



Report to the Chairman, Subcommittee
on Environment, Energy, and Natural
Resources, Committee on Government
Operations, House of Representatives

December 1994

CHEMICAL WEAPONS DISPOSAL

Plans for Nonstockpile Chemical Warfare Materiel Can Be Improved



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National Security and
International Affairs Division

B-253645

December 20, 1994

The Honorable Mike Synar
Chairman, Subcommittee on Environment,
Energy, and Natural Resources
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

This report responds to your request that we review the Department of the Army's disposal program for chemical munitions, materiel, and facilities that are not specifically included in the U.S. stockpile of unitary chemical weapons.¹ These items are referred to as nonstockpile chemical warfare materiel and consist of binary chemical weapons, miscellaneous chemical warfare materiel, recovered chemical weapons, former chemical weapon production facilities, and buried chemical warfare materiel. As requested, we collected and analyzed information on (1) the status of the Army's planning process for the nonstockpile disposal program, (2) the Army's estimated disposal cost and schedule, and (3) lessons learned from the Army's ongoing stockpile disposal program that may also apply to the proposed nonstockpile program. Our scope and methodology are described in appendix I.

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Background

In November 1985, the Congress directed the Army to destroy the Department of Defense's (DOD) stockpile of unitary chemical weapons. The stockpile is stored at eight Army installations in the continental United States and one installation on the Johnston Atoll in the Pacific Ocean. It consists of various lethal weapons, such as rockets, bombs, and projectiles, and bulk containers that contain nerve and mustard agents. Exposure to the agents can result in death.

In 1993, the United States signed the U.N.-sponsored Convention on the Prohibition of the Development, Production, Stockpiling and the Use of Chemical Weapons and on Their Destruction, commonly referred to as the Chemical Weapons Convention. The United States agreed to dispose of (1) binary chemical weapons, recovered chemical weapons, and former chemical weapon production facilities within 10 years and (2) miscellaneous chemical warfare materiel within 5 years of the date the convention becomes effective. If ratified by the U.S. Senate, the

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¹A unitary chemical weapon is a munition containing a single lethal chemical agent.

convention becomes effective 180 days after the 65th nation ratifies the treaty, but not sooner than January 13, 1995. Under the terms of the convention, chemical weapons buried prior to 1977 are exempt from disposal as long as they remain buried. In the United States, burial was a common disposal method for chemical warfare materiel until the late 1950s. Should the United States choose to excavate the sites and remove the chemical weapons, the provisions of the convention would apply. DOD officials estimate that the convention will enter into force in fiscal year 1996.

In the fiscal year 1993 National Defense Authorization Act (P.L. 102-484), the Congress directed the Army to report on its plans for disposing of all nonstockpile chemical warfare materiel within the United States. In 1993, the Army issued a report describing the nonstockpile chemical materiel, potential disposal methods, transportation alternatives, and disposal cost and schedule estimates.² The report concluded that it would cost the Army \$1.1 billion (\$930 million in direct project disposal costs and \$170 million in programmatic costs) to destroy, primarily by incineration, demolition, and neutralization,³ the nonstockpile chemical materiel required by the convention within the required time frames. Programmatic costs are associated with more than one disposal project or program category. For example, the portion of management and personnel costs that support more than one project is considered programmatic costs. Also, estimated costs to procure and test equipment to be used at more than one site are included in the programmatic cost estimate. The Army also reported that it would cost \$16.6 billion (\$12.04 billion in direct disposal costs and \$4.56 billion in programmatic costs) to recover and destroy, primarily by incineration and neutralization, buried chemical materiel within 40 years. These estimates are considered rough order of magnitude estimates, typically used when a program is not fully developed. According to program officials, the Army plans to issue a supplement to its 1993 survey and analysis report, which will include revised cost and schedule estimates, in mid-1995. Appendix II describes the Army's nonstockpile chemical warfare materiel.

The Army Chemical Demilitarization and Remediation Activity, formerly named the Army Chemical Materiel Destruction Agency, is responsible for

²Survey and Analysis Report: Non-Stockpile Chemical Materiel Program, U.S. Army Chemical Materiel Destruction Agency (Nov. 1993).

³The neutralization process involves altering the chemical, physical, and toxicological properties of the chemical agent to render it ineffective for use as intended. The process may be followed by incineration of the remaining materiel.

storing, transporting, and disposing of nonstockpile chemical warfare materiel. The extent to which other federal and state agencies will be involved in the program depends on the location and particulars of the nonstockpile chemical materiel. Appendix III describes federal and state agencies' roles and responsibilities for the nonstockpile disposal program.

Results in Brief

The Army's plans for destroying nonstockpile chemical warfare materiel are not final and, as a result, its \$17.7-billion cost estimate is uncertain and cannot be used for budget purposes. This uncertainty is largely because the amount of materiel to be disposed of has not been fully identified and the disposal methods cannot be selected until the Army is further along in the environmental assessment and permitting process. Although the Army has good information about some categories of nonstockpile materiel, the amount and condition of other materiel are unknown. For example, the Army knows little about the agents inside recovered chemical weapons or the nature of contaminated materiel at former production facilities. Also, the Army has limited and often imprecise information about the nature and extent of buried chemical warfare materiel, which are estimated to be located at 215 sites in 33 states, the U.S. Virgin Islands, and Washington, D.C. Although the Army has determined that 30 of the 215 burial sites warrant no further remediation activity, the nature and extent of buried chemical warfare materiel at the other sites will remain unknown prior to excavation, and additional burial sites may be identified.

The Army's cost and schedule estimates, and its ability to complete the nonstockpile chemical disposal program, are likely to be affected by issues similar to those experienced in the stockpile disposal program. These include actions necessary to comply with federal, state, and local laws and requirements; obtain the necessary environmental approvals and permits; and address the strong public opposition to chemical weapons incineration.⁴ In addition, the Army has limited experience destroying nonstockpile chemical materiel and is unfamiliar with what types of environmental and technical problems to expect. Based on the difficulties experienced in the stockpile disposal program, the Army's estimated cost of the nonstockpile disposal program is likely to increase and its proposed schedule to slip.

⁴The baseline incineration process involves a disassembly procedure that breaks down munitions into their component parts. Once disassembled, the chemical agent and components are burned separately in high temperature furnaces.

The Army's Planning Process and Cost and Disposal Estimates Are Affected by Uncertainties

As of November 1994, the Army had not issued a comprehensive implementation plan to dispose of nonstockpile chemical warfare materiel. Moreover, based on the Army's experience with the stockpile disposal program, it is likely to be several years before the Army can develop a disposal plan that includes reliable cost and schedule estimates.⁵ The Army's 1993 report provides an initial scoping of the magnitude of effort required to safely destroy all nonstockpile chemical materiel in the United States if so directed. However, because of uncertainties about the nature and magnitude of the materiel or the disposal methods to be used, the Army recognizes that its \$17.7-billion cost estimate for the nonstockpile disposal program cannot be relied on for budget purposes. Appendix IV lists the disposal methods used by the Army to develop its program cost and schedule estimates.

Whenever possible, the Army plans to dispose of nonstockpile chemical materiel on-site. However, there may be occasions when it is not feasible or practical for the Army to do so, and transportation to another disposal location may be required. Factors the Army intends to consider are population proximity and density, chemical weapon type, condition of the munitions, and public safety and environmental policy. In addition, the opinions and concerns of the affected states, local governments, and the public will affect the Army's decisions. For example, there is strong public opposition to incineration and transportation of chemical weapons across state boundaries.

The Army's level of knowledge and stage of planning by category of nonstockpile materiel are summarized in table 1.

⁵In November 1985, the Congress directed the Army to destroy the DOD stockpile of unitary chemical weapons. Nine years later, the stockpile disposal program continues to experience cost growth and schedule slippages.

Table 1: Summary of the Army's Level of Knowledge and Stage of Planning, Including Disposal Cost and Schedule Estimates

Dollars in billions

Category	Characteristic	Number of sites	Disposal cost estimate	Time frame (years)
Binary chemical weapons	The locations and quantities are well-documented. The nature of the chemical elements and the components are understood by the Army.	4	\$0.19	10
Miscellaneous chemical warfare materiel	The locations and quantities are well-documented, and most materiel are not contaminated with a chemical agent.	10	0.21	5
Recovered chemical weapons	The locations and quantities are well-documented, but the inventory will change as additional weapons are recovered. The chemical fill of 25 percent of the weapons is unknown, and the weapons are likely to be in deteriorated condition.	6	0.11	10
Former chemical weapon production facilities	The facilities that are to be destroyed have been identified. However, the levels of contamination and deterioration are unknown.	4	0.42	10
Buried chemical warfare materiel	The actual amount, chemical agent, condition, and type of materiel are unknown, and the number and locations of potential burial sites are uncertain. The Army has limited experience in disposing of buried chemical materiel.	215	12.04	40
Programmatic costs	The estimated programmatic costs are based on little actual experience, limited data, and key uncertain assumptions.	a	4.73	a
Total cost			\$17.70	

^aNot applicable.

Source: Based on the Army's 1993 Survey and Analysis Report.

Binary Chemical Weapons

The locations and quantities of binary chemical weapons are well-documented and understood by the Army. Binary weapon systems principally involve an artillery projectile and components of the bigeye bomb. The projectile is composed of chemical elements, a metal casing, and explosive components. Although the bigeye bomb was never produced or stockpiled, some associated chemical elements must be destroyed.

Although the method for destroying binary chemical weapons has not been determined, the Army estimates that, subject to the availability of

funds, it can destroy the binary weapons within 10 years for \$190 million. According to Army officials, the chemical elements in binary weapons are not lethal agents until they are combined during flight to a target; therefore, handling and disposing of the chemical elements and components should not pose any major problems. Some of the disposal options being considered for binary weapon components are incineration, landfill, crushing, and smelting. The actual disposal method will be selected by the Army after a comprehensive environmental review.

Miscellaneous Chemical Warfare Materiel

The Army has a good understanding of miscellaneous chemical warfare materiel to be destroyed and has documented them by location, configuration, quantity, and type. However, changes are likely to occur as materiel is added or deleted as a result of the Chemical Weapons Convention verification process. The materiel is predominantly metal containers and munitions components. Some of the components contain explosive charges that may need to be extracted before disposal.

Despite an uncertainty about the disposal method, the Army estimates that, subject to the availability of funds, it can destroy the miscellaneous chemical warfare materiel within 5 years for \$210 million. According to Army officials, disposal options are numerous since most of the materiel is not contaminated with a chemical agent. The options include incineration, smelting, and crushing. However, the decision on disposal methods will be based on (1) the location, configuration, and type of materiel, (2) results of the required environmental analyses and studies, and (3) input from the affected states, local governments, and the general public.

Recovered Chemical Weapons

The Army has some information on the recovered chemical weapons that it must dispose of, but the inventory will change as additional weapons are recovered. According to Army documents, chemical weapons have been recovered from range-clearing operations, chemical burial sites, and research and development test areas. As of November 1993, there were 7,056 recovered chemical items in the Army's inventory, consisting of mortar cartridges, projectiles, bombs, German rockets, chemical agent identification sets, and bulk containers.

With appropriate funding, the Army estimates that the destruction of recovered chemical items can be completed within 10 years, at a cost of \$110 million. The Army believes that handling and disposing of recovered chemical weapons will be difficult as (1) they are more likely to have

deteriorated than other nonstockpile materiel and (2) the identity of the agent is unknown in 25 percent of the weapons. The Army is studying several destruction options, including transportable incineration and neutralization systems. However, the actual method for destroying the recovered chemical weapons cannot be selected until after the Army completes the required technical and environmental studies.

Former Chemical Weapon Production Facilities

The Army has identified former chemical weapon production facilities that need to be cleaned up. They consist of buildings and equipment for producing, loading, storing, and assembling chemical munitions and agents. These facilities are located in four states and are in various degrees of contamination and deterioration.

The Army estimates that it will take 10 years and \$420 million to dispose of former chemical weapon production facilities. However, the Army has no experience in destroying former production facilities in compliance with the Chemical Weapons Convention. It is still in the process of determining the levels of contamination, identifying potential problems in the demolition process, and determining how to safely dispose of the buildings and their components. Some of the disposal options being considered are incineration of contaminated materiel and demolition of uncontaminated facilities and equipment. The final disposal decision will not be made until comprehensive environmental studies are completed with the participation of the affected states, local governments, and the public.

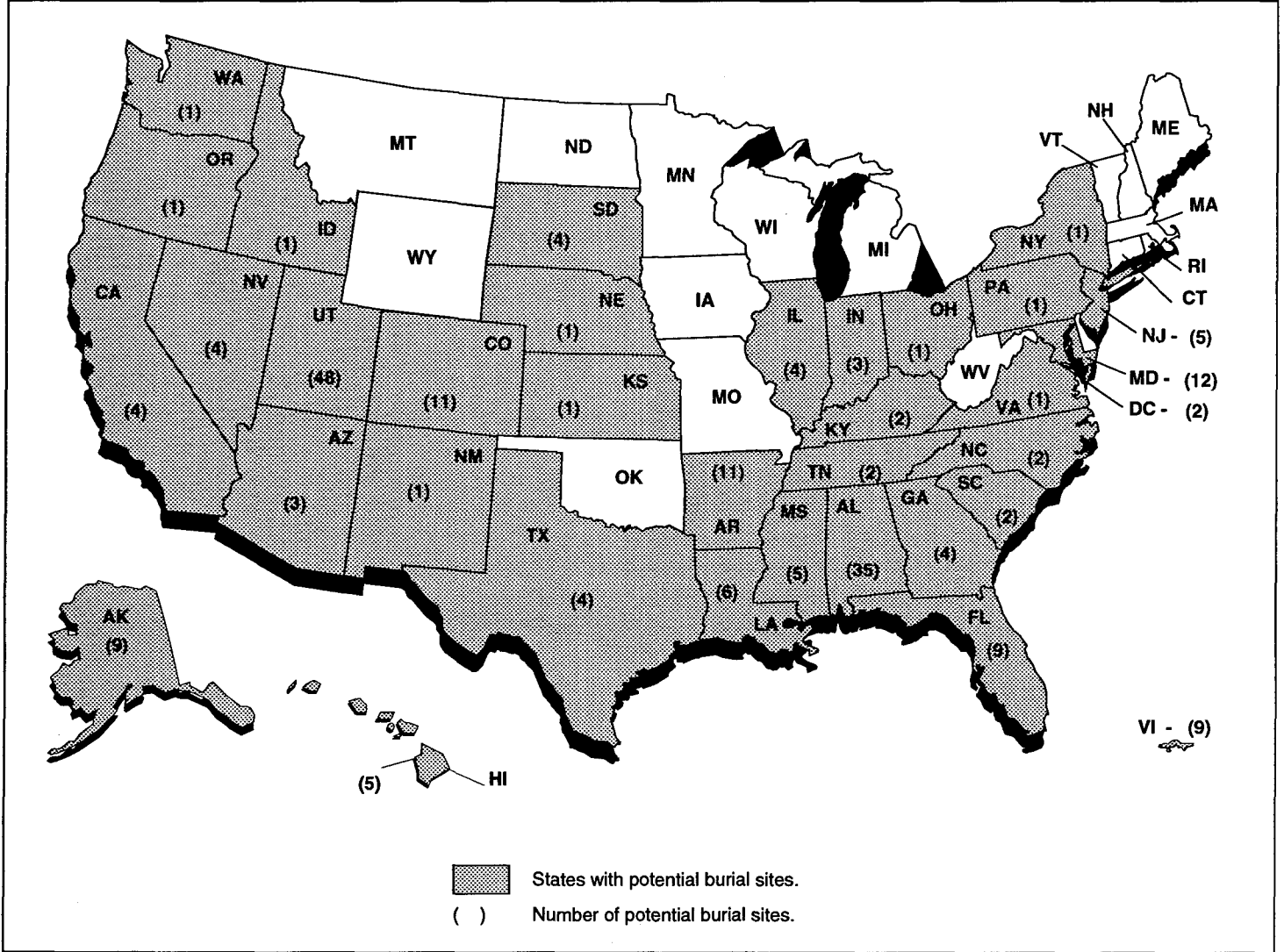
Buried Chemical Warfare Materiel

The Army has limited and often imprecise information about the nature and extent of buried chemical materiel. However, it has begun to develop site characterization, excavation, removal, and treatment procedures for the burial sites. Since burial was considered to be the final disposal act, little record-keeping was done for burial activities and additional sites are likely to be identified. Available records indicate that some burial sites may still contain active chemical agents and explosives; therefore, they pose a threat to human health and the environment.

According to Army officials, the lack of knowledge about buried chemical warfare materiel has created considerable difficulty in selecting appropriate disposal methods. The Army has conducted various analyses, including comprehensive documentation surveys, site visits, and interviews, to identify potential burial sites. Even at well-documented sites, the actual amount, chemical agent, condition, and type of buried

materiel will remain relatively unknown prior to excavation and visual identification. Based on preliminary analyses, the Army has identified potential chemical warfare materiel at 215 burial sites in 33 states, the U.S. Virgin Islands, and Washington, D.C. (See fig. 1.) The Army has determined that 30 of the 215 potential burial sites warrant no further remediation activity. This determination is based on the Army's site assessment, prior completed remedial work, or the restricted accessibility of the site.

Figure 1: Potential Chemical Warfare Materiel Burial Sites



Note: According to Army officials, the potential burial sites in Kansas, New York, Virginia, and Washington do not require additional remediation activities. The remaining 29 states contain one or more potential burial sites that require further analyses and appropriate actions.

The Army is studying (1) several different on-site disposal technologies, (2) the plausibility of leaving the materiel in the ground while controlling access to the site and containing potential contamination, and (3) transportation of the materiel to an Army facility capable of storage

and destruction. Prior to excavation, the Army will conduct soil samples and metal detection surveys as well as install monitoring wells to estimate the nature and extent of contamination and develop remedial alternatives. The Army could excavate by hand, which has been frequently used in the past. It is also studying the use of robotics in excavating buried materiel, although acceptable technology is not readily available. According to Army officials, mechanical means are more likely to cause a chemical release or detonation. The actual excavation method for recovering buried chemical warfare materiel cannot be selected until the Army completes further technical and environmental studies and the public has been involved in the Army's selection.

The Army estimates that it will cost \$12.04 billion, plus \$4.56 billion in programmatic costs, and take 40 years to recover and dispose of the buried chemical materiel. It included the estimated costs (1) of fixed incinerators for three of the four large burial sites, (2) for capping the remaining large site, and (3) of transportable incineration and neutralization systems for small sites. The transportable incineration and neutralization systems, when developed, will comply with safety and environmental requirements and be capable of moving or being moved from one disposal site to another. The Army expects the systems will use a batch-style process to treat relatively small quantities of chemical warfare materiel.

Appendix V contains our case study of the Army's investigation and disposal activities at the Spring Valley chemical burial site in Washington, D.C. Remediation of the Spring Valley site took 2 years and cost \$20.22 million. The recovered chemical warfare materiel has not yet been destroyed.

Lessons From the Stockpile Disposal Program Should Be Applied to the Nonstockpile Planning Process and Cost and Schedule Estimates

Because both chemical disposal programs involve similar environmental requirements and potentially similar disposal methods, many of the lessons learned from the stockpile disposal program may apply to the nonstockpile program. In the 1990s, we reported that the Army did not adequately anticipate and plan for (1) the time needed to obtain the necessary environmental approvals and permits for the stockpile disposal program and (2) the strong public opposition to the chemical weapons incineration process.⁶ Further, we reported that the stockpile program had been delayed by design, equipment, and construction problems at the new disposal facility at Johnston Atoll. As a result of these factors, the estimated cost of the stockpile disposal program increased and the Army's destruction schedule slipped.

According to Army officials, they have applied some lessons learned, such as the Army's experience with environmental compliance procedures and research of alternative disposal methods from the stockpile program, to the nonstockpile disposal program. However, lessons learned were not discussed in the Army's 1993 survey and analysis report on the nonstockpile program. In addition, because the Army based its disposal program and estimates on numerous assumptions as well as generic cost categories and work statements, we could not determine the effects of the lessons on the Army's nonstockpile planning process and estimates.

Obtaining Environmental Approvals and Permits May Take Longer Than Anticipated

Prior to recovering, storing, moving, or destroying nonstockpile chemical warfare materiel, the Army must comply with federal and state environmental laws and regulations. These laws and regulations differ from state to state and change frequently. In its 1993 report, the Army reported that changes to environmental regulations could significantly affect its estimated disposal cost and schedule for the nonstockpile disposal program. Even when state regulatory agencies grant the Army permission to recover, move, or dispose of nonstockpile materiel, the Army is not insulated from legal actions by concerned citizens and groups. Previously, we reported that because of the Army's difficulty in anticipating the time needed to comply with environmental requirements and to obtain environmental approvals and permits, the chemical stockpile disposal program cost more and took longer than planned.

⁶Chemical Weapons: Obstacles to the Army's Plan to Destroy Obsolete U.S. Stockpile (GAO/NSIAD-90-155, May 24, 1990); Chemical Weapons: Stockpile Destruction Cost Growth and Schedule Slippages Are Likely to Continue (GAO/NSIAD-92-18, Nov. 20, 1991); Chemical Weapons Destruction: Issues Affecting Program Cost, Schedule, and Performance (GAO/NSIAD-93-50, Jan. 21, 1993); and Chemical Weapons Destruction: Advantages and Disadvantages of Alternatives to Incineration (GAO/NSIAD-94-123, Mar. 18, 1994).

Army facilities must have environmental permits for the storage and disposal of the nonstockpile chemical materiel, and the methods for transporting and disposing of the materiel must adhere to appropriate environmental regulations and be based on comprehensive studies. In general, state governments are authorized, under federal environmental statutes, to adopt federal concepts and to promulgate and implement additional rules and regulations, which in some instances, are more stringent than federal standards. For example:

- The Resource Conservation and Recovery Act, as amended, is likely to apply to most aspects, including transportation and storage, of the nonstockpile disposal program. Under the act, the Environmental Protection Agency may authorize individual states to administer and enforce hazardous waste programs in lieu of the federal program. The act also allows states to establish requirements more stringent than federal standards. For example, the states of Kentucky and Indiana enacted legislation that require the Army to demonstrate the absence of any acute or chronic health or environmental effects from incineration of chemical weapons before an environmental permit will be granted. There are miscellaneous chemical warfare materiel, former chemical weapon production facilities, and five potential burial sites located in these states.
- The Comprehensive Environmental Response, Compensation, and Liability Act provides overall cleanup procedures for nonstockpile sites and incorporates the standards of other federal and state statutes if they are applicable or relevant and appropriate to the cleanup process. A specific sequence of activities, guaranteeing the participation of federal and state agencies and the public in key decisions, must be followed before cleanup of a nonstockpile site proceeds.
- The Hazardous Materials Transportation Act governs the transportation of most nonstockpile chemical materiel and limits the movement of the materiel without special permits, licenses, and authorizations. The act delegates regulatory and enforcement responsibilities to the states but limits some state regulations. Nevertheless, states may still implement routing restrictions, transportation curfews, notification deadlines, and public right-to-know requirements. The Army anticipates that each state the materiel originates in, passes through, or terminates in will have some jurisdiction over part of the transportation program.

The nonstockpile disposal program has not reached the stage where appropriate laws, regulations, and concerns can be specifically identified for each location with nonstockpile chemical materiel. The applicability of laws and regulations to the recovery, transportation, storage, and disposal

of nonstockpile materiel ultimately depends on the circumstances of the materiel. The participation of the states, local governments, and the public also affects the Army's decisions concerning the transportation and disposal of the nonstockpile materiel. With respect to the nonstockpile program, the Army's planning process must cover at least 185 potential burial sites with various environmental conditions and considerations, 29 different states with state-oriented environmental laws and regulations, numerous local governments, and the general public.

Strong Public Opposition to Incineration

As demonstrated in the stockpile disposal program, there is considerable public opposition to the incineration of chemical munitions or agents. However, the Army based its 1993 preliminary cost and schedule estimates on the use of incinerators to destroy potentially large portions of its nonstockpile chemical materiel. The opposition centers around concerns about adverse health effects and environmental hazards. This opposition, which has come from several citizen groups, environmental organizations, and state governments, has extended the environmental review and approval process and resulted in postponing the construction and operation of fixed incinerators. The actual disposal methods for the nonstockpile program will be selected by the Army after comprehensive environmental reviews are completed with the participation of the affected states, local governments, and public.

In our 1994 report on the stockpile disposal program, we concluded that alternative technologies were unlikely to reach maturity in time to destroy the chemical weapons stockpile because they are in the initial development stages and over a decade away from full operations. Similarly, it is unlikely that these alternative technologies, if ever operational, will be available within the Chemical Weapons Convention's established time frames for the nonstockpile disposal program. According to Army officials, they believe that the neutralization process will be operational in the 1996-97 time frame. The Environmental Protection Agency has stated that any proposed chemical disposal technology would have to undergo the same type of rigorous analysis and evaluation that the incineration process has gone through—a process that has required at least 9 years.

Potential Technical and Mechanical Problems

The nonstockpile disposal program is vulnerable to change because it depends on disposal methods and destruction rates that have not been demonstrated. In our 1991 report on the stockpile program's cost growth

and schedule slippages, we concluded that the Army had limited experience with destroying stockpile chemical weapons and was unfamiliar with types of technical and mechanical problems to expect. As a result of these problems, the Army has not achieved its expected disposal rates for the stockpile program. Similarly, no nonstockpile chemical disposal project has been completed. Therefore, little procedure, cost, schedule, or engineering data are available, and the Army's proposed disposal methods and estimated destruction rates have not yet been demonstrated. In its 1993 report, the Army concluded that the technical risk for the nonstockpile disposal program was high because none of the disposal projects were completed. The Army also concluded that if effective processes or procedures were not discovered, it would have to fund "a major research and development program."

The Army has reported that unforeseen events, such as an accidental chemical release or explosion, would increase the cost and duration of the nonstockpile disposal program. For example, the Army's stockpile disposal facility at Johnston Atoll was shut down on March 23, 1994, and restarted again on July 12, 1994, because of a chemical agent release. According to Army officials, the release was small—approximately 11 milligrams. In addition, because of a hurricane and subsequent damage, the Johnston stockpile disposal facility was shut down on August 25, 1994, for more than 2 months.

Recommendations to the Secretary of the Army

We recommend that the Secretary of the Army

- ensure that lessons learned from the stockpile disposal program are systematically incorporated into the nonstockpile planning process and
- establish milestones for developing accurate and complete cost data to effectively plan for and control future program expenditures.

We conducted our review from June 1993 to November 1994 in accordance with generally accepted government auditing standards.

Unless you publicly announce this report's contents earlier, we plan no further distribution until 30 days from its issue date. At that time, we will send copies to the Chairmen, House and Senate Committees on Armed Services and on Appropriations; the Secretaries of Defense and the Army; the Director of the Office of Management and Budget; and other interested parties. We will make copies available to others upon request.

Please contact me at (202) 512-8412 if you or your staff have any questions.
Major contributors to this report are listed in appendix VI.

Sincerely yours,



Donna M. Heivilin
Director, Defense Management
and NASA Issues

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Abbreviations

DOD Department of Defense

Scope and Methodology

In reviewing the Army's nonstockpile chemical disposal program, we interviewed and obtained data from officials of the Department of Defense (DOD), the Department of the Army, the Army Chemical Demilitarization and Remediation Activity, the Army Chemical and Biological Defense Agency, and the U.S. Army Corps of Engineers. We also met with U.S. Environmental Protection Agency officials to discuss and collect data on environmental and legal issues related to the nonstockpile disposal program. We did not include overseas abandoned chemical warfare materiel in our review.

To identify lessons learned from the Army's stockpile disposal program, we reviewed our previous reports and testimonies and their supporting documentation. To assess the estimated disposal cost and schedule, we analyzed pertinent documentation and discussed the estimation methodology and problems that could affect the cost and duration of the program with Army and contractor officials. To assess the extent and nature of the nonstockpile disposal program, we visited Aberdeen Proving Ground, Maryland; Rocky Mountain Arsenal, Colorado; the former Raritan Arsenal, New Jersey; and the Spring Valley site, Washington, D.C.

As requested, we did not obtain official agency comments, but we discussed our findings with officials from DOD and the Army and incorporated their views where appropriate.

Description of the Army's Nonstockpile Chemical Warfare Materiel

Binary chemical weapons: Chemical weapons formed from two nonlethal elements (called precursors) through a chemical reaction after the munitions are fired or launched. Binary weapons were manufactured, stored, and transported with only one of the chemical elements in the weapon. The second element was to be loaded into the weapon at the battlefield. As of November 1993, the precursors for the binary chemical weapons are stored at Aberdeen Proving Ground, Maryland; Pine Bluff Arsenal, Arkansas; Tooele Army Depot, Utah; and Umatilla Depot Activity, Oregon.

Miscellaneous chemical warfare materiel: Materiel designed for use in the employment of chemical weapons, including unfilled munitions and components and support equipment and devices. According to Army records, miscellaneous materiel are stored at the Aberdeen Proving Ground, Maryland; Anniston Army Depot, Alabama; Blue Grass Army Depot, Kentucky; Dugway Proving Ground, Utah; Johnston Atoll, Pacific Ocean; Newport Army Ammunition Plant, Indiana; Pine Bluff Arsenal, Arkansas; Pueblo Depot Activity, Colorado; Tooele Army Depot, Utah; and Umatilla Army Depot Activity, Oregon.

Recovered chemical weapons: Chemical weapons recovered from range-clearing operations, chemical burial sites, and research and development test areas. According to the Army's 1993 report, recovered items are stored at Aberdeen Proving Ground, Maryland; Anniston Army Depot, Alabama; Dugway Proving Ground, Utah; Johnston Atoll, Pacific Ocean; Pine Bluff Arsenal, Arkansas; and Tooele Army Depot, Utah.

Former chemical weapon production facilities: Government-owned or -contracted facilities used to (1) produce chemical agents, precursors for chemical agents, or other components for chemical weapons or (2) load or fill chemical weapons. These facilities are located at Aberdeen Proving Ground, Maryland; Newport Army Ammunition Plant, Indiana; Pine Bluff Arsenal, Arkansas; and Rocky Mountain Arsenal, Colorado.

Buried chemical warfare materiel: Chemical warfare materiel, which are buried on both private lands and military installations, consisting of various munitions, bombs, rockets, and containers that may have been contaminated with nerve, blister, blood, or choking agents. At some sites, chemical munitions and agents were drained into holes in the ground, covered with lime or burned in an open pit, and finally covered with earth. Based on preliminary analyses, the Army has identified potential chemical warfare materiel at 215 burial sites in 33 states, the U.S. Virgin Islands, and

Appendix II
Description of the Army's Nonstockpile
Chemical Warfare Materiel

Washington, D.C. The Army has determined that 30 of the 215 potential burial sites warrant no further remediation activity. This determination is based on the Army's assessment of the potential burial site, prior remedial work, or accessibility to the site.

Roles and Responsibilities for the Nonstockpile Chemical Warfare Disposal Program

The U.S. Army Chemical Demilitarization and Remediation Activity is responsible for implementing the destruction of all U.S. chemical warfare-related materiel, including the chemical weapons stockpile and nonstockpile chemical materiel, and for ensuring maximum protection to the environment, general public, and personnel involved in the destruction. The activity's office of Program Manager for Nonstockpile Chemical Materiel is responsible for

- collecting and analyzing data on nonstockpile chemical materiel;
- identifying and assessing sites with possible buried chemical warfare materiel;
- coordinating the transportation of recovered chemical weapons to locations for interim storage;
- destroying recovered chemical warfare materiel on-site as needed to protect the general public and environment;
- researching, developing, evaluating, and selecting disposal methods for all nonstockpile chemical materiel;
- destroying binary chemical weapons, miscellaneous chemical warfare materiel, recovered chemical weapons, and former production facilities in accordance with the Chemical Weapons Convention, in compliance with public safety and environmental requirements and regulations, and in coordination with the potentially affected public; and
- reclaiming and destroying buried chemical warfare materiel in the interest of safeguarding the general public and environment.

Although the Army Chemical Demilitarization and Remediation Activity has overall responsibility for disposing of nonstockpile chemical materiel, other organizations within or outside DOD contribute to the disposal program. The involvement of the following organizations depends on the location and particulars of the materiel, storage area, or burial site:

- The Army Corps of Engineers provides technical support for site investigations, recoveries, and site restorations to Army and DOD organizations and is responsible for cleaning up formerly used defense sites. Restoration activities concerning the handling and disposal of nonstockpile chemical warfare materiel are coordinated with and authorized by the Army Chemical Demilitarization and Remediation Activity.
- The Technical Escort Unit, the Army Chemical and Biological Defense Agency, is responsible for the escort of nonstockpile chemical materiel, emergency destruction of chemical munitions, and emergency response to chemical agent incidents.

**Appendix III
Roles and Responsibilities for the
Nonstockpile Chemical Warfare Disposal
Program**

- The Army Environmental Center develops and oversees environmental policies and programs for the Army.
- The Army Surgeon General's office provides advice to Army commands on health and safety issues related to handling, transporting, and processing chemical agents and materiel.
- The Air Force Civil Engineer provides program management and technical support to Air Force commands and installations on environmental compliance and restoration programs.
- The Environmental Protection, Safety & Occupational Health Division, Office of Naval Operations, provides environmental policy and management support to Navy activities on environmental or safety-related programs.
- The Office of Installation Services and Environmental Protection, Defense Logistics Agency, provides environmental policy and management support to the agency's field commands and installations.
- The U.S. Environmental Protection Agency enforces federal laws protecting the environment and ensures that regulations mandated by federal statutes are followed.
- The U.S. Department of Health and Human Services reviews and provides recommendations on the Army's plans to transport or destroy chemical warfare materiel in order to help ensure public health and safety.
- The Occupational Safety and Health Administration oversees and regulates safety and health conditions at the workplace.
- The U.S. Department of Transportation enforces regulations governing the transportation of hazardous or nonhazardous materiel.

State governments and communities affected by the nonstockpile disposal program provide information for and have input into the Army's decision-making process. They also review and comment on the Army's planning and decision documents; grant necessary permits; and monitor and enforce their state, regional, and local statutes.

The responsibilities for remedial activities differ between burial sites located on active defense installations and formerly used defense sites. At active installations, the installation commander has overall responsibility for remedial activities at the potential burial sites. The Army Corps of Engineers and the Army Environmental Center support the installation commander in site investigation, excavation, and environmental cleanup. At formerly used defense sites, the Corps of Engineers has overall responsibility for site investigations, planning, excavations, and environmental cleanups of the potential burial sites. In both instances, the Army Chemical Demilitarization and Remediation Activity is responsible

**Appendix III
Roles and Responsibilities for the
Nonstockpile Chemical Warfare Disposal
Program**

for the transportation, interim storage, and destruction of recovered chemical warfare materiel. The activity is also responsible for the development of the equipment and technologies to safely dispose of the materiel.

Disposal Methods Used by the Army to Develop the 1993 Program Cost and Schedule Estimates

Category	Disposal method
Binary chemical weapons	
Liquid precursors	Off-site incineration
Sulfur	Landfill
Metal bodies and other uncontaminated materiel	Crushing and smelting
Miscellaneous chemical warfare materiel	
Energetic materiel, such as fuses, bursters, and propellants	Incineration
Uncontaminated metal parts and materiel	Crushing and smelting
Recovered chemical weapons	Neutralization ^a
Former chemical weapon production facilities	
Contaminated materiel	Incineration
Uncontaminated equipment and facilities	Demolition
Buried chemical warfare materiel	
Large quantity, explosive sites	Large fixed incineration
Small quantity, explosive sites ^b	Portable incineration
Small quantity, nonexplosive sites ^b	Portable neutralization ^a
Chemical agent identification sets	Portable neutralization ^a

^aThe neutralization process may be followed by incineration of the remaining materiel.

^bSmall sites are less than 10 acres, and the total excavation volume is less than 1,000 cubic yards.

Case Study: Investigation and Disposal Activities at the Spring Valley Site in Washington, D.C.

In January 1993, a construction crew unearthed World War I-era chemical and high-explosive munitions during routine residential construction activities in an area known as Spring Valley in Washington, D.C., setting in motion emergency recovery and removal operations, called phase I of Operation Safe Removal. Over 140 items, including mortars, projectiles, and debris, were recovered and removed from the area by the Army's Chemical and Biological Defense Agency during this phase. Some of the recovered items were subsequently analyzed and determined to contain chemical agents. The Army Corps of Engineers is currently proceeding with phase II of Operation Safe Removal, which is the comprehensive investigation and cleanup of the Spring Valley site under the Defense Environmental Restoration Program.

History of the Spring Valley Site

In 1917, the Chemical Warfare Service of the U.S. Bureau of Mines leased 92 acres from American University to establish the American University Experiment Station. The station was used by the Chemical Warfare Service, with personnel from the Army and the Navy, to research and conduct testing of chemical warfare items. Subsequently, additional land was leased northwest of American University to field test the chemicals and munitions developed at the station. In 1918, the Chemical Warfare Service was transferred from the Bureau of Mines to the War Department, and the station was renamed Camp American University Experiment Station, encompassing a total of 425 acres. During this period, the War Department also leased 84 acres northeast of American University to establish Camp Leach. This camp had mainly tents and barracks, along with staging and training areas for troops. According to the Army, no chemical testing was conducted at Camp Leach.

From mid-1917 through 1918, 100,000 troops were trained in trench warfare and the handling of chemical munitions at Camps American University and Leach. In addition, mortars and projectiles were test-fired and chemical munitions were tested in various areas of the camps. The American University Experiment Station was also used to

- prepare and test chemical warfare agents and munitions for possible use in gas warfare;
- develop procedures and methods to produce chemical warfare agents and munitions; and
- develop gas masks, protective clothing, canisters, incendiaries, smokes, and signals.

In December 1918, the War Department discontinued using Camps American University and Leach and burned all temporary buildings that had become unusable. In 1920, the department vacated the remaining buildings. The trenches and pits were filled in and the land returned to the original owners. Between 1942 and 1946, the Department of the Navy leased 5 acres and 15 buildings from American University to establish the Navy Bomb Disposal School. The Navy used the property and buildings for educational purposes.

Description of the Spring Valley Site

The Spring Valley site is a residential community located in northwest Washington, D.C., near the American University, schools, churches, a community park, hospital, a theological seminary, a new housing development project, and approximately 1,200 residences. The community is comprised of upper middle and upper income families, and the houses are valued from \$600,000 to \$1 million. The area immediately surrounding the initial discovery site consists of recently constructed or under-construction homes. Since the initial discovery of the munitions, the area of concern expanded to approximately 616 acres based on archival records.

Two Phases of Operation Safe Removal

Operation Safe Removal is conducted under the Comprehensive Environmental Response, Compensation, and Liability Act procedures and provisions in two operational phases. The Chemical and Biological Defense Agency was responsible for phase I, or the emergency recovery and removal operational phase. Phase I was completed on February 2, 1993. The Army Corps of Engineers is proceeding with phase II, or the long-term investigation and cleanup operational phase of the site with the fieldwork scheduled to be completed in January 1995.

Phase I Is Completed

On January 5, 1993, a construction crew unearthed a World War I-era chemical and high-explosive munitions disposal pit while installing a sewer line in the Spring Valley area. This discovery set in motion phase I of Operation Safe Removal.

Shortly after the discovery, the Army's emergency response force confirmed that several of the unearthed munitions were filled with chemical warfare materiel. Personnel in protective clothing recovered the visible munitions, sifted through the dirt piles, and segregated the liquid-

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Case Study: Investigation and Disposal
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and solid-filled munitions. During this period, residents of the Spring Valley area were evacuated. On the third day of the initial discovery, the Army activated a service response force to complete the removal operation. The service response force consisted of specialists to coordinate the on-site safety, security, and medical support; historical research; public affairs; hazard analysis; legal advice; environmental issues; and transportation of the recovered munitions. Within a few days, specialists from the Army Corps of Engineers, Army Chemical Demilitarization and Remediation Activity, Environmental Protection Agency, Federal Emergency Management Agency, Centers for Disease Control, Occupational Safety and Health Administration, American National Red Cross, local police and fire departments, and others were on-site.

Numerous miscellaneous items, tons of scrap, and over 140 munitions were removed from the Spring Valley site during phase I. Most liquid-filled munitions were flown off-site by helicopter to Andrews Air Force Base, Maryland, and then air-shipped to Pine Bluff Arsenal, Arkansas, for storage. The solid-filled munitions were flown to Fort A.P. Hill, Virginia, for explosive destruction. The miscellaneous items were moved off-site for testing, and the scrap materiel were sent to a landfill in New York. Both on-site and off-site analyses confirmed that some of the recovered munitions contained or at one time contained chemical or toxic smoke agents. Table V.1 shows the disposition of the recovered materiel.

**Table V.1: Disposition of Materiel
 Removed From the Spring Valley Site
 During Phase I**

Recovered materiel	Amount removed	Destination	Purpose
Suspected chemical rounds	35 rounds	Pine Bluff Arsenal, Arkansas	Storage
	9 rounds	Aberdeen Proving Ground, Maryland	Testing
Conventional explosive rounds and components	97 items	Fort A.P. Hill, Virginia	Detonation
Miscellaneous items	Several items	Aberdeen Proving Ground, Maryland	Testing
Scrap materiel	Several tons	Landfill site in New York	Disposal

**Phase II Fieldwork Is
 Scheduled to Be
 Completed in January 1995**

The Army Corps of Engineers is responsible for the overall project management, investigation, design, and construction activities during phase II of Operation Safe Removal. Its mission is to investigate and verify

that no additional World War I-era munitions remain in the Spring Valley area and, if necessary, to excavate, remove, and destroy any munitions discovered.

Site Investigation

The decision to continue the investigation of the Spring Valley site was based on research of archival data, topographic maps, aerial photographs, and anecdotal information, which indicated that more areas of interest existed. The Army also conducted geophysical investigations, including ground conductivity surveys, magnetometer sweeps, and soil and water sampling at the Spring Valley site. A computer system merged these data and maps and allowed the Corps of Engineers to create visual composite maps that summarized the investigations. Based on the results of the process, the Corps located suspected anomalies that required excavation to verify the presence or absence of munitions.

Excavation

The excavation process, which was approved in a safety plan, began with a Corps contractor mechanically digging to within 12 inches of the suspected anomaly, and then the process was turned over to the Army Technical Escort Unit for final excavation, exposure, identification, and removal. The excavation recovered several munitions and potential chemical warfare materiel. A brief description of some of the recovered materiel follows:

- A corroded piece of pipe, similar to shipping containers for liquid and gases during World War I, was recovered and moved to Pine Bluff Arsenal, Arkansas, for storage in June 1993.
- A 75-mm projectile, identified as a suspected chemical weapon, was recovered and flown to Pine Bluff Arsenal, Arkansas, for storage in October 1993.
- Shrapnel from several expended 75-mm projectiles were recovered and disposed of as scrap.
- A Livens smoke projectile was recovered and destroyed by incineration as waste munition in April 1994.
- Three glass vials, containing a clear liquid, were recovered and moved to Aberdeen Proving Ground, Maryland, for testing in November 1994.

Also, various nonmilitary metallic materiel encompassing ferrous rocks, a bundle of 14-gauge wire, a 28- by 10-foot steel plate, and construction debris were recovered and moved to other locations.

Interim Holding Area

As part of the Spring Valley Safety and Work Plans, an interim holding area and helicopter pad were constructed at a cost of \$284,000. They were

designed to provide immediate, although temporary safe storage, for any recovered munitions prior to being moved by Army helicopter out of the Spring Valley area. The holding area and pad contain a fire suppression system, air filtration system, lightning arrester system, and beacon lights. They are located on federal property and are government controlled for security reasons.

The interim holding area contains three storage magazines, one for high-explosive munitions and two for chemical munitions. The two chemical magazines are modified to include fire suppression and air filtration systems. The magazines are enclosed by a timber structure and earth embankment that provides a minimum of 3 feet of soil encompassing the magazines. No munition will remain in the interim holding area for longer than 10 consecutive days. The Corps of Engineers intends to demolish the holding area and helicopter pad once excavations at Spring Valley are completed.

Transportation

Recovered chemical weapons were moved by helicopter from the interim holding area to Andrews Air Force Base, Maryland, and then flown to Pine Bluff Army Arsenal, Arkansas, for storage and future destruction. Recovered high-explosive, conventional munitions were moved by helicopter from the area and transported to Letterkenny Army Depot, Pennsylvania. No shipment of other hazardous waste will be moved into or out of the interim holding area.

Investigation and Cleanup Costs of Operation Safe Removal

As of November 29, 1994, the Army Corps of Engineers estimated that the investigation and cleanup of the Spring Valley site would cost \$20.22 million. (See table V.2.) The estimate includes the costs of completing phase I operations, researching and investigating the site, constructing and operating the interim holding area, removing and sampling the recovered munitions and materiel, fulfilling safety and environmental requirements, and performing management activities.

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Table V.2: The Army Corps of Engineers Costs of Operation Safe Removal

Dollars in millions

Cost element	Fiscal year			Total
	1993 Actual	1994 Actual	1995 Estimated	
Phase I reimbursement	\$4.06	\$0.20		\$4.26
Baltimore District	2.31	1.94	\$0.50	4.75
Huntsville Division	5.56	5.15	0.50	11.21
Total	\$11.93	\$7.29	\$1.00	\$20.22

The Army Corps of Engineers costs include support costs for the Army Technical Escort Unit; the Army Chemical and Biological Defense Agency; Washington, D.C., government; resident office facilities; community evacuation; and others.

Community Issues and Concerns

According to the Army Corps of Engineers, the primary issues and concerns of the residents in Spring Valley are related to

- their personal safety,
- the effects of the presence of chemical munitions on the value of their property,
- the length of time their lives will be disrupted by the ongoing investigation and cleanup of the site,
- when the Spring Valley site will be certified safe and clear of dangerous munitions after Operation Safe Removal is completed, and
- the question of whether the Army is telling all that is known about or going on at the site.

To address these issues and concerns, the Corps of Engineers developed a public involvement and response plan to promote efficient and effective communication among the Corps; various federal, city, and local agencies and officials; property owners; the housing development corporation; general public; and news media. The primary objectives of the plan are to (1) provide for clear and open exchange of information regarding current and planned investigation and cleanup activities, (2) address local community issues and concerns, (3) provide government agencies and the public the opportunity to participate in the Corps of Engineers' planning and decision-making process, and (4) provide government agencies and the public with a centralized point of contact. According to the Corps of Engineers, the plan is flexible and can be modified as events, community

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issues and concerns, and situations change. We did not evaluate the effectiveness of the Army's public involvement and response plan.

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