be disposed. The GAO recommendations would remove these protections without any assurance that wastes have been appropriately reclassified and disposed of in a safe manner.

See comment 3

Third, the draft report touts what it views as significant long-term cost savings to USDOE from large-scale grouting and off-site disposal of Hanford tank wastes. Based on prior documentation that we provided to the GAO, Washington disputes that grouting will result in the significant cost savings USDOE claims and that the GAO simply repeats in its draft report. At the very least, we believe that the final GAO report should reflect prior analyses showing that the question of whether grout will save large sums of money at Hanford is far from settled.[2]

See comment 4

But, even if assertions of cost savings are accurate, the GAO fails to identify a critical fact: any cost benefits flowing from large-scale TBI implementation would occur *regardless* of whether TBI is pursued through existing regulatory requirements or from a blanket exemption from Congress. In other words, even if grout cost savings are indeed extensive, those savings will come from not vitrifying the waste and not having to deposit that waste in a deep geologic repository. While complying with the law does have some overhead, no significant savings are gained by exempting USDOE from the regulatory process. As a result, the potential for cost savings exists with the regulatory path Ecology and EPA have identified. Both Congress and the public deserve to know that potential savings exist with or without a congressional end-run around environmental protections.

See comment 5

Finally, the GAO's recommendations actually undermine the very process the GAO is attempting to support. One of the primary goals of TBI Phase 2 is for the parties to explore potential regulatory pathways for alternative treatment and off-site disposal of Hanford waste. But exempting TBI Phase 2 from all regulatory requirements obliterates this goal and leaves the parties uncertain as to whether it remains a viable option in the long term. Viewed in this context, it is baffling to us that the GAO would recommend that Congress create a loophole in one of the nation's foundational environmental

[2] As we have pointed out, the 2012 Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391) provides a list of prior studies showing that the cost of vitrification for Hanford Low Activity Waste is not appreciably greater than grout.

statutes over recommending the clear, viable, and protective path that already exists for USDOE to move TBI forward under existing law.

B. Ecology Has Significant Concerns Over the GAO's Process

See comment 6

In addition to our concerns about the substance of the draft GAO report, we are also troubled by the process in which it was drafted. Most critically, the GAO seems driven towards a pre-determined outcome rather than toward a hard and honest look at existing regulatory options. This is highlighted by the fact that the GAO's efforts to seek input from Ecology and EPA on the core questions with which the GAO purportedly sought to analyze came far too late in the process. Indeed, the GAO waited until August of this year—more than a year into its efforts—to seek input from regulators on the key aspects of what the GAO was actually looking into. And, even when that feedback was finally solicited, it is unclear whether the GAO actually gave serious consideration to what either Ecology or EPA had to say. The result is a report that fails to engage on the most important aspect of how to actually accomplish TBI.

See comment 7

The GAO's failure to properly address regulator input also led to a report that is full of errors both large and small, and that Ecology has now repeatedly attempted to get the GAO to correct to no avail. For example, the draft report continues to assert that Ecology believes USDOE cannot classify Hanford wastes as anything other than High Level Waste for off-site disposal. This is false, and only highlights how the GAO either simply failed to read the voluminous materials we provided to it or—even more troubling—fundamentally misunderstands the difference between disposal restrictions and treatment requirements under applicable legal standards. We have, in fact, never denied that the Waste Incidental to Reprocessing determination process under USDOE Manual 435.1-1 can be used to accomplish this goal. Indeed, USDOE is *actively using* this process at Hanford in multiple contexts.[3]

What we have said, time and again, is that the reclassification of High Level Waste to Low Activity Waste managed as Mixed Low Level Waste allows for disposal of re-classified Hanford waste in the near-surface rather than in a deep geologic repository as otherwise mandated by AEA/NWPA requirements. We have repeatedly communicated to GAO, however, that reclassification (via any of the three methods the GAO references) does not impact *treatment* standards under RCRA, which attach at the point of generation and cannot be removed absent a very narrow set of circumstances not applicable to these wastes at this phase of the treatment process.[4] Thus, High Level Waste reclassified to Low Activity Waste and managed as Mixed Low Level Waste can be disposed of in a landfill, but only after meeting the applicable treatment standard of High Level Vitrification. But this is not the end of the analysis. As discussed in detail below, RCRA contains multiple, viable mechanisms that allow USDOE to avoid the High Level Vitrification treatment standard for TBI Phase 2 wastes, including RCRA's treatability variance provisions. Instead of honestly engaging with Ecology and EPA and conducting an analysis of these existing mechanisms, the GAO simply jumps to the conclusion that Congress should create a regulatory loophole for USDOE.

See comment 8

The GAO also inaccurately portrays the urgency of a Supplemental Low Activity Waste treatment decision. The GAO is incorrect that USDOE has missed a Tri-Party Agreement deadline related to Supplemental Low Activity Waste. As we have pointed out, this deadline has not been missed

[3] This includes C-Farm closure, Vitrified Low Activity Waste disposal, and TBI Phase 1.

[4] For a detailed discussion, please see the attached regulatory analysis.

See comment 8

because, pursuant to the Tri-Party Agreement, it is the subject of an ongoing dispute resolution process. The need for supplemental treatment needs to be timed with the startup of the Pretreatment System. That system may not occur until 2040 or 2050. In the meantime, Direct Feed Low Activity Waste will have been vitrifiying Low Activity Waste saltcake and supernate, reducing the volume of waste over a period of 20 to 30 years. Direct Feed High Level Waste will have been operating for 10 to 20 years. Many questions will have to be answered on the actual capacity need for Supplemental Treatment including: How much waste has already been treated? Has glass loading increased reducing the need for additional treatment? Has the capacity of Low Activity Waste Vitrification been increased through enhancements? What are the budget constraints? At the time Supplemental Low Activity Waste is an active issue, critical new information will be available, including: cost estimates based on actual experience; current information on new treatment techniques; current information on waste form durability; and, current information on pretreatment techniques for key constituents. Ecology certainly understands lead-time issues on complex construction projects. But, from a practical and fundamental perspective, it is hard to imagine we know key information *now* on something that should be built so many decades into the future.

These concerns aside, however, the GAO report fails to establish how a congressional loophole for TBI Phase 2 waste furthers a treatment decision for Supplemental Low Activity Waste. As noted, a key goal of TBI Phase 2 was to evaluate the regulatory path forward for re-classification and off-site disposal of non-vitrified Low Activity Waste. The GAO's proposal is a setback in that regard. And, aside from vague references to "third-party lawsuits," the GAO fails explain how continued engagement on the existing regulatory path causes any more delay to an ultimate Supplemental Low Activity Waste decision than securing legislative action from the United States Congress. These and other errors permeate the draft report.

While we appreciate the willingness of the GAO to share a portion of the draft report for our comment, we urge the GAO work with Ecology and EPA to ensure that an accurate and independent appraisal of the regulatory pathway for TBI Phase 2 is addressed. If you have any questions or would like to discuss our comments further, please feel free to contact me or the Nuclear Waste Program Manager, David Bowen, at david.bowen@ecy.wa.gov or (509) 372-7905.

Yours truly,

Laura Watson
Director

GAO Comments

1. Our second Matter for Congressional Consideration, which would support the second phase of the Test Bed Initiative, would not create a loophole in the Resource Conservation and Recovery Act of 1976 (RCRA) and does not address RCRA beyond a narrow application for the second phase of the Test Bed Initiative. While Ecology has stated that the Test Bed Initiative can move forward under existing regulatory standards, there is a fundamental disagreement among the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) about RCRA's application, and DOE officials told us that they believe that this issue of whether RCRA's vitrification standard remains attached to the waste regardless of waste reclassification will be litigated in the courts. DOE, like Ecology, disagrees with our Matter but on a different basis: DOE's position is that the HLW vitrification standard will not apply to this volume of waste assuming DOE is successfully able to classify the waste as something other than high-level waste pursuant to DOE Manual 435.1-1. This disagreement between Ecology and DOE about whether and when the standard applies underscores the need for congressional action—which will allow decision-makers to obtain additional information related to the feasibility of the off-site disposal of grouted supplemental low-activity waste (LAW).

   We do not make any legal determination on how RCRA may apply to the treatment and disposal of Hanford's LAW. The intent of our Matter for Congressional Consideration is to allow the second phase of the Test Bed Initiative Phase to move forward without delay due to litigation or other reasons. Nonetheless, a longer-term, more durable resolution of this dispute will likely be required in the future if grouting waste for off-site disposal is determined to be a viable option.

2. Our Matter for Congressional Consideration to support the Test Bed Initiative is not an attempt to remove safeguards related to the overall supplemental LAW treatment and disposal mission. In response to Ecology's concerns, we have clarified the Matter to note that any legislation introduced by Congress should not impair any state's authority to determine whether to accept this waste for disposal. Moreover, the Matter for Congressional Consideration is narrowly drafted to apply only to the limited volume of waste being treated under the second phase of the Test Bed Initiative and only to address the potential application of RCRA's HLW vitrification standard. We are not suggesting that Congress alter, amend, or otherwise address the potential application of RCRA's HLW vitrification standard for any other volume or category of waste.

3. We and others have found that DOE could realize significant long-term savings by grouting supplemental LAW. For example, in 2017, we found that DOE could save tens of billions of dollars by considering alternate treatment options (grout) for supplemental LAW.[1] Similarly, in 2017, a Federally Funded Research and Development Center team conducted a review—which was peer reviewed by the National Academies of Sciences, Engineering, and Medicine—of options for treating Hanford's supplemental LAW and found that DOE could save billions of dollars by grouting this waste.[2] DOE has also reported—including in an update to Hanford's System Plan and a December 2020 report to Congress—that it could save tens of billions of dollars by grouting supplemental LAW.[3] Finally, in this new report, we found that even with the costs of off-site disposal, DOE could save billions of dollars by grouting supplemental LAW and shipping it off-site for disposal.

4. We agree with Ecology that the Test Bed Initiative itself will not realize long-term savings for DOE. However, as both DOE and Ecology officials agree, the information obtained from conducting the second phase of the Test Bed Initiative will provide decision-makers with information needed to determine whether the off-site disposal of grouted supplemental LAW is a feasible option. As noted above, we and others have found that alternate treatment and disposal options could save DOE tens of billions of dollars over the long-term and have the potential to treat and dispose of waste sooner and reduce short-term risks.

5. The second phase of the Test Bed Initiative has several benefits beyond exploring regulatory pathways, including assessing the supplemental treatment technologies, regulatory agreements in recipient states, and the disposal process itself. If the issue of how RCRA applies to the treatment and disposal of Hanford's LAW is litigated, the second phase of the Test Bed Initiative will likely be delayed, and decision-makers will not have the benefit of additional information from this phase about the feasibility of grouting this waste

[1]GAO, *Nuclear Waste: Opportunities Exist to Reduce Risks and Costs by Evaluating Different Waste Treatment Approaches at Hanford*, GAO-17-306 (Washington, D.C.: May 3, 2017).

[2]Savannah River National Laboratory, *Report of Analysis of Approaches to Supplemental Treatment of Low-Activity Waste at the Hanford Nuclear Reservation*, SRNL-RP-2018-00687 (Aiken, SC: October 18, 2019).

[3]Department of Energy, *River Protection Project System Plan*, ORP-11242 rev. 9 (Richland, WA: November 2020).

for off-site disposal and will not have all relevant information as they work to satisfy the Tri-Party Agreement. By moving forward with the second phase of the Test Bed Initiative, as supported by our Matter for Congressional Consideration, DOE and Ecology may concurrently continue discussions regarding how to resolve disagreement about whether and how RCRA applies to this situation, while simultaneously realizing the benefits of the initiative.

GAO's Response to Ecology's Comments on Our Review Process and Findings

6. In line with our core values, our report presents an objective, independent analysis of issues surrounding Hanford's supplemental LAW and includes both Ecology's and DOE's views. We met with officials from Ecology at several points in this review, including in November 2020, March 2021, August 2021, and September 2021. GAO also regularly meets with Ecology regarding our work pertaining to Hanford.

   We took numerous steps to obtain regulatory input on this topic, including meeting with Ecology on the four occasions noted above and reviewing documentation provided to us. In our August meeting on RCRA issues, we met with Ecology officials for 2 hours and also obtained written information summarizing their views. GAO's mission is not to be a voice for Ecology or any other party, but rather to provide Congress, the heads of executive agencies, and the public with timely, fact-based, nonpartisan information that can be used to improve government and save taxpayer dollars.

7. As noted above, we took numerous steps to obtain regulatory input. Ecology stated that it is not factual that Ecology believes DOE cannot classify Hanford wastes as anything other than HLW for off-site disposal. In June 2021, a senior official from Ecology stated at a public meeting that Ecology is concerned with DOE's HLW interpretation and stated that congressional action is needed to clarify DOE's authority. However because Ecology commented that this does not reflect Ecology's official position on the issue, we struck this statement from our report. We also note that this report section and related Matter for Congressional Consideration expands on a similar

analysis that we have reported on four times since 2003.[4] In particular, DOE has been sued by a party other than Ecology about DOE's authority to apply DOE Manual 435.1-1 to manage its waste as a type other than HLW, and we have made similar recommendations or Matters for Congressional Consideration in these four other reports over the last two decades.

8. We continue to believe that DOE faces urgency in selecting a treatment and disposal option for Hanford's supplemental LAW. Ecology and DOE agreed in the Tri-Party Agreement that DOE would select a supplemental LAW treatment by April 30, 2015—more than 6 years ago. In addition, as we found in 2017, grouting a portion of Hanford's LAW could be used in parallel to vitrification, allowing DOE to complete the treatment mission at Hanford sooner and address the risks associated with leaking tanks sooner. Moreover, we found in January 2021 that DOE may soon run out of tank space, and DOE's project management documents estimate that there is a 95 percent chance that it will run out of double-shell tank space. By beginning supplemental LAW treatment sooner, DOE may be able to remove waste from the double-shell tanks sooner, thereby freeing up additional tank space.

9. Our Matter for Congressional Consideration would not create a loophole in RCRA. The Matter for Congressional Consideration asks Congress to direct that, in a single very narrow circumstance, a relatively small volume of waste corresponding to the second phase of the Test Bed Initiative does not need to be vitrified, notwithstanding the potential applicability of RCRA's HLW vitrification standard. Our report does not make any legal determinations on whether or how RCRA may apply to this situation or any other waste generated across the cleanup complex. The intent of our Matter for Congressional Consideration is to allow the second phase of the Test Bed Initiative to move forward without years of delays that could arise if the issue of how RCRA applies to the treatment and disposal of Hanford's LAW were litigated in the context of the Test Bed Initiative.

   A continuation of the next phase of the Test Bed Initiative would allow decision makers to obtain additional information and data related to

[4]GAO, *Hanford Cleanup: DOE's Efforts to Close Tank Farms Would Benefit from Clearer Legal Authorities and Communication,* GAO-21-73 (Washington, D.C.: Jan. 7, 2021); GAO-17-306; GAO, *Nuclear Waste: Uncertainties and Questions about Costs and Risks Persist with DOE's Tank Waste Cleanup Strategy at Hanford*, GAO-09-913 (Washington, D.C.: Sept. 30, 2009); and GAO, *Nuclear Waste: Challenges to Achieving Potential Savings in DOE's High-Level Waste Cleanup Program*, GAO-03-593 (Washington, D.C.: June 17, 2003).

the feasibility of the off-site disposal of grouted supplemental LAW. Nonetheless, a longer-term, more durable resolution of this dispute will likely be required in the future, if grouting waste for off-site disposal is determined to be a feasible option. Nothing prevents Ecology and DOE from meeting to discuss long-term regulatory options for the disposal of the vast majority of remaining LAW, including off-site disposal of grouted LAW, in parallel with the Test Bed Initiative.

Appendix VI: GAO Contact and Staff Acknowledgments

GAO Contact

Nathan J. Anderson, Director, Natural Resources and Environment, (202) 512-3841 or andersonn@gao.gov

Staff Acknowledgments

In addition to the contact named above, Amanda K. Kolling, Assistant Director; Jeffrey T. Larson, Analyst in Charge; William Gerard; Michael Kendix; Katrina Pekar-Carpenter; and Courtney Tepera made key contributions to this report. Also contributing to this report were Tara Congdon and Sara Sullivan.

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