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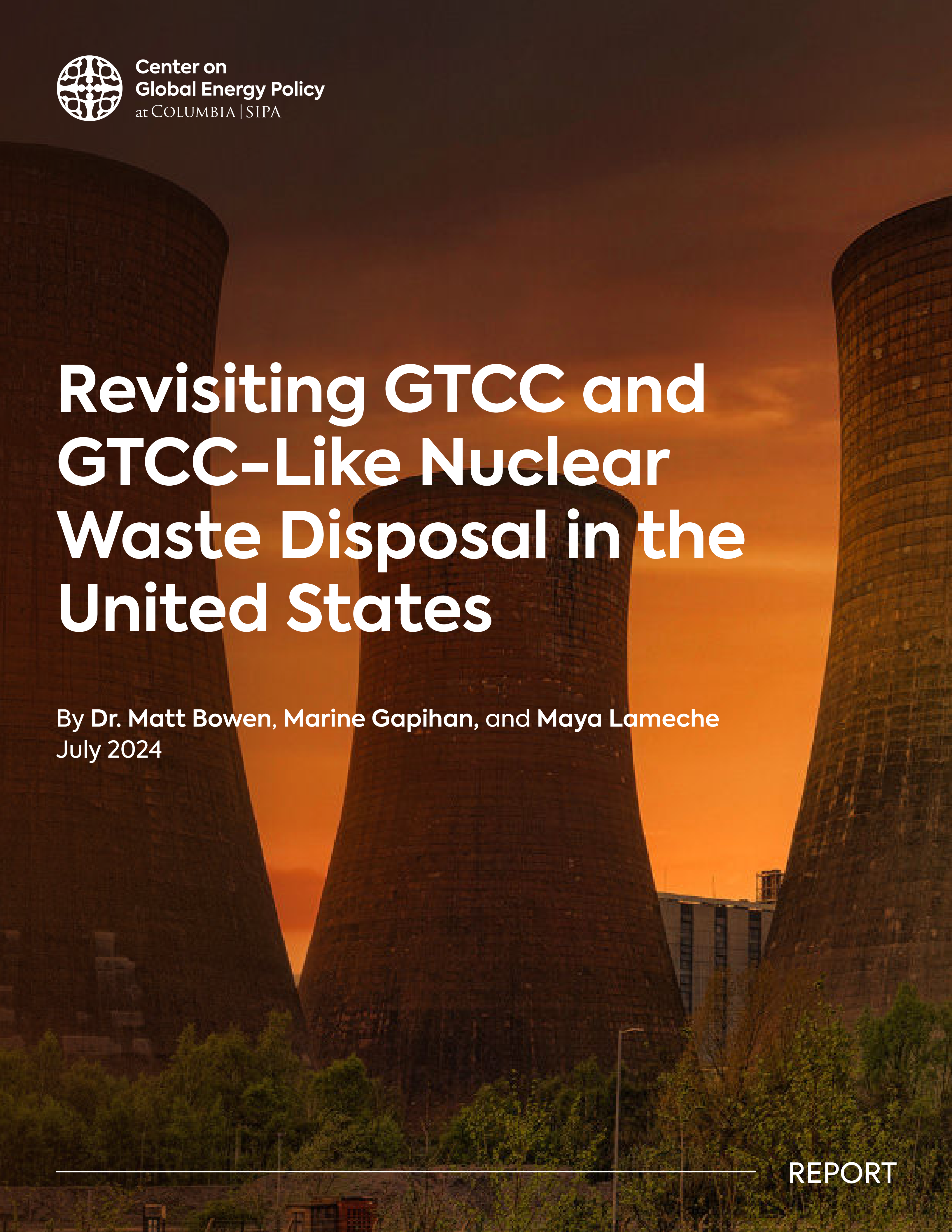

Revisiting GTCC and GTCC-Like Nuclear Waste Disposal in the United States

By **Dr. Matt Bowen**, **Marine Gapihan**, and **Maya Lameche**
July 2024

REPORT

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Executive Summary

While the United States (US) has facilities that can and do dispose of most low-level nuclear waste (LLW), it does not yet have a viable disposal pathway for two categories of waste: so-called greater-than-class-c (GTCC) nuclear waste, and nuclear waste with characteristics similar to it, or "GTCC-like." These two categories essentially straddle the United States' LLW inventory, for which disposal facilities are in operation, and high-level nuclear waste (HLW) inventory, for which no disposal capability exists.

GTCC nuclear waste is produced by multiple sources: commercial nuclear power plants, medical procedures, industrial and research activities, and Department of Energy (DOE) missions, including those related to national security and the cleanup of legacy facilities. These activities carry with them an ethical responsibility to dispose of the nuclear waste they generate rather than pass it on to the next generation. Security task forces have also identified the lack of a disposal pathway for sealed sources of GTCC nuclear waste as a concern, given the potential for its theft and use in a dispersal device.

This report, part of a series of publications on nuclear waste policy at the Center on Global Energy Policy, Columbia University SIPA, explores the history of DOE, Nuclear Regulatory Commission (NRC), and state efforts to develop disposal capabilities for GTCC and GTCC-like inventories. It explains why this gap merits greater attention from policymakers now and identifies measures Congress, the DOE, and the NRC could take, should they decide to address it.

US government efforts to develop disposal capabilities for GTCC waste date back to 1985 when Congress made it a federal responsibility. For a time, disposal in the planned repository at Yucca Mountain, Nevada, was contemplated. But in the absence of appropriations to move that project forward since 2010, the federal government recently issued planning documents that identify generic commercial LLW disposal facilities and the Waste Isolation Pilot Plant (WIPP) deep geologic repository in New Mexico as preferred alternatives. Of the commercial LLW disposal facilities in operation, only the WCS facility in Texas has expressed interest in the GTCC disposal mission. The political climate for GTCC disposal in both New Mexico and Texas has darkened in recent years, though, casting doubt on the federal government's plans.

If the US government decides to prioritize the goal of establishing disposal capability for GTCC and GTCC-like nuclear waste, Congress, the DOE, and the NRC could take the following steps to help realize it in the near term.

- The NRC could finish its Part 61 rulemaking to authorize the near-surface disposal of some GTCC nuclear waste streams. Given the history and value of the Part 61 rulemaking (for GTCC disposal and other purposes), bringing that process to completion would clarify and enable one potential pathway to progress.
- The US secretary of energy's personal involvement in working with any states that may be willing to consider hosting a GTCC disposal facility could in some cases help address a given state's concerns and needs. The secretary has broader authority to negotiate provisions than a single DOE program office, and the GTCC program is indirectly affected by other nuclear waste policy issues.
- For public education purposes, it may be valuable for the DOE to publish a report on the approach and progress made by other countries in dealing with nuclear waste inventories that are similar to US GTCC waste.
- The DOE cannot move forward on GTCC disposal absent congressional action, per the Energy Policy Act of 2005. One action Congress could take is to amend the Low-Level Radioactive Waste Policy Amendments Act of 1985—specifically Section 3(b)—in a way that clearly allows agreement states to license GTCC nuclear waste disposal facilities. This amendment would presumably not encounter opposition, given that agreement states would still have to explicitly consent to move forward with licensing.

Introduction

Fissioning (or splitting) atoms for heat generation or isotope production is a common practice with a diverse array of important applications. Inevitably, these activities produce some amount of nuclear waste. In the United States, commercial nuclear power plants are responsible for most of the country's new nuclear waste, but national defense programs (i.e., nuclear weapons and naval reactors), certain widely used medical procedures, and some industrial activities and research programs generate streams of their own. Thus, all these activities carry with them an ethical responsibility to establish corresponding disposal facilities so that the nuclear waste they produce will not be passed on to future generations for them to deal with.

Most of the nuclear waste produced in the United States is categorized by the Nuclear Regulatory Commission (NRC) as Class A, B, or C low-level waste (LLW), organized in order of increasing radiological concentration. The United States has four operating disposal facilities that collectively can process all three categories. A lesser volume of waste is from spent nuclear fuel (SNF) generated by commercial power reactors and high-level nuclear waste (HLW) principally produced by the US nuclear weapons program, for which the United States lacks a disposal capability. SNF and HLW have been a focus of policymakers in recent decades, but another category of nuclear waste that straddles these two inventories and is often overlooked is so-called greater-than-class-c (GTCC) nuclear waste as well as what is called "GTCC-like" nuclear waste. The former is defined as materials and equipment that are LLW but exceed the radioactive concentration limits set for Class C LLW according to NRC regulations; the latter is DOE-owned or -generated nuclear waste that has characteristics similar to GTCC nuclear waste (a more in-depth description is provided in Chapter 1). The United States currently has no disposal capability for GTCC nuclear waste.

This report focuses on GTCC and GTCC-like nuclear waste in the United States. Based on interviews with experts from the US government, the DOE national laboratories, the nuclear industry, and academia—as well as published documents from Congress, the NRC, and the DOE—this report analyzes the legislative and regulatory history, as well as the current politics surrounding this often-overlooked category of waste. It shows that while the United States works toward an SNF and HLW disposal capability, which will take decades to achieve, there are some reasons it may want to focus on establishing partial, if not full, disposal capability for GTCC nuclear waste in the nearer term.

Chapter 1 explains what GTCC and GTCC-like nuclear waste is and what activities produce it, including energy activities, national security missions, medical and industrial research and operations, and the cleaning up of existing DOE sites. Chapter 2 presents a short history of the DOE, the NRC, and state efforts to develop disposal capabilities for these inventories. Building on this historical background, Chapter 3 explains why GTCC and GTCC-like nuclear waste disposal merits greater attention from US policymakers today. Chapter 4 then reviews the pertinent policy actions that Congress, the DOE, and the NRC could take if they want to address disposal needs for this type of nuclear waste.

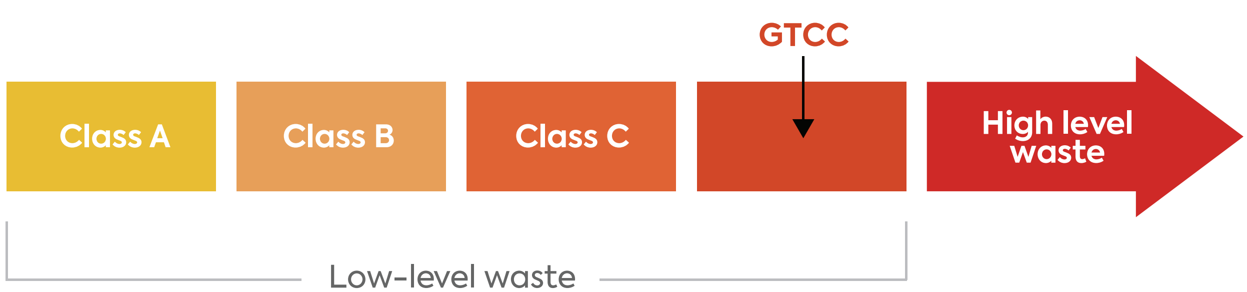
1. What Is GTCC Nuclear Waste?

The US nuclear waste taxonomy derives from a set of statutes and regulations. This chapter introduces them before explaining how a given material or component may be designated as GTCC nuclear waste. It also lists the major sources of GTCC nuclear waste production. Finally, this chapter describes the GTCC nuclear waste inventories at shutdown nuclear power plant sites in comparison with the SNF also being stored at those sites to provide an example of one inventory connected with the operation of commercial reactors.

A. Definition

US statutes divide nuclear waste into various categories. The largest of these is LLW, which includes GTCC waste. Other categories include spent nuclear fuel (SNF), high-level nuclear waste (HLW), and uranium mill tailings.[1] LLW is defined in large part by what it is not. According to the NRC, it is "generally defined as radioactive wastes other than high-level and wastes from uranium recovery operations . . . commonly disposed of in near-surface facilities rather than in a geologic repository."[2] The disposal of LLW is governed by the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985 and the associated NRC regulations, 10 CFR Part 61, which specify land disposal procedures and criteria.

Figure 1: Low-level nuclear waste and high-level nuclear waste from left to right in increasing radiological concentration



Source: Adapted from GAO, "DOE Needs to Improve Transparency in Planning for Disposal of Certain Low-Level Waste," September 29, 2022, p. 6, https://www.gao.gov/assets/gao-22-105636.pdf.

The latter regulations divide LLW into three subcategories: Class A, B, and C, ranked in order of increasing concentration of specific radionuclides. They also define the limits on radionuclide concentrations (typically in curies per cubic meter) for Class C LLW that, if exceeded, would then qualify a waste as GTCC. This waste classification system dictates increased physical and administrative controls for increased hazard levels, and declares that quantities of LLW with radionuclide concentrations in excess of certain values (i.e., GTCC) are not generally acceptable for near-surface disposal and indicate disposal in a geologic repository defined in Part 60 or 63 absent alternatives approved by the Commission. The NRC regulations list two radionuclide tables with Class C limits that, if exceeded, would qualify a waste as GTCC: Table 1 includes a list of some principally long-lived key radionuclides, while Table 2 consists of some shorter-lived key radionuclides (half-lives less than 100 years).[3]

By way of example, metal structures inside the reactor pressure vessel of commercial power reactors may become activated over time (i.e., a nonradioactive isotope may be turned into a radioactive one) by the neutrons produced during power reactor operation. Table 1 from 10 CFR 61.55 shows Class C LLW concentration limits in activated metals; 10 CFR 61.55 also defines concentration limits (in terms of nanocuries per gram) for alpha-emitting transuranic nuclides with half-lives greater than five years (e.g., plutonium-239).

Table 1: Class C low-level nuclear waste concentration limits in activated metals

Radionuclide	Class C Concentration Limit (curies per cubic meter)
Carbon-14	80
Nickel-59	220
Niobium-94	0.2
Nickel-63	7,000

Source: Tables 1 and 2 in 10 CFR Part 61.55.

The C-14 and Ni-63 radionuclides have different Class C concentration limits when they are part of other waste materials (i.e., not activated metals), and 10 CFR 61.55 delineates additional radionuclides beyond those shown in Table 1 and their Class C concentration limits. To take another example, filters and resins are used in the chemical and volume control systems (CVCSs) of pressurized water reactors to remove certain radionuclides from the primary coolant. If a given resin or filter removed from the CVCS after being used has a concentration of the alpha-emitters specified in 10 CFR Part 61.55 exceeding 100 nanocuries per gram, it would be characterized as GTCC.

In terms of actual disposal, four operating sites have been licensed by NRC agreement states to dispose of LLW in near-surface land disposal facilities: the EnergySolutions facility in Clive, Utah (the only one of the four not licensed to receive Class B or Class C); the US Ecology facility in Richland, Washington; the Waste Control Specialists facility in Andrews, Texas; and the EnergySolutions facility in Barnwell, South Carolina. In 2022, these collectively disposed of about 65,700 cubic meters (m^3) of Class A, B, and C nuclear waste—which contained about 154,000 curies of radioactivity.[4]

None of the four sites is licensed to dispose of GTCC and GTCC-like nuclear waste. Although the total volume of these types (1,100 m^3 accumulated according to the DOE in 2016) is substantially smaller compared with Class A, B, and C LLW, its radioactivity is two orders of magnitude more concentrated (i.e., 1,545 curies per m^3 for the 2016 estimate of the total GTCC and GTCC-like inventory versus an averaged concentration for the Class A, B, and C LLW of 2.3 curies per m^3 for the LLW disposed of in 2020).[5]

When estimating both stored and projected GTCC and GTCC-like nuclear waste (including from proposed actions or planned facilities not yet in operation), the DOE scoped about 12,000 m^3 containing 160 million curies (which is an average ~13,000 curies per m^3 concentration), with most not being generated until after 2030 when commercial nuclear reactors are expected to undergo decommissioning.[6] To put these figures in context, in 2014, Sandia National Laboratories assessed that the commercial SNF inventory at the time, when disposed of in dual-purpose canisters, constituted a volume of 90,299 m^3 and a radioactivity of 23,000 million curies (MCi)—or a concentration of 256,000 curies per cubic meter.[7] In terms of concentration, then, GTCC nuclear waste tends to fall between the Class A, B, and C LLW that the United States has been disposing of for decades at various near-surface land disposal sites, and the commercial SNF from commercial nuclear power plants for which there is currently no US disposal capability. There is a larger amount of GTCC projected for when power reactors retire than what is currently stored—though lifetime extensions for the existing fleet would push out the timeline for when that inventory is created.

It should be noted that higher radionuclide concentrations for waste materials does not necessarily mean more challenging disposal at a given facility or greater risk to the surrounding community. In terms of the potential for off-site migration of a given radionuclide over time, the associated analysis depends upon multiple factors, including waste form, waste package, the engineered barriers of the disposal facility, and the natural environmental around it. An individual radionuclide—for example, Ni-63 or Nb-94—in an activated metal may be present in concentrations higher than the Class C limits established in Part 61.55 but turn out to be relatively immobile in the evaluation. In the end, the NRC will still require an LLW site disposing of GTCC to meet the same public health protection standard as a site disposing of Class A, B, and C wastes (the NRC performance objectives are found in Subpart C of Part 61).

B. Sources of production

GTCC nuclear waste can come from nuclear utilities, hospitals, universities, and industries including oil and gas, pharmaceuticals, and radiography. Table 2 shows amounts of GTCC currently in storage and projected through 2083 for currently operating production sources of LLW, including commercial nuclear power (the largest by activity [curies]), national defense programs, sealed sources for medical use, industrial activities, and research programs. The table also shows "GTCC-like waste," which, according to the DOE, is radioactive waste owned or generated by the DOE (including LLW and nondefense-generated transuranic waste [TRU][8]) that has no identified path to disposal and characteristics similar to those of GTCC waste, suggesting that a common disposal approach may be appropriate.[9] The term *GTCC-like* itself is not defined by US law or regulation, however. The DOE's definition of *GTCC-like* also includes recovered sealed sources that the DOE has taken title to from NRC and agreement states licensees.[10]

Table 2: Stored and projected amounts of GTCC nuclear waste from currently operating facilities

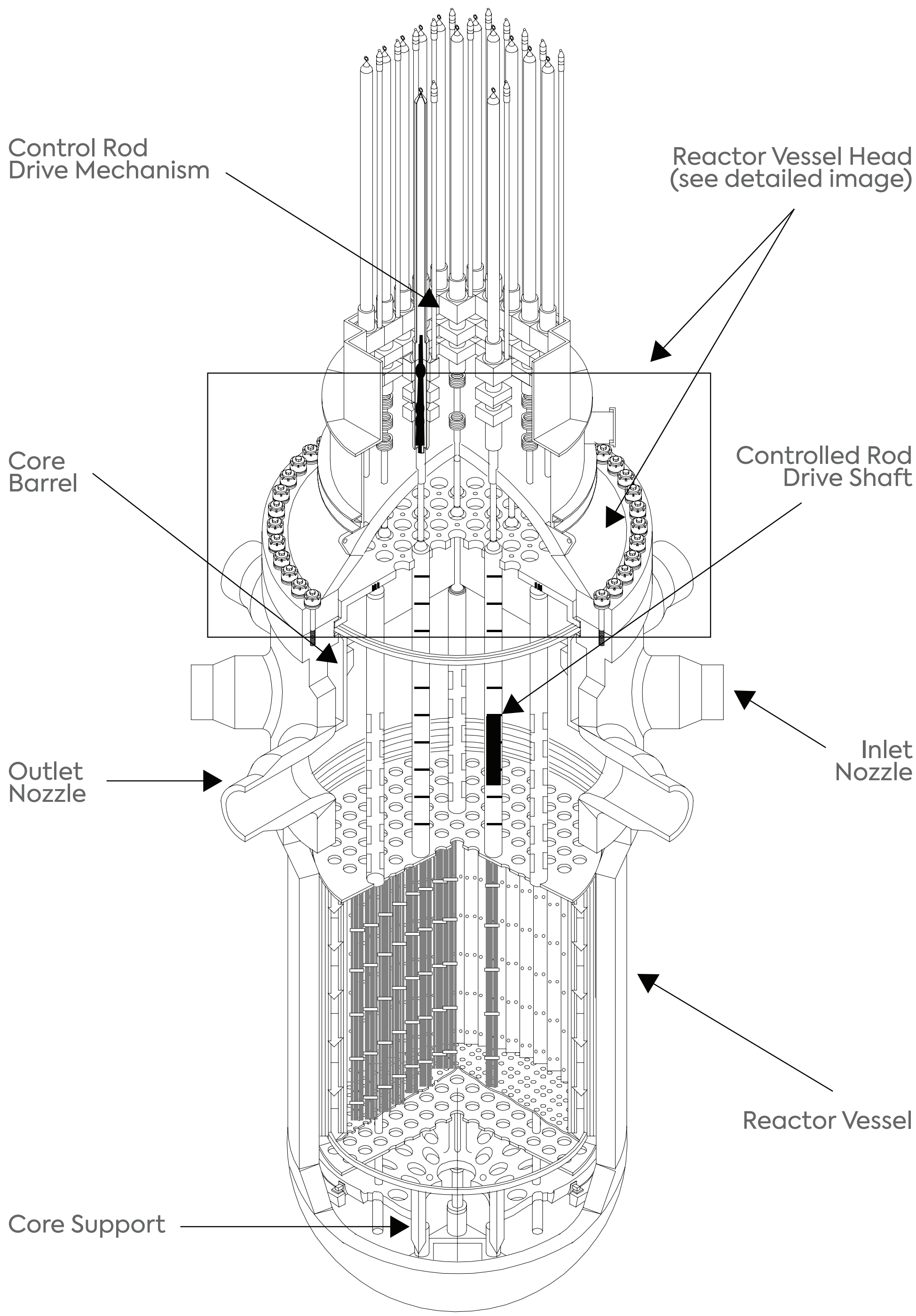
Waste Type	In Storage		Projected (to 2083)	
	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Private GTCC LLW				
Activated metals (BWRs)	7.1	0.22	200	30
Activated metals (PWRs)	51	1.1	620	76
Sealed sources (small)	—	—	1,800	0.28
Sealed sources (Cs-137 irradiators)	—	—	1,000	1.7
Other waste	75	0.0042	1.0	0.00013
DOE GTCC-like waste				
Activated metals	6.2	0.23	6.6	0.0049
Sealed sources	0.21	0.0000060	0.62	0.000071
Other waste	950	0.11	510	0.18

Note: Contact-handled and remote-handled "other waste" numbers are added (combined) together in this table.

Source: DOE 2016.

Each source of GTCC and GTCC-like nuclear waste is described in greater detail below.

Figure 2: A typical pressurized water reactor



Source: NRC website, https://www.nrc.gov/reactors/operating/ops-experience/vessel-head-degradation/vessel-head-degradation-files/pwr-rx-vessel.html.

Commercial nuclear power plants

Inside a commercial nuclear power plant (e.g., a pressurized water reactor like that depicted in Figure 1), GTCC waste may be produced in several places. Inside the reactor pressure vessel, the structures near the fuel assemblies are exposed to many neutrons over the operational lifetime of the reactor. For example, by the time of decommissioning, metal structures with niobium or nickel will contain longer-lived radioisotopes such as nickel-59 and niobium-94 due to neutron irradiation. The concentrations of these radioisotopes may exceed the limits in Table 1 of 10 CFR Part 61.55 for Class C nuclear waste. Metal structures will also contain trace amounts of nitrogen, and neutron irradiation will lead to the production of carbon-14, with the same possible implications.

Separate from the reactor internals, GTCC nuclear waste can be produced in the CVCS that extracts radioisotopes from the water coolant. The continuous cleaning of the primary coolant results in filters and resins that absorb radioisotopes (e.g., Co-60, Ni-63). This could lead to concentrations exceeding the limits specified in Tables 1 and 2 in 10 CFR Part 61.55, and thus a GTCC classification.

DOE missions, including national security and cleanup

Nuclear wastes that have radiological concentrations exceeding the defined limits for Class C nuclear waste in 10 CFR 61.55 are also generated within the US national security complex. For example, the US nuclear weapons program has generated an inventory contaminated with TRU elements, including equipment and clothes, at various DOE sites that work with nuclear materials. This particular stream of defense-generated TRU waste does have a disposal pathway at the deep geologic repository facility near Carlsbad, New Mexico: the Waste Isolation Pilot Plant (WIPP). WIPP began operations in 1999 and has since received over 13,000 shipments from DOE sites around the United States.[11] During the facility's development, Congress passed legislation (i.e., the Waste Isolation Pilot Plant Land Withdrawal Act) that limited disposal at the site to TRU waste from atomic energy defense activities.

The DOE has noted that some GTCC-like waste may come from the production of radioisotope power systems "in support of space exploration (e.g., from the plutonium 238 production project) and national security."[12] In addition, the cleanup of DOE sites with contaminated debris from building, piping, and/or equipment—such as the West Valley Demonstration Project site in New York—would lead to GTCC-like nuclear waste in need of disposal.

While outside the scope of this report, the US navy also generates a stream of nuclear waste, separate from the spent nuclear fuel from its reactors, that includes activated metal products produced by the irradiation of structures surrounding naval nuclear reactor cores on submarines and aircraft carriers. In that sense, the waste stream is similar to the activated metals in the GTCC inventory generated by reactor cores in commercial nuclear power plants. Activated structures from naval ships have been disposed of at Trench 94 at the Hanford site in Washington,[13] and they contain some of the same radionuclides as activated metals in the commercial GTCC inventory, such as Cobalt-60, Niobium-94, and Nickel-63.[14]

Medical procedures

Doctors use radioactive materials to diagnose or treat about one-third of all patients admitted to hospitals.[15] Eighty percent of all diagnostic medical scans worldwide rely on the availability of the radioisotope molybdenum-99 and its daughter product, technetium-99m. Sealed sources are regularly used to diagnose and treat illnesses (especially cancer), sterilize medical devices, irradiate blood for transplant patients, and more. GTCC nuclear waste can be generated by facilities and licensees involved in manufacturing radiopharmaceuticals (drugs that contain a radioactive substance and are used to diagnose or treat disease) and other products with medical applications.

Cancer can be treated using radiation therapy, which delivers an accurate radiation dose to a target site. For example, one category of radiation therapy called brachytherapy uses radioactive material that is sealed inside capsules. As Table 2 indicates, some of the sealed sources used in medical procedures exceed concentration limits in NRC regulations and are thus classified as GTCC nuclear waste at the end of their useful lifetimes.

Industrial and research activities

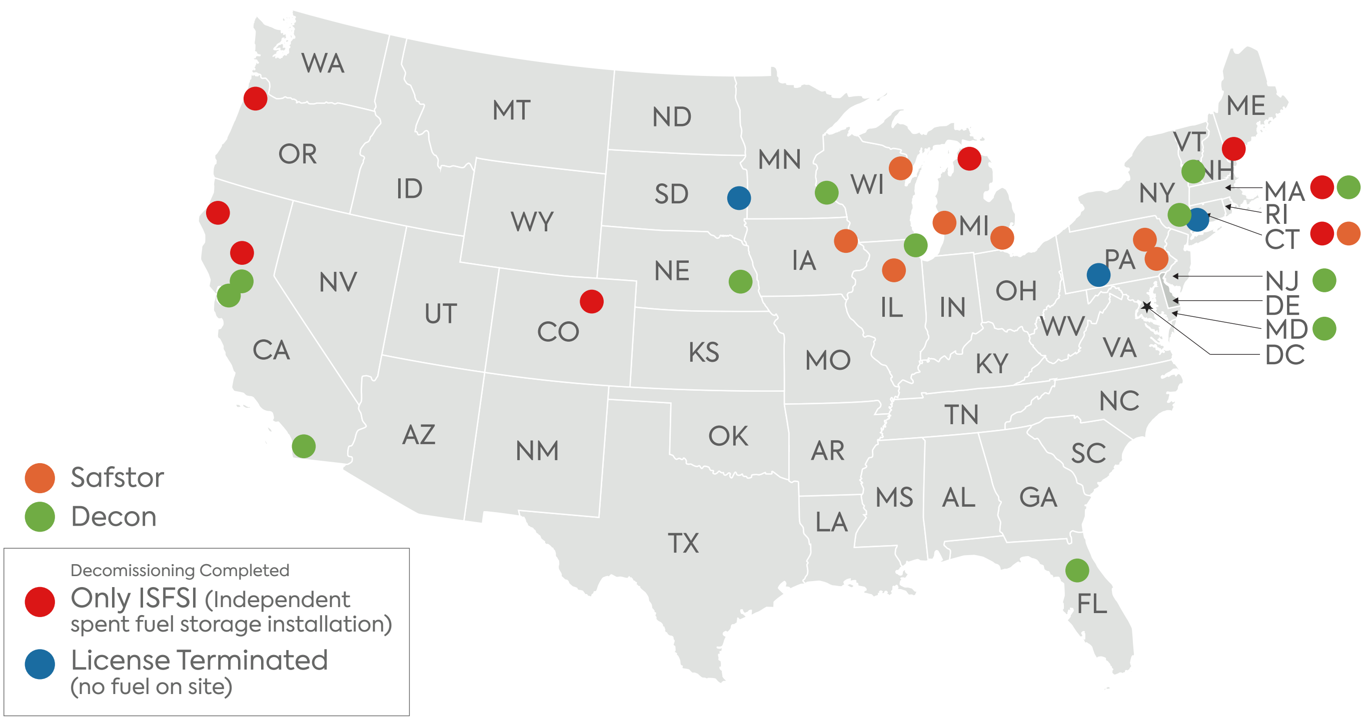
Various industries use radioisotopes to improve productivity and, in some cases, gain information that cannot otherwise be obtained. Sealed sources may be used in density and moisture gauges, well-logging equipment for oil and gas exploration, radiography devices (e.g., to check the integrity of pipe welds), and more.[16] GTCC nuclear waste can result from the use of sealed sources in many sectors: from the manufacturing industry to determine the content of moisture in products to coastal engineering to determine sediment levels in rivers and estuaries. To offer another example, Americium-241 is a transuranic isotope that is mixed with beryllium to create neutron sources that are used to search for oil and gas deposits underground. In the agricultural sector, the US Food and Drug Administration has approved the use of irradiation to eliminate harmful germs and insects from food. The NRC and agreement states license around 50 commercial irradiators in which up to 10 million curies of radioactive material can be used.[17]

Research facilities in the United States also generate nuclear waste. The NRC currently regulates 30 research and test reactors located primarily at universities.[18] These relatively small (typically under 100 MW) reactors serve primarily as sources of neutrons.[19] Researchers use the produced radiation to study, for example, material characteristics that are otherwise challenging to measure.

C. Selected example: GTCC nuclear waste at shutdown nuclear power plant sites

As Table 2 indicates, in terms of curies, the largest source of projected future GTCC nuclear waste comes from nuclear reactors reaching the end of their operating lifetimes. This inventory is generated by the reactor decommissioning process (e.g., from the segmentation of reactor vessel internals) and resides at shutdown nuclear power reactors that have ceased operations. Figure 3 depicts the locations of these reactors across the United States. The plants at these sites are either decommissioned—in which case, either there is still an independent spent fuel storage installation (ISFSI) remaining or the license was terminated and no fuel remains—or they are in the process of being decommissioned.

Figure 3: Shutdown power reactor sites and decommissioning status



Note: Red circles are "Only ISFSI"; blue circles represent licenses that have been terminated (i.e., there is no fuel on-site).

Source: US NRC (as of February 2023); https://www.nrc.gov/reading-rm/doc-collections/maps/decommissioning-sites.html.

After the power reactors are shut down, the components of the plants can themselves be decommissioned, and any resulting LLW will require disposal. As with commercial SNF, however, there is no consolidated interim storage site or disposal facility where GTCC nuclear waste can be shipped, so it remains on-site with the SNF. Table 3 shows examples of shutdown sites that have storage casks containing SNF and, in all but two cases, storage casks containing GTCC nuclear waste.

Table 3: Examples of shutdown plant sites with SNF and GTCC casks

Name	Location	SNF casks	GTCC casks
Humboldt Bay	Eureka, CA	5	1
LaCrosse	Genoa, WI	5	0
Zion	Zion, IL	61	4
Maine Yankee	Wiscasset, ME	60	4
Yankee Rowe	Rowe, MA	15	1
Connecticut Yankee	Haddam Neck, CT	40	3
Big Rock Point	Charlevoix, MI	7	1
Rancho Seco	Herald, CA	21	1
Trojan	Columbia County, OR	34	0

Source: Table 2-7 of Shan Peters, Joe T. Carter, Kaushik Banerjee, "Spent Nuclear Fuel and Reprocessing Waste Inventory: Spent Fuel and Waste Disposition," November 2022. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-33938.pdf.

2. The History of Federal Planning for GTCC Disposal

The Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985 made disposal of GTCC nuclear waste a federal responsibility. This chapter presents a short history of DOE planning efforts for GTCC and GTCC-like nuclear waste disposal and the development of NRC regulations applicable to GTCC disposal. Then, it analyzes the current state of play regarding US efforts to establish disposal capability.

A. The Low-Level Radioactive Waste Policy Act of 1980 and 10 CFR Part 61

Passed by Congress in 1980, the Low-Level Radioactive Waste Policy Act (LLRWPA) placed responsibility for the disposal of commercial LLW with the states. The new legislation encouraged states to form "compacts" that would allow them to dispose of LLW at a common disposal site. (As of 2023, most states belonged to one of the ten compacts that have been created since 1980, though some are unaffiliated.[20]) The LLRWPA defined LLW as any waste that is not high-level nuclear waste, TRU waste, SNF, or by-product material, as defined in Section 11e.(2) of the Atomic Energy Act (tailings or wastes produced by the extraction of uranium or thorium).

In 1982, the NRC promulgated its first comprehensive regulations for disposal of LLW: 10 CFR Part 61. This set of regulations mandated near-surface land disposal for LLW and defined a "land disposal facility" to include the land, building, structures, and equipment that would be used collectively to protect human health. A "near-surface disposal facility" was defined as a type of facility "in which radioactive waste is disposed of in or within the upper 30 meters of the earth's surface."[21]

In terms of protecting the general population from releases of radioactivity, 10 CFR 61.41 has a performance objective that any radioactive material released to the surrounding environment from a LLW disposal facility not lead to an annual dose "exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public." For context, the average individual in the United States receives an annual radiation dose of about 620 millirem per year, where half of that dose is from natural sources and half is from man-made sources (mostly medical).[22] From soil and rocks, on average, citizens living in the Colorado Plateau receive 67 millirems per year more than those in the Gulf States and the Atlantic Coast. From cosmic radiation, individuals living at 5,000 to 6,000 feet of elevation receive almost 30 millirem per year more than those living at sea level.[23]

As Chapter 1 explained, the Part 61 regulations defined three categories of LLW: Class A, B, and C, in order of increasing concentration of specified radionuclides. The Federal Register Notice for the Final Part 61 Rule in 1982 explained that the disposal of higher concentrations of isotopes than those listed in Table 1 of Part 61.55 would have to be done "by disposal technologies having greater confinement capacity or protection than 'normal' near-surface disposal." The notice explained that this could potentially involve incorporating better waste forms, packaging or burial at depths greater than five meters, or other measures. According to the notice, the NRC believed that some flexibility should be permitted, provided that the Part 61 performance objectives were met, and would evaluate exceptions on a case-by-case basis while it was beginning studies to establish criteria for disposal of wastes "not normally suited for near-surface disposal." The 1982 notice indicated that such criteria would be the subject of future rulemaking.

In 1985, Congress passed the LLRWPAA (PL99-240). Section 3(b)(1)(D) of that legislation made disposal of GTCC nuclear waste a federal responsibility. Section 3(b)(2) required that GTCC waste resulting from NRC-licensed activities under the Atomic Energy Act of 1954, as amended, be disposed of in a facility licensed by the NRC as adequate to protect public health and safety. The 1985 amendments (Section 3[b][3]) also required the secretary of energy to submit a report to Congress within a year with recommendations for ensuring the disposal of GTCC waste.

In 1987, the DOE sent the requisite report to Congress, explaining that several factors made it impossible to recommend specific federal and nonfederal disposal options for GTCC nuclear waste.[24] The most important regulatory uncertainty was whether the NRC would proceed with a definition of high-level radioactive waste based on radionuclide concentrations, which, in turn, could affect the definition of GTCC. The DOE also cited the need to update the NRC's 10 CFR Part 61 regulations to include technical criteria for facilities using disposal methods specific to GTCC nuclear waste disposal. Finally, the DOE report noted the lack of a general environmental standard for disposal of "non-transuranic GTCC low-level waste,"[25] which precluded the development of any GTCC waste disposal facility.

B. Developments after the 1987 DOE report to Congress

In February of 1988, the NRC published a proposed rule in the Federal Register that it described as a "technically conservative approach" to GTCC waste disposal involving burial in a deep geologic repository, unless an alternative had been approved by the Commission.[26] The proposed rule reflected the Commission's view at the time that "intermediate disposal facilities may never be available," making a deep geologic repository the only viable disposal option for GTCC waste going forward.

By the end of 1987, Congress had legally designated Yucca Mountain in Nevada as the only site to be characterized for a potential deep geologic repository for high-level nuclear waste. Unsurprisingly, given the NRC's above-described position on GTCC waste and its role in licensing the Yucca Mountain facility, the DOE studied Yucca Mountain as a potential disposal pathway for GTCC waste. Indeed, an Office of Technology Assessment report from 1988 cited preliminary calculations indicating that the costs of disposing GTCC at Yucca Mountain would be comparable to or less than those of developing a smaller, separate disposal facility for GTCC. Given this and other factors, the US Office of Technical Assistance assessed: "At this time, the most likely disposal option appears to be the Yucca Mountain repository."[27] The only other deep geologic repository under development in the 1980s and 1990s, WIPP (which began disposal operations in 1999), was not (and still is not) an NRC-licensed facility and thus would not satisfy the criteria for GTCC disposal established by the 1985 amendments act.

Nearly two decades later, in 2005, Congress passed the Energy Policy Act, Section 631, of which required reports and planning related to GTCC waste disposal. The law also required the secretary of energy to "await action by Congress" before deciding on a final GTCC waste disposal path.

As late as 2008, the DOE was still considering GTCC nuclear waste disposal at the Yucca Mountain site.[28] However, in 2010, the Obama administration reduced the budget request for the Yucca Mountain project to zero and moved to withdraw the construction authorization application that had been submitted to the NRC. Since then, the Yucca Mountain project has received no appropriations from Congress, and more recent DOE planning documents for GTCC disposal discussed below do not list Yucca Mountain as one of the sites under consideration.

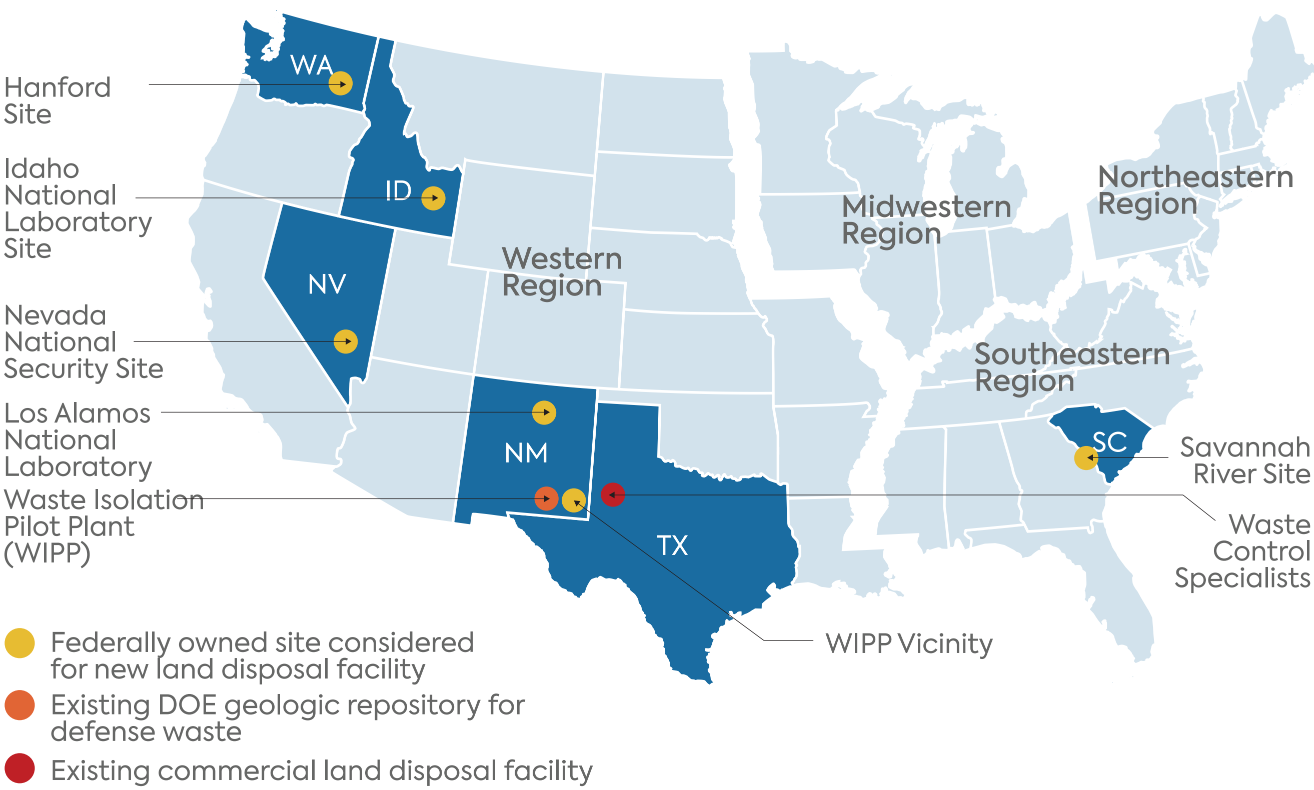
In 2015, the Texas Commission on Environmental Quality sought clarification from the NRC[29] regarding Texas's authority to license the disposal of GTCC waste streams. The commercial site in question was the Waste Control Specialists facility in Andrews County, Texas, which had filed a petition for rulemaking with Texas to remove prohibitions on GTCC waste disposal from the State's administrative code.[30] Subsequently, the NRC directed its staff to prepare a regulatory basis for the disposal of GTCC nuclear waste (other than deep geologic disposal) that would analyze whether such disposal presents a hazard that the NRC should retain exclusive authority over, or whether an agreement state such as Texas could license a GTCC waste disposal facility.[31]

In its draft regulatory basis document from 2019,[32] the NRC concluded that "most of the GTCC waste streams analyzed are potentially suitable for near-surface disposal" (around 80 percent of the overall volume) and that "most GTCC waste could be safely regulated by an Agreement State" (around 95 percent of the volume). The staff identified two GTCC waste streams as not suitable for near-term surface disposal: sealed sources associated with neutron irradiators and remote-handled "other waste" from decontamination activities at the West Valley Demonstration Project. The NRC concluded that one other waste stream (produced as part of Molybdenum-99 generation activities) could not be regulated by an agreement state due to restrictions put in place by Section 274 of the Atomic Energy Act of 1954.

In 2016, the DOE published a final environmental impact statement (FEIS) on potential disposal options for GTCC and GTCC-like nuclear waste.[33] The agency identified four different approaches: above-grade vaults, enhanced near-surface trenches, intermediate depth boreholes, and a deep geologic repository at WIPP. Figure 4 lists all the sites that were evaluated, while Figure 5 illustrates the various heights and depths for each disposal approach. The preferred alternatives for disposal were generic commercial facilities and/or WIPP.

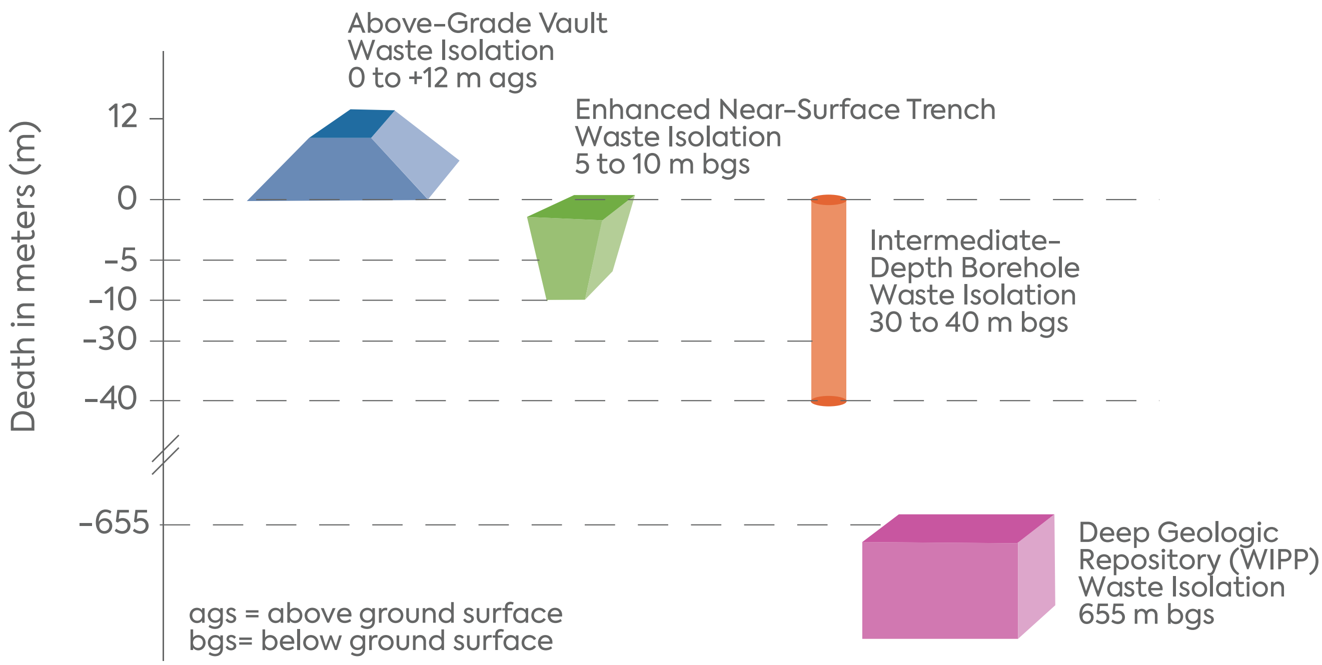
While the DOE did not identify intermediate depth boreholes as a preferred alternative, the United States did dispose of some nuclear waste in such a manner back in the 1980s. The Greater Confinement Disposal Test used boreholes 3m in diameter and 36m deep to dispose of various nuclear wastes, including TRU reaching concentrations of 14,000 nCi/gram.[34] This trial operated from 1984 to 1989 in Area 5 of the Nevada Test Site.

Figure 4: Locations the DOE evaluated for GTCC and GTCC-like nuclear waste disposal



Source: GAO, "DOE Needs to Improve Transparency in Planning for Disposal of Certain Low-Level Waste," 16.

Figure 5: DOE illustration of waste isolation depths for proposed disposal methods



Source: DOE FEIS 2016. Figure 1.4.2-1.

In 2017, the DOE sent a report on the options for GTCC and GTCC-like nuclear waste disposal to Congress, as required by Section 631 of the Energy Policy Act of 2005.[35] The report identified statutory and regulatory actions that would be required for the DOE to implement the preferred alternatives in the 2016 FEIS. It also noted that, on account of the same section of the 2005 Act, "Congressional action is required before DOE can make a final decision and issue a record of decision on the disposal of GTCC LLRW and GTCC-like waste."

In 2018, the DOE published an environmental assessment (EA) of the WCS LLW disposal site in Texas.[36] The commercial 1,338-acre facility located on a 14,900-acre site in western Andrews County holds a license with the Texas Commission on Environmental Quality (TCEQ) to dispose of Class A, B, and C LLW and mixed LLW. The EA provides a site-specific analysis of the potential environmental impacts of disposing of the entire inventory (12,000 cubic meters) of GTCC LLRW and GTCC-like waste at WCS.

On October 21, 2020, the NRC staff provided the Commission with options and a recommendation for the path forward on GTCC waste disposal.[37] The staff recommended combining an ongoing Part 61 rulemaking activity with an effort to promulgate requirements for the near-surface disposal of GTCC waste. On April 5, 2022, the Commission issued SRM-SECY-20-0098, approving the staff's recommendation that there be one consolidated rulemaking.

C. Current state of play

In May of 2024, the NRC staff sent a proposed integrated LLW radioactive waste disposal rule to the Commission.[38] The Commission has more steps ahead to complete the rulemaking, but the major obstacles for GTCC disposal ahead lie elsewhere, beyond the NRC. Specifically, the current political climate for GTCC disposal in both New Mexico and Texas—the two states where past governors had been open to the idea of expanding existing nuclear waste disposal facilities' missions—has darkened considerably over the past decade or so.

In New Mexico, the prior governor, Susana Martinez, had been open to expanding WIPP's mission and potentially incorporating GTCC disposal at the facility.[39] But this was before two accidents occurred at the WIPP site in 2014, which led the state and the federal government to focus on improving safety measures at the site so that it could reopen.[40] The current governor, Michelle Lujan Grisham, does not appear supportive of expanding WIPP's mission.[41]

Similarly, in Texas, after the state government sent its letter to the NRC inquiring about GTCC disposal authority in 2015, the people of Texas elected a new governor in Greg Abbott, who, unlike his predecessor Rick Perry, has not been supportive of GTCC nuclear waste disposal at the WCS site. The state government has also been upset by WCS's efforts to develop a consolidated interim storage project at its site in Andrews County that would receive commercial SNF from other states, and passed a law in 2021 intended to block that project.[42] This comes on top of the state's long-standing displeasure with the federal government for failing to meet its obligation to remove containers of TRU waste in temporary storage at the WCS site, where they were shipped after operations at WIPP were suspended because of the previously mentioned February 2014 incidents.[43]

The potential disposal of GTCC nuclear waste has been opposed by some Texas lawmakers in addition to Governor Abbott in recent years, as well as by some environmental groups, local oil companies, and residents.[44] In 2023, political ads were run against elected officials in Andrews who had supported GTCC disposal at the WCS site,[45] and a resolution opposing disposal of GTCC was put to a vote on December 6 by Andrews County Commissioners and narrowly failed 2-2, reflecting both support and opposition locally.[46]

3. Rationale for Greater Attention from Policymakers

Although the political climate in Texas and New Mexico for possible GTCC disposal has gotten worse, not better, in recent years, there are still important reasons for decisionmakers to pay greater attention to GTCC policy.

A. Supporting essential energy, national defense, medical, industrial, research, and cleanup missions

The commercial, research, and governmental activities that produce GTCC waste—including energy generation, national defense, medical procedures, industrial production, research, and cleanup—are both diverse and in some cases indispensable, and are in need of a disposal solution to the waste streams they produce, lest the burden be passed on to the next generation.

GTCC nuclear waste in the form of activated metals is produced when an existing commercial power reactor is decommissioned. Keeping existing power reactors running is generally regarded as "low-hanging fruit" as part of strategies to enable a reliable, affordable transition to a low-carbon energy supply in the United States.[47] For planning purposes, lifetime extensions have the effect of pushing out the time of reactor decommissioning, which means that the resulting GTCC nuclear waste is not created until much later. Still, a disposal capability will eventually be needed. Future deployments of advanced nuclear reactors, whenever they are decommissioned at the end of their operating lifetimes, may lead to GTCC nuclear waste that will also require a disposal pathway.[48] Even fusion reactors, should they be commercialized, may produce some amount of GTCC waste.[49] Neutrons produced by deuterium-tritium reactions in tokamaks, for example, will irradiate the metal structures surrounding the core, producing some of the same radioisotopes generated by fission reactors (e.g., nickel and niobium isotopes).

With respect to disused sealed sources specifically, security task forces have urged that comprehensive, sustainable disposal pathways must be developed for national security reasons through continued coordinated effort.[50]

While the public may disagree about the use of commercial nuclear power (the existing fleet and perhaps especially new reactors) alongside or instead of other energy sources, in the medical world, where radionuclides are used to diagnose, treat disease, and save lives, viable alternatives do not exist. Sealed sources are widely used to diagnose and treat illnesses, sterilize medical devices, and irradiate blood for transplant patients. Doctors use radioactive materials to diagnose or treat about one-third of all patients admitted to hospitals.[51] They also use radioactive materials and radiation-producing devices to treat medical conditions such as hyperthyroidism and some cancers. Some therapy treatments involve placing sealed radioactive sources near or directly in cancerous tissue, while other treatments involve giving radioactive materials to patients that will concentrate in different regions of organ systems. Medical practitioners around the world rely on a continuous supply of molybdenum-99 in order to produce technetium-99m, which is used in approximately 50,000 medical diagnostic procedures daily in the United States alone.[52]

Outside of medical applications, sealed sources are also used to nondestructively test structures and industrial equipment, as well as explore geologic formations to find oil and gas. Radioactive sources and detection equipment are used to make a record of geological formations from within a well—a process that is widely used for oil, gas, coal, and mineral exploration.[53]

Research reactors are particularly important due to their diverse industrial applications. Neutron beams from these reactors are crucial for studying atomic structures and material properties. They also enable experiments under various conditions and offer essential tools for different purposes, including environmental monitoring, materials studies, imaging, and advanced nuclear energy development.

Finally, the lack of a disposal option for GTCC and GTCC-like nuclear waste could impede cleanup efforts at sites like West Valley, where the cost of storing such waste has been estimated to be $1.2 million annually.[54]

B. Bolster the broader US nuclear waste management program

In addition to addressing a more hazardous form of nuclear waste than Class A, B, and C LLW, establishing a GTCC disposal capability would help advance the broader US nuclear waste management program. GTCC disposal was made a federal responsibility in 1985, and the federal program was made responsible for establishing an HLW/SNF disposal capability at around the same time (1982), but both efforts have been unsuccessful as of early 2024. A campaign to transport GTCC nuclear waste from shutdown nuclear power plant sites to a disposal site (or disposal sites) could function as a smaller-scale model (both in terms of the number of casks and concentrated radioactivity) for a future campaign to move commercial SNF to either a consolidated interim storage facility or a deep geologic repository. Planning would still be needed to remove and transport the GTCC casks at each site—and the transportation casks would be very similar if not the same—just as would be needed to transport SNF away from the same shutdown sites.

On the other hand, from a logistics and perhaps also a cost point of view, having only one transportation campaign for a given shutdown site—that is, keeping the GTCC and SNF together—may be preferable to separate campaigns. The removal of GTCC waste at shutdown sites is also unlikely to alleviate continuing storage costs significantly, given the larger number of remaining SNF casks that will still have to guarded and maintained. Still, it would be a tangible step forward for the US nuclear waste management program, generating more implementation experience and perhaps creating some momentum for the broader efforts.

Under direction from Congress, the DOE has begun a consent-based siting effort to establish a consolidated interim storage facility.[55] If a community or group of communities were to agree to host this type of facility for commercial SNF, it appears as of now that GTCC would be likely to be transported there as well.

As discussed in Chapter 2, a small percentage of the US GTCC and GTCC-like inventories will require a deep geologic repository. Apart from the technical rationales underlying the assessments that one inventory may need greater isolation than another, the public acceptance challenges for some of the GTCC and GTCC-like inventories may prove different.

Some, albeit older, research has argued that the public views the disposal of nuclear waste from national security missions differently from that of commercial nuclear power; and thus, the defense nature of the waste that was proposed for disposal at WIPP played a role in successfully opening that facility, which has now been operating for a quarter century.[56] Similarly, it is possible that given the medical nature of some sealed sources as well as the greater urgency to collect and dispose of disused sealed sources—in order to mitigate associated security risks—a state and local community might be open to a disposal plan solely focused on them.

4. Actions for Policymakers

If the US government decides to prioritize establishing US disposal capability for GTCC and GTCC-like nuclear waste, there are multiple actions that Congress, the DOE, and the NRC could take in the next few years to help materialize such a capability in the near term.

A. Action for the NRC

First initiated in 2009, the ongoing 10 CFR Part 61 rulemaking has now spanned 15 years. The initial purpose of this legislation was to specify requirements for site-specific analysis as well as for unique waste streams, including significant quantities of depleted uranium.[57] Along the way, the NRC staff recommended (in 2020), and the Commission approved, that GTCC rulemaking efforts be folded in. Given the long duration as well as the value of the new Part 61 rulemaking (for GTCC disposal and other purposes), it is still important that it be completed in order to clarify and enable one potential pathway to GTCC disposal.

B. Actions for the secretary of energy

The secretary of energy is responsible for implementing the GTCC nuclear waste disposal program, and so has the authority to elevate it as a policy priority. Although it may make sense for the secretary to wait to do so until the NRC finishes the Part 61 rulemaking that would apply to commercial sites, this does not preclude holding discussions between Congress and state and DOE officials in the interim. The secretary's personal involvement might prove necessary in some cases to address a given state's needs, as the secretary has broader authority to negotiate provisions than a single DOE program office, and the GTCC program is indirectly affected by other nuclear waste policy issues. The private consolidated interim storage projects for commercial SNF under development in New Mexico and Texas are opposed by both states for numerous reasons,[58] and that issue could be creating a more challenging environment for potential negotiations that the secretary may need to address as part of any discussions.

While not the focus of this report, other countries also generate nuclear waste as part of the same activities discussed herein, and thus have to contend with associated low-level, intermediate-level, and high-level nuclear waste.[59] It may be valuable for the DOE to publish a report for public education purposes on the approach and progress made by other countries in dealing with nuclear waste inventories that are the equivalent to US GTCC waste.

C. Actions for Congress

At the end of the day, per the Energy Policy Act of 2005, the DOE cannot move forward on GTCC disposal absent congressional action. A 2022 Government Accountability Office (GAO) report also recommended that Congress consider providing direction to the DOE on GTCC nuclear waste disposal in order for the DOE to proceed with a decision for the same reason.[60] But Congress is unlikely to act unless it is presented with a potentially workable political solution (i.e., one that the states involved in any disposal plan will not oppose outright), and this has not occurred as of early 2024.

That said, Congress can still seek to amend the LLRWPAA of 1985—specifically Section 3(b)—to eliminate uncertainty over whether agreement states can license GTCC nuclear waste disposal facilities. Presumably, this amendment would not encounter opposition from members of Congress since potential agreement states would still have to explicitly consent to move forward with licensing.

As the DOE noted in its 2017 Report to Congress, other congressional actions will be needed later. These include granting the DOE legislative authority to set and collect disposal fees from the generators of GTCC nuclear waste to pay for disposal, and potentially revising US statutes, depending upon the disposal pathway. For example, if New Mexico were ever to consent to allow disposal of some GTCC disposal at WIPP (where consent could take the form of a renegotiated bilateral agreement), Congress would still need to amend the WIPP Land Withdrawal Act, which currently permits only disposal of defense-generated TRU waste at WIPP, to permit GTCC disposal, as well as potentially other modifications.[61] It would also need to amend the Low-Level Radioactive Waste Policy Amendments Act (LLRWPA) of 1985, as it specified that GTCC nuclear waste must be disposed of in a facility licensed by the NRC, and WIPP is not an NRC-licensed facility.

5. Concluding Thoughts

Federal responsibility for the disposal of GTCC nuclear waste now stretches back almost 40 years. While the plan over a decade ago was to dispose of GTCC and GTCC-like nuclear waste at Yucca Mountain, the absence of appropriations to move that project forward since 2010 suggests it has fallen by the wayside.

From a technical point of view, the disposal of nuclear waste exceeding the concentration limits for Class C waste in 61.55 is not unprecedented in the United States. As explained, WIPP has been disposing of such material for decades. As also noted in Chapter 2, the United States has operated (the Greater Confinement Borehole Test in Nevada) and continues to operate facilities (Hanford in Washington) with waste acceptance criteria that overlap with GTCC definitions.

But at the moment, the political climate to establish GTCC disposal facilities is not promising. A previous administration in Texas seemed open to the possibility of GTCC disposal at the WCS site, but the current administration is not. Similarly, a previous administration in New Mexico seemed open to the possibility of expanding WIPP's mission—including potentially to incorporate GTCC disposal—but the current administration is not. Given that the DOE identified these as preferred alternatives in its 2017 report to Congress, at some point, if circumstances in each state do not change, the DOE may need to rethink its plan. Some of the assumptions in the 2016 final EIS have already changed, such as operating power reactors that have since shut down; new reactor projects being canceled; and programs and tax credits to extend the operating lifetimes of the existing fleet being established, which could push out decommissioning dates and thus when the activated metal GTCC is generated.[62] If the DOE is forced to reassess its plan and/or formulate a new one, updating these assumptions would likely improve the accuracy of the projected amounts of GTCC as well as their timing.

Absent any near-term advances, GTCC and GTCC-like waste from commercial nuclear power plants, medical procedures, environmental remediation of sites such as West Valley, and other activities may have to wait for a new deep geologic repository to be developed. If WIPP—the only operating deep geologic repository in the United States—is used as a benchmark for how long it might take to develop a new repository (from exploratory work to the start of disposal operations[63]), this would imply approximately 25 years. But even this lengthy window of time assumes a near-term effort to develop a new deep geologic repository that has not yet begun in earnest—another area awaiting action from Congress.

Notes

1. For example, Section 11 of the Atomic Energy Act of 1954, Section 2 of the Nuclear Waste Policy Act of 1982, and Section 101 of the Uranium Mill Tailings Radiation Control Act of 1978.

2. NRC website, "Backgrounder on Radioactive Waste," accessed April 4, 2023, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.html.

3. The regulations also define a "sum of fractions" rule for waste that contains a mixture of the radionuclides listed in the tables, whereby even if waste does not exceed Class C concentration limits for any single radionuclide, the mixture may still be determined to be GTCC if the sum of two or more radionuclides exceeds a calculated limit.

4. NRC website, "Low-Level Waste Disposal Statistics," https://www.nrc.gov/waste/llw-disposal/licensing/statistics.html.

5. US Department of Energy, "Summary: Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste" (DOE/EIS-0375), January 2016 (DOE 2016), Table S-1.

6. See presentation by John R. Cochran, "Greater-Than-Class C LLW Environmental Impact Study," Sandia National Laboratories," 2016, https://www.osti.gov/servlets/purl/1406956.

7. SNL, "Evaluation of Options for Permanent Geologic Disposal of Used Nuclear Fuel and High-Level Radioactive Waste, Vol. 1," 2014, p. 7 and Table 6-3, https://www.energy.gov/ne/articles/evaluation-options-permanent-geologic-disposal-spent-nuclear-fuel-and-high-level.

8. According to the NRC, transuranic (TRU) waste is "material contaminated with transuranic elements—artificially-made, radioactive elements, such as neptunium, plutonium, americium, and others—that have atomic numbers higher than uranium in the periodic table of elements." NRC website, "Transuranic Waste," updated March 9, 2021, https://www.nrc.gov/reading-rm/basic-ref/glossary/transuranic-waste.html. The current definition of LLW in 10 CFR 61.2 explicitly excludes TRU, although Table 1 in 10 CFR 61.55 allows waste streams with concentrations of transuranic radionuclides less than 100 nanocuries per gram to be managed as LLW. Accordingly, at present waste streams with concentrations of transuranic radionuclides greater than 100 nanocuries per gram cannot be disposed of in a Part 61 disposal facility.

9. DOE, "Alternatives for the Disposal of Greater-Than Class C Low-Level Radioactive Waste and Greater-Than-Class C-Like Waste," Report to Congress (November 2017), https://www.

energy.gov/sites/prod/files/2018/09/f55/GTCC-2017-Report-to-Congress-on-Disposal-Alternatives.pdf.

10. NRC, "Disposal of Greater-Than-Class C (GTCC) and Transuranic Waste," 2019 (NRC 2019), https://www.nrc.gov/docs/ML1905/ML19059A403.pdf.

11. WIPP website: https://wipp.energy.gov/shipment-information.asp.

12. US Department of Energy, "Summary: Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste" (DOE/EIS-0375), January 2016, p. S-12.

13. For example, Mark Peck, "For Only the Second Time in Its History, the US Navy Is Beginning the Slow, Tricky Process of Taking Apart a Nuclear-Powered Aircraft Carrier," *Business Insider*, May 1, 2023, https://www.businessinsider.com/us-navy-begins-planning-to-decommission-nimitz-nuclear-power-carrier-2023-5.

14. Consortium for Risk Evaluation with Stakeholder Participation, "Hanford Site-Wide Risk Review Project—Final Report," August 31, 2018, Appendix H.11, https://www.cresp.org/Hanford/Final/H.11_CP-OP-09_Naval_Reactors_Trench.pdf.

15. NRC, "Information Digest," Section 4 Nuclear Materials, 2021–2022, p. 47, https://www.nrc.gov/docs/ML2130/ML21300A287.pdf.

16. Office of Technology Assessment, "An Evaluation of Options for Managing Greater-Than-Class-C Low-Level Radioactive Waste," 1988, p. 5.

17. NRC "Information Digest 2020–2021," https://www.nrc.gov/docs/ML2028/ML20282A632.pdf.

18. NRC, "Backgrounder on Research and Test Reactors," accessed November 10, 2023, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/research-reactors-bg.html.

19. World Nuclear Association. "Research Reactors," June 2021, https://world-nuclear.org/information-library/non-power-nuclear-applications/radioisotopes-research/research-reactors.aspx.

20. NRC website, "Low-Level Waste Compacts," https://www.nrc.gov/waste/llw-disposal/licensing/compacts.html.

21. Federal Register Vol. 47, No. 248. Monday, December 27, 1982, 57446 (10 CFR Part 61 was effective January 26, 1983).

22. National Council on Radiation Protection & Measurements, Report No. 160, https://ncrponline.org/publications/reports/ncrp-report-160-2/.

23. DOE 2016, p. S-xii.

24. DOE, "Recommendations for Management of Greater-Than-Class-C Low-Level Radioactive Waste," DOE/NE-0077, February 1987.

25. This term is not defined in the report per se, but there is a related discussion on p. 3-1: "Work is underway on an EPA standard for disposal of low-level waste. This standard will cover all low-level waste, including GTCC, but excluding the transuranic waste covered by 40 CFR Part 191. Such a standard covering nontransuranic GTCC low-level waste would assist development of NRC-licensing disposal capability for GTCC low-level waste, and would enhance confidence in the technical disposal planning and licensing decisions."

26. Federal Register Vol. 53, No. 96. Wednesday, May 18, 1988.

27. Office of Technology Assessment, "An Evaluation of Options for Managing Greater-Than-Class-C Low-Level Radioactive Waste," October 1988.

28. Supplemental Environmental Impact Statement for Yucca Mountain, 2008.

29. Letter from Texas Commission on Environmental Quality to NRC, dated January 30, 2015, https://www.nrc.gov/docs/ML1503/ML15034A181.pdf.

30. 30 Tex. Admin. Code § 336.701(b)(4), (5), https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=336&rl=701.

31. NRC, "Disposal of Greater-than-Class C (GTCC) and Transuranic Waste: Draft Regulatory Basis—for Public Comment," https://www.nrc.gov/docs/ML1905/ML19059A403.pdf.

32. NRC, "Disposal of Greater-Than-Class C (GTCC) and Transuranic Waste," Draft Regulatory Basis—for Public Comment, posted on July 22, 2019, https://www.regulations.gov/document/NRC-2017-0081-0014.

33. DOE, "Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste" (DOE/EIS-0375), 2016, https://www.energy.gov/nepa/articles/eis-0375-final-environmental-impact-statement.

34. John R. Cochran, "Greater Confinement Disposal Operations," Sandia National Laboratory, presentation from 2016, https://www.osti.gov/servlets/purl/1408347.

35. DOE, "Alternatives for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste and Greater-Than-Class C-Like Waste Report to Congress," 2017.

36. DOE, "Environmental Assessment for the Disposal of Greater-Than-Class (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste at Waste Control Specialists, Andrews Country, Texas," October 2018, https://www.energy.gov/nepa/ea-2082-disposal-greater-class-c-gtcc-low-level-radioactive-waste-and-gtcc-waste-waste-control.

37. SECY-20-0098, "Path Forward and Recommendations for Certain Low-Level Radioactive Waste Disposal Rulemakings," November 5, 2020, https://www.nrc.gov/docs/ML2014/ML20143A164.html.

38. SECY-24-0045: Proposed Rule—Integrated Low-Level Radioactive Waste Disposal, https://www.nrc.gov/docs/ML2324/ML23242A249.html.

39. A 2011 letter from Governor Susana Martinez to Secretary of Energy Steven Chu states that "in recent correspondence to the DOE by my Cabinet Secretary for the Environment, New Mexico encourages the DOE to support the proposed location of WIPP as the preferred alternative in the Draft EIS for the disposal of Greater Than Class C (GTCC) Low-Level Radioactive Waste and GTCC-like waste." In addition, a 2017 Energy Communities Alliance report notes Governor Martinez's openness to expanding WIPP's mission, "Waste Disposition: A New Approach to DOE's Waste Management Must Be Pursued," September 2017, p. 14, https://static1.squarespace.com/static/55c4c892e4b0d1ec35bc5efb/t/59ce7384cd39c3b12b97f988/1506702214356/ECA+Waste+Disposition+Report.pdf.

40. The two unrelated accidents at WIPP in February of 2014—a salt haul truck fire and a radiological release—have been covered in reports by various organizations, including the Defense Nuclear Facilities Safety Board (https://www.dnfsb.gov/), and are also described on DOE's WIPP page with the associated accident investigation reports, https://wipp.energy.gov/wipprecovery-accident-desc.asp.

41. For example, see a 2022 letter from Governor Lujan Grisham to Secretary of Energy Jennifer Granholm that forwards a petition from over a thousand New Mexico residents opposing an expansion of the WIPP project, and adding that she takes "these concerns seriously" before requesting that the DOE take action to address the issues raised therein, https://www.env.nm.gov/wp-content/uploads/2022/04/2022-04-08-Gov-MLG-Letter-to-DOE-re-WIPP-Petition.pdf.

42. Erin Douglas, "Texas Bans Storage of Highly Radioactive Waste, but a West Texas Facility

May Get a License from the Feds Anyway," *Texas Tribune*, September 10, 2021, https://www.texastribune.org/2021/09/10/texas-nuclear-waste-ban/.

43. Nuclear Newswire, "DOE Late in Removing Los Alamos TRU Waste, Texas Says," June 6, 2022, https://www.ans.org/news/article-4019/doe-late-in-removing-los-alamos-tru-waste-texas-says/.

44. Erin Douglas, "West Texas Is on Track to Get Even More Nuclear Waste—Thanks to the Federal Government," *Texas Tribune*, February 10, 2021, https://www.texastribune.org/2021/02/10/nuclear-waste-government-rules/.

45. For example, Citizens Against Federal Corruption, https://www.youtube.com/watch?v=DIqensGULPA.

46. Dan Leone, "Local Resolution to Stop GTCC Waste Disposal in Texas Fails," *Exchange Monitor*, December 15, 2023, https://www.exchangemonitor.com/local-resolution-to-stop-gtcc-waste-disposal-in-texas-fails-2/.

47. For example, Rhodium Group, "Pathways to Build Back Better: Investing in 100% Clean Electricity," March 23, 2021, https://rhg.com/research/build-back-better-clean-electricity/.

48. National Academies of Sciences, Engineering, and Medicine, 2023. *Merits and Viability of Different Nuclear Fuel Cycles and Technology Options and the Waste Aspects of Advanced Nuclear Reactors*, Washington, DC: The National Academies Press, pp. 158–168. https://doi.org/10.17226/26500.

49. National Academies of Sciences, Engineering, and Medicine, 2021. Bringing Fusion to the U.S. Grid, Washington, DC: The National Academies Press, pp. 40–45. https://doi.org/10.17226/25991.

50. For example, "The lack of disposal pathways for radioactive sealed sources, which make up less than 1 percent of all low-level radioactive waste by volume and activity, poses a national security concern. During their service lives, these sources have numerous essential and beneficial medical, industrial, and research applications. However, due to their high activity and portability, some of these sources could be used either individually or in aggregate in radiological dispersal devices commonly referred to as 'dirty bombs,' resulting in economic impacts in the billions of dollars and significant social disruption." NRC, "The 2010 Radiation Source Protection and Security Task Force Report," p. 32, https://www.nrc.gov/security/byproduct/2010-task-force-report.pdf.

51. NRC 2021–2022 Information Digest, p. 47, https://www.nrc.gov/docs/ML2130/ML21300A280.pdf.

52. Ibid., p. 40.

53. Ibid., p. 48.

54. GAO, Nuclear Waste: Congressional Action Needed to Clarify a Disposal Option at West Valley Site in New York, GAO-21-115 (Washington, DC: January 13, 2021).

55. DOE, "DOE Awards $26 Million to Support Consent-Based Siting for Spent Nuclear Fuel," June 9, 2023, https://www.energy.gov/articles/doe-awards-26-million-support-consent-based-siting-spent-nuclear-fuel.

56. Downey, "Politics and Technology in Repository Siting: Military Versus Commercial Nuclear Wastes at WIPP 1972-1985," *Technology in Society*, Vol. 7 (1985): 47–75. In a more recent DOE report, it was suggested that a similar dynamic might be present for SNF and HLW disposal: "Available information indicates that a repository limited to DOE-managed HLW and SNF not of commercial origin could be more likely to gain public acceptance than a repository OR that includes commercial waste, all other factors being equal. . . . In contrast to a repository for commercial SNF, siting a repository for DOE-managed HLW and SNF may be viewed as a national responsibility whereby all states have a share in the benefits and responsibilities." DOE, "Assessment of Disposal Options for DOE-Managed High-Level Radioactive Waste and Spent Nuclear Fuel," October 2014, p. 25, https://www.energy.gov/ne/articles/assessment-disposal-options-doe-managed-high-level-radioactive-waste-and-spent-nuclear.

57. A full history of this Part 61 rulemaking can be found on the NRC website: https://www.nrc.gov/waste/llw-disposal/llw-pa/uw-streams.html (accessed August 13, 2023).

58. See Matt Bowen, "Nuclear Waste Policy Actions for the 117th Congress and Biden Administration," Center on Global Energy Policy, January 2022, https://www.energypolicy.columbia.edu/wp-content/uploads/2022/01/Nuclear_Waste_Final.pdf.

59. International Atomic Energy Agency (IAEA), "Management of Disused Sealed Radioactive Sources," 2014, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1657_web.pdf; IAEA, "Disposal Approaches for Long-Lived Low and Intermediate Level Radioactive Waste," 2009, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1407_web.pdf; OECD-NEA, "Management and Disposal of High-Level Radioactive Waste: Global Progress and Solutions," 2020, https://www.oecd-nea.org/upload/docs/application/pdf/2020-07/7532-dgr-geological-disposal-radioactive-waste.pdf.

60. GAO, "Nuclear Waste: DOE Needs to Improve Transparency in Planning for Disposal of Certain Low-Level Waste," September 29, 2022, https://www.gao.gov/assets/gao-22-105636.pdf.

61. The 2017 DOE Report to Congress mentions on p. 13 several other modifications that may be necessary for the WIPP option, depending upon which inventories are to be disposed of there.

62. For example, in Table 3.4-1 of the 2016 final EIS, there are 104 operating reactors, where as of May 2024, there are now 94. There are no clear signs at the moment that any of the 33 reactor projects listed in the table as "proposed" are going to move forward (with the exception of the two units at Vogtle that have now turned on), though a new generation of reactors is under development. The incentives for the existing fleet in the Bipartisan Infrastructure Law and the Inflation Reduction Act are discussed by DOE here: https://www.energy.gov/ne/articles/inflation-reduction-act-keeps-momentum-building-nuclear-power.

63. DOE WIPP website, "History/Timeline": https://wipp.energy.gov/historytimeline.asp.

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