



March 2021

DEFENSE CLEANUP

Efforts at Former
Military Sites on
Vieques and Culebra,
Puerto Rico, Are
Expected to Continue
through 2032

GAO@100 Highlights

Highlights of [GAO-21-268](#), a report to congressional committees

Why GAO Did This Study

For several decades, DOD used the islands of Vieques and Culebra, Puerto Rico, for training sites that left extensive amounts of munitions, hazardous substances, and other contaminants on the islands and in their surrounding waters. DOD began cleanup efforts on Culebra in the early 1990s and on Vieques in the mid-2000s. Both efforts are conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended. On Vieques, the U.S. Navy funds and leads the cleanup efforts, and the Environmental Protection Agency (EPA) has oversight responsibilities. On Culebra, the Corps funds and leads the cleanup efforts, and the Commonwealth of Puerto Rico has oversight responsibilities.

The conference report accompanying the National Defense Authorization Act for Fiscal Year 2020 (H.R. Rep. No. 116-333) contained a provision for GAO to study the status of the federal cleanup on Vieques and Culebra. This review (1) discusses the status and cost of cleanup efforts, (2) identifies challenges to the cleanup efforts and examines how DOD is addressing them, and (3) describes the cleanup technologies DOD is using at these sites and how federal agencies assess the feasibility of innovative technologies. GAO reviewed agency data, documentation, and guidance; and interviewed DOD, EPA, and other federal officials, Commonwealth officials, academic researchers, and residents of both islands.

View [GAO-21-268](#). For more information, contact Alfredo Gómez at (202) 512-3841 or gomezj@gao.gov or Elizabeth A. Field at (202) 512-2775 or fielde1@gao.gov.

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Efforts at Former Military Sites on Vieques and Culebra, Puerto Rico, Are Expected to Continue through 2032

What GAO Found

The Department of Defense (DOD) continues to make progress on cleanup efforts at the former military sites in Vieques and Culebra, Puerto Rico, but substantial work remains. The U.S. Navy and the U.S. Army Corps of Engineers (Corps) estimate that cleanup efforts will continue through fiscal year 2032. The Navy has completed cleanup on nearly all sites contaminated with hazardous materials on Vieques, but substantial work remains for the Navy and the Corps on both islands at sites with munitions, especially underwater sites where unexploded munitions are buried in the sea floor. The costs of prior cleanup, combined with DOD's reported estimates for planned cleanup on both islands, through fiscal year 2032, total nearly \$800 million.

DOD faces a number of challenges in its cleanup efforts, according to agency documentation and interviews with Navy, Corps, and other federal officials. Challenges include logistics, the islands' topography and environment, and the safety concerns around handling unexploded munitions. The Navy also faces challenges on Vieques with community distrust of the military handling cleanup efforts. DOD is taking steps to address these challenges, including establishing procedures and protocols, and mechanisms for community input. For example, to address environmental challenges, the agencies established a standard operating procedure to protect endangered and threatened species and their habitats.

The Navy and Corps use a variety of technologies in their cleanup efforts. For example, the agencies use technologies, such as advanced geophysical classification, to detect munitions on land and the towed magnetometer array to detect munitions underwater. The agencies assess the feasibility of innovative cleanup technologies through active participation in DOD environmental research programs and military-specific technology transfer processes.

Example of Two Technologies Used to Detect Unexploded Munitions on Land and Underwater as Part of Cleanup Efforts on Vieques and Culebra, Puerto Rico



The image on the left is of Advanced Geophysical Classification technology on Culebra, which is used to identify properties, such as size or depth, of a buried metal object. The other image is of a towed magnetometer array on Vieques, Puerto Rico, used to identify magnetic anomalies caused by the presence of iron objects lying on or beneath the seafloor.

Sources: U.S. Army Corps of Engineers and U.S. Navy. | [GAO-21-268](#)

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Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
Corps	U.S. Army Corps of Engineers
COVID-19	Coronavirus Disease 2019
DOD	Department of Defense
EPA	Environmental Protection Agency
FUDS	Formerly Used Defense Sites
IRP	Installation Restoration Program
MMRP	Military Munitions Response Program
NOAA	National Oceanic and Atmospheric Administration
RAB	Restoration Advisory Board

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March 26, 2021

Congressional Committees

For several decades, the U.S. military conducted exercises and operated training facilities on the islands of Vieques and Culebra, located off the eastern coast of the main island of Puerto Rico. Beginning in the 1900s, the U.S. Navy and other military forces conducted ship-to-shore gunfire exercises and live-fire training activities on these islands. In response to concerns about risks to public safety, human health, and the environment, the Navy ceased military exercises and closed its training facilities on Culebra in 1975 and on Vieques in 2003. Following the end of military activities, extensive amounts of munitions, including unexploded ordnance, as well as hazardous substances and other contaminants, were identified on both islands and in their surrounding waters. Unexploded ordnance can leach residues that cause soil, ground water, and surface water contamination. These residues can include explosives and heavy metals, including depleted uranium.

Cleanup efforts on both islands are currently being conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), which established the federal program known as Superfund to address sites with hazardous substances that pose a danger to public health or the environment.¹ CERCLA and its implementing regulations outline a process for how cleanup decisions are made at individual sites and establish standards and requirements for cleanups but do not require specific cleanup actions. In 2005, the U.S. Environmental Protection Agency (EPA) placed the island of Vieques and its surrounding waters on its National Priorities

¹The Environmental Protection Agency (EPA) issued a Resource Conservation and Recovery Act Corrective Action Order to the Navy in 2000 for a portion of the Superfund site on Vieques. The order required the Navy to clean up contamination from hazardous waste at that location. In 2007, EPA, the Navy, the Department of the Interior, and the Commonwealth of Puerto Rico entered into an agreement pursuant to CERCLA regarding the Vieques Superfund site that, among other things, integrated all requirements of the order, specified that all response actions undertaken pursuant to the agreement would be deemed to satisfy the order, and terminated the order.

List of the most contaminated sites—private, federal, and former federal properties—identified for long-term cleanup.²

On Vieques, the Navy is responsible for funding and leading cleanup efforts, with oversight by EPA. On Culebra, the U.S. Army Corps of Engineers (Corps) is responsible for funding and leading cleanup efforts through the Department of Defense's (DOD) Formerly Used Defense Sites program. The Commonwealth of Puerto Rico's Department of Natural and Environmental Resources provides oversight of the Corps' cleanup efforts. DOD conducts cleanup activities on both islands under the Defense Environmental Restoration Program. Other federal agencies are also involved in the cleanup, including the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service and National Ocean Service and the Department of the Interior's U.S. Fish and Wildlife Service.

The conference report accompanying the National Defense Authorization Act for Fiscal Year 2020 contained a provision for GAO to study the status of the federal cleanup on the islands of Vieques and Culebra, Puerto Rico.³ This review (1) discusses the status and cost of ongoing cleanup efforts at the former military sites on the islands of Vieques and Culebra, Puerto Rico; (2) identifies challenges to the cleanup efforts at these sites and examines how DOD is addressing these challenges; and

²In 2003, the Governor of Puerto Rico designated certain areas on and around Vieques and Culebra as Puerto Rico's single highest-priority facility pursuant to section 105(a)(8)(B) of CERCLA and requested that EPA list them on the National Priorities List. In 2005, EPA listed those areas on and around Vieques but elected to take no action on the listing decision for Culebra because of ongoing negotiations between Puerto Rico and the U.S. Army to reach an agreement to govern the cleanup. 70 Fed. Reg. 7182 (Feb. 11, 2005). Section 105(a)(8)(B) allows each state to designate a single site as its top priority to be listed on the National Priorities List regardless of its score on the hazard ranking system, which is a screening device to evaluate the relative potential of hazardous substance releases to cause human health or safety problems or ecological or environmental damage. CERCLA's definition of "state" includes U.S. territories, such as the Commonwealth of Puerto Rico.

³H.R. Rep. No. 116-333, at 1190 (2019).

(3) describes the cleanup technologies DOD is using at these sites and how federal agencies assess the feasibility of innovative technologies.⁴

To determine the status and cost of cleanup efforts at the former military sites on the islands of Vieques and Culebra, Puerto Rico, we reviewed relevant laws, regulations, and guidance that governs such cleanup efforts. We also obtained and analyzed data on the status and cost for each cleanup site on Vieques and Culebra from DOD's Knowledge-Based Corporate Reporting System on environmental restoration efforts.⁵ In addition, we also reviewed our prior work related to the status of cleanup efforts on Vieques, as well as DOD reports to Congress on environmental restoration and cleanup efforts on Vieques and Culebra.

To identify challenges to the cleanup efforts at these sites and how DOD is addressing these challenges, we analyzed documentation that included information on cleanup alternatives and associated challenges, such as site management plans. We also interviewed federal officials, residents from both islands, and academics on the challenges and steps that the Navy and Corps have taken to address these challenges.

To describe the cleanup technologies that DOD is using at these sites and how agencies assess the feasibility of innovative technologies, we reviewed DOD and EPA guidance on the development, testing, and consideration of technologies, including innovative technologies. We analyzed documentation from DOD's environmental research programs to learn about technologies, as well as site-specific program documentation from EPA, the U.S. Fish and Wildlife Service, and NOAA's National Marine Fisheries Service to learn about their role in assessing technology. We interviewed federal officials to gain an understanding of what technologies were used or proposed for use and how these officials learn about and assess the feasibility of technology for use at cleanup

⁴For purposes of this report, the term "cleanup site" or "sites" refers to any location on Vieques and Culebra where the Navy or Corps are conducting cleanup efforts, activities, or projects; and the term "innovative technology" refers to breakthrough technology concepts that are either (1) mature technologies being used in a new manner; or (2) technologies under development that require additional testing, evaluation, and commercial availability in order to transition to full-scale implementation.

⁵We did not assess the reliability of each cleanup site's future cost estimates, such as the underlying engineering calculations, but instead focused on the reliability of the overall reporting system.

sites. For further information about our scope and methodology, see appendix I.

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

Background

Vieques and Culebra, Puerto Rico

The islands of Vieques and Culebra are located in the Caribbean Sea, to the east of the main island of Puerto Rico (see fig. 1). Vieques, which consists of 33,000 acres of land, is located 7 miles southeast of the main island of Puerto Rico. Culebra, which is approximately 7,400 acres, is located 17 miles east of the main island of Puerto Rico and 9 miles north of Vieques. According to census data, as of 2019, the population of Vieques was approximately 8,300 residents, and the population of Culebra was approximately 1,700 residents. A ferry provides transportation between each island and the main island of Puerto Rico, and each island also has an airport.

Figure 1: Location of Vieques and Culebra, Puerto Rico



Sources: Department of Defense documentation; Federal Emergency Management Agency (Culebra map); Map Resources (inset map). | GAO-21-268

During the years when the military conducted active exercises and trainings on the islands, the U.S. government required residents to relocate to areas outside of the bombardment zones. On Vieques, the residents relocated to the central part of the island within the Municipality of Vieques. Their access to most of the remaining parts of the island was restricted due to safety concerns. On Culebra, most of the civilian population currently resides in areas where people relocated away from training sites.

Halting of Military Activities, Subsequent Land Transfers, and Cleanup Responsibilities

On Vieques, the U.S. Navy administered lands on both the western and eastern ends of the island from the 1940s until 2003. On the eastern side, the Vieques Naval Training Range occupied over 14,500 acres and consisted of four distinct areas.⁶ The western portion of the island was the location of the former Naval Ammunition Support Detachment, which covered about 8,200 acres.⁷

In early 2001, the Navy stopped live-fire training operations in the eastern portion of the island, and the military transferred about half of the acreage (4,200 acres) at the Naval Ammunition Support Detachment to the Municipality of Vieques; about 3,000 acres to the U.S. Fish and Wildlife Service for a wildlife refuge; and 800 acres to the Puerto Rico Conservation Trust. In 2003, with all training on Vieques ended, the former Vieques Naval Training Range was transferred to the U.S. Fish and Wildlife Service and is administered now as the Vieques National Wildlife Refuge, with one area—the Live Impact Area—managed as a wilderness area with no public access. EPA listed Vieques on the National Priorities List in 2005, which elevated the priority for its cleanup. The lands on Vieques were transferred from DOD to the U.S. Fish and Wildlife Service and others, pursuant to a statutory mandate; however, the Navy is funding and implementing cleanup of these areas from the Defense Environmental Restoration Account.

On Culebra, between 1903 and 1975, the Navy and Marine Corps used portions of the island and its cays, as well as surrounding waters, as a live practice range for bombing exercises, weapons testing, and small arms fire. From 1972 through 1988, DOD transferred the majority of the land to either Puerto Rican entities, including the Municipality of Culebra, or the U.S. Fish and Wildlife Service. For example, almost 1,400 acres were transferred to the U.S. Fish and Wildlife Service and currently comprise the Culebra Island National Wildlife Refuge.

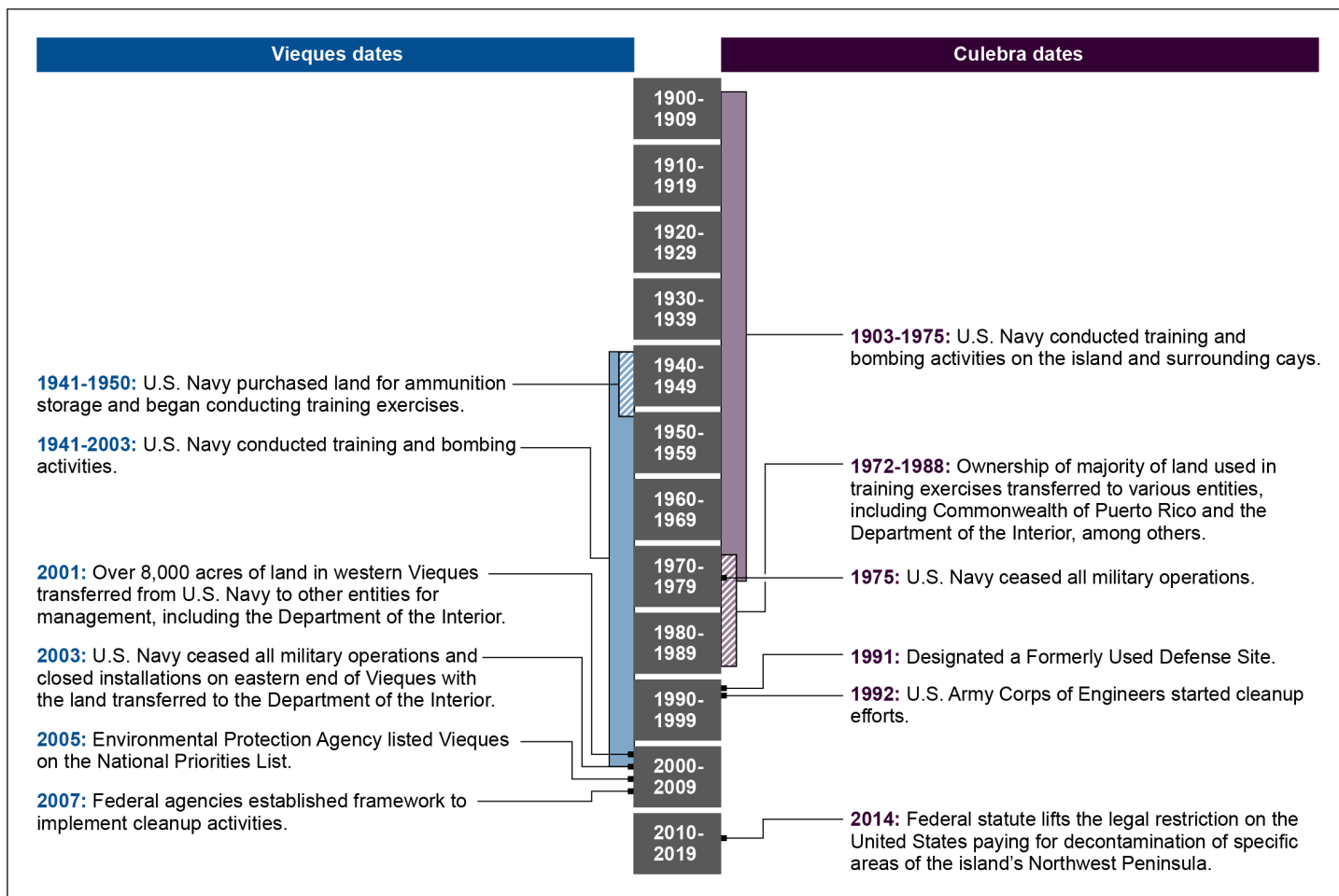
Properties once formerly owned, leased, or otherwise possessed by the United States and under the jurisdiction of DOD at the time of the actions leading to contamination by hazardous substances, and that DOD conveyed to other entities and relinquished jurisdiction over prior to

⁶The four areas were the Eastern Maneuver Area, the Surface Impact Area, the Live Impact Area, and the Eastern Conservation Area. The military used these areas primarily for ground warfare and amphibious training, naval gunfire support training, and air-to-ground training.

⁷The military used this area to store munitions and other support facilities for training of the U.S. Atlantic Fleet.

October 17, 1986, are known as Formerly Used Defense Sites (FUDS). Culebra received the designation of a FUDS site in 1991. Similar to the Navy's efforts on Vieques, the FUDS environmental cleanup program is funded by the Defense Environmental Restoration Account. Starting in 1992, the Corps began to fund limited surface removal of munitions on publicly accessible areas, including beaches and campgrounds where munitions were found in the soil or washed up on the beach. Figure 2 provides a time line of some of the federal activities on Vieques and Culebra.

Figure 2: Time Line of Department of Defense and Other Federal Activities on Vieques and Culebra, Puerto Rico



Source: GAO analysis of Department of Defense documentation. | GAO-21-268

DOD's Defense Environmental Restoration Program

The Navy and Corps follow DOD's Defense Environmental Restoration Program statute, which requires, among other things, the agencies to comply with CERCLA, CERCLA's implementing regulations, and implementing guidance for their cleanup of Vieques and Culebra. Specifically, the Navy and Corps generally follow a phased process when implementing cleanup efforts on Vieques and Culebra. Table 1 provides a brief description of each phase.

Table 1: Defense Environmental Restoration Program Phases for Cleanup Efforts

Site discovery	Includes conducting documentation searches and visual inspections to determine if a site warrants further investigation and if there is a risk to public health and the environment.
Preliminary assessment	Includes conducting reviews of existing information and potential site visits to determine if a hazardous substance, pollutant, or contaminant release requires additional investigation or action.
Site inspection	Includes conducting site visits and often involves taking preliminary soil and water samples, as well as collecting and analyzing other data to determine the need for further action.
Remedial investigation/feasibility study	Includes taking soil and water samples and conducting a health and ecological health risk assessment and evaluating alternatives for site remediation. This phase also includes developing proposed remediation objectives and a plan to clean up the site, including what technologies may be used in the effort. At the end of this phase, a Record of Decision is issued that explains which cleanup alternative(s) will be used at the site.
Remedial design	Includes developing design plans and specifications for the selected cleanup alternative(s).
Remedial action	Includes the implementation of the cleanup alternative documented in the Record of Decision until cleanup objectives are achieved.
Long-term monitoring	Involves site monitoring to evaluate the performance of the remedial action in achieving remediation objectives and site conditions.
Site closeout	Includes a determination that no further response is required at the site and that all cleanup levels have been achieved.

Source: GAO analysis of the Department of Defense's Defense Environmental Restoration Program policy. | GAO-21-268

Under DOD's Defense Environmental Restoration Program, environmental restoration efforts are organized under two primary cleanup programs: the Installation Restoration Program (IRP) and the Military Munitions Response Program (MMRP). The IRP includes sites that require response actions to address hazardous substances, pollutants, or other contaminants, such as petroleum, oil, and lubricants; hazardous wastes or waste constituents; and explosive compounds released into sediment, soil, surface waters, or groundwater from the production of ammunition or explosives. The MMRP includes sites that are known or suspected to contain unexploded ordnance, discarded

military munitions, or munitions constituents, as well as sites where addressing the release of hazardous substances, pollutants, or contaminants is incidental to the munitions response.⁸ For these programs, data collected during the preliminary assessment and site inspection phases are used to determine if there is a need for further action and the type of response action (i.e., removal action or remedial action). In general, removal actions are shorter-term or emergency cleanups to mitigate immediate threats, and remedial actions typically are longer-term actions that involve a more elaborate process to permanently and significantly reduce contamination. It is DOD policy to facilitate the development of and transition to cost-effective, innovative technologies to aid in cleanup efforts at these sites.⁹

Entities Involved in the Cleanup Efforts

The Navy and Corps implement and lead the cleanup efforts on Vieques and Culebra, respectively. Other federal and Commonwealth agencies are also involved with various aspects of the cleanup efforts, including as natural resource trustees under CERCLA.¹⁰ See table 2 for a list of other federal and Commonwealth agencies involved in the cleanup efforts.

Table 2: Other Federal and Commonwealth Agencies' Involvement in Cleanup Efforts on Vieques and Culebra, Puerto Rico

Environmental Protection Agency	The Environmental Protection Agency is responsible for oversight of the Navy's cleanup activities on Vieques. The agency also participates as an advisor for the U.S. Army Corps of Engineers' (Corps) cleanup efforts on Culebra.
Department of the Interior's U.S. Fish and Wildlife Service	The U.S. Fish and Wildlife Service manages wildlife refuges. The agency owns and manages wildlife refuges on both islands and provides input on cleanup decisions. In addition, the U.S. Fish and Wildlife Service implements the Endangered Species Act for terrestrial and freshwater species, as well as for manatees and nesting sea turtles. Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended (CERCLA), the Secretary of the Interior serves as trustee for natural resources located on, over, or under land administered by the Department of the Interior, including wildlife refuges.

⁸Surface munitions are found on the ground, while subsurface munitions are found below ground.

⁹DOD Instruction 4715.07, Defense Environmental Restoration Program (May 21, 2013) (Incorporating Change 2, Aug. 31, 2018).

¹⁰As a natural resource trustee, the agency can, among other things, request that the agency leading the cleanup take action to address a hazardous substance when it threatens or causes injury to those natural resources. Natural resources include land, fish, wildlife, air, water, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States.

National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service and National Ocean Service

The National Marine Fisheries Service implements the Endangered Species Act for marine and anadromous (fish that migrate between saltwater and freshwater during their lifetime, such as salmon) species. The National Ocean Service's mission is to provide science based solutions through collaborative partnerships to address evolving economic, environmental, and social pressures on oceans and coasts. Specifically, the Office of Response and Restoration within the National Ocean Service provides support to agencies leading cleanups to maximize the benefits while minimizing any adverse impacts to natural resources that may occur during cleanup. These two NOAA agencies primarily coordinate and consult with the other federal agencies on cleanup efforts on Vieques and Culebra. Under CERCLA, the Administrator of NOAA serves as trustee for natural resources managed or controlled by the Department of Commerce and for natural resources managed or controlled by other federal agencies that are found in, under, or using certain waters.

Puerto Rico's Department of Natural and Environmental Resources

Puerto Rico's Department of Natural and Environmental Resources protects, conserves, and manages the natural and environmental resources of Puerto Rico. This agency oversees the Corps' cleanup activities on Culebra and participates as an advisor for, as well as monitors, cleanup efforts on Vieques.

Source: GAO analysis of agency documentation, reports, and information from officials. | GAO-21-268

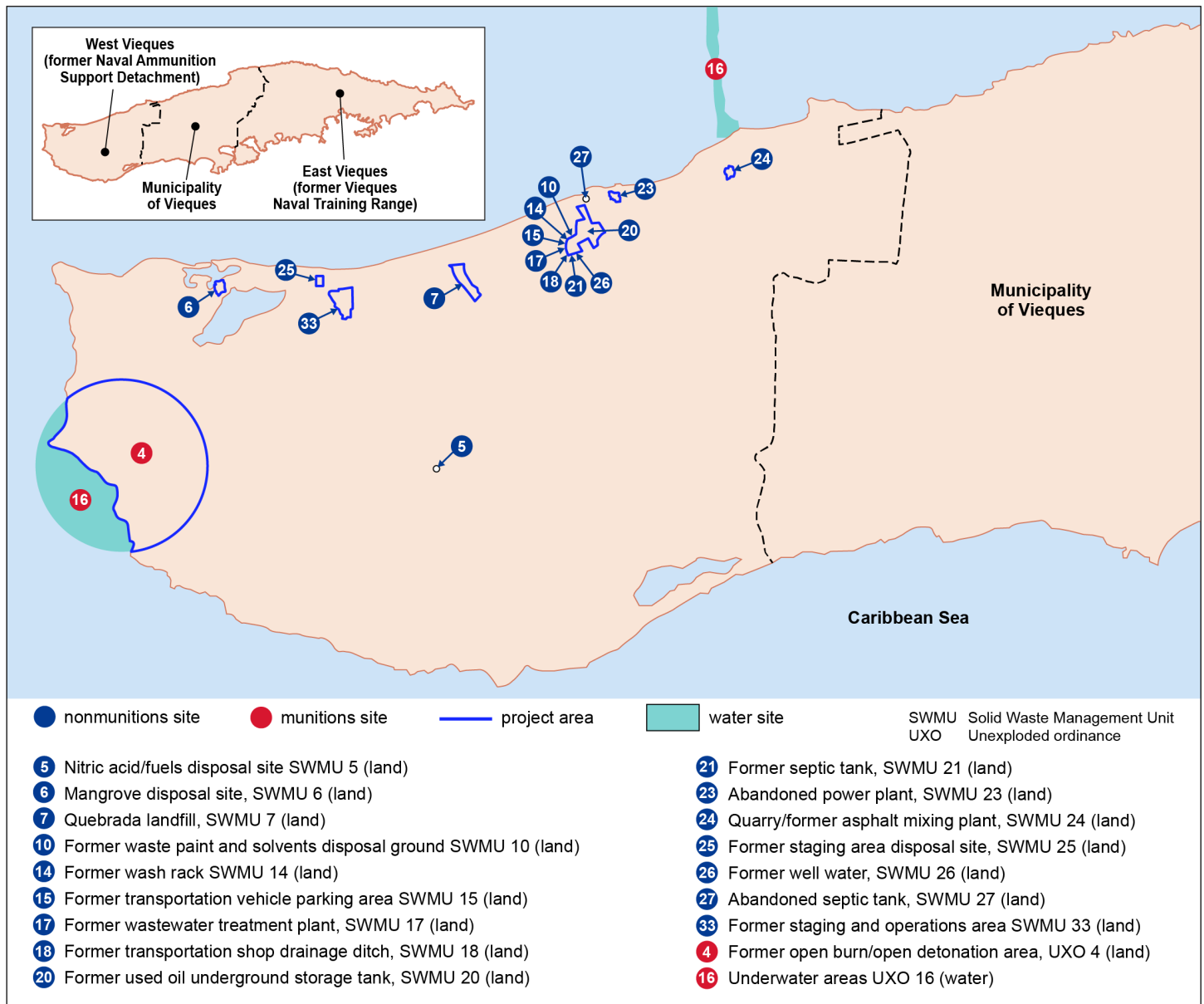
Navy and Corps Have Made Progress on Cleanup, but Substantial Work Remains

The Navy Has Completed Cleanup at Nearly All IRP Sites on Vieques, but Substantial Work Remains at MMRP Sites

The Navy has completed cleanup at nearly all IRP sites on Vieques, but substantial work remains at MMRP sites known or suspected to contain unexploded ordnance, discarded military munitions, or munitions constituents. The Navy has a total of 73 sites for cleanup on Vieques: 54 are IRP sites, and 19 are MMRP sites. After conducting preliminary assessments and site inspections of the 54 IRP sites, the Navy found that 25 had no contamination and warranted no additional studies or actions; the Navy continued cleanup efforts at the remaining 29 IRP sites.

Thus, 48 sites in total required cleanup efforts (29 IRP and 19 MMRP). Of these, one MMRP and 16 IRP sites are located in western Vieques at the former Naval Ammunition Support Detachment; 13 IRP and 17 MMRP sites are located in eastern Vieques at the former Vieques Naval Training Range; and one underwater MMRP site spans both locations (see figs. 3 and 4).

Figure 3: Installation Restoration Program and Military Munitions Response Program Cleanup Sites at the Former Naval Ammunition Support Detachment on Western Vieques, Puerto Rico, as of October 2020

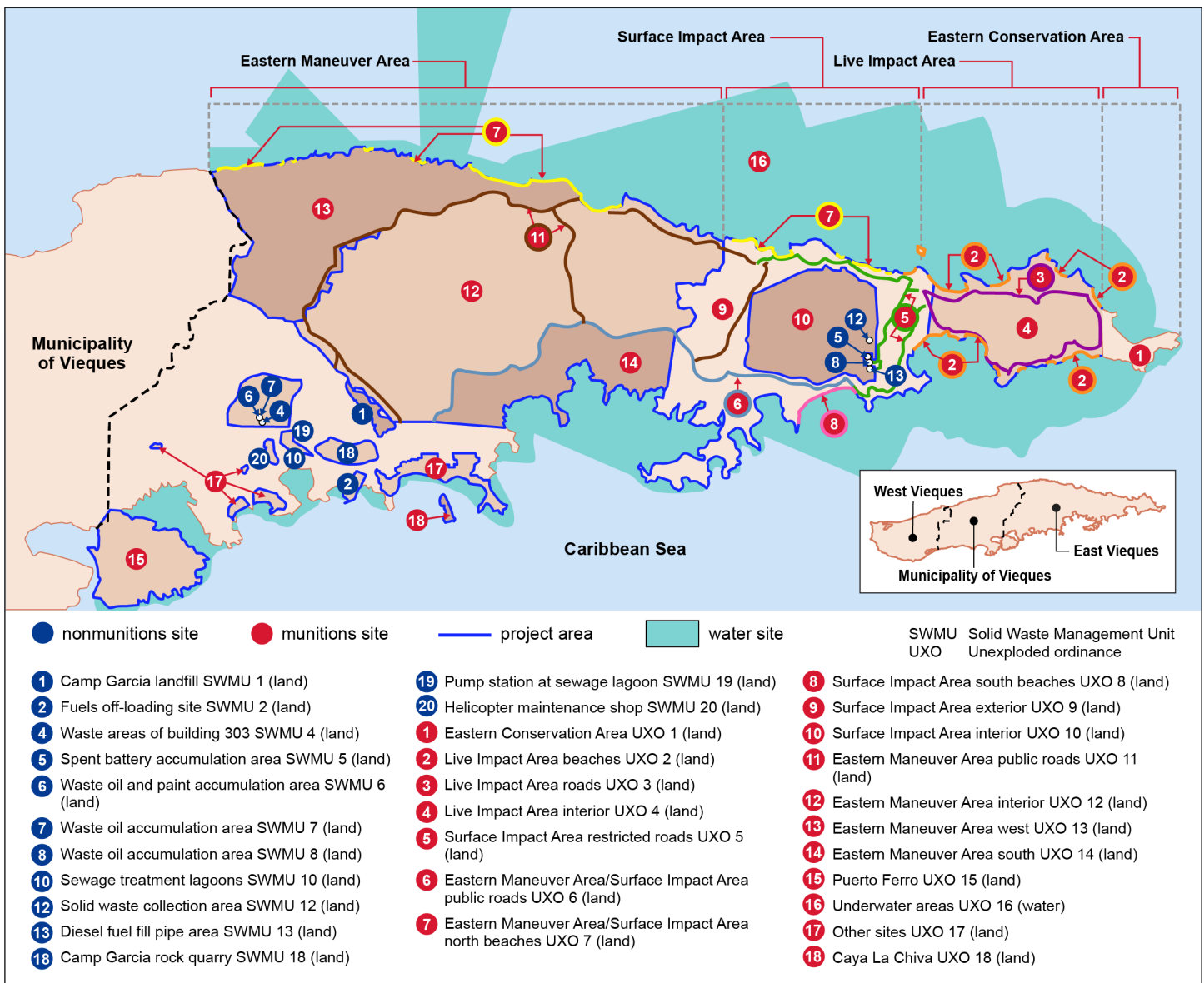


Source: GAO analysis of Department of Defense documentation. | GAO-21-268

Note: The Department of Defense's two categories of cleanup programs are (1) the Installation Restoration Program, which includes sites that require response actions to address hazardous substances, pollutants, or contaminants; and (2) the Military Munitions Response Program, which includes sites that are known or suspected to contain unexploded ordnance, discarded military

munitions, or munitions constituents, as well as sites where addressing the release of hazardous substances, pollutants, or contaminants is incidental to the munitions response.

Figure 4: Installation Restoration Program and Military Munitions Response Program Cleanup Sites at the former Naval Training Range on Eastern Vieques, Puerto Rico, as of October 2020



Source: GAO analysis of Department of Defense documentation. | GAO-21-268

Note: The Department of Defense's two categories of cleanup programs are (1) the Installation Restoration Program, which includes sites that require response actions to address hazardous substances, pollutants, or contaminants; and (2) the Military Munitions Response Program, which

includes sites that are known or suspected to contain unexploded ordnance, discarded military munitions, or munitions constituents, as well as sites where addressing the release of hazardous substances, pollutants, or contaminants is incidental to the munitions response.

Cleanup Efforts at IRP Sites on Vieques

Fifty-four of the 73 sites on Vieques are part of IRP. As shown in table 3, as of October 2020, the Navy completed preliminary assessments and site inspections, as well as any necessary remedial actions, at 51 of the sites. EPA also approved site closure status for these 51 sites, which indicates that they are suitable for unrestricted use and require no further cleanup actions. The three sites that have not achieved closeout status are in different phases, although only one is in the early phase of site inspection.

Table 3: Status of Cleanup for Installation Restoration Program Sites on Vieques, Puerto Rico, by Phase (as of October 2020)

Cleanup phase	Total, by phase
Preliminary assessment	0
Site inspection	1
Remedial investigation/ feasibility study	0
Remedial design	0
Remedial action	1
Long-term monitoring	1
Site closeout	51
Total	54

Source: GAO presentation of U.S. Navy information. | GAO-21-268

Cleanup Efforts at MMRP Land Sites on Vieques

Nineteen of the 73 sites on Vieques are part of the MMRP. Of the 19 sites, 18 are on land, and one site involves a grouping of underwater areas offshore. As shown in table 4, as of October 2020, the Navy completed preliminary assessment and site inspection for all sites, and the majority of sites are in the remedial investigation phase. The Navy estimates cleanup will continue through fiscal year 2031.

Site-Specific Land-Use Designs Help to Prioritize Cleanup Efforts in Vieques

The U.S. Navy works to accelerate cleanup on Vieques in order to facilitate the public’s access to areas for residents’ recreational use and commercial tourist activities. For example, the U.S. Fish and Wildlife Service has developed a Comprehensive Conservation Plan for the Vieques National Wildlife Refuge that outlines its concept for managing the refuge, as well as site-specific land-use designs for certain areas. Priority areas for munitions removal actions include beaches, roads, hunting and crabbing areas, parking areas, paths, and picnic areas. These areas have been prioritized with input from the Environmental Protection Agency, U.S. Fish and Wildlife Service, local residents, local businesses, community leaders, the Puerto Rico Governor’s office, and other Commonwealth leaders.

For example, according to Navy documentation:

- In 2014, the Navy accelerated cleanup of the land and beach around the Puerto Ferro historic lighthouse, and the U.S. Fish and Wildlife Service opened this area for public use in March 2015, several years ahead of the original project schedule.
- As of 2020, accelerated cleanup at the Carenera peninsula, which has several beaches, a sheltered bay, and snorkeling areas that residents and local outfitters wish to access, is underway.
- By 2021, approximately 5,000 acres in the former Eastern Maneuver Area may become available for hiking and other activities that the U.S. Fish and Wildlife Service manages if cleanup efforts are completed.



Vieques National Wildlife Refuge.

Sources: GAO analysis of U.S. Navy documentation; U.S. Fish and Wildlife Service (photo). | GAO-21-268

Table 4: Status of Cleanup for Military Munitions Response Program Sites on Vieques, Puerto Rico, by Phase (as of October 2020)

Cleanup phase	Total, by phase
Preliminary assessment	0
Site inspection	0
Remedial investigation/ feasibility study	14
Remedial design	2
Remedial action	1
Long-term monitoring	2
Site coseout	0
Total	19

Source: GAO presentation of U.S. Navy information. | GAO-21-268

Since 2005, the Navy has been removing munitions and explosive hazards that pose an imminent threat to the public in order to allow workers to safely conduct environmental sampling, as well as to facilitate public access to more areas on Vieques (see sidebar).

In March 2020, the Navy reported to Congress that, as part of its cleanup efforts, removal actions were needed to address munitions at 16 of the 18 MMRP land sites. The Navy also reported it had completed removal actions at six sites and expected to complete removal actions at the remaining 10 sites by fiscal year 2022. More specifically, according to Navy officials:

- The Navy completed removal actions at one land munitions site in western Vieques. Specifically, the Navy surface cleared 165 acres, including 17 acres of roads and 7 acres of beaches. These roads and beaches were also subsurface cleared. Site investigations indicated that the likelihood of additional surface or subsurface munitions was low but did not determine that there were no additional munitions. No cleanup of the 285 acres at this munitions site is planned, but the Navy remains responsible for any cleanup, if any additional munitions and explosives of concern are located.
- The Navy completed removal actions at five of the 15 land munitions sites in eastern Vieques. Specifically, the Navy surface cleared a total of 3,976 acres at these five sites, including 92 acres of roads, 101 acres of beaches, and 104 acres of inland area. These roads, beaches, and inland areas were also subsurface cleared. For the other 10 sites, the Navy estimates that 760 acres need to be surface cleared, including 177 acres of roads and 93 acres of beaches.

Further, according to the Navy, 1,000 acres need to have their subsurface cleared to support U.S. Fish and Wildlife Service planned activities, such as the construction of parking lots, bridges, and observation towers. Site investigations suggest that no additional surface clearing is needed on 6,428 acres, but the CERCLA process has not advanced to the point where Records of Decision have been issued for these sites. Navy officials acknowledge that additional surface clearance may be needed, which contributes to the uncertainty of future actions.

As of March 2020, removal actions at MMRP land sites across Vieques resulted in the collection and disposal of over 8 million items of material potentially presenting an explosive hazard, and approximately 109,000 munitions items: 41,000 projectiles; 32,000 bombs; 4,700 mortars; 1,300 rockets; 18,000 submunitions; and 12,000 grenades, flares, pyrotechnics, and other munitions.¹¹ According to Navy documentation, once sufficient munitions removal actions have occurred, site workers can safely enter a site and gather environmental samples from the soil, sediment, surface water, and groundwater. The Navy and others use these environmental samples to conduct, for example, human health risk assessments, which EPA reviews and comments on.¹² The Navy has completed human health risk assessments for nine of the 18 MMRP land sites and found that eight sites do not contain any chemicals of concern and that no further remedial actions for munitions constituents are needed. At the one other site, however, the Navy identified perchlorate in the groundwater and is now undertaking a groundwater remedial action and conducting long-term monitoring at the site.¹³

Substantial Work Remains at One MMRP Underwater Site

Cleanup at the one MMRP underwater site off of Vieques is in the remedial investigation phase and will require substantial work to complete, according to DOD environmental program officials. This site is approximately 11,500 acres and consists of areas that are known or suspected to have been impacted by munitions or explosives of concern. According to Navy documentation, approximately 600 acres of this site

¹¹A submunition is any munition that separates from the parent munition to perform its task.

¹²According to EPA, a human health risk assessment is the process used to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environments, now or in the future.

¹³According to EPA, perchlorate is a naturally occurring and manufactured anion, which is a negatively charged ion. Perchlorate contamination has been found at sites involved in the manufacture, maintenance, use, and disposal of ammunition. Perchlorates can have public health impacts, if ingested.

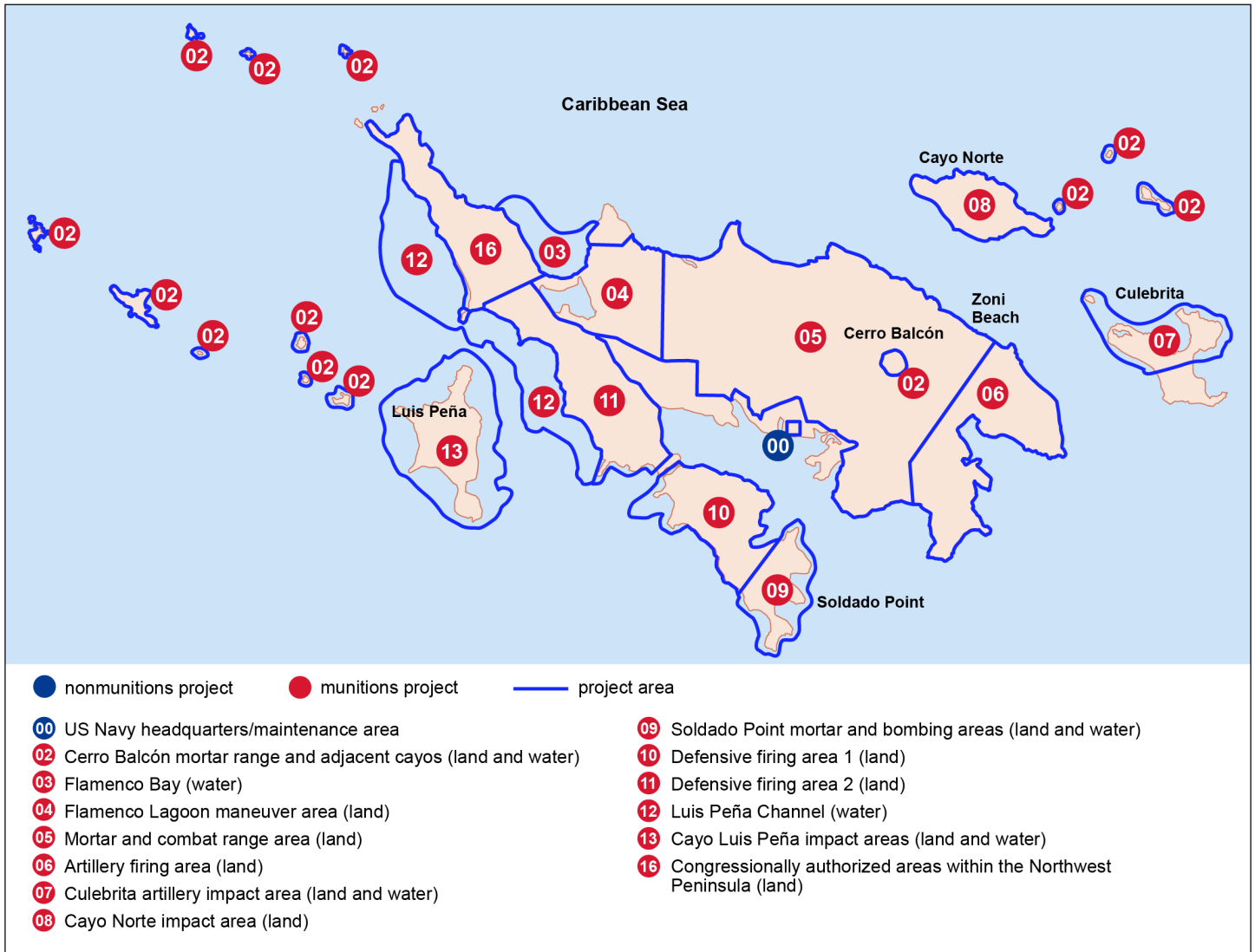
are classified as nearshore, which, for this site, is an area that extends from the shoreline to a water depth of between 10 and 15 feet. This site includes 29 offshore areas adjacent to public beaches, as well as three former ship anchoring areas and a pier where munitions may have been loaded, offloaded, or transferred; areas where munitions from naval gunfire training or air-to-ground bombing may have been inadvertently fired into the water; and areas where explosives from artillery ranges and adjacent onshore open detonation activities may have extended into the water.

The Navy developed an approach for the investigation of these underwater areas and, in 2017, completed a survey across 12,000 underwater acres, using specialized technology to identify and investigate the general location of underwater munitions around Vieques. The Navy has prioritized removal actions for underwater munitions in nearshore areas around Vieques, including the areas offshore of a public beach, as well as for the waters adjacent to the island of Cayo La Chiva, in order to facilitate public use of the island and surrounding waters. The Navy anticipates conducting more detailed remedial investigations and estimates completing cleanup of this site by fiscal year 2032.

The Corps Identified 15 Sites on Culebra and Estimates Cleanup at 14 Sites to Continue through Fiscal Year 2031

The Corps identified 15 former military sites for cleanup on Culebra and estimates that cleanup at 14 of the sites will continue through fiscal year 2031. For the other site, the Corps concluded there were no munitions or environmental contamination from the military's use. Of the 15 sites, one is part of the IRP, and 14 are part of the MMRP (see fig. 5).

Figure 5: Installation Restoration Program and Military Munitions Response Program Cleanup Sites on Culebra, Puerto Rico, as of October 2020



Sources: GAO analysis of U.S. Army Corps of Engineers documentation; Federal Emergency Management Agency (map). | GAO-21-268

Note: The Department of Defense’s two categories of cleanup programs are (1) the Installation Restoration Program, which includes sites that require response actions to address hazardous substances, pollutants, or contaminants; and (2) the Military Munitions Response Program, which includes sites that are known or suspected to contain unexploded ordnance, discarded military munitions, or munitions constituents, as well as sites where addressing the release of hazardous substances, pollutants, or contaminants is incidental to the munitions response. The one site with completed cleanup activities on Culebra is not shown on the figure.

Culebra's one IRP site is located at the Navy's former island headquarters and maintenance area. The site is slightly smaller than 1 acre and contains contaminated sediments. As of October 2020, the site was in the remedial investigation/feasibility study phase, and the Corps expects this phase will be completed in fiscal year 2022.

The 14 MMRP sites are located on the mainland, adjacent cays, on smaller islands off the island's mainland, or in the surrounding waters.¹⁴ The Corps, in 2009, concluded that there was no evidence of the presence of munitions or environmental contamination from the military's use at one MMRP site. The site encompassed land around Culebra's airport and was the former location of a military airfield and possibly a small arms range. As of October 2020, 12 of the 13 remaining MMRP sites were in the remedial investigation/feasibility study phase, where the nature and extent of the risks posed by munitions are categorized in order to help develop cleanup options.

As of October 2020, the Corps estimated that cleanup of three of the 13 MMRP sites, which are located on the main island of Culebra, will be completed by fiscal year 2025. Six more sites have estimated cleanup completion dates in fiscal year 2030, and cleanup at the remaining four sites are estimated to be completed by fiscal year 2031. The Corps expects that long-term management will continue at all 13 sites after the planned remediation is complete.

The remaining MMRP site—the Northwest Peninsula—was a former bombardment area that was subject to a statutory restriction on cleanup.¹⁵ The restriction was lifted for certain portions of this area in 2014. In 2019, the Corps completed a removal action to clean up those areas except where there were structures. Subsequently, the Municipality of Culebra started renovations at Flamenco Beach and Flamenco campground, including demolition of structures that previously prevented

¹⁴Five of the 14 sites are located within the Culebra National Wildlife Refuge, which the U.S. Fish and Wildlife Service manages.

¹⁵The Northwest Peninsula is an area of approximately 572 acres; DOD transferred the bombardment area, which was 408 acres of the peninsula, to the Commonwealth of Puerto Rico and 164 acres to the U.S. Fish and Wildlife Service. Cleanup of the 408-acre area was initially subject to statutory restrictions on use that would require decontamination at the expense of the United States. Pub. L. No. 93-116, § 204(c), 87 Stat. 661, 668 (1974). As a result, the peninsula was not considered part of the Corps' cleanup efforts under FUDS. However, in 2014, a federal statute lifted the restriction on the United States paying for decontamination of specific portions of the bombardment area. Pub. L. No. 113-291, § 317(b), 128 Stat. 3292, 3340 (2014).

access for the Corps' fieldwork beneath those structures. The additional fieldwork to address the areas that formerly had structures was initiated in July 2020 and is expected to be completed in fiscal year 2022.

Table 5 lists all cleanup sites and their phases on Culebra as of October 2020. To date, the Corps has reported clearing over 86 acres of the 8,900 acres in the MMRP projects. In addition, the Corps reported clearing 5,000 unexploded ordnances as of January 2020.

Table 5: Status of Cleanup for Installation Restoration Program and Military Munitions Response Program Sites on Culebra, Puerto Rico, by Phase (as of October 2020)

Cleanup phase	Total, by phase
Preliminary assessment	1
Site inspection	0
Remedial investigation/ feasibility study	13
Remedial design	0
Remedial action	0
Long-term monitoring	0
Site closeout	1
Total	15

Source: GAO presentation of U.S. Army of Corps of Engineers information. | GAO-21-268

Note: One of the sites—the Northwest Peninsula—is currently undergoing interim remedial actions and is represented in the table by the phase it most recently completed (the preliminary assessment phase).

DOD Reported Spending about \$380 Million for Cleanup Efforts on Vieques and Culebra and Estimates an Additional \$420 Million to Complete Cleanup through Fiscal Year 2032

According to DOD data, DOD reported spending \$327 million on cleanup efforts on Vieques and \$52 million on Culebra through fiscal year 2019.¹⁶

On Vieques, cleanup efforts at five sites account for 65 percent of the \$327 million total costs.¹⁷ To date, the most costly cleanup on Culebra is the Cerro Balcon Mortar Range and Adjacent Cayos site, which has cost over \$12 million, according to DOD data.¹⁸

DOD anticipates that cleanup activities on both islands will continue through fiscal year 2032, for a total additional cost of about \$420 million. For Vieques, DOD estimated as of September 2020 that it would need an additional \$306 million to complete the cleanup efforts, with nearly half of this funding to be dedicated to cleanup at the underwater site on Vieques.¹⁹ For Culebra, DOD estimated that it would need \$114 million to complete the remaining cleanup. (See sidebar for impacts of Coronavirus Disease 2019 [COVID-19] on cleanup efforts on Culebra and Vieques.) The Navy and Corps acknowledge uncertainties in the cost estimates they developed for DOD. As discussed earlier in this report, the majority of munitions sites on both islands are in the remedial investigation/feasibility study phase. According to Navy and Corps officials, when a site does not have a Record of Decision, the Navy or Corps assumes a selected remedy as a path forward to address the nature and extent of contamination, based on general assumptions about

¹⁶The estimate of funding needed for future work was calculated based on information in DOD's Knowledge-Based Corporate Reporting System on environmental restoration efforts, as of September 2020. The estimate includes funding for fiscal year 2020's planned execution of cleanup efforts, as well as DOD estimates of future work necessary to complete the cleanup.

¹⁷The sites are located in eastern Vieques in the Eastern Conservation Area, Live Impact Area, interior and exterior of the Surface Impact Area, and northwestern portion of the Eastern Maneuver Area. These sites were used for training activities, including target practice for aerial bombing, naval gunfire, and marine artillery; and six ranges on these sites were used for over 30 years for the firing of small arms, grenades, and rockets. Cleanup actions at these sites have included removal of nearly 100,000 surface and subsurface munitions or explosives of concern.

¹⁸This site includes cleanup of land and underwater areas throughout the cays and adjacent islands of Culebra.

¹⁹The estimate of funding needed for future work was calculated based on information in DOD's Knowledge-Based Corporate Reporting System on environmental restoration efforts, as of September 2020. The estimate includes the funding for fiscal year 2020's planned execution of cleanup efforts, as well as DOD estimates of future work necessary to complete the cleanup.

Impacts of COVID-19 on the Vieques and Culebra Cleanup Efforts

In March 2020, the U.S. Navy and Corps reported that they paused their cleanup activities on Vieques and Culebra due to the global COVID-19 pandemic.

- Vieques: the Navy began field operations at the end of May 2020 and trained all field teams on changes to procedures and safety measures related to COVID-19, according to Navy officials.
- Culebra: the Corps was able to mobilize field teams in mid-July 2020 to begin cleanup efforts at one of its Military Munitions Response Program sites, according to Corps officials.

As of August 2020, officials from both agencies said the pandemic had not affected the costs associated with the cleanup efforts and that the agencies are cognizant of the fact that the Governor of Puerto Rico may issue restrictions or other measures to address COVID-19 that may affect cleanup efforts.

Source: GAO analysis of U.S. Navy and Corps documentation. | GAO-21-268

the contamination.²⁰ However, during the remedial investigation/feasibility study phase, the actual nature and extent of contamination is still being assessed. Therefore, when the Navy and Corps estimated the cost to complete cleanup at sites in this phase, they did so while critical information was still being collected. In addition, the Navy and Corps generally assume that future costs will be similar to historical costs. We have previously reported on uncertainties associated with preparing cost estimates for environmental remediation work, including uncertainty associated with estimating the amount and extent of contaminants at a site.²¹

²⁰A Record of Decision typically documents the selected cleanup remedy for an individual site and contains the cost estimate for implementing the remedy.

²¹In addition, we reported that, according to EPA officials, actual cleanup costs were often higher than estimates because contamination was greater than expected. See GAO, *Superfund: EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites Are Expected to Be Added to the National Priorities List*, [GAO-10-380](#) (Washington, D.C.: May 6, 2010).

DOD Faces a Number of Challenges to Complete Cleanup Efforts and Is Taking Steps to Address Them

DOD Faces Key Challenges on Both Islands Related to Logistics, Topography, the Environment, and Safety Concerns and Is Taking Steps to Address Them

Logistics

According to Navy and Corps officials, the location of Vieques and Culebra—miles off the main island of Puerto Rico—creates logistical challenges for the agencies to deliver the materials and personnel necessary to conduct cleanup efforts. Agency officials told us that the cessation of military activities and closure of military facilities on the islands compound the logistical challenges associated with delivering necessary materials and increases the costs of cleanup actions. For example, Navy and Corps officials who are responsible for overseeing cleanup efforts are not stationed on either island. In addition, some personnel involved with cleanup efforts, such as some of the technicians trained to work with unexploded ordnance, often do not live on the islands, according to agency officials. The transportation infrastructure on each island is not very developed, often with sites accessible only on ungraded and unpaved roadways. Further, transportation to the islands is limited to either ferries or airplanes from the main island of Puerto Rico. Navy and Corps officials we interviewed told us that the weather makes ferry schedules unreliable.

To address logistical challenges posed by the remote location of the islands, Navy and Corps officials told us that they factor the additional time that it may take to deliver materials to the islands into their planning

for cleanup efforts. In addition, the Navy has sought to hire residents from Vieques to help establish a readily available workforce. Specifically, the Navy has funded training for residents of Vieques to become site workers, according to agency officials. Navy officials stated that since the start of cleanup efforts, they have hired and trained over 30 Vieques residents to work as unexploded ordnance technicians. Likewise, Corps officials stated that Culebra residents work on cleanup efforts, including as biologists and as part of vegetation removal crews. EPA and the U.S. Fish and Wildlife Service also have field offices that employ island residents to assist in their mission-related efforts on both Vieques and Culebra.

Topography

According to Navy and Corps officials and agency documents, various topographical features on the islands create challenges for cleanup efforts. The topography of both islands is generally rugged and irregular and includes steep hillsides and mountainous terrain; densely vegetated areas, including mangrove forests; long coastlines, with sandy and rocky beaches and lagoons; coastal wetlands; adjacent cays and small islands; and underwater reefs. These topographical features create unique challenges for certain cleanup efforts.

Steep hillsides and mountainous terrain make some areas difficult to traverse or inaccessible, which creates challenges to both locating and cleaning up unexploded ordnance, according to agency documentation. Densely vegetated areas also make it difficult to locate, assess, and safely remove unexploded ordnance in these areas. Officials told us that the beaches and coastlines present a challenge because some beaches, for example, are open to the public, and closures need to be coordinated with local officials, potentially affecting tourism.

In addition, officials told us that locating munitions in the “nearshore” area between the shore and the open water presents specific challenges due to conditions such as undertows. Adjacent cays and surrounding underwater reefs have additional challenges other than topography. For example, access to sites at these locations may require additional logistics and depend on specific equipment (such as boats or underwater technologies) and certain weather conditions. Figure 6 provides images of some of the challenging topographical features of the islands.

Figure 6: Examples of Topography on Vieques and Culebra, Puerto Rico



The image on the left shows Vieques topography, including a beach and underwater reef. The middle image shows the dense vegetation on Culebra. The image on the right shows steep, rocky terrain on Vieques.

Sources: National Oceanic and Atmospheric Administration (first photo); U.S. Army Corps of Engineers (second photo); and U.S. Navy (third photo). | GAO-21-268

To address challenges posed by topography, the Navy and Corps report that they use various methods and technologies to locate and dispose of the munitions. The methods include nonmechanized efforts, such as having cleanup site crews use machetes to clear brush to locate munitions and use controlled burns to remove thick vegetation. The Navy and Corps also use mechanized technologies, such as mechanical tools and vehicles, to clear cleanup sites. On Vieques, the Navy has also started to use drones to help evaluate the field conditions, as drones can assess larger areas of land compared with site workers assessing areas on foot.

Environment

According to officials, environmental factors on the islands, including climate and weather, as well as the presence of endangered and threatened species, can create challenges for conducting various cleanup action, such as limiting when cleanup efforts occur. It is generally warm and humid year-round on both islands due to the tropical, marine climate. According to agency documentation, heat and humidity can affect when cleanup work occurs, due to concerns about site workers' health. The island climate includes both wet and dry seasons, with the months of August through November generally being the wet season and the driest months usually occurring January through April.

Weather can also affect cleanup efforts. Navy and Corps officials also told us that large swells in the Caribbean Sea can complicate underwater cleanup, including efforts by divers or boats conducting surveys. On Culebra, Corps officials we interviewed said that cleanup crews had

removed munitions from some sites but had to resurvey the sites to determine if a hurricane had caused munitions to settle in sites that had previously been cleared. Figure 7 below provides images of some of the challenging environmental features of the islands. The island environments also include the presence of endangered species, as well as nesting areas for sea turtles and migratory birds, which can pose challenges to cleanup efforts on the islands.

Figure 7: Examples of Environmental Challenges in Culebra and Vieques, Puerto Rico



The image on the left shows the sea condition that can limit access to the cays on Culebra. The image on the right shows a washout to an access road on Vieques.

Sources: U.S. Army Corps of Engineers (first photo); U.S. Navy (second photo). | GAO-21-268

The Navy and Corps have taken several actions to address the environmental conditions that can pose challenges to cleanup efforts on Vieques and Culebra. For example, the Navy and Corps limit cleanup actions during the nesting season for sea turtles and some migratory birds. In 2014, the Corps established a standard operating procedure with other federal and Commonwealth agencies involved in cleanup efforts at sites on Culebra, including the U.S. Fish and Wildlife Service, NOAA, and Puerto Rico's Department of Natural and Environmental Resources. The procedure provides guidance for how to avoid or minimize the potential effects of cleanup efforts—including land and water investigations and removal actions—on endangered and threatened species and their critical habitats. The procedure states that all personnel working at cleanup sites shall receive briefings regarding endangered species, including information on how to identify critical habitats of endangered and

threatened species. The procedure outlines potential actions to take when an endangered or threatened species, or its critical habitat, is identified. Officials we interviewed from NOAA and the U.S. Fish and Wildlife Service told us that they regularly communicate with the Navy and Corps during cleanup efforts to ensure the protection of critical environmental resources on both islands.

Safety

According to Navy and Corps officials and agency documents, ensuring the safety of residents, visitors, and site workers is a challenge for the cleanup efforts on Vieques and Culebra. Navy, Corps, and EPA officials told us that ensuring the safety of site workers is a priority, and safety poses a key challenge to cleanup efforts because unexploded ordnance and other munitions are dangerous, as they have the potential to explode when moved or handled improperly. In addition, federal and Commonwealth officials we interviewed told us ensuring the safety of residents and tourists also creates challenges for cleanup efforts because such individuals may trespass onto dangerous cleanup sites while attempting to access remote beaches.

To address the safety of cleanup site workers, the Navy and Corps rely on trained munition technicians to conduct cleanup efforts at the sites. In addition, DOD uses a safety protocol that limits the number of personnel allowed to conduct cleanup efforts at any given time. To address the safety of residents and visitors on the islands, the Navy and Corps use education programs designed to inform the public about how to recognize and respond to an unexploded ordnance. Additionally, the agencies continuously seek to educate residents and other members of the public, including tourists, about the “three Rs” of munitions safety: Recognize, Retreat, Report. Navy officials stated that they use multiple means to share safety information with the public, including meetings, flyers, fact sheets, and community outreach events, such as a STEM fair for high school students on Vieques. The agencies’ educational materials and signage around cleanup sites present information in both English and Spanish. Other steps the Navy and Corps take to help ensure the safety of residents and visitors on the islands include erecting fences and other physical barriers designed to limit access to cleanup sites. Figure 8 shows examples of safety measures taken by the Navy.

Figure 8: Physical Barriers and Signage on Vieques, Puerto Rico



The image on the left shows how concrete monuments establish a permanent warning system along the boundary of the former Live Impact Area on Vieques. The image on the right is an example of a safety sign on Vieques.

Source: U.S. Navy (photos). | GAO-21-268

The Navy Faces Challenges with Community Distrust Related to Cleanup Efforts on Vieques and Is Taking Steps to Address the Distrust

According to Navy officials and documentation, community distrust by some island residents of the Navy’s cleanup efforts on Vieques is a challenge.²² This distrust is attributable, in part, to the military’s longtime presence on the island conducting activities, such as weapons tests and other military exercises, which were responsible for the contamination of sites across the island. Navy and EPA officials acknowledge that the transformation in the military’s role—going from being the source of contamination to becoming the lead federal agency responsible for cleaning up the contamination—further contributes to the community’s distrust of the Navy’s actions.

In addition, according to academics and residents of Vieques, other sources of residents’ distrust regarding federal cleanup efforts involve concerns related to:

- Air quality. Vieques residents have raised concerns that open, controlled burning of vegetation to locate munitions, followed by open

²²We did not identify community distrust of Corps’ cleanup efforts on Culebra based on our analysis of agency documentation or our interviews with federal and Commonwealth officials and residents of Culebra.

detonation of unexploded munitions, leads to negative impacts on air quality. From 2005 to 2013, the Navy conducted on-site air sampling during open detonation events on Vieques to measure the air concentration of particulate matter (such as dust and soot), metals, and other explosive chemicals at over 170 detonation events. The Navy's air samples showed no detection of explosive chemicals nor were there any violations to the national ambient air quality standards.²³ In 2013, the Navy discontinued the air sampling effort due to the lack of violations over the prior 8 -year testing period. Further, Navy officials told us that after discussions with the community, they agreed to limit controlled burns to 2 acres per day on cleanup sites. In response to residents' concerns about air quality, in 2019, the Secretary of the Navy was required by statute to purchase and operate a portable closed detonation chamber for use at some cleanup sites on Vieques. The Navy expects to begin use of the closed detonation chamber in late 2021, according to officials.

- The presence of depleted uranium. During a training exercise in February 1999, the Navy discharged over 250 rounds of depleted uranium penetrators—armor-piercing incendiaries—into the Live Impact Area at the Vieques Naval Range.²⁴ According to academic researchers and a Vieques resident, the discharge was unauthorized and initially denied by the military. The Navy reported the discharge to the Nuclear Regulatory Commission in March 1999 and confirmed the discharge in August 1999. Academic researchers and others raised concerns about contamination and potential exposure to depleted uranium. According to Navy documentation, recovery teams collected roughly 100 of the 250 expended rounds that contained the depleted uranium in 1999 and 2000. A subsequent inspection of the area by the Nuclear Regulatory Commission, as well as groundwater and environmental sampling conducted by the agency, found there was no public exposure to the depleted uranium discharged on Vieques; however, some residents and academic researchers cite the discharge as a reason for their distrust of the Navy's cleanup efforts, as they expect some contamination to have occurred.

²³The Clean Air Act requires EPA to set national ambient air quality standards for six criteria pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide.

²⁴Depleted uranium is a potential source of radiation.

EPA's Split Samples on Vieques

A split sample is a type of field sample collected and then "split" or divided for independent analysis to evaluate variability. EPA officials stated the agency has performed split sampling at four sites on Vieques. The first split sampling occurred in 2006 in eastern Vieques, where EPA provided oversight and collected soil samples around the site. The purpose of the oversight and sampling was to ensure proper sampling procedures were followed by the Navy contractor and to provide verification analyses for a representative number of samples collected by the contractor. EPA also conducted split sampling in 2011, 2016, and 2018 at other Vieques sites. For each of the four sites, EPA's findings from the split samples were comparable to the Navy's analytical data.



Source: GAO analysis of EPA Information; EPA (photo).
GAO-21-268

- Disagreement with scientific findings and conclusions. Some residents and academics disagree with the scientific findings and conclusions used to support the Navy's cleanup efforts on Vieques. Specifically, the academic researchers have disagreed with findings by the U.S. Department of Health and Human Services Agency for Toxic Substances and Disease Registry that the Navy's past military actions and current cleanup efforts pose no risks to public health.²⁵ According to EPA and Navy officials, the conclusions of the Agency for Toxic Substances and Disease Registry are reliable and are consistent with their respective agencies' findings (see sidebar). Nonetheless, residents and others contend that the federal agencies' scientific findings are not complete and that residual environmental risks remain, which may negatively affect the health of Vieques residents. In 2020, EPA awarded a grant to the University of Massachusetts-Boston to conduct a 3-year, community-driven assessment of environmental health risks on Vieques. EPA officials told us they are hopeful that Vieques residents will have greater trust in the study's results, as this type of assessment should involve community members at each stage of the study.

We found that the Navy has taken several steps to address communities' distrust regarding the agency's cleanup efforts on Vieques. Statutory and regulatory requirements exist for involving and informing the community for federal cleanup efforts, and DOD and the EPA have issued guidance to implement these requirements. We analyzed steps taken by the Navy to involve and inform the community about the cleanup efforts on Vieques by comparing these steps with DOD and EPA guidance.²⁶ These steps include:

- Involve the local community in the environmental restoration throughout the process. The regulations implementing CERCLA require the lead agency at a cleanup site to develop a Community Involvement Plan for certain response actions, which typically provides a blueprint for community involvement activities throughout the cleanup process. We determined that the Navy has prepared

²⁵The Agency for Toxic Substances and Disease Registry's 2013 evaluation included a review of environmental, biological, and health outcome data for Vieques, and it issued conclusions and recommendations on the following topics: (1) consumption of fish from reefs off the Vieques coast, (2) biomonitoring, (3) health outcome data, (4) local produce and livestock pathway, (5) air pathway, (6) soil pathway, and (7) drinking water pathway.

²⁶Department of Defense, *Defense Environmental Restoration Program Management Manual* (Washington, D.C.: Mar. 9, 2012); Department of the Navy, *Environmental Restoration Program Manual* (Washington, D.C.: 2018); and EPA, *Superfund Community Involvement Handbook* (Washington, D.C.: March 2020).

Community Involvement Plans that include information about the history of the military's use of the island, demographics about Vieques and its residents, and the structure of the community involvement program. In developing these plans, the Navy surveyed and interviewed Vieques residents, as well as solicited feedback at community meetings, to learn about their perspectives on cleanup efforts and related issues. The Navy issued its first Community Involvement Plan for Vieques in 2007; is currently revising its 2015 plan; and intends to issue an updated plan in 2021, according to agency officials.

- Establish a Restoration Advisory Board (RAB). RABs provide a formal, structured mechanism for community input; exchange of information; and opportunities for partnership among the Navy, EPA, and other major stakeholder groups in the community, including residents. The Navy formed a RAB for Vieques in 2004. The Vieques RAB generally holds quarterly meetings that include bilingual presentations that address community questions, ongoing and planned cleanup efforts, and other relevant topics. The Navy disseminates bilingual announcements for upcoming RAB meetings via social media, mailings, and signage at common areas on the island, and via broadcast by megaphone truck.

Some of the residents with whom we spoke expressed frustration and disappointment with the RAB. For example, some residents expressed feeling disenfranchised over the fact that they may participate in the RAB and yet do not make any final decisions on the cleanup efforts. Academic researchers also told us that they believe that RAB meetings are a formality the Navy follows to involve the community and that the community's input is not considered in final decisions related to the cleanup efforts.

Officials we interviewed from the Navy, EPA, and other agencies recognized that some residents are dissatisfied with the RAB on Vieques. However, Navy officials told us that they believed the number of discontented residents was relatively small and that they had no plans to disband the RAB. In addition, other federal and Commonwealth officials involved with cleanup efforts on Vieques told us that discontent and distrust is inherent to any cleanup effort and that the Navy is implementing appropriate actions to engage citizens and other interested stakeholders.

- Provide the public with information on the environmental cleanup efforts. We found that, as required by the regulations implementing CERCLA, the Navy maintains an administrative record file that provides the public with access to documents that form the basis for

the selection of response actions that will be taken at the cleanup sites. The file also provides access to documents, such as minutes from public meetings, which serve as vehicles for public participation in the selection of response actions at cleanup sites. In addition, as outlined in the Navy's 2015 Community Involvement Plan for Vieques, the agency employs a number of mechanisms to inform the public and other interested stakeholders on cleanup efforts in Vieques. For example, the agency uses the internet and social media, flyers, and public notices, and other community events, such as outreach activities at schools and public tours, to inform the community about the cleanup efforts. Most of the reports on cleanup efforts are published or available in English and Spanish. An agency official, island residents, and others stated that the language used in documentation related to the cleanup process, especially documents used to satisfy CERCLA requirements (such as Records of Decisions) are technical and difficult to understand, which leads to frustration and confusion by island residents.

- Provide Technical Assistance for Public Participation. Pursuant to statute, DOD operates the Technical Assistance for Public Participation program to provide the RAB and others with independent technical assistance to assist their ability to provide advice to decision makers by seeking to improve the public's understanding of the conditions and activities at a cleanup site. In 2002, the Navy awarded a Technical Assistance for Public Participation contract to support the public's understanding of the cleanup work on the east end of Vieques, according to officials. A second contract was awarded in 2004 to support cleanup work on the west end of Vieques. According to Navy officials, both contracts provided the Vieques RAB with an independent consultant who was bilingual, had experience with the CERCLA process, and was knowledgeable about the scientific disciplines related to environmental restoration.

DOD Uses a Variety of Cleanup Technologies, and Agencies Assess the Feasibility of Innovative Technologies Relative to Their Role

The Navy and Corps Use a Variety of Technologies for Land and Underwater Cleanup Efforts

Technology to Detect and Remove Land Munitions

The Navy and Corps use a variety of technologies to detect munitions for land and underwater cleanup efforts on Vieques and Culebra. However, limited technologies are available to clean up land and underwater munitions once detected because of topographical conditions on land and the need for more research on underwater technologies.

Technologies that the Navy and Corps use to detect munitions on land on Vieques and Culebra are well researched. Two such technologies include advanced geophysical classification and remotely operated excavators.

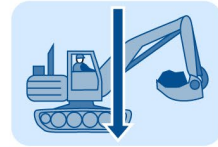
- Advanced geophysical classification. This technology is used to detect munitions on land using sensors to collect data on the properties of a buried metal object, such as object depth, size, density, and shape. Data collected at cleanup sites are used to classify and distinguish munitions or explosives of concern from subsurface metallic scrap or debris.²⁷ On Vieques, this technology has been deployed to investigate potential subsurface munitions for roads and beaches, as well as on the Northwest Peninsula on Culebra, as shown in figure 9. The Navy used this technology at multiple sites on Vieques to assess hundreds of acres, including Red Beach, Garcia Beach, and selected public and restricted roadways throughout the Live Impact Area, Surface Impact Area, and Eastern Maneuver Area. On Culebra, the Corps used this technology in the southern portion of the Northwest Peninsula at recreational, hiking, and camping areas, including portions of the Flamenco, Tamarindo, and Carlos Rosario beach areas.

²⁷These technologies have different platforms, including the time-domain electromagnetic multisensory towed array detection system and a commercially available MetalMapper system.

Figure 9: Advanced Geophysical Classification Technology Used at Cleanup Sites on Vieques and Culebra, Puerto Rico



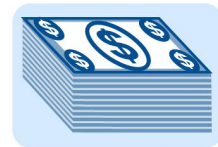
Department of Defense officials estimate that the use of this technology can:



Reduce the number of intrusive investigative digging by approximately 80 percent



Save time



Result in 40 to 50 percent cost savings



Increase worker safety

These images show advanced geophysical classification technology, which is used to identify properties, such as size or depth, of a buried metal object. The images at the top show advanced geophysical technology being used on Vieques roadways, and the images at the bottom show this technology being used at beaches in the Northwest Peninsula on Culebra.

Sources: U.S. Navy (top photos); U.S. Army Corps of Engineers (bottom photos). | GAO-21-268

According to DOD officials, advanced geophysical classification is a proven technology that is used at DOD cleanup sites and has demonstrated benefits, including producing time and cost savings. According to documentation, DOD reported that use of the technology can reduce the amount of intrusive investigative diggings up to 80 percent and thereby achieve 40- to 50-percent cost savings. This technology can also increase worker safety because detailed classification data allow workers to better understand the potential hazard(s) related to the individual munitions being excavated. However, the technology has its limitations. Challenging topography, such as areas with dense vegetation, steep slopes, or active beaches, limit its use. In addition, areas saturated with metallic debris inhibit the technology's effectiveness by prohibiting the sensors' ability to distinguish munitions. DOD and EPA officials explained that they can conduct a survey during the remedial investigation of a site to evaluate metallic density and determine if this technology will be effective.

- Remotely operated excavators. This technology is used to remove land munitions at cleanup sites on Vieques. The excavator, which can be operated remotely from over a mile away, uses a video screen for maneuvering, has attachments to cut and rake vegetation, and has a magnetic attachment to pick up and remove large munitions. The excavator also has a large basket for sifting (see fig. 10). Navy officials stated that this technology provides the ability to dig deeper than can be done manually at beaches or from the surf zone, but it may not be effective at all cleanup sites due to topographical challenges.

Figure 10: Remotely Operated Excavator Used at Cleanup Sites on Vieques, Puerto Rico



This image shows a remotely operated excavator with a sifting attachment being used to dig and sift munitions from the surf zone.

Source: U.S. Navy (photo). | GAO-21-268

On Vieques, the Navy used this technology as part of remedial investigations to evaluate the potential presence of munitions and associated contamination on several berms on the island. These berms, which are soil mounds used during military training, are located across six training ranges that operated for over 30 years within the former Eastern Maneuver Area. In addition, according to Navy officials, this technology has been part of the overall process used to safely clear tens of thousands of submunitions, allowing workers to enter sites to conduct soil sampling to help determine the potential presence of contaminants.

Technology to Clean Up Land Munitions

Open Detonation of Munition Items on Vieques, Puerto Rico

The detonation is initiated:



after approximately 30 seconds;



after approximately 1 minute, and;



after approximately 4 minutes.



Sources: GAO Analysis of Department of Defense information; U.S. Navy (photos). | GAO-21-268

DOD officials told us that there are limited options to clean land munitions: (1) blow-in-place, a type of open detonation that must be used for the most sensitive munitions, or consolidated open detonation for more stable munitions that can be moved a few feet to be detonated together, if unexploded ordnance technicians determine handling is safe and acceptable (see sidebar); or (2) closed detonation chambers.

- Open detonation or consolidated open detonation. DOD's Defense Explosives Safety Regulation states that blow-in-place (a type of open detonation) is the preferred method to destroy unexploded munition items, as this method is considered the least dangerous.²⁸ Navy and EPA officials told us that open detonation is the safest option for site workers because it can be performed with little or no handling of unexploded munitions, which are extremely dangerous because they can detonate when moved or handled improperly. The Navy and EPA have also reported that open detonation can be conducted in a manner that safeguards public health. Specifically, the Navy and EPA have found through air monitoring and environmental sampling that open detonations do not affect public health on Vieques. According to Navy documentation, over 1,600 air samples have been collected and analyzed for explosive chemicals, metals, and particulate matter. No explosive chemicals were detected during any of the air monitoring events, concentrations of all metals were at least 99-percent below health-based standards, and concentrations of particulate matter were within existing regulatory standards.
- Closed detonation chambers. A detonation chamber is a large, heavy structure designed to contain the metal fragments, noise, heat, shockwave, and gases when detonating land munitions (see sidebar). Despite the findings above, some RAB members and members of the public continue to have concerns about open air detonation. Specifically, we learned that on Vieques, RAB members and local residents have been advocating over the past decade for the Navy to purchase and use a detonation chamber on Vieques to address public health concerns of open detonation. Island residents we spoke with shared public health fears that highly explosive chemicals could be released into the environment during open detonation, impacting air

²⁸Defense Explosives Safety Regulation 6055.09, Edition 1 (Jan. 13, 2019).

quality and contributing to higher rates of chronic illness.²⁹ Likewise, community advocates shared fears that outer casings or internal parts made of metal could leach pollutants into the soil or groundwater, which may run off into lagoons or the Caribbean Sea.

About Detonation Chambers

A detonation chamber, also known as a contained detonation chamber or blast chamber, is a method used to destroy munitions and explosives of concern in a closed chamber where technicians can safely detonate the item(s). If the risk to the workers is deemed acceptable, and munitions can be moved, items are relocated and consolidated into a storage bunker. Then, when ready, the items are moved for destruction in the chamber.

The amount of munitions and explosives of concern that can be treated per day in a detonation chamber depends on the net explosive weight of the items. There are different types of detonation chambers. For example, the smallest portable chambers can treat up to 13 pounds net explosive weight, and the largest can treat up to 40 pounds net explosive weight. The portable detonation chamber for Vieques is designed to handle up to 19.84 pounds of net explosive weight. The Navy expects to treat approximately 20,000 unexploded ordnances with the detonation chamber on Vieques.

Source: GAO analysis of DOD Information. | GAO-21-268

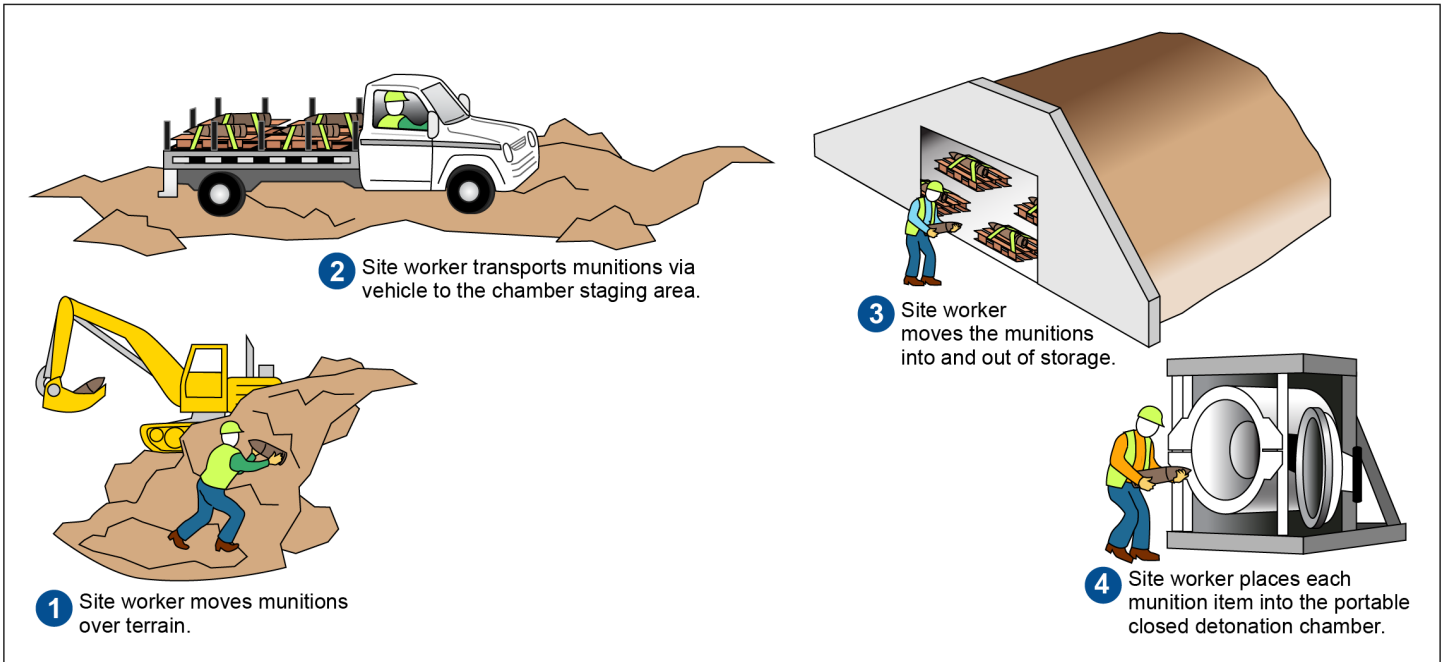
The National Defense Authorization Act for Fiscal Year 2020 requires the Secretary of the Navy to purchase and operate a portable closed detonation chamber to be deployed in Vieques at the former naval bombardment area.³⁰ The law did not include a deadline for purchasing the chamber or completing detonations. The Navy is in the early stages of complying with this statutory requirement. As of August 2020, the Navy was awaiting the reprogramming of funds to award a contract to purchase a chamber. Navy officials anticipate completion of contract award, shipment, and setup in order to begin operation of the portable closed detonation chamber on eastern Vieques by late 2021.

DOD and EPA officials acknowledge that detonation chambers are an effective technology in the appropriate setting; however, officials from both agencies stated that Vieques is not such a setting, primarily due to safety risks. In general, the handling of unexploded ordnance is dangerous because unexploded ordnance can explode when moved or handled improperly. The difficult topography and road infrastructure of Vieques further complicate unexploded ordnance's safe handling, according to agency officials. If a munition is deemed safe to move for destruction in a portable closed detonation chamber on Vieques, the munition item may be repeatedly handled, as shown in figure 11.

²⁹The chemicals of concern included TNT, RDX, and HMX, which are commonly used acronyms for explosive chemicals found in military munitions.

³⁰Pub. L. No. 116-92, § 378(a), 133 Stat. 1198, 1334 (2019).

Figure 11: Site Workers Repeatedly Handle Munitions on Vieques When Using a Portable Closed Detonation Chamber



Source: GAO analysis of U.S. Navy documentation and interviews. | GAO-21-268

DOD and EPA officials told us that repeated handling of munitions presents a significant safety risk at each stage and exposes site workers to accidental injury or death. Once a munition item is located, unexploded ordnance technicians determine if it is safe and acceptable to be handled. Navy and EPA officials told us that, in addition to posing safety risks, due to size and tonnage limitations, a portable detonation chamber will only be able to accommodate a limited number of unexploded ordnance on Vieques. The Navy plans to initially stage the chamber at a site in the exterior portion of the former Surface Impact Area in eastern Vieques. Navy and EPA officials also stressed that the use of this chamber will not eliminate the need for open detonations on Vieques.³¹

Technology to Detect Underwater Munitions

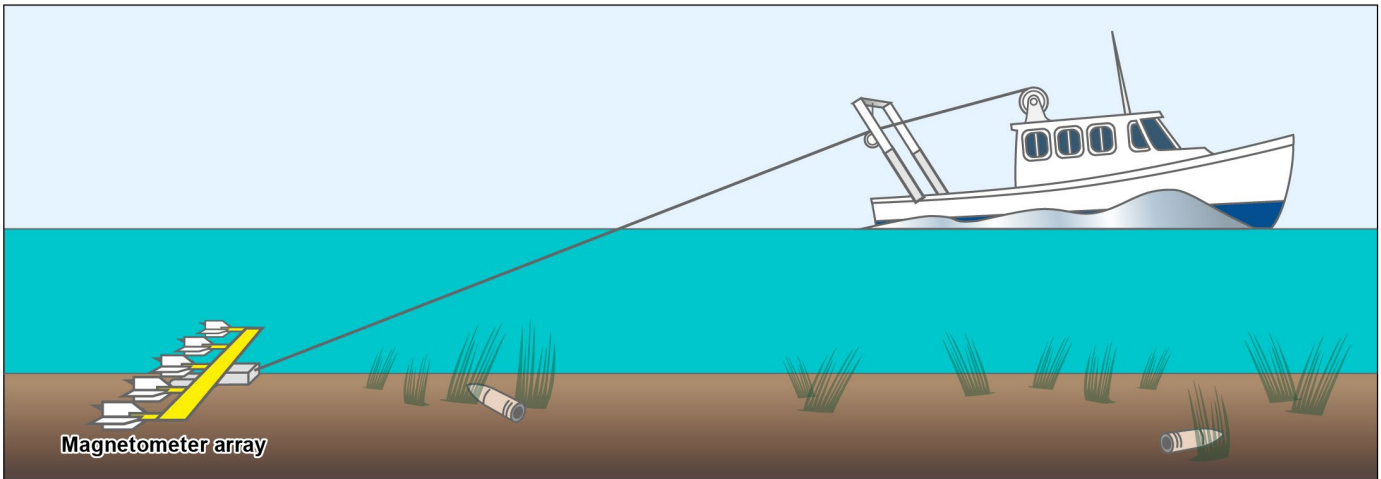
Technologies used to detect underwater munitions continue to be researched while the Navy and Corps use available technologies.

³¹According to Corps officials, there are no plans or requests to use a portable closed detonation chamber on Culebra. Culebra residents we interviewed also told us they have not expressed interest in this technology for use on Culebra.

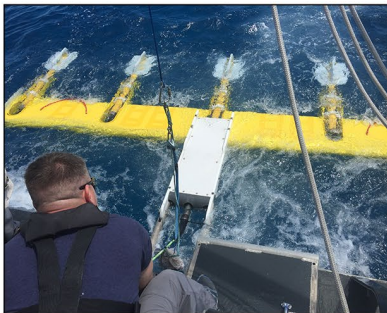
Available technologies include the towed magnetometer array and shark navigation systems.

- Towed magnetometer array. This technology is towed from a survey vessel and can detect the potential presence of munitions on the seafloor, as shown in fig. 12. The magnetometer array is mounted on a wing, along with sensors to help control its depth and angle and a video camera to provide live-feed images. Detection of potential munitions is done through measuring and recording magnetic anomalies caused by the presence of iron objects lying on or beneath the seafloor. According to Navy officials, anomalies require further investigation to determine whether they may be potential ordnance and to further specify location, size, and burial depth.

Figure 12: Towed Magnetometer Array Technology Used in Vieques, Puerto Rico



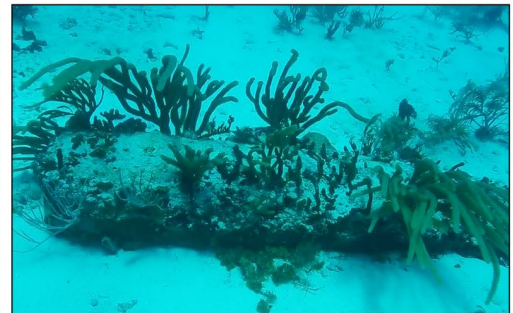
The magnetometer array is a technology that can detect the potential presence of munitions on or beneath the seafloor. It is mounted on a water wing and towed from a survey vessel.



Deployment of water wing during Wide Area Assessment in Vieques, Puerto Rico.



Detection of potential munitions is done by measuring and recording magnetic anomalies caused by the presence of iron objects lying on or beneath the seafloor.



Images of munitions are captured live by a video camera mounted on the water wing.

Sources: GAO analysis of U.S. Navy (data); U.S. Navy (photos). | GAO-21-268

DOD officials told us this technology has many benefits, including, for example, the ability to survey large underwater areas in a short time, which results in cost savings, accelerated cleanup, and diver safety. Navy officials told us that this technology has provided key information and insight into the conceptual understanding of the presence and distribution of potential underwater munitions around Vieques. For example, the Navy used this technology in 2016 and 2017 to perform a Wide Area Assessment, which involved surveying approximately 208 miles of transects across 11,500 acres of the underwater

munitions response site on Vieques. According to documentation, the assessment identified areas with potential munitions, which were primarily adjacent to the former Live Impact Area but also along the northern and southern coasts and within the westernmost and northwestern anchorage areas.³² The assessment did not identify areas with elevated density offshore of the Eastern Conservation Area or within the northern anchorage area. These findings help the Navy plan future cleanup efforts for this underwater site, including prioritizing areas for further investigation and munitions response actions.

Towed magnetometer array technology can be challenging to implement at some underwater sites, however. The array must be close to the seafloor to detect magnetic anomalies and, therefore, irregularities in the seafloor, such as corals, rocks, or trenches, need to be identified in advance to avoid contact. Additionally, deployment of this technology may be impacted by poor weather, choppy seas, or boat traffic.

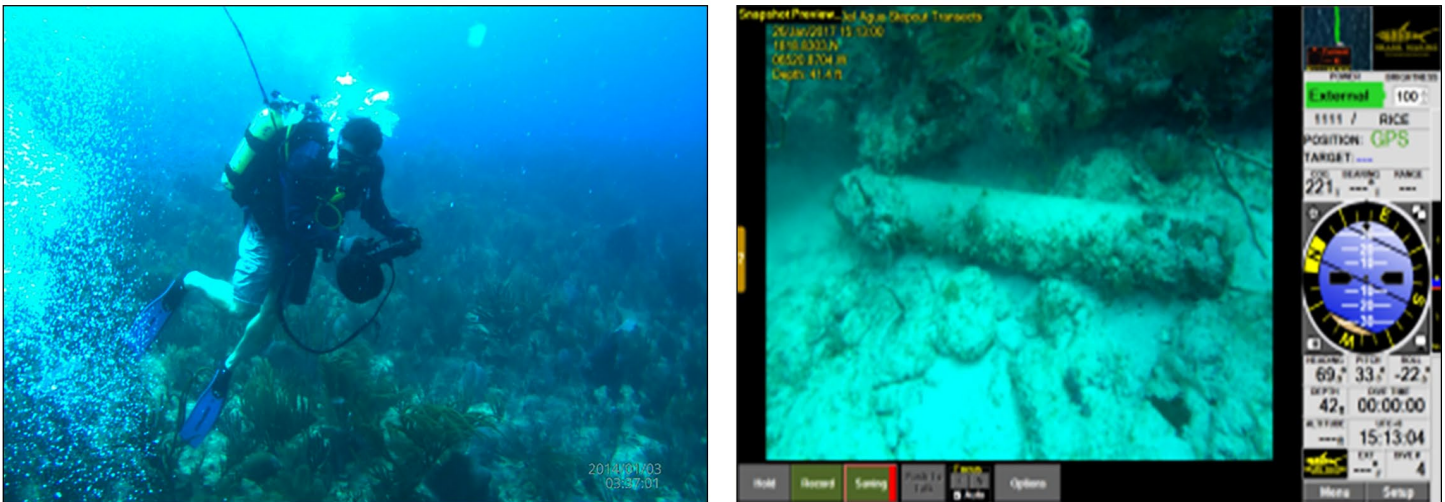
- Shark marine navigation system. This commercially available technology is used to detect underwater munitions using a handheld tablet that allows divers to precisely navigate underwater to preloaded global positioning system points (see fig. 13). The tablet provides divers with a moving map that enhances their ability to determine their location underwater in real-time. The tablet receives a global positioning system navigation signal from a surface-towed buoy, and it is capable of generating logs to track the precise location of underwater munitions and anomalies.

At Vieques, the Navy used this technology as part of a time-critical removal action in the waters around Cayo la Chiva, located on the south side of the island. Using previously identified global positioning system coordinates, unexploded ordnance divers located and recovered nine potential munitions items, according to documentation. At Culebra, the Corps also used this technology at four underwater sites. According to Corps officials, using this technology nearly doubled the dive team's production rate for investigating underwater anomalies and thereby reduced the amount of time the team needed to be in boats collecting data, which can result in cost and time savings. However, the use of this technology is impacted when the

³²Former ship anchoring points, known as anchorage areas, are areas where munitions were loaded, offloaded, or transferred and may have been inadvertently dropped into the water.

seas are choppy because the global positioning system signal can drop.

Figure 13: Shark Marine Navigation System Technology Used in Culebra, Puerto Rico



The above images show the Shark Marine Navigation System, a technology that allows divers to precisely navigate underwater to preloaded global positioning system points. Used at four sites in Culebra, Puerto Rico, this technology nearly doubled the dive team's productivity for investigating underwater anomalies, according to officials from the U.S. Army Corps of Engineers, which can result in cost and time savings.

Sources: GAO analysis of U.S. Army Corps of Engineers documentation; U.S. Army Corps of Engineers (photos). | GAO-21-268

Technology to Clean Up Underwater Munitions

We found there are limited technologies available to clean underwater munitions due to the need for more research on innovative underwater technologies. The Navy uses a process in which underwater munitions are raised by float bags, towed to shore, and destroyed by open detonation on the beach. According to DOD officials, more research and testing is needed for technologies that can clean underwater munitions safely and protect natural resources, especially when munitions are located near or embedded in threatened coral or a designated or proposed coral critical habitat.

To address this concern, other technologies are being researched. One example is a high-pressure, abrasive waterjet cutting system and capture tool. Specifically, this technology can cut into and remove the explosive chemicals from underwater unexploded ordnance, including those encased in coral, with little or no damage to the coral and without causing the ordnance to detonate. As the explosive chemicals are washed out of the unexploded ordnance, an attempt is made to capture the waste

stream, but the Navy and EPA have concerns that some explosive chemicals will be released into the underwater environment. This technology is lowered by crane into the water on top of the munition to be removed.

The National Defense Authorization Act for Fiscal Year 2020 also requires the Secretary of the Navy to purchase and operate a water jet cutting system to be deployed in the former bombardment area on Vieques.³³ RAB members and local residents were aware of this technology and requested that the Navy provide updates on implementing this technology at RAB meetings. According to the Navy, the system has been used successfully on land, but the system is still being tested in the underwater environment, with research funding provided by DOD environmental research programs. Test demonstrations will be conducted in the Gulf of Mexico at Panama City and in the Eglin Air Force Base's water ranges located in the Gulf of Mexico, according to Navy officials. As of December 2020, the Navy has no plans to use this technology to address underwater munitions in Vieques. Navy officials told us that the Navy may use this technology in the future, but only if concerns can be addressed.

The Navy and Corps Assess Feasibility of Innovative Technologies through Environmental Research Programs and Technology Transfer Processes

DOD Environmental Research Programs

The Navy and Corps assess the feasibility of innovative technologies through active participation in DOD environmental research programs and military-specific technology transfer processes. It is DOD policy to maximize the effectiveness and efficiency of the Defense Environmental Restoration Program by facilitating the development and implementation of cost-effective innovative technologies. Navy and Corps' environmental policy direct the military services to consider and evaluate innovative technologies for use at cleanup sites.

DOD's environmental research programs are the Strategic Environmental Research and Development Program and the Environmental Security Technology Certification Program. These programs, managed from a Joint Office, coordinate to address DOD environmental issues through research, development, technology demonstration, and validation, in an effort to transfer successful innovative technologies for use at cleanup sites. Pursuant to statute, DOD established the Strategic Environmental Research and Development Program, which is managed by a council comprised of officials from DOD, the Department of Energy, and EPA. According to DOD environmental program officials, projects within this

³³Pub. L. No. 116-92, § 378(a), 133 Stat. 1198, 1334 (2019).

program focus on basic and applied research and, typically, are in development in the laboratory or test pond. Projects within the Environmental Security Technology Certification Program involve a higher level of readiness and focus instead on demonstration and evaluation of technologies in real-world settings.

Navy and Corps officials told us that they learn about, research, and assess the feasibility of various innovative technologies for use in their cleanup efforts through these DOD environmental research programs. First, Navy and Corps engineers and scientists participate on program technical committees, and this participation provides insight into new technologies being developed and demonstrated. Second, federal agency officials involved with the Vieques and Culebra cleanup efforts participate in program events to provide and receive information on commercially available technologies. Team members also attend conferences, including the annual Strategic Environmental Research and Development Program Symposium and the National Association of Ordnance Contractors conference.

Additionally, Navy and Corps officials told us that the program research community, which includes academia, industry, the military services, and other federal agencies, regularly asks remedial project managers to describe the kinds of cleanup technologies needed. We found, for example, remedial project managers working at cleanup sites in Vieques and Culebra identified the need for innovative technologies, including

- technologies to more accurately distinguish and classify buried ordnance from other metals on land and underwater, which resulted in advanced geophysical classification technologies;
- technologies to survey large-scale underwater munitions sites safely and more efficiently, which resulted in the towed magnetometer array;
- technologies to destroy underwater munitions encased in coral in a manner that is protective of natural resources, which has resulted in the development and testing of a potential water jet cutting technology; and
- technologies that can aid in nearshore or surf-zone cleanup efforts, which have helped facilitate the development and testing of potential robotic crabs.

Finally, Navy and Corps officials told us they work with program researchers who have used Vieques and Culebra as demonstration sites to test the feasibility of technologies, including the towed magnetometer

array in 2016 and 2017, and upcoming operation of the water jet cutting system on land.

Military Service Technology Transfer Processes

Navy and Corps officials told us they assess the feasibility of innovative technology through military-specific technology transfer processes, including, for example, the following programs:

- The Navy's Environmental Sustainability Development to Integration Program. This program invests in projects focused on the development and transfer of innovative cleanup technologies that can improve the quality and speed of investigations and cleanup work and relies on technical input and feedback from project managers.
- The Corps' Environmental Innovative Technology Program and Innovative Technology Advocate Program. The Environmental Innovative Technology Program supports the transfer of new and innovative environmental technologies to Corps' projects. The Innovative Technology Advocate Program helps to implement, coordinate, and provide oversight of technology transfer and has a formal process to identify innovative technologies. Corps policy provides guidance on the consideration, implementation, use, and documentation of innovative technologies for all Corps projects to reduce costs, expedite project schedules, minimize risk, and maximize effectiveness. For example, as of April 2017, the Corps requires teams to consider the use of advanced geophysical classification technology at any FUDS cleanup effort for all phases of the munitions response process and provides implementation instructions.

Federal and Commonwealth Agencies Involved in the Puerto Rico Cleanup Efforts Assess the Feasibility of Innovative Technologies Relative to Their Agency's Role

Stakeholders from federal and Commonwealth agencies involved in the cleanup efforts of former military sites on Vieques and Culebra, including EPA, NOAA, the U.S. Fish and Wildlife Service, and Puerto Rico's Department of Natural and Environmental Resources, assess the feasibility of innovative technologies relative to their agency's role. Officials from these agencies told us they provide input to the Navy and Corps on the potential public health, environmental, or both impacts of a technology. This input is provided during site-specific meetings with the Navy and Corps, as well as in written comments provided during required comment periods on CERCLA documents such as the remedial investigation and feasibility study. Officials from the federal and Commonwealth agencies told us the process for providing input works well, and the Navy and Corps are receptive to their concerns and modify their use of a technology accordingly. For example:

-
- EPA. EPA officials reported assessing the feasibility respective to their role to protect human health and safeguard the natural environment by protecting the air, water, and land. EPA generally reviews and approves the use of various technologies (traditional or innovative) for sites on the National Priorities List. On Vieques, for example, EPA officials told us because the majority of the unexploded ordnance cannot be safely handled or moved more than a short distance, the agency has told the Navy that open detonation is EPA's preferred method for disposing of unexploded ordnance, versus the use of a closed detonation chamber. Also, EPA officials shared concerns with the Navy on the potential use of water jet cutting technology for underwater munitions in Vieques. Specifically, EPA has concerns that the seal on the bag or filter, which serves as a pollution abatement system for secondary waste (such as ash from the cutting) may not work properly and that secondary waste may be released into the surrounding waters. The Navy has been responsive and, as of December 2020, does not have any plans to test the technology in Vieques, according to Navy officials. Moreover, EPA officials share relevant research on remediation and remedial technologies with the Navy, such as EPA research on in-situ chemical oxidation, as well as an approach to measure the effectiveness of a remedy, which the Navy implemented.³⁴
 - NOAA. NOAA officials from the National Marine Fisheries Service and the National Ocean Service reported assessing the feasibility of technologies respective to their role as trustees for natural resources and in implementing the Endangered Species Act. The National Marine Fisheries Service conducts consultations on federal agency actions that may affect endangered or threatened marine species or their designated critical habitat.³⁵ For example, the National Marine Fisheries Service conducted a consultation with the Navy regarding the impact of the Navy's use of the towed magnetometer in the waters around Vieques. The consultation resulted in standard operating procedures to mitigate the risk of the array dragging or bumping on seagrass and threatened corals. The Navy was responsive to the National Marine Fisheries Service's concerns and adjusted the

³⁴According to Navy documentation, in-situ chemical oxidation is a remediation technology in which a chemical oxidant is injected into subsurface soil or groundwater to oxidize target contaminants.

³⁵Section 7 of the Endangered Species Act requires federal agencies to consult with the National Marine Fisheries Service when it determines that an activity it intends to authorize, fund, or carry out may affect a species listed as endangered or threatened, or critical habitat for such species, for which the National Marine Fisheries Service is responsible.

weighting of the array, according to National Marine Fisheries Service officials.

On Culebra, NOAA worked with the Corps on the testing of an airboat technology. The airboat, which floated with propulsion of air, was being used in shallow water. The Corps was responsive to NOAA's input about the impact of downdraft and acoustics on corals and marine mammals and decided to use snorkelers instead. Presently, NOAA has shared concerns with the Navy and Corps about sonar technology for underwater munitions on Vieques and Culebra. These concerns include the acoustic impacts that can cause temporary or permanent shifts in hearing for marine mammals, sea turtles, and fish species. According to Navy and Corps officials, these concerns will be addressed during feasibility studies to support the long-term response action.

- U.S. Fish and Wildlife Service. U.S. Fish and Wildlife Service officials reported assessing the feasibility of technologies respective to their role as land owner and refuge manager and as trustee for natural resources. U.S. Fish and Wildlife Service officials stated they provide comments to the Navy and Corps that focus on how the land will be used after cleanup, such as for hunting, fishing, and the construction and use of observation towers and trails. The U.S. Fish and Wildlife Service developed Comprehensive Conservation Plans for Vieques and Culebra, as well as actions for specific areas of the refuge—known as step-down plans—to ensure the refuges are safe for public use and accessible yet sufficiently protect natural habitats and resources, including threatened and endangered species. For example, in Vieques, U.S. Fish and Wildlife Service officials have to ensure there is enough vegetation to prevent erosion, and thus protect adjacent marine resources and reduce the loss of topsoil, as well as to provide a seed source for natural regeneration of the island's vegetation and for the native fauna.

On Vieques and Culebra, U.S. Fish and Wildlife Service officials have shared their concerns about the accuracy of advanced geophysical classification technology. The level of trust in the technology differs, depending on the future use of the cleanup site. For example, the detection of subsurface munitions at a proper depth is imperative when creating a road because there is a significant amount of heavy equipment, digging, and moving dirt. U.S. Fish and Wildlife Service officials told us the Navy and Corps have been responsive to their concerns.

Agency Comments

We provided a draft of this report to DOD, EPA, the Department of the Interior, the Department of Commerce, and Puerto Rico's Department of

Natural and Environmental Resources for review and comment. The agencies 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 Acting Secretaries of the Army and Navy, the EPA Administrator, the Secretary of the Interior, the Secretary of Commerce, and the Secretary of Puerto Rico's Department of Natural and Environmental Resources. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff has any questions about this report, please contact Alfredo Gómez at (202) 512-4101 or GomezJ@gao.gov or Elizabeth A. Field at (202) 512-2775 or FieldE1@gao.gov. Contact points for our Office of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff that made key contributions to this report are listed in appendix II.



Alfredo Gómez
Director, Natural Resources and Environment



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 Jon Tester
Chairman
The Honorable Richard Shelby
Ranking Member
Subcommittee on Defense
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 Betty McCollum
Chair
The Honorable Ken Calvert
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Objectives, Scope, and Methodology

This report (1) discusses the status and cost of ongoing cleanup efforts at the former military sites on the islands of Vieques and Culebra, Puerto Rico; (2) identifies challenges to the cleanup efforts at these sites and examines how the Department of Defense (DOD) is addressing these challenges; and (3) describes the cleanup technologies DOD is using at these sites and how agencies assess the feasibility of innovative technologies.¹

To determine the status and cost of ongoing cleanup efforts at the former military sites on the islands of Vieques and Culebra, Puerto Rico, we reviewed relevant laws; regulations; and DOD, the U.S. Navy, U.S. Army Corps of Engineers (Corps), and U.S. Environmental Protection Agency (EPA) guidance that govern such cleanup efforts.² We reviewed these laws, regulations, and guidance to gain an understanding of roles and responsibilities for each agency, phases of the cleanup effort, and required documentation during the cleanup phases.

We requested and analyzed data on the status and cost for each cleanup site on Vieques and Culebra from DOD's Knowledge-Based Corporate Reporting System on environmental restoration efforts. To assess the reliability of the data system, we interviewed relevant officials from the Office of the Secretary of Defense and Navy and Corps headquarters who have direct knowledge of the system about the steps taken to ensure the quality and accuracy of data. We determined that the data were sufficiently reliable for our reporting purposes. Moreover, we interviewed Navy and Corps officials to gain an understanding of what information is

¹For purposes of this report, the term "cleanup site" or "sites" refers to any location on Vieques and Culebra where the U.S. Navy or U.S. Army Corps of Engineers (Corps) are conducting environmental cleanup efforts, activities, or projects; and the term "innovative technology" refers to breakthrough technology concepts that are either (1) mature technologies being used in a new manner; or (2) technologies under development that require additional testing, evaluation, and commercial availability in order to transition to full-scale implementation.

² Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Pub. L. No. 96-510, 94 Stat. 2767 (codified, as amended, at 42 U.S.C. §§ 9601-9675); 10 U.S.C. §§ 2700-2711; 32 C.F.R. pt. 203; National Contingency Plan, 40 C.F.R. pt. 300. EPA, *Superfund Community Involvement Handbook* (March 2020); DOD Instruction 4715.07, *Defense Environmental Restoration Program (DERP)* (May 21, 2013) (Incorporating Change 2, Aug. 31, 2018); DOD Manual 4715.20, *Defense Environmental Restoration Program (DERP) Management* (March 9, 2012); Department of the Navy, *Environmental Restoration Program Manual* (2018); and Department of the Army, Regulation No. 200-3-1, *Environmental Quality: Formerly Used Defense Sites (FUDS) Program Policy* (May 10, 2004).

used in preparing environmental cleanup cost estimates for Vieques and Culebra, including the sources of data, assumptions, analytical processes, and general limitations and uncertainties DOD has identified.³ We analyzed documentation on the status and cost, including site management plans and sampling and analysis plans, for the Navy and Corps' cleanup efforts.

We also analyzed the Department of the Interior's U.S. Fish and Wildlife Service's Comprehensive Conservation Plans for Vieques and Culebra to gain additional detail on future land use plans. Additionally, we interviewed DOD officials responsible for defense environmental restoration efforts from the Office of the Deputy Assistant Secretary of Defense (Environment); the Office of the Assistant Secretary of the Army (Installations, Energy and Environment); the Office of the Assistant Secretary of the U.S. Navy (Energy, Installations, and Environment); the Naval Facilities Engineering Command Atlantic; and the Corps; as well as EPA officials and officials from Puerto Rico's Department of Natural and Environmental Resources to gain an understanding of the status of cleanup efforts. Finally, we reviewed our prior work related to the status of cleanup efforts on Vieques, as well as DOD reports to Congress on environmental restoration and cleanup efforts on Culebra and Vieques, Puerto Rico.⁴

To identify challenges to the cleanup efforts at these sites and how DOD is addressing these challenges, we reviewed statutes and regulations, as well as DOD and EPA guidance that govern cleanup efforts, to gain an understanding of steps taken to mitigate risk, including for example, guidance on Restoration Advisory Boards (RAB), public awareness, and community involvement.⁵ We analyzed documentation that included

³We did not assess the reliability of each cleanup site's future cost estimates, such as the underlying engineering calculations, but instead focused on the reliability of the overall reporting system.

⁴GAO, *Defense Infrastructure: Environmental Cleanup of Former Naval Facilities on Vieques*, [GAO-07-552R](#) (Washington, D.C.: Mar. 26, 2007); Department of the Navy, the Assistant Secretary of the Navy (Energy, Installations & Environment), *Report to Congress on Vieques Environmental Restoration* (March 2020); *Report to Congress on Previously Released Information Related to Ordnance on Vieques* (February 2020); and U.S. Army Corps of Engineers, *Culebra Island Report to Congressional Defense Committees* (August 2018).

⁵Department of Defense, *Defense Environmental Restoration Program (DERP) Management Manual* (Washington, D.C.: Mar. 9, 2012); Department of the Navy, *Environmental Restoration Program Manual* (Washington, D.C.: 2018); and EPA, *Superfund Community Involvement Handbook* (Washington, D.C.: March 2020).

information on cleanup alternatives and associated challenges, such as site management plans.

We also analyzed documentation relating to community involvement, including Navy and Corps Community Involvement Plans, fact sheets, RAB meeting minutes, and survey results from Vieques residents on the Navy's cleanup efforts. We interviewed DOD officials responsible for defense environmental restoration efforts from the Office of the Secretary of Defense; Navy and Army headquarters; the Naval Facilities Engineering Command Atlantic; and the Corps, as well as officials from EPA to gain an understanding of site-specific cleanup challenges. We interviewed officials from the U.S. Fish and Wildlife Service; the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service and National Ocean Service; and Puerto Rico's Department of Natural and Environmental Resources to gain an understanding of site-specific cleanup challenges, given their roles.

We also interviewed academic researchers, members of the Vieques RAB, and residents from both islands to gain an understanding of cleanup challenges from their perspectives. We sent notifications of our review to all Vieques RAB members and interviewed those willing to speak with us. We also selected island residents to talk with by reviewing documents that identified residents serving as community advocates, as well as by asking the Navy, Corps, and Puerto Rico's Department of Natural and Environmental Resources to identify residents active in the cleanup efforts. We also compared steps the Navy took to address the challenge of community distrust on Vieques with DOD and EPA guidance, including EPA's 2020 Superfund Community Involvement Handbook, to analyze the extent to which the Navy was taking the steps called for in the guidance.

To describe cleanup technologies that DOD is using at these sites and how agencies assess the feasibility of innovative technologies, we reviewed DOD and EPA guidance on the development; testing; and consideration of technologies, including innovative technologies. We also reviewed Navy and Corps guidance on the transfer of validated technologies for use at cleanup sites. We analyzed documentation from DOD's environmental research programs, including project overviews and final reports, to learn about technologies and gain an understanding of how the Navy and Corps participate in the testing of technologies at cleanup sites in Vieques and Culebra. We analyzed the Federal Facilities Agreement that EPA, Navy, the Department of the Interior, and the Commonwealth of Puerto Rico signed in 2007, which established a

procedural framework and schedule for response actions at the Vieques site on the National Priorities List.⁶ We also analyzed EPA, U.S. Fish and Wildlife Service, and NOAA's National Marine Fisheries Service's site-specific program documentation to gain an understanding of their role in assessing technology and how they share any concerns with the Navy and Corps.

We interviewed officials from DOD's environmental research programs, including the Strategic Environmental Research and Development Program and the Environmental Security Technology Certification Program, as well as Navy and Corps environmental restoration officials. We interviewed these officials to gain an understanding of what technologies were used or proposed for use and how they learn about, assess the feasibility of, and transfer technologies for use at cleanup sites. We also interviewed officials at EPA, Puerto Rico's Department of Natural and Environmental Resources, U.S. Fish and Wildlife Service, and NOAA's National Marine Fisheries Service and National Ocean Service to gain an understanding of how they learn about and assess the feasibility of technologies for use on Vieques and Culebra.

We conducted this performance audit from February 2020 to March 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.

⁶The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended requires federal facility agreements for all federal facilities on the National Priorities List.

Appendix II: GAO Contacts and Staff Acknowledgments

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