



June 2021

FIREFIGHTING FOAM CHEMICALS

DOD Is Investigating
PFAS and
Responding to
Contamination, but
Should Report More
Cost Information

Accessible Version



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GAO@100 Highlights

Highlights of [GAO-21-421](#), a report to congressional committees

Why GAO Did This Study

DOD has long used PFAS-containing firefighting foam to extinguish fires quickly and keep them from reigniting. PFAS can migrate into the environment (e.g., drinking water) and may have adverse effects on human health. The federal government has issued two nonenforceable advisories but has not yet regulated PFAS in drinking water; some states have adopted PFAS regulations.

Conference Report 116-333, accompanying the National Defense Authorization Act for Fiscal Year 2020, included a provision for GAO to review DOD's response to PFAS contamination. This report (1) describes DOD's progress in the investigation and cleanup of PFAS at its installations, and DOD's actions to address PFAS in drinking water; (2) describes DOD's actual and estimated costs for PFAS investigation and cleanup, and evaluates the extent to which DOD has reported those figures to Congress; and (3) describes DOD's progress in identifying PFAS-free firefighting alternatives.

GAO analyzed DOD data on PFAS cleanup, costs (actual and estimated obligations), and foam alternatives; evaluated DOD's PFAS cost reporting against policy; and interviewed officials from DOD and selected installations and state environmental agencies.

What GAO Recommends

GAO recommends that DOD annually include cost estimates for future PFAS investigation and cleanup—including their scope and any limitations—in the environmental report to Congress. DOD concurred with the recommendation.

View [GAO-21-421](#). For more information, contact Elizabeth A. Field at (202) 512-2775 or fielde1@gao.gov.

June 2021

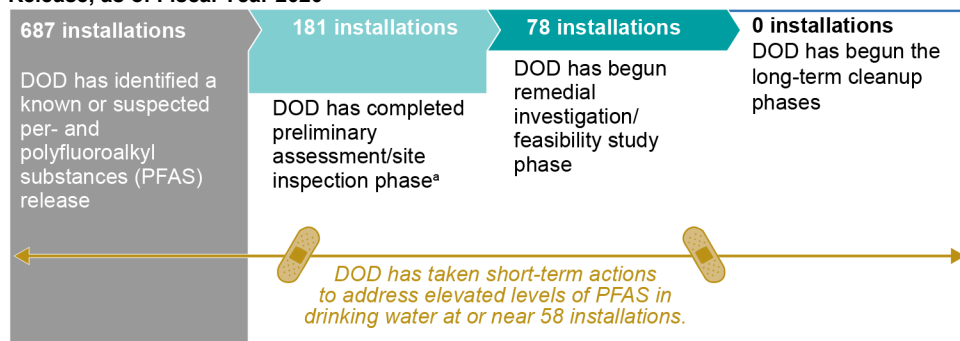
FIREFIGHTING FOAM CHEMICALS

DOD Is Investigating PFAS and Responding to Contamination, but Should Report More Cost Information

What GAO Found

The Department of Defense (DOD) is early in the environmental restoration process at or near the 687 installations with a known or suspected release of certain per- and polyfluoroalkyl substances (PFAS)—heat-resistant chemicals found in certain firefighting foams that can contaminate drinking water (see fig.).

DOD Installations in the Environmental Restoration Process with a Known or Suspected PFAS Release, as of Fiscal Year 2020



Source: GAO analysis of Department of Defense (DOD) information. | GAO-21-421

^aAccording to DOD officials, in fiscal year 2021 the Air Force changed its definition for when this phase is considered complete, resulting in a lower number of DOD installations (129 installations) that had completed this phase as of March 2021.

DOD has taken actions (e.g., providing bottled water, installing water treatment systems) to address PFAS in drinking water at or near its installations when PFAS amounts exceeded federal health advisory levels. DOD generally has not taken actions to address PFAS in drinking water where PFAS amounts were below the federal advisory levels, but above state PFAS standards.

DOD estimates that its future PFAS investigation and cleanup costs will total more than \$2.1 billion beginning in fiscal year 2021, which is in addition to \$1.1 billion in actual PFAS costs incurred through fiscal year 2020. These costs will likely increase significantly, because DOD is still in the early phases of its PFAS investigation. DOD officials also cited regulatory uncertainty at the federal and state levels as a significant challenge in estimating PFAS environmental restoration costs. However, DOD has not reported future PFAS cost estimates, or the scope and limitations of those estimates, in its annual environmental reports to Congress. By reporting this information to Congress, DOD would ensure that Congress has increased visibility into the significant costs and efforts associated with PFAS investigation and cleanup at or near military installations.

As of March 2021, DOD had identified six potential PFAS-free foam candidates; however, PFAS-free foams have been unable to fully meet DOD's current performance requirements. By law, DOD must ensure that a PFAS-free firefighting alternative is available for use at its installations by October 2023. DOD is funding research to address challenges associated with identifying PFAS-free alternatives. DOD plans to continue using PFAS-containing foam aboard ships at sea—as allowed for by the National Defense Authorization Act for Fiscal Year 2020—until a PFAS-free alternative can meet existing requirements.

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Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOD	Department of Defense
EPA	Environmental Protection Agency
OSD	Office of the Secretary of Defense
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate

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June 22, 2021

Congressional Committees

In 1967, a fire on the aircraft carrier USS *Forrestal* stationed off the coast of Vietnam resulted in the deaths of 134 servicemembers. Following this event, the Department of Defense (DOD) began using firefighting foam containing per- and polyfluoroalkyl substances (PFAS)—chemicals with heat-resistant properties that make them effective at extinguishing fires quickly and keeping them from reigniting. During use in fighting fires, PFAS can also migrate into the environment, such as into groundwater or soil, where they can persist for years.

According to the Environmental Protection Agency (EPA), exposure to certain PFAS—such as perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)—may have adverse effects on human health, to include effects on fetal development, the immune system, and the thyroid, and may cause liver damage and cancer.¹ People are most likely to be exposed to PFAS by consuming the chemicals, such as by drinking contaminated water. EPA does not currently regulate PFAS in drinking water.² However, EPA has issued nonenforceable health advisory levels for two of the most studied PFAS—PFOA and PFOS—in

¹PFAS are a group of chemicals that include PFOA, PFOS, and many other chemicals. PFOA and PFOS are the two types of PFAS most produced and studied. Both chemicals are persistent in the environment and the human body, which means that they do not break down and can accumulate over time.

²Under the Safe Drinking Water Act, EPA is required to identify unregulated contaminants that present the greatest health concern, establish a program to monitor drinking water for unregulated contaminants, and decide whether or not to regulate at least five such contaminants every 5 years. EPA decisions about whether or not to regulate these contaminants are called regulatory determinations. EPA completed three cycles of regulatory determinations for a total of 24 contaminants in 2003, 2008, and 2016, deciding not to regulate any of the contaminants. However, in March 2020, EPA proposed a preliminary regulatory determination to regulate PFOA and PFOS. As of January 2021, EPA officials had not indicated a time frame for when a final regulation would be issued but stated that the regulatory process typically takes several years to complete. For more information on EPA's efforts to regulate certain PFAS in drinking water, see GAO, *Man-Made Chemicals and Potential Health Risks: EPA Has Completed Some Regulatory-Related Actions for PFAS*, [GAO-21-37](#) (Washington, D.C.: Jan. 27, 2021).

drinking water.³ In the absence of federal regulations, some states have adopted or are developing their own regulatory standards for PFAS. For example, Massachusetts and Michigan have each adopted regulations that limit the amount of PFAS in drinking water, and these levels are more stringent than the EPA's advisory levels.⁴

As health and environmental concerns exist with the use of PFAS-containing firefighting foam, the National Defense Authorization Act for Fiscal Year 2020 requires DOD to ensure that a PFAS-free firefighting agent is available for use by October 1, 2023.⁵ The law also prohibits DOD from using PFAS-containing foams at installations starting on October 1, 2024, subject to certain conditions.⁶ In response, DOD is funding research into developing and identifying PFAS-free alternatives.

Conference Report 116-333, accompanying the National Defense Authorization Act for Fiscal Year 2020, included a provision for us to review DOD's response to PFAS contamination.⁷ This report (1) describes DOD's progress in the investigation and cleanup of PFAS at its installations, and DOD's actions to address PFAS in drinking water; (2) describes DOD's actual and estimated costs for PFAS investigation and cleanup, and evaluates the extent to which DOD has reported those

³EPA, *Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)*, EPA 822-R-16-005 (May 2016); *Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)*, EPA 822-R-16-004 (May 2016). EPA's May 2016 health advisory levels for PFOA and PFOS in drinking water, either individually or combined, are 70 parts per trillion (one part per trillion is comparable to one drop in a swimming pool covering the area of a football field, 43 feet deep). EPA health advisories are nonenforceable and nonregulatory. These advisories provide information on contaminants not subject to drinking water regulations, including those that can cause human health effects and are known or anticipated to occur in drinking water.

⁴In 2020, both Michigan's and Massachusetts' new regulatory limits for PFOA and PFOS went into effect. Michigan's maximum contaminant level is 8 parts per trillion for PFOA and 16 parts per trillion for PFOS. Massachusetts' maximum contaminant level is 20 parts per trillion for both PFOS and PFOA. EPA's lifetime health advisory level for PFOS and PFOA is 70 parts per trillion. EPA's health advisories are nonenforceable and nonregulatory.

⁵National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, § 322(a)(1) (Dec. 20, 2019).

⁶For example, the prohibition does not apply to shipboard use of firefighting foam, and the Secretary of Defense can waive the prohibition for up to 2 years with congressional notification.

⁷H.R. Rep. No. 116-333, at 1190 (2019).

figures to Congress; and (3) describes DOD's progress in identifying PFAS-free firefighting alternatives.

For our first objective, we reviewed DOD's manual on the management of the Defense Environmental Restoration Program to determine how the department conducts environmental restoration activities to reduce risk to human health and the environment.⁸ We analyzed DOD data to determine, as of the end of fiscal year 2020, which U.S. installations had an actual or suspected PFAS release; what phase of the environmental restoration process those installations had reached; and which installations had reported taking actions to address the presence of PFAS in drinking water. We also discussed this information with officials from the Office of the Secretary of Defense (OSD), the military departments, and the Defense Logistics Agency.⁹ We reviewed documentation, conducted interviews, and examined the data for obvious anomalies, and we found the data to be sufficiently reliable for our purposes of describing DOD's PFAS investigation and cleanup progress.

We also selected a nonprobability sample of eight of the 55 military installations that had a remedial investigation ongoing or planned, as of March 2020, reflecting the most recent data available at the time we made this selection.¹⁰ Specifically, we selected one installation from each military department (Army, Navy, and Air Force) by type of installation (active, closed, and National Guard).¹¹ In selecting installations, we also considered whether any state-level PFAS regulations or guidance existed in the installation's state; whether the installation had responded to PFAS in drinking water; and the installation's actual or expected PFAS investigation and cleanup costs. We interviewed installation officials to

⁸DOD Manual 4715.20, *Defense Environmental Restoration Program (DERP) Management* (March 9, 2012) (Incorporating Change 1, Aug. 31, 2018).

⁹The military departments are the Department of the Army, the Department of the Navy (which includes the Marine Corps), and the Department of the Air Force.

¹⁰The remedial investigation occurs during the second phase of DOD's environmental restoration process and includes collecting detailed information to characterize site conditions, determining the nature and extent of the contamination, and evaluating risks to human health and the environment.

¹¹We selected three active installations (Joint Base Lewis-McChord, Washington; Marine Corps Logistics Base Barstow, California; Cannon Air Force Base, New Mexico); three closed installations (Fort Devens, Massachusetts; Naval Air Station Joint Reserve Base Willow Grove, Pennsylvania; Reese Air Force Base, Texas); and two National Guard installations (Camp Grayling, Michigan; Horsham Air Guard Station, Pennsylvania).

understand how they have responded to PFAS contamination and the extent to which they have incorporated any state PFAS regulations into the response. For each selected installation we also interviewed or obtained information from state environmental agency officials where the installation is located, to understand any PFAS regulations or guidelines that the state had issued and the extent to which DOD had incorporated any applicable state regulations or guidelines into its PFAS response.

For our second objective, we analyzed DOD data on the actual costs through fiscal year 2020 and the estimated costs beginning in fiscal year 2021 associated with PFAS investigation and cleanup at DOD's installations.¹² We analyzed these data from fiscal year 2020 to identify DOD's actual costs (through fiscal year 2020) and estimated costs (beginning in fiscal year 2021) for the investigation and cleanup of PFAS. We assessed the reliability of DOD's cost data by examining the data for obvious anomalies or inconsistencies and by interviewing OSD, military department, and installation officials regarding how they developed estimates. We found these data to be sufficiently reliable for our purposes of reporting DOD's current cost estimates for PFAS investigation and cleanup.

Further, we reviewed DOD's annual reports to Congress on its defense environmental programs (which we refer to as DOD's environmental report to Congress) for fiscal years 2016 through 2019 to identify what information the department had reported to Congress on PFAS costs.¹³ We compared the information DOD had reported with the requirements in the department's manual on the management of its environmental restoration program.¹⁴ For example, the manual states that DOD components (which include the military departments and the Defense Logistics Agency) should develop cost-to-complete estimates for

¹²For the purposes of our report, we use "costs" to refer to actual and estimated obligations. An obligation is incurred when an agency places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another.

¹³At the time of our review, DOD had not released its annual report to Congress on its environmental programs for fiscal year 2020.

¹⁴DOD Manual 4715.20.

environmental restoration activities to support DOD's environmental report to Congress.¹⁵

For our third objective, we reviewed the National Defense Authorization Act for Fiscal Year 2020 to identify the legal requirements for DOD to develop a PFAS-free firefighting alternative and cease using firefighting foam containing PFAS.¹⁶ We reviewed DOD's current military specification to identify the performance and other requirements for existing firefighting foam.¹⁷ In addition, we analyzed DOD documentation on projects related to researching, developing, testing, and evaluating PFAS-free alternatives. Further, we interviewed DOD officials to discuss the progress they have made in finding PFAS-free alternatives to the current firefighting foam, the challenges they face in doing so, and steps they are taking to address those challenges. In appendix I we list the DOD and state organizations that we contacted for our review.

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

¹⁵DOD is required to submit to Congress an annual report of environmental programs not later than 45 days after the President's budget is submitted to Congress. 10 U.S.C. § 2711. According to DOD, this annual report to Congress describes the department's accomplishments during the past year in its restoration, conservation, compliance, and pollution prevention programs by addressing plans and funding needs for protecting human health, sustaining the resources that DOD holds in the public trust, meeting its environmental requirements, and supporting the military mission.

¹⁶Pub. L. No. 116-92 (2019).

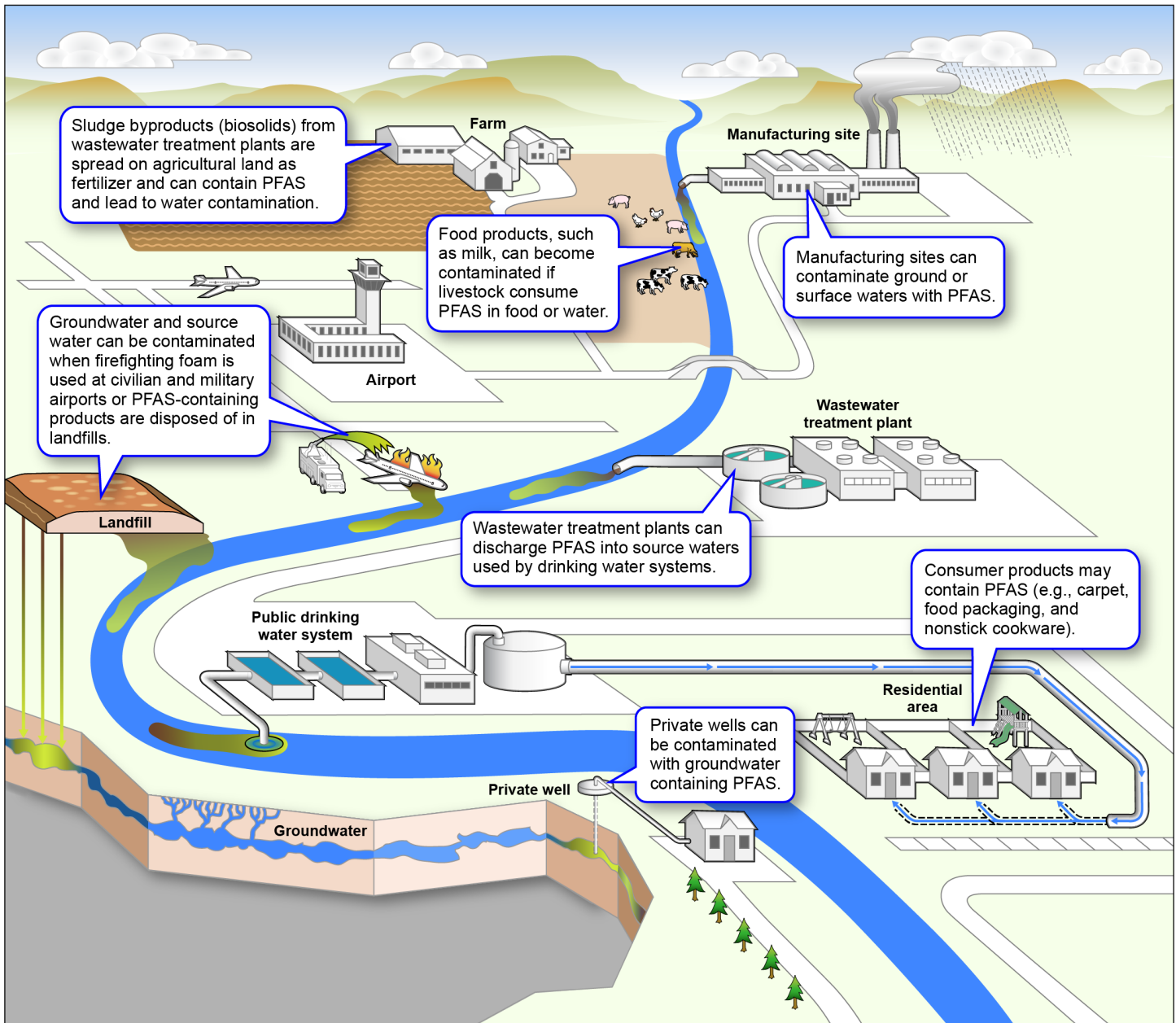
¹⁷DOD, *Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate for Fresh and Sea Water*, MIL-PRF-24385F(SH), Amendment 4 (April 7, 2020). According to DOD, a military specification is a document prepared to support acquisition that describes the essential technical requirements for purchased material and the criteria for determining whether those requirements are met.

Background

PFAS Pathways into the Environment

Due to their heat- and stain-resistant properties, PFAS are used in a wide range of commercial and consumer products besides firefighting foam, including carpet, food packaging, nonstick cookware, and waterproof clothing. PFAS are used at manufacturing and processing facilities, as well as at airports and military installations. PFAS can enter the environment in a number of ways, such as by seeping underground and contaminating groundwater from areas where firefighting foam was used. Additionally, PFAS in biosolids—sludge byproducts from wastewater treatment plants that are deposited on agricultural lands as fertilizer—can run off into surface waters or groundwater. PFAS can also enter groundwater from landfill leachate when materials with high levels of PFAS are disposed of, and they can enter ground and surface water from the discharge of wastewater effluent or from rain contaminated by industrial facilities' air emissions. Figure 1 shows examples of how PFAS can enter the environment, including through the use of firefighting foam.

Figure 1: Examples of How Per- and Polyfluoroalkyl Substances (PFAS) Can Enter the Environment and Water

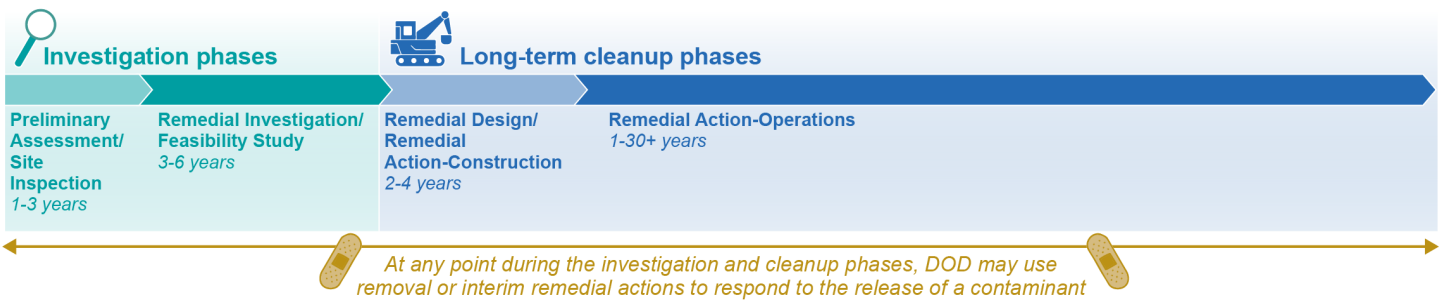


Source: GAO. | GAO-21-421

DOD’s Environmental Restoration Process

DOD’s environmental restoration process follows the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and other relevant statutes and regulations.¹⁸ DOD conducts environmental restoration activities to reduce risk to human health and the environment resulting from the department’s actions.¹⁹ For example, DOD is to identify, evaluate, and, where appropriate, respond to a release or threat of release of contaminants into the environment—such as the release of PFAS during the use of certain firefighting foam. The Under Secretary of Defense for Acquisition and Sustainment is responsible for establishing policy, issuing guidance, and providing oversight for the department’s environmental restoration program. DOD components—which include the military departments and the Defense Logistics Agency—are to budget for and conduct environmental restoration activities at their installations. DOD’s process for environmental restoration comprises both investigation and cleanup phases (see figure 2).

Figure 2: Phases of DOD’s Environmental Restoration Process



Source: Department of Defense (DOD). | GAO-21-421

Investigation phases. The first investigation phase is the preliminary assessment/site inspection. During the preliminary assessment, DOD reviews existing information to determine whether a hazardous substance or pollutant or contaminant release requires additional investigation or action. A site inspection typically involves sampling of environmental

¹⁸42 U.S.C. §§ 9601-9675. Under the authority and direction of the Undersecretary of Defense (Acquisition & Sustainment), DOD components implement provisions of CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan regulations, and the Solid Waste and Disposal Act, commonly known as the Resource Conservation and Recovery Act of 1976, in addition to complying with other legal requirements governing environmental restoration.

¹⁹DOD Instruction 4715.07, *Defense Environmental Restoration Program (DERP)* (May 21, 2013) (Incorporating Change 2, Aug. 31, 2018).

media (e.g., groundwater and soil) and the collection and analysis of other data. If further investigation is required, DOD proceeds to the remedial investigation/feasibility study phase. The remedial investigation emphasizes data collection and site characterization, and it is generally performed concurrently with a feasibility study. Using data gathered during the remedial investigation, the feasibility study is used to develop and evaluate options for remedial actions, enabling decision makers to select a permanent solution that is protective of human health and the environment. According to DOD, the investigation phases can take 4 to 9 years to complete.

Long-term cleanup phases. During the remedial design/remedial action-construction phase, DOD develops the design plans and specifications of the remediation option selected from the feasibility study and then constructs or implements the selected remedial alternative at the site. During the remedial action-operation phase, DOD operates, maintains, and monitors actions for the remediation system and site until the remedial action objectives are met (e.g., attaining certain concentration levels for a contaminant at the site). DOD officials stated that options for long-term remediation of PFAS may include pumping and treating contaminated groundwater, or disposing of contaminated soil. According to DOD, these long-term cleanup phases could take decades to complete.

Removal or interim remedial actions. At any point during the investigation and cleanup phases, DOD may use removal actions or interim remedial actions. Removal actions are a mechanism for taking prompt action where there is a release, or threat of release, of hazardous substances or pollutants or contaminants to the environment. These actions, such as providing alternative water supplies, typically do not provide the protection or permanence of long-term remediation. Remedial actions are consistent with but are not permanent remedies taken instead of or in addition to removal actions to prevent or minimize the release of hazardous substances. DOD refers to these as interim remedial actions and uses them as a partial solution to a complex contaminant problem.

Prior GAO Work on PFAS

In October 2017 we reported that DOD had taken actions, at times in response to EPA and state orders, to address elevated levels of PFOA and PFOS in drinking water at or near military installations (e.g., by shutting down drinking water wells, providing alternative drinking water, or

installing treatment systems).²⁰ We also found that, as of December 2016, DOD had reported spending about \$200 million on environmental investigations and responses related to PFAS, and that it could take several years for the department to determine how much PFAS cleanup would cost. Additionally, we found that DOD was taking steps to address health and environmental concerns with its use of PFAS-containing firefighting foams, to include restricting the use of these foams and funding research into the development of PFAS-free foams. In a September 2018 testimony, we summarized the findings of our October 2017 report and also provided updated information on DOD's PFAS response.²¹

We have also reported on other federal agencies' actions related to PFAS. In January 2021 we reported that EPA had completed some regulatory-related actions for addressing PFAS that were outlined in the agency's PFAS Action Plan, and that other actions were ongoing.²² For example, we reported that EPA had announced a preliminary regulatory determination to regulate PFOA and PFOS under the Safe Drinking Water Act.²³ In addition, we found that EPA had not designated PFOA and PFOS as hazardous substances under CERCLA—doing so would have made the parties that are responsible for the contamination also liable for associated cleanup costs—but that EPA planned to continue the regulatory process for such designation.

Further, we reported in January 2021 that the National Aeronautics and Space Administration's future environmental liability could increase if new

²⁰GAO, *Drinking Water: DOD Has Acted on Some Emerging Contaminants but Should Improve Internal Reporting on Regulatory Compliance*, [GAO-18-78](#) (Washington, D.C.: Oct. 18, 2017). In this report, we found that the military departments had not reported to OSD all violations of health-based drinking water regulations at their installations. We also found that DOD had not used its data to determine why its two types of drinking water systems—one that provides DOD-treated water and another that provides non-DOD-treated water—had different compliance rates. DOD has implemented the five recommendations we made to improve its reporting and use of data on compliance with health-based drinking water regulations.

²¹GAO, *Drinking Water: Status of DOD Efforts to Address Drinking Water Contaminants Used in Firefighting Foam*, [GAO-18-700T](#) (Washington, D.C.: Sept. 26, 2018).

²²[GAO-21-37](#).

²³42 U.S.C. § 300f et seq. A regulatory determination is a decision about whether or not to begin the process to propose and promulgate a national primary drinking water regulation.

cleanup requirements are established for PFAS.²⁴ We found that the agency was conducting preliminary assessments at 15 locations at which past or present activities may have resulted in a release of PFAS, such as through the use of firefighting foam or from land disposal of PFAS-containing materials. Agency officials stated that planning and estimating the cost of PFAS cleanup projects are difficult because of the absence of federal standards and the unknown extent of contamination across the agency. As a result, officials were uncertain as to how PFAS contamination will affect the agency's environmental liability in the future.

We have included the federal government's environmental liability on our High-Risk List since 2017, in part because environmental liability represents the fourth-largest liability on the federal government's financial statements and because of continued growth in environmental liabilities.²⁵ The federal government's environmental liability has been growing for the past 20 years, and this growth is likely to continue even as the federal government spends billions of dollars each year on cleanup efforts. In fiscal year 2020, the federal government's total environmental liability was \$602.7 billion, and DOD accounted for the second-largest share of that liability at \$75 billion, or about 12 percent.²⁶

²⁴GAO, *Environmental Liabilities: NASA's Reported Financial Liabilities Have Grown, and Several Factors Contribute to Future Uncertainties*, [GAO-21-205](#) (Washington, D.C.: Jan. 15, 2021).

²⁵GAO, *High Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas*, [GAO-21-119SP](#) (Washington, D.C.: Mar. 2, 2021).

²⁶The Department of Energy is responsible for the largest share of the liability (\$512.3 billion in fiscal year 2020, or 85 percent of the federal government's total liability), related primarily to retrieving, treating, and disposing of nuclear and hazardous waste.

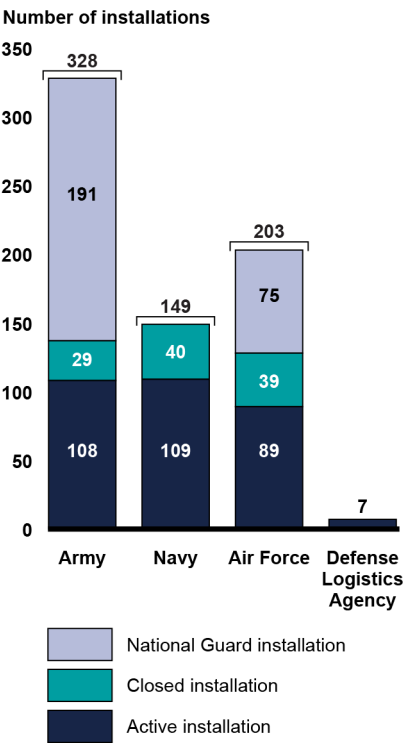
DOD Is Engaged in Early Phases of PFAS Investigation at Its Installations and Has Taken Some Actions to Address PFAS Contamination in Drinking Water

DOD Has Identified Nearly 700 Installations with a Known or Suspected PFAS Release

As of the end of fiscal year 2020, DOD had identified 687 installations—including active, closed, and National Guard installations—with a known or suspected release of PFAS. This includes 328 Army installations, 149 Navy installations, 203 Air Force installations, and seven Defense Logistics Agency installations (see figure 3).²⁷

²⁷The Defense Logistics Agency installations include five fuel support points, one distribution center, and one supply center. According to agency officials, these locations may have a PFAS release due to the use of certain firefighting foams.

Figure 3: Number of DOD Installations with a Known or Suspected Release of Per- and Polyfluoroalkyl Substances (PFAS), as of the End of Fiscal Year 2020



Source: GAO analysis of Department of Defense (DOD) information. | GAO-21-421

	Active	Closed	National Guard
Army	108	29	191
Navy	109	40	
Air Force	89	39	75
Defense Logistics Agency	7		

The number of installations with a known or suspected PFAS release has increased significantly over the past several years—up from 393 installations in December 2016. Most of that increase can be attributed to the Army’s identifying more installations with a known or suspected PFAS release. Specifically, the Army went from having 61 such installations identified in December 2016 to having 328 identified in September 2020. Army officials stated that this was because of their having started later than the Navy and Air Force in identifying such installations, and because of the high number of small Army National Guard installations identified

after December 2016 that may have used or released PFAS.²⁸ According to DOD officials, they do not expect the total number of installations with a known or suspected PFAS release to increase much more.

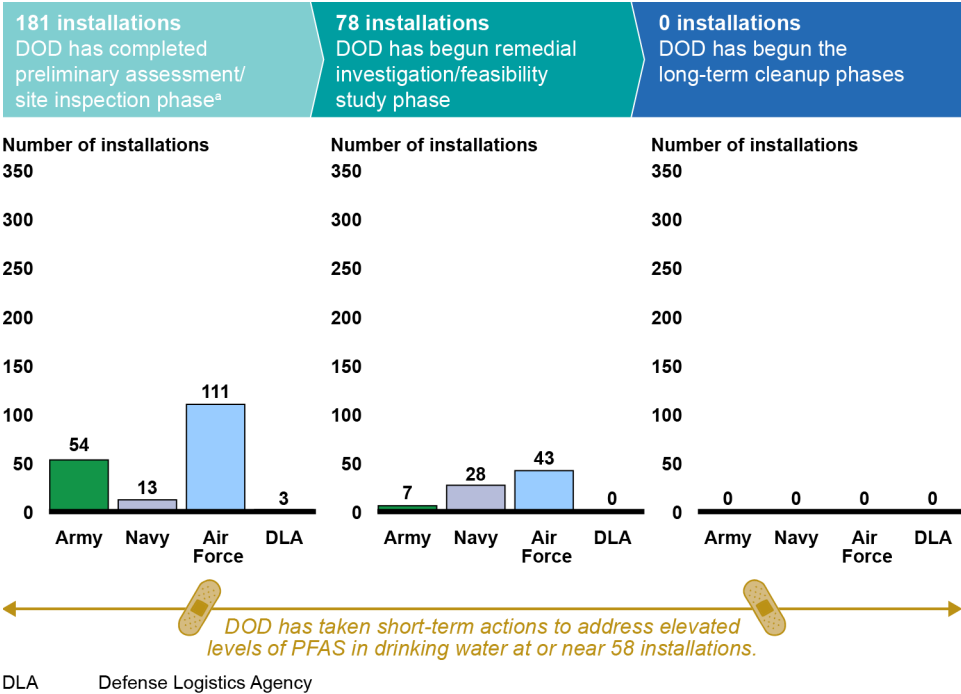
DOD Is Engaged in the Early Phases of the Environmental Restoration Process at Its Installations

As of the end of fiscal year 2020, DOD was engaged in the early phases of the environmental restoration process at installations with a known or suspected PFAS release. For example, DOD had completed the first phase of the environmental restoration process—the preliminary assessment/site inspection phase—at 181 installations, constituting about 26 percent of the 687 installations with a known or suspected PFAS release.²⁹ Figure 4 shows the progress DOD has made in the investigation and cleanup of PFAS at its installations.

²⁸According to the Army, when EPA issued its drinking water health advisories for PFOA and PFOS in May 2016, the Navy and Air Force had already identified PFAS releases at sites where they were already conducting environmental restoration activities, whereas the Army had not yet identified any sites with PFAS releases.

²⁹In May 2021, the Deputy Assistant Secretary of Defense (Environment and Energy Resilience) testified to the House Appropriations Committee's Defense Subcommittee that 129 DOD installations had completed the preliminary assessment/site inspection phase as of March 2021—52 installations fewer than what DOD data showed were complete in September 2020. *Defense Environmental Restoration*; Hearing Before the House Comm. on Appropriations, Subcomm. on Defense, 117th Cong. (2021) (statement of Richard Kidd, Deputy Assistant Secretary of Defense (Environment and Energy Resilience)). According to OSD and Air Force officials, the decrease in installations was due to the Air Force making a change at the beginning of fiscal year 2021 to its definition of when a site inspection is considered complete. Specifically, the officials stated that the Air Force previously considered a site inspection to be complete once the on-installation work had been completed, even if off-installation work continued; now, the Air Force considers a site inspection to be complete when both the on- and off-installation work is completed. As a result, as of March 2021, DOD data showed that 55 Air Force installations had completed the preliminary assessment/site inspection phase, compared to 111 installations as of September 2020.

Figure 4: DOD Installations Engaged in the Environmental Restoration Process with a Known or Suspected Per- and Polyfluoroalkyl Substances (PFAS) Release, as of the End of Fiscal Year 2020



DLA Defense Logistics Agency

Source: GAO analysis of Department of Defense (DOD) information. | GAO-21-421

	Army	Navy	Air Force	DLA
687 installations DOD has identified a known or suspected PFAS release	328	149	203	7
181 installations DOD has completed preliminary assessment/site inspection phase	54	13	111	3
78 installations DOD has begun remedial investigation/feasibility study phase	7	28	43	0
0 installations DOD has begun the cleanup phases	0	0	0	0

Note: DOD officials stated that the department had begun the remedial investigation/feasibility study phase at some installations prior to

completing the preliminary assessment/site inspection phase, because early results from the preliminary assessment/site inspection showed that moving forward to the next phase would be needed. Additionally, not all installations that complete the preliminary assessment/site inspection phase will need to proceed to the remedial investigation/feasibility study phase.

^aAccording to DOD officials, in fiscal year 2021 the Air Force changed its definition for when this phase is considered complete, resulting in a lower number of DOD installations (129 installations) that had completed this phase as of March 2021.

After DOD completes the preliminary assessment/site inspection phase at an installation, the department determines whether the installation should proceed to the next phase (the remedial investigation/feasibility study) or, alternatively, whether no further action is required.³⁰ Installations proceed to the remedial investigation/feasibility study phase if PFAS levels at the installation exceed certain screening levels, which are consistent with EPA's 2019 interim recommended screening levels.³¹ For example, the EPA screening levels for PFOS and PFOA in groundwater are 40 parts per trillion. According to DOD, if PFOA and PFOS amounts in groundwater exceed the EPA screening levels, then an installation proceeds to the remedial investigation/feasibility study phase; but if the EPA screening levels are not exceeded, the installation does not proceed to that phase. OSD officials stated that the EPA screening levels provide nationwide, risk-based toxicity information to make consistent decisions on whether additional action is required.³²

³⁰According to DOD officials, some installations have begun the remedial investigation/feasibility study phase prior to completing the preliminary assessment/site inspection phase, because early results from the preliminary assessment/site inspection showed that moving forward to the next phase would be needed.

³¹DOD, Assistant Secretary of Defense (Sustainment) Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (October 2019); EPA, Office of Land and Emergency Management Directive No. 9283.1-47, *Interim Recommendations to Address Groundwater Contaminated with Perfluorooctanoic Acid and Perfluorooctanesulfonate* (Dec. 19, 2019).

³²OSD officials stated that if PFAS levels in groundwater at an installation exceeded a state standard but not the EPA screening levels, the installation would not proceed to the next phase. According to OSD officials, CERCLA requires them to use the EPA screening levels to make these kinds of decisions nationwide. If EPA were to issue lower screening levels, OSD officials said that DOD would follow those lower screening levels, which could result in additional installations proceeding to the remedial investigation/feasibility study phase. OSD officials added that this was the case for managing the cleanup process in general and was not specific to PFAS.

According to DOD, as of the end of fiscal year 2020, about 61 percent of the installations for which the preliminary assessment/site inspection phase had been completed (110 of 181 installations) were proceeding to the remedial investigation/feasibility study phase; about 38 percent of the installations (68 of 181 installations) would require no further action; and the remaining installations (3 of 181 installations) were still being evaluated.³³ Most Air Force installations (97 of 111) and Navy installations (nine of 13) that had completed the first phase have proceeded or will proceed to the second phase, while most Army installations (50 of 54) have required no further action, according to the military departments. According to Army officials, fewer Army installations have proceeded to the remedial investigation/feasibility study phase at this time because many of the smaller National Guard installations with a suspected PFAS release have not required further investigation. Officials stated that they expect up to 70 percent of the installations that are currently in the preliminary assessment/site inspection phase will move to the remedial investigation/feasibility study phase.

DOD Has Taken Actions to Address PFAS Contamination in Drinking Water Based on Federal Advisory Levels

While DOD is in the early phases of its PFAS investigation, the department has taken actions to address PFOA and PFOS contamination in drinking water at or near its installations when levels of those chemicals have exceeded EPA's health advisory levels of 70 parts per trillion. These actions include providing bottled water, installing drinking water treatment systems, and connecting homes with private wells to municipal water.³⁴ As of the end of fiscal year 2020, DOD had reported taking actions to address PFOA and PFOS contamination in drinking water at or near 58 installations where, according to DOD officials, contamination had resulted from DOD activities (see appendix II for the list of these

³³In May 2021, the Deputy Assistant Secretary of Defense (Environment and Energy Resilience) testified to the House Appropriations Committee's Defense Subcommittee that 129 DOD installations had completed the preliminary assessment/site inspection phase as of March 2021, and that 66 of these installations would proceed to the remedial investigation/feasibility study phase while the remaining 63 installations would require no further action. *Hearing on Defense Environmental Restoration*. As discussed above, OSD and Air Force officials attributed the decrease in installations with a completed preliminary assessment/site inspection since September 2020 to the Air Force making a change to its definition of when a site inspection is considered complete.

³⁴According to EPA, technologies that have been found to remove PFAS from drinking water include activated carbon adsorption, ion exchange resins, and high-pressure membranes.

installations). The following are examples of actions DOD has taken at or near installations we selected for this review:

- **Joint Base Lewis-McChord, Washington.** According to installation officials, the Army has temporarily removed from service several wells that provide drinking water for the installation until treatment systems are constructed and fully operational for those wells.
- **Former Naval Air Station Joint Reserve Base Willow Grove, Pennsylvania.** The Navy has funded actions outside this closed installation, to include connecting homes with private wells to municipal water and installing a treatment system on a nearby town's drinking water supply.³⁵
- **Cannon Air Force Base, New Mexico.** According to Air Force and installation officials, the Air Force is providing bottled water to one dairy farm near the installation until a treatment system can be installed at the property.
- **Horsham Air Guard Station, Pennsylvania.** The Air Force is providing bottled water to personnel who work on the installation until a treatment system is completed for the installation's drinking water supply. The Air Force has also provided funding to install treatment systems on two nearby towns' drinking water supplies.

In contrast, DOD generally has not acted to address the presence of PFAS in drinking water when levels exceed state-established PFAS standards but do not exceed the EPA's health advisory levels. For example, at two of the eight installations in our sample, DOD has not funded actions to address the presence of PFAS levels exceeding the state-established standards:

- **Camp Grayling, Michigan.** The Army has provided funding to install treatment systems or connect homes to municipal water for properties near the installation with PFOA and PFOS amounts exceeding the EPA health advisory levels. However, according to installation officials, the Army has not provided similar funding for approximately 60 private drinking water wells near the installation with PFAS

³⁵According to Navy officials, a pilot pump-and-treat system has been installed at the former Naval Air Station Joint Reserve Base Willow Grove to extract contaminated groundwater, treat it using activated carbon and ion exchange resins, and then discharge the treated water to a nearby storm drain. Navy officials also said that approximately 4,000 tons of soil contaminated with PFAS at the installation had been disposed of at a landfill in the state.

amounts exceeding the maximum contaminant levels set by Michigan (e.g., 8 parts per trillion for PFOA and 16 parts per trillion for PFOS), because the EPA's health advisory levels (i.e., 70 parts per trillion for PFOA and PFOS) have not been exceeded.³⁶

- **Former Fort Devens, Massachusetts.** The Army has provided funding to a nearby town for drinking water treatment because that town's drinking water had PFAS amounts that exceeded the EPA's health advisory levels. However, according to the Army, it has not provided similar funding to another nearby town because even though that town's drinking water has PFAS amounts that exceed the maximum contaminant level set by Massachusetts (i.e., 20 parts per trillion for six PFAS compounds, including PFOA and PFOS), the EPA's health advisory levels for PFOA and PFOS have not been exceeded.

However, we identified one exception to this practice, at a third installation:

- **Former Reese Air Force Base, Texas.** The Air Force has funded actions to address PFAS levels in nearby private wells that exceed EPA lifetime health advisory levels for PFOA or PFOS, or that exceed Texas-established levels for 14 additional PFAS. Air Force and installation officials stated that they were required to take these actions for the 14 additional PFAS due to site-specific language in their state permit to operate their wastewater treatment plant. OSD and military department officials told us that, while it is possible other installations may have similar permits with language requiring them to take actions based on state PFAS standards, they were not aware of any at the time of our review.

According to DOD, the department generally takes actions to address PFAS in water based on EPA's health advisory levels—and not state-established standards—because the EPA advisory provides risk-based toxicity information that applies nationwide, and the use of EPA-

³⁶In addition to PFOA and PFOS, Michigan has also adopted maximum contaminant levels for five other PFAS chemicals in drinking water.

established levels is the CERCLA process for such actions.³⁷ However, OSD officials said that they are considering a policy that would incorporate more stringent, state-established drinking water standards as applicable or relevant and appropriate requirements for taking actions to address PFAS in drinking water. According to OSD officials, EPA currently has this authority at EPA-managed cleanup sites, and DOD is reviewing its legal authorities and plans to work through an interagency process to discuss this issue. At the time of our review, OSD officials did not have a time frame for when this policy may go into effect, citing uncertainty about how long the interagency process would take.

³⁷According to DOD, the department evaluates any state-established PFAS standards during an installation's feasibility study phase to determine whether the state standards are applicable or relevant and appropriate requirements for long-term cleanup at the installation. For example, OSD officials stated that—if found to be applicable or relevant and appropriate—a state's maximum contaminant level for PFAS in drinking water could be used as a long-term cleanup goal for contaminated groundwater at an installation, even if that is below the EPA health advisory level. According to DOD officials, a state's PFAS standard may not be applicable or relevant and appropriate if, for example, the standard does not apply to every location within the state; these decisions are made on a site-specific basis in each state.

DOD's Actual and Estimated Costs for PFAS Investigation and Cleanup Will Likely Increase Significantly, but DOD Has Not Reported Its PFAS Cost Estimates to Congress

DOD Reported \$1.1 Billion in Actual Costs for PFAS Investigation and Cleanup and Estimated Another \$2.1 Billion in Future Costs, but This Estimate Will Likely Increase Significantly

At the end of fiscal year 2020, DOD estimated that its future PFAS investigation and cleanup costs will total more than \$2.1 billion beginning in fiscal year 2021, which is in addition to the \$1.1 billion in actual PFAS costs that DOD incurred through fiscal year 2020.³⁸ However, DOD officials told us that these estimates were preliminary and were significantly lower than what PFAS investigation and cleanup was likely to cost DOD in the future, because the department is still in the early phases of investigating PFAS at its installations. Table 1 shows, according to DOD, the actual costs through fiscal year 2020 and the estimated costs beginning in fiscal year 2021 for PFAS investigation and cleanup, by DOD component.

Table 1: DOD Actual and Estimated Costs for Per- and Polyfluoroalkyl Substances (PFAS) Investigation and Cleanup, as of Fiscal Year 2020 (in thousands of dollars)

Component	Actual costs through fiscal year 2020	Estimated costs beginning in fiscal year 2021 ^c	Total actual and estimated costs
Army	74,609	189,100	263,708
Navy ^a	272,074	361,126	633,200
Air Force	737,602	1,567,423	2,305,025
Defense Logistics Agency	1,586	400	1,986
Total^b	1,085,871	2,118,049	3,203,920

Source: GAO analysis of Department of Defense (DOD) data. | GAO-21-421

³⁸For the purposes of our report, we use "costs" to refer to actual and estimated obligations. These actual and estimated costs include the costs for investigations (e.g., contracts for preliminary assessments/site inspections) and, when available, cleanup costs for removal actions (e.g., providing bottled water) and long-term remediation.

Note: For the purposes of our report, we use “costs” to refer to actual and estimated obligations. The numbers in this table may not add due to rounding.

^aThe Department of the Navy includes both the Navy and the Marine Corps.

^bDOD reported an additional \$244,000 in actual costs and \$240,000 in estimated costs for PFAS investigation and cleanup at Formerly Used Defense Sites.

^cAccording to DOD officials, these estimates are likely to increase significantly in the future because the department is still in the early phases of investigating PFAS at its installations.

DOD officials told us that PFAS cost estimates will likely increase significantly as the department progresses through the investigation phases. As discussed previously in this report, as of the end of fiscal year 2020, no installations had fully completed the investigation phases and moved to the cleanup phases of the environmental restoration process.

According to the military departments, they generally have only enough information to estimate PFAS environmental restoration costs through the remedial investigation. During the feasibility study, potential remedial alternatives (e.g., pumping and treating groundwater, disposing of soil) are evaluated and costs for these alternatives are estimated. Because the military departments have not completed this phase at any installation, DOD’s current cost estimates generally do not include the future costs of long-term PFAS remediation. Moreover, military department officials told us that PFAS cost estimates must meet a certain standard (“probable and reasonably estimable”) for inclusion in DOD’s annual financial report.³⁹ These officials also told us that there are a limited number of installations with sufficient data to develop such estimates at this time. As a result, DOD expects the amount of environmental liabilities it reports in future annual financial statements to increase significantly due to PFAS.

In addition to being in the early phases of their PFAS investigation, DOD officials cited regulatory uncertainty as another significant challenge they face in estimating environmental restoration costs. As discussed above, there are currently no federal regulations for PFAS in drinking water or groundwater, although EPA has issued nonenforceable health advisory

³⁹According to federal accounting standards, costs for cleanup work must be included in environmental liability estimates when they are both probable and reasonably estimable. “Probable” relates to whether a future outflow of resources will be required—specifically, that it is “more likely than not” that the agency will incur a financial liability. “Reasonably estimable” relates to the ability to reliably quantify in monetary terms the outflow of resources that will be required. Federal Accounting Standards Advisory Board, *FASAB Handbook of Federal Accounting Standards and Other Pronouncements, as Amended* (June 30, 2020). According to DOD, its cost estimates for PFAS investigation and cleanup are included as environmental liabilities in the department’s fiscal year 2020 financial statement. See DOD, *Agency Financial Report, Fiscal Year 2020* (Nov. 16, 2020).

levels in drinking water and interim recommendations for screening levels and preliminary remediation goals in groundwater for PFOA and PFOS. EPA has taken an initial step in developing drinking water regulations for PFOA and PFOS, but it could be several years before EPA releases its proposed maximum contaminant levels for these chemicals.⁴⁰

If EPA issues federal drinking water or cleanup standards for PFAS that are lower than the current health advisory levels for PFOA and PFOS, DOD may face higher costs to clean up PFAS. For example, officials from OSD and the military departments stated that if the military departments have to clean up PFAS to levels lower than 70 parts per trillion (e.g., because EPA establishes a federal drinking water or cleanup standard at a lower level), this would likely increase the overall cost and time for PFAS cleanup. As a result, the uncertainty of potential future federal drinking water or cleanup standards for PFAS—as well as the uncertainty of potential additional state standards—makes it difficult for DOD to estimate long-term costs for PFAS cleanup. As DOD progresses through the environmental restoration process and gains greater clarity on PFAS regulations at the federal and state levels, the department should have more information by which to develop cost estimates for PFAS investigations and cleanup.

DOD Has Not Reported Its Estimated Future PFAS Costs in Its Annual Environmental Report to Congress

At the time of our review, DOD's most recent environmental report to Congress was its report for fiscal year 2019.⁴¹ In that report, DOD included the actual costs for PFAS investigation and cleanup through fiscal year 2019. DOD also reported that increases in environmental costs over the past few years were due in large part to the cleanup of chemicals of emerging concern, such as PFAS. However, DOD did not report the department's estimated costs for future PFAS investigation and cleanup,

⁴⁰In March 2020, EPA proposed a preliminary drinking water regulatory determination to regulate PFOA and PFOS under the Safe Drinking Water Act. As of January 2021, EPA officials had not indicated a time frame for when EPA would issue a final regulation for PFOA and PFOS but stated that the regulatory process typically takes a few years to complete.

⁴¹DOD, *Under Secretary of Defense for Acquisition and Sustainment, Defense Environmental Programs Annual Report to Congress for Fiscal Year 2019* (April 2020).

or that DOD expects future PFAS costs to increase significantly as it proceeds through the environmental restoration process.

We previously recommended improvements to DOD's environmental reporting to Congress. In January 2017 we reported that DOD had not reported to Congress in its annual report that the costs for environmental cleanup at closed installations would significantly increase due to the high cost of remediating emerging contaminants, primarily PFOA and PFOS.⁴² We recommended that DOD include in future annual environmental reports to Congress that the cleanup of PFAS and other emerging contaminants would increase cleanup costs at closed installations, and that DOD estimate such costs as information became available. DOD implemented this recommendation by stating in its fiscal year 2016 environmental report to Congress (issued in June 2018) that cleanup costs would increase due to the investigation and cleanup of PFOS and PFOA, and that DOD would include a best estimate of these costs in its environmental cleanup costs, as additional information became available. However, estimated costs for PFAS investigation and cleanup were not included in DOD's fiscal year 2017 (issued in August 2018) or fiscal year 2018 (issued in April 2019) environmental reports to Congress.⁴³

DOD's manual for its defense environmental restoration program states that DOD shall improve its financial management and reporting of environmental cleanup costs by providing accurate, complete, reliable, timely, and auditable financial information.⁴⁴ DOD's environmental restoration manual further directs that DOD components are to develop

⁴²GAO, *Military Base Realignment and Closures: DOD Has Improved Environmental Cleanup Reporting but Should Obtain and Share More Information*, [GAO-17-151](#) (Washington, D.C.: Jan. 19, 2017).

⁴³DOD, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Defense Environmental Programs Annual Report to Congress for Fiscal Year 2017* (August 2018); DOD, Office of the Under Secretary of Defense for Acquisition and Sustainment, *Defense Environmental Programs Annual Report to Congress for Fiscal Year 2018* (April 2019).

⁴⁴DODM 4715.20 (March 9, 2012) (Incorporating Change 1, Aug. 31, 2018). Additionally, pursuant to statute, the Secretary of Defense must submit an annual report to Congress on DOD's environmental restoration activities and major activities under the environmental quality programs at both the department and military services level. The report with respect to major activities of environmental quality programs includes a statement of the amounts expended, or proposed to be expended during the four prior fiscal years, the current fiscal year, and the following fiscal year. See 10 U.S.C. § 2711.

cost-to-complete estimates for environmental restoration activities to support the annual environmental report to Congress.

DOD officials stated that estimated future costs for PFAS investigation and cleanup were not included in DOD's environmental report to Congress for fiscal year 2019 because each report provides an overview of the status of the environmental programs for that specific fiscal year, not estimates for future years' costs. While we recognize that the annual report is primarily focused on a specific fiscal year's activities, prior reports have discussed the future fiscal year and thus it is an appropriate vehicle to annually communicate estimated planned future costs. For example, DOD's fiscal year 2019 environmental report to Congress included the amount to be requested for environmental programming for fiscal year 2021.

According to DOD officials, the department does not usually track environmental restoration costs by chemical, but it has begun collecting PFAS cost data annually from the DOD components because Congress and others have expressed interest in DOD's PFAS response.⁴⁵ Officials told us that collecting these data will enable DOD to provide PFAS cost information to Congress, if requested.

While DOD officials have said that they can provide information to Congress upon request, Congress would likely benefit from DOD's proactively and routinely providing estimates for future PFAS costs in the department's annual environmental report, which is to include information on costs for the following fiscal year. Although DOD does not yet know the exact amount of future PFAS costs, it can provide its best estimate based on information available at the time of an annual report and can notify Congress of an estimate's scope and limitations. By including estimated future costs and their scope and any limitations, DOD would increase Congress's visibility into the significant costs and efforts associated with PFAS investigation and cleanup at military installations. These estimates would provide the basis for informed decision making and realistic budget formulation and program resourcing.

⁴⁵According to DOD officials, DOD does not normally collect environmental restoration cost information by chemical and instead collects cost information by installation.

DOD Has Identified Potential PFAS-Free Firefighting Alternatives and Is Attempting to Address Challenges Associated with These Alternatives

DOD is making progress in identifying potential PFAS-free alternatives to the department's current PFAS-containing firefighting foams, as required by the National Defense Authorization Act for Fiscal Year 2020.⁴⁶ As of March 2021, DOD's environmental research and testing programs—the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP)—had identified six promising PFAS-free firefighting foam candidates that the department might be able to use in the future. According to SERDP and ESTCP, two of the foams have been developed through SERDP-funded projects, and the other four are commercially available products that have been evaluated by ESTCP. DOD officials stated that these candidates will undergo ecotoxicity testing on the extent to which they might be harmful to environmental health, as DOD wants to avoid replacing PFAS-containing firefighting foam with an alternative that might also be harmful.⁴⁷

However, these PFAS-free foam candidates have been unable to fully meet DOD's existing performance requirements for firefighting foam, as laid out in DOD's military specification, and it is unclear whether they can meet certain compatibility requirements. DOD outlined various performance and compatibility requirements in its April 2020 amendment to the current specification for firefighting foam, such as how long it should take for foam to extinguish a fire and then prevent it from reigniting.⁴⁸ For example, the military specification requires that firefighting foams be able to extinguish a 28-square foot gasoline fire in no more than 30 seconds, and to limit the size of a reignited fire to 25

⁴⁶Pub. L. No. 116-92, § 322 (Dec. 20, 2019).

⁴⁷These SERDP-funded ecotoxicity projects will study the effects of PFAS-free foams on terrestrial plants, soil invertebrates, mice, fish, and aquatic invertebrates, among other things.

⁴⁸DOD, *Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate for Fresh and Sea Water*, MIL-PRF-24385F(SH), Amendment 4 (Apr. 7, 2020).

percent (7 square feet) of the test fire for at least 6 minutes. The military specification also requires that DOD-approved firefighting foams be compatible with each other and with both sea and fresh water.⁴⁹ Figure 5 shows selected performance and compatibility requirements for firefighting foam and how PFAS-containing foams and PFAS-free foam candidates compare against those requirements.

Figure 5: Selected Performance and Compatibility Requirements for DOD Firefighting Foam

Military specification requirements for firefighting foam ^a	PFAS-containing foams	PFAS-free candidate foams
Extinguishment The foam extinguishes a 28 square foot fire in 30 seconds or less.	 Less than 30 seconds	 More than 50 seconds
Re-ignition time The extinguished fire shall not reignite to encompass at least 25% of the 28 square foot pan within 6 minutes.	 More than 6 minutes	 More than 6 minutes
Fuel type The foam shall be tested against an unleaded gasoline fire.	 Effective against gasoline fires and jet fuel fires	 Less effective against gasoline fires; effective against jet fuel fires
Water type The foam shall be tested with both fresh water and sea water.	 Effective with fresh water and sea water	 Effective with fresh water; less effective with sea water
Cross-foam compatibility Foams shall be compatible with formulations from other manufacturers without adversely impacting performance.	 Yes	 Unclear

PFAS

Per- and polyfluoroalkyl substances

Source: GAO analysis of Department of Defense (DOD) information. | GAO-21-421

⁴⁹Firefighting foam concentrate is mixed with water to create firefighting foam that is then applied to fires.

Military specification requirements for firefighting foam^a	PFAS-containing foams	PFAS-free candidate foams
Extinguishment The foam extinguishes a 28 square foot fire in 30 seconds or less.	Less than 30 seconds	More than 50 seconds
The extinguished fire shall not reignite to encompass at least 25% of the 28 square foot pan within 6 minutes.	More than 6 minutes	More than 6 minutes
Fuel type The foam shall be tested against an unleaded gasoline fire.	Effective against gasoline fires and jet fuel fires	Less effective against gasoline fires; effective against jet fuel fires
Water type The foam shall be tested with both fresh water and sea water.	Effective with fresh water and sea water	Effective with fresh water; less effective with sea water
Cross-foam compatability Foams shall be compatible with formulations from other manufacturers without adversely impacting performance.	Yes	Unclear

^aThese requirements are from DOD's military specification for firefighting foam. DOD, *Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate for Fresh and Sea Water*, MIL-PRF-24385F(SH), Amendment 4 (Apr. 7, 2020).

Most tested PFAS-free foams are able to meet the requirement that an extinguished test fire should not reignite for at least 6 minutes, according to SERDP and ESTCP. However, no tested PFAS-free foams have been able to extinguish a test fire within 30 seconds, as required by the military specification. SERDP and ESTCP data show that the most promising PFAS-free foam candidate needs approximately 50 seconds to extinguish a test fire—nearly twice as long as the current requirement.⁵⁰ Additionally, SERDP and ESTCP data show that PFAS-free foams underperform when tested against gasoline fires (as required by the military specification) but perform better when tested against jet fuel fires.

DOD officials stated that PFAS-free foams tend to underperform when used with sea water as compared with fresh water. This could limit their

⁵⁰According to OSD, DOD has tested a PFAS-free foam that is used by the militaries of two European countries, but the foam did not meet the performance requirements of the military specification, and its high viscosity would make it incompatible with DOD's firefighting systems.

effectiveness on ocean-going vessels—such as an aircraft catching fire on the deck of an aircraft carrier—or in other areas where fresh water may not be available. However, the National Defense Authorization Act for Fiscal Year 2020 provides an exception for the use of PFAS-containing foam on ocean-going vessels.

DOD officials also told us that they do not yet know whether PFAS-free foam from one manufacturer will be compatible with PFAS-free foams from other manufacturers, as required by the military specification. According to DOD, foam concentrate from one manufacturer needs to be able to be mixed with concentrate from another manufacturer when used in firefighting situations without negatively affecting performance. If this is not possible with PFAS-free foams, DOD officials said, DOD may need to work with only one supplier.

DOD is funding research projects to try to address some of these challenges. For example, in fiscal year 2018 ESTCP began funding projects to evaluate firefighting equipment modifications, such as different nozzles and delivery systems that could increase performance. Testing has also shown that the performance of PFAS-free foams improves when the flow rate is increased from 2 gallons per minute, which the military specification requires, to 3 gallons per minute. However, DOD officials stated that the use of foams at a faster flow rate would lead to using more foam and may require DOD to purchase more fire trucks or larger tanks to carry the additional foam that would be needed to fight fires. Additionally, in fiscal year 2020 SERDP began funding research on chemical additives that could improve the performance of PFAS-free firefighting foam. The goal of this research is to identify additives that, when combined with PFAS-free foam, might enable the foam to meet DOD's military specification requirements. According to DOD, SERDP and ESTCP research into PFAS-free alternatives has cost about \$16 million through fiscal year 2020, and another \$34 million in costs are expected through fiscal year 2025.

According to the National Defense Authorization Act for Fiscal Year 2020, DOD has until January 2023 to publish a military specification for a PFAS-free firefighting agent for use at all military installations and to ensure that such an agent is available for use no later than October 2023. DOD is planning to publish a new military specification specifically for PFAS-free firefighting foam for land-based use. According to DOD officials, they are waiting for SERDP and ESTCP to complete more of their research and testing before finalizing the performance and other requirements for PFAS-free foams, as they do not intend to set requirements that cannot

be met.⁵¹ Due to the potentially increased fire risk from munitions within the tight confines of the shipboard environment, DOD expects to continue using PFAS-containing foam aboard ships—as allowed by the National Defense Authorization Act for Fiscal Year 2020—until a PFAS-free foam can be identified that meets the performance requirements of the current April 2020 military specification.⁵²

Conclusions

DOD's decades-long use of PFAS-containing firefighting foam has led to the known or suspected release of these chemicals at or near hundreds of installations across the United States. As of the end of fiscal year 2020, DOD was in the early phases of investigating PFAS at these installations, and the department estimated that future costs for PFAS investigation and cleanup will exceed \$2.1 billion—cost information that has not been included in DOD's annual environmental reports to Congress. DOD expects its PFAS cost estimates, and thus its environmental liability, to increase significantly as the department makes progress in the investigation and cleanup of PFAS—a process that could take decades to fully complete. By providing its best estimates of future PFAS costs, along with their scope and any limitations, in its annual environmental reports to Congress, the department could ensure that Congress has increased visibility into the substantial costs and efforts associated with responding to PFAS contamination—key information for evaluating funding needs and decisions moving forward.

Recommendation for Executive Action

The Secretary of Defense should ensure that the Under Secretary of Defense for Acquisition and Sustainment annually includes the latest cost estimates for future PFAS investigation and cleanup—including their

⁵¹DOD's issuance of a new military specification for PFAS-free firefighting foams may also have implications for the Federal Aviation Administration, which requires that airport operators purchase firefighting foam that meets DOD's current military specification.

⁵²DOD's current military specification states that the maximum allowable level of PFOS and PFOA in firefighting foam concentrate is 800 parts per billion. According to DOD officials, this maximum level applies to firefighting foam concentrate before it is mixed and diluted with water, and 800 parts per billion is the lowest level of PFOS and PFOA that can be detected in firefighting foam concentrate by current testing methods and technologies. DOD's current military specification does not require firefighting foam to contain PFAS.

scope and any limitations—in DOD’s environmental reports to Congress. (Recommendation 1)

Agency Comments

We provided a draft of this product to DOD for comment. In its comments, reproduced in appendix III, DOD concurred with our recommendation. DOD also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees; the Secretary of Defense; the Secretary of the Army; and the Acting Secretaries of the Air Force and Navy. In addition, the report is available at no charge on our website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-2775 or FieldE1@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.



Elizabeth A. Field
Director, Defense Capabilities and Management

List of Committees

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

The Honorable Thomas R. Carper
Chairman
The Honorable Shelley Moore Capito
Ranking Member
Committee on Environment and Public Works
United States Senate

The Honorable Jon Tester
Chairman
The Honorable Richard Shelby
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Martin Heinrich
Chair
The Honorable John Boozman
Ranking Member
Subcommittee on Military Construction, Veterans Affairs, and Related
Agencies
Committee on Appropriations
United States Senate

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

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

The Honorable Betty McCollum
Chair
The Honorable Ken Calvert
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

The Honorable Debbie Wasserman Schultz
Chair
The Honorable John Carter
Ranking Member
Subcommittee on Military Construction, Veterans Affairs, and Related
Agencies
Committee on Appropriations
House of Representatives

Appendix I: Organizations Contacted during GAO's Review

We contacted the following organizations during our review. Unless otherwise specified, these organizations are located in or near Washington, D.C.

Office of the Secretary of Defense

- Office of the Assistant Secretary of Defense for Sustainment
 - Office of the Deputy Assistant Secretary of Defense for Environment & Energy Resilience
- Strategic Environmental Research and Development Program
- Environmental Security Technology Certification Program

Department of the Army

- Office of the Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health)
- Camp Grayling, Michigan
- Former Fort Devens, Massachusetts
- Joint Base Lewis-McChord, Washington

Department of the Navy

- Office of the Assistant Secretary of the Navy (Energy, Installations, and Environment)
- Former Naval Air Station Joint Reserve Base Willow Grove, Pennsylvania
- Marine Corps Logistics Base Barstow, California

Department of the Air Force

- Office of the Deputy Assistant Secretary of the Air Force (Environment, Safety, & Infrastructure)
- Cannon Air Force Base, New Mexico
- Former Reese Air Force Base, Texas

- Horsham Air Guard Station, Pennsylvania

Defense Logistics Agency

- Defense Logistics Agency Installation Management, Environmental Management

State Environmental Agencies

- California State Water Resources Control Board, California
- Massachusetts Department of Environmental Protection, Massachusetts
- Michigan Department of Environment, Great Lakes, and Energy, Michigan
- New Mexico Environment Department, New Mexico
- Pennsylvania Department of Environmental Protection, Pennsylvania
- Texas Commission on Environmental Quality, Texas
- Washington State Department of Health and Department of Ecology, Washington

Appendix II: Military Installations Addressing Elevated Levels of Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS)

As of the end of fiscal year 2020, the Department of Defense had reported taking actions to address PFOA and PFOS in drinking water at or near 58 installations (see table 2)—including 12 Army installations, 15 Navy and Marine Corps installations, and 31 Air Force installations. Actions include providing bottled water, installing drinking water treatment systems, and connecting homes with private wells to municipal water. The actions were taken on military installations where people live and work, or outside of military installations where people live and work in the community near affected military bases.

Table 2: Military Installations at Which the Department of Defense Has Reported Taking Actions to Address Elevated Levels of Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) in Drinking Water, as of the End of Fiscal Year 2020

Military department	Installation name	State	Actions on installation	Actions outside of installation
Army	Fort Hunter Liggett	California	Checked	Unchecked
	Sierra Army Depot	California	Checked	Unchecked
	Fort Leavenworth	Kansas	Checked	Unchecked
	Former Fort Devens	Massachusetts	Unchecked	Checked
	Belmont Armory	Michigan	Checked	Unchecked
	Camp Grayling	Michigan	Unchecked	Checked
	Picatinny Arsenal	New Jersey	Checked	Unchecked
	Camp Smith	New York	Checked	Unchecked
	Former North Penn	Pennsylvania	Unchecked	Checked
	El Campo Armory	Texas	Checked	Unchecked
	Joint Base Lewis-McChord	Washington	Checked	Unchecked
	Yakima Training Center	Washington	Checked	Unchecked

**Appendix II: Military Installations Addressing
Elevated Levels of Perfluorooctanoic Acid
(PFOA) and Perfluorooctane Sulfonate (PFOS)**

Military department	Installation name	State	Actions on installation	Actions outside of installation
Total Army 12				
Navy	Marine Corps Base Camp Pendleton	California	Checked	Unchecked
	Marine Corps Logistics Base Barstow	California	Unchecked	Checked
	Naval Support Activity Monterey	California	Checked	Unchecked
	Naval Air Station Saufley Field	Florida	Unchecked	Checked
	Naval Air Station Whiting Field	Florida	Unchecked	Checked
	Guam Hospital Compound	Guam	Checked	Unchecked
	Naval Computer and Telecommunications Area, Master Station Atlantic Detachment Cutler	Maine	Checked	Checked
	Naval Weapons Station Earle	New Jersey	Unchecked	Checked
	Marine Corps Air Station Cherry Point	North Carolina	Unchecked	Checked
	Former Naval Air Station Joint Reserve Base Willow Grove	Pennsylvania	Unchecked	Checked
	Former Naval Air Warfare Center Warminster	Pennsylvania	Unchecked	Checked
	Naval Support Activity Mechanicsburg	Pennsylvania	Unchecked	Checked
	Naval Air Station Oceana (Naval Auxiliary Landing Field Fentress)	Virginia	Checked	Checked
	Naval Air Station Whidbey Island	Washington	Unchecked	Checked
	Naval Base Kitsap Bangor	Washington	Unchecked	Checked
Total Navy 15				
Air Force	Eielson Air Force Base	Alaska	Checked	Checked
	Luke Air Force Base	Arizona	Unchecked	Checked
	Morris Air National Guard Base	Arizona	Unchecked	Checked
	Little Rock Air Force Base	Arkansas	Unchecked	Checked
	Former Castle Air Force Base	California	Unchecked	Checked
	Former March Air Force Base	California	Unchecked	Checked
	Former Mather Air Force Base	California	Unchecked	Checked
	Travis Air Force Base	California	Unchecked	Checked
	Peterson Air Force Base	Colorado	Unchecked	Checked
	Dover Air Force Base	Delaware	Unchecked	Checked
	Mountain Home Air Force Base	Idaho	Checked	Unchecked
	Scott Air Force Base	Illinois	Unchecked	Checked
	McConnell Air Force Base	Kansas	Unchecked	Checked

**Appendix II: Military Installations Addressing
Elevated Levels of Perfluorooctanoic Acid
(PFOA) and Perfluorooctane Sulfonate (PFOS)**

Military department	Installation name	State	Actions on installation	Actions outside of installation
	Barnes Air National Guard Base	Massachusetts	Unchecked	Checked
	Joint Base Cape Cod	Massachusetts	Unchecked	Checked
	Former K.I. Sawyer Air Force Base	Michigan	Unchecked	Checked
	Former Wurtsmith Air Force Base	Michigan	Unchecked	Checked
	Former Pease Air Force Base	New Hampshire	Unchecked	Checked
	New Boston Air Force Station	New Hampshire	Checked	Unchecked
	Joint Base McGuire-Dix-Lakehurst	New Jersey	Unchecked	Checked
	Cannon Air Force Base	New Mexico	Unchecked	Checked
	Former Plattsburgh Air Force Base	New York	Unchecked	Checked
	Francis S. Gabreski Air National Guard Base	New York	Unchecked	Checked
	Toledo Express Air National Guard Base	Ohio	Unchecked	Checked
	Wright-Patterson Air Force Base	Ohio	Checked	Unchecked
	Horsham Air Guard Station	Pennsylvania	Checked	Checked
	Shaw Air Force Base	South Carolina	Unchecked	Checked
	Ellsworth Air Force Base	South Dakota	Unchecked	Checked
	Former Reese Air Force Base	Texas	Unchecked	Checked
	Fairchild Air Force Base	Washington	Unchecked	Checked
	Shepherd Field Air National Guard Base (Eastern West Virginia Regional Airport)	West Virginia	Unchecked	Checked
Total Air Force 31				
Total Installations 58				

Legend:

Checked = Department of Defense has reported taking action to address elevated levels of PFOA and/or PFOS in drinking water.

Source: GAO analysis of Department of Defense data. | GAO-21-421

Appendix III: Comments from the Department of Defense



SUSTAINMENT

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3500 DEFENSE PENTAGON
WASHINGTON, DC 20301-3500

05/27/2021

Ms. Elizabeth Field
Director, Defense Capabilities Management
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Ms. Field:

This is the Department of Defense (DoD) response to the U.S. Government Accountability Office (GAO) Draft Report, GAO-21-42ISU, "Firefighting Foam Chemicals: DoD Is Investigating PFAS and Responding to Contamination, but Should Report More Cost Information," dated April 20, 2021 (GAO Code 104308).

In general, the report summarizes the status of DoD's progress in capturing and reporting environmental cleanup costs at active installations, base realignment and closure properties, and National Guard locations. I have enclosed DoD's response to the GAO recommendation.

Sincerely,

CRAMER, PAUL D
AVID.1146906539

Digitally signed by
CRAMER, PAUL, DAVID.1146906
539
Date: 2021.05.27 15:13:31 -0400

Paul D. Cramer
Performing the Duties of Assistant Secretary of
Defense for Sustainment

Enclosure:
As stated

GAO DRAFT REPORT DATED APRIL 20, 2021
GAO-21-42ISU (GAO CODE 104308)

**“FIREFIGHTING FOAM CHEMICALS: DOD IS INVESTIGATING PFAS AND
RESPONDING TO CONTAMINATION, BUT SHOULD REPORT MORE COST
INFORMATION”**

**DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATION**

RECOMMENDATION: The GAO recommends that the Secretary of Defense for Acquisition and Sustainment annually includes the latest cost estimates for future PFAS investigation and cleanup- including their scope and any limitations- in DOD’s environmental reports to Congress.

DoD RESPONSE: Concur. As the DoD Components complete the initial assessments for PFAS releases and determine required cleanup actions, they will develop auditable cost estimates. The Department will plan and program for these requirements as they are defined and note the estimated cost in future Defense Environmental Programs Annual Reports to Congress.

Agency Comment Letter

Text of Appendix III: Comments from the Department of Defense

Page 1

May, 27, 2021

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Director, Defense Capabilities Management
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

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Sincerely,

Paul D. Cramer
Performing the Duties of Assistant Secretary of Defense for Sustainment

Enclosure: As stated

Page 2

**“FIREFIGHTING FOAM CHEMICALS: DOD IS INVESTIGATING PFAS AND
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Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Elizabeth A. Field, (202) 512-2775 or fielde1@gao.gov

Staff Acknowledgments

In addition to the contact named above, Maria Storts (Assistant Director), Geoffrey Peck (Analyst-in-Charge), Pedro Almoguera, Nirmal Chaudhary, Tanya Doriss, Michele Fejfar, Karen Howard, Amie Lesser, Felicia Lopez, William Neely, Diane Raynes, Leigh Ann Sheffield, Maria Staunton, Cheryl Weissman, and Rachel Wexler made key contributions to this report.

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