

# Remediation of Buried Chemical Warfare Materiel

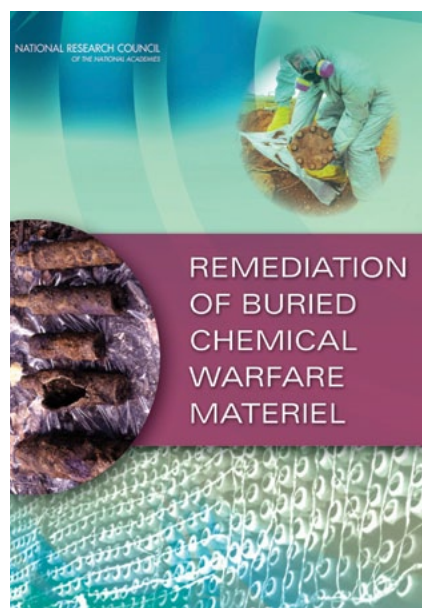
Board on Army Science and Technology · Division on Engineering & Physical Sciences · August 2012

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). Neither the Chemical Weapons Convention (CWC) treaty enacted in 1997, nor existing CWM domestic legislation, require recovery of buried CWM; however, pressure to take this action is becoming more intense while the cost of characterization, remedy selection, and even containment of these large buried CWM sites is likely to be significant. This National Research Council report reviews the technologies currently used in the detection, excavation, packaging, storage, transportation, assessment, and destruction of buried CWM and the tools that may be needed in the future. It also examines the roles and funding of the organizations responsible for these remediation efforts.

## Background

Much of the buried CWM at the approximately 250 possible or known chemical warfare sites is likely to occur as small finds that would necessitate the continuation of the Army's capability to transport treatment systems to each location for destruction. Of greatest concern for the future are sites in residential areas—such as, the now urban Spring Valley section of Washington, D.C.—and large sites on legacy military installations.

For example, more than 5 miles of disposal trenches have been identified at Redstone Arsenal in Alabama. The upper-end estimate for completely recovering and destroying buried CWM at Redstone Arsenal alone is estimated to be several billion dollars. Redstone Arsenal is an excellent example of a site where 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. (See insert summarizing a case study of Redstone Arsenal for details.)



The Army mission regarding the remediation of recovered chemical warfare materiel (RCWM) is turning into a program that will rival the existing conventional munition and hazardous substance cleanup programs. In addition, the existing structure utilized by the Army in its capacity

as executive agent for destruction of non-stockpile chemical material must now be reconfigured to prepare for the remediation of CWM at over 250 sites in the United States. 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 that will rival the existing conventional munition and hazardous substance cleanup programs.

### **Organizations involved in the Remediation of CWM Disposal Sites**

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.

The Non-Stockpile Chemical Material Project (NSCMP), which reports to the Chemical Materials Agency (CMA), now plays a central role in the remediation of recovered chemical warfare materiel. 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—for example, in the remediation of 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, including the identification of, and disbursement of funds for, assessment and disposal costs and preparation of project schedules. In addition to the NSCMP and the USACE, other organizations are involved in hands-on aspects of remediation of buried CWM.

### **Technologies for Remediation of Buried CWM**

Typically, once suspected subsurface CWM are located through the application of geophysical technologies—usually 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 onsite transport to an interim holding facility in preparation for the arrival of a mobile munitions assessment system (MMAS), which provides a nonintrusive assessment of the container contents.

If chemical agent fill is found, the RCWM is again placed in interim storage to await review of the assessment by the Materiel Assessment Review Board (MARB). In this scenario, the interim holding facility is off-site and the RCWM is packaged into a multiple round container that has been certified by the Department of Transportation and is then carried over public roads by the 20th Support Command Chemical, Biological, Radiological, Nuclear and Explosives Analytical and Remediation Activity (CARA).

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

- The U.S. Army's Explosive destruction system (EDS);
- The CH2MHILL Transportable detonation chamber (TDC);
- The Kobe Steel Detonation of ammunition in a vacuum integrated chamber (DAVINCH); or
- The Dynasafe Static detonation chamber (SDC).

### **Targeted Research and Development on Remediation Technologies**

The report recommends targeted research and development options in a number of areas, including air monitoring technologies and the destruction of contaminated RCWM using, for example, the EDS. Other targeted research and development options include:

#### ***Robotic Excavation Equipment***

Robotic technology has continued to grow in versatility and reliability. 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.

#### ***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 portable isotopic neutron spectroscopy (PINS)—an essential, though not totally reliable, tool in the assessment of recovered munitions. Research and development should continue on the processing of data from PINS 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, such as Redstone Arsenal, might entail assessing tens or hundreds of thousands of munitions or opened munitions. The NSCMP 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***

In addition to a substantial product improvement program that is under way to increase the capabilities of the EDS, the Dynasafe technology is a viable approach to processing large numbers of burned and

open chemical munition bodies that might contain residual agent or energetics. However, many problems were encountered as the SDC 1200 was operating on chemical munitions at the Anniston Chemical Agent Disposal Facility (ANCDF), and work has begun on correcting these problems. A well-planned, major process improvement program for the Dynasafe SDC 1200 system is currently under way at the ANCDF and is expected to increase the reliability of the process. The NSCMP should investigate the benefits of the larger thermal oxidizer now used in Dynasafe's standard SDC 1200 and should evaluate the costs and benefits of improving the reliability of the Dynasafe static detonation chamber 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 full NRC report outlines several recommendations for current funding and organization of the RCWM program. For example, 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.

Another example explores the effort made at Redstone Arsenal to assemble a comprehensive inventory of suspected buried munitions and sites—of the known large burial sites, only at Redstone Arsenal has such an effort been made. The lack of an accurate inventory of the buried munitions and of a reliable cost estimate for the RCWM program limits the ability to establish budget requirements and draw up an appropriate funding plan for a new and separate RCWM account. Therefore, 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.

## 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. Public participation in Army policy decisions regarding RCWM remediation is recommended. In addition, 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.

The report identifies several regulatory issues, some of which include 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; consideration of unique circumstances presented by the recovery of buried chemical warfare materiel at active operational ranges; management of remediation wastes using corrective action management units; the need to store hazardous wastes for longer than 90 days under a RCRA corrective action; and identifying regulatory approval mechanisms for the use of explosive destruction technologies to destroy RCWM.

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## Redstone Arsenal: Summary of a Case Study

from the full NRC report *Remediation of Buried Chemical Warfare Materiel*

**The challenges facing the Non-Stockpile Chemical Materiel Project (NSCMP) can be examined in a more holistic manner through a case study of one of the small number of sites that contain especially large quantities of chemical warfare materiel (CWM). There are 249 known and suspected sites in the United States that contain CWM, including several sites that could contain large quantities of CWM.**

### The Challenges at Redstone Arsenal

The cleanup at RSA in Huntsville, Alabama is a huge challenge. The site comprises some 38,300 acres of land containing over 300 solid waste management units. Seventeen of these are suspected CWM sites for which the state regulatory authority is requesting removal as an interim measure to satisfy the Resource Conservation and Recovery Act (RCRA). RSA is also believed to be the largest and most challenging of the sites in terms of estimated quantities, the condition and variety of items, operational complexity, regulatory issues, and potential remediation costs. Each of these units not only is likely to require a customized approach but also has more than 5 miles of disposal trenches and various burn and disposal areas for chemical munitions and related wastes as a result of operations that began in the early 1940s.

### CWM Inventory

From 1940 until 1945, this was the site of three chemical agent plants at the Huntsville Arsenal, where toxic agents such as mustard, lewisite, phosgene, and adamsite were produced and where the RSA Ordnance Plant assembled and packaged chemical munitions such as 75-mm to 155-mm shells and 30-lb and 100-lb chemical bombs. These plants also produced many munitions filled with smoke and incendiary chemicals.

Following the Second World War, the Ammunition Returned from Overseas program brought up to 1 million munition items to RSA for evaluation and demilitarization. These munitions came from Germany, Japan, and Great Britain and contained agents not produced in the United States, such as British mustard, the German nerve agent tabun, German

mustard, thickened German mustard, and nitrogen mustard. Destroying these agents presented challenges to the Army at the time.

The total quantities of remaining items cannot be known until source removal action is taken and disposal begins. However, based on archival research and interviews with former employees, there is a potential for significant quantities of munitions, both conventional and chemical, and chemical warfare-related items—such as drums and production equipment—to be found in various states within burial sites at RSA.

CERCLA remedy investigation, selection, and implementation related to RSA has been ongoing since 1983, when the state of Alabama, EPA, and Olin Corporation entered into a consent decree requiring Olin to implement a DDT sediment cleanup. The facility was first placed on the National Priorities List in 1994. At least 10 CERCLA remedies have been or are being implemented at RSA, including the dismantling of the lewisite manufacturing plant sites (RSA-122) and closing the arsenic waste ponds.

While most of the buried munitions are actually remnants of exploded munition bodies and previously decontaminated chemical munitions that may still contain detectable quantities of agent, some explosively configured munitions and unexploded bursters and fuzes can be expected.

In 2011, ADEM mandated interim action at the 17 units that would consist of the immediate removal of the buried CWM. Once removed from their interim and identified as CWM, the chemical muni-

tions would need to be destroyed, as required by the Chemical Weapons convention. Additional site investigations are likely to be performed, and it appears that a final RCRA Facility Investigation has not yet been conducted. Army guidance requires a risk assessment for final cleanup decisions at all locations, including on and off operational ranges to ensure that the remedy is protective. The remedy selection process normally considers many factors, including, but not limited to, the following:

- Existing land use—for example, whether the material is located on an operational range;
- Potential future uses—for example, whether the Army can control access to the site and the potential for exposure for as long as the buried CWM remain on-site; and
- Short-term and long-term risk.

## Community Concerns

Alabama's Madison County and the town of Huntsville, which surround the RSA, are experiencing significant economic development. While some of the area's recent construction activity can be attributed to RSA's status as a BRAC "gaining facility," much of the community's economic expansion began before that impact. Indeed, the area's economic growth has been identified as an important factor in ADEM's preference for a removal and cleanup remedy rather than a leave-in-place remedy. Contaminants have been identified in the vicinity of the RSA site, including solvents, metals, pesticides, CWM, and hazardous remnants from rocket fuel R&D and testing, such as perchlorate. These contaminants have impacted groundwater, soil, sediments, and surface waters in the region and are of concern for both public health and economic prosperity. The proximity to the Tennessee River, which is used for drinking water and recreation, increases the importance of selecting the best remediation approach.

Public engagement and education will be critical during the protracted and complex cleanup of RSA. It will be important that the Army, the state of Alabama, the federal regulatory agencies, and the community work closely together to maximize the efficiency of the cleanup program and protect the health and environment of the community.

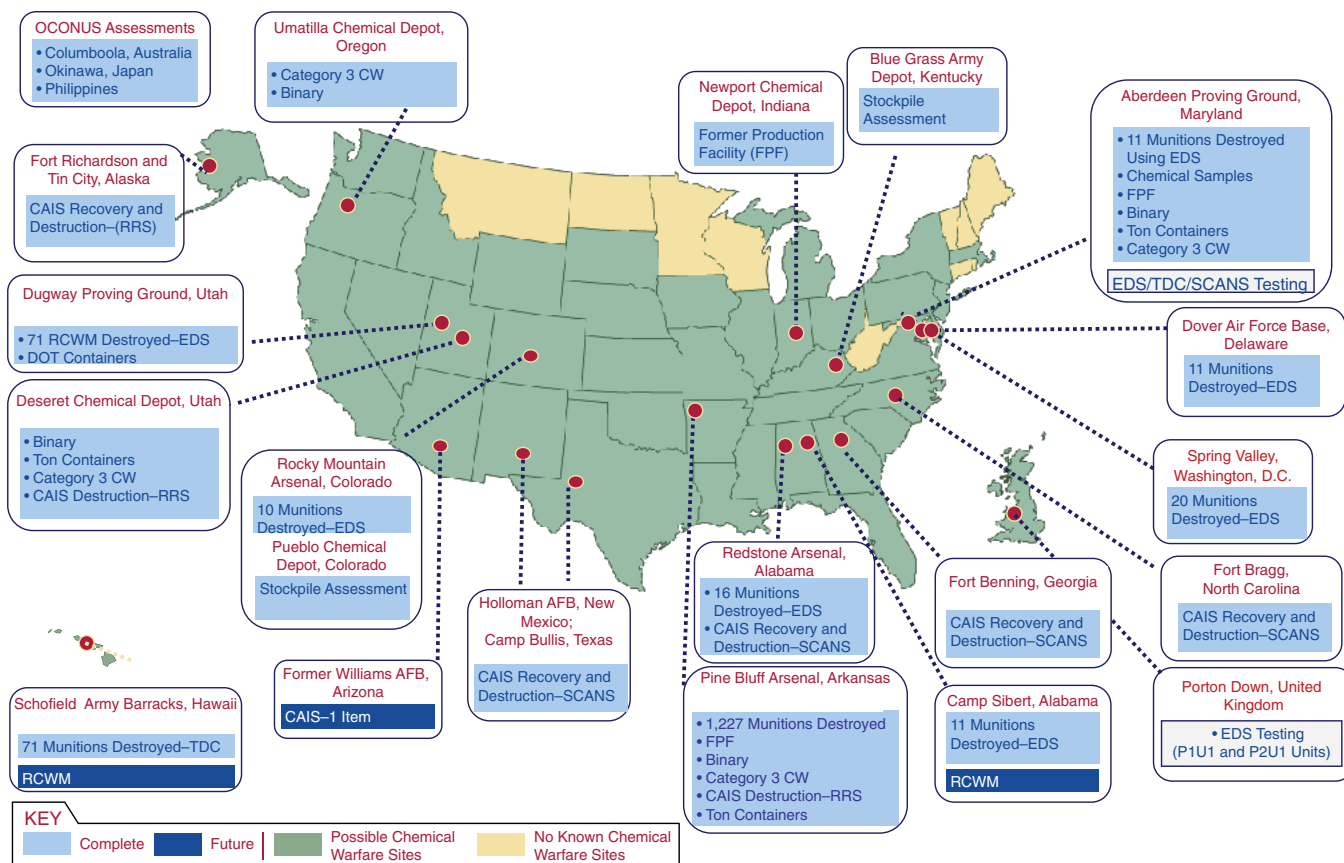


FIGURE 1-2 Past and future mission areas 1-4 activities; locations and munitions destroyed. RRS, rapid response system; DOT, Department of Transportation; SCANS, single (chemical agent identification set) accessing and neutralization system; FPF, former production facility.  
SOURCE: Laurence G. Gottschalk, Project Manager for Non-Stockpile Chemical Materiel, presentation to the committee on September 27, 2011.