



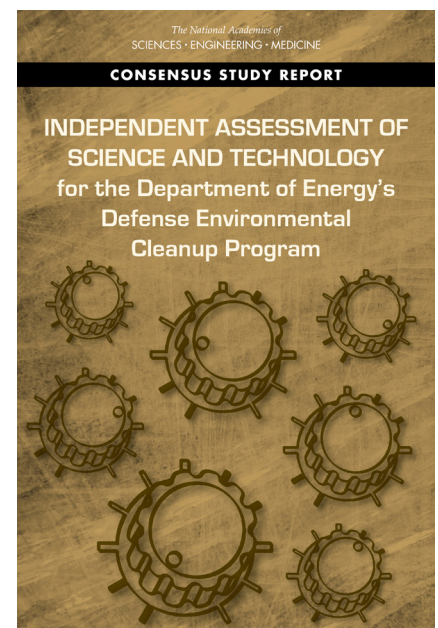
February 2019

## Independent Assessment of Science and Technology for the Department of Energy's Defense Environmental Cleanup Program

The U.S. Department of Energy's Office of Environmental Management (DOE-EM) is responsible for cleaning up 107 sites in 31 states and one territory that were utilized for nuclear weapons development, testing and related activities during the Manhattan Project (1942-1946) and Cold War (1947-1991). The DOE-EM cleanup program began in 1989 and has, over the past 3 decades, cleaned up 91 sites at a cost of about \$170 billion.

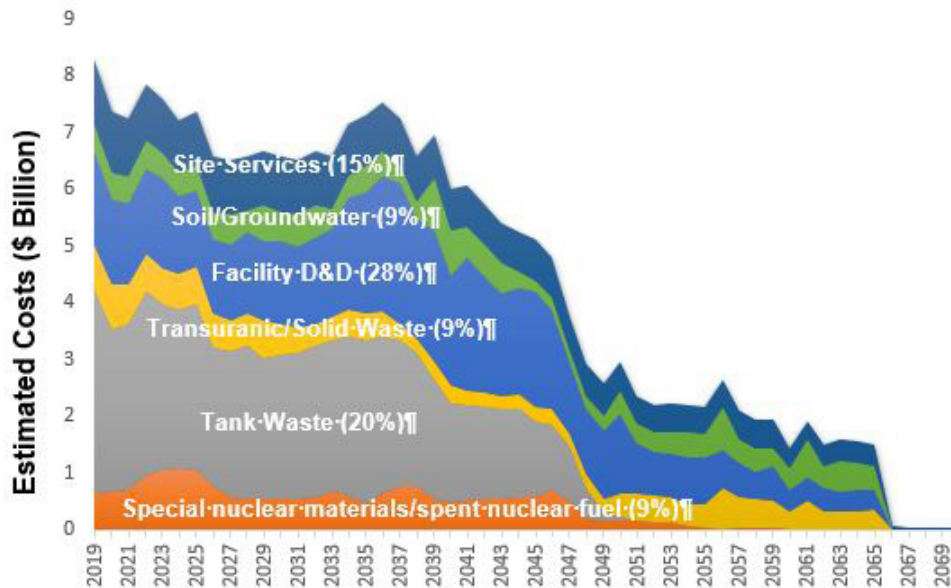
Despite progress, the cleanup program has not yet reached its halfway point from either a cost or a schedule standpoint. The 16 sites remaining to be cleaned include the largest and most complex sites in DOE-EM's portfolio: the Hanford Site in Washington, the Savannah River Site in South Carolina, Oak Ridge Reservation in Tennessee, and the Idaho Site. DOE-EM estimates that cleanup will continue for at least another 50 years (until 2070 or beyond) at a cost of about \$384 billion (see Figure 1.1). If the cleanup mission is expanded to include sites now managed by other DOE entities, the timeline and costs could grow substantially.

The remaining life of the cleanup program provides ample time for new cleanup approaches and technologies to be developed and deployed in order to reduce cleanup costs and schedules, and mitigate cleanup risks and uncertainties. In response to a Congressional request, the National Academies of Sciences, Engineering and Medicine convened a committee of experts to evaluate DOE-EM's technology development efforts and review and assess the types of technologies and alternative approaches for the cleanup program that might be effective in accomplishing those goals.



### THE VALUE OF SCIENCE AND TECHNOLOGY DEVELOPMENT

The National Academies have published more than 100 advisory reports to the federal government on the management and cleanup of nuclear wastes resulting from nuclear weapons production. A recurring theme of many of these reports is the importance of science and technology (S&T) development for DOE-EM's cleanup mission.



**FIGURE 1.1**

Projected lifecycle costs for the DOE-EM cleanup program. The current projection is that the DOE-EM cleanup effort will continue for at least another 50 years (until 2070 or beyond) and the remaining cleanup work is estimated to cost \$384 billion. Tank waste activities account for about 20 percent of the lifecycle costs and facility decontamination and decommissioning for about 28 percent. SOURCE: Integrated Planning, Accountability, and Budgeting System - Information System (IPABS), 9/17/18. Provided by Rod Rimando, Director, Technology Development Office, DOE-EM.

DOE-EM has sponsored S&T development since its creation to improve the efficacy, effectiveness, and safety of its cleanup efforts. Sponsored S&T development has included mission-directed basic scientific research, technology development and demonstration, and technology deployment into the cleanup program. Funding for S&T development (headquarters-directed) has varied substantially over time; it peaked at around 5 percent (about \$300 million) of the annual DOE-EM budget in the 1990s through early 2000s and has declined steadily since then. DOE-EM's S&T budget has been a miniscule (0.3–0.5 percent) portion of the annual DOE-EM budget for at least the past decade.

DOE-EM does not hold a comprehensive list of the technologies it has deployed, therefore it is difficult to link technology advancements with cost and schedule savings. However, the experience from cleaning up large and complex sites, for example Rocky Flats near Denver, Colorado, showed that new technology development can have major impacts in accelerating schedules and reducing costs. The complexity of the remaining cleanup tasks provides an opportunity for S&T to have similar impacts.

## FINDINGS AND RECOMMENDATIONS

To undertake its work, the committee received briefings from national and international subject-matter experts and visited five major DOE-EM sites: Savannah River Site; Hanford Site; Idaho Site; Oak Ridge Reservation and the Portsmouth site, Ohio. The committee's findings and recommendations are listed below.

**Finding 1:** DOE-EM projects that it will spend at least another 50 years and \$377 billion to complete its cleanup of the nuclear weapons complex. These time and cost estimates are highly uncertain—and probably low—because of (1) substantial remaining uncertainties in the cleanup program's lifecycle costs, schedules; and risks; and (2) the possible future inclusion of additional DOE sites and facilities into the DOE-EM cleanup program.

**Recommendation A:** DOE-EM should obtain an independent assessment of the cleanup program's lifecycle costs and schedules from a government engineering organization—for example, the U.S. Army Corps of Engineers—that is specifically focused on identifying key remaining technical risks and uncertainties. DOE-EM should use this assessment to reevaluate the major cleanup challenges it faces, including the timeline and costs associated with addressing them with current S&T investments, and make any necessary adjustments to its S&T development program.

**Finding 2:** Most DOE-EM-related S&T activities are site-based, contractor-driven and managed, and have a short-term focus on addressing technical challenges in existing cleanup projects. DOE-EM headquarters has a limited role in selecting, managing, and coordinating this site-based S&T to ensure that it meets the cleanup program's needs, particularly over the long term and across different sites.

**Finding 3:** DOE-EM's management of S&T is ad hoc and uncoordinated and thus less effective than it should be. DOE-EM lacks formal, documented processes for (1) managing the technology lifecycle—from basic research through technology deployment—and (2) sharing lessons learned, including failures, successes, and good practices, from its technology development and deployment efforts both within and outside of DOE-EM.

**Recommendation B:** DOE-EM should design and implement an S&T management process for identifying, prioritizing, selecting, developing, and deploying the new knowledge and technologies needed to address its cleanup challenges, including the technical risks and uncertainties identified from the assessment in Recommendation A. Independent peer review should be used to evaluate (1) the S&T management process before it is implemented, (2) S&T projects before they are funded, and (3) the overall effectiveness and impact of DOE-EM's S&T efforts.

**Finding 4:** DOE-EM has substantially reduced investments in S&T development over the past 15 years and has focused instead on technology deployment in current cleanup projects. In particular, DOE-EM has demonstrated little to no interest in investing in S&T development that might lead to breakthrough solutions and technologies that can substantially reduce cleanup lifecycle costs, schedules, risks, and uncertainties.

**Recommendation C:** A portion of the technology development effort for the DOE-EM cleanup program should focus on breakthrough solutions and technologies that can substantially reduce cleanup lifecycle costs, schedules, risks, and uncertainties. Such a program would require substantial new funding separate from the DOE-EM budget and a different model for managing research and stimulating innovation. This technology development effort should be:

- **Managed by the Advanced Research Projects Agency—Energy (ARPA-E), a division within**

**DOE with a record of investing in innovative solutions for complex technical challenges.**

- **Informed by the independent assessment of the cleanup program's key remaining risks and uncertainties called for in Recommendation A and the S&T management process for identifying, prioritizing, selecting, developing, and deploying the new knowledge and technologies called for in Recommendation B.**
- **Be independently peer reviewed to evaluate its impact on the cleanup program.**

**DOE-EM should work cooperatively with ARPA-E to identify and implement these breakthrough technologies and solutions into the cleanup program.**

**Finding 5:** The committee identified seven technologies and alternative approaches that could substantially reduce long-term cleanup costs; accelerate cleanup schedules; and mitigate uncertainties, vulnerabilities, or risks, or otherwise significantly improve the cleanup program. These involve changes to the following:

1. Waste chemistry at bulk and interfacial scales to facilitate treatment and disposal.
2. Nuclear properties of waste to facilitate treatment and disposal.
3. Human involvement in cleanup activities to increase cleanup efficiencies and reduce worker risks.
4. Interrogation approaches to characterize wastes and monitor cleanup remedies and environmental impacts.
5. Modeling and visualization approaches to manage large cleanup-related data sets and improve predictive capabilities.
6. Disposal pathways to increase waste disposition options
7. Decision-making approaches to improve the quality and durability of cleanup decisions.

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## COMMITTEE ON INDEPENDENT ASSESSMENT OF SCIENCE AND TECHNOLOGY FOR THE DEPARTMENT OF ENERGY'S DEFENSE ENVIRONMENTAL CLEANUP PROGRAM

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**For More Information . . .** This Consensus Study Report Highlights was prepared by the National Academies of Sciences, Engineering, and Medicine based on the Consensus Study Report *Independent Assessment of Science and Technology for the Department of Energy's Defense Environmental Cleanup Program* (2019). The study was sponsored by the U.S. Department of Energy's Office of Environmental Management. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; <http://www.nap.edu> or via the Nuclear and Radiation Studies Board web page at <http://www.nationalacademies.org/nsrb>.

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