Remediation of Buried Chemical Warfare Materiel

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Committee on Review of the Conduct of Operations for Remediation of Recovered Chemical Warfare Materiel from Burial Sites; Board on Army Science and Technology; Division on Engineering and Physical Sciences; National Research Council

Summary

As the result of disposal practices from the early to mid-twentieth century, approximately 250 sites in 40 states, the District of Columbia, and 3 territories are known or suspected to have buried chemical warfare materiel (CWM). Much of this CWM is likely to occur in the form of small finds that necessitate continuation of the Army's capability to transport treatment systems to such locations for destruction.[1] Of greatest concern for the future are sites in residential areas (e.g., the now urban Spring Valley section of Washington, D.C.) and large sites on legacy military installations such as Redstone Arsenal, Alabama, where over 5 miles of disposal trenches have been identified.

Neither the Chemical Weapons Convention (CWC) treaty (CWC, 1997) nor existing CWM domestic legislation requires recovery of buried CWM, but pressure to do so is becoming more intense. The cost of characterization, remedy selection, and even containment of these large buried CWM sites is likely to be significant. The upper-end estimate for completely recovering and destroying buried CWM at Redstone Arsenal in Alabama alone is estimated to be several billion dollars. Although it is impossible at this time to predict the ultimate cost of completely remediating all buried CWM, the Department of Defense (DOD) should initially plan for multi-billion-dollar costs over several years.

The Army mission regarding the remediation of recovered chemical warfare materiel (RCWM) is turning into a program much larger than the existing munition and hazardous substance cleanup programs. The organizational structure being used by the Army to achieve its original mission of handling ad hoc CWM finds consists of about a dozen organizations within the Army and several offices within the DOD. For example, different offices design and acquire the specialized CWM destruction and other equipment; other offices operate the equipment; another unit transports the equipment and personnel; and various offices within the U.S. Army Corps of Engineers (USACE) and the Offices of the Secretary of the Army and of the Secretary of Defense play significant roles in setting policy, obtaining federal funding, prioritizing sites for remediation, and participating in remedy selection decisions with regulators.

In the committee's view, the Army asked the National Research Council (NRC) to examine this evolving mission in part because this change in mission is significant and becoming even more prominent as the stockpile destruction is nearing completion. One focus of the study has been the current and future status of the Non-Stockpile Chemical Material Project (NSCMP), which now plays a central role in the remediation of recovered chemical warfare materiel and which reports to the Chemical Materials Agency (CMA). The tasks that were presented in the statement of task inherently required a review of funding based on the committee's interpretation of the statement of task, discussions with Army and Office of the Secretary of Defense (OSD) personnel, and the link between organizational efficiency and funding for DOD missions. In addition to examining the organizations and their roles and the funding, the NRC was asked to review the technology tools now used in the detection, excavation, packaging, storage, transportation, assessment, and destruction of buried CWM and the tools that may be needed in the future. The full statement of task is set forth in Chapter 1. The committee's main responsibilities were as follows:

- Survey the organizations involved with remediation of suspected CWM disposal sites to determine current practices and coordination.
- Review current supporting technologies for cleanup of CWM sites.
- Identify potential deficiencies in operational areas based on the review of current supporting technologies for cleanup of CWM sites and develop options for targeted research and development efforts to mitigate potential problem areas.
- Suggest means by which the coordination among organizations involved in conducting investigations,

[1]This rapid, short-term response is often called the "firehouse" function.

recoveries, and cleanup activities concerning nonstockpile CWM can be made more efficacious and effective.

ORGANIZATIONS INVOLVED IN THE REMEDIATION OF CWM DISPOSAL SITES

The NSCMP is the key provider of services and equipment for CWM destruction, both planned and in response to emergencies. In planned response operations such as those in Spring Valley in Washington, D.C., and Camp Sibert in Alabama, NSCMP would normally operate under the direction of a project manager from the USACE. In emergency response operations, such as remediating the 75-mm chemical munitions discovered at Dover Air Force Base, Delaware, it would operate under its own direction.

The NSCMP is responsible for managing all projects for the assessment and disposal of RCWM. Activities include identification of assessment and disposal costs, disbursement of funds for assessment and disposal, and preparation of project schedules. The NSCMP prepares the relevant documentation and obtains the approvals needed. The documents include the site plan, the site safety submission, the destruction plan, and the environmental permits. If a recovered munition is identified as a possible chemical fill, all information germane to that munition must be forwarded to the Materiel Assessment Review Board (MARB), which conducts an assessment of the munition to determine its chemical fill and explosive configuration. The NSCMP has responsibility for satisfying the obligations of the CWC.

NSCMP provides the equipment used for assessment, storage, and destruction of recovered munitions, and it has an active, ongoing program to improve this equipment and to develop new technologies.

In addition to the NSCMP, the MARB, and the USACE, other organizations are involved in hands-on aspects of remediation of buried CWM: the 20th Support Command Chemical, Biological, Radiological, Nuclear and Explosives Analytical and Remediation Activity (CARA); the Edgewood Chemical and Biological Center (ECBC); the U.S. Army Technical Center for Explosives Safety (USATCES); and the Department of Defense Explosives Safety Board (DDESB).

TECHNOLOGIES FOR REMEDIATION OF BURIED CWM

The committee's other main responsibilities involved (1) the review of the technologies now in use for cleanup of CWM sites and identification of any deficiencies and (2) the development of recommendations for targeted research and development to correct these deficiencies. Many technologies are employed, as exemplified by a typical project in which suspected subsurface CWM are located through the application of geophysical technologies, typically magnetometry or active electromagnetic sensors. An object is uncovered by mechanized or manual excavation and the air around the site is monitored for agent. Qualified personnel remove and evaluate the suspected CWM and package it in a container approved for on-site transport to an installation bunker or an interim holding facility (IHF).

The suspected CWM will then be removed from storage and a mobile munitions assessment system (MMAS) sent to the site to provide a nonintrusive assessment of its contents. The key MMAS tools are these:

- Digital radiography and computed tomography (DRCT),
- Portable isotopic neutron spectroscopy (PINS), and
- Raman spectrometer.

The RCWM is again placed in interim storage to await review of the assessment by the MARB. In this scenario, the IHF may be off-site. If transport is required, the RCWM is packaged in a multiple round container (MRC) that has been certified by the Department of Transportation and can then be carried over public roads by CARA.

After the contents have been assessed by the MARB, they are destroyed or treated by one of the following technologies:

- Explosive destruction system (EDS),
- Transportable detonation chamber (TDC),
- Detonation of ammunition in a vacuum integrated chamber (DAVINCH), or
- Static detonation chamber (SDC).

If the RCWM is a chemical agent identification set (CAIS), the single CAIS access and neutralization system (SCANS) is used to destroy the CAIS. Secondary waste is transported to a commercial facility for final disposal.

The committee had no recommendations to make on any research and development for the following aspects of the aforementioned technologies:

- *Geophysical detection*. Other organizations have large R&D programs under way in this area. The best policy for NSCMP is to track developments in these programs.
- *Personal protective equipment*. No needs identified.
- *Conventional excavation equipment*. No needs identified.
- *CWM packaging and transportation*. As described in Chapter 4, the NSCMP is developing a universal munitions storage container. It is fabricated from high-density polyethylene, and its use will allow the destruction of overpacked munitions in the EDS without removing them from the overpack. No additional R&D needs identified.
- *CWM storage*. No needs identified.
- *SCANS*. No needs identified.
- *DRCT*. No needs identified.

- *DAVINCH or TDC detonation technologies*. No needs identified, although improvements to or refinement of the technology might be justified, depending on the application.

TARGETED RESEARCH AND DEVELOPMENT ON REMEDIATION TECHNOLOGIES

Targeted research and development options were recommended in a number of areas.

Robotic Excavation Equipment

Robotic technology has continued to grow in versatility and reliability. The committee judges that further investigation in and development of this technology for use in the remediation of buried chemical materiel would be fruitful.

Recommendation 6-1. The Army should demonstrate that robotic systems can be reliably utilized to access and remove buried chemical warfare materiel, and, where applicable, it should use them.

Air Monitoring

As a detected subsurface object is excavated, the air in the area is monitored for agent. The Miniature Chemical Agent Monitoring System (MINICAMS) is used for this purpose, but it is a fragile system, not sufficiently robust to be moved from anomaly to anomaly. This results in long downtimes. A more rugged and portable system for near-real-time air monitoring is needed to reduce downtime. The multiagent meter now being developed by NSCMP might fit this need.

Assessment of Recovered Munitions

Before RCWM can be destroyed, each item is assessed to determine the nature of the contained agent and energetics. The noninvasive analytical method used for this purpose is PINS. While PINS is an essential tool in the assessment of recovered munitions, it is not totally reliable. Munitions have been misidentified, and improvements are needed in the PINS analytical method to provide more definitive information for the identification of chemical fills in recovered munitions.

Recommendation 6-3. Research and development should continue on the processing of data from portable isotopic neutron spectroscopy to provide more definitive information for the identification of chemical fills in recovered munitions.

After conducting the PINS analysis for fill and explosive content, the MARB reviews all available information for each RCWM and presents its assessment. The procedure is involved and lengthy and the results are sometimes heavily qualified. Future large remediation projects, e.g., Redstone Arsenal, might entail assessing tens or hundreds of thousands of munitions or opened munitions. When dealing with such large quantities, the current PINS/DRCT/MARB approach may not be able to carry out its assessments in a sufficiently timely fashion, and the results may not be sufficiently accurate to guarantee the safety of treatment equipment operators.

Recommendation 6-4. The Non-Stockpile Chemical Materiel Project should recommend modifications to the current PINS/DRCT/MARB assessment approach or adopt an alternative approach that will function more quickly and with more definitive and more accurate results when tens of thousands or hundreds of thousands of munitions are to be assessed at a single site.

Destruction of Contaminated RCWM

As noted above, the committee did not identify any areas of research for two of the four explosive destruction technologies—the DAVINCH and the TDC—available for treatment of RCWM. It did, however, identify areas of research for the EDS and the SDC.

Explosive Destruction System

The NSCMP has a substantial product improvement program under way to increase the capabilities of the EDS, including the use of steam injection to decrease cycle time and the identification of a universal reagent that will be effective for neutralization of all chemical warfare agents.

Dynasafe Static Detonation Chamber

The committee judges that the Dynasafe technology is a viable approach to processing large numbers—tens or hundreds of thousands—of burned and open chemical munition bodies that might contain residual agent or energetics.

As described in Chapter 4, many problems were encountered as the SDC 1200 was operating on chemical munitions at the Anniston Chemical Agent Disposal Facility (ANCDF), and work was begun on correcting these problems. One such problem was the sometimes incomplete combustion of carbon monoxide. Since then, Dynasafe has enlarged the thermal oxidizer for its SDC 1200s. This will allow better control of excess oxygen and hence more reliable combustion of carbon monoxide.

Recommendation 6-5. The Non-Stockpile Chemical Materiel Project should investigate the benefits of the larger thermal oxidizer now used in Dynasafe's standard SDC 1200. If, as expected, the larger oxidizer aids in controlling excess oxygen, leading to the more complete and consistent combustion of carbon monoxide, the project should con-

sider replacing the current thermal oxidizer with the larger oxidizer.

Since the SDC system was started up, it has become clear that the spray dryer is not effective at preventing the formation of dioxins and furans, and the activated carbon adsorbers in the off-gas treatment system must be depended on to capture the dioxins and furans formed there. Also, the solids formed in the spray dryer sometimes accumulate on its interior walls. Eliminating the spray dryer and using a heat exchanger to cool the hot gases from the detonation chamber, as is done in the CH2M HILL TDC process, might improve the reliability of the process.

Recommendation 6-6. The Non-Stockpile Chemical Materiel Project should evaluate the costs and benefits of improving the reliability of the Dynasafe static detonation chamber system by replacing the spray dryer with a water-cooled heat exchanger and continuing to rely on activated carbon adsorbers to capture the dioxins and furans formed as off-gas from the thermal oxidizer is cooled. If disposal of liquid waste (i.e., spent scrubber solution) becomes a problem, the Non-Stockpile Chemical Materiel Project should consider replacing the caustic scrubbers with a dry lime injection system.

A major process improvement program for the Dynasafe SDC 1200 system was under way at the ANCDF as this report was being written. This program was well planned and was expected to increase the reliability of the process.

Recommendation 6-7. The Non-Stockpile Chemical Materiel Project should continue its efforts to improve throughput and reliability of the Dynasafe static detonation chamber system.

Some of the RCWM at large burial sites will not contain energetics such as bursters and fuzes but may still contain detectable quantities of agent. Many options exist for decontaminating these items to either the ≤1 vapor screening level (VSL) or to the suitable for unrestricted release level, including the following:

- Processing through high-temperature furnaces, including furnaces similar to those used in stockpile chemical weapon plants.
- Processing through a commercial transportable hazardous waste incinerator.
- Processing through a car bottom furnace.
- Treating with decontamination solution until a headspace agent concentration of ≤1 VSL is achieved.
- Using the Dynasafe SDC 1200, as noted above.

Recommendation 6-8. The Non-Stockpile Chemical Materiel Project should evaluate the Dynasafe static detonation chamber for its ability to destroy recovered chemical warfare materiel, including burned and previously opened munition bodies that still contain detectable traces of agent and agent-contaminated scrap metal. This evaluation should include possible modifications to the SDC feed system, changes in the residence time in the SDC chamber, and changes to its off-gas treatment system.

CURRENT FUNDING AND ORGANIZATION FOR EXECUTION OF THE RCWM PROGRAM

As noted, the existing structure utilized by the Army, in its capacity as executive agent for destruction of non-stockpile chemical materiel, must now be reconfigured to prepare for the remediation of CWM at over 250 sites in the United States.

The current organizational structure was set on March 1, 2010, when the Under Secretary of Defense for Acquisition, Technology and Logistics [USD(AT&L)] formally designated the Secretary of the Army as executive agent for the RCWM program (see Appendix C). In 2011 the Army established a provisional RCWM integrating office to integrate, coordinate, and synchronize the DOD's RCWM response program and related activities. The USD(AT&L) memo required the Army to prepare and submit to the DOD a final implementation plan for the RCWM program. As of April 30, 2012, neither the responsible officials within the Office of the Secretary of Defense—the Deputy Under Secretary of Defense for Installations and Environment [DUSD(I&E)], the Office of the OSD comptroller, and the Assistant Secretary of Defense (Nuclear, Chemical, and Biological Defense) [ASD(NCB)]—nor the responsible officials within the Army had completed the task assigned to them by the USD(AT&L) memorandum of March 1, 2010.

Recommendation 7-1. The Army should formally approve, then submit, a final implementation plan for the recovery and destruction of buried chemical warfare materiel as required by the Under Secretary of Defense for Acquisition, Technology and Logistics in its memorandum of March 1, 2010.

Funding Issues

Three major funding programs may come into play at an RCWM remediation site: Chemical Agent and Munitions Disposal, Defense (CAMD,D); Defense Environmental Restoration Program (DERP); and Operations and Maintenance (O&M). The committee was informed of the following funding practices:

- CAMD,D funding is used for the Chemical Stockpile Elimination (CSE), the NSCMP, and other projects. As is the case for other budget elements, the President's budget request for the project is authorized and appropriated annually by Congress. The President's budget request includes annual budget estimates for the following 4 years and, when available, the esti-

mated cost to complete the project. All are subject to change. Annual funding for the program beyond 2017 has not been determined; however, the cost and time to complete the program were recently estimated to exceed the previous estimate by about $2 billion and 2 years.[2]

- DERP is a very broad program encompassing funding for early site investigation and characterization through funding for remediation, including, by definition, chemical warfare agents and chemical munitions. DERP funds are commonly used for conventional munitions cleanup at RCWM sites for site characterization and remediation up to the point of the identification of RCWM munitions. Once RCWM is discovered, DERP funding can no longer be used and funding from CAMD,D is then used for the assessment and remediation of the RCWM.
- O&M funding, in the context of RCWM, is used for the O&M of active training ranges for each of the military services, including environmental restoration of the ranges. Like funding for DERP, O&M funding is not used to assess and remediate RCWM on active training ranges. Rather, CAMD,D funding is employed.

DOD (and the Army as the RCWM executive agent) adhere carefully to congressional direction on the use of these appropriations. However, the committee notes that the current practice of not allowing the use of DERP and O&M funding for RCWM assessment and remediation might not be a statutory requirement.

Recommendation 7-2. The Secretary of Defense should seek a legal interpretation of the perceived prohibition on spending Defense Environmental Restoration Program (DERP) and Operations and Maintenance (O&M) funds to assess and remediate recovered chemical warfare materiel. If it is determined that only Chemical Agents and Munitions Destruction, Defense (CAMD,D) funds may be used for RCWM assessment and remediation, the Secretary should seek legislative authority to change this stricture in order to permit the commingling of DERP, O&M, and CAMD,D funding for these RCWM activities.

Authority and funding for RCWM activities, depending on how and where CWM is discovered, emanate from two OSD and two Army Secretariat offices. The two OSD offices are the ASD(NCB) for CAMD,D and the DUSD(I&E) for DERP and O&M. The two Army Secretariat offices are the Assistant Secretary of the Army for Acquisition, Logistics, and Technology [ASA(ALT)] for CAMD,D and the Assistant Secretary of the Army for Installations, Energy and Environment [ASA(IE&E)] for DERP and O&M, as shown in Figure S-1. Thus, there is no single advocate for the program. In addition, at present the NSCMP must compete annually for funding from the CAMD,D budget account, which is also the source of funding for the much larger chemical stockpile destruction program. Not only have estimates for completing the stockpile program been extended to 2021-2023, they have also increased significantly.[3] As the stockpile program nears completion, the CAMD,D account can be expected to come under increasing pressure for significant reductions, if not total elimination. The long-term funding and oversight issues inherent in a growing and enduring RCWM remediation mission need to be addressed and an enduring funding stream established that is integrated with other enduring environmental remediation programs.

Recommendation 7-3. The Office of the Secretary of Defense and the Army should each select a single office to champion and fund remediation of all RCWM.

Of the known large burial sites, only at Redstone Arsenal (RSA) has an effort been made to assemble a comprehensive inventory of suspected buried munitions and sites (see Chapter 5). The remediation of buried munitions (including CWM) is not clearly defined, in part because the inventory of suspected buried munitions and sites is incomplete. The lack of an accurate inventory of the buried munitions and of a reliable cost estimate for the RCWM program limits the ability of the DUSD(I&E) and the comptroller in consultation with the ASD(NCB) and the Army to establish budget requirements and draw up an appropriate funding plan for a new and separate RCWM account.

Recommendation 7-4a. The Secretary of Defense should, as a matter of urgency, increase funding for the remediation of chemical warfare materiel to enable the Army to complete the inventories of known and suspected buried chemical munitions no later than 2013 and develop a quantitative basis for overall funding of the program, with updates as needed to facilitate accurate budget forecasts. Pending establishment of a final RCWM management structure, this task should be assigned to the director of the CMA as chair of the provisional RCWM integrating office.

Recommendation 7-4b. As the RCWM executive agent, the Secretary of the Army should establish a policy that addresses all aspects of the remediation of chemical warfare materiel and that prioritizes remediation requirements, and the Secretary of Defense should identify a new long-term funding source to support the program.

[2]U.S. Army Element, Assembled Chemical Weapons Alternatives, press release "Department of Defense approves new cost and schedule estimates for chemical weapons destruction plants." Aberdeen Proving Ground, Md., April 17, 2012.

[3]U.S. Army Element, Assembled Chemical Weapons Alternatives, press release "Department of Defense approves new cost and schedule estimates for chemical weapons destruction plants." Aberdeen Proving Ground, Md., April 17, 2012.

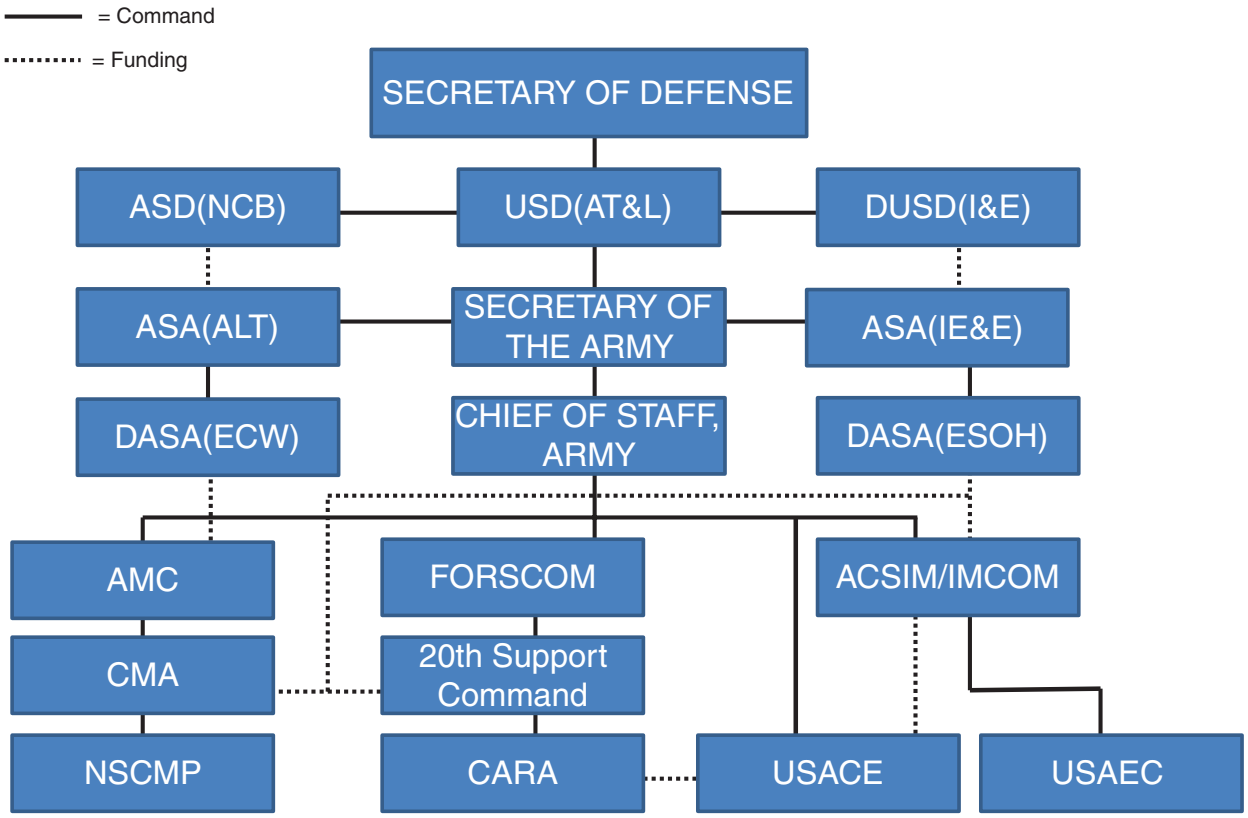

FIGURE S-1 Current organization for policy, oversight, and funding for RCWM. DASA(ECW), Deputy Assistant Secretary of the Army for Elimination of Chemical Weapons; DASA(ESOH), Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health); AMC, U.S. Army Materiel Command; FORSCOM, Forces Command (U.S. Army); ACSIM/IMCOM, Assistant Chief of Staff, Installation Management/Installation Management Command (U.S. Army); USAEC, U.S. Army Environmental Command.

Recommendation 7-5. The Deputy Under Secretary of Defense for Installations and Environment and the Under Secretary of Defense, Comptroller, in coordination with the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Programs and the Army, should proceed immediately to establish a separate budget account for recovered chemical warfare materiel, as directed by the memorandum of the Under Secretary of Defense for Acquisition, Technology and Logistics dated March 1, 2010, and to ensure that funding requirements for the recovered chemical warfare materiel program are included in the FY 2014-2018 Program Objectives Memorandum (POM).

Organization for Execution

At the OSD level, two major offices, ASD(NCB) and DUSD(I&E), work on RCWM policy and funding matters (Figure S-2). Within the Department of the Army, two secretariat (i.e., policy) offices—ASA(IE&E) and ASA(ALT)—have been very involved with the RCWM program. The Army would assign responsibility to ASA(IE&E), which has enabled the Army to begin setting up a long-term organization to lead the program. At the Army staff level, the main player is the ACSIM office, and its field operating agency, IMCOM. The committee judges that the ACSIM and IMCOM are performing a creditable job of integrating the Army's cleanup requirements, including DERP and CAMD,D, and presenting them in a defendable POM and budget. Some remaining duplication of effort on the part of IMCOM's Army Environmental Command (AEC) and the USACE merits the Army's attention.

Recommendation 7-6. The Army should examine the RCWM roles and responsibilities to determine where money can be saved by eliminating duplication of functions, such as those of the Army Environmental Command and the U.S. Army Corps of Engineers.

Provisional RCWM Integrating Office

The provisional RCWM integrating office (IO) coordinates emergency response and planned RCWM projects for DOD in keeping with the Army's roles as RCWM executive agent. The member organizations are shown as the integrated product team in Figure S-2. The provisional RCWM IO has conducted some meetings while it awaits formal approval by

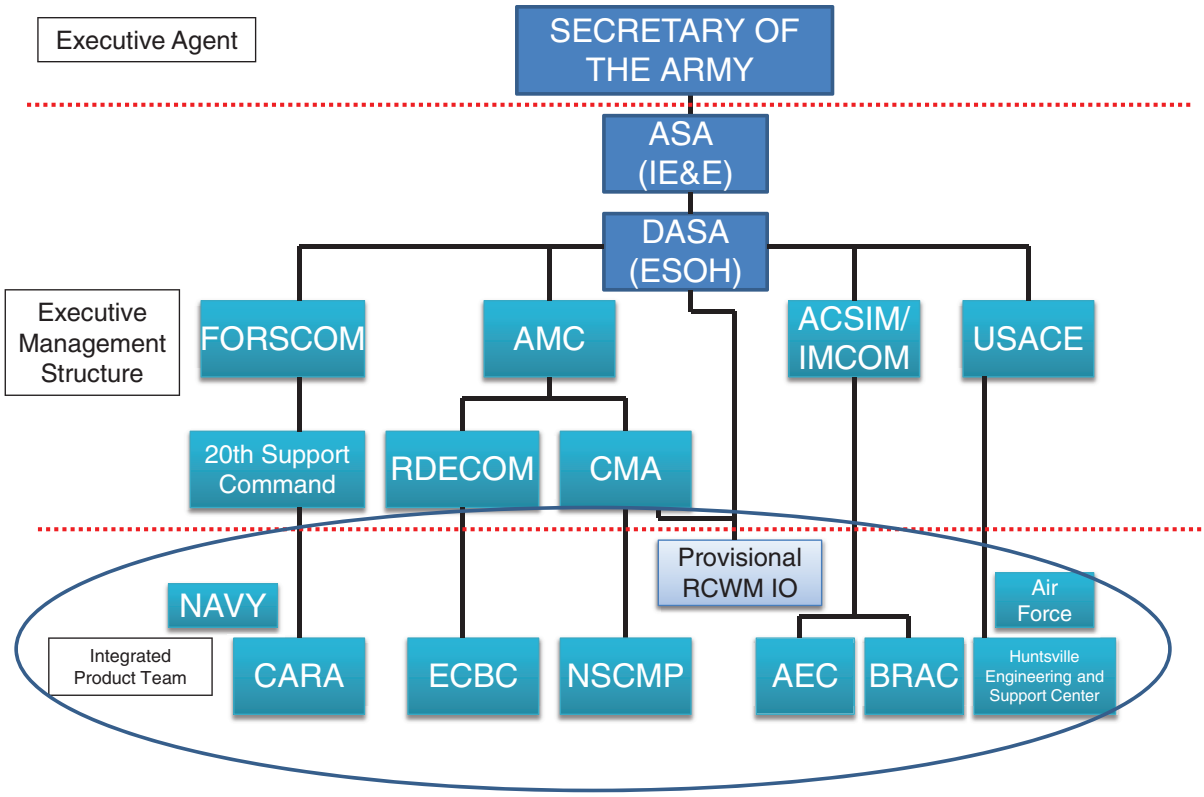

FIGURE S-2 RCWM Army execution structure. RDECOM, Research, Development, and Engineering Command; BRAC, base realignment and closure. SOURCE: Adapted from the presentation of J.C. King to the committee on September 26, 2011.

the Army and DOD. The committee considers the establishment of the provisional IO to be a step in the right direction in the overall management of the program but has some significant concerns. In brief, the provisional RCWM IO leader lacks directive authority, is placed too low in the Army organization, and is too junior in rank to be held accountable for the execution of the RCWM program.

The CMA's NSCMP and the USACE's Huntsville Engineering and Support Center are key players for the execution of both emergency responses and planned RCWM projects. NSCMP has depth in project planning and technology utilization, while USACE has hands-on technical skills in RCWM project management, construction management, and contract management. The committee is also concerned that CMA may not have a sustaining role in the Army once the stockpile program winds down in the next several years, leaving NSCMP without an enduring higher authority to report to. These factors bring significant risk and uncertainty to the RCWM program, raising the possibility that emergency responses or large planned remediation projects will not have adequate or sustainable management and funding support.

Recommendation 7-7. The Army should reexamine the roles and responsibilities of Edgewood Chemical Biological Center and the Chemical Biological Radiological Nuclear (Enhanced) Analysis and Remediation Activity with the objective of eliminating any overlapping functions, particularly on emergency response activities.

Recommendation 7-8. The Army should review the long-term requirements for executing the RCWM program with the objective of making organizational changes that will eliminate duplication of effort and ensure sustainable organizational integrity.

ORGANIZATIONAL ALTERNATIVES

Based on the findings and recommendations above, the committee evaluated two significant organizational changes to the baseline organization (Figure S-2) to improve the efficiency, effectiveness, and accountability of the RCWM program and its leadership.

In light of the committee's conclusion that the IO and its leadership lack directive authority and are placed too low in the Army organization, the first change addresses the provisional IO and the accountability and effectiveness of its leadership. As discussed in Chapter 7, the grade of the RCWM IO leader, GS-15, is too low to allow recruitment of an individual who can effectively lead the program. The com-

1. SINGLE ACCOUNT FOR SITE REMEDIATION (Would comingle DERP, RCWM, & O&M)
2. INTEGRATED PROGRAM PLAN AND BUDGET (RCWM)
    a. Required RCWM emergency response infrastructure
    b. Research and Development, technology, procurement
    c. Planned remediation support
    d. Response to emergency response contingencies
3. INTEGRATED DOD PRIORITY LIST FOR POTENTIAL RCWM REMEDIATION
4. COORDINATED FIVE YEAR PROGRAM PLAN AND BUDGET ESTIMATE FOR REMEDIATION OF IDENTIFIED PRIORITY RCWM SITES

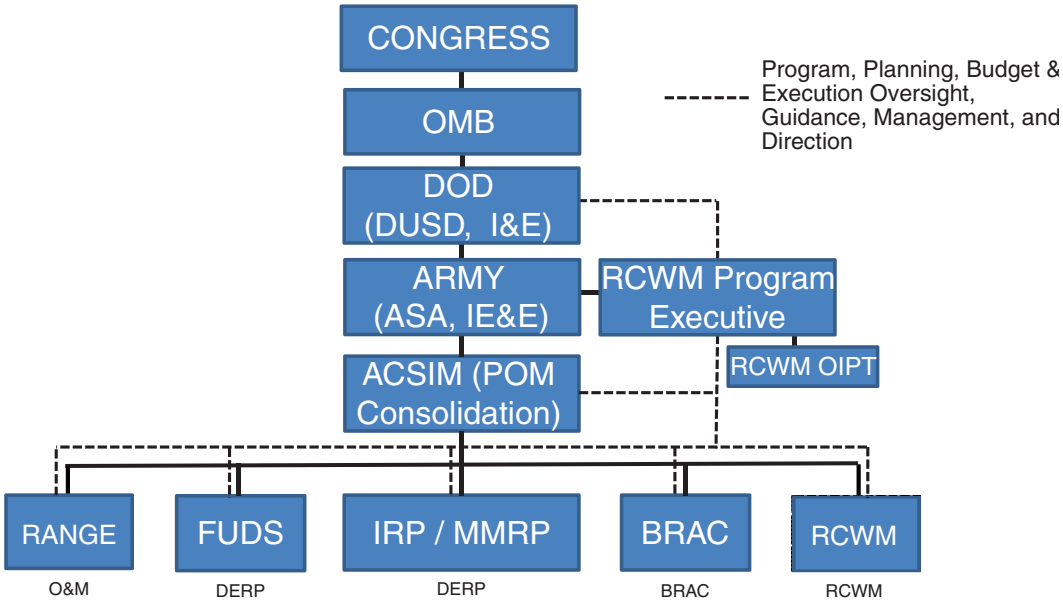

FIGURE S-3 RCWM program future funding.

mittee further concluded that the position should be upgraded to a civilian SES or a military general officer.

Recommendation 7-9. The Secretary of the Army should establish a new position at the level of the Senior Executive Service (civilian) or a general officer (military) to lead the RCWM program. The person who fills this position would report directly to the Assistant Secretary of the Army (Installations, Energy and Environment). The Secretary should delegate full responsibility and accountability for RCWM program performance to this person, including for programming, planning, budgeting, and execution and for day-to-day oversight, guidance, management, and direction of the program.

As previously recommended, the RCWM program requires a leader at the civilian SES or military general officer level who is assigned overall responsibility and accountability for program performance. This person would have directive authority over other program participants within the Army and, through agreements with the other Services, within appropriate RCWM activities of the Air Force and Navy and would establish, chair, and direct a new overarching integrated product team (OIPT) for RCWM.

The committee sought a reporting level within the Army at which this program executive would be most effective and concluded that the best reporting relationship would be for the program executive to report directly to the ASA(IE&E), giving him or her the organizational reach and authority needed to lead the program effectively. The new RCWM OIPT, composed of higher-level representatives of the organizations in the current provisional RCWM IO and appropriate members from OSD, would replace the provisional RCWM IO. OIPT members should be fairly senior in grade, knowledge, and experience**,** and their parent organizations should give them authority to make decisions (see Figure S-3).

The second organizational change evaluated by the committee involved the organizations executing the RCWM program. The committee evaluated several alternatives for the long-term reporting relationship for the NSCMP and selected one that would provide continuity of program execution, cost-effective synergy, and an enduring reporting organizational relationship for NSCMP.

Recommendation 7-10. The Army should realign the nonstockpile chemical materiel program from the Army Materiel Command/Chemical Materials Agency to the U.S. Army

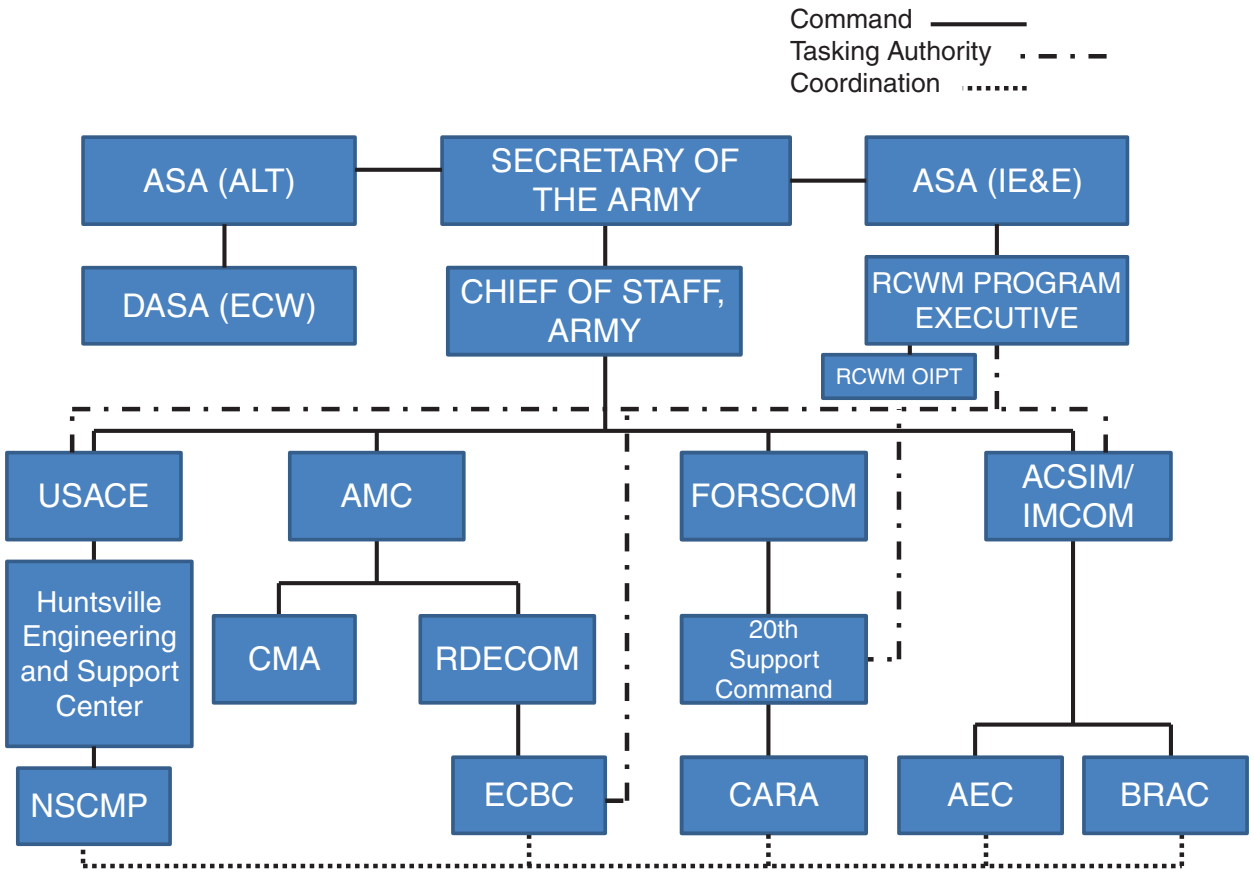

FIGURE S-4 Army RCWM organization and authority recommended by committee. NOTE: Tasking authority is the authority of the RCWM Program Executive with respect to day-to-day oversight, guidance, management, and direction of Army elements on all RCWM matters, including program and budget planning and allocation, and program and budget execution and performance by the RCWM commands, agencies, and organizations.

Corps of Engineers Huntsville Engineering and Support Center.

Recommendation 7-11. To provide for an effective transition, the new program executive should enter into a memorandum of understanding with the Commander of the U.S. Army Corps of Engineers and the Army Materiel Command/ Chemical Materials Agency outlining the reporting ladder and transition plan for the realignment of the non-stockpile chemical materiel program.

The committee believes that the assignment of an SES civilian or general officer RCWM program executive with full authority and responsibility for planning, programming, budgeting, and execution for the RCWM program, who has direct access to and visibility at the highest levels of the Department of the Army and the OSD secretariat is absolutely critical to the future success of the program. It will be vital to the effectiveness of the program executive and the program that the executive possess the authority and ability to exercise oversight, management, and provide fiscal and operational guidance and direction to the operating elements of the RCWM and control the funds for RCWM, both during development and defense of the program plan and budget, and during the execution of the annual program.

The committee's recommendations for RCWM program and budget planning are illustrated in Figure S-3.

Once the new RCWM program executive position and the recommended OIPT are set up, the Army can begin transitioning the alignment of NSCMP from AMC/CMA to the USACE Huntsville Center.

Recommendation 7-12. As a necessary first step the Deputy Under Secretary of Defense for Installations and Environment, the Under Secretary of Defense Comptroller, the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Programs, and the Secretary of the Army should proceed immediately to implement the guidelines contained in the March 1, 2010, memorandum from the Under Secretary of Defense for Acquisition, Technology and Logistics.

The committee's recommended structure for Army RCWM organization and authority is shown in Figure S-4, which incorporates the recommended program executive organization with the civilian SES or military general officer-level RCWM program executive reporting to the ASA(IE&E); the RCWM OIPT under the direction of the RCWM program executive; the tasking authority of the RCWM program executive; and the realignment of NSCMP under the USACE. The figure also delineates the lines of command, tasking authority, and coordination among the various elements of the program.

REGULATORY ISSUES

The history of the stockpile and non-stockpile programs demonstrates that regulatory concerns and a failure to involve the public can significantly delay implementation and increase costs. Much of the regulatory experience gained in the implementation of the stockpile and non-stockpile programs can be utilized in the remediation of buried CWM to increase the effectiveness and efficiency of the regulatory process. As discussed in Chapter 3, remediations must be done under appropriate federal and state environmental regulations and in compliance with the CWC. These regulations, principally the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA), along with existing Army Military Munitions Response Remedial Investigation/Feasibility Study (MMRP RI/FS) Guidance, govern the recovery of buried CWM. This guidance recommends following the Army's Technical Project Planning process prior to the commencement of field activities.

The committee identified several regulatory issues, including (1) a need for regulatory flexibility, expedited approaches, and risk reduction activities where minimal but sufficient data are available to enable selection of a cleanup technology, (2) consideration of unique circumstances presented by the recovery of buried chemical warfare materiel at active operational ranges, (3) management of remediation wastes using corrective action management units (CAMUs), (4) the need to store hazardous wastes for longer than 90 days under a RCRA corrective action, and (5) identifying regulatory approval mechanisms for the use of explosive destruction technologies to destroy RCWM.

The committee also noted the importance of public participation in Army policy decisions regarding RCWM remediation. Public involvement is embedded in both RCRA and CERCLA, in the Emergency Planning and Community Right-to-Know Act (EPCRA), and in DOD and Army regulations and policies. For the remediation project at Spring Valley in Washington, D.C., for example, partnering and planning were shown to be key to minimizing unnecessary delay and costs. Findings and recommendations related to regulatory issues and public involvement can be found in Chapter 3.

CASE STUDY: REDSTONE ARSENAL

During the course of this study, the committee was made aware of the existence of what is arguably the largest and most complex RCWM site in the United States (in terms of the quantity and variety of materiel, regulatory issues, and existing use)—namely, Redstone Arsenal (RSA) in Huntsville, Alabama. RSA provides an excellent example of a site where, to paraphrase the committee's Statement of Task, supporting technologies and operational procedures may not be sufficient, targeted research and development may be needed, and coordination among existing organizations involved in RCWM remediation may need to be improved. The committee used RSA as a case study to illustrate the technological and operational challenges and community relations issues that the Army will face in remediating large CWM sites. Findings and recommendations concerning the application of regulatory issues to the special case of RSA may be found in Chapter 5.

REMEDIATION OF BURIED CHEMICAL WARFARE MATERIEL

Committee on Review of the Conduct of Operations for Remediation of Recovered Chemical Warfare Materiel from Burial Sites

Board on Army Science and Technology

Division on Engineering and Physical Sciences

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Front cover—Upper: Worker in personnel protective equipment lifting a single-round container (U.S. Army Corps of Engineers photo). *Left:* Degraded military munitions found at Spring Valley, District of Columbia (U.S. Army Corps of Engineers photo). *Lower background:* German Traktor rocket bases filled with hydrogen mustard, Huntsville (now Redstone) Arsenal, Alabama (U.S. Army photo from 1948).

Back cover—Ton containers used for storage of lewisite, a blister agent and lung irritant, Huntsville (now Redstone) Arsenal, Alabama (U.S. Army photo from 1947).

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COMMITTEE ON REVIEW OF THE CONDUCT OF OPERATIONS FOR REMEDIATION OF RECOVERED CHEMICAL WARFARE MATERIEL FROM BURIAL SITES

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Preface

The Committee on Review of the Conduct of Operations for Remediation of Recovered Chemical Warfare Materiel from Burial Sites was appointed by the National Research Council in response to a request by Conrad F. Whyne, Director of the Chemical Materials Agency (CMA). The study dealt primarily with the activities of the Non-Stockpile Chemical Materiel Project (NSCMP), which falls organizationally under the CMA and is headed by Laurence G. Gottschalk, Project Manager for Non-Stockpile Chemical Materiel. Mr. Whyne, Mr. Gottschalk, and their staffs heavily supported the activities of the committee.

This report is concerned with the investigation and, if required, the remediation of sites that contain buried chemical materiel. About 250 such sites, located in 40 states and territories of the United States, are thought to exist. Remediation efforts are currently under way in the Spring Valley area of Washington, D.C., and at the Camp Sibert site in Alabama. A substantially larger effort is anticipated at the Redstone Arsenal in Alabama.

The NSCMP plays a major role in remediation efforts. It has project management responsibilities for the assessment and disposal of all recovered chemical warfare materiel (RCWM) and for this purpose identifies assessment and disposal costs, disperses funds for assessment and disposal, prepares project schedules and other required documents, and obtains all approvals needed for the destruction of the RCWM. The NSCMP owns several explosive destruction systems (EDSs), used for destruction of RCWM, and arranges for use of commercial explosive destruction technologies for RCWM when needed.

One focus of the committee was investigating the technologies available to the NSCMP for investigating a burial site that is thought to contain buried chemical weapons, assessing any chemical materiel recovered, and destroying the RCWM. Deficiencies in the available technologies and research and development targeted at those deficiencies are identified.

The committee's second focus was to investigate the roles and responsibilities of the numerous organizations and offices within the Department of Defense and the Department of the Army that are involved with buried chemical materiel issues. In carrying out its assigned role, the NSCMP coordinated with these agencies and offices to set priorities, obtain funding, and carry out assessment and destruction activities. It also recommended changes to the relationships between some of these organizations and offices.

The committee held six meetings. The first was at the Chemical Demilitarization Training Facility at the Aberdeen Proving Ground in Edgewood, Maryland. The second meeting, held at the Keck Center in Washington, D.C., featured a visit to the nearby Spring Valley chemical weapon remediation site. The third, fourth, and sixth meetings were also held at the Keck Center, and the fifth was held at the Beckman Center in Irvine, California. A total of 38 presentations were received from the following entities:

- Twenty agencies and offices within the Department of Defense;
- Regulatory officials from the District of Columbia, the states of Alabama and Utah, and U.S. Environmental Protection Agency regions 4 and 8;
- The Spring Valley Community Restoration Advisory Board;
- Vendors for the commercially available explosive destruction technologies; and
- A member of the staff of the Senate Armed Services Committee.

The presentations are listed in Appendix B.

This report was prepared under the auspices of the Board on Army Science and Technology (BAST) of the National Research Council. The committee offers its thanks to Bruce A. Braun, the Director of BAST, and to Nancy T. Schulte, the Study Director, for their very effective support in the

conduct of this study. It also offers its thanks to the BAST staff members who capably assisted in information-gathering activities, meeting and trip arrangements, and the production of this report; they include Ann Larrow, Research Assistant, Joe Palmer, Senior Program/Project Assistant, and Harrison T. Pannella, Senior Program Officer.

Richard J. Ayen, *Chair*
Committee on Review of the Conduct of Operations
for Remediation of Recovered Chemical Warfare Materiel
from Burial Sites

Acknowledgment of Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Fred S. Celec, Institute for Defense Analyses,
Martin Gray, State of Utah Department of Environmental Quality,
Henry J. Hatch, NAE, U.S. Army Corps of Engineers (retired),
John R. Howell, NAE, University of Texas at Austin,
Michael F. McGrath, ANSER (Analytic Services Inc.),
Leonard M. Siegel, Center for Public Environmental Oversight, and
Michael V. Tumulty, P.E., STV Incorporated.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Elisabeth M. Drake, NAE. Appointed by the National Research Council, she was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Contents

Tables and Figures

TABLES

FIGURES

Acronyms and Abbreviations

ACAT I	Acquisition Category I
ACSIM	Assistant Chief of Staff, Installation Management (U.S. Army)
ACWA	Assembled Chemical Weapons Alternatives
ADEM	Alabama Department of Environmental Management
AEC	U.S. Army Environmental Command
AEL	airborne exposure limit
AFCEE	Air Force Center for Engineering and Environment
AMC	U.S. Army Materiel Command
ANCDF	Anniston Chemical Agent Disposal Facility (Alabama)
ARAR	applicable, relevant, and appropriate requirement
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics and Technology
ASA(IE&E)	Assistant Secretary of the Army (Installations, Energy and Environment
ASA(ILE)	Assistant Secretary of the Army for Installation, Logistics and Environment
ASA(RDA)	Assistant Secretary of the Army for Research, Development and Acquisition
ASD(NCB)	Assistant Secretary of Defense (Nuclear, Chemical, and Biological Defense Programs)
BES	budget execution submission
BRAC	base realignment and closure
CAIRA	chemical accident or incident response and assistance
CAIS	chemical agent identification set(s)
CAM	Chemical Agent Monitor
CAMD,D	Chemical Agent and Munitions Disposal, Defense
CAMU	corrective action management unit
CARA	Chemical Biological Radiological Nuclear (Enhanced) Analysis and Remediation Activity
CBARR	Chemical Biological Applications and Risk Reduction
CBRNE	chemical, biological, radiological, nuclear and high yield explosives
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CG	phosgene
CMA	Chemical Materials Agency
CNB	CN tear gas mixed with carbon tetrachloride and benzene
CNO	Chief of Naval Operations
CNS	CN tear gas mixed with chloropicrin and chloroform
CONUS	continental United States
CSA	Chief of Staff of the Army
CSDP	chemical stockpile disposal program
CSE	Chemical Stockpile Elimination (project)
CSEPP	Chemical Stockpile Emergency Preparedness Project
CW	chemical weapons
CWC	Chemical Weapons Convention
CWM	chemical warfare materiel
DA	diphenylchloroarsine (Clark I)
DAAMS	Depot Area Air Monitoring System
DAB	Defense Acquisition Board
DASA(ECW)	Deputy Assistant Secretary of the Army for Elimination of Chemical Weapons

DASA(ESOH)	Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health)
DAVINCH	detonation of ammunition in a vacuum integrated chamber
DC	diphenylcyanoarsine (Clark II)
DDESB	Department of Defense Explosives Safety Board
DERP	Defense Environmental Restoration Program
DM	adamsite
DMM	discarded military munitions
DOD	Department of Defense
DOT	Department of Transportation
DRCT	digital radiography and computed tomography
DUSD(I&E)	Deputy Under Secretary of Defense for Installations and Environment
EA	executive agent
ECBC	Edgewood Chemical Biological Center
EDS	Explosive Destruction System
EDS-1	EDS Phase 1
EDS-2	EDS Phase 2
EDS-3	EDS Phase 3
EDT	explosive destruction technology
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER,A	Environmental Response, Army
FFA	federal facility agreement
FORSCOM	Forces Command (U.S. Army)
FSS	fragment suppression system
FTO	flameless thermal oxidizer
FUDS	formerly used defense site(s)
GA	tabun (a nerve agent)
GB	sarin (a nerve agent)
GD	soman (a nerve agent)
H	sulfur mustard
HD	sulfur mustard (distilled)
HEPA	high-efficiency particulate air (filter)
HN	nitrogen mustard
HN-3	nitrogen mustard
HNC	Huntsville Engineering Center
HS	sulfur mustard
HSWA	Hazardous and Solid Waste Amendments
HT	sulfur mustard, T-mustard combination, also British mustard
IHF	interim holding facility
IMCOM	Installation Management Command (U.S. Army)
INST CDR	installation commander
IO	integrating office
IPT	integrated product team
IRP	Installation Restoration Program
ITRC	Interstate Technology Regulatory Council
L	lewisite or liter
LDR	land disposal restrictions
LITANS	large item transportable access and neutralization system
MARB	Materiel Assessment Review Board
MC	munitions constituents
MDAP	major defense acquisition program(s)
MEA	monoethanolamine
MEC	munitions and explosives of concern
MEL	mobile expeditionary laboratory (CARA)
MIL-SPEC	military specification
MINICAMS	Miniature Chemical Agent Monitoring System(s)
MMAS	mobile munitions assessment system
MMRP	Military Munitions Response Program
MR	munitions rule
MRC	multiple round container
MRP	munitions response program
MRS	munitions response site
MRSPP	Munitions Response Site Prioritization Protocol
MSU	munitions storage unit
NAVFAC	Naval Facilities Engineering Command
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDAA	National Defense Authorization Act
NEW	net explosive weight
NPL	National Priorities List
NRC	National Research Council
NSCM	non-stockpile chemical materiel
NSCMP	Non-Stockpile Chemical Materiel Project
NSCWM	non-stockpile chemical warfare materiel
OB/OD	open burn/open detonation
OCONUS	outside the continental United States
OIPT	overarching integrated product team

O&M	operations and maintenance
OMA	Operations and Maintenance, Army
OP-FTIR	Open-Path Fourier Transform Infrared Spectrometry air monitoring
OSD	Office of the Secretary of Defense
PIG	package in-transit gas (container)
PINS	portable isotopic neutron spectroscopy
PMCD	program manager for chemical demilitarization
PMNSCM	Project Manager for Non-Stockpile Chemical Materiel
POM	Program Objective Memorandum
PPBES	planning, programming, budgeting and execution
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
RCWM	recovered chemical warfare materiel
RDECOM	Research, Development, and Engineering Command
RDT&E	research, development, test, and evaluation
RFI	RCRA Facility Investigation
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RRS	remediation response section (CARA)
RSA	Redstone Arsenal
SCANS	Single Chemical agent identification set Access and Neutralization System
SDC	static detonation chamber
SES	Senior Executive Service
SPP	site prioritization protocol
SPT CMD	Support Command
SRC	single round container
STEL	short-term exposure limit
SWMU	solid waste management unit
TDC	transportable detonation chamber
TNT	trinitrotoluene
TOCDF	Tooele Chemical Agent Disposal Facility (Utah)
TPP	Technical Project Planning
TRAM	throughput, reliability, availability, and maintainability
TSDF	treatment, storage, and disposal facility
TU	temporary unit
UMSC	universal munitions storage container
USACE	U.S. Army Corps of Engineers
USACMDA	U.S. Army Chemical Materiel Destruction Agency
USAEC	U.S. Army Environmental Command
USAESCH	U.S. Army Engineering Support Center, Huntsville
USATCES	U.S. Army Technical Center for Explosives Safety
USD(A&T)	Under Secretary of Defense for Acquisition and Technology (renamed USD(AT&L))
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics [formerly USD(A&T)]
USD(Comptroller)	Under Secretary of Defense Comptroller
USD(I&E)	Under Secretary of Defense for Installations and Environment
UTS	universal treatment standards
UXO	unexploded ordnance
VSL	vapor screening level
WP	white phosphorus
3X	level of agent decontamination (suitable for transport for further processing) (obsolete)
5X	level of agent decontamination (suitable for release for unrestricted use) (obsolete)