

Nuclear Materials: DOE Plans for Savannah River Site's H-Canyon Facility (Accessible Version)

GAO-24-106494

Q&A Report to Congressional Committees

December 7, 2023

Why This Matters

The Department of Energy (DOE) Savannah River Site's (SRS) H-Canyon facility is the sole chemical separations facility in the U.S. It is integral to DOE's disposition of nuclear materials from across the DOE complex. DOE's Office of Environmental Management (EM) manages the operations of H-Canyon, a contractor operates it, and other federal programs use it as a resource. EM uses H-Canyon to help process certain materials for disposition, such as spent nuclear fuel—used fuel from nuclear reactors—that contains highly enriched uranium.¹ Some of these materials have no other means of disposal; are unstable; and pose risks to safety, health, and the environment.

DOE plans to conclude H-Canyon's missions in the 2030s (i.e., stop processing in H-Canyon), at which point the facility will be around 80 years old. In April 2022, DOE announced plans to accelerate processing spent nuclear fuel and other materials in H-Canyon to better align with some of EM's environmental cleanup plans for SRS that are set to conclude in the late 2030s. DOE and other federal officials have raised concerns that continued operations may present challenges related to cost and safety.

Senate Report 117-130 includes a provision for GAO to assess how EM's proposed plans for H-Canyon would affect other programs' missions, how H-Canyon can meet DOE safety assessment standards, and the costs to operate H-Canyon.² We are providing information on H-Canyon's current missions, integration of plans to support these missions, key safety requirements, and operating costs.

Key Takeaways

- DOE uses written agreements, such as memorandums of agreement (MOA), to help facilitate collaboration between EM and some of the federal programs that rely on H-Canyon but not for other programs with ongoing mission needs. We are recommending that DOE document EM's agreements with all programs that rely on H-Canyon to better align all components of its work and provide a solid basis on which to plan next steps for mid- and long-term operation of H-Canyon.
- EM conducted planned and unplanned safety assessments of varying breadths in fiscal year 2023. One independent entity did not identify major findings related to safety, and another highlighted the thoroughness of safety assessments at H-Canyon.

- Annual contractor costs to operate H-Canyon averaged just over \$154 million, adjusted for inflation, from fiscal years 2013 through 2023, and EM officials said the overall budget has been relatively stable.

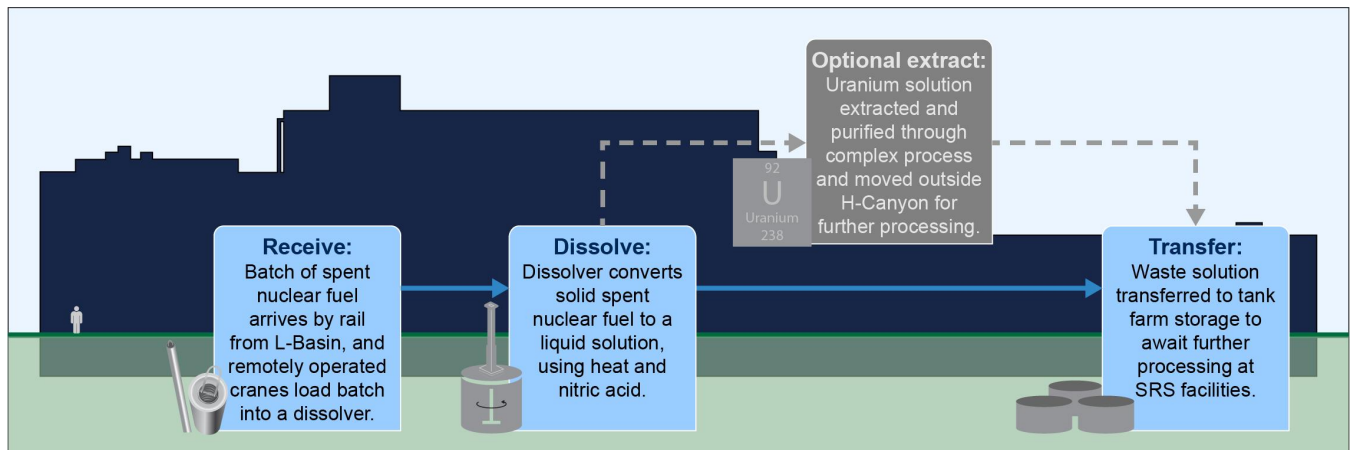
What is H-Canyon?

H-Canyon is a chemical separations facility located at SRS in Aiken, South Carolina. SRS historically produced the basic materials used in production of nuclear weapons during the Cold War era. H-Canyon began operations at SRS in 1955, and it was used to process highly radioactive nuclear materials from SRS’s reactors to extract and recover primarily highly enriched uranium and plutonium.

Since the Cold War ended in the early 1990s, DOE has used H-Canyon in support of environmental cleanup and efforts to minimize the spread of nuclear materials that can be used in weapons.³ Primarily, DOE has used H-Canyon to process the significant amount of nuclear materials that were located at SRS and other DOE sites that were not readily disposable in their existing forms. This has included spent nuclear fuel from domestic research reactors, such as those managed by universities, and spent fuel and other materials from foreign research reactors included in a program to return U.S.-origin enriched uranium to the U.S. Most of this spent fuel and other materials have been stored at SRS in the L-Basin storage facility’s water-filled pool until processed through H-Canyon. In recent years, the inventory of spent fuel and other materials has approached L-Basin’s capacity.

In practice, DOE processes at least one “batch” of nuclear materials per year at H-Canyon to meet its statutory requirement to “continue operations and maintain a high state of readiness” at H-Canyon.⁴ Spent fuel and other materials vary in size and shape, so the number of pieces in one batch depends on the type of materials being processed. A batch arrives by SRS’s rail system to H-Canyon and is moved by a crane system through the H-Canyon airlock to the areas of the facility that shield workers from radiation for processing (see fig. 1).

Figure 1: Processing a Batch of Spent Nuclear Fuel in the Savannah River Site’s (SRS) H-Canyon Facility



Source: GAO analysis of Department of Energy documents. | GAO-24-106494

Accessible Data for Figure 1: Processing a Batch of Spent Nuclear Fuel in the Savannah River Site's (SRS) H-Canyon Facility

Process 1a

- **Receive:** Batch of spent nuclear fuel arrives by rail from L-Basin, and , remotely operated cranes load batch into a dissolver.
- **Dissolve:** Dissolver converts solid spent nuclear fuel to a liquid solution, using heat and nitric acid.
- **Transfer:** Waste solution transferred to tank farm storage to await further processing at SRS facilities.

Process 1b

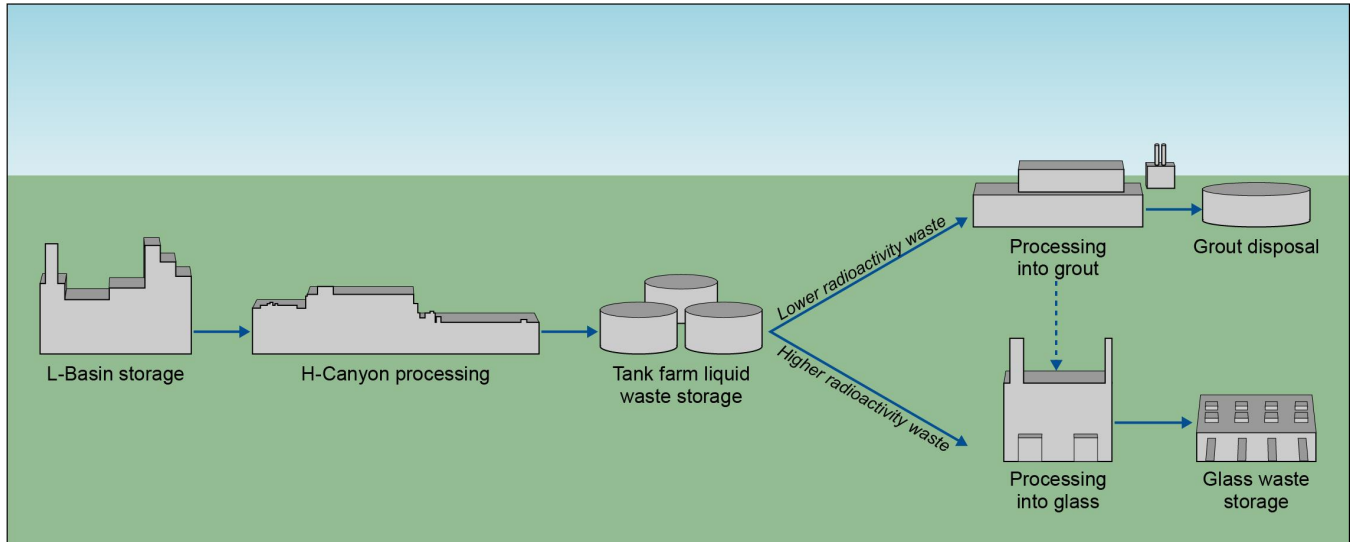
- **Receive:** Batch of spent nuclear fuel arrives by rail from L-Basin, and , remotely operated cranes load batch into a dissolver.
- **Dissolve:** Dissolver converts solid spent nuclear fuel to a liquid solution, using heat and nitric acid.
- **Optional extract:** Uranium solution extracted and purified through complex process and moved outside H-Canyon for further processing. [92 U Uranium 238]
- **Transfer:** Waste solution transferred to tank farm storage to await further processing at SRS facilities.

Source: GAO analysis of Department of Energy documents. | GAO-24-106494

Note: Figure 1 depicts conventional processing in H-Canyon for aluminum-clad spent fuel. From the early 2000s through 2022, DOE used H-Canyon to extract uranium before transferring waste for further processing and disposal. The extracted uranium was used for commercial nuclear reactors until 2011. Some types of nuclear fuel require processing using a different type of dissolver—an electrolytic dissolver—to apply an electric current to the nitric acid solution in addition to heating with steam.

Once batches are processed in H-Canyon, the resulting waste solutions enter SRS's liquid waste system to be further processed for disposal or storage (see fig. 2).

Figure 2: Processing Path of Spent Fuel Stored in L-Basin for Disposal or Storage at the Savannah River Site



Source: GAO analysis of Department of Energy documents. | GAO-24-106494

Accessible Data for Figure 2: Processing Path of Spent Fuel Stored in L-Basin for Disposal or Storage at the Savannah River Site

- L-Basin storage
- H-Canyon processing
- Tank farm liquid waste storage
- Lower radioactivity waste (sub-process one of two)
 - Processing into grout
 - Grout disposal
- Lower radioactivity waste (sub-process two of two)
 - Processing into grout
 - Processing into glass
 - Glass waste storage
- Higher radioactivity waste
 - Processing into glass
 - Glass waste storage

Source: GAO analysis of Department of Energy documents. | GAO-24-106494

Note: Figure 2 depicts spent fuel and liquid waste processing facilities at SRS, which has many other systems and facilities at the site. The liquid waste solutions from H-Canyon are transferred to the tank farm for interim storage and to settle into layers of lower and higher radioactivity waste. The lower activity waste is further processed to remove any remaining higher activity waste. The lower activity waste is stabilized by combining it with cement to form grout and disposed of on-site. The higher activity waste is stabilized through glass vitrification and stored on-site.

What are H-Canyon's current missions?

H-Canyon's current missions include

- processing spent fuel and other materials stored in L-Basin,
- processing a unique type of fuel from the Japan Atomic Energy Agency (JAEA), and
- downblending (mixing) available uranium solutions with lower assay forms.

Process spent fuel and other materials stored in L-Basin. DOE plans for H-Canyon to process 29.2 metric tons of spent fuel and other materials to significantly reduce the inventory in the L-Basin storage facility, according to DOE's April 2022 amended record of decision. To accelerate this effort, EM is no longer extracting and recovering uranium for other use. This will optimize EM's use of H-Canyon before the facility's eventual closure, according to EM's plan for the mission.⁵ EM officials located at SRS said that they are still working to address challenges related to processing all types of fuel stored in L-Basin and plan to use an electrolytic dissolver for some of it. H-Canyon began processing spent fuel under this mission in April 2022. DOE plans to conclude the mission in 2034 (i.e., stop processing in H-Canyon) to align with the planned closure of SRS's downstream liquid waste system in 2037. Once SRS's liquid waste system facilities are shut down, EM will not have the same capability to store and further process waste solutions from H-Canyon on-site.

The spent fuel and other materials stored in L-Basin include

- spent fuel from a domestic research reactor managed by DOE's Office of Science,
- spent fuel from domestic university research reactors managed by DOE's Office of Nuclear Energy's University Fuel Services program,
- spent fuel from the domestic research reactor managed and operated by the National Institute of Standards and Technology (NIST),
- spent fuel and other materials from foreign research reactors received by the National Nuclear Security Administration's (NNSA) nonproliferation program, and
- fuel remaining from the operation of SRS reactors.

Process JAEA Fast Critical Assembly fuel. One of NNSA's missions is to reduce the amount of nuclear materials in foreign countries that can be used in nuclear weapons. In 2014, the U.S. and Japan agreed that Japan would remove all highly enriched uranium and plutonium from JAEA's Fast Critical Assembly research reactor, and the U.S. would dispose of it.⁶ As part of this effort, NNSA has a contract with JAEA to process and dispose of stainless steel clad plutonium fuel from JAEA's Fast Critical Assembly research reactor. Due to the fuel's characteristics, DOE and NNSA determined that it will be processed with an electrolytic dissolver in H-Canyon. SRS began installation of a replacement electrolytic dissolver and other physical modifications to H-Canyon in 2021 to prepare to process the fuel starting in fiscal year 2024. JAEA agreed to provide about \$81.8 million in funding for this effort.

Downblend highly enriched uranium to high-assay low-enriched uranium. DOE plans for SRS to downblend highly enriched uranium to produce high-assay low-enriched uranium for use in advanced nuclear reactors, among other things.⁷ EM officials at SRS said this partnership with DOE's Office of Nuclear Energy will use uranium solution accumulated between 2011 and 2022—a period when H-Canyon extracted but did not send the recovered uranium for use in commercial nuclear reactors. EM officials estimate they can produce about 2.5 metric tons of high-assay low-enriched uranium from the amount currently stored at H-Canyon. These officials and Office of Nuclear Energy officials noted benefits of the partnership, including that SRS will have reduced storage and disposal costs after downblending the on-site highly enriched uranium to high-assay low-enriched uranium. This type of uranium is in short supply. The Office of Nuclear Energy will fund the downblending process, packaging, and transportation of material from SRS to an off-site fuel fabrication facility. EM officials said that the mission should last through 2028.

How does DOE integrate its plans for H-Canyon across these missions?

DOE has generally integrated its plans for H-Canyon operations at the site and federal program levels. Integration involves strategic alignment of components of work done across an organization to fulfill an objective or goal, according to the Project Management Institute, Inc.⁸

Site-level integration includes specific facilities that operate upstream or downstream from H-Canyon at SRS. Upstream facilities to H-Canyon include L-Basin, and downstream facilities include the tank farm and facilities that process lower and higher radioactivity waste. We found that DOE's planning documents demonstrated integrated plans for H-Canyon at the site level. For example, EM's plan for the accelerated L-Basin de-inventory mission describes how the streamlined processing in H-Canyon impacts and requires integration with the liquid waste system.

Program-level integration includes other DOE programs and a NIST program that rely on H-Canyon operations. We found that DOE's planning documents generally demonstrated integrated plans at the program level for NNSA, the Office of Science, the Office of Nuclear Energy, and NIST. For example, EM's August 2019 report on the future of H-Canyon operations describes the importance of considering the impacts of changes to H-Canyon's mission on programs that rely on the facility for processing spent fuel and other materials.

To what extent does DOE use written agreements to ensure that EM and other programs have integrated their plans?

We found that in some instances, DOE uses written agreements, including MOAs, to help ensure that EM and programs that rely on H-Canyon have integrated their plans. These short documents detail various components of the work to be executed by H-Canyon. These agreements are intended to help facilitate collaboration between programs. Officials from EM and these other DOE programs stated that the MOAs and similar written agreements have provided benefits by (1) formalizing agreements and responsibilities for each program, (2) helping align programs' expectations of cost and time frames related to H-Canyon's operations, and (3) providing structure and consistency for collaboration. EM officials at SRS stated that the MOAs and similar written agreements also help inform DOE's broader planning efforts for future spent fuel processing capabilities.

Specifically, EM has MOAs or similar written agreements with the following three DOE entities:

- **Office of Science.** EM and the office signed an MOA in 2022 for an ongoing mission—H-Canyon's processing of a particular type of spent fuel from the Oak Ridge National Laboratory. The MOA details the two programs' mutual goals for the spent fuel's shipment, storage, and disposal, with consideration of H-Canyon's broader mission to accelerate the de-inventory of L-Basin. This includes describing how much spent fuel will be sent to SRS and the planned time frames. The MOA also includes who will be responsible for resolving disputes and problems.
- **Office of Nuclear Energy.** EM and the office signed an MOA in 2023 for the discrete mission to downblend highly enriched uranium previously extracted and recovered by H-Canyon for further use. The MOA includes agreement on funding for the work and who is responsible for transportation. The MOA also

includes the duration of that agreement and who will be responsible for resolving disputes and problems.

- **NNSA.** EM concurred on a memorandum from NNSA in May 2019 for H-Canyon's discrete mission to process the JAEA Fast Critical Assembly fuel. This written agreement details the funding for the work and other roles and responsibilities for each program. Also, NNSA concurred on a memorandum from EM in June 2021 related to fees for accepting foreign research reactor spent nuclear fuel shipments. This written agreement details the maximum fee that EM will charge to receive spent fuel shipments through May 2029.

EM, however, does not have MOAs or similar written agreements to support ongoing missions with the following three entities:

- **Office of Nuclear Energy.** For processing the domestic research reactor fuel that is part of the office's University Fuel Services program.
- **NNSA.** For processing any future shipments of foreign research reactor spent fuel and other materials that are not specifically covered by an existing MOA or similar written agreement. While the June 2021 memorandum covers fees for accepting foreign research reactor spent fuel, the memorandum does not include specific information such as the number of shipments expected through May 2029, up to date time frames for these shipments, or other terms and conditions for these shipments.
- **NIST.** For processing the fuel from the NIST Center for Neutron Research reactor.

EM officials, as well as officials from NNSA and NIST, said that the agencies and offices have instead relied on less formal ways of strategically managing the spent fuel and other materials that have been, or will be, processed in H-Canyon. These less formal ways included periodic check-ins and discussion, as needed, among officials. EM officials at SRS said that they would like to enter into MOAs for the ongoing missions and would need the support of EM headquarters to do so. Officials from the Office of Nuclear Energy and NIST said that they have not yet experienced any insurmountable challenges, so they have not yet proactively pursued MOAs or similar written agreements with EM for their missions.

DOE's program management policy describes effective program management as organizations working in concert to achieve benefits and advance outcomes toward accomplishing the agency's mission, goals, and objectives.⁹ EM's program management protocol provides requirements and guidance on how EM integrates project and operations activities to accomplish the overall EM program and site program missions.¹⁰ Further, program management leading practices developed by the Project Management Institute, Inc., describe the use of integrated methods to ensure common understanding of work, deliverables, and outcomes and state that proactive planning and management of integration may help achieve desired outcomes.¹¹ An MOA or similar written agreement is one tool that programs can use to enable integration, create a common understanding of work, and document significant interactions.

Officials described some potential challenges associated with not having a written agreement, such as an MOA. These challenges are related to DOE's plans to conclude H-Canyon's missions in the 2030s. For example:

- EM officials at SRS said that they may not be aware of how long programs outside of DOE—for example, NIST—plan to send spent fuel to SRS for processing in H-Canyon. Officials said they were unsure as to whether all levels of NIST officials were fully aware of DOE's plans to stop processing spent fuel in H-Canyon.

- NIST officials noted that they would face a significant challenge if EM does not continue to accept spent fuel for processing in H-Canyon. Officials said they will rely on H-Canyon to process spent fuel into the 2030s and until their reactor can switch to a different type of fuel in the future.
- Office of Nuclear Energy officials said that if EM does not continue to accept spent fuel at SRS, then reactors in its university program may be left without a disposition pathway for the fuel.

By documenting EM's agreements with other programs that rely on H-Canyon in MOAs or similar written agreements, EM would better align all components of work and provide a solid basis on which to plan next steps for the mid- and long-term operation, and eventual shutdown, of H-Canyon.

What are the key safety requirements for H-Canyon operations?

Key nuclear and facility safety requirements for H-Canyon are intended to protect workers, the public, and the environment from consequences associated with an accident at the facility. Key requirements found in DOE regulations generally apply to both DOE and the contractor operating H-Canyon. For example:

- The contractor and DOE must ensure the safety of its nuclear facilities by establishing hazard controls, such as fire protection, criticality protection, conduct of operations, maintenance of safety systems, and others.¹² For example, the contractor must identify hazards and establish controls to ensure safe operations in a documented safety analysis updated at least annually. DOE must also approve of the contractor's analysis and any updates.
- The contractor and DOE must ensure worker safety and health.¹³ For example, the contractor must have a DOE-approved worker safety and health program that reduces or prevents occupational injuries, illnesses, and accidental losses updated at least annually. DOE must follow procedures for investigating and remedying violations of these requirements.
- The contractor and DOE must ensure that individuals are protected from radiation.¹⁴ For example, the contractor must comply with radiation protection programs that contain standards and limits for radiation exposure. DOE may approve and can make modifications to the programs.

These regulations, among others that protect the public and workers, are contained in Chapter III in Title 10 of the *Code of Federal Regulations*.¹⁵

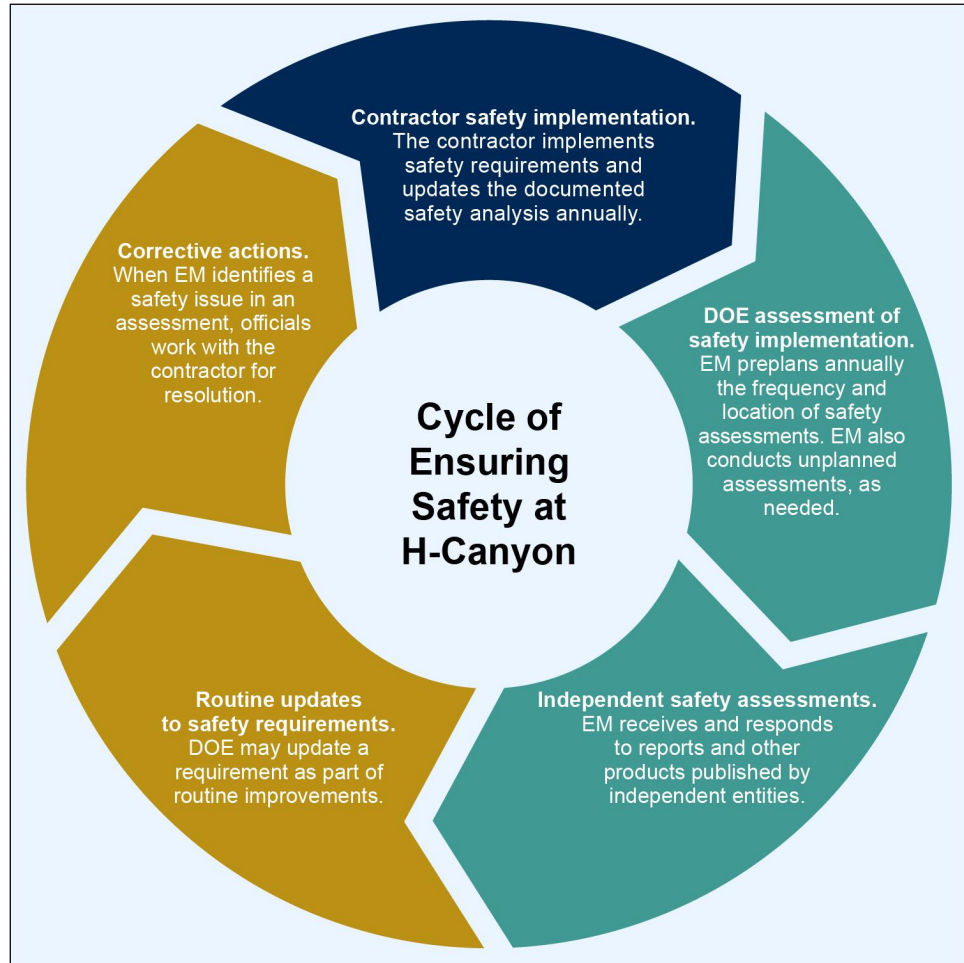
To implement these high-level regulations that contain key safety requirements, DOE provides all staff working at H-Canyon with directives (e.g., DOE orders, policies, or manuals), guidance (e.g., DOE guides), technical standards, and handbooks. For example, DOE's orders contain essential requirements for meeting regulations, while its technical standards and handbooks may contain both required and recommended practices. Guides contain recommended practices.

The contractor may request and receive DOE's approval for an exemption or variance from a safety code or standard if the request satisfies regulatory criteria. SRS officials stated that H-Canyon has not requested an exemption from any safety codes or standards. H-Canyon has received approval for a permanent variance from certain fire protection codes and standards. In these instances, it uses an alternative method of operation that provides an equivalent level of facility safety.

How does DOE assess H-Canyon’s ability to meet safety requirements?

The contractor operating H-Canyon implements safety requirements, and EM assesses the implementation of those requirements via safety assessments (see fig. 3).

Figure 3: Cycle of Ensuring Safety at the Savannah River Site’s H-Canyon Facility



Source: GAO analysis of Department of Energy (DOE) and Office of Environmental Management (EM) documents. | GAO-24-106494

Accessible Data for Figure 3: Cycle of Ensuring Safety at the Savannah River Site’s H-Canyon Facility

Cycle of Ensuring Safety at H-Canyon

- **Contractor safety implementation:** The contractor implements safety requirements and updates the documented safety analysis annually.
- **DOE assessment of safety implementation:** EM preplans annually the frequency and location of safety assessments. EM also conducts unplanned assessments, as needed.
- **Independent safety assessments:** EM receives and responds to reports and other products published by independent entities.
- **Routine updates to safety requirements:** DOE may update a requirement as part of routine improvements.
- **Corrective actions:** When EM identifies a safety issue in an assessment, officials work with the contractor for resolution.

Source: GAO analysis of Department of Energy (DOE) and Office of Environmental Management (EM) documents. | GAO-24-106494

EM routinely reviews and inspects safety implementation at H-Canyon through planned and unplanned assessments. With the streamlined processing of spent fuel in H-Canyon, EM officials at SRS and documentation stated that H-Canyon has reduced operational and maintenance activities and, therefore, reduced safety concerns like potential exposure to radiation.

EM officials at SRS said resources needed to complete assessments vary. Some assessments take a single staff member a few days to complete or can be as simple as staff pointing out issues during a walk-through. Other assessments take a team of staff more than a month to complete. Table 1 lists examples of EM's safety assessments and the DOE orders that govern these assessments and help staff carry out high-level regulations.

Table 1: Examples of Safety Assessments for H-Canyon Facility Conducted by the Office of Environmental Management (EM)

What is a key safety assessment requirement?	What are examples of how EM assesses implementation of the requirement?	How often does EM conduct the assessment?
EM is responsible for ensuring that the contractor implements facility and programmatic safety requirements at H-Canyon, including fire protection and criticality protection. ^a	EM reviews and approves of the contractor's documented safety analysis. EM reviews and approves of revisions to the documented safety analysis.	Planned, annual Planned, as needed, per revision schedule
EM is responsible for ensuring that the conduct of operations at H-Canyon minimizes the likelihood and consequences of human fallibility or technical and organizational system failures. ^b	EM conducts facility tours to observe and assess operations activities. EM conducts assessments to observe and assess operations activities.	Nonplanned, daily Planned, daily, monthly, every other month, and quarterly
EM is responsible for ensuring that maintenance activities and programs comply with requirements, including reliable performance of structures, systems, and components. ^c	EM conducts facility tours to observe and assess maintenance activities. EM conducts assessments to observe and assess maintenance activities.	Nonplanned, daily Planned, quarterly
EM is responsible for ensuring that contractors implement worker safety requirements, providing technical direction, and reviewing contractor requests to be exempt from or to deviate from worker safety and protection requirements. ^d	EM reviews and approves the contractor's worker safety and health program, as well as processes related to hazard prevention, identification, and assessment.	Planned, annual
EM is responsible for ensuring that radiation exposure of individuals is within dose limits, as well as ensuring that capabilities are maintained to monitor and assess radiological releases. ^e	EM assesses standards for internal and external exposure and radiation safety training, among other aspects of the contractor's radiation protection efforts.	Planned, annual

Source: GAO analysis of Department of Energy (DOE) orders, EM assessments, and interviews with EM officials. | GAO-24-106494

Note: We listed the frequency that EM conducted assessments for fiscal year 2023.

^aDOE, *Facility Safety*, Order 420.1C, Chg 3 (LtdChg) (Washington, D.C.: Nov. 14, 2019).

^bDOE, *Conduct of Operations*, Order 422.1, Chg 4 (LtdChg) (Washington, D.C.: Feb. 3, 2022). Conduct of operations consists of "formal documentation, practices, and actions implementing disciplined and structured operations that support mission success and promote worker, public, and environmental protection." *Id.* at 7.

^cDOE, *Maintenance Management Program for DOE Nuclear Facilities*, Order 433.1B, Chg 3 (Admin Chg) (Washington, D.C.: Mar. 12, 2013).

^dDOE, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*, Order 440.1B, Chg 4 (Admin Chg) (Washington, D.C.: May 2, 2022).

^eDOE, *Radiation Protection of the Public and the Environment*, Order 458.1, Chg 4 (LtdChg) (Washington, D.C.: Sept. 15, 2020).

After conducting assessments, EM officials at SRS determine a path forward for any issues identified. Officials said they use both formal and informal approaches to raising and addressing issues with the contractor. Informally, officials use an in-person conversation, phone call, or email exchange with the contractor to address a minor issue. Formally, officials said they can request that the contractor issue a corrective action plan for a major issue, when needed. Officials said that they have not recently had to request that the contractor issue a corrective action plan.

Although EM officials at SRS spoke positively about safety implementation and assessment at H-Canyon, they also noted staffing shortages for completing these assessments. For example, recent retirements have decreased the number of experienced staff available for assessments. Officials said that they have managed this issue by temporarily using fully trained staff assigned to other SRS facilities to assess safety at H-Canyon.

Beyond conducting assessments, EM engages with independent entities that also assess safety at H-Canyon.

- **DOE’s Office of Enterprise Assessments** is an organizationally independent entity that reports directly to the Secretary of Energy on the safety of DOE employees and the public, among other topics. EM officials at SRS and Enterprise Assessments officials said they meet at least annually to discuss report topics. Officials from the Office of Enterprise Assessments generally have commended safety at H-Canyon and did not identify major findings related to H-Canyon over the past 10 years.
- **The Defense Nuclear Facilities Safety Board** (Board) is an independent organization established by Congress in 1988 responsible for providing recommendations and advice to the Secretary of Energy regarding public health and safety issues at DOE defense nuclear facilities. EM officials at SRS engage daily with on-site Board resident inspectors, who monitor H-Canyon, in addition to other SRS defense nuclear facilities. The Board has published letters, reports, and weekly resident inspector reports that include H-Canyon. The Board’s resident inspectors told us about some recurring issues within the past few years, such as radiological spills, but highlighted the breadth and thoroughness of DOE facility representative safety assessments at H-Canyon.

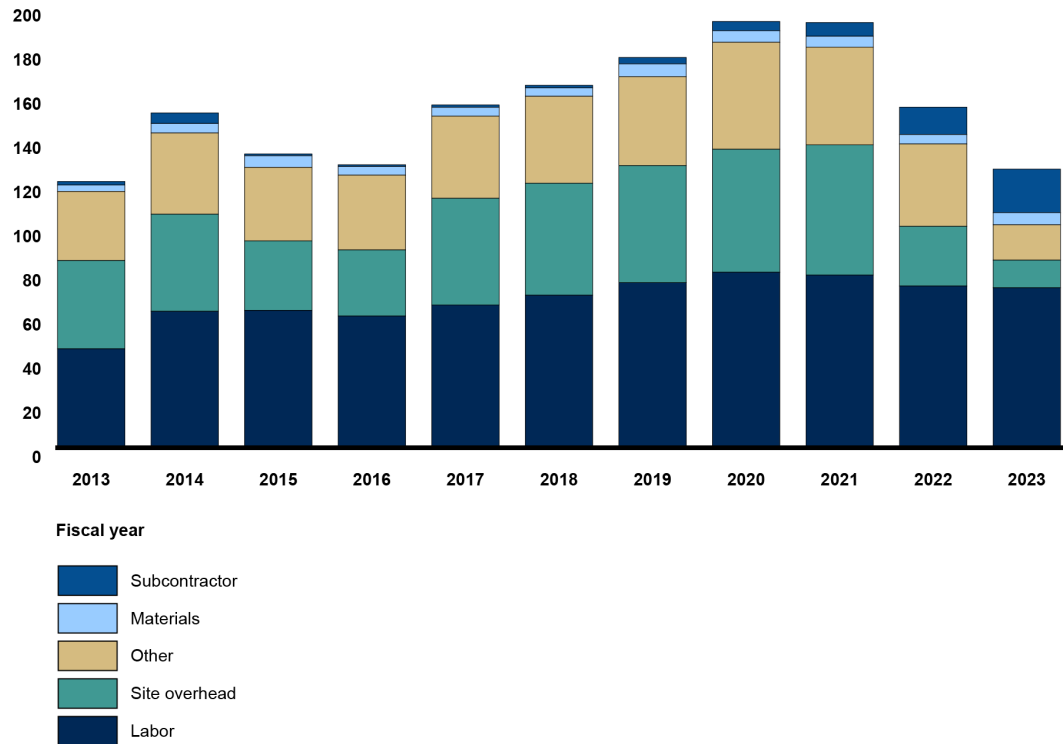
How much has H-Canyon cost to operate since 2013?

Annual contractor costs averaged just over \$154 million, adjusted for inflation, from fiscal years 2013 through 2023 (see fig. 4).¹⁶ The contractor reported operating costs divided into five categories:

- **Labor.** The labor category includes any labor cost identified as only supporting H-Canyon operations.
- **Materials.** The materials category includes costs of raw materials, parts, and manufacturing supplies identified as only supporting H-Canyon operations.
- **Subcontractor.** The subcontractor category includes costs for work performed by a subcontractor hired by the contractor identified as only supporting H-Canyon operations.
- **Other.** The other category includes costs other than labor, material, site overhead, and subcontractor identified as only supporting H-Canyon operations. This category includes the cost of utilities.
- **Site overhead.** The site overhead category includes costs that cannot be identified as supporting H-Canyon operations only. These costs are expended for the common benefit of multiple SRS facilities, such as landlord services, general and administrative services, and legacy pension benefits.

Figure 4: Inflation-Adjusted Contractor Operating Costs for H-Canyon Facility, Fiscal Years 2013–2023

Dollars (millions, adjusted for inflation)



Source: GAO analysis of Department of Energy data. | GAO-24-106494

Accessible Data for Figure 4: Inflation-Adjusted Contractor Operating Costs for H-Canyon Facility, Fiscal Years 2013–2023

Fiscal Year (FY)	FY2013 Inflated	FY2014 Inflated	FY2015 Inflated	FY2016 Inflated	FY2017 Inflated	FY2018 Inflated	FY2019 Inflated	FY2020 Inflated	FY2021 Inflated	FY2022 Inflated	FY2023 Deflated
Labor	44.7	61.7	62.1	59.6	64.6	69.0	74.7	79.4	78.1	73.2	72.4
Materials	2.9	4.3	5.3	3.9	4.0	3.8	5.8	5.2	4.9	4.3	5.5
Subcontractor	1.6	4.8	0.8	0.8	1.1	1.2	2.9	4.2	6.2	12.4	19.7
Other	31.3	36.8	33.3	33.9	37.2	39.4	40.3	48.5	44.3	37.3	16
Site overhead	40.0	44.0	31.5	29.9	48.3	50.7	53.0	55.7	59.0	27.0	12.5
Total contractor costs	120.6	151.7	133.0	128.2	155.1	164.0	176.7	193.0	192.6	154.2	126.2

Source: GAO analysis of Department of Energy data. | GAO-24-106494

Note: GAO used the fiscal year 2022 gross domestic product price index to adjust for inflation. All categories—except site overhead—include costs identified as supporting only H-Canyon operations. The other category includes the cost of utilities. The site overhead category includes costs expended for the common benefit of multiple facilities at the Savannah River Site, such as general and administrative services.

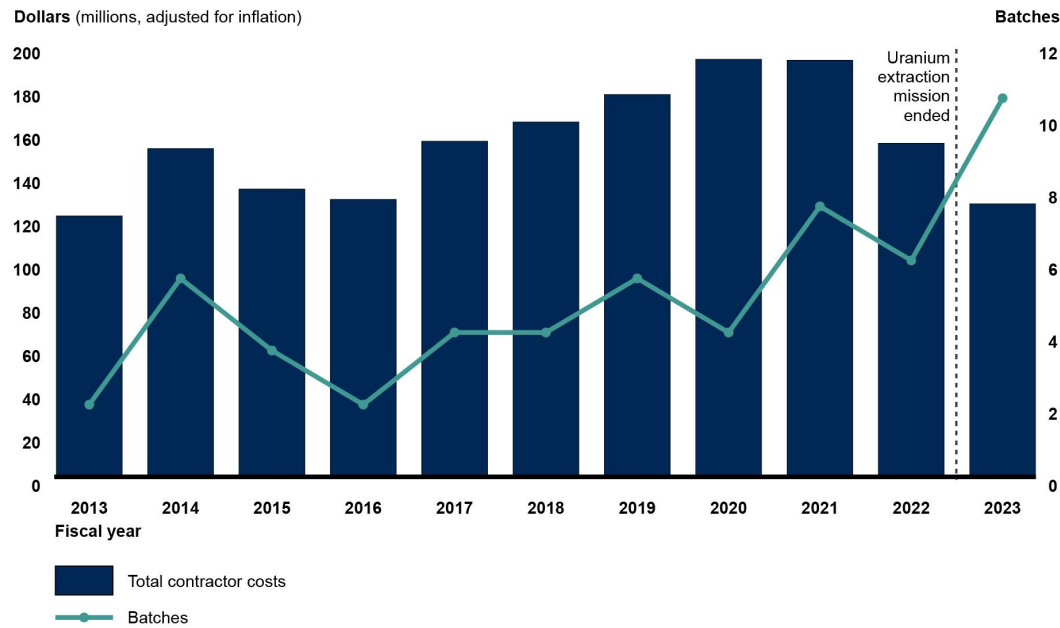
Beyond the contractor operating costs, EM may spend additional funds related to H-Canyon operations, maintenance, and upgrades. EM has paid an award fee to the contractor for meeting key operational performance objectives each year. The average award fee was \$11.8 million, adjusted for inflation, from fiscal years 2013 through 2023. EM may also use funds to support maintenance or upgrades to H-Canyon. For example, EM officials at SRS said that they have replaced system parts, such as the motor on one of the cranes used in the facility, which constitutes maintenance. Officials also said that they have upgraded a camera for one of the cranes to improve its operation, which constitutes an upgrade.

What factors affected the cost to operate H-Canyon?

EM officials at SRS said that the actual costs to operate H-Canyon have varied over time, although the overall budget has generally been flat, due to a few factors:

Number of batches processed. Costs increase as H-Canyon processes more batches of spent fuel and other materials. However, costs do not rise considerably, as many costs are fixed, not variable. Therefore, once H-Canyon is in a “high state of readiness” (per its statutory requirement) to process one batch of spent fuel, it can process additional batches for little additional costs. Although H-Canyon will be processing significantly larger volumes of spent fuel over many more batches during the accelerated L-Basin de-inventory mission, it will not be extracting and recovering uranium. Skipping these steps will decrease the complexity and cost per batch of processing (see fig. 5).

Figure 5: Batches of Spent Nuclear Fuel Processed, and Inflation-Adjusted Contractor Operating Costs at H-Canyon Facility, Fiscal Years 2013–2023



Source: GAO analysis of Department of Energy (DOE) information. | GAO-24-106494

Accessible Data for Figure 5: Batches of Spent Nuclear Fuel Processed, and Inflation-Adjusted Contractor Operating Costs at H-Canyon Facility, Fiscal Years 2013–2023

Fiscal Year (FY)	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Batches*	2	5.5	3.5	2	4	4	5.5	4	7.5	6	10.5
Total contractor costs	120.6	151.7	133.0	128.2	155.1	164.0	176.7	193.0	192.6	154.2	126.2

Source: GAO analysis of Department of Energy (DOE) information. | GAO-24-106494

Note: GAO used the fiscal year 2022 gross domestic product price index to adjust for inflation. To accelerate the DOE’s L-Basin de-inventory effort, Environmental Management stopped extracting and recovering uranium in H-Canyon for other use in 2022. Batches vary in volume, depending on the type of spent nuclear fuel processed and the dissolver used. Specifically, batches processed in one dissolver are half the volume of another dissolver. Figure 5 represents the number of batches processed, as converted to the larger dissolver’s volume equivalent.

Funding received from other federal programs. Programs that send spent fuel and other materials to SRS contribute funding for H-Canyon’s operating costs. For example, NNSA officials said that certain countries have paid EM an acceptance fee for receipt of their spent nuclear fuel from research reactors since 1996. In 2016, JAEA agreed to provide about \$81.8 million through a contract with NNSA for disposition of fuel. If the cost of disposition exceeds the funding provided by Japan, NNSA will be responsible for requesting additional appropriated funds. Other programs that rely on H-Canyon fund the transport of domestic spent fuel to SRS. EM is responsible for all costs associated with storing and processing the spent fuel from domestic research reactors—so the cost of processing spent fuel from these domestic users is included in the actual costs.

Shutting down certain processes. EM officials at SRS said that shutting down processes in H-Canyon helps to decrease costs. For example, they have shut down the processes used to extract and recover uranium and do not plan to upgrade or maintain related equipment. These processes would be difficult to restart. Officials said they are operating under the assumption that H-Canyon will have limited use after the accelerated L-Basin de-inventory mission concludes.

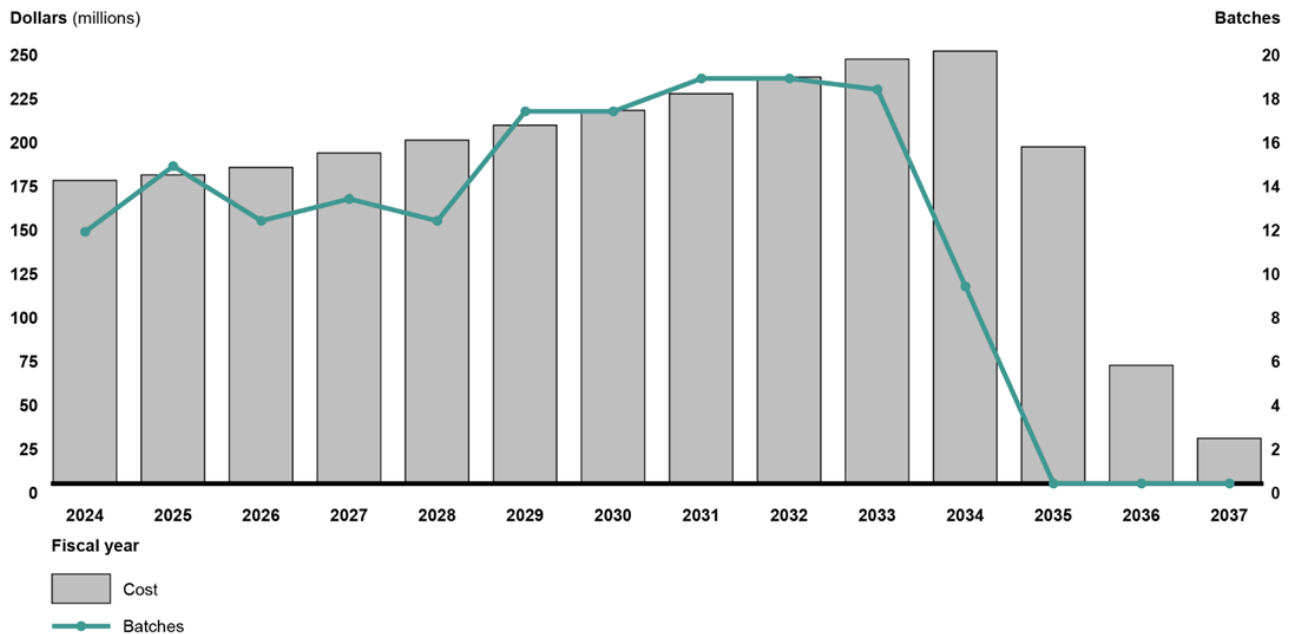
Decreasing site overhead costs. EM officials at SRS said that site overhead expenses have decreased in recent years as a percentage of overall costs at H-Canyon, and they expect a continued decrease. This is because site overhead expenses are shared across all SRS facilities. As NNSA’s mission at other SRS facilities grows, it will take on a larger share of site overhead expenses. In addition, the cost of legacy pensions is expected to decrease.

What are DOE’s future plans for H-Canyon?

DOE plans to continue H-Canyon operations with relatively stable cost estimates through fiscal year 2034 and has two ongoing planning efforts for processing and managing spent nuclear fuel and other materials after H-Canyon’s current missions end.

EM officials and contractor representatives at SRS said they plan to keep costs relatively stable through fiscal year 2034. However, they have increased cost estimates for anticipated labor, utilities, and some facility modifications. Officials said they have intentionally planned their budget requests for H-Canyon to remain relatively stable over the accelerated L-Basin de-inventory mission so that the mission may receive a consistent level of funding. Officials and representatives said costs will decrease during fiscal years 2035 to 2037 due to wrapping up H-Canyon’s missions (see fig. 6).

Figure 6: Cost and Batch Estimates for H-Canyon Facility through the Accelerated L-Basin De-Inventory Mission, Fiscal Years 2024–2037



Source: GAO analysis of Department of Energy (DOE) information. | GAO-24-106494

Accessible Data for Figure 6: Cost and Batch Estimates for H-Canyon Facility through the Accelerated L-Basin De-Inventory Mission, Fiscal Years 2024–2037

Fiscal Year (FY)	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37
Cost Estimate	173.1	176.2	180.5	188.7	196.1	204.6	213.1	222.6	232.1	242.3	246.9	192.2	67.5	25.8
Batches estimate*	17.5	17.5	18	18	18	18	18	18	18	18	10	0	0	0

Source: GAO analysis of Department of Energy (DOE) information. | GAO-24-106494

Note: DOE officials said they used a rate of 2.7 percent to adjust for inflation. Batches vary in volume, depending on the type of spent nuclear fuel processed and the dissolver used. Specifically, batches processed in some dissolvers are half the volume of the other dissolver. Figure 6 represents DOE's November 2023 estimate of the number of batches to be processed, as converted to the larger dissolver's volume equivalent.

DOE has two ongoing planning efforts for processing and managing spent nuclear fuel and other materials after H-Canyon's current missions end. Both efforts have recognized the necessary balance between ongoing missions—such as those of federal programs with the need to dispose of nuclear materials—and cleanup missions—such as that of SRS's liquid waste system.

Future need for DOE nuclear material processing capability. EM leads an integrated project team focused on DOE's future infrastructure needs comprised of officials from other DOE programs and NNSA. The team aims to develop a mission needs statement for nuclear materials infrastructure. As of November 2023, the team's draft mission needs statement and plan for nuclear materials infrastructure is awaiting management review and approval. The team may continue efforts related to assessing how DOE may meet the identified mission need and may expand participants to include other federal agencies, DOE laboratories, and contractors. EM officials said the team understands the technical challenges of continuing operation at the H-Canyon facility and is focused on preserving the nuclear materials processing capability at H-Canyon or elsewhere. Officials said they signed the charter for the team in March 2023 and have met twice per month.

Future of DOE spent nuclear fuel management. EM leads a future spent nuclear fuel receipts working group that includes other DOE programs and NNSA. The working group aims to plan an integrated approach to receiving, storing, and managing current and future spent fuel inventory under DOE ownership. EM officials said that the working group plans to issue a report by the end of 2023, potentially recommending that EM develop a spent fuel management strategy for after the conclusion of H-Canyon's accelerated L-Basin de-inventory mission. The group has met twice a month since March 2023, according to officials.

Conclusions

Leading up to the eventual closure of H-Canyon in the 2030s, DOE is optimizing its use of H-Canyon to support, and better align with, some of EM's environmental cleanup plans for SRS. To help ensure the success of this effort, DOE has integrated its plans for H-Canyon at the site level, as well as at the program level for those federal programs that rely on H-Canyon operations.

While EM has written agreements, including MOAs, with some of the programs that rely on H-Canyon, EM does not have such agreements with other programs that also have ongoing mission needs. Officials stated that the MOAs and similar written agreements have provided benefits to DOE, such as helping to align programs' expectations with EM's plans for H-Canyon's operations and storage in L-Basin. Documenting EM's agreements would help the office ensure that all federal programs that rely on H-Canyon understand each other's roles and responsibilities and time frames for each mission. In preparing such written agreements, EM could communicate DOE's plans to stop processing spent fuel in H-Canyon so that federal programs relying on H-Canyon can appropriately plan for the storage or disposition of their nuclear materials. These materials must be safely stored or disposed of to mitigate risks to public safety, health, and the environment.

Recommendations for Executive Action

We are making three recommendations to DOE. Specifically:

The Secretary of Energy should ensure that the Senior Advisor of EM and the Assistant Secretary of the Office of Nuclear Energy enter into a written agreement for the planned use of H-Canyon to process any future shipments of domestic research reactor fuel, including fuel from the University Fuel Services program. (Recommendation 1)

The Secretary of Energy should ensure that the Senior Advisor of EM and the Administrator of NNSA enter into a written agreement for the planned use of H-Canyon to process any future shipments of foreign research reactor fuel not already included in an MOA or written agreement. (Recommendation 2)

The Secretary of Energy should direct the Senior Advisor of EM to work with the Director of NIST to enter into a written agreement for the planned use of H-Canyon to process any future shipments of domestic research reactor fuel from the NIST Center for Neutron Research program. (Recommendation 3)

Agency Comments

We provided a draft of this report to DOE and NIST for review and comment. In its comments, reproduced in appendix I, DOE concurred with our recommendations. DOE and NIST provided technical comments, which we incorporated as appropriate.

How GAO Did This Study

We assessed documents and data related to DOE's integration of plans for H-Canyon operations, as well as to the safety and cost of H-Canyon. Specifically, we reviewed relevant DOE planning documents that detail DOE's actions to integrate plans for H-Canyon at the site and program levels. We reviewed relevant laws, regulations, and orders on safety and EM's related procedures, planning documents, and assessments.

We analyzed past cost data from fiscal years 2013 through 2023 and cost estimates for fiscal years 2024 through 2037. We used the fiscal year 2022 gross domestic product price index to adjust past cost data for inflation. We assessed the reliability of the data by interviewing DOE officials about their data management practices and reviewing relevant documentation. We determined that the data are sufficiently reliable for describing past costs and cost estimates of H-Canyon operations.

We visited SRS to help us understand H-Canyon's role in spent fuel and other nuclear materials disposition, as well as integration of H-Canyon with other facilities at the site. As part of our site visit, we interviewed EM officials and contractor representatives to gain their views on integration of plans, safety, and cost related to H-Canyon. In addition, we interviewed officials from other DOE programs, NNSA, and NIST to help us understand their programs' mission reliance on H-Canyon. We also interviewed officials from independent entities, such as from the Defense Nuclear Facilities Safety Board, to gain their views on safety at H-Canyon.

We conducted this performance audit from January 2023 to December 2023 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.

List of Addressees

The Honorable Jack Reed
Chairman
The Honorable Roger Wicker
Ranking Member
Committee on Armed Services
United States Senate

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

The Honorable Mike Rogers
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Chuck Fleischmann
Chair
The Honorable Marcy Kaptur
Ranking Member
Subcommittee on Energy and Water Development and Related Agencies
Committee on Appropriations
House of Representatives

GAO Contact Information

For more information, contact: Nathan Anderson, Director, Natural Resources and Environment, andersonn@gao.gov, (202) 512-3841

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A. Nicole Clowers, Managing Director, Congressional Relations, ClowersA@gao.gov, (202) 512-4400

Staff Acknowledgments: Jonathan Gill (Assistant Director), Elizabeth Luke (Analyst in Charge), Adrian Apodaca, Lily Folkerts, Cindy Gilbert, Katrina Pekar-Carpenter, Caitlin Scoville, and Linda Tsang.

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Appendix I: Comments from Department of Energy



Department of Energy

Washington, DC 20585

November 27, 2023

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

Dear Mr. Anderson:

The Department of Energy (DOE) Office of Environmental Management (EM) appreciates the opportunity to comment on the U.S. Government Accountability Office (GAO) Draft Report, GAO-24-106494, *NUCLEAR MATERIALS: DOE Plans for Savannah River Site's H-Canyon Facility* (Report).

The Savannah River Site's (SRS) H-Canyon facility is the only production-scale, radiologically shielded chemical separations facility operating in the United States. This facility remains integral to the disposition of nuclear materials across the DOE complex. DOE appreciates the GAO's recognition that the Department is actively optimizing the use of H-Canyon to support, and better align with EM's environmental cleanup plans at SRS while balancing future mission needs. DOE recognizes the technical, cost, and staffing challenges associated with the H-Canyon operations and will complete its evaluation on maintaining this unique capability for future mission needs.

H-Canyon's current mission includes processing spent nuclear fuel and other materials stored in L-Basin; processing a unique type of fuel from the Japan Atomic Energy Agency; and converting some available uranium solutions to another form. In 2022, the Department granted approval for SRS operations to move forward with a new approach to disposition, called the Accelerated Basin De-inventory, which is anticipated to result in a life cycle cost reduction and a more than 20-year acceleration over the prior approach.

Thank you for the opportunity to review the Report and the recognition that DOE is integrating plans at the site and program levels for the National Nuclear Security Administration, the Office of Science, the Office of Nuclear Energy, and the National Institute of Standards and Technology. The Department understands the importance of robust collaboration between programs and in support of these efforts, we have established written agreements and concur with GAO's recommendations to establish additional agreements.

EM's response to the recommendations and technical and general comments are provided as enclosures. If you have any questions, please contact me or Mr. Dae Y. Chung, Associate Principal Deputy Assistant Secretary for Corporate Services, at (202) 586-9636.

Sincerely,

A handwritten signature in blue ink, appearing to read "Wm White", with a long horizontal flourish extending to the right.

William I. White
Senior Advisor for Environmental Management

Enclosures

Management Response to Recommendations
GAO-24-106494 Draft Report
NUCLEAR MATERIALS: DOE Plans for Savannah River Site's H-Canyon Facility

Recommendation 1: The Secretary of Energy should ensure that the Assistant Secretary of Environmental Management (EM) and the Assistant Secretary of the Office of Nuclear Energy (NE) enter into a written agreement for the planned use of H-Canyon to process any future shipments of domestic research reactor fuel, including fuel from the University Fuel Services program.

Management Response: Concur

The Department of Energy (DOE) already actively prepares and plans its storage and processing of domestic research reactor fuel. This is an integral part of DOE's initiative to provide safe and secure storage and disposition of excess weapons-usable materials. EM and NE will develop a written agreement describing the collaborative process the two programs will use to plan shipments and receipts of domestic research reactor fuel.

Estimated Completion Date: December 2024

Recommendation 2: The Secretary of Energy should ensure that the Senior Advisor of EM and the Administrator of the National Nuclear Security Administration (NNSA) enter into a written agreement for the planned use of H-Canyon to process any future shipments of foreign research reactor fuel not already included in a memorandum of agreement (MOA) or written agreement.

Management Response: Concur

DOE already actively prepares and plans its storage and processing of foreign research reactor fuel. This is an integral part of DOE's initiative to provide safe and secure storage and disposition of excess weapons-usable materials. EM and NNSA will develop a written agreement describing the collaborative process the two programs will use to plan shipments and receipts of foreign research reactor fuel not already included in an MOA or written agreement.

Estimated Completion Date: December 2024

Recommendation 3: The Secretary of Energy should direct the Assistant Secretary of EM to work with the Director of National Institute of Standards and Technology (NIST) to enter into a written agreement for the planned use of H-Canyon to process any future shipments of domestic research reactor fuel from the NIST Center for Neutron Research program.

Management Response: Concur

EM receives spent nuclear fuel from the NIST Center for Neutron Research, one of the world's premier neutron research facilities. EM will work with NIST to develop a written agreement describing the collaborative process that will be used to plan shipments and receipts of domestic research reactor fuel from the NIST Center for Neutron Research program.

Estimated Completion Date: December 2024

Accessible Text for Appendix I: Comments from Department of Energy

November 27, 2023

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U.S. Government Accountability Office
Washington, DC 20548

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William I. White
Senior Advisor for Environmental Management

Enclosures

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GAO-24-106494 Draft Report
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Estimated Completion Date: December 2024

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Estimated Completion Date: December 2024

Endnotes

¹Uranium is categorized by concentration of the isotope uranium-235, expressed as a percentage “assay.” Natural uranium must be enriched to increase its assay to the level required for a certain purpose. Highly enriched uranium, which may be used in nuclear weapons, generally has an assay level of at least 20 percent uranium-235.

²S. Rep. No. 117-130, at 364 (2022).

³GAO, *Nuclear Material: DOE Needs to Take Action to Reduce Risks Before Processing Additional Nuclear Material at the Savannah River Site’s H-Canyon*, [GAO-08-840](#) (Washington, D.C.: July 25, 2008).

⁴Under section 3137 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (Pub. L. No. 106-398), as amended by section 3115 of the National Defense Authorization Act for Fiscal Year 2004 (Pub. L. No. 108-136), DOE must continue operations and maintain a “high state of readiness” at H-Canyon and provide necessary technical staff to operate and maintain the facility. 50 U.S.C. § 2633.

⁵Savannah River Nuclear Solutions, LLC, *Accelerated Basin Deinventory (ABD) Program Plan* (Aiken, S.C.: Aug. 2020).

⁶The JAEA Fast Critical Assembly research reactor was used to study the physics characteristics of fast nuclear reactor configurations using highly enriched uranium and plutonium fuels.

⁷Low-enriched uranium, which is typically used in commercial nuclear reactors, has an assay of 3 to 5 percent uranium-235. High-assay low-enriched uranium, which may be used for research and isotope production reactor fuel, has an assay below 20 percent but above the standard 3 to 5 percent uranium-235 used in most commercial reactors.

⁸Project Management Institute, Inc., is a not-for-profit association that provides global standards for project, program, and portfolio management. These standards are generally recognized as leading practices and used worldwide by private companies, nonprofits, and others.

⁹Department of Energy, *Program Management Policy*, Policy 410.3 (Washington, D.C.: Sept. 23, 2021).

¹⁰Department of Energy, Office of Environmental Management, *Program Management Protocol* (Washington, D.C.: Oct. 30, 2020).

¹¹Project Management Institute, Inc., *The Standard for Program Management*, Fourth Edition. (2017).

¹²10 C.F.R. pt. 830, subpt. B. According to DOE regulations, “criticality” is defined as the condition in which a nuclear fission chain reaction becomes self-sustaining. 10 C.F.R. § 830.3(a).

¹³10 C.F.R. pt. 851.

¹⁴10 C.F.R. pt. 835.

¹⁵10 C.F.R. pts. 706 – 963.

¹⁶GAO used the fiscal year 2022 gross domestic product price index to adjust for inflation.