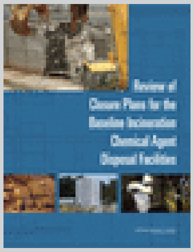

Review of Closure Plans for the Baseline Incineration Chemical Agent Disposal Facilities

ISBN
978-0-309-15858-9

106 pages
8 1/2 x 11
PAPERBACK (2010)

Committee to Review and Assess Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System; National Research Council

Review of Closure Plans for the Baseline Incineration Chemical Agent Disposal Facilities

Committee to Review and Assess Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System

Board on Army Science and Technology

Division on Engineering and Physical Sciences

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS **500 Fifth Street, N.W.** **Washington, DC 20001**

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This study was supported by Contract No. W911NF-09-C-0081 between the National Academy of Sciences and the U.S. Army. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

Front cover—Upper left: Demolition of filter housing at Aberdeen Chemical Agent Disposal Facility (Maryland). *Lower, from left:* Scabbling (removal of a layer of concrete) at Johnston Atoll Chemical Agent Disposal System; tented titanium reactor at Aberdeen Chemical Agent Disposal Facility (Maryland); and pressure washing at Newport Chemical Agent Disposal Facility (Indiana). Images superimposed on a diagram of potentially contaminated areas, to be enclosed by tents, processing bay, Newport Chemical Agent Disposal Facility (Indiana).

Back cover—Mass demolition of ton container cleanout building, Aberdeen Chemical Agent Disposal Facility (Maryland).

Photographs courtesy of U.S. Army Chemical Materials Agency.

International Standard Book Number 13: 978-0-309-15858-9
International Standard Book Number 10: 0-309-15858-3

Limited copies of this report are available from

Board on Army Science and Technology
National Research Council
500 Fifth Street, N.W., Room 940
Washington, DC 20001
(202) 334-3118

Additional copies are available from

The National Academies Press
500 Fifth Street, N.W.
Lockbox 285
Washington, DC 20055
(800) 624-6242 or
(202) 334-3313
(in the Washington metropolitan area)
Internet, http://www.nap.edu

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council

www.national-academies.org

COMMITTEE TO REVIEW AND ASSESS CLOSURE PLANS FOR THE TOOELE CHEMICAL AGENT DISPOSAL FACILITY AND THE CHEMICAL AGENT AND MUNITIONS DISPOSAL SYSTEM

PETER B. LEDERMAN, *Chair*, Hazardous Substance Management Research Center (retired), New Providence, New Jersey
GARY S. GROENEWOLD, Idaho National Laboratory, Idaho Falls, Idaho
DEBORAH L. GRUBBE, Operations and Safety Solutions, LLC, Chadds Ford, Pennsylvania
JOHN R. HOWELL (NAE), University of Texas, Austin
TODD A. KIMMELL, Argonne National Laboratory, Washington, D.C.
KALATHIL E. PHILIPOSE, Atomic Energy of Canada Limited (retired), Ontario, Canada
LOUIS T. PHILLIPS, Resource: PM, Chadds Ford, Pennsylvania
DANNY D. REIBLE (NAE), University of Texas, Austin
W. LEIGH SHORT, Woodward Clyde & Associates (retired), Williamstown, Massachusetts
LEONARD M. SIEGEL, Center for Public Environmental Oversight, Mountain View, California
DAVID A. SKIVEN, Worldwide Facilities, General Motors Corporation (retired), Brighton, Michigan
SHERYL A. TELFORD, DuPont Corporate Remediation Group Director, Wilmington, Delaware
LAWRENCE J. WASHINGTON, The Dow Chemical Company (retired), Midland, Michigan

Staff

NANCY T. SCHULTE, Study Director
HARRISON PANNELLA, Senior Program Officer
NIA D. JOHNSON, Senior Research Associate
ALICE V. WILLIAMS, Senior Program Assistant

BOARD ON ARMY SCIENCE AND TECHNOLOGY

Preface

For over half a century the United States has maintained a stockpile of chemical weapons and bulk agent at Army depots distributed around the country. This stockpile contained approximately 30,000 tons of chemical nerve agents GB and VX, and several forms of mustard agent. These agents were contained in about 3 million munitions of various types as well as in bulk storage containers.

The U.S. Army has been engaged in destroying this stockpile since 1986. On July 1, 2010, the U.S. Army's Chemical Materials Agency (CMA) announced that 75 percent of the nation's stockpile had been destroyed. This work has taken place at nine chemical agent destruction facilities. Five of these used incineration technology. The first of these, the Johnston Atoll Chemical Agent Disposal System, completed its mission in 2000. It was subsequently closed and dismantled. The other four incineration-based chemical agent destruction facilities and a related testing facility will be finishing their missions in the next two years, and preparations are being made for the start of closure operations. An examination of the means for properly planning for the safe and efficient closure of these facilities is the subject of this study, and it is the charge given to the committee by the director of the CMA. The statement of task is shown in Chapter 1 on pages 7 and 8.

The first of the remaining four facilities to proceed with agent disposal, the Tooele Chemical Agent Disposal Facility (Utah), began operations in 1996, followed by chemical agent disposal facilities in Anniston, Alabama, in 2003; Umatilla, Oregon, in 2004; and Pine Bluff, Arkansas, in 2005. This study evaluates the closure planning and makes recommendations regarding closure activities.

As the chair of the committee, I wish to express my appreciation to my fellow committee members for their contributions to the preparation of this report, which included interviewing CMA and contractor staff and stakeholders, visiting sites, and collecting and analyzing scores of planning documents in a short time. Every member of the committee made significant contributions to the writing of the report.

The committee in turn is grateful to the many CMA staff members and the prime contractor, the URS Corporation, for making themselves readily available, for their extensive efforts to ensure that data were available in a clear format, and for ensuring that all of the committee's questions were answered. All this was done in spite of their many other duties. The committee also greatly appreciates the assistance of the NRC staff who assisted in the fact-finding activities, carried on significant research in support of the report, and were instrumental in the production of the report.

The Board on Army Science and Technology (BAST) members listed on page vi were not asked to endorse the committee's conclusions or recommendations, nor did they review the final draft of this report before its release, although board members with appropriate expertise may be nominated to serve as formal members of the study committees or as report reviewers.

Peter B. Lederman, Ph.D., *Chair*
Committee to Review and Assess Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System

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:

Joan B. Berkowitz, Farkas Berkowitz & Company,
Jan Beyea, Consulting in the Public Interest,
Elisabeth M. Drake, NAE, MIT Laboratory for Energy and the Environment,
Harold K. Forsen, NAE, Bechtel Corporation (retired),
Charles E. Kolb, Aerodyne Research, Inc.,
George W. Parshall, NAS, E.I. du Pont de Nemours & Company (retired),
William J. Rogers, Tennessee Valley Authority,
William J. Walsh, Pepper Hamilton, LLP, and
Charles F. Zukoski, NAE, University of Illinois at Urbana-Champaign.

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 Hyla Napadensky. Appointed by the NRC, 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

APPENDIXES

Tables, Figures, and Box

TABLES

FIGURES

BOX

Acronyms and Abbreviations

ABCDF Aberdeen Chemical Agent Disposal Facility (Maryland)
ACAMS automatic continuous air monitoring system
ANCA Anniston Chemical Activity (Alabama)
ANCDF Anniston Chemical Agent Disposal Facility (Alabama)

BAST Board on Army Science and Technology
BRAC Base Realignment and Closure

CAC Citizens Advisory Commission
CAMDS Chemical Agent Munitions Disposal System (Utah)
CDF chemical agent disposal facility
CEMS continuous emissions monitoring system
CERCLA Comprehensive Environmental Response, Compensation and Liability Act
CMA Chemical Materials Agency (U.S. Army)
CTUIR Confederated Tribes of the Umatilla Indian Reservation
CWC Chemical Weapons Convention

DAAMS depot area air monitoring system
DCD Deseret Chemical Depot
DWP decommissioning work package

EPA Environment Protection Agency

GB nerve agent (sarin)
GPL general population limit

H mustard agent
HD distilled mustard agent
HT distilled mustard mixed with bis-(2-(2-chloroethylthio)ethyl) ether

IDLH immediately dangerous to life and health

JACADS Johnston Atoll Chemical Agent Disposal System

L lewisite
LDR land disposal restriction
LIC liquid incinerator

MINICAMS Miniature Chemical Agent Monitoring System

NECD Newport Chemical Depot (Indiana)
NECDF Newport Chemical Agent Disposal Facility
NRC National Research Council

ODEQ Oregon Department of Environmental Quality
OSHA Occupational Safety and Health Administration

OST	occluded space team
PAH	polycyclic aromatic hydrocarbon
PBCA	Pine Bluff Chemical Activity (Arkansas)
PBCDF	Pine Bluff Chemical Agent Disposal Facility (Arkansas)
PCB	polychlorinated biphenyl
PCC	permit compliance concentration
PMCD	Program Manager for Chemical Demilitarization
PMCMA	Program Manager, Chemical Materials Agency
RCRA	Resource Conservation and Recovery Act
STEL	short-term exposure limit
STL	short-term limit
TOCDF	Tooele Chemical Agent Disposal Facility (Utah)
TSDF	treatment, storage, and disposal facility
UCD	Umatilla Chemical Depot
UDAQ	Utah Division of Air Quality
UDSHW	Utah Division of Solid and Hazardous Waste
UMADRA	Umatilla Army Depot Re-Use Authority
UMCD	Umatilla Chemical Depot
UMCDF	Umatilla Chemical Agent Disposal Facility (Oregon)
UMT	unventilated monitoring testing
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
VSL	vapor screening level
VX	nerve agent
WCL	waste control limit
WPL	worker population limit

Summary

This report responds to a request by the director of the U.S. Army Chemical Materials Agency (CMA) for the National Research Council to examine and evaluate the ongoing planning for closure of the four currently operational baseline incineration chemical agent disposal facilities and the closure of a related testing facility. The report evaluates the closure planning process as well as some aspects of closure operations that are taking place while the facilities are still disposing of agent. These facilities are located in Anniston, Alabama; Pine Bluff, Arkansas; Tooele, Utah; and Umatilla, Oregon. They are designated by the acronyms ANCDF, PBCDF, TOCDF, and UMCDF, respectively. Although the facilities all use the same technology and are in many ways identical, each has a particular set of challenges.

Initially, the Committee to Review and Assess Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System was requested to use the programmatic closure plan developed for the TOCDF as the basis of this study. When the CMA first commissioned this study, the TOCDF was expected to be the first of the four facilities to close. However, the anticipated order of closure has since changed based on when each facility is now expected to complete agent disposal operations. At the present time, it is expected that PBCDF will close first, with UMCDF, ANCDF, and TOCDF to follow. It became clear both to the committee and the Army that it would be advisable to examine planning for all four facilities and the pilot testing facility near the TOCDF known as the Chemical Agent Munitions Disposal System (CAMDS).

The committee prepared an initial letter report that looked at overall closure planning as well as closure operations in progress at CAMDS. This was followed by several committee meetings to gather information and evaluate how closure planning for each of the facilities had progressed. Meetings by subgroups of the committee were also held with contractor personnel responsible for data resources relevant to closure such as the "lessons learned" program. A subgroup of the committee attended a coordination meeting of the closure managers from each facility.

The committee found that closure planning is progressing under the competent leadership of the closure managers and that the facilities were sharing information and experiences with each other. However, each facility was found to be developing closure plans independently of the other facilities but within the broad guidance provided by the CMA program office and using, as appropriate, the experience of the other three facilities. Information is also being used in the planning process that was gained from the previous closure of a baseline incineration facility on Johnston Island in the Pacific Ocean near Hawaii, the Johnston Atoll Chemical Agent Disposal System (JACADS), and the more recent closures of two chemical agent disposal facilities that used chemical neutralization (hydrolysis) to destroy bulk mustard agent and VX nerve agent—the Aberdeen Chemical Agent Disposal Facility (ABCDF) in Maryland, and the Newport Chemical Agent Disposal Facility (NECDF) in Indiana. In its evaluation, the committee found that there appeared to be only limited coordination and

policy guidance from the senior CMA and contractor leadership. An exception is a CMA document, "Strategic Plan Fiscal Years 2010–2015," that defines the goals of having safe closures while minimizing cost and schedule (CMA, 2009). In order to achieve this goal, the CMA document encourages the use of mass demolition wherever possible. As discussed below, the committee agrees that these are appropriate goals, but it believes that additional policy guidance from CMA in key areas is required.

Finding 2-1. The closure managers and their teams appear to be highly competent and to coordinate their needs and approaches well through frequent contacts and meetings. Each site is taking its own approach to the planning activities because of differing end use, facility, and regulatory situations. There does not appear to be sufficient senior policy guidance in key issues such as the critical unventilated monitoring test.

Recommendation 2-1. Senior Chemical Materials Agency management should provide policy guidance for closure in critical areas such as the unventilated monitoring test to ensure that these critical activities are planned and executed in a uniform manner across all facilities.

The committee expended significant effort to evaluate the various regulatory and stakeholder challenges pertaining to closure at each of the facilities. While many of the requirements are common to all four sites, there are significant differences in both the intended end use of each site and the permit and regulatory requirements to which each site is subject. Thus, each facility will have to develop its own particular plan to meet these varying challenges. Nevertheless, the overriding principle of achieving a safe closure that meets the criteria necessary for the eventual end use does not really change from site to site. Closure is an entirely different type of operation from the agent disposal operations that have been carried out for much of the past decade and with which the staff is comfortable. Closure and demolition will require workers having different skills in addition to those residing in the current operations staff. In order to have a safe operation, both groups will have to be knowledgeable in their particular operations, especially with regard to the safety challenges involved. Closure activities will occur over a much shorter duration than will disposal operations. In order to achieve the goals of a safe closure while minimizing cost and schedule, it will be necessary for managers to set goals for a number of new management parameters and to use leading indicators to become aware of potential problems before they actually happen. The committee has provided a number of suggested parameters and metrics for the Army to consider that could help it to achieve its stated goals for the closure of these facilities.

Finding 3-2. Tracking and reporting parameters and metrics will facilitate the safe and successful management of the closure of the Army's baseline incineration chemical agent disposal facilities.

Recommendation 3-2a. At a minimum, the Army should track parameters and metrics used for disposal facility closure at two levels: the program level and the project level. Thereafter, it should determine whether additional parameters and metrics are required.

Recommendation 3-2b. The Army should ensure that appropriate and timely management reports are developed that enable tracking results for parameters and metrics to be used to make management decisions and take necessary actions.

The Army, through its systems contractor, has developed an improved lessons learned program. This is available to all staff, both those at CMA headquarters and those at the facilities. Unfortunately, not all the lessons learned applicable to closure are in searchable form. This is particularly true of some of the lessons learned during the JACADS closure. It also seems that while there is prompt verbal communication and coordination of lessons learned concerning agent disposal operations, this may not be as true for those involving closure. It is therefore important that lessons learned relevant to closure be promptly entered into the system and be adequately highlighted to bring them to the attention of the working staff.

The Army contractor for both disposal operations and closure administers an electronic database, the "eRoom," that is a repository for plans, drawings, and reports. Access to this database is limited in that it must be requested, and a person's access is terminated if he or she has not used the database in 60 days. The committee recognizes the sensitivity of providing access to this corporate database, yet it believes arrangements should be made to make access easier for a broader group of staff members.

Finding 4-2. Lessons learned over the course of conducting closure operations at chemical agent disposal facilities will be helpful to completing without incident future closure activities within the chemical stockpile disposal program, and they will minimize costs by reducing the time and effort needed for learning curves and training.

Recommendation 4-2. The Army should continue to support the closure lessons learned processes and to encourage the prime contractor for closure operations to strengthen the timeliness and manner in which the lessons learned are shared. In this regard, it is important that all contractors on-site have access to or knowledge of the lessons learned applicable to their specific site activities.

Finding 4-6. The eRoom is a very powerful information sharing and management tool, both for developing new documents and for allowing users to find information that is pertinent to a particular issue or problem.

Recommendation 4-6a. The committee strongly supports the concept of the eRoom and encourages its use as often as possible.

Recommendation 4-6b. The committee suggests that the Army and its contractor examine current eRoom usage and, if appropriate, develop procedures to increase its usage, including the development of new documents and determining who should have access during closure and dismantling activities.

The restrictive practices that state regulatory agencies have used to address agent disposal operations at the baseline stockpile facilities were developed as operations began to destroy the chemical agents. During closure, in contrast with disposal operations, there will not be any significant amount of agent present, and there will be no munitions. Potential minimal amounts of agent can remain in occluded spaces or, even less likely, in pockets on floors and walls. Thus, the risks to human health and the environment from agent and munitions will be significantly reduced during closure from those that existed during disposal processing. This difference in risk represents a fundamental change from disposal operations to closure operations. It should provide the basis for considering less restrictive practices.

Finding 5-1. The risk of exposure to chemical agents during closure operations is expected to be significantly lower than what potentially could be encountered during agent disposal operations. The regulatory standards and practices used by some states for controlling agent-contaminated materials were developed early in the program, when there was little experience with managing the risks of materials exposed to agent. These practices and regulations may be more restrictive than necessary considering the nature of the closure operations.

Recommendation 5-1. The Army should evaluate the reduced risk of exposure to chemical agents and their degradation products from closure operations and waste materials in view of restrictive regulatory practices. It should also consider negotiating with the regulatory community to obtain less restrictive, but still safe, regulatory practices that allow for more efficient closure operations.

The Army, in setting overall goals for the program for facilities' closure, has opted to use mass demolition wherever possible. This depends on ensuring that all the spaces to be demolished are safe and essentially agent free, as determined by meeting agent clearance levels that provide for an environment that is safe for workers and the public. Two protocols are essential for mass demolition to be used successfully: first, the occluded space survey, followed by, second, the unventilated monitoring test (both discussed more fully in Chapter 6). Mass demolition, which enables the use of mechanical deconstruction using conventional construction equipment to remove structures and minimizes human actions required for deconstruction, should not take place until management is assured that these tasks have been accomplished properly and successfully. The committee examined both of these protocols and believes that they should be uniformly applied at every site. Further, the committee believes that a second survey should be done to verify the results of the first. In addition to uniformly applying the occluded space survey and unventilated monitoring test protocols at every site, the committee believes that guidance from senior CMA and site leadership to ensure that these protocols and steps are carried out very carefully is warranted to ensure safe operations.

Finding 6-1. The occluded space survey is a key component of the overall monitoring strategy for closure, and it requires occluded space survey teams with a high level of expertise and significant training for proper execution.

Recommendation 6-1. Occluded space survey protocol should be standardized across the entire enterprise, and training should be strengthened, standardized across the program, and continually updated.

Finding 6-4. Unventilated monitoring testing—conducted in sequence with site exposure and spill histories, ventilated monitoring, and occluded space surveys—is appropriately designed to ensure protection of workers and the general population from agent exposure via airborne pathways. It is the final "critical step" in clearing a site for mass demolition.

Recommendation 6-4a. The Army should ensure both that the unventilated monitoring testing (UMT) protocol is uniform throughout the enterprise and that the information gained by the UMT sequence is aggressively communicated to subsequent closure sites.

Recommendation 6-4b. Locations of prior exposures and spills should be compared with the results of the unventilated monitoring testing (UMT) measurements. Correlation (or not) of past exposure events with UMT release rates could provide valuable insight into residual contamination, effectiveness of occluded space surveys, and UMT efficacy.

REFERENCE

CMA (U.S. Army Chemical Materials Agency). 2009. Strategic Plan Fiscal Years 2010–2015 Revision 0. Aberdeen Proving Ground—Edgewood Area, MD. Washington, D.C.: Chemical Materials Agency.

1

Introduction

The disposal of the chemical weapons stockpile has been a major undertaking of the Army under a 1985 mandate from Congress (Public Law 99-145). This stockpile contained approximately 30,000 tons of chemical nerve agents GB or VX, and several forms of mustard agent. These agents were contained in about 3 million munitions of various types, as well as in bulk storage containers.

There were nine chemical stockpile storage sites at the start of the program. Eight were located in the continental United States and one was on Johnston Atoll in the Pacific Ocean southwest of Hawaii. By Act of Congress, no stockpile was to be relocated (Public Law 103-337). Consequently, nine chemical agent disposal facilities were to be built contiguous to the stockpile storage sites. The locations, types, and percentage of stockpiled agent, and the range of munitions and containers that were stored at each of these stockpile sites, are shown in Figure 1-1.

Since 1984, the National Research Council (NRC) has provided scientific and technical guidance to the Army on important aspects of the stockpile disposal plans and programs with an overarching goal of safe and expeditious implementation of stockpile destruction. This guidance has taken the form of approximately 50 reports to date.

Initially, incineration (combustion) was selected as the destruction process of choice. But in the early 1990s, Congress required the Army to evaluate alternative, noncombustion technologies and utilize them if they were as safe and cost-effective as incineration (Public Law 102-484). At that time, all but four of the disposal facilities were either constructed or in design, with one facility, the Johnston Atoll Chemical Agent Disposal System (JACADS), in operation.[1]

Two basic processes are used in the disposal program: incineration and chemical neutralization. Five facilities employed incineration: Johnston Atoll Chemical Agent Disposal System (JACADS), Tooele (Utah) Chemical Agent Disposal Facility (TOCDF), Anniston (Alabama) Chemical Agent Disposal Facility (ANCDF), Umatilla (Oregon) Chemical Agent Disposal Facility (UMCDF), and Pine Bluff (Arkansas) Chemical Agent Disposal Facility (PBCDF). These all had a mix of agent and weapons in the related stockpile. The two storage sites at Newport Chemical Depot (Indiana), and at the Edgewood Chemical Activity at the Aberdeen Proving Ground, Maryland, stored nerve agent VX and mustard agent, respectively. The agent was stored only in bulk ton containers at these sites. The disposal facilities constructed at these two sites—namely, the Newport Chemical Agent Disposal Facility (NECDF) and the Aberdeen Chemical Agent Disposal Facility (ABCDF)—used chemical neutralization. The final two facilities, at Pueblo (Colorado) and Blue Grass (Kentucky), are under design and construction. To destroy the agent and meet the international Chemical Weapons Convention treaty requirement for complete destruction of the agent and first-stage degradation products, neutralization followed

[1]The Johnston Atoll Chemical Agent Disposal System (JACADS), the U.S. Army's first full-scale chemical weapons disposal facility, completed its mission in 2000. Available online at http://www.cma.army.mil/johnston.aspx.

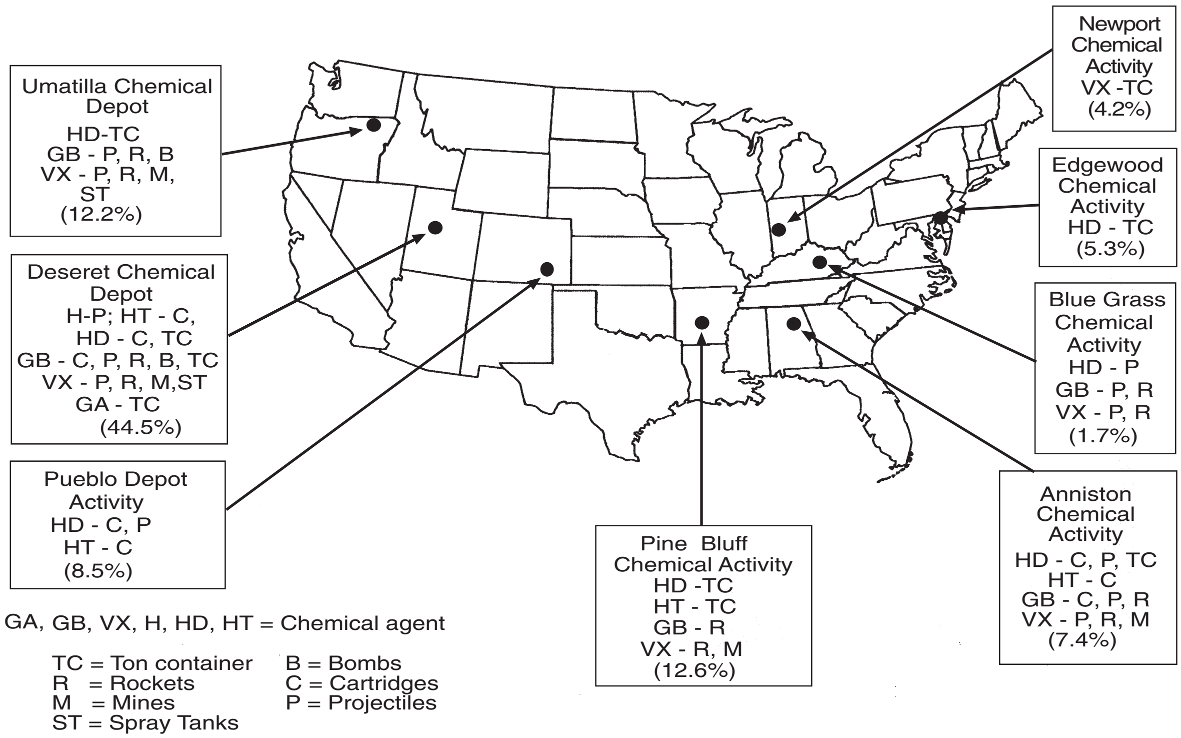

FIGURE 1-1 Location and original size (percentage of original chemical agent stockpile) of eight continental U.S. storage sites. SOURCE: OTA, 1992.

by biodegradation will be used in the case of Pueblo, and neutralization followed by supercritical water oxidation in the case of Blue Grass.

FACILITIES COVERED IN THIS REPORT

This report focuses on the four incineration or "baseline" facilities that are operating, as well as the Chemical Agent Munitions Disposal System (CAMDS). Located at Deseret Chemical Depot (DCD) in Utah, CAMDS was a pilot facility for testing destruction processes and equipment. Not included in the study are ABCDF and the NECDF. These relatively small facilities have both completed their mission and have already been dismantled. Regulatory closure of ABCDF and NECDF has been completed. The destruction facilities for the Pueblo, Colorado, and Blue Grass, Kentucky, sites will be full-scale pilot plants. Their facility and process designs are completed, and the facilities are currently under construction under the auspices of a separate DoD program, the Assembled Chemical Weapons Alternatives (ACWA) program. These facilities likewise are not addressed in this study.

The four baseline incineration facilities in the continental United States—TOCDF, ANCDF, UMCDF, and PBCDF—are nearing the end of their missions. They will then go into closure operations in order to prepare the facility sites for future use. This report addresses the issues and challenges that should be focused on during the planning and the conducting of closure operations for these facilities. The TOCDF was the first of these facilities to begin agent disposal operations in August 1996. At the time this study was initiated, it was thought that it would be the first of these facilities to close. The Army initially intended to use the closure plans for TOCDF as the programmatic closure plans and the basis for closure plans for the other three facilities. That no longer appears to be the case. It appears now that PBCDF will be the first of the four facilities to undergo closure, with ANCDF most likely to be the second facility closed. The committee with the concurrence of the Army's Chemical Materials Agency (CMA), therefore, examined the available information for all four baseline facilities and CAMDS and discussed closure plans with representatives from each of these facilities.

Whereas each facility has unique characteristics and issues, many of the issues and challenges for closure will be the same for all of them.[2] Thus, this report addresses the general challenges while also considering the specific issues related to each facility. Throughout this report, CAMDS is addressed as part of the baseline group of facilities.

The CAMDS facility, a research and development pilot facility colocated with TOCDF at the Deseret Chemical Depot, has been undergoing closure operations for some time. Closure operations at CAMDS were initially undertaken under a separate contract that has been terminated. Responsibility for the closure of CAMDS and the requisite operations transferred to the operating contractor for TOCDF. The Committee to Review and Assess Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System (CMA Closure Committee) previously addressed the CAMDS closure (see Appendix A for this committee's initial letter report). In this current report, CAMDS is considered a part of TOCDF.

JACADS CLOSURE

CMA currently provides managerial leadership and oversight of the chemical stockpile disposal activities. A predecessor organization of the CMA, the Program Manager for Chemical Demilitarization (PMCD), had requested the NRC to undertake a study of the closure of JACADS. This request culminated in the issuance of the report *Closure and Johnston Atoll Chemical Agent Disposal System* (NRC, 2002). That study was undertaken before any closure activities were begun at JACADS. It examined the planning for closure and closure operations from late 1999 through early 2001. The report reviewed planning but did not review or assess actual demolition activities because no such activities had been undertaken before the report was finalized.

The JACADS report provided the Army with 19 recommendations to help in closure planning and operations. These covered decision making and project planning, personnel retention, acquisition strategy and procurement, cost control, monitoring, security, safety, and public involvement (NRC, 2002). The CMA Closure Committee has reviewed the report for applicability to the closure of the other baseline incineration facilities, and it has included these considerations in the development of and recommendations in this report to the extent that this information is applicable to the current facilities' closure situations The 19 recommendations are still applicable. The lessons learned as a result of the JACADS closure operations are of equal import and provide valuable insights that are incorporated in this report and are being incorporated into the Army's closure planning activities.

COMMITTEE LETTER REPORT

A team of the committee undertook a preliminary evaluation of the program closure planning for the facilities using TOCDF and CAMDS closure planning documents and presentations from October to December 2009. The report of that evaluation (Appendix A) provided a set of key parameters for successful closure against which development and subsequent execution of closure plans can be evaluated. These parameters are part of the basis of the present report, which examines the closure planning process and configurations for each of the four baseline incineration chemical agent disposal facilities. The preliminary report addresses the CAMDS closure, which is ongoing. The findings of the preliminary report are incorporated into the current full report.

STATEMENT OF TASK

The CMA Closure Committee was given the following statement of task:

> The NRC will form a committee to provide two reports. The first is an interim report assessing the following:
>
> - Examine the current closure plans for TOCDF and CAMDS and make recommendations as required.
> - Recommend key parameters to assess an integrated approach to common closure requirements.
> - Assess planning for compliance with unique regulatory requirements of the State of Utah towards closure of the two chemical disposal facilities.
>
> Following the issuance of the interim TOCDF-CAMDS closure report, the National Research Council will issue a comprehensive report as follows:

[2]Depending on the particular site, the planning for closure of the chemical agent disposal facilities that are the subject of this report is designed to achieve Resource Conservation and Recovery Act (RCRA) clean closure to either industrial or residential standards. The facility closure process includes management of waste generated during processing operations as well as management of surplus buildings and equipment.

- Update the 2002 NRC report *Closure and Johnston Atoll Chemical Agent Disposal System*, as required.
- Using the key parameters to assess an integrated approach to common closure requirements (as recommended in the interim TOCDF-CAMDS closure report), determine applicable lessons learned from the closure of JACADS, ABCDF, and the ongoing closure of NECDF for potential use during incineration facility closure.

As described previously, at the time the committee commenced its study activities, it became apparent to the members, and was acknowledged by CMA, that closure planning for TOCDF—and to a lesser extent CAMDS—had not evolved to a point that would allow for detailed evaluation of those plans either for those facilities or as models for the other sites. Therefore, the committee examined closure documents that were available from all four incineration facilities as well as applicable documents from ABCDF and NECDF. As a result, the committee's focus, with the concurrence of the CMA Program Manager, considered each of the four facilities, particularly those that would be closing before TOCDF.

THE COMMITTEE'S APPROACH

The committee focused its attention primarily on the approach to closure planning by the Army and, where available, on the closure plans for those chemical agent disposal facilities that were currently expected to be the first to close and whose closure planning was the furthest evolved. These are PBCDF and ANCDF. At the time this report was prepared, it was anticipated that PBCDF would be the first facility to begin closure operations, followed by ANCDF and then, depending on the situation at the time, by either UMCDF or TOCDF. A summary of available and planned closure documents for the facilities is found in Chapter 2.

STRUCTURE OF THE REPORT

This chapter summarizes the history of the Army's chemical stockpile disposal program and chemical agent disposal facilities. The first full-scale facility, JACADS, operated from 1986 until its closure in 2001. Four second-generation facilities—TOCDF, ANCDF, UMCDF, and PBCDF, constructed from 1989 through 2005—are in various states of preparation for closure in the 2013–2015 time frame.

In Chapter 2, the committee examines the overall closure planning for the four baseline incineration chemical agent disposal facilities, including facility decommissioning and closure objectives, regulatory drivers, and expectations for future use. A brief discussion of the status of the planning for each of the four facilities is also presented, as is a summary of the available and planned closure documents for each facility. It should be noted here that, as is discussed in more detail throughout the report, all four facilities present different challenges because the closure goals are in some ways different for each facility.

In Chapter 3, the committee identifies a series of key parameters along with associated metrics for overall management of the current and upcoming closures. These parameters and metrics are differentiated into program- and project-level considerations and activities. It is left to the Army and its contractors to develop a similar set of parameters and metrics applicable to work at the task level. The relevance of using leading indicators is discussed in view of the transition from disposal operations to the new types of activities being undertaken as deconstruction becomes the central activity.

Chapter 4 examines the Army's lessons learned process as it pertains to closure operations. The chapter also discusses the Army's use of a more recent but key management tool, the eRoom. The lessons learned program has, by the nature of activities to date, emphasized operations and must for the next several years place equal emphasis on closure planning and eventually closure execution. The contractor-operated eRoom is an invaluable tool for viewing and obtaining detailed plans and documents. Provided that accessibility is properly structured, it can be a valuable aid in the closure planning process as well as being a useful tool for reviewing similar documents for consistency between sites.

Chapter 5 examines regulatory issues and constraints including general and site-specific Resource Conservation and Recovery Act (RCRA) closure requirements, programmatic constraints, and installation-specific constraints. These constraints are often facility specific and if not properly managed can be very time-consuming and costly.

Chapter 6 examines the monitoring and analytical challenges that will be new and different from those experienced during the disposal operations phase of the facility. The role of the usual RCRA extractive analysis testing of waste and the difficulty in using that traditional methodology is discussed. The use of vapor screening as a monitoring tool that will be protective of workers and the general public while allowing for efficient deconstruction, or mass demolition, is evaluated in detail. The committee concerned itself primarily with the waste materials that have been or could have been in contact with agent during the life of the facility. Material not in those categories is discussed in an earlier report on secondary waste (NRC, 2008). Waste of a general industrial or commercial nature can be managed as such waste materials are routinely handled. Therefore, the committee considered that it could not contribute additional advice regarding their management.

Throughout the report, findings and recommendations follow the relevant discussion.

REFERENCES

OTA (Office of Technology Assessment). 1992. Disposal of Chemical Weapons: An Analysis of Alternatives to Incineration. Washington, D.C.: U.S. Government Printing Office.

NRC (National Research Council). 2002. Closure and Johnston Atoll Chemical Agent Disposal System. Washington, D.C.: The National Academies Press.

NRC. 2008. Review of Secondary Waste Disposal Planning for the Blue Grass and Pueblo Chemical Agent Destruction Pilot Plants. Washington, D.C.: The National Academies Press.

2

Overall Closure Planning for Baseline Facilities

BACKGROUND

Successful closure of the baseline chemical agent disposal facilities will require programmatic, facility-specific, and task-level planning. At the program level, the U.S. Army's Chemical Materials Agency (CMA) management staff has articulated certain expectations it has of each site preparing to undergo site closure through its Strategic Plan for 2010 to 2015 and other CMA policy guidance (CMA, 2009). Closure planning by each of the four chemical agent disposal facilities must integrate these expectations while addressing the unique or specific processes and circumstances that exist at each site.

Plans for all four of the baseline facilities must address the safety of workers and the community and the requirements of applicable regulations. In addition, they must include, at a minimum, the following planning elements:

1. An overall site-specific closure plan that describes, at a high level, the closure strategy for the site, consistent with any articulated CMA direction;
2. A decommissioning plan that describes the process to take the facility, including units and equipment out of service;
3. A decontamination plan that addresses how hazardous substances (both agent and non-agent) will be removed or destroyed prior to demolition and subsequent management of waste/material; and
4. A demolition plan that describes the approach to removing equipment and razing structures.

The committee asked the Army to provide the status of planning for each of the above key elements and several other associated facility-specific planning elements, shown in Column 1 of Table 2-1, for each baseline facility. The Army's response is provided in Columns 2 through 6 of Table 2-1. Planning components completed as of June 16, 2010, when the committee ceased gathering information, are indicated in Table 2-2. As shown, each of the facilities is in a different state of closure planning. Site-specific closure planning is most advanced at the Pine Bluff facility, followed by the Umatilla, Anniston, and Tooele facilities, respectively. Relevant to the statement of task, most of the planning components in Tables 2-1 and 2-2 were not yet developed for the Tooele facility by this date.

PROGRAMMATIC PLANNING

A programmatic plan sets CMA leadership's standards and expectations for closure planning at the four baseline facilities. The committee believes that at a minimum, a programmatic plan should include: any pertinent Army policy statements, goals and metrics, expectations on safety and regulatory requirements, and quality assurance.

Key Parameters, Metrics, and Goals—The Army's Definition of Success

It is critical to the success of any program to identify what is important; put simply, "What does success look like?" A key mechanism for the realization of an

TABLE 2-1 Status of Closure Planning Documentation for Each Baseline Chemical Agent Disposal Facility

Planning Component	Anniston Chemical Agent Disposal Facility (ANCDF)	Pine Bluff Chemical Agent Disposal Facility (PBCDF)	Tooele Chemical Agent Disposal Facility (TOCDF)	Chemical Agent Munitions Disposal System (CAMDS)	Umatilla Chemical Agent Disposal Facility (UMCDF)
Site Facility Closure Plan (FCP)	The RCRA FCP has been submitted, approval expected in January 2011. Final plan will follow this approval, estimated for March 2011.	The Facility Closure Plan (PB-PL-110) was issued in February 2010.	The FCP is scheduled for issuance in September 2010.	Scope is captured in the Facility Decontamination and Disposition Plan (FDDP) issued in March 2010.	The FCP is included in the Decommissioning Plan (UM-PL-108) issued in May 2010.
Closure Planning Implementation Strategy (CPIS)	The ANCDF CPIS was issued in November 2008.	The CPIS is included in the FCP (PB-PL-110) and in the Decommissioning Plan (PB-PL-108) issued in February 2010.	The CPIS is included in the FCP that is scheduled for issue September 2010 and in the Decommissioning Plan (scheduled for issue in August 2010). For the preparation of the CPIS TOCDF used the Capstone document that was developed during the Programmatic Closure Project, the CMA closure guide, and other programmatic documents as a basis.	Scope is captured in the FDDP and was issued in March 2010.	The CPIS is included in the Decommissioning Plan (UM-PL-108) issued in May 2010.
Decommissioning Plan	The ANCDF Decommissioning Plan is included in the Facility Disposition Plan issued on March 29, 2010.	The PBCDF Decommissioning Plan (PB-PL-108) was issued in February 2010.	The Decommissioning Plan is part of the FDDP. The FDDP is scheduled for issuance in August 2010.	This scope is captured in the FDDP issued in March 2010.	The Decommissioning Plan (UM-PL-108), rev. 1, was issued in May 2010.
Decontamination Plan	ANCDF is updating the Decontamination Plan that was included in the Permit modification that was submitted to ADEM for review on April 29, 2010. Approval is expected by March 2011.	The Decontamination Plan (PB-PL-118) was issued on February 12, 2010.	The Decontamination Plan is part of the FDDP. The FDDP is scheduled for issuance in July 2010.	This scope is captured in the FDDP issues in March 2010.	Content on decontamination was included in the RCRA FCP. ODEQ approval of the FCP is expected in September 2010.
Demolition Plan	In lieu of a separate distinct Demolition Plan ANCDF will provide detailed demolition scope of work in the Closure Work Proposal and Engineering Work Packages for the areas to be demolished along with an Estimate and a Request for Proposal to be put out for bid to qualified demolition contractors. The detailed packages for the MDB and the Pollution Abatement Areas (the only areas to undergo mass demolition) are due to be issued by June 1, 2011.	The Demolition Plan will be addressed in the Final Site Decontamination Decommissioning and Demolition (DDD) Package (DDD-16-040). Issuance of this plan is estimated in January 2011.	The TOCDF Demolition Plan is part of the Demolition and Disposition Plan. Issuance on this plan is estimated in September 2010.	The CAMDS Demolition Plan is being developed with the TOCDF Demolition and Disposition Plan and is scheduled to be issued in September 2010.	Content on demolition was included in the RCRA FCP. This plan is currently under review by ODEQ. (PMR-09-006). Approval is expected in September 2010.

Continued

TABLE 2-1 Continued

Planning Component	Anniston Chemical Agent Disposal Facility (ANCDF)	Pine Bluff Chemical Agent Disposal Facility (PBCDF)	Tooele Chemical Agent Disposal Facility (TOCDF)	Chemical Agent Munitions Disposal System (CAMDS)	Umatilla Chemical Agent Disposal Facility (UMCDF)
Regulatory Closure Plan	The RCRA Closure Plan was submitted to ADEM as part of the Permit modification submitted to ADEM in April 2010. Approval is expected in January 2011.	This plan is included in the FCP and in the Decommissioning Plan (PB-PL-108) that were issued in February 2010.	The RCRA Closure Plan is scheduled for submittal in June 2010. Approval is expected in December 2010.	The CAMDS RCRA Closure plan was approved by DSHW on February 25, 2010.	The RCRA Closure Plan update has been submitted to ODEQ (PMR-09-006). Approval is expected in September 2010.
Programmatic Documents Review (TOCDF)	The TOCDF programmatic documents have been made part of the site library and are continuously used for development of closure work packages.	PBCDF continually evaluates Closure Lessons Learned during DDD package development. Programmatic documents are addressed in the Facility Closure Plan (PB-PL-110), as appropriate. A set of parallel programmatic documents were prepared for PBCDF and are maintained for internal use at PBCDF during development of the DDD packages. This effort is ongoing.	This review task is being performed as part of the development of the Facility Closure Plan.	This is being performed as part of the TOCDF effort. There were site-specific documents developed for CAMDS modeled from the TOCDF programmatic documents that are being used internally.	Because of the similarities between the TOCDF and UMCDF, Umatilla conducted an in-depth review of TOCDF programmatic documents and has developed work plans for closure making extensive use of these documents.
Personnel Planning	A Transition De-staffing Plan is planned to be incorporated into the Closure Integrated Master Schedule in September 2010.	De-staffing plans are under development at PBCDF. Issuance is anticipated in August 2010.	De-staffing plans are being addressed via a Human Resources initiative. A Project Management Plan has been approved for this effort and a schedule is being developed for issue by September 2010. High-level de-staffing plans have been communicated to the workforce via Visions and Values meetings held in March 2010. This was also communicated to the Citizens Advisory Commission in March and will be updated in the Fall of 2010.	De-staffing planning for CAMDS is part of the overall TOCDF planning effort.	The UMCDF De-staffing Plan has been drafted. Issuance is expected in July 2010. A Transition Plan is in draft; issuance is expected in July 2010.
Closure Safety Plan (CSP)	ANCDF will use the existing plan with appropriate revisions. Revision is scheduled for March 2011.	The CSP is addressed under the System Safety Implementation Plan Volume II (PB-PL-025), the Occupational Health and Hygiene Plan Volume II (PB-PL-027), and the Accident Prevention Plan Volume II (PB-PL-039).	Closure safety plans will be summarized in the Facility Closure Plan, expected for issuance in September 2010.	Safety planning for CAMDS Closure utilizes safety plans and procedures incorporated from TOCDF.	UMCDF will use the existing plan, revised to address unique closure conditions. Issuance of the revision is expected in October 2010.

TABLE 2-1 Continued

Planning Component	Anniston Chemical Agent Disposal Facility (ANCDF)	Pine Bluff Chemical Agent Disposal Facility (PBCDF)	Tooele Chemical Agent Disposal Facility (TOCDF)	Chemical Agent Munitions Disposal System (CAMDS)	Umatilla Chemical Agent Disposal Facility (UMCDF)
Public Participation Plan	ANCDF encourages public participation in round table meetings, to be held in the community, with the goal of discussing the impact of ANCDF closure on the employees and the community in general.	Public participation in PBCDF closure planning is addressed in the Facility Closure Plan (PB-PL-110). This plan is scheduled to be issued June 25, 2010.	Public participation is being addressed as part of the human resources initiative. A Project Management Plan has been approved for this effort and a schedule is being developed for issue by September 2010. Also closure discussions took place with the Citizens Advisory Commission in March and will be addressed again in the Fall of 2010.	Public participation for CAMDS is being addressed along with the TOCDF effort.	UMCDF does not plan to develop a self-standing public participation plan. Continued community participation in both Land Reuse Authority coordination meetings and in routine Citizens Advisory Commission meetings will form the basis for public participation in UMCDF closure plans.

NOTE: ADEM, Alabama Department of Emergency Management; ANCDF, Anniston Chemical Agent Disposal Facility (Alabama); CAMDS, Chemical Agent Munitions Disposal System (Utah); CPIS, closure planning implementation strategy; CSP, closure safety plan; DSHW, Division of Solid and Hazardous Waste (Utah); FCP, facility closure plan; FDDP, facility decontamination and disposition plan; MDB, munitions demilitarization building; ODEQ, Oregon Department of Environmental Quality; PBCDF, Pine Bluff Chemical Agent Disposal Facility (Arkansas); RCRA, Resource Conservation and Recovery Act; TOCDF, Tooele Chemical Agent Disposal Facility (Utah); UMCDF, Umatilla Chemical Agent Disposal Facility (Oregon).

SOURCE: P.C. Mohondro, URS Programmatic Closure Planning Manager, with input from R.J. Gramatges, URS Specialty Group Manager, and from the ANCDF, CAMDS, PBCDF, TOCDF, and UMCDF Site Closure Managers, June 2010.

TABLE 2-2 Closure Planning Documents Completed by June 16, 2010, for Each Baseline Chemical Agent Disposal Facility

Planning Component	Anniston Chemical Agent Disposal Facility (ANCDF)	Pine Bluff Chemical Agent Disposal Facility (PBCDF)	Tooele Chemical Agent Disposal Facility (TOCDF)	Chemical Agent Munitions Disposal System (CAMDS)	Umatilla Chemical Agent Disposal Facility (UMCDF)
Site Facility Closure Plan (FCP)	✔	✔		✔	✔
Closure Planning Implementation Strategy (CPIS)	✔	✔		✔	✔
Decommissioning Plan	✔	✔		✔	✔
Decontamination Plan	✔	✔		✔	✔
Demolition Plan					
Regulatory Closure Plan	✔	✔		✔	✔
Programmatic Documents Review (TOCDF)	✔	✔		✔	✔
Personnel Planning					
Closure Safety Plan (CSP)	✔	✔			✔
Public Participation Plan	✔	✔			✔

NOTE: The committee ceased data gathering for this study on June 16, 2010.

organization's view of success is the establishment of key parameters and metrics. The management of the closure of the four baseline facilities is a complicated task requiring diverse teams at multiple sites around the country to advance the program in a way that ensures the safety and protection of workers and communities. The establishment of key parameters and metrics sends a message from the CMA headquarters staff about what the program leadership feels is critical to the success of the facility closure phase of the program. Key parameters and metrics are also an important mechanism to unify and integrate approaches across the four baseline facilities.

Initially, CMA envisaged a programmatic plan developed for the Tooele Chemical Agent Disposal Facility that would serve as the basis for plans for the other facilities. This plan was never completed when it was determined that the Tooele Chemical Agent Disposal Facility would not, as previously discussed, be the first facility to undergo closure.[1] Parts of the plan do exist and serve as a basis for planning as deemed appropriate by each facility. The closure managers and their senior staffs for the baseline facilities coordinate their activities both with a weekly conference call and regular in-person coordinating meetings. It appears to the committee that the senior closure managers are very competent in coordinating and carrying out the planning activities. However, each facility is developing its plans to meet its particular situation. This is to be expected because of the particular situations at each facility. But it would appear that some guidance from senior CMA management in policy-critical areas such as the unventilated monitoring test (see Chapter 6) would promote uniformity of approach and execution of planning and, as a result, the closure operations. The committee believes that at a minimum the programmatic plan should include goals and metrics, Army policy, expectations on safety and regulatory requirements, and quality assurance.

Finding 2-1. The closure managers and their teams appear to be highly competent and to coordinate their needs and approaches well through frequent contacts and meetings. Each site is taking its own approach to the planning activities because of differing end use, facility, and regulatory situations. There does not appear to be sufficient senior policy guidance in key issues such as the critical unventilated monitoring test.

[1] Personal communication between Rafael Gramatges, Specialty Group Manager, URS, and Peter Lederman, committee chair, June 16, 2010.

Recommendation 2-1. Senior Chemical Materials Agency management should provide policy guidance for closure in critical areas such as the unventilated monitoring test to ensure that these critical activities are planned and executed in a uniform manner across all facilities.

In addition to parameters and metrics, it is desirable and appropriate to establish measurable goals, or "targets." Clearly articulated goals send strong messages from the CMA leadership and may also be used to drive continuous improvement. The committee discusses parameters in Chapter 3.

Finding 2-2. The Chemical Materials Agency's Strategic Plan for closure of baseline chemical agent disposal facilities identifies a number of parameters and metrics, but it does not articulate measurable goals (targets) against which progress will be tracked. Goals drive behavior and performance. For example, the Army measures 12-month rolling recordable injury rates. However, it is not clear to the committee whether the Army establishes a target for reduction of the recordable injury rate. Similarly, the Army measures schedule slippage, but it is not clear whether it wants to reduce schedule slippage by a certain amount over some period of time.

Recommendation 2-2a. Parameters and the associated metrics for successful closure of the Army's baseline chemical agent disposal facilities should be established at the programmatic (headquarters) and site (project) levels of the chemical stockpile disposal program administered by the Chemical Materials Agency. While the strategic plan addresses key parameters that will be tracked at the headquarters level, the committee recommends that parameters be established at the project level that are consistent with the strategic parameters. These parameters should be tracked and measured at the project level at each of the baseline facilities.

Recommendation 2-2b. The Army should develop specific and quantifiable targets for parameters important to the overall chemical stockpile disposal program and for which the Chemical Materials Agency headquarters wants to drive improvement.

Essential Program Elements and Army Policy

Programmatic closure planning must provide the foundation for the development of site-specific closure plans, ensuring consistency in approach and establishing requirements of those critical elements that should be evaluated and integrated into every site specific plan. Further, any specific policies or strategies that the Army would like to see executed in site-specific closure plans should be articulated in programmatic planning.

The CMA's "Strategic Plan: Fiscal Years 2010–2015," November 2009, describes the vision and mission of the Programmatic Closure Planning process (CMA, 2009). This document articulates a vision that "Creates a safer tomorrow by making chemical weapons history." It further articulates the strategic processes that the Army will use to develop its programmatic approach as well as establishing management systems to measure progress toward the CMA vision and mission.

A December 17, 2008, Memorandum from the Chief, Secondary Waste, Closure Compliance and Assessment, titled a "Program Manager for Chemical Stockpile Elimination (PMCSE) Chemical Disposal Facility Closure Strategy," describes the PMCSE's vision for closure (O'Donnell, 2008). This strategy emphasizes the importance of safety and seeks also to minimize cost and schedule by encouraging mass demolition to the greatest extent possible. Mass demolition enables use of mechanical deconstruction employing conventional construction equipment to remove structures and minimizes human actions required for deconstruction. The memo states, "Put in simplest form, the strategy uses in situ decontamination followed by confirmatory head-space monitoring as a gateway to mass demolition of the facility" (O'Donnell, 2008).

Finding 2-3a. The Chemical Material Agency's (CMA's) "Strategic Plan: Fiscal Years 2010–2015," November 2009, describes the Army's vision and mission for the programmatic closure planning process. This document also articulates the key parameters and metrics that the Army will measure and evaluate at the headquarters level. These key parameters include safety, schedule, and cost. The CMA's "Policy Statement #21, Strategic Baseline Accountability," March 8, 2010, sets forth the Army's expectations on accountability and reporting of key parameters to CMA leadership.

Finding 2-3b. The Chemical Materials Agency has placed high importance on implementing mass demolition, a strategy that has positive implications for safety, cost, environmental impact, and scheduled completion of the project.

Finding 2-3c. Waste characterization (both agent and non-agent), decontamination, and associated confirmation monitoring are critical to the safe execution of the Chemical Materials Agency strategy for closure.

Recommendation 2-3. The Chemical Materials Agency's closure strategy to emphasize mass demolition should continue to be actively pursued. However, this strategy should be supported in planning and execution by testing and monitoring necessary for successful execution of the strategy.

Waste characterization is discussed more fully in Chapters 5 and 6. The Army is proposing to decontaminate the buildings by first removing some of the equipment, then checking for agent contamination, and, as necessary, decontaminating surfaces using standard caustic decontamination solutions (O'Donnell, 2008). This process will be followed by locating occluded spaces where agent could be sequestered, and then opening and decontaminating those spaces. Finally, ventilated and unventilated monitoring tests, which are discussed in detail in Chapter 6, will be performed.

FACILITY-SPECIFIC CLOSURE PLANNING

The major planning components that the committee believes are necessary to execute a safe and successful site closure are listed in Figure 2-1. Starting with the end use in mind, each facility will need to develop: an overall facility closure plan, decommissioning plans, decontamination plans, demolition plans, and materials and waste disposition plans.

Each of these "phase" plans should incorporate safety and health, personnel planning (retention, skill sets, etc.), public participation, regulatory requirements, and any requirements specific to the Army. Program parameters and metrics should be established and cascaded down from CMA to the facilities. Targets should be established and the metrics monitored for achievement and updating where the Army seeks to drive continuous improvement. Each facility should report performance against parameters and any established goals back to CMA. Lessons learned should be continually evaluated and incorporated into all components of site closure planning. Incorporating lessons learned from prior facility closures, such as the Johnston Atoll Chemical Agent Disposal System, is critical to continuous improvement and ensuring overall success of the closure program. The committee discusses lessons learned in more detail in Chapter 4.

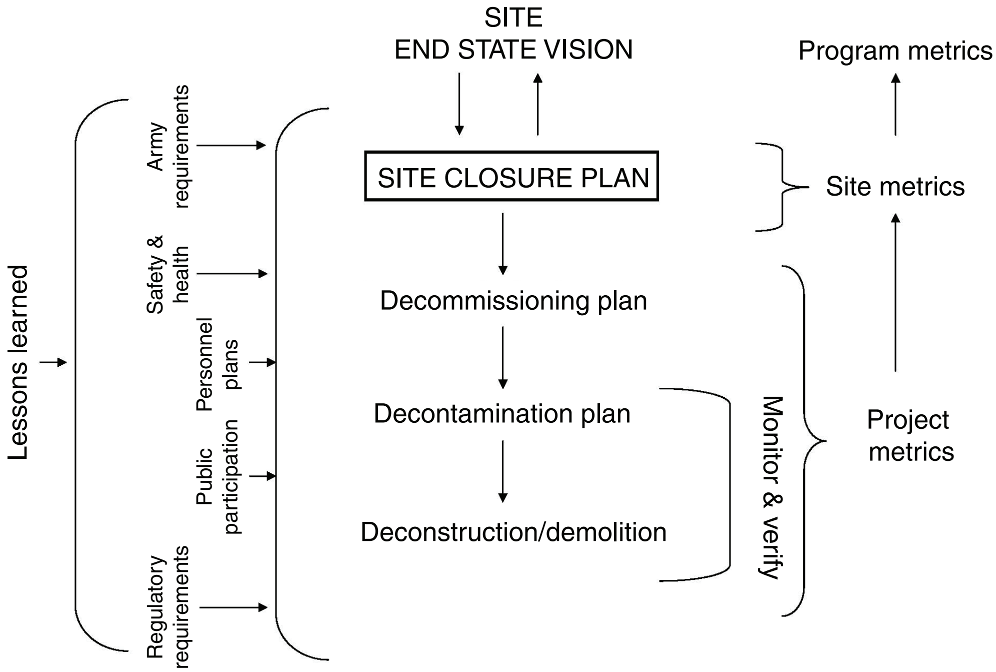

FIGURE 2-1 Site-specific closure planning.

Each of the four baseline facilities is in the process of developing key site-specific documents that will contribute to overall success at both the site level and the programmatic level. However, each site is at a different stage of development of the closure planning documents. Therefore, it is difficult to compare the plans.

Based on a review of existing planning documents, the key elements of site-specific closure planning are discussed below and shown in Figure 2-1.

Safety

The committee believes that the plan for each phase of work should incorporate industry-wide best practices to achieve the Army's safety objectives. As the work toward closure progresses and a facility transitions from chemical agent demilitarization operations to decommissioning to decontamination and ultimately demolition, the competencies and skill sets needed to safely accomplish the work will change. During demilitarization, most activities are standardized and repetitive. As sites progress into closure activities, the types of work hazards will change. The level of personal protective equipment necessary will decrease as closure progresses and the facility is decontaminated. The potential hazards will change from agent-related exposures to hazards associated with deconstruction. Further, workers who will be involved in these different phases of closure need to understand the different risks that will be encountered and the different health and safety requirements as closure proceeds.

In discussions with site and CMA staff, the committee learned about the strong commitment to safety by those involved in the process, and the committee lauds this commitment. In reviewing many documents, the committee has seen safety integrated throughout top level documents, including the CMA Strategic Plan and the "Program Manager for Chemical Stockpile Elimination (PMCSE) Chemical Disposal Facility Closure Strategy," as well as in specific work procedures (O'Donnell, 2008). The committee recognizes that the CMA's strategy of in situ decontamination followed by mass demolition will reduce hazards as decontamination activities progress, but that changing hazards related to new and different work processes will result.

Project team members responsible for the execution of the work should be trained to recognize situations in which something unexpected is occurring, and they should have the authority to initiate work stoppages in these situations. Further, team members should be prepared to expect an investigation or decision by the project manager before proceeding.

Personnel

There is an active program in place, fashioned after one used at JACADS, to retain and maintain the well-trained workforce with bonus incentives. As the facilities transition from demilitarization operations to closure, there are likely to be personnel challenges, including losses of talented, competent employees before the completion of closure activities. There will also be a need to retrain current employees to work in a less production-focused, more construction-focused environment. Training of personnel (new or existing) who will be involved in the progression of activities from demilitarization to closure is essential. Furthermore, management of workforce needs and the potential loss of jobs will likely be a key issue in surrounding communities.

Finding 2-4. There are numerous personnel challenges associated with the transition of the baseline chemical agent disposal facility sites from demilitarization operations to closure that include retention of personnel; retraining and matching of skills and competencies of existing workers to new work; and integration of new personnel into the site closure process. Personnel retention and training, and the management of changing personnel, are critical to program success.

Recommendation 2-4. The management at each baseline chemical agent disposal facility must develop a personnel planning document that addresses retention of personnel; matches the skills and competencies of the current workforce to future work; retrains current personnel to the new work processes; and integrates new personnel to facility safety procedures.

Public Participation

In general, environmental issues associated with closure are not a major concern of the communities surrounding the demilitarization facilities addressed in this report.[2] However, the communities are concerned that the end of demilitarization operations will lead to workforce layoffs and associated economic consequences. Furthermore, the communities are to varying degrees concerned about issues related to cleanup of areas of depots that are outside the chemical disposal facilities, corrective action, and related disposal activities, but those issues are for the most part beyond the scope of the task for this committee. As a site executes its deconstruction and demolition plans, there is the potential for additional truck traffic. There may also be concerns about management of noise or dust. It is important that the local government and community at large be informed of and engaged in preparing for these possibilities before they occur.

The committee believes that in some cases the public may express concerns over the disposition of materials that may have been exposed to chemical agent. On the one hand, where the public believes waste materials contain agent or other highly toxic substances, they may advocate additional treatment and/or more restrictive disposal practices. On the other hand, where the public believes that materials have been shown to be clean, the committee, based on years of observing recycling activities, judges that the public is likely to support reuse or recycling.

In general, given the anticipated future uses of the chemical agent disposal facility sites and the absence of groundwater contamination associated with demilitarization (USACHPPM, 1999), host communities are expected to accept closure standards based upon industrial/commercial future uses.

At Umatilla, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) have made their position on closure standards clear. The CTUIR assert their rights under the Treaty of 1855 to the customary use of ceded lands and their resources, including the entire Umatilla Chemical Depot (UCD). The tribes insist that the U.S. government "protect the interests of the CTUIR by ensuring that lands, water, soil, air, biological, and cultural resources are clean and safe to use" (CTUIR, 2008, p. 1). In general, CTUIR believes that the land should be restored by the Army to its 1855 condition, so as to support hunting, gathering, fishing, and other cultural practices, and to protect the area's water resources.[3] The proposed reuse plan for the UCD sets aside large tracts for management by the U.S. Fish and Wildlife Service and the Oregon National Guard,

[2]Committee members visited and met with members of local communities at Deseret and Anniston, monitored news reports from all four sites, and discussed community input with Army and contractor personnel.

[3]Tribal governments, in addition to their possible role as regulators, have a distinct decision-making role to play as derived from rights that are specified in treaties with the U.S. government. In some instances, these treaty rights may result in legally binding obligations on the part of the U.S. government that must be accounted for during the conduct of federal facility cleanup activities (FFERDC, 1996).

and the tribes expect access to those lands—although use of the National Guard's ranges may be limited in both time and space.

However, the actual chemical agent disposal facility is proposed for transfer to the Port of Umatilla for industrial use, and the tribes acknowledge that this area, largely paved, should be remediated only to industrial standards.[4] The CTUIR believes that cleanup resources could be better spent sampling and, if necessary, remediating open lands it believes to be contaminated by the deposition of emissions from the demilitarization incinerators. The tribes have submitted a sampling and analysis plan in support of that goal (CTUIR, 2009). They view investigation and cleanup of surrounding UCD property as an essential part of the chemical agent disposal facility closure.

While public concerns over closure, beyond those of the CTUIR, have not yet crystallized, it is essential that the Army and its contractors remain prepared for other issues to arise and continue their extensive community relations activities at all four baseline facilities. Any mishap associated with closure would immediately heighten public concern at these sites and prompt more intense oversight. In the committee's earlier letter report (Appendix A), it recommended that the Army work with the Utah Citizens Advisory Commission (CAC) "to establish a continuing, constructive public involvement [program] between the end of demilitarization and formal closure." Since then the Army has explained that it intends to extend the life of the CACs through closure. The committee is pleased with this decision and hopes that the public members of those bodies will continue their efforts after completion of their original mission: oversight of demilitarization.

Finding 2-5. At each of the four baseline chemical agent disposal facility sites, the Army has created a successful community relations and public participation program through its Citizens Advisory Commission, Outreach Office, and other forums. The Army plans to continue these essential activities through closure.

Recommendation 2-5. The committee supports the Army continuing public involvement during closure and recommends an active program to address public concerns by promoting public awareness and participation.

Regulatory Drivers and Work Planning for Compliance

Each site will be subject to state, federal, and local regulations, including, but not limited to, the Clean Air Act and the Resource Conservation and Recovery Act. There may be state-specific requirements, such as the Uniform Environmental Covenants Act in Alabama and Utah, that each site will need to integrate into site-specific closure plans. Each site will also need to consider the appropriate regulatory end point as required under federal and/or state laws and how best to meet those end points. Based on its experience, the committee believes that risk-based[5] approaches work best when the future site use and regulatory end points are integrated with the closure planning. Further, decommissioning plans that address the end of life of systems/equipment will need to be developed and conducted in accordance with the Resource Conservation and Recovery Act regulatory requirements. Issues associated with regulatory requirements and compliance are further discussed in Chapter 5.

FUTURE USE AND CLOSURE END-USE VISION

In order to effectively conduct closure, knowledge of the future use of the site (or area) is necessary. Indeed, the future use and end use must drive the plan, and the plan must be executed in a way that allows realization of the end use. Questions such as whether storage igloos or other structures will be reused, or whether or not the real property will continue as part of military operations, should be primary factors in the development of site-specific closure plans.

In addition, the Army needs to consider the assets that exist at a facility as well as the materials, waste, residues, and other media that exist or will be generated as part of the closure process. To be efficient, planning for reuse/recycling of assets, materials, waste, and

[4]Question-and-answer session with Rodney Skeen, Manager, Engineering and Modeling Program, Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation; and Todd Kimmell and Lenny Siegel, committee members, May 26, 2010.

[5]"Risk-based" closure means closure of a site to a level that results in minimal levels of risk to human health and the environment so as to require no further action or monitoring on the part of the responsible party nor any notice of hazardous waste management on the deed to the property.

residues should be integrated into the overall closure planning process.

Finally, if cleanup is required, knowledge of future site use can be employed to plan for risk-based cleanup that will ensure protection of those who will have access to the site in the future and will be cost-effective.

Documentation of Site History

In order to prepare the facility for decommissioning, dismantling, and demolition to achieve end-use requirements and to complete the work without incident or injury, it is essential to review the history of operational practices. This is necessary to establish engineering controls before initiating activities within a previously contaminated area, to determine surveys to be done to verify existing conditions—including occluded space surveys—and other operational activities such as decontamination of equipment and removal of liquids. A thorough review of agent and non-agent contamination history and lessons learned information obtained from interviews with site personnel will help facilitate safe closure activities.

The committee has been told by CMA and facility staff that there is detailed operational information on contamination history for each facility, and due to the stringency of the operational controls, there is good information on site history.

In addition to understanding documented site history, lessons learned from other sites further advanced in the closure process provide important information to understand regarding program history. See Chapter 4 for a discussion of lessons learned.

Finding 2-6. An accurate site history is important to safe and environmentally sound closure. Site-specific records on spills and releases, detailed operational site contamination historical information, and programmatic lessons learned are important to understanding a site's history.

Recommendation 2-6a. The programmatic closure plan and the site-specific plans should ensure that all available information on site history as well as lessons learned are incorporated into closure planning.

Recommendation 2-6b. Even though a great amount of site history is available, each site should develop a site contingency plan to deal with finding agent contamination where testing does not indicate its presence in the event that the documented site history proves to be incomplete or inaccurate.

Selection of Decontamination Methods

Selection of decontamination methods includes preparation of an equipment decontamination plan and identification of the appropriate methods to be used for decontamination, procedures to document decontamination, and the future uses planned for the equipment and the appropriateness of the decontamination criteria employed. Decontamination methods and monitoring are explored further in Chapter 6.

Decontamination

Decontamination is the removal of hazardous substances (agent and non-agent) that have been deposited or absorbed on internal and/or external surfaces at a facility by use of air-washing, chemical, mechanical, and/or thermal methods. In order to determine the most effective method for decontamination, the plan should consider the documented site operational history, worker and community safety, regulatory requirements, and waste management (whether disposal or reuse/recycling).

Occluded Space Survey

The occluded space survey is designed to identify locations where agent liquid may have accumulated to ensure effective decontamination. Successful completion of the occluded space survey is key to the mass demolition strategy. A detailed discussion is found in Chapter 6.

Demolition and Equipment/Debris Removal

Prior to mass demolition, equipment that has been determined to be contaminated must be dismantled and decontaminated. Similarly, equipment or materials areas that are intended to be reused or redeployed must be identified and decontaminated. If decontamination of any item in the area, such as equipment, equipment support, or concrete floor, is not possible, the item should be removed and managed as hazardous waste. Subsequent to dismantling, decontamination, and confirmatory monitoring, the facility/structure is prepared for mass demolition by deactivating all utilities to the area to be decontaminated and isolating the utilities that may be located in the utility corridor. Demolition refers to the mechanical removal of structures with conventional construction equipment and industrial demolition techniques. Planning documents that address mass demolition will need to consider dust suppression, noise, and traffic studies and plans. As discussed above, the Army's preference is to move toward mass demolition in order to improve safe working conditions and to minimize manual labor.

Cost and Schedule

Integrated cost and schedule should be tracked at the program level. It is important to forecast and track cost and schedule against the project schedule and allotted budget. The committee heard from Army and contractor staff that they currently use project tracking tools such as earned value to measure progress against scope, schedule, and budget.[6] Earned value is a commonly accepted project management tool.

Closure Project Management and Closure Team

The experience of committee members is that for successful project execution, the project management quality assurance document, in addition to the project organization chart, should clearly indicate the roles and responsibilities of the project team members. The decommissioning work packages should contain steps such as daily (or as necessary) project briefing before starting a task and hold points for effective project control. This is also a good opportunity to reflect on health, safety, and security issues.

Finding 2-7. It was not evident to the committee that a project quality assurance plan for closure was developed for every baseline chemical agent disposal facility site.

Recommendation 2-7. The Army should create a project management quality assurance plan for each baseline chemical agent disposal facility site, describing the project organization, accountability, and lines of responsibilities for closure project execution for routine and unforeseen work situations.

REFERENCES

CMA (U.S. Army Chemical Materials Agency). 2009. Strategic Plan Fiscal Years 2010–2015 Revision 0. Aberdeen Proving Ground—Edgewood Area, MD. Washington, D.C.: Chemical Materials Agency.

CTUIR (Confederated Tribes of the Umatilla Indian Reservation). 2009. Annual Report. Pendleton, OR: Confederated Tribes of the Umatilla Indian Reservation.

CTUIR. 2008. Annual Report. Pendleton, OR: Confederated Tribes of the Umatilla Indian Reservation

FFERDC (Federal Facilities Environmental Restoration Dialogue Committee). 1996. The Final Report of the Federal Facilities Environmental Restoration Dialogue Committee: Consensus Precipices and Recommendations for Improving Federal Facilities Cleanup. Available online at http://epa.gov/fedfac/fferdc.htm. Last accessed August 4, 2010.

O'Donnell, B. 2008. Memorandum: Program Manager for Chemical Stockpile Elimination Chemical Disposal Facility Closure Strategy. Closure Compliance and Assessments, Chemical Materials Agency.

USACHPPM (U.S. Army Center for Health Promotion and Preventive Medicine). 1999. Derivation of Health-based Environmental Screening Levels for Chemical Warfare Agents, A Technical Evaluation. Aberdeen Proving Ground, MD: U.S. Army CHPPM.

[6] Personal communication between Carla Heck, Project Manager, URS, and the committee, January 27, 2010.

3

Important Parameters for Successful Closure

BACKGROUND

The committee provided a series of key parameters for overall management of the current and upcoming chemical agent disposal facility closures in an earlier interim letter report (Appendix A). As an initial basis for developing these parameters, the committee considered the lessons learned by the U.S. Army Chemical Materials Agency (CMA) from closure of the Johnston Atoll Chemical Agent Disposal System (JACADS), which was the first full-scale incineration-based disposal facility. The Aberdeen Chemical Agent Disposal Facility (ABCDF), which was the first neutralization-based disposal facility, and the Newport Chemical Agent Disposal Facility (NECDF), another neutralization-based facility, were also considered.

The committee has modified the original list of parameters given in the interim report and developed a structured approach that presents the parameters and the associated metrics more effectively. Using these in conjunction with the experiences gained from previous closures, along with earlier programmatic plans for closure of TOCDF and CAMDS and the knowledge and experience of the committee members, the committee developed recommendations that it believes can improve the current and future closures of disposal facility sites. It is imperative to track the critical criteria, including the agency and regulatory requirements, necessary to successfully managing a closure project.

The committee continues to emphasize that the foremost goal of the parameters and metrics is to promote a safe and successful program for facility closure. To accomplish this, the effective use of well-developed management reports can serve as a feedback mechanism for the continuous improvement of closure activities and, where necessary, can serve as a mechanism for stopping work until appropriate corrective actions can be made. The role of a management reporting process is best described by the plan-do-check-act cycle used by many organizations and described at the American Society for Quality website.[1] As originally identified in the interim letter report, metrics are of two kinds: leading metrics, which help to predict performance, and lagging metrics, which indicate the actual performance. While the committee considers the listed parameters and corresponding metrics to be important, it notes that they need not be considered all-inclusive.

KEY PARAMETERS

The parameters in Table 3-1 and Table 3-2 are shown along with associated metrics as a starting point for the management of closure activities at the program and project levels. It is imperative that different parameters be tracked at the appropriate management and activity levels. This section develops a parameter framework for both the program and the project level that is defined later. The list of parameters has been revised from the original list in the interim letter report and includes

[1]A discussion of the plan-do-check-act cycle is found at http://www.asq.org/learn-about-quality/project-planning-tools/overview/pdca-cycle.html.

TABLE 3-1 Program-Level Parameters and Metrics

Metric	Definition	Type
Safety, Health, and Security		
Near-miss	Number of unsafe conditions	Leading
Incident investigations completed within 30 days	Percent complete	Leading
Cross-training for workforce/supervisors	Percent complete	Leading
Random drug testing	Percent complete	Leading
Occluded space survey process	Yes/No	Leading
Unventilated monitoring test process	Yes/No	Leading
Numbers of recordable injuries (RIs)	Number	Lagging
Number of lost workday cases	Number	Lagging
Days away from work due to workplace incident/injury	Number	Lagging
Fatalities (all causes)	Number	Lagging
Training and Development		
Continuing education	Hours/year	Leading
Communication		
Safety culture survey	1-5 scale	Leading
Leadership communication sessions	Number/year	Leading
Cost		
Federal requirements	Standard metrics	Lagging
Program cost objectives	Program cost targets metrics	Lagging
Schedule		
Schedule status	Percent complete	Lagging
Earned value	Compare progress to expenditures	Lagging
Environmental Compliance		
Establish facility future use for all sites (RCRA and BRAC)	Yes/No	Leading
Establish RCRA closure performance standards for all sites	Yes/No	Leading
Develop RCRA permit closure plan for all sites and coordinate with state regulators	Yes/No	Leading
Develop supplemental closure plans at each site and coordinate with state regulators	Yes/No	Leading
Develop plan in coordination with state regulators at each site to minimize waste/maximize reuse and recycling	Yes/No	Leading
Develop plan in coordination with state regulators at each site for disposition of waste	Yes/No	Leading
Management		
Develop roles and responsibilities for key personnel	Yes/No	Leading
Develop quality assurance management program including design control, training, document control, revision control, performance review, and internal audits for a comprehensive quality assurance program	Yes/No	Leading

TABLE 3-2 Project-Level Parameters and Metrics for the Chemical Agent Disposal Facilities

Metric	Definition	Type
Safety, Health and Security		
Near-miss	Number of unsafe conditions	Leading
Incident investigations completed within 30 days	Percent complete	Leading
Cross-training for workforce/supervisors	Percent complete	Leading

TABLE 3-2 Continued

Metric	Definition	Type
Appropriate personal protective equipment for all tasks	Yes/No	Leading
Closure of open safety items in a timely manner	Percent complete	Leading
First aid cases	Number	
Recordable injuries and exposures[a]	Number	Lagging
Lost-time injuries[a]	Number	Lagging
Fatalities (all causes)	Number	Lagging
Hazardous assessment plan	Yes/No	Leading
Occluded space survey #1	Yes/No	Leading
Occluded space survey #2	Number of failures	Lagging
Unventilated monitoring test	Number of failures	Lagging
Maintenance		
Planning and scheduling all maintenance	Yes/No	Leading
Appropriate maintenance for deconstruction equipment	Percent complete	Leading
Appropriate calibration and checking of monitoring equipment	Yes/No	Leading
Preventive/predictive maintenance program for key equipment	Percent complete	Leading
Monitoring/audit of maintenance plan	Percent complete	Leading
Training and Development		
Cross-training for critical operation deconstruction positions	Yes/No	Leading
Proper certification for employees and contractors	Yes/No	Leading
Hazardous waste certification for appropriate workers	Yes/No	Leading
Workforce training on the facility and on non-normal situations	Yes/No	Leading
Workforce training for deconstruction personnel	Yes/No	Leading
Communication		
Schedule(s) communications with local citizens advisory commission	Yes/No	Leading
Proactive two-way communications with neighboring communities	Yes/No	Leading
Proactive and frequent communications by senior site personnel with the state regulatory personnel	Yes/No	Leading
Regularly scheduled two-way communications with workforce	Yes/No	Leading
Cost		
Periodic cost spending plan	Yes/No	Leading
Track costs to spending plan	Yes/No	Lagging
Schedule		
Develop project schedule milestones	Yes/No	Leading
Track engineering changes	Percent complete	Lagging
Track project schedule milestones	Percent complete	Lagging
Environmental Compliance		
Establish closure performance standards for closure waste[b]	Yes/No	Leading
Closure plans included in RCRA permit, supplemented by more detailed plans[b]	Yes/No	Leading
Closure addressed in other applicable permits[b]	Yes/No	Leading
Approval of waste analysis plan and characterization protocols[b]	Yes/No	Leading
Approval of monitoring plans for other appropriate media	Yes/No	Leading
Establish where generator knowledge can be used[b]	Yes/No	Leading
Develop plans for optimizing reuse and recycling	Yes/No	
Develop protocols for segregation of hazardous and nonhazardous waste materials[b]	Yes/No	Leading
Monitor compliance with RCRA permit closure plan	Monitor percent compliance and notices of violation	Lagging
Monitor compliance with other permits	Monitor percent compliance and notices of violation	Lagging
	Yes/No	Leading
Management		
Develop effective records retention process	Yes/No	Leading
Regularly review lessons learned database for effectiveness	Yes/No	Leading
Review material management process including reuse/recycling	Yes/No	Leading

[a]OSHA requirement.
[b]Per state approval.

additional parameters from the list developed in the NRC report *Evaluation of Safety and Environmental Metrics for Potential Application at Chemical Agent Disposal Facilities* (NRC, 2009). That report served as an excellent framework for operating disposal facilities as well as a starting point for closure planning. Appendix B of the present report includes the complete list developed in that study. This current report expands the list with additional critical management parameters required for closure. The overriding purpose of the parameters and metrics is to instill a culture of continuous improvement for all aspects of closure and deconstruction, including safety, regulatory, and program and project management. The list developed by the committee is more complete than the one previously developed in the interim report; nevertheless, it still need not be considered all-inclusive. The following findings and recommendations are provided by the committee for consideration by the Army.

Finding 3-1. A formal and structured system of parameters and metrics, including leading as well as lagging metrics, provides important guidance for planning, organizing, and implementing efficient closure of baseline incineration chemical agent disposal facilities.

Recommendation 3-1. The Army should consider the parameters and metrics presented in this report as it plans and executes the closure of the baseline chemical agent disposal facilities.

Finding 3-2. Tracking and reporting parameters and metrics will facilitate the safe and successful management of the closure of the Army's baseline incineration chemical agent disposal facilities.

Recommendation 3-2a. At a minimum, the Army should track parameters and metrics used for disposal facility closure at two levels: the program level and the project level. Thereafter, it should determine whether additional parameters and metrics are required.

Recommendation 3-2b. The Army should ensure that appropriate and timely management reports are developed that enable tracking results for parameters and metrics to be used to make management decisions and take necessary actions.

Following is a summary of each of the categories of parameters.

Safety, Health, and Security

The CMA programmatic staff, along with the site management personnel and workers at chemical agent disposal facilities, continues to promote an operational culture focused on safety, health, and security. The performance record of the various sites during the disposal operations phase demonstrates the management focus and employee awareness of the safety programs. Table 3-3 summarizes site injury rates for the baseline chemical disposal sites through the first quarter of 2010. These data indicate the performance of operations management in maintaining a safe work environment. However, a major concern related to safety not present in the day-to-day operations is the new and nonrepetitive activities during closure, which can result in unexpected situations that present safety issues. An effective safety program for closure requires that both leading and lagging metrics be tracked, documented, reported in a timely manner, and communicated as part of the process. As reported in the interim letter report, satisfactory results concerning safety, health, and security are supported by the establishment of systematic data collection, site observations, incident reporting, and an effective investigation process. This requires the involvement of the entire organization from the programmatic and site management personnel, project planners, operational personnel, contractors, and all workers involved in the execution of the closure activities. As the site transitions from operations to closure, the potential for unforeseen/unexpected safety occurrences may increase in number and complexity, requiring close surveillance and awareness on the part of not only the closure teams but also the existing operations teams.

Maintenance

The successful closure of the baseline incineration disposal facilities requires correct execution of all maintenance work activities on equipment that will impact the closure. Execution includes effective planning and timely scheduling of all maintenance work on key equipment used for disposal operations, closure, and monitoring. In the deconstruction business, many safety and regulatory problems can be prevented through well-managed maintenance work processes. Additionally, negative impacts on schedule can be minimized when critical equipment is properly maintained. Benchmark studies have shown that results

TABLE 3-3 Chemical Demilitarization Site Recordable Injury Rates as of March 31, 2010

Facility	Employee Hours Worked Since Last LWC (hr)	Current 12-Month RIR	Highest 1-Month RIR[a]	Lowest 1-Month RIR[b]	Highest 12-Month RIR[c]	Lowest 12-Month RIR[d]
ANCDF	4.5 million (988 days)	0.69	5.18	0.0	1.75	0.27
NECDF	1.9 million (914 days)	0.33	4.45	0.0	1.95	0.18
PBCDF	3.0 million (770 days)	0.13	3.32	0.0	1.17	0.00
TOCDF	8.9 million (1,624 days)	0.76	14.54[e]/11.26	0.0	4.82	0.46
UMCDF	6.2 million (1,369 days)	1.06	3.83	0.0	2.25	0.34

NOTE: LWC, lost workday case; RIR, recordable injury rate.
[a]Highest 1-Month RIR in entire facility operational history.
[b]Lowest 1-Month RIR in entire facility operational history.
[c]Highest 12-Month RIR in entire facility operational history.
[d]Lowest 12-Month RIR in entire facility operational history.
[e]The higher number includes 11 cases of food poisoning that occurred at a safety celebration. The lower number excludes these 11 cases.
SOURCE: Cheryl Maggio, Deputy Project Manager Chemical Stockpile Elimination, CMA, May 28, 2010.

are optimized by having 80-85 percent of all required maintenance activities planned and scheduled.[2]

Training and Development

The basis for successful completion of closure of baseline chemical agent disposal facilities is the active involvement and proper preparation of each site's entire workforce. Strategic elements identified by the committee that should be tracked and reported include the employee selection, training, and development process.

The leading and lagging metrics provided in Table 3-1 for this parameter represent critical items that, when successfully addressed, will result in a more qualified workforce and a higher probability of success. For example, the technical aspects, complexity, and unique safety and environmental requirements of a facility closure mandate that the workforce be properly selected and prepared through education and training. That training drives performance results for new activities, especially when new personnel are involved, is a well-established fact, and closure will constitute a new activity at baseline chemical agent disposal facilities. The committee continues to believe that concerted efforts should be made to train the deconstruction workforce on hazards and awareness pertinent to the site and facility situations. Cross-training between personnel familiar with operations and individuals responsible for closure constitutes a critical interface for promoting safe and successful outcomes for closure activities. Training requirements for closure operations are very different from operational activities and therefore must be closely monitored. An example of the importance of workforce training is the criticality of the unventilated monitoring process for the closure facilities and the need to develop solid training materials (as discussed in detail in Chapter 6).

Communications

The committee believes that a strong, positive communication strategy engages a full range of stakeholders involved in the execution of the closure programs. The committee appreciates the strong, positive safety culture that has been developed at TOCDF, CAMDS, and other CMA sites, and it believes that that culture will continue into the closure phase as long as the frequent formal and informal sharing of information and ongoing dialogue continue. Additionally, the closure management must actively lead and support commu-

[2]A discussion of benchmark studies that establish optimal levels of maintenance is available online at http://www.reliabilityweb.com/excerpts/excerpts/Maintenance_Benchmarks.pdf. Last accessed July 1, 2010.

nications with all key stakeholders, including federal and state authorities and local community groups. Good communications build trust and provide more opportunities to understand the changing nature of risk. The committee has selected the metrics identified as critical to ensuring a proactive communication strategy.

Cost

Program cost objectives comprise a key strategic parameter for successful completion of the site closure as indicated in the committee's interim report for successful completion of the site closure. The committee was neither tasked nor provided with the financial data necessary to assess how the programs are progressing in terms of cost management. The committee believes strongly that the various levels of management, including CMA at the program level and the prime and subcontractors at the project level, should be able both to forecast anticipated costs and to effectively understand, manage, and explain all expenditures during the implementation of program and project work and have a robust cost control system. It is imperative that all federal financial requirements be met for the projects to be successfully undertaken in the closure and closure process.

Schedule

Based on the complexity and cost of the satisfactory completion of the chemical agent disposal facilities site closures, the committee believes that the leadership needs to develop and adhere to a comprehensive schedule. Additionally, how management addresses programs and project changes and delays within the closure process are critical to timely and cost-effective completion and are therefore identified as a parameter to be tracked. Safety becomes a critical item when tracking schedule changes and when pressure develops to complete an activity on time.

Environmental Compliance

Environmental compliance issues associated with the closure of the baseline chemical agent disposal facilities are a priority for management. The tracking of performance in this regard will be critical. The CMA closure team and the teams at each facility have evidenced a strong understanding of regulatory compliance and monitoring requirements. Key attributes for successful closure include obtaining regulatory agreement with the closure plans with the state authorities on a timely basis. This requires close coordination with the state regulatory community to obtain early agreement on the anticipated future use for the facility and the related closure performance standards that must be achieved. State environmental regulatory authorities have been engaged throughout the process in the review of plans and specifications for the closure.

Just as important as the closure performance standards are reaching agreement with the state regulatory authorities on the manner in which performance standards will be achieved. Throughout the closure process, compliance monitoring will be required. The metrics provided herein are designed to track timely selection of future use, agreement on the performance standards, and the manner in which the performance standards will be achieved, leading eventually to final facility closure.

The committee's metrics for environmental compliance are based in part on the recommendations established within the NRC report *Evaluation of Safety and Environmental Metrics for Potential Application at Chemical Agent Disposal Facilities* (NRC, 2009).

Management

The responsibility of management is to set the tone and direct the site effort for all work activities. The metrics listed for this parameter offer ways to consider how management measures its activities and their effectiveness. Management is responsible for developing and structuring parameters and metrics for each segment of the workforce. Not all of the workforce can or should receive and react to all of the information resulting from the metrics discussed in this chapter. However, each parameter and each metric must be reviewed for its intended audience.

Closure program quality is a key strategic element for successful program completion. Quality elements such as adequate and appropriate analytical capabilities, inventory and material management, records retention, and lessons learned comprise critical management items that can significantly affect the efficiency of the overall closure effort. Careful materials management is a key to successful facilities closure and management control while quality protocols for segregation of generated hazardous and nonhazardous materials must be implemented. This will require proper identification and inventory control of these materials. The committee has identified a set of key metrics to be tracked for successful closure.

GROUPINGS OF PARAMETERS

The large number of parameters and associated metrics to be tracked and reported over the course of the closure of chemical agent disposal facilities will result in the generation of significant amounts of information. In managing the closure operations, management should divide the parameters and metrics into two levels: the program level and the project level. The committee did not attempt to address task-level activities. However, the Army and its closure contractors should do so to track the key parameters identified and the corresponding metrics.

Program Level

Program management is the process of managing one or more related projects, often with the intention of improving an organization's performance. The management of the site and the CMA is concerned with the aggregate result or end use. Typically, a program approach is broken down into projects that reflect the overall objective. The emphasis for the program management staff involves coordination and prioritization of resources across projects as well as supervision of links between the projects and the overall costs and risks of the project. Closure and deconstruction activities require the possession or acquisition of an understanding of the unique aspects of these operations, and therefore the parameters and metrics must reflect such an understanding. At the program level, the intent is to focus more on the leading metrics in the hopes of anticipating future issues.

Project Level

The key difference between a program and a project is the finite nature of the project. A project is designed to deliver an output or deliverable, and its success will be determined in terms of delivering the right output at the right time and at the right cost. Project-level metrics will primarily be the responsibility of the contractors, both prime and subcontractors, to track the results and manage accordingly. The project-level metrics will be more heavily weighted to lagging metrics and focused on continuous improvement.

REFERENCE

NRC (National Research Council). 2009. Evaluation of Safety and Environmental Metrics for Potential Application at Chemical Agent Disposal Facilities. Washington, D.C.: The National Academies Press.

4

Management Systems: Lessons Learned Process and the eRoom Tool

LESSONS LEARNED—A MANAGEMENT SYSTEM

An important management system in any manufacturing process with high hazard potential is one in which institutional knowledge and experiences are captured and shared with all affected personnel. Management systems can be composed of both information technology elements and processes whereby human work is performed. The chemical stockpile disposal program makes use of both techniques. There are frequent and focused (usually telephone) meetings on lessons learned. These meetings involve the lessons learned coordinator for each site plus appropriate experts to provide advice/information on any particular topic. The lessons learned database was set up in 2002 and has been continually updated. The current (2010) version enables personnel to query the database to obtain information about procedures and specific topics and to search site spill history and prior closure activities. The database covers multiple years of operation and multiple facilities and would appear to be serving the needs of the program. Many management personnel, both Army and civil service, have access to this database. While similar commercial systems do exist, the lessons learned database, which was developed internally by the Army and its contractors, is able to codify and catalogue, as well as search and retrieve, needed information.

In setting up the database, the program has successfully wrestled with most of the key questions surrounding use of the database; information collection, retrieval, and sharing; worker training; and systems support and management. The database has been in use since early 2002, but the design and operational details were revised in 2006. The newer version is more complete in controlling how information gets into the database, in review mechanisms to ensure the accuracy and usefulness of the data, and in delineating to whom and what type of access will be available. In a teleconference call with members of the committee, the Army asserted that the database program is substantially improved over that in use in 2002 particularly with regard to some shortcomings identified in the earlier National Research Council (NRC) report *Evaluation of Chemical Events at Army Chemical Agent Disposal Facilities* (NRC, 2002).[1] The Army attributed the improvement to a unified ownership of all aspects of the database by its contractor, the URS Corporation, with support from the Army. This includes keeping it up to date. The Army also provided the committee access to the most recent version of the lessons learned program.

Finding 4-1. The current version of the lessons learned database is significantly improved over the 2002 version; it is much easier to access and use the search functions. The Army is to be commended on implementing the changes that made the database more usable.

[1]Teleconference with participants Timothy Garrett, Site Project Manager, ANCDF; Amy Dean, Environmental Engineer, Project Manager for Elimination of Chemical Weapons, CMA; Peter Lederman, committee chair; and Leigh Short, committee member, February 11, 2010.

It is noted that having a good lessons learned system is a widely used operations tool in industry. The development of the current programmatic database took a more bottom-up approach than the previous (2002) version discussed in NRC (2002). With continuing support by the Army, the current version of the database has gone through several iterations to arrive at its present form. The data in the system are almost entirely specific to operational issues arising during weapon destruction at their respective facilities. Nonetheless, the data on closure, while currently limited to the three facilities that have closed thus far—Johnston Atoll Chemical Agent Disposal System, Aberdeen Chemical Agent Disposal Facility, and Newport Chemical Agent Disposal Facility—are likely to be of interest to demolition contractors, for example. The committee strongly supports the concept of continuous improvement of the existing system for programmatic data.

The Importance of Lessons Learned

In any endeavor, the experience that comes from doing offers opportunities for learning and gaining wisdom. This is true whether the outcome of the activity was good and as anticipated—or otherwise. That is to say that we learn from our past, both good and bad. Similarly, the chemical stockpile disposal program has embraced a lessons learned approach. When dealing with chemical agents and other toxic substances, protecting the safety and health of the workforce and the surrounding communities becomes an essential priority. This is true for activities spanning construction and agent disposal operations, and it extends to the closure and dismantlement of the disposal facilities. It becomes an even more critical priority as the majority of the workforce shifts from workers trained in agent disposal operations to those trained in demolition but who are less familiar with chemical agent properties and safe practices in agent issues.

Strong anecdotal evidence indicates that a lessons learned approach has been helpful in the planning, construction, operation, closure, and deconstruction of chemical agent disposal facilities over the course of the chemical stockpile disposal program.[2] The committee judges that a continued, formalized, lessons learned process has and continues to significantly benefit the conduct of chemical demilitarization closure activities.

Defining Lessons Learned and the Lessons Learned Process

A lesson learned is derived from knowledge, experience, training, exercises, and actual incidents, and it reflects both positive and negative lessons. The lessons learned process can be divided into four discrete steps (see Figure 4-1):

1. Identify idea and articulate concepts.
2. Codify, catalogue, approve, and store.
3. Search and retrieve.
4. Integrate into current work activity.

Only by completing all of the above steps is the value of the prior knowledge and experience able to be fully assimilated and be useful in planning and executing a specific task or change. If any of the four steps is not completed, the objective of having a functioning lessons learned process is not fully realized. Likewise, the continuous improvement process applies to all steps. It is also important that any staff member, government, or contractor be able to easily access the data and find any lesson learned that is applicable to a particular issue. Moreover, the committee believes that a mechanism should exist whereby proposed lessons learned that are initially rejected be independently reviewed and potentially reconsidered for inclusion in the database.

The current lessons learned process flow (shown in Figure 4-2) was adapted by the committee from a more detailed flow sheet prepared by the Army. Many of the current documented lessons learned are pertinent to agent processing operations. Some of the information concerning closure lessons learned from the Johnston Atoll Chemical Agent Disposal System and associated procedures apparently exists only in hard copy and is not able to be digitally searched. However, there is a growing body of electronically searchable knowledge and experience relevant to closure, deconstruction, and dismantlement. This latter body of knowledge, the closure-based lessons learned, is the focus of the evaluation done by the committee.

This committee has focused its attention on the programmatic lessons learned process that is managed by the Army and its prime contractor. Useful data reside

[2]Personal communication among Brad Tibbils, Project Manager, URS; Peter Lederman, committee chair; Leigh Short, committee member; and Deborah Grubbe, committee member, March 3, 2010.

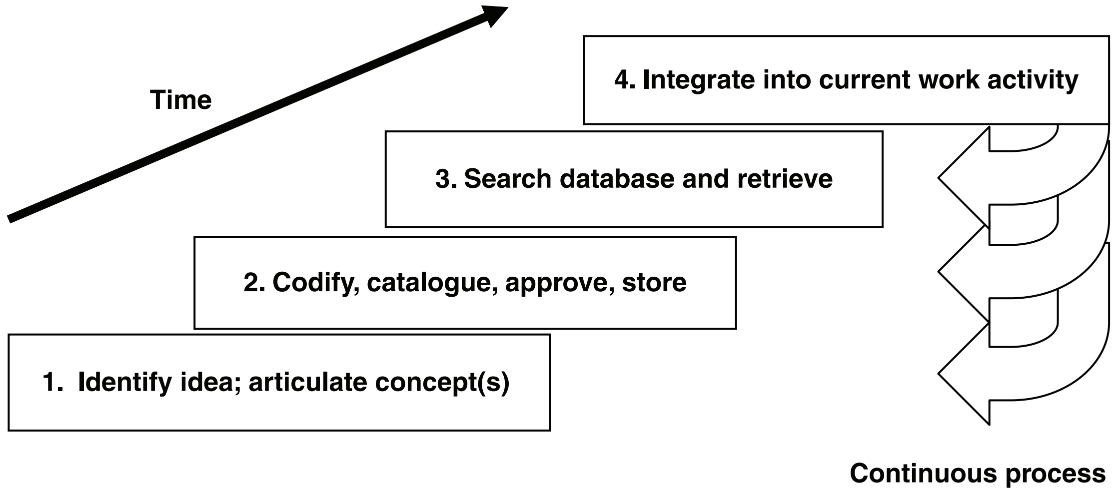

FIGURE 4-1 Steps of the lessons learned process.

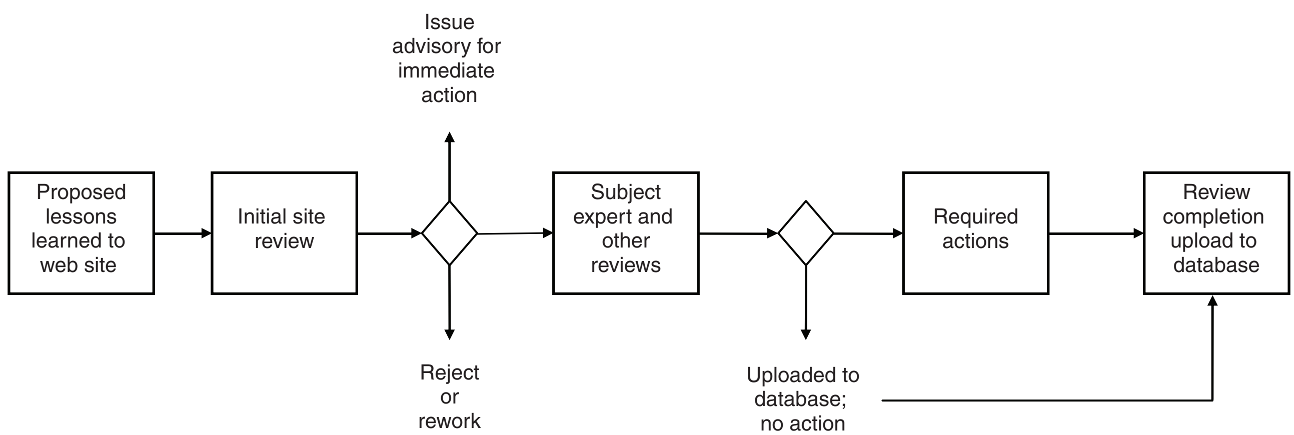

FIGURE 4-2 Flow sequence for lessons learned.
SOURCE: Closure community portal document 100218–LL Flow Chart–CMA.ppt.

in the information system and are reasonably straightforward to use, although a little training is needed. The current programmatic lessons learned program is very much improved over the earlier (2002) versions with regard to searchability, accessibility, and a more formalized process of entering the lessons learned. However, it is incumbent on the Army and its contractors to remain good stewards and to continuously improve the process.

Any staff person who has an account on the system can submit a lesson learned. There is a lessons learned submission form that is available electronically and in hard copy. Subcontractors who do not have accounts must take the extra step of raising a potential lesson learned with a prime contractor representative. This limitation could become an issue during closure activities as some new lessons learned may originate from other than Army or prime contractor sources.

Finding 4-2. Lessons learned over the course of conducting closure operations at chemical agent disposal facilities will be helpful to completing without incident future closure activities within the chemical stockpile disposal program, and they will minimize costs by reducing the time and effort needed for learning curves and training.

Recommendation 4-2. The Army should continue to support the closure lessons learned processes and to encourage the prime contractor for closure operations to strengthen the timeliness and manner in which the lessons learned are shared. In this regard, it is important that all contractors on-site have access to or knowledge of the lessons learned applicable to their specific site activities.

Each site has a lessons learned coordinator who receives the submitted lessons learned forms and logs them into the system for review. This coordinator ensures that the data are complete and assigns each data set a lessons learned number. At this point, one of three outcomes is possible: the lesson learned can be rejected; it can be accepted and entered into the system; or it can be reworked at the initiating site and then forwarded.

Because each site has a lessons learned coordinator, system variation is introduced by having different people exercising judgment. However, terms and categories for the system are preprogrammed into the software, which reduces variability. The title for a lesson learned is at the discretion of the submitter and is free form. The submitter is also allowed to categorize suggested priority ratings for timing and safety. If site managers determine that a lesson has imminent relevance to safety, an email is generated and uploaded to the database. This determination of a high priority requiring immediate notification of the other sites is made by the lessons learned coordinator and subject expert at the site.

The site coordinator and other appropriate personnel verify the uniqueness of the proposed lesson learned and, if appropriate, recommends inclusion in the database. An email accompanies any lesson learned that is forwarded beyond its originating facility. The proposed lesson learned is subject to further review, and appropriate actions (if any) are conducted.

Once the lesson learned is forwarded from the site, it is subject to external review by a program-wide subject matter expert who reviews and approves, or reviews and issues, the lesson learned for information only. A lesson learned issued only for information indicates that no specific action is required by any facility. This review process at the program level allows for greater consistency within the specified subject area. Coordination among the subject matter experts is vital to ensure consistency in lessons learned treatment across subject areas. The subject matter expert is the person who can revise or alter a lesson learned entry during the review process, as well as being qualified to make a determination that the lesson learned is only for informational purposes.

There is no documented appeal process in place if the submitter disagrees with the decision at the site level by the lessons learned coordinator or site subject matter expert to reject the lesson learned. The individual(s) who submitted the lesson learned may disagree with the disposition decision and should have an opportunity to document this position and make a case for inclusion. There does not appear to be an opportunity to question this rejection. Rejected submissions should be reviewed independently from the initial review to ascertain that in fact the lesson might not be useful to, for example, a demolition contractor. While the committee has not seen evidence of serious problems with this part of the process, the inability to capture what information was discarded at a given point in time is not optimal.

The search mechanism for the lessons learned database is significantly improved over the 2002 version. However, the novice or inexperienced user may not have adequate ability to conduct a search without help or extra training. It was not apparent to the committee that novice users are sufficiently familiar with the search functions. This may become a more serious issue during closure when most of the activities are not typical of the more standardized activities that take place during agent disposal operations.

Finding 4-3. There is no system in place to review a determination to reject a proposed lesson learned. Rejection may become a more important issue during closure than it is during operations because the review system is not geared to closure. The current system depends in part upon knowledge of how the search mechanism is constructed and upon use of the appropriate search words or terms.

Recommendation 4-3a. The Army should require a mechanism to validate the decision to reject a lesson learned.

Recommendation 4-3b. The Army should require implementation of a means to familiarize people with those paper-based lessons learned from the experiences at the Johnston Atoll Chemical Agent Disposal System that are not accessible through the electronic lessons learned database.

Recommendation 4-3c. The Army should consider developing a real-time user support tool to help novice users search the lessons learned database.

In addition to the searchable electronic database, the Army and its contractors participate in weekly teleconferences and conduct quarterly meetings on lessons learned relevant to closure preparations. These activities serve to make the preparatory efforts directed toward closure lively and current, and attendance has been high. The ability to query an expert in real time is another excellent way to ensure that lessons learned deliver the benefits intended.

Access to the Lessons Learned Database

There are two levels of access to the database, one of which is widely available, and another that in addition to access allows data input/changes, but is not widely available. It appears to the committee that the current system operates in a manner that could inhibit a potential user (particularly during closure activities) from correctly locating an applicable lesson (assuming it is present). The Army should consider how the closure lessons learned information could be made available to all potential subcontractors during the bidding phase for particular closure tasks. Such information may be pertinent to all bidders, only one of whom will be selected.

During actual closure operations, a different set of contractors will be on-site and a very different set of problems may arise. There appears to be no current means of ensuring that the lessons learned will be accessible during closure and/or the knowledge contained in the database will be made available to appropriate subcontractor personnel. The information in lessons learned documents can provide a firm foundation to facilitate safe, fast, and cost-effective closure operations, but the information must be readily available.

Currently, although a detailed database does exist, it may be somewhat difficult for an inexperienced user (such as any closure contractors) to access or obtain the pertinent information contained therein. This has not seemed to be an issue during chemical agent destruction operations, but as indicated above, it might be more problematic during closure. At present, management holds periodic meetings and phone calls to share lessons; however, during closure, that approach could suffer from unfortunate timing, and it may require participants to have good memories. A user who is looking for closure information to, for example, prepare a work plan for occluded space surveys might have difficulty finding any appropriate information in the database as currently configured. The Army should consider implementing a more proactive system by which information is immediately pushed out to users who are specifically notified when a lesson learned is approved in their area or for their facility. This will become increasingly more critical as closure activities accelerate. Such a system could have subject matter experts taking a greater leadership role in the process, for example, by checking the type of data a user is seeking and ensuring that the user is able to find all pertinent information. One of the key aspects of lessons learned is their value as an appropriate "just in time" tool. A lesson learned too early can be lost and forgotten, and a lesson learned too late may be disastrous for individuals and the program.

Finding 4-4. Since the number and type of contractors on-site will differ during closure and agent disposal operations, the use of the lessons learned database and its applicability may be different during closure operations from what has been the case previously.

Finding 4-5. The lessons learned database is searchable, but the search mechanism is relatively difficult to use by the novice user.

Recommendation 4-5. Rather than relying completely on the current means of searching the lessons learned database system, the Army should develop a proactive mechanism that assists new or novice users, particularly dismantling subcontractors to find, or be made aware of, the data in the lessons learned that would apply to a particular problem.

THE eROOM

The contractor maintains an eRoom, an electronic repository of documents related to the chemical stockpile disposal program that includes closure-related documents, permit-related documents, and documents relating to operational matters (see Box 4-1). However, there does not appear to be a very strong in-place training system to familiarize all appropriate employees (including those primarily involved with closure) with the use and benefits of the eRoom. It is potentially a very strong management tool. Other companies that have a similar system typically find it necessary to devote a considerable amount of time and resources to ensuring that it is used to the fullest possible extent. The Army and its contractor might evaluate whether the current training is adequate, and whether the use of the eRoom could be strengthened to benefit closure activi-

BOX 4-1 Description of the CMA eRoom

An eRoom is an electronic space established by project management to enable members of a team selected by project management to collaborate and share information pertaining to work-in-progress. This is accomplished by making project information available to the team members for reviewing, copying, commenting upon, and possible editing irrespective of organizational affiliation or geographic location.

Project management selects a member of the team to establish, implement, and coordinate eRoom activities. This team member is referred to as the coordinator. There may be more than one coordinator for an eRoom.

A coordinator, with IT support, adds other team members to the eRoom membership (list) at the request of project management and, with management guidance, assigns one of three possible roles to each member.

Team member roles are that of observer, participant, and coordinator. Each role provides different levels of functionality within the eRoom. An observer may view and copy contents located within the eRoom; a participant may view, copy, add, and modify contents; a coordinator may view, copy, add, modify, and delete any content. A coordinator may also modify roles and access permissions to content for team members. The coordinator monitors the eRoom for usage and periodically consults with management as to whether access to the eRoom by any individual should be maintained or terminated.

The eRoom content primarily consists of files, folders, and objects, including audio and video. A team member who has been assigned a role which would enable them to add content may either drag and drop or upload content from another location. The team member who adds the content becomes the "owner" and may specify at the time of content addition which other team members may view the content, are identified as co-owners of the content, and may edit the content. The team member may also send an email alert to individual or multiple team members to advise them of the content availability.

The eRoom incorporates additional functionality which may be deployed by the implementing organization. The Closure eRoom was established to disseminate programmatic information to stakeholders and to exchange information from the various sites for enhancement in the development of site-specific documents.

SOURCE: Rafael J. Gramatges, Specialty Group Manager, URS Corporation, March 29, 2010.

ties. As an example, the wording of specific documents such as sampling strategies and permit language at different sites could be reviewed for internal consistency before submission to a regulatory agency.

An individual must ask for access to the eRoom. If an individual has not used the eRoom within 60 days the access is canceled. An individual may be granted access to portions of the eRoom (for example, closure-related topics only or monitoring-related topics only). The committee was told that this security protocol is needed because the eRoom is URS company-wide and not restricted to Chemical Materials Agency activities only. For this reason access is limited; a change would require action at a high URS corporate level.

Typical screens for the eRoom show who has access to the room, what role the individuals have in the organization, and where their offices are physically located. From the screens the committee reviewed, it is apparent that a relatively small number of individuals actively use the eRoom. In order for the eRoom closure lessons learned to be an effective management tool, the room would typically need to be used by a wide variety of people, and during closure. For example, selected portions might need to be made available to subcontractors since they will be a key part of the closure process.

One eRoom screen shows the details of how each topic area within the eRoom is addressed. For example, a screen on the topic of coordination and collaboration outlines when the eRoom was created, who the main contact is, key news and information items for the users, and a legal disclaimer about privileged information. This is followed by a listing of all the files, documents, and training materials deemed pertinent to the subject area of closure.

Another eRoom screen outlines the history of document retention and change. This is extremely helpful when determining the age and relevance of information. The records retention page lists the document's name, the date it was modified, the name of the document owner, and the document's size.

The eRoom is a potentially very powerful tool both for coordination purposes during draft markups or for someone looking for information on a particular topic (for example, a Resource Conservation and Recovery Act permit and its contents). The use of the eRoom appears to be relatively widespread, but relatively few individuals are heavy users. The committee noted that the closure managers at their June meeting consistently referred to the eRoom and often asked for certain specific documents to be uploaded so that all sites could have access to them. As with the lessons learned, use of the eRoom is for the most part from the bottom up in terms of personnel. There appears to be less indication of a proactive use of the eRoom as a design tool or by the Chemical Materials Agency management as a means of promoting consistent sets of information among similar documents. The eRoom would perhaps be more useful if the contractor had a system that was more aggressive in "pushing" information in the documents to users. The concept of timely access to lessons learned was described above, and this same concept also needs to be considered in any use of the eRoom during closure, particularly by subcontractors active in closure activities.

Finding 4-6. The eRoom is a very powerful information sharing and management tool, both for developing new documents and for allowing users to find information that is pertinent to a particular issue or problem.

Recommendation 4-6a. The committee strongly supports the concept of the eRoom and encourages its use as often as possible.

Recommendation 4-6b. The committee suggests that the Army and its contractor examine current eRoom usage and, if appropriate, develop procedures to increase its usage, including the development of new documents and determining who should have access during closure and dismantling activities.

REFERENCE

NRC (National Research Council). 2002. Evaluation of Chemical Events at Army Chemical Agent Disposal Facilities. Washington, D.C.: National Academy Press.

5

Regulatory Requirements Affecting Closure

BACKGROUND

In closing the baseline chemical agent disposal facilities, the Army must comply with regulations established under a number of different environmental regulatory statutes. The most challenging among these are the facility closure regulations established under the Resource Conservation and Recovery Act (RCRA) (40 CFR Part 264, Subpart G). This chapter focuses on RCRA closure and related issues. It also addresses the influence of Base Realignment and Closure (BRAC) and cleanup programs under RCRA and the Comprehensive Environmental Response, Compensation and Liability Act. It is interesting to note that the Chemical Weapons Convention (CWC), which dictated many requirements pertaining to the destruction of chemical warfare materiel, is not a factor during closure.[1] Once the stockpile is destroyed, the substantive requirements of the CWC have been satisfied.

General RCRA Closure Requirements

Under RCRA, the Environmental Protection Agency (EPA) was charged with developing regulations that define certain wastes as hazardous and establishing controls for their management. States adopt these regulations but may choose to be more stringent. Moreover, through their authority to dispense RCRA permits, some states impose conditions that are not reflected in their established regulations. Of the four states with baseline incineration sites, Utah and Oregon have established more stringent regulations than those of the EPA, and all have imposed permit conditions that go beyond regulatory requirements.[2] All are different in regard to how the chemical agent disposal facilities were regulated during operations and are to be regulated during closure.

RCRA closure regulations require facilities to comply with a "closure performance standard" (40 CFR 264.111). This qualitative standard requires facilities to close in a manner that is protective of human health and the environment and that minimizes post-closure releases of hazardous waste or hazardous waste constituents. When a facility is "clean-closed," the performance standard is typically translated into risk-based quantitative criteria (e.g., concentrations) that are determined to be protective of human health and the environment for specific constituents contained in waste materials, media, and debris. These criteria are dependent on the future use of the site. Criteria developed for residential uses are generally more protective (i.e., have lower allowable concentrations) than those developed for industrial uses.

[1] Formally, the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and Their Destruction. The treaty was signed by the United States in 1993 and ratified by Congress in 1997.

[2] Several of the states addressed in this report that have baseline incineration sites have specifically identified waste containing chemical warfare agents as hazardous waste, whereas such waste is not so identified under the federal hazardous waste laws.

The RCRA closure regulations further require facilities to submit detailed closure plans as part of the permit application submitted during the permitting process. The closure plan becomes part of the permit when the permit is issued. The closure plan may be amended for a number of reasons, but such amendments require facilities to undergo a permit modification. Permit modifications are designated Class 1, 2, or 3, reflecting an increase in impact and complexity. Closure plans are typically amended one or more times as the date for actual facility closure approaches. Some closure permit modifications can be processed as Class 1; more complex modifications would be processed as Class 2 or 3. The decision as to the class of a modification is made by the regulatory authority, often in consultation with the permittee. In addition, especially with complex facilities, more detailed closure plans for specific operations may be prepared that, although not officially part of the permit, may still require regulatory approval. These supplemental closure documents may also be modified as a closure approaches and as it is under way.

Under RCRA regulations, there are also strict requirements pertaining to the time allowed for closure, but extensions to these deadlines may be approved by the regulatory authority. At the completion of closure, requirements for submitting certifications and survey plats must likewise be met. If a facility is closed in conformance with a residential performance standard, few if any limitations are placed on future land use. However, if a facility is closed in conformance to an industrial standard, use restrictions may be imposed to prevent uses requiring a more protective cleanup (e.g., residential).

Both non-agent and agent-contaminated waste materials, residues, and contaminated media would also be expected to be generated during closure.[3] These could be treated if required and disposed of on-site, reused or recycled, or sent off-site to a commercial treatment, storage, and disposal facility (TSDF). For the third option, off-site TSDF permits would need to be broad enough to allow acceptance of closure waste. However, TSDFs would not be obligated to accept agent-associated[4] or other waste.

[3] *Review of Chemical Agent Secondary Waste Disposal and Regulatory Requirements* provides an overview of the types of wastes that would likely be generated during closure (NRC, 2007).

[4] The term "agent associated" is used to refer to wastes that retain the agent designation but may, nevertheless, not contain agent above analytical detection limits.

State-Specific RCRA Closure Requirements

Utah

In adopting EPA's RCRA regulations, Utah has imposed more stringent regulations as well as permit conditions that go beyond regulatory requirements.[5,6] Utah has listed "Nerve, Military, and Chemical Agents" as an acute hazardous waste[7] under waste code P999 and "Residues from Demilitarization, Treatment and Testing of Nerve Military and Chemical Agents" as a listed waste[8] under hazardous waste code F999. Throughout the disposal campaigns at the Chemical Agent Munitions Disposal System (CAMDS) and the Tooele Chemical Agent Disposal Facility (TOCDF), waste materials resulting from treatment of the P999 waste were designated F999. In accordance with the RCRA "derived from rule,"[9] residues from treatment, storage, or disposal of F999 waste retain the hazardous waste designation and the code F999. Thus, waste materials produced during closure, even those that result from treatment of F999 waste, are required to be managed as F999 hazardous waste, even if they are known or suspected to contain no detectable agent or other hazardous constituents.[10]

Utah has also established specific requirements for "Cleanup Action and Risk-Based Closure Standards." Risk-based closure performance standards are determined on a case-by-case basis for nearly all facility closures. Closure performance standards for CAMDS and TOCDF facilities may be expected to be at least as stringent as those established using a risk-based approach for nonchemical agent facilities in Utah.

[5] Utah's hazardous waste management program was established by the Utah Solid and Hazardous Waste Act and is defined within R315 of the Utah Administrative Code (R315-1 to 17, 50, 101 and 102).

[6] Stringency, in this context, means additional requirements imposed on chemical demilitarization facilities that are not imposed on commercial treatment storage and disposal facilities within Utah or across the United States.

[7] Acute hazardous wastes are established under the RCRA program at 40 CFR 261.33(e) (Utah R315-2-9).

[8] F999 is added to the EPA listing of hazardous waste from nonspecific sources found in 40 CFR 261.31 (Utah R315-2-11).

[9] The derived-from rule is established under the RCRA program at 40 CFR 261.3 (c)(2)(i) (Utah R315-2-3 (c)(2)(i)).

[10] While RCRA and the Utah regulations provide means of demonstrating that listed wastes are not hazardous (e.g., "delisting"), the demonstration required is often arduous and prohibitively expensive.

Utah has also established the following permit conditions pertaining to chemical agent operations that go beyond regulatory requirements.

Agent Vapors. Utah includes as F999 waste those waste materials that result from actual or potential contact with agent vapors. Consequently, significant additional volumes of various types of materials, which have or potentially have contacted agent vapors even if such materials present little or no risk, could be regulated as hazardous waste during closure.

Off-Site Restrictions. Utah has placed restrictions on transport of potentially agent-contaminated waste off-site for further treatment and/or disposal. In Utah, waste must be tested against waste control limits (WCLs) and may only be transported off-site if these levels are met. The WCLs are based on meeting the Army's own criteria for what were initially developed as drinking water standards for soldiers in the field (U.S. Army, 2007). Even if the WCL is met, these waste materials are still controlled as hazardous waste under the State F999 waste code (NRC, 2008).

Waste Characterization. Since the early days of the chemical stockpile disposal program, the Army, being concerned primarily with worker exposure to hazardous agent vapor, has applied a vigorous program of vapor screening of materials and waste that have been exposed to chemical agents (AR 385-61). In contrast, RCRA has historically relied upon a system of direct analysis of waste for constituents of concern (EPA, 2009). Utah has been reluctant to accept vapor screening as a means of waste characterization for chemical agent-associated waste. In those limited cases where Utah has accepted vapor screening, Utah has required the Army to apply more stringent criteria than the Army has established. Further, some waste streams—particularly those that may absorb chemical agent—are required to have been decontaminated before being cleared for off-site shipment.

Waste Carbon and P999. Waste carbon that is actually or potentially contaminated with chemical agent is designated P999 in Utah. Because P999 waste may not be sent off-site for treatment and disposal in Utah, the Army must develop appropriate on-site treatment options or other means of ensuring that the carbon does not pose an unacceptable risk during subsequent handling—including transport, treatment, or disposal.

Dual Waste Code for Some Materials. Some types of waste materials, primarily permeable solids, can be difficult to sample and analyze for chemical agents. A good example is demilitarization protective ensemble suits for worker protection, which become waste after being used. Because of the difficulty in sampling and analyzing these suits, application of a WCL is problematic for this waste. In these cases, Utah has required decontamination of the materials and application of a dual P999/F999 waste code prior to off-site transport for disposal.

Generator Knowledge. RCRA allows hazardous waste generators to use generator knowledge in lieu of actual testing in characterizing waste as hazardous or not.[11] In many cases throughout the commercial sector, generator knowledge is used to identify waste as nonhazardous without any testing. Utah has been cautious, and in some cases reluctant, to allow CAMDS and TOCDF the use of generator knowledge for characterizing agent-related waste. A good example would be using generator knowledge to classify waste as non-F999 based on its having had a low potential for contact with agent vapors.[12]

Arkansas

In adopting EPA's RCRA regulations, Arkansas retained its primary structure, but in contrast to Utah, the state did not specifically designate chemical agents or chemical munitions as listed hazardous waste.[13] Hence, in Arkansas, chemical agent-associated waste is considered hazardous waste only if it exhibits any of the four hazardous waste characteristics (ignitability, corrosivity, reactivity, or toxicity; 40 CFR 261.21 to 261.24)[14,15] Arkansas has not imposed more stringent

[11] *Review of Chemical Agent Secondary Waste Disposal and Regulatory Requirements* (2007) provides a definition and discussion on generator knowledge (NRC, 2007).

[12] Testing of wood pallets upon which chemical munitions or bulk agents are stored is typically required even if there is no history of agent leaking from the munitions or bulk containers.

[13] Arkansas's hazardous waste management program was established by Regulation 23.

[14] Generators may manage waste as hazardous even if the waste would not otherwise be classified as hazardous waste.

[15] The most likely characteristic that would be exhibited would be the RCRA toxicity characteristic, which assesses leachable hazardous constituents. Of these constituents, arsenic and mercury are of primary concern. Additional characteristics that may be exhibited would include corrosivity and, potentially, reactivity.

regulations but has established some permit conditions pertaining to chemical agents or associated wastes.

At the Pine Bluff Chemical Agent Disposal Facility (PBCDF), generator knowledge, quality assurance data, and analytical data are used to make waste characterization decisions. Under the PBCDF RCRA permit, the term "chemical agent free"[16] refers to contaminated or potentially contaminated solid materials that have been tested per the PBCDF waste analysis plan and found to be below the WCL or to have been thermally treated for 15 minutes at 1,000°F (NRC, 2008).

Under the waste analysis plan, PBCDF waste may be shipped off-site for treatment and/or disposal only if:

- The waste was not agent contaminated (as determined via generator knowledge), or
- The waste meets the criteria established in the permit for chemical agent free, or
- The waste has been decontaminated and/or monitored to a vapor concentration less than the short-term exposure limit (NRC, 2008).[17]

Under the PBCDF waste analysis plan, waste from areas where a chemical agent may be present must be sampled and tested for the agent, or the vapor space above the waste must be monitored. For those batches of waste characterized by sampling and testing, extraction and analysis is used to determine agent concentrations. Agent vapor space monitoring is performed by placing wastes in a container (e.g., drum or bag) and allowing at least 4 hours at 70°F for the agent vapor in the headspace of the container to reach equilibrium. After equilibrium is reached, the concentration of agent in the headspace is measured. The specific methodology to be used for characterization analysis of wastes is detailed in the waste analysis plan (NRC, 2008).

Alabama

In adopting EPA's RCRA regulations, Alabama retained the primary structure of the RCRA regulations and adopted EPA's regulations verbatim, with minor administrative changes only.[18] Alabama has not specifically designated chemical agents or chemical munitions as listed hazardous waste. Hence, in Alabama, chemical agent-associated wastes would be considered hazardous waste only if they exhibited any of the four hazardous waste characteristics (40 CFR 261.21 to 261.24).[19,20] Alabama has not imposed more stringent regulations, but the state has established some permit conditions pertaining to chemical agents or associated waste.

The Anniston Chemical Agent Disposal Facility (ANCDF) RCRA permit defines "chemical agent free"[21] as agent concentrations below the lowest achievable method detection limits as specified by the analytical method used. In addition, any waste at ANCDF not exposed to chemical agent liquids or to vapors >1 STL (short-term limit) is nonhazardous with respect to chemical agent and may be disposed of off-site as nonhazardous waste (NRC, 2008). [22]

Under the ANCDF waste analysis plan, EPA's analytical methods must be used to determine whether a sample contains agent or other hazardous constituents. Methods developed by the Army are used for materials with no prescribed EPA methods. The ANCDF waste analysis plan allows agent vapor monitoring for nonporous waste that has been exposed to liquid chemical agent or chemical agent vapor concentrations >1 STL to determine suitability for off-site shipment (NRC, 2008).

Under the ANCDF waste analysis plan, specific waste streams are screened based on the STL values for each chemical agent. If the concentrations are <1 VSL (vapor screening level) this waste may be shipped to an off-site TSDF. Only nonporous solid waste that is

[16]The term "chemical agent free" or "agent-free" is used by some of the stockpile states to refer to waste that is "safe" for off-site handling. The committee notes that in reality, these terms denote waste materials that have been treated to a certain specification or tested and shown not to contain agent above analytical detection limits.

[17]The short-term exposure limit is defined as an exposure that is acceptable for a short period of time, i.e., averaged over 15 minutes without a respirator.

[18]Alabama's hazardous waste management program is defined within the Alabama Administrative Code 335-14-2.

[19]Generators may manage wastes as hazardous even if the waste would not otherwise be classified as hazardous waste.

[20]The most likely characteristic that would be exhibited would be the RCRA toxicity characteristic, which assesses leachable hazardous constituents. Of these constituents, arsenic and mercury would be of primary concern. Additional characteristics that may be exhibited would include corrosivity and, potentially, reactivity.

[21]The term "chemical agent free" or "agent-free" is used by some of the stockpile states to refer to waste that is "safe" for off-site handling. The committee notes that in reality these terms denote waste that has been treated to a certain specification or tested and shown to not contain agent above analytical detection limits.

[22]The STL is a concentration typically expressed in terms of milligrams of a specific agent per cubic meter of air. It is similar in numerical value to the exposure limits found in the STEL but without the 15-minute time component.

combustible in nature or objects that do not possess occluded spaces may be evaluated for off-site disposal using chemical agent vapor monitoring (NRC, 2008).

In addition to RCRA requirements, Alabama—like a number of other states—recently established a program of uniform environmental covenants. The Alabama Uniform Environmental Covenants Act places limitations on properties undergoing a response action (e.g., RCRA closure) that are not approved for unrestricted use.[23] Specifically, this statute includes a new "Uniform Environmental Covenants Program" that places statewide restrictions on hazardous waste facilities that chose to close according to an industrial standard.[24] This new law might force the facility to close according to residential standards.[25]

Oregon

Oregon has specifically listed chemical agents as acute hazardous waste, similar to what Utah has done.[26] Blister agents such as mustard are listed under the hazardous waste code P998, and nerve agents, including GB and VX, are listed under the hazardous waste code P999. The Oregon regulations also list residues from demilitarization, treatment, and testing of blister agents as F998, and residues from demilitarization, treatment, and testing of nerve agents as F999.

The Oregon regulations define "demilitarization" as all processes and activities at both the Umatilla Chemical Depot (UMCD) and the Umatilla Chemical Agent Disposal Facility (UMCDF) from the start of operations through approval for closure of all permitted treatment, storage, and disposal units and facility-wide corrective actions. Also, as with Utah, the derived-from rule would render waste produced during closure—including waste that result from treatment of listed waste—to be managed as listed hazardous waste materials even if they are known or suspected to contain no detectable agent or other hazardous constituents.

Oregon has also established some permit conditions that go beyond regulatory requirements. Examples of these additional requirements are described below.

Off-Site Restrictions. The Umatilla facility's hazardous waste permit requires on-site treatment of all agent-contaminated waste. This would include waste, residues, and media generated during closure.

"Agent-Free" Criterion. Oregon also has an "agent-free" criterion.[27] Permit compliance concentration (PCC) limits establish levels at which waste materials are considered agent-free. At UMCDF, waste must be agent-free prior to shipment to an off-site TSDF. Samples are considered agent-free if they are below the established PCCs. The PCCs included in the UMCDF permit were selected based on (1) generator knowledge; (2) similar waste streams at Johnston Atoll Chemical Agent Disposal System and TOCDF; and (3) RCRA land disposal restriction (LDR) requirements.[28] These PCCs are lower than the WCLs for GB and VX used at CAMDS and TOCDF, and they may be difficult to achieve using the existing analytical methods for some closure waste, residues, and media (see Chapter 6 for a discussion on analytical issues) (NRC, 2008).

Analytical Methods. At UMCDF, PCCs are determined using EPA's analytical methods unless another methodology is approved. For detection of chemical agents, UMCDF standard operating procedure UM-0000-M-559, "Agent Extraction and Analyses," is used. This procedure tailors the analysis to the sample matrix (NRC, 2008).

[23]Question-and-answer session between Timothy Garrett, Site Project Manager, ANCDF, and the committee, January 27, 2010.

[24]The Uniform Environmental Covenant Act is a uniform statute drafted by the National Conference of Commissioners on Uniform State Laws and enacted by Alabama in 2007. The statute is available online at http://www.law.upenn.edu/bll/archives/ulc/ueca/2003final.htm. The Alabama Uniform Environmental Covenant Program is available online at http://www.adem.state.al.us/alEnviroRegLaws/files/Div5Eff5-26-09.pdf.

[25]Question-and-answer session between Timothy Garrett, Site Project Manager, ANCDF, and the committee, January 27, 2010.

[26]Oregon has incorporated by reference the federal RCRA regulations under Oregon Administrative Rules [OAR] 340-101-0001.

[27]The term "chemical-agent-free" or "agent-free" is used by some of the stockpile states to refer to wastes that are "safe" for off-site handling. The committee notes that in reality these terms denote waste that has been treated to a certain specification or tested and shown to not contain agent above analytical method detection limits.

[28]In short, the LDR program requires hazardous wastes to be treated prior to land disposal to reduce the toxicity or mobility of hazardous constituents and minimize short- and long-term threats to human health and the environment. Regulations establishing LDR requirements may be found in 40 CFR Part 268. A summary of the LDR program is available online at http://www.epa.gov/osw/inforesources/pubs/hotline/training/ldr05.pdf.

Background Concentrations Closure Performance Standard. The RCRA permit issued to UMCD goes beyond conventional residential standards to require the entire depot to be closed to background concentrations. Closure according to background can be considered a type of residential standard; however, it is a considerably more stringent requirement.

The Influence of Base Realignment and Closure

Since the late 1980s, many military installations or portions of installations have been identified for realignment or closure under BRAC. BRAC is the process the Department of Defense uses to "reorganize its installation infrastructure to more efficiently and effectively support its forces, increase operational readiness and facilitate new ways of doing business."[29]

Two of the four baseline disposal facilities addressed in this report are impacted by BRAC:

- The Deseret Chemical Depot is expected to be closed under BRAC. However, much of the facility, including storage igloos, land, and remaining structures, is expected to be turned over to the Tooele Army Depot.[30]
- The Umatilla Chemical Depot, which includes the UMCDF, will close entirely under BRAC. The Umatilla Army Depot Re-Use Authority (UMADRA), which includes representatives from Umatilla County, Morrow County, the Port of Umatilla, the Confederated Tribes of the Umatilla Indian Reservation, and two ex officio state representatives, have proposed a reuse plan that would divide the property among the Oregon National Guard (20 percent), the U.S. Fish and Wildlife Service (40 percent), and the reuse authority (40 percent). Under this plan, UMCDF would be transferred to UMADRA and then to the Port of Umatilla for future use.

The Pine Bluff Chemical Activity (PBCA) and Anniston Chemical Activity (ANCA) are not subject to BRAC. Following closure, the land and remaining structures at the disposal facilities will be returned to the respective installations.

Facility closure under RCRA can be conducted independent of BRAC realignment or closure, but it is important to consider future land use during the RCRA closure process. Hence, RCRA closure and BRAC should be coordinated. Because PBCA, ANCA, and Deseret Chemical Depot (DCD) will remain under Army control, there is more flexibility at these installations to consider a range of closure performance standards under RCRA; an industrial or residential standard may be pursued depending on situation-specific factors.

At UMCD, which will be transferred from Army ownership, closure according to residential standards may preserve a broader range of future land uses, to include farming or residential use. Even at UMCD, if portions of the land are to be slated for post-closure industrial use, closure to an industrial performance standard will be significantly less expensive and time-consuming. As indicated above, however, Oregon currently requires that the closure performance standard over the entire installation be set based on background concentrations.

PROGRAMMATIC CONSTRAINTS

Risk During Closure Versus Risk During Operations

The committee noted in its letter report (Appendix A) that the restrictive practices the state regulatory agencies have used to address disposal operations at the baseline chemical agent disposal facilities were developed early in the program, when there was little experience with managing the risks of materials exposed to agent. During closure, in contrast with agent disposal operations, there will not be any significant amount of agent present and there will be no munitions. Thus, the risks to human health and the environment from agent and munitions will be significantly reduced during closure from those that existed during disposal processing. This difference in risk represents a fundamental change in the working environment that will exist during closure operations from that which will have existed during disposal operations, and it should provide a basis for considering less restrictive practices.

Finding 5-1. The risk of exposure to chemical agents during closure operations is expected to be significantly lower than what potentially could be encountered during agent disposal operations. The regulatory standards and practices used by some states for controlling

[29] Additional information is available online at http://www.defense.gov/brac/definitions_brac2005.html. Last accessed June 9, 2010.

[30] This is the current status and may be subject to change.

agent-contaminated materials were developed early in the program, when there was little experience with managing the risks of materials exposed to agent. These practices and regulations may be more restrictive than necessary considering the nature of the closure operations.

Recommendation 5-1. The Army should evaluate the reduced risk of exposure to chemical agents and their degradation products from closure operations and waste materials in view of restrictive regulatory practices. It should also consider negotiating with the regulatory community to obtain less restrictive, but still safe, regulatory practices that allow for more efficient closure operations.

One of the means by which less restrictive but still protective requirements could be employed is by allowing more use of generator knowledge for waste classification during closure activities. As indicated previously, some states have been cautious, and in some cases reluctant, about allowing stockpile facilities to use generator knowledge for characterizing agent waste as either hazardous or nonhazardous.

Another means to tailor current regulatory practices to the conditions likely to be faced during closure is to use tailored (more appropriate) off-site requirements. As indicated above, most of the baseline facility RCRA permits restrict off-site transportation of chemical agent-associated waste. Instead they require that such waste meet state-specific "agent-free" criteria prior to being able to be released off-site.

Because closure does not normally entail dealing with materials having significant agent contamination, tailoring requirements to closure conditions such as those described above can be a reasonable approach that does not compromise worker or public safety. By focusing on controlling only wastes that are truly hazardous, the Army could actually strengthen its protection of human health and the environment. Furthermore, if regulatory authorities and the public are made aware of the Army's intention to focus on waste that is truly hazardous, they are likely to support such a strategy.

One additional area where more tailored practices can be employed during RCRA closure is in allowing baseline facilities to delay the formal commencement of closure operations until building environmental controls (e.g., operation of the carbon filter system) have been turned off and actual demolition begins. In this manner, gutting of the internal units and equipment within the building may be conducted as a normal part of facility operations, rather than as part of the official closure. By keeping the building environmental controls in place during this dismantlement and removal period, protection of human health and the environment is maintained. This practice was conducted successfully during closure of the Aberdeen Chemical Agent Disposal Facility (Bechtel Aberdeen, 2007).

Finding 5-2. Closure will not entail dealing with significant amounts of agent or munitions. The following are examples of practices that can be used to expedite the overall closure schedule while still protecting human health and the environment: (1) expanded use of generator knowledge for waste characterization; (2) relaxed requirements for off-site transportation of agent-associated waste; and (3) allowing baseline facilities to initiate formal closure after building environmental controls (operation of the carbon filter system) have been turned off.

Recommendation 5-2. The Army should consider proposing to regulatory authorities and the public (1) expanded use of generator knowledge for waste characterization; (2) more tailored requirements for off-site transportation of chemical agent-associated waste; and (3) allowing baseline facilities to initiate formal closure after building environmental controls (operation of the carbon filter system) have been turned off.

There are other areas as well where more tailored practices may be employed during closure while still protecting human health and the environment. The committee has not examined all of these but urges the Army to continually identify additional means of replacing prior regulatory practices that may have been needed during operations with more tailored and appropriate practices.

RCRA Closure Plan and Decommissioning Work Packages

Closure operations are already under way for CAMDS, and planning for closure is under way at TOCDF. The approach taken has been to prepare a general RCRA closure plan that describes the type of closure and standards that will be established, but to rely on decommissioning work packages (DWPs) that are not part of the permit for closure of individual units and processes.[31] In this manner, the most significant regulatory issues associated with closure can be settled during the development of the official closure plan that becomes part of the permit. Issues that may be associated with individual units or processes can thus be addressed outside the permitting process, saving time and preserving the overall closure schedule. For example, at CAMDS, the Army anticipates that as many as 15 individual DWPs will ultimately be necessary. The practice of developing a general closure plan that is part of the permit and DWPs for individual units or processes provides a means to save time and preserve the overall closure schedule.

Managing Permit Modifications Associated with Closure

The above process for establishing a general RCRA closure plan and associated DWPs notwithstanding, permit modifications may still be needed prior to or during the closure process. Class 1 RCRA permit modifications are far less arduous and time-consuming than are Class 2 or 3 RCRA permit modifications.

Where permit modifications associated with closure are necessary, the Class 1 modifications would expedite the approval process. Where Class 2 or 3 permit modifications are anticipated, discussion of the nature of the modification and processes and procedures with the regulatory authority well before anticipated submittal would facilitate processing and approval.

Closure Performance Standards

Without exception, the Army's baseline chemical agent disposal facilities addressed in this report have indicated that they will pursue a clean closure approach.[32] It appears, however, that closure for PBCDF, CAMDS, and TOCDF will be based on an industrial closure standard, whereas closure for ANCDF and UMCDF will be based on a residential standard. Further, it appears that the residential standard at UMCDF will go beyond conventional levels protective of the general population by requiring closure to background, a much more stringent standard. Each facility is also unique with respect to the way the respective state authorities determine how agents, degradation products, and other hazardous constituents that will be constituents of concern are regulated.

Finding 5-3. While it appears that the type of risk-based approach to closure (industrial versus residential) has been established by the Army at each baseline chemical agent disposal facility site, the Army has not negotiated quantitative closure standards for wastes, residues, and media with the regulatory authorities at all of these facility sites.

Recommendation 5-3. At the earliest possible time, the Army should initiate the negotiation process with state regulatory authorities at all the baseline chemical agent disposal facility sites for the closure performance standards that will need to be achieved in wastes, residues, and media, with the goal of having these standards established well before facility closure actually begins.

Analytical Methods

Each facility will have to identify analytical methods that will be used for measuring compliance with closure standards in waste, residues, and media. Some modifications to analytical methods may be needed to achieve state-specific closure standards, and in these cases, significant time and effort may be required for the technical development of these modifications and for achieving regulatory authority approval. Analytical methods are discussed further in Chapter 6.

Secondary Waste

Secondary waste materials are those that were generated in the course of agent disposal processing and similar waste that may be generated during closure activities. In addition to waste from demolition, large amounts of secondary waste may need to be managed during closure. These waste materials may contain agent degradation products and/or RCRA hazardous constituents; they may also exhibit RCRA characteristics. Common hazardous constituents that may be encountered include polychlorinated biphenyls (PCBs) and a variety of heavy metals, including arsenic and mercury.[33] Activated carbon that is contaminated with mercury will present a special challenge, a topic dis-

[31] Among the baseline facilities, a variety of terms have been used to refer to the same type of document.

[32] Question-and-answer session between Timothy Garrett, Site Project Manager, ANCDF, and the committee, January 27, 2010.

[33] PCB disposal is regulated under the Toxic Substances Control Act (40 CFR Part 761).

cussed in detail in two prior NRC reports (NRC, 2008, 2009). Any of the four RCRA characteristics (ignitability, corrosivity, reactivity, or toxicity; 40 CFR 261.21 to 261.24) may also be exhibited.

For secondary waste to be treated or disposed of, it must be properly characterized. As with many RCRA requirements, regulatory authority acceptance will be required for a determination of the adequacy of proper characterization. In addition, secondary waste will need to be sufficiently characterized to allow acceptance by off-site TSDFs. Disagreements between the Army and the regulatory authority, or between the Army and off-site TSDFs, as to what constitutes proper waste characterization have the potential to cause significant delays. In addition, even if the permit issued for off-site TSDFs allows acceptance of the Army's secondary waste, the off-site TSDF must agree to accept the waste.

Finding 5-4. The determination of the adequacy of proper characterization of secondary waste will require regulatory authority acceptance and acceptance by the off-site treatment, storage, and disposal facility. Disagreements about what constitutes proper waste characterization have the potential to cause significant delays.

Recommendation 5-4. The Army and the regulatory authority, as well as off-site treatment storage and disposal facilities, should agree on the definition and process for proper characterization of secondary waste well before closure operations begin.

Land Disposal Restrictions for Waste, Residues, and Media

RCRA LDR requirements impact many of the waste materials, residues, and media that will be generated during closure, as well as the legacy waste from storage activities and other secondary waste present at TOCDF. These waste materials may contain RCRA hazardous constituents at levels above LDR treatment requirements and may exhibit RCRA characteristics as well, thus requiring treatment prior to ultimate disposal. The Army has already established a classification system for segregating waste produced during closure, but it is unclear whether this system adequately considers treatment requirements for LDR compliance (URS, 2008).

Finding 5-5. Large amounts of many different types of waste, residues, and media will be generated during closure activities along with any preexisting (i.e., legacy) and newly generated secondary waste. These materials may contain agent degradation products, but in many cases they will also exhibit Resource Conservation and Recovery Act (RCRA) characteristics and therefore will be subject to the RCRA land disposal restrictions.

Recommendation 5-5. To facilitate handling and disposal of closure waste, residues, and media, as well as any legacy and newly generated secondary waste, the Army should ensure that its tracking system facilitates segregation of materials by subsequent handling, including land disposal restriction treatment requirements, so as to avoid unnecessary handling, including treatment, of some waste types.

Reuse or Recycling of Valuable Materials

In accordance with federal acquisition regulations, U.S. government property at the baseline chemical agent disposal facilities to be closed must be evaluated for suitable reuse at another Chemical Materials Agency (CMA) facility, some other government facility, or commercial facilities. For example, at the Aberdeen Chemical Agent Disposal Facility (ABCDF), where bulk stocks of mustard agent were destroyed using a chemical neutralization (hydrolysis) process, reusable nonagent-contaminated equipment (e.g., Miniature Chemical Agent Monitoring Systems, laboratory instruments, electrical equipment) was transferred to other facilities. Generator knowledge was used to identify materials that were not contaminated with agent (Bechtel Aberdeen, 2007).

Materials known to have been exposed to liquid agent or agent vapor, along with reusable or recyclable items, are decontaminated and tested using monitoring and analytical methods as required by the RCRA permit. Scrap metal is of particular concern due to its intrinsic value. At ABCDF, scrap material was segregated for recycling. This included uncontaminated structural steel, steel rebar, electrical conduit, wire, pipe supports and racks, and vent piping. Approximately 1,350,000 pounds were recycled (Bechtel Aberdeen, 2007).

The steel from the hydrolysate storage tanks at ABCDF was also evaluated for scrap potential. The tanks were cleaned, but an odor caused by the presence of residual hydrolysate was present. Consequently, the recycling alternative was not considered viable (Bechtel Aberdeen, 2007). Attempts were also made to release titanium tanks at ABCDF to allow recycling. The tanks were tented and monitored to determine if they would meet the general population limit (GPL) for mustard agent. However, monitoring results were invalidated by interference from residual hydrolysate, which prevented detection of mustard agent at the GPL. Further attempts to address the residual hydrolysate or monitor other tanks were not attempted (Bechtel Aberdeen, 2007). The steel from the ABCDF hydrolysate storage tanks and the titanium tanks were landfilled as hazardous waste. In both cases, the committee believes that decontamination is effective in reducing chemical agents to below levels of concern.

In view of the above experience, the Army has expressed concern that the costs associated with release of materials for reuse and recycling may outweigh the benefits of reuse or recycling.[34,35] The committee believes that it would be best if valuable materials could be decontaminated as needed and reused or recycled. At TOCDF and CAMDS, for example, the Army has indicated that it intends to dispose of all materials from the facility as hazardous waste even after decontamination. The committee believes it is undesirable to take up valuable landfill space with materials that can be recycled and have so much intrinsic value.

Regulatory authorities and the public are typically in favor of recycling, although they may show some reluctance to accept recycling of materials from chemical agent disposal facilities. However, if the public is made aware of the environmental and financial benefits associated with reuse and recycling of materials, including those that have been safely and thoroughly decontaminated, it is likely to support strategies that distinguish such materials from those that are truly hazardous and thus require treatment and subsequent disposal in a hazardous waste landfill. While members of the public might not necessarily be interested in helping the Army save money, they are likely to support strategies that divert materials from disposal through reuse or recycling, as long as it can be determined that such practices are safe. In addition, the Army must ensure that materials sent for reuse and recycling are safe for the receiving facility to handle, and that future uses of reused and recycled materials are safe as well. Maintaining the confidence of recyclers, regulatory authorities, and the public in the safety of materials received for recycling, as well as in reused or recycled products, is an important consideration.

Finding 5-6. Many valuable high-grade materials, including steel, tungsten, and other metals, are used within or constitute materials of construction at baseline chemical agent disposal facilities. At some of these facilities, the Army is planning to dispose of these materials in hazardous waste landfills.

Recommendation 5-6. To the extent feasible, the Army should avoid landfilling valuable materials and instead seek ways in which to reuse or recycle them. Where chemical analyses are insufficient to definitively classify a material as below levels of concern (as was the case with tungsten at the Aberdeen Chemical Agent Disposal Facility), generator knowledge can provide additional assurance that materials are suitable for reuse or recycling.

State Resources

State regulatory permitting and oversight programs have been losing staff to other programs as the baseline chemical agent disposal facilities approach and begin the closure process. At the same time, state resources are required to review and approve closure plans, DWPs, data produced during closure, permit modifications, administrative closure documents, and similar activities both from within the baseline facilities and from nonmilitary industrial facilities in each state that compete for the attention of state regulatory personnel.

Finding 5-7. A general concern for each of the baseline chemical agent disposal facility sites is that state resources for reviewing and approving closure plans and related documentation and data are expected to become limiting factors for achieving timely review and approval by the respective regulatory authorities.

Recommendation 5-7. The Army should coordinate upcoming review and approval needs concerning closure plans and documentation of the baseline chemical agent disposal facilities with state regulatory authorities well ahead of anticipated deliveries to them.

The Army schedules for facility closures assume a 3-month period for administrative closure. The Army defines administrative closure as "everything associated with Contract closeout, including everything necessary

[34] Amy Dean, Environmental Engineer, Project Manager for Elimination of Chemical Weapons, CMA, "Status of Overall Closure Planning," presentation to the committee, March 1, 2010.

[35] Question-and-answer session between Brian O'Donnell, Chief, PMCSE Secondary Waste and Closure Team, CMA, and the committee, March 2, 2010.

to close out facility permits (most notably administrative closeout of the RCRA Permit)."[36] Administrative closeout includes the period required by state regulatory authorities to review all data and information provided to show that closure performance standards have been achieved and to officially approve the facility as closed. While administrative closure of 3 months is possible, experience at complex facilities, such as the Johnston Atoll Chemical Agent Disposal System, shows that administrative closure can take considerably longer.

Finding 5-8. The time allotted by the Army for administrative closure of the baseline chemical agent disposal facilities is just three months. The committee believes that the assumption of three months for achieving administrative closure is unlikely to be achieved.

Recommendation 5-8. The Army should be more realistic about the time it assumes will be needed for administrative closure of the baseline chemical agent disposal facilities.

Disposition of Igloos Used to Store Chemical Munitions and Waste

In addition to closure of the baseline destruction facilities, the igloos used to store chemical munitions and other wastes (e.g., secondary wastes, legacy wastes) will also need to undergo closure in accordance with RCRA requirements. Storage (and the closure/disposition of igloos) is conducted under an entirely different RCRA permit from the chemical agent destruction facility. In some cases, ownership of the storage permit is by a different entity within the Army. For example, the permit for the igloos used to store munitions and other wastes at TOCDF belongs to DCD. RCRA closure of the igloos is beyond the scope of the committee because closure of the chemical agent disposal facilities does not entail closure of the igloos used for storage. Nevertheless, it would be prudent for the Army to prepare closure planning documents that pertain specifically to closure of the igloos and to obtain regulatory authority approval for these planning documents well before chemical agent disposal facility closure begins, so as not to impede closure plans for the chemical agent disposal facilities. In addition, closure activities should be coordinated.

[36]Personal communication between Raj Malhotra, Deputy, Mission Support Directorate, CMA, and Nancy Schulte, study director, April 27, 2010.

INSTALLATION-SPECIFIC CONSTRAINTS

As a result of discussions between the committee members and Army personnel and contractors at the baseline facilities, as well as with CMA staff, a number of installation-specific issues were identified.

CAMDS/TOCDF

Legacy Waste

At DCD there are 2 million pounds of legacy waste stored within storage igloos adjacent to TOCDF that will require disposition as part of closure (Appendix A). These materials may contain agent degradation products and/or RCRA hazardous constituents; they may also exhibit RCRA characteristics. Common hazardous constituents that may be encountered include PCBs and a variety of heavy metals, including arsenic and mercury.[37] This waste may also contain asbestos. Any of the four RCRA characteristics (ignitability, corrosivity, reactivity, or toxicity; 40 CFR 261.21 to 261.24) may also be exhibited.

Most of the legacy waste was generated from operation of the chemical agent storage facilities at DCD over a period of decades. Examples include discarded samples, spill cleanup materials, used personal protective equipment, metals parts, laboratory and sampling/monitoring waste, and used/spent decontamination fluids. The exact nature of the materials may be uncertain. However, in order for this waste to be treated/disposed of, proper characterization will be necessary. As with other secondary waste, the determination of the adequacy of proper characterization for legacy waste will require regulatory authority acceptance. Potential disagreements between the Army and the regulatory authority on what constitutes proper waste characterization for these wastes may cause significant delays. Many of the drums containing these wastes are expected to be heterogeneous in content, and physical sampling and analysis of the materials in all of the drums would entail a significant effort with substantial delay. The Army has already experienced delays in similar situations: at TOCDF, for instance, it had to sample many of the ton containers and munitions containing mustard agent to ensure that levels of arsenic and mercury were

[37]The committee recognizes that As is formally a metalloid. However, it is treated in a manner similar to other metals by the EPA. Thus, in the vernacular of this report, As is referred to as a metal.

adequately determined. Similar delays were also experienced in sampling the M55 rocket shipping tubes for the presence of PCBs.

Finding 5-9. Disagreements between the Army and the regulatory authority on what constitutes proper waste characterization of legacy waste at Deseret Chemical Depot has the potential to cause significant delays for facility closure at the site.

Recommendation 5-9. The Army and the regulatory authority should agree on the definition and process for proper characterization for legacy wastes at Deseret Chemical Depot well before closure of the Tooele Chemical Agent Disposal Facility begins.

PBCDF

There appear to be no significant facility-specific regulatory closure constraints at PBCDF. By monitoring closure progress carefully the Army will be ready to respond to unforeseen challenges.

ANCDF

Uniform Environmental Covenant Provision in Alabama

The one significant facility-specific constraint for ANCDF deals with the new Uniform Environmental Covenant provision in Alabama, as discussed earlier. The Army recognizes that it must comply with the requirements of the Alabama Uniform Environmental Covenant Act in closing ANCDF.

Prior to the Restricted Covenant provision, the Army had planned to close the ANCDF site according to an industrial standard. This would make sense since the property would revert back to Anniston Army Depot. However, the Army has indicated that this new law might force the facility to close against residential standards simply because of the internal Army legal hurdles that ANCDF would face were it to pursue an industrial standard in compliance with the provisions of the covenant.[38]

The committee did not further investigate the internal legal hurdles that would be encountered by the Army were it to pursue an industrial standard in compliance with the covenant. However, the committee did become aware of a similar situation at Redstone Arsenal, also located in Alabama and subject to the covenant. Specifically, the Record of Decision for a cleanup action at Redstone Arsenal establishes an institutional control to prohibit future use of the property for anything other than industrial use.[39] Thus, at the Redstone Arsenal, industrial use was selected for the remedy even though the facility was subject to the Alabama Uniform Environmental Covenant Act.

Finding 5-10. The Army recognizes that it must comply with the requirements of the Alabama Uniform Environmental Covenant Act in closing ANCDF. Although the Army initially considered closing ANCDF against an industrial standard, due to the provisions of the covenant and the internal legal hurdles it would face in pursuing an industrial closure standard, the facility may instead choose to close against a residential standard. Closing against a residential standard may entail a significant increase in closure costs and may extend the closure schedule as well.

Recommendation 5-10. The Army should weigh the costs and benefits of legal requirements and use limitations associated with closure against an industrial standard with those associated with cleanup against a more stringent residential standard. If the costs and benefits of closure against a residential standard outweigh those associated with an industrial standard, the Army should endeavor to overcome its internal legal hurdles and close ANCDF according to an industrial closure standard.

UMCDF

Closure Performance Standards (Agent-Free Criterion and Background)

As indicated previously, the RCRA permit issued to UMCD goes beyond conventional residential standards to require the entire depot to be closed according to back-

[38]Question-and-answer session between Timothy Garrett, Site Project Manager, ANCDF, and the committee, January 27, 2010.

[39]Record of Decision for RSA- 122, Dismantled Lewisite Manufacturing Plant Sites; RSA-056, Closed Arsenic Waste Ponds; and RSA-139, Former Arsenic Trichloride Manufacturing; Disposal Area, Operable Unit 6 the Redstone Arsenal in Alabama at 1-2 (September 2009), available online at http://www.epa.gov/region4/waste/npl/nplal/redsrod122_056_arpond_139_ou6_artri.pdf.

ground concentrations. There is no explicit state regulation that requires such a stringent cleanup level. Moreover, this background closure requirement is inconsistent with EPA regulations and with the risk-based closure requirements established by other states under RCRA.

The standard for the agents and the breakdown products of concern would be based on the limits of detection of the analytical methods used, in concert with any analytical interference or similar challenges posed by closure waste, residues, and media. As indicated previously, the Army will need to carefully evaluate the analytical methods that will be used for the types of wastes, residues, and media that will be produced during closure.

A complication that affects the state's requirement that UMCD be closed to background concentrations is that, like many military installations across the United States, UMCD is in the middle of a cleanup program for its hazardous waste sites. Umatilla was placed on the Comprehensive Environmental Response, Compensation and Liability Act National Priorities List (Superfund site) in 1987, and a Federal Facility Agreement was signed in 1989. Records of Decision have been signed and a number of remediations are ongoing. In addition, several areas within UMCD may be contaminated with munitions and explosives of concern and are subject to the Army's Military Munitions Response Program.[40]

The areas undergoing long-term cleanup will likely need to remain under federal control until the state and stakeholders agree that cleanup requirements have been met. Such requirements may include leaving wastes or contamination in place with long-term monitoring and institutional controls. If areas remain contaminated, enforceable long-term institutional controls limiting access and use will need to be put into place.

Finding 5-11. Old disposal sites and contaminated areas at Umatilla Chemical Depot, including landfills and areas with munitions and explosives of concern, will be difficult to close according to a background closure performance standard and may remain on the installation well beyond the completion of closure of the Umatilla Chemical Agent Disposal Facility.

Recommendation 5-11. The Army should open a dialogue with Oregon regulatory authorities and other stakeholders to separate Umatilla Chemical Depot areas subject to cleanup under the Federal Facility Agreement and the Army's Military Munitions Response Program from other areas of the depot that can be closed to meet the background performance standard.

BRAC

Another complication particularly relevant to UMCD is that the installation will close entirely under BRAC, with its land and remaining facilities most likely being turned over to a local land-reuse authority, the U.S. Fish and Wildlife Service, and the Oregon National Guard for a mix of potential future uses, including industrial. The proposed reuse plan supported by the Confederated Tribes of the Umatilla Indian Reservation calls for transfer of the UMCDF site to the Port of Umatilla for industrial reuse. The expectation is that the existing infrastructure will be retained in support of that reuse. The tribes have indicated that these areas should be closed to an industrial standard.[41]

Finding 5-12. Future industrial use is planned for the Umatilla Chemical Agent Disposal Facility; however, the state of Oregon is requiring closure according to background.

Recommendation 5-12. The Army should work with all stakeholders to close the Umatilla Chemical Agent Disposal Facility according to an industrial-based closure performance standard.

The Confederated Tribes of the Umatilla Indian Reservation, in asserting their treaty rights to customary use of the Umatilla Chemical Depot (UCD), want open areas of the depot (outside of UMCDF) cleaned to background as part of the UMCDF closure. However, the confederated tribes' interpretation of the term "background" is different from the conventional use of the term. Unlike the Oregon regulatory authorities, the tribes' interpretation of background applies to the surface of the land but not to buried waste and munitions. The tribes have proposed that surface soil downwind from UMCDF be sampled for contaminants that may have been emitted from UMCDF. Their intent is to have

[40]Additional information is available online at http://deparc.xservices.com/PDFS/Installation_Summary/OR021382091700.pdf. Last accessed June 9, 2010.

[41]Teleconference with Rodney S. Skeen, Manager, Engineering and Modeling Program, Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation; Todd Kimmell and Leonard Siegel, committee members; and Nancy Schulte and Harrison Pannella, NRC staff; May 26, 2010.

the Army remove compounds of potential concern that exceed naturally occurring levels. Munitions or other waste buried below depths of concern for hunting and farming are not a concern for the Umatilla tribes.[42]

It is beyond the scope of the committee's work to consider cleanup standards outside the UMCDF portion of the UCD, but the Army should work with the Oregon regulatory authorities and UMADRA to resolve the tribes' request so as to avoid unnecessary delays to completing closure.

[42]Teleconference with Rodney S. Skeen, Manager, Engineering and Modeling Program, Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation; Todd Kimmell and Leonard Siegel, committee members; and Nancy Schulte and Harrison Pannella, NRC staff; May 26, 2010.

REFERENCES

Bechtel Aberdeen. 2007. 24719-100-30L-B93H-00009—Revision 0 Aberdeen Chemical Agent Neutralization Facility RCRA Closure Certification Report. APG Edgewood Area, MD: Bechtel Aberdeen.

EPA (U.S. Environmental Protection Agency). 2009. SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Washington, D.C.: U.S. Environmental Protection Agency.

NRC (National Research Council). 2007. Review of Chemical Agent Secondary Waste Disposal and Regulatory Requirements. Washington, D.C.: The National Academies Press.

NRC. 2008. Review of Secondary Waste Disposal Planning for the Blue Grass and Pueblo Chemical Agent Destruction Pilot Plants. Washington, D.C.: The National Academies Press.

NRC. 2009. Disposal of Activated Carbon from Chemical Agent Disposal Facilities. Washington, D.C.: The National Academies Press.

URS. 2008. Decommissioning Plan Appendix 3: Material and Waste Management Plan. Princeton, NJ: URS.

U.S. Army. 2007. TB MED 577: Sanitary Control and Surveillance of Field Water Supplies. Washington, D.C.: Headquarters, Department of the Army.

6

Monitoring and Analytical Issues

OVERVIEW OF CLOSURE STRATEGY

Depending on the particular site, the planning for closure of the chemical agent disposal facilities that are the subject of this report is designed to achieve Resource Conservation and Recovery Act (RCRA) clean closure according to either industrial or residential standards (Bechtel Aberdeen, 2007; EG&G, 2009b). Facility closure is complete when these conditions are met: all waste management units have been decontaminated, dismantled, and demolished; all ancillary buildings are dispositioned per contractual agreements; and the regulatory authority agrees that closure performance standards have been achieved. The facility closure process includes management of surplus buildings and equipment and waste generated during processing operations.

During closure operations, the concern with respect to potential agent exposure primarily deals with occluded spaces. These are confined volumes within a system, structure, or component that were exposed, or potentially exposed, to liquid agent and therefore have the potential to contain some quantity of agent-contaminated liquid (Bechtel, 2006; Herbert, 2010; Battelle Memorial Institute, 2010; Parsons, 2009).[1] Although in most instances the quantity of agent that may be encountered in such spaces is likely to be small, it takes only a small amount of agent to generate an exposure incident. Therefore, accurate measurement of residual agent is a critical activity in the closure processes.

The challenges posed for closure of chemical agent disposal facilities relate to the measurement of agent quantities that remain in waste media, structures, and equipment. Sampling and analysis of many of these materials is difficult and may not be suited to conventional approaches used for measuring agent contamination. Examples include concrete, polymeric materials, and other waste solids, as well as metal equipment parts. In all of these, small amounts of agent can be retained in occluded spaces or sorbed onto porous materials. Moreover, the agent will not be uniformly distributed, which means that using a reasonable sampling plan structured on a strictly statistical basis may be prone to underrepresentation of the extent of contamination. In view of the extreme toxicity of agents and certain degradation products, there may be significant consequences from misidentifying or underestimating contamination. These conditions carry the additional consequence of high costs and delays derived from the need to collect and analyze many samples.

A potentially sensitive and protective means of identifying residual agent in materials and equipment during closure is the unventilated monitoring testing (UMT) (Herbert, 2009).[2,3] This is a variation on the headspace monitoring approach traditionally used by

[1]Battelle, "Occluded Space Training," presentation to UMCDF, March 3, 2010, provided to the committee by Raj Malhotra, Deputy, Risk Management Directorate, CMA, via email to Nancy Schulte, study director, May 3, 2010.

[2]Carla Heck, Project Manager, URS, "Programmatic Closure Document Development and Status of Closure Planning," presentation to the committee, January 26, 2010.

[3]Richard Sisson, Senior Research Scientist, Battelle, "Closure Tips and Tricks," presentation to UMCDF, provided to the commit-

the Army for clearing material that was suspected to be agent contaminated.[4] What is measured by UMT is the agent in the atmosphere associated with the location being evaluated, which requires that that agent be present in the gas phase. UMT involves enclosing the room or object to be sampled with a plastic barrier that prevents diffusion and allows concentrations to build to the point where the agent can be readily detected by current near-real-time monitoring equipment. The method is designed to protect against airborne exposures to agent, but due to the vapor pressure of the agents and the sensitivity of the analyses, it is also used to infer the presence or absence of liquid agent. UMT, in sampling headspace, can be used for evaluating contamination in many different types of wastes and media. It does not require the time-consuming collection of solid samples and the extractive analyses thereof, which are also subject to uncertainties arising from nonuniform contamination distribution, a feature inherent to closure situations. UMT has been successfully applied in the closure of both the Aberdeen and the Newport facilities (Battelle Memorial Institute, 2010; Parsons, 2009).[5,6]

Chemical or physical phenomena that limit the volatilization of the agent are a potential limitation of the UMT approach, and occluded spaces are a particular concern in this regard. Any agent occupying occluded spaces (for example, agent trapped in small cracks or sorbed into porous materials) may not volatilize sufficiently for headspace measurements. Occluded spaces can prevent (a) contact of the agent with a decontamination solution; (b) volatilization of agent; and (c) subsequent detection using UMT.

In this chapter, the strengths and weaknesses of both conventional analyses and UMT for monitoring equipment and spaces undergoing closure are considered, with a primary focus on identifying approaches that maximize the utility and effectiveness of UMT during closure. Utilization of physical sampling followed by extractive analysis is also briefly discussed.

tee by Raj Malhotra, Deputy, Risk Management Directorate, CMA, via email to Nancy Schulte, study director, May 3, 2010.

[4]Headspace is the gaseous atmosphere associated with an object normally confined by an enclosure or container.

[5]Brian O'Donnell, Chief, PMCSE Secondary Waste and Closure Team, CMA, "CMA Programmatic Closure," presentation to the committee, January 27, 2010.

[6]Jerry Spillane, Closure Engineer, NECDF, "NECDF Closure Lessons Learned," presentation to the committee, October 20, 2009.

Properties of Agents Significant to Closure Situations

The chemical and physical properties of chemical agents affect their toxicity and their detectability. In the context of closure, agent volatility and hydrolysis behavior are the two most significant properties. While all three of the agents processed at the baseline chemical agent disposal facilities are considered semivolatile liquids, the nerve agent GB has a markedly higher vapor pressure (2.9 mm Hg at 25ºC), consistent with faster rates of volatilization (Reutter, 1999). In addition, GB has the greatest ability to diffuse through porous or permeable materials, and hence it is less likely to survive for long periods of time on surfaces or in near-surface environments. Mustard is relatively nonvolatile, with a vapor pressure of 0.11 mm Hg at 25°C. The nerve agent VX has an even lower vapor pressure (only 0.0007 mm Hg at 25°C) (Reutter, 1999).[7] In situations in which mustard or VX fills cracks or diffuses into permeable materials, volatilization may be inhibited, but subsequent disturbances of the system could expose intact agent. This could produce a potential for exposure from volatilization, or more likely from direct dermal contact. Migration or volatilization of mustard or VX from porous or permeable surfaces may not occur.

Chemical agent residues may also become depleted by chemical degradation processes that are principally hydrolysis reactions and that result in significant agent detoxification (with a salient exception of VX as described below). Since the majority of hydrolysis reactions produce degradation products having low toxicity, further discussion is not provided here; additional details can be found in Appendix C. However, VX hydrolysis via P-O bond cleavage is not in this category: this reaction produces S-(N,N-diisopropylaminoethyl) methylphosphonothioic acid (known as EA-2192 in the Army vernacular), which is a compound that retains much of the neurotoxicity of intact VX. Hence, the possible presence of this compound is an ongoing source of concern (Yang et al., 1990; Munro et al., 1999).[8] However, concerns related to EA-2192 are reasonably mitigated by the following considerations:

[7]In the context of this report, bis-(2-chloroethyl) sulfide, or sulfur mustard, is referred to as H, HD (distilled mustard), or HT (distilled mustard mixed with bis-(2-(2-chloroethylthio)ethyl) ether).

[8]The state of Utah requires measurement of EA-2192 to ensure detoxification to closure standards (see Chapter 5).

- EA-2192 has extremely low volatility and therefore poses virtually no inhalation hazard.
- EA-2192 does not diffuse through the skin barrier (as does VX).
- Hydrolysis of EA-2192 proceeds fairly rapidly, with a rate constant on the order of that of the parent compound (0.1 day^{-1}) (Kaaijk and Frijlink, 1977; Verweij and Boter, 1976).[9]

The rate of VX degradation is expected to be fast (on the order of 0.1 day^{-1}), which suggests that residual agent concentrations are likely to be low[10] unless protected in an occluded environment. The degradation rates of G agents will be even faster than those of VX.

RESIDUAL AGENT MEASUREMENT IN CLOSURE

Closure operations at chemical agent disposal facilities are to be conducted in a manner that is intended to eliminate the potential for exposure to agent and hazardous by-products. Each facility will have to comply with closure standards for waste, residues, and media that may be different depending on individual state regulations.

Closure operations are conducted in a series of steps, the explicit definition of which can vary somewhat depending on the site and the individual area undergoing closure. However, all closure operations have common activities, which in general include (Herbert, 2009; Battelle Memorial Institute, 2010):[11,12]

1. *Identification of all areas of historical contamination* (URS, 2009; EG&G, 2009a).[13] This phase is designed primarily to document the history of chemical agent contamination in assessing whether the component or area in question may have come in contact with agent and, if so, in what form. This phase is used to guide where and how occluded space surveys should be conducted, and it may have value for correlating historical exposure events with residual agent when retrospectively compared with the results of UMT.
2. *Identification and elimination of occluded spaces.* This includes conducting an occluded space survey, which is designed to identify locations where agent liquid or vapor may have accumulated, in order to ensure that effective decontamination takes place.
3. *Applying decontamination methods.* This includes the preparation of an occluded space decontamination plan and identification of the appropriate methods to be used for decontamination. These methods will be dependent on the agent and the equipment or material to be decontaminated. Procedures to document decontamination are also defined, as are the future uses planned for the equipment and the appropriateness of the decontamination criteria employed. This step also encompasses decontamination of equipment and areas.
4. *Removal of equipment or leave in place.* Equipment removal requires dismantling and decontamination of the equipment. These activities, as well as the decontamination of areas, are guided by the planning done in the previous phases with a goal of achieving maximum efficacy and with a focus on areas identified in the occluded space surveys.
5. *Verification of equipment decontamination.* This may include wipe testing, extractive analysis, or vapor monitoring. Because many pieces of equipment are not appropriately characterized by wipe testing or extractive analysis, this normally involves tented headspace monitoring of the equipment to ensure that airborne concentrations are less than 1 VSL (<1 vapor screening level), indicating that any residual contamination is minimal.[14]

---

[9]Rate studies of degradation of EA-2192 are few, and rates will certainly vary depending on the specific temperature, moisture present, and the surface with which the compound is in contact.

[10]See Appendix C for citations from the Livermore National Laboratory group, which indicate that rates of 0.1 day^{-1} can be expected for VX, as well as Groenewold (2010).

[11]Brian O'Donnell, Chief, PMCSE Secondary Waste and Closure Team, CMA, "CMA Programmatic Closure," presentation to the committee, January 27, 2010.

[12]Richard Sisson, Senior Research Scientist, Battelle, "Closure Tips and Tricks," presentation to UMCDF, provided to the committee by Raj Malhotra, Deputy, Risk Management Directorate, CMA, via email to Nancy Schulte, study director, May 3, 2010.

[13]Teleconference with Brian O'Donnell, Chief, Secondary Waste, Closure Compliance and Assessments, CMA; Amy Dean, Environmental Engineer, Project Manager for Elimination of Chemical Weapons, CMA; Jeffrey Kiley, Chief, Quality Assurance Office, Risk Management Directorate, CMA; and the committee; May 4, 2010.

[14]A vapor screening level (VSL) is an internal control limit used to clear materials for off-site shipment based on agent concentration in the atmosphere surrounding the materials. The VSL for each agent is set to the short-term exposure limit (STEL)—the

6. *Monitoring to demonstrate adherence to appropriate closure performance standards.* Physical sampling followed by extractive analyses may be employed, but unventilated area monitoring is primarily used as a more sensitive indicator of residual contamination.
7. *Demolition.* Destruction of the physical plant structure, including components found within it, is conducted upon successful completion of all previous steps.

Throughout this process, measurements of residual agent levels constitute a critical activity. Specific objectives of residual agent monitoring are as follows:

- Protecting the workforce during disassembly and demolition;
- Supporting accurate decision making with regard to disposition of secondary wastes, residues, and media;
- Ensuring that contaminant levels at the site are at or below clearance levels; and
- Protecting the general public.

The analytical approaches used to demonstrate adherence to the standards related to the above objectives fall into two categories: either sampling and extractive analysis or vapor space monitoring, which is achieved through tented headspace monitoring (for individual pieces of equipment) or unventilated area monitoring. Procedural details employed for the sampling and extractive analyses can vary substantially depending on the agent, the degradation product, or the matrix being examined. Similarly, temporal variations in the headspace and unventilated area monitoring procedures are employed to cover different sampling volumes that are related to the size of the equipment or room to be monitored. The analytical methods employed, and their variants, must satisfy required method quality control specifications, including accuracy, precision, and detection and quantitation limits for all matrices. Differences in the material and equipment matrices may cause deviations in method performance; these are discussed in more detail below. Analytical method modification may be needed to achieve state-specific closure standards; in these cases, significant time and effort may be required to develop and achieve regulatory approval of modifications.

Sampling Followed by Extractive Analysis

Closure requires that waste, residues, media, buildings, and equipment be decontaminated to concentrations below the applicable closure performance standards appropriate for subsequent facility dismantling and disposal. Similarly, soil at the site must be demonstrated to be below required closure performance standards. Analysis of solid samples from these environments has traditionally been based upon extractive analysis of materials to ensure adherence to closure standards. Extractive analysis has been used both to show that concentrations are below RCRA limits and to establish that decontamination is effective (Bechtel Aberdeen, 2007; EG&G, 2009b).[15]

The appropriate closure standards that may be applied at various facilities may differ, but in general, the standards should recognize that closure will result in waste disposal or recycling of material and equipment. This suggests that the most relevant standards are for occupational exposures. But specific closure standards will be determined on a state-specific basis.

At the Umatilla Chemical Agent Disposal Facility (UMCDF) there is a regulatory requirement that all materials sent off-site, such as construction debris, must be cleared using sampling and extractive analysis. The same is true of the soil sampling to be carried out to certify that the site meets closure requirements. The sampling and extractive analysis of concrete debris presents particular issues due to the difficulty of collecting and analyzing representative samples. Thus, unventilated air monitoring may be a more reliable means to identify the presence of residual agent. There also appears to be a difference of opinion between the EPA and the Oregon Department of Environmental Quality (ODEQ) as to the proper procedure for analyzing concrete debris.[16] UMCDF has ODEQ's approval for a method that includes pH adjustment before extraction, while the EPA method does not allow for pH adjustment. If the EPA method is to be adopted it will require

concentration to which workers can be exposed continuously for a short period—established by the Centers for Disease Control and Prevention (Federal Register, 2003a, 2003b).

[15]CAMDS/TOCDF Closure Team, URS, "CAMDS/TOCDF Closure Status Implementing Programmatic Closure Approach," presentation to the committee, January 27, 2010.

[16]Personal communication between Mike Daniels, closure manager, UMCDF, and Peter Lederman, committee chair, June 16, 2010.

an estimated year to carry out laboratory validation and ODEQ acceptance. This type of challenge can become a major impediment to meeting schedules.

Although sampling and extractive analysis is available as a means to define the status of agent decontamination for closure and to guide the disposition of waste, residues, media, equipment, and buildings potentially contaminated with agent, the problems of representative sampling, accuracy, time requirements, and cost of extractive analysis remain. Due to the difficulty of measuring concentrations in porous solids, particularly construction debris and equipment, the Army has chosen to pursue alternative measurement approaches, namely, headspace monitoring of individual pieces of equipment and unventilated area monitoring for buildings and large areas. As noted previously, these are collectively referred to as unventilated monitoring testing (UMT); they are discussed below. States may nevertheless require sampling and extractive analyses in some cases, such as for clearing wastes for transportation off-site to a treatment, storage, and disposal facility.

Unventilated Vapor Monitoring: An Alternative Approach

The Army has developed alternatives to sampling and extractive analysis. These alternatives use unventilated monitoring of the vapor space around equipment and areas, which reduces the effects of heterogeneity and matrix interferences. Briefly, UMT involves sealing off the equipment or area to be tested; ensuring that the temperature within the sealed volume is 70°F or above; and then monitoring the vapor space within the sealed volume. If volatilized agent is present, this approach allows its concentration to build up by increasing volatilization and preventing diffusion to other parts of the atmosphere. The performance of the UMT will be dependent upon maintaining the specified temperature, which will require actively heating the areas using space heaters and careful temperature monitoring, particularly during the colder months. The result is that concentrations measured in the UMT are much higher than in a comparable *ventilated* test, and for this reason, UMT would be conservatively protective of the workforce.

The unventilated vapor monitoring is applied to both individual pieces of equipment and to buildings and areas. When applied to individual pieces of equipment, the approach involves sealing with plastic sheeting (i.e., tenting of the equipment) and monitoring the vapor concentration of agent after a fixed period of time dependent upon the tented volume (i.e., 15 minutes for a tented volume equal to or less than 0.8 m^3, 45 minutes for a tented volume between 0.8 and 20 m^3, and 4 hours for a tented volume in excess of 20 m^3). The vapor concentration within the sealed volume at the end of the hold time must be less than the vapor screening level. The VSL for each agent is set at the short-term exposure limit—the concentration to which workers can be exposed continuously for a short period—established by the Centers for Disease Control and Prevention (Federal Register, 2003a, 2003b). The use of a standard of 1 VSL in a sealed environment ensures that concentrations much less than 1 VSL would be observed in a ventilated environment.

In buildings or large areas, the area is first subjected to ventilated monitoring over a period of 12 hours to ensure that the VSL is not exceeded before initiating the more severe unventilated test. The area is then sealed to the extent possible and the unventilated monitoring begun. At CAMDS, for example, the unventilated monitoring must show that the concentration does not exceed 1 VSL during any 4-hour period. If time-averaged sampling is used, this means that an average of 0.5 VSL will not be exceeded in any 4-hour period (i.e., assuming a linear rate of increase during the 4 hours). Sampling over multiple periods may be needed to document conformance to closure standards (e.g., 36 hours for CAMDS as per procedure PRP-CAM-002), but the standard remains 1 VSL in any 4-hour period.

The UMT is focused on airborne pathways of exposure and is used to compare potential worker exposure to worker population limits (WPLs) and potential public exposure to general population limits (GPLs). That is, the agent release rate that might lead to 1 VSL within the unventilated monitoring area is such that WPL would not be exceeded in a ventilated area and GPL would not be exceeded outside the work area. As with the VSL/STEL, the WPL and the GPL are set by the Centers for Disease Control and Prevention (Federal Register, 2003a, 2003b). The airborne pathway is the primary path of exposure to residual agent since the demolition strategy is designed to eliminate contact exposure to agent in liquid or solid phases (i.e., areas of potential contamination are subjected to decontamination) and since the facility destruction is done mechanically. Airborne sampling also can be a sensitive indicator of the presence of agent, but only as long as occluded spaces are properly identified and eliminated even though the precise location of the contamination is unknown. Measurement of airborne agent in the headspace can reduce analytical complexity because it effectively samples the entire environment being sampled, and it avoids problems with low extraction efficiency and high chemical background and interference that can accompany an extractive analysis. To date, UMT has been approved for use at CAMDS by the state of Utah.

The UMT approach maximizes the concentrations of agent in the sampled headspace by allowing the concentration to build up in the absence of air exchange, thus making measurements of vaporized agent concentrations easier. This approach thus takes advantage of the stringent precision and accuracy capabilities of the agent air monitors.[17,18] The measured values provide an estimate of agent release rate, which can then be used to estimate maximum airborne exposure in a ventilated configuration. The approach is attractive because it does not require extensive analysis (i.e., sample collection and extraction). UMT is easy to apply in the field and is relatively rapid, and therefore can be implemented with relatively minimal effort. The waste acceptance criteria are straightforward data quality objectives (in particular, detection limits to <1 VSL and avoidance of false negatives).[19]

The acceptably protective airborne limits of exposure to agents for workers (the WPLs) and for the general public (the GPLs) are shown in Table 6-1, together with the corresponding vapor screening level (VSL-STEL) used to evaluate airborne exposures in UMT measurements.

The UMT is designed to ensure that monitored items or areas will successfully meet WPL and GPL levels in a ventilated configuration when the tented or unventilated concentration is maintained below 1 VSL. In the event of agent measurement above the VSL, the area is decontaminated (or decontaminated again), and airborne concentrations are again measured in a ventilated configuration. If vented monitoring meets the <1 VSL criterion, a final unventilated area monitoring is performed. Measured UMT concentrations <1 VSL will ensure that exposure concentrations are greater than WPL in the working area and greater than GPL outside the working area. The previously described seven steps of the approach are designed to ensure that mass demolition of areas and equipment is limited to only those materials that have been decontaminated of agent or have been otherwise cleared. The approach ensures that workers are not exposed to vapors in excess of the WPL and the general population to vapors in excess of the GPL, but it does not directly address direct contact exposures. The effectiveness of the monitoring procedures to support this alternative testing protocol will be discussed in the next section.

ASSESSMENT OF MONITORING PROCEDURES

The overall monitoring procedure involves ventilated workplace monitoring (near-real-time measurements); occluded space identification and decontamination as needed; and, finally, UMT.

Assessment of Workplace Monitoring, Ventilated Environment Configuration

Near-real-time monitoring (i.e., having a response time of approximately 3 to 15 minutes) is used in areas where the presence of agent is possible (NRC, 2005b). Miniature Chemical Agent Monitoring Systems (MINICAMS) are used at the Tooele Chemical Agent Disposal Facility (TOCDF) for this purpose, while automatic continuous air monitoring systems (ACAMS) units are used at CAMDS.[20] The same types of instruments are used at the other baseline disposal facilities. Confirmation monitoring is used to validate or invalidate a positive result from another monitoring system, such as MINICAMS and ACAMS, and is accomplished with the depot area air monitoring systems (DAAMS), which employs variable sampling times. The DAAMS backs up the MINICAMS and ACAMS and reduces false positives.[21] These systems

[17]Richard Sisson, Senior Research Scientist, Battelle, "Closure Tips and Tricks," presentation to UMCDF, provided to the committee by Raj Malhotra, Deputy, Risk Management Directorate, CMA, via email to Nancy Schulte, study director, May 3, 2010.

[18]CAMDS/TOCDF Closure Team, URS, "CAMDS/TOCDF Closure Status Implementing Programmatic Closure Approach," presentation to the committee, January 27, 2010.

[19]Richard Sisson, Senior Research Scientist, Battelle, "Closure Tips and Tricks," presentation to UMCDF, provided to the committee by Raj Malhotra, Deputy, Risk Management Directorate, CMA, via email to Nancy Schulte, study director, May 3, 2010.

[20]Thaddeus Ryba, Site Project Manager, TOCDF, "TOCDF Introduction (DEMIL-101)," presentation to the committee, January 26, 2010.

[21]Thaddeus Ryba, Site Project Manager, TOCDF, "TOCDF Introduction (DEMIL-101)," presentation to the committee, January 26, 2010.

TABLE 6-1 Airborne Exposure Limits for GB, VX, and H, and Ratios of Worker Protection Limit and General Population Limit to Vapor Screening Level

Agent	VSL (mg/m^3)	WPL (mg/m^3)	WPL/VSL	GPL (mg/m^3)	GPL/VSL
GB	0.0001	0.00003	0.3	0.000001	0.01
VX	0.00001	0.000001	0.1	0.0000006	0.06
H	0.003	0.0004	0.13	0.00002	0.0067

NOTE: The ratio of WPL to VSL and the ratio of GPL to VSL provide an indication of the magnitude of the respective WPL and GPL as a fraction of VSL.

SOURCE: NRC, 2005a; Battelle Memorial Institute, 2010; Washington Demilitarization Company, 2010.

comprise the continuous emissions monitoring systems (CEMS) for the sites.

Workplace monitoring measures actual exposures during operations and closure activities and should be used to confirm that acceptable closure standards have been met. It does not provide pre-demolition standards for decontamination, however, nor does it predict the potential for exposure during closure and dismantling activities. It is toward the latter goal that occluded space surveys and unventilated monitoring tests are directed.

Assessment of Occluded Space Identification for Decontamination

The occluded space survey is a key step in the unventilated monitoring test and the ultimate clearance of the site. As such, it is important that it be carried out very carefully and uniformly at all sites.

As previously indicated, occluded spaces are confined volumes within a system, structure, or component that were exposed, or potentially exposed, to liquid agent, and thus have the potential to contain small quantities of agent or agent-contaminated liquid (Battelle Memorial Institute, 2010; Herbert, 2010; Parsons, 2009; Washington Demilitarization Company, 2010). An example is found at the former Newport Chemical Depot (Indiana) facility for the production of the nerve agent VX, in piping that was not knowingly exposed to agent but in fact had residual agent contamination.[22] Piping could represent an occluded space if capped, or merely by slow diffusion rates from an interior run to an opening to the ambient atmosphere (NRC, 2005a, pp. 16-26). Occluded spaces can potentially trap liquid agent, prevent contact with a decontamination solution, and prevent agent vaporization, and hence prevent detection during unventilated monitoring. Some common examples of occluded spaces include internal cavities of pumps and other equipment, cavities or cracks in concrete, internal sections of closed pipes and other systems, flat parallel surfaces in close proximity to each other, pipe and tank supports, and caulking seals around equipment supports and concrete joints.

Occluded spaces can be present in clean and screened material (<1 VSL); this includes decontaminated rooms within facilities and materials such as waste, residues, media, or decontaminated equipment removed for disposal. Of particular concern are items and areas that were potentially contacted by high concentrations of agent, either in liquid form or in vapor form at concentrations above the immediately dangerous to life and health (IDLH) levels.[23] Past exposure to high vapor concentrations does not necessarily lead to significant liquid entrapment, but using an IDLH vapor concentration as an indicator of a need for special decontamination procedures is conservative (protective).

Occluded space teams (OSTs) have the responsibility for identifying occluded spaces and are the key to finding agent that might not be identified by other means. That is, extractive testing may not involve testing of the specific space containing the occluded liquid; likewise, vapor testing is more likely to detect the presence of occluded agent, but even that may not be successful if the agent is completely contained or tightly sorbed into the material. Accordingly, identification of occluded

[22]VX degradation products were found in a 0.5-inch nitrogen line at NECDF in February 2004. The nitrogen had been used to purge tanks and reactors, for transferring liquids using pressure, and in the munitions filling process. Contamination of nitrogen systems is not uncommon in the petrochemical industry. It can occur if the supply pressure of the nitrogen system is not designed to be greater than the maximum system pressure or if the nitrogen supply failed during the operation of the process.

[23]IDLH values are 0.1, 0.003, and 0.7 mg/m^3 for GB, VX, and HD, respectively (NRC, 2005a).

spaces requires significant expertise and thoroughness that are achieved in the form of a multidisciplinary team trained for this extremely important purpose (Battelle, 2010; Herbert, 2010).[24]

The Army utilizes contractor experts for training the OSTs because of the diversity of possible occluded spaces. However, training expertise is concentrated in a relatively small number of individuals. Ideally, it would be desirable to draw upon the skills and experience of as broad a cross section of occluded space expert trainers as possible. Expertise should be solicited from those who have participated in various closure activities and from various organizations within a site, and such personnel should be tapped to provide OST training. This would ensure that occluded space surveys would benefit from information exchanged with other locations and would include formal transference of occluded space survey experiences through regular meetings focused on discussing common challenges. To ensure that the results of the OSTs are shared, they should be made part of the lessons learned program and reported as lessons learned.

Because of the complexity of the occluded space survey activity, and because it is possible for potential occluded spaces to be missed in the survey process, a second occluded space survey is carried out at the direction of management.[25] The committee believes that at a minimum, a second survey is necessary. Based on a comparison of the first two surveys, management may in its judgment decide to do a third survey.

In an occluded space survey, the OST conducts a preliminary occluded space inspection and generates an occluded space task list. The occluded spaces thus identified are opened, decontaminated, and wedged open or supported to eliminate the occluded space potential. The OST then performs a physical survey by walk through. If any additional occluded spaces are identified at this stage, they are then decontaminated prior to final unventilated monitoring.

[24]Teleconference with Brian O'Donnell, Chief, Secondary Waste, Closure Compliance and Assessments, CMA; Amy Dean, Environmental Engineer, Project Manager for Elimination of Chemical Weapons, CMA; Jeffrey Kiley, Chief Quality Assurance Office, Risk Management Directorate, CMA; and the committee; May 4, 2010.

[25]Teleconference with Brian O'Donnell, Chief, Secondary Waste, Closure Compliance and Assessments, CMA; Amy Dean, Environmental Engineer, Project Manager for Elimination of Chemical Weapons, CMA; Jeffrey Kiley, Chief, Quality Assurance Office, Risk Management Directorate, CMA; and the committee; May 4, 2010.

Finding 6-1. The occluded space survey is a key component of the overall monitoring strategy for closure, and it requires occluded space survey teams with a high level of expertise and significant training for proper execution.

Recommendation 6-1. Occluded space survey protocol should be standardized across the entire enterprise, and training should be strengthened, standardized across the program, and continually updated.

Finding 6-2. The expertise for occluded space survey training is concentrated in a few individuals within the overall closure activity.

Recommendation 6-2. Occluded space survey training should be diversified to include multiple experts to provide redundancy commensurate with the importance of this activity.

Finding 6-3. It is possible to fail to identify occluded spaces during the survey process, but a second survey can provide a more comprehensive identification.

Recommendation 6-3a. A second occluded space survey should be conducted by an occluded space team independent of the team that conducted the initial survey as a means of providing a higher level of confidence that all occluded spaces have been identified.

Recommendation 6-3b. A third occluded space survey should be considered based on a comparison of the first and second surveys.

Assessment of Unventilated Monitoring Testing

Upon completion of decontamination of equipment and small areas, buildings and larger areas are subjected first to ventilated and then to unventilated monitoring as described earlier. If the headspace concentrations are measured at <1 VSL in the UMT, further decontamination is not required, and the area can be made available for demolition. The unventilated environment does not represent the conditions that demolition workers would encounter, but nonetheless, it enables measurement at lower levels and thus provides a more conservative evaluation of a potentially exposed environment. The product of the UMT measurement is actually a rate at which vapor source is emitted, which is calculated by dividing the measured concentration by the time during which the sample was collected. The rate is converted to an unventilated-environment concentration by dividing the rate by the rate of air exchange in the fully ventilated configuration. It should be noted that extractive sampling requires defining a statistically valid sampling protocol, and this can be very difficult to achieve in a heterogeneous environment. The approach assumes that the concentration versus time profile generated in the UMT is linear. In actuality, the time plot usually produces a logarithmic profile, which results from the depletion of the source or reduction in the release rate as the system approaches equilibrium. A grab sample after a relatively short time will provide the initial slope and overestimate the average emission rate. Thus, UMT measured concentrations will tend to provide conservatively high emission rates for agents.[26,27]

The UMT is appropriately designed to protect the worker and general populations against exposure via airborne pathways. The data resulting from this approach can be used to verify that workers are not exposed to vapor concentrations in excess of the WPL and that the general population is not exposed to vapor concentrations in excess of the GPL. However, the approach does not evaluate the presence of agent in occluded spaces that were not properly identified and from which agent does not partition into the vapor phase at sufficient rates to exceed the VSL during the testing hold times. Since these residual quantities will be small, risks due to inhalation exposure will likely be negligible. In local instances, however, some dermal contact risk may arise during demolition. This should be mitigated by the fact that there will be no human contact with the demolition waste, as all handling will be done mechanically.

While the Army is applying its UMT for clearance of equipment and structures, there may be additional applications for this test. First, the committee believes that because the UMT is being used to clear buildings, the resulting debris from building demolition does not need to be subject to additional agent testing, either vapor screening or direct analysis. This assumes that the ultimate disposition of all materials is in industrial waste or industrial recycling facilities where WPLs (the focus of the UMT) will be protective and where there is no potential for dermal contact. In addition, the UMT may have potential for clearing other types of materials produced during closure—including waste, residues, and media (e.g., soil)—as being below levels of concern for agent contamination. By employing this test for waste, residues, and media as well, expensive and time-consuming direct sampling and extraction and analysis could be avoided, and the committee believes that overall closure schedules could be expedited while still protecting human health and the environment.

The Army may benefit from an evaluation of whether or not UMT is protective of human health and the environment when applied to a broader ensemble of waste, residues, and media (e.g., porous matrices). Finally, the results of the UMT measurements may be particularly valuable when correlated with agent spill or release histories. Careful comparisons of UMT results with past exposures may enable conclusions regarding agent persistence, occluded space surveying, and UMT efficacies.

It is highly probable that this approach will be protective of the workforce against airborne exposure. It should be noted that the series of protocols that culminate in the UMT provide only information on the absence or presence of agent. They are, as has been stated, aimed at protecting workers. The protocols do not provide any information about the presence of such other hazardous materials as semi-volatiles or heavy metals (e.g., mercury (Hg) or arsenic (As)), which could affect the options for disposing of materials that could be contaminated with such materials.

Finding 6-4. Unventilated monitoring testing—conducted in sequence with site exposure and spill histories, ventilated monitoring, and occluded space surveys—is appropriately designed to ensure protection of workers and the general population from agent exposure via airborne pathways. It is the final “critical step” in clearing a site for mass demolition.

Recommendation 6-4a. The Army should ensure both that the unventilated monitoring testing (UMT) protocol is uniform throughout the enterprise and that the information gained by the UMT sequence is aggressively communicated to subsequent closure sites.

Recommendation 6-4b. Locations of prior exposures and spills should be compared with the results of the unventilated monitoring testing (UMT) measurements.

---

[26]Richard Sisson, Senior Research Scientist, Battelle, “Closure Tips and Tricks,” presentation to UMCDF, provided to the committee by Raj Malhotra, Deputy, Risk Management Directorate, CMA, via email to Nancy Schulte, study director, May 3, 2010.

[27]CAMDS/TOCDF Closure Team, URS, “CAMDS/TOCDF Closure Status Implementing Programmatic Closure Approach,” presentation to the committee, January 27, 2010.

Correlation (or not) of past exposure events with UMT release rates could provide valuable insight into residual contamination, effectiveness of occluded space surveys, and UMT efficacy.

Finding 6-5. The unventilated monitoring testing sequence does not protect against dermal contact arising from waste contaminated with small quantities of agent that could be sequestered in occluded spaces. Worker protection against this risk is reliant on the occluded space surveys and on the all-mechanical handling of the demolition wastes.

Recommendation 6-5. Worker training should reinforce the use of proper protective measures against dermal contact even where vapor space monitoring shows no inhalation risk.

Finding 6-6. The monitoring program is appropriately focused on agent. Agent hydrolysis products are nontoxic or have low toxicity, with the salient exception of EA-2192 (see discussion earlier in this chapter), which does not have probable exposure routes and hence does not pose a significant risk. Other waste components (e.g., Hg and As) may affect ultimate disposal of waste materials and debris, but these can be managed within existing waste disposal rules.

Recommendation 6-6. The Army should ensure that procedures are in place to adequately analyze for other waste components that may affect ultimate disposal of waste materials and debris.

Finding 6-7. The unventilated monitoring testing can potentially be used for screening many different types of closure waste, residues, and media as being below levels of concern for the agents. Additional evaluations may demonstrate that vapor screening will meet regulatory approval in states in which it will be used to characterize debris for disposal, and they may determine whether the method is protective against dermal exposure.

Recommendation 6-7. The Army should consider conducting additional evaluations for two reasons: to demonstrate that vapor screening will meet regulatory approval in all states in which it will be used to characterize debris for disposal, and to determine whether the method is protective of human health and the environment for waste, residues, and media.

Finding 6-8. Some analytical method modifications may be needed to achieve state-specific closure and disposition standards, and in such cases, significant time and effort may be required for these modifications and for achieving regulatory approval.

Recommendation 6-8. Where method modification is needed, the Army should begin the modification and approval process as early as possible. In all cases, the Army should present its method modifications plans, including acceptance criteria, to the regulatory authority before method modification begins to gain preliminary approval. In addition, where method modifications at individual baseline facilities appear to be similar, the Army should coordinate its method modification activities among the sites to avoid duplication of efforts.

REFERENCES

Battelle Memorial Institute. 2010. Occluded Space Survey Plan Revision A. Columbus, Ohio: Battelle Memorial Institute.

Bechtel. 2006. Attachment VII. DWO18941 Occluded Space Survey. Gunpowder, MD: Bechtel.

Bechtel Aberdeen. 2007. 24719-100-30L-B93H-00009—Revision 0 Aberdeen Chemical Agent Neutralization Facility RCRA Closure Certification Report. APG Edgewood Area, MD: Bechtel Aberdeen.

EG&G Defense Materials, Inc. 2009a. CAMDS Due Diligence Review Contamination History Review. Stockton, Utah: EG&G Defense Materials, Inc.

EG&G Defense Materials, Inc. 2009b. Chemical Agent Munitions Disposal System (CAMDS) Closure Verification Sampling and Analysis Plan (Draft). Stockton, Utah: EG&G Defense Materials, Inc.

Federal Register. 2003a. Final Recommendations for Protecting Human Health from Potential Adverse Effects of Exposure to Agents GA (tabun), GB (sarin), and VX. Federal Register 68(196): 58348-58351.

Federal Register. 2003b. Proposed Airborne Exposure Limits for Chemical Warfare Agents H, HD, and HT (sulfur mustard). Federal Register 68(140): 43356-43357.

Groenewold, G. 2010. Degradation Kinetics of VX. Main Group Chemistry. In press.

Herbert, J. 2010. PRP-CAM-004—Occluded Space Process. Stockton, Utah: URS, EG&G Division.

Herbert, J. 2009. Unventilated Monitoring Prerequisites and Conduct to Support Closure. Stockton, Utah: URS, EG&G Division.

Kaaijk, J., and C. Frijlink. 1977. Degradation of S-2-di-isopropylaminoethyl O-ethyl methylphosphonothioate in Soil. Sulphur-Containing Products. Pesticide Science 8(5): 510-514.

Munro, N., S. S. Talmage, G. D. Griffin, L. C. Waters, A. P. Watson, J. F. King and V. Hauschild. 1999. Environ. Health Perspect. 107:933-974.

NRC (National Research Council). 2005a. Impact of Revised Airborne Exposure Limits on Non-Stockpile Chemical Materiel Program Activities. Washington, D.C.: The National Academies Press.

NRC. 2005b. Monitoring at Chemical Agent Disposal Facilities. Washington, D.C.: The National Academies Press.

Parsons. 2009. Final Clearance Report to Support Termination of Engineering Controls and Mass Demolition of the UB. Indianapolis, IN: Parsons.

Reutter, S. 1999. Hazards of Chemical Weapons Release during War: New Perspectives. Environmental Health Perspectives 107(12): 985-990.

URS. 2009. CAMDS Chemical Test Facility (CTF) Building C-7071 Decommissioning Work Package (DWP). Stockton, Utah: EG&G Division.

Verweij, A., and H. Boter. 1976. Degradation of S-2-Di-isopropylaminoethyl O-ethyl Methylphosphonothioate in Soil: Phosphorus-Containing Products. Pesticide Science 7(4): 355-362.

Washington Demilitarization Company. 2010. PB-PL-110 Facility Closure Plan (Draft). White Hall, AR: Washington Demilitarization Company.

Yang, Y.-C., L. Szafraniec, W. Beaudry, and D. Rohrbaugh. 1990. Oxidative Detoxification of Phosphonothiolates. Journal of the American Chemical Society 112(18): 6621-6627.

Appendixes

Appendix A

Reprinted 2010 Letter Report

The following report is a reprint of National Research Council, "Review and Assessment of Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System: Letter Report" (The National Academies Press, Washington, D.C., 2010), available online at http://www.nap.edu/catalog.php?record_id+12838.

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

Board on Army Science and Technology

Mailing Address:
500 Fifth Street, NW
Washington, DC 20001
www.nationalacademies.org

January 7, 2010

Mr. Conrad F. Whyne
Director
Chemical Materials Agency
5183 Blackhawk Road
Edgewood Area
Aberdeen Proving Ground, MD 21010-5424

RE: Letter Report on Review and Assessment of Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System

Dear Mr. Whyne:

The Chemical Materials Agency (CMA), under your direction, requested the National Academies' Board on Army Science and Technology to examine the current state of closure activities for the Tooele Chemical Agent Disposal Facility (TOCDF) and the Chemical Agent Munitions Disposal System (CAMDS). In this brief interim report, the Committee on Review and Assessment of Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System addresses some of the issues pertaining to closure at the TOCDF and CAMDS facilities. It also provides insights into what the committee believes are important parameters to ensure the success of the CMA's closure program for these and CMA facilities at other locations. As indicated in the statement of task for the committee (see Attachment A), this interim report is to be followed by another report, referred to hereinafter as "the full report," which will use these parameters to conduct a comprehensive assessment of closure activities and issues.

For this interim report, the committee examined the current status of closure plans for both the TOCDF and CAMDS based on presentations by key members of your staff and the systems contractor. It then developed a set of parameters based on this high-level evaluation that it believes are important in ensuring a consistently effective approach to the closures of the four currently operating CMA chemical agent disposal facilities. The committee also assessed regulatory requirements imposed by the state of Utah, where TOCDF and CAMDS are located.

TOCDF and CAMDS are totally different facilities with different missions and different life cycles. They are located at Deseret Chemical Depot (DCD) near Tooele, Utah, and share the same systems contractor for closure. Likewise, both are under the jurisdiction of the same Utah state regulatory authorities and share many of the same regulatory challenges. They are often viewed by the public as one facility. At present, it is

anticipated that both facilities will stay under Army control after closure as part of the nearby Tooele Army Depot.

TOCDF is a large, active facility where disposal operations for mustard agent munitions and ton containers will continue until well into 2011. In addition to the baseline facility, a small skid-mounted liquid combustion unit, complete with a pollution abatement system, is being designed and will be constructed in the adjacent munitions storage area known as Area 10 to dispose of small quantities of the nerve agent tabun (GA) and lewisite. It is further anticipated that an explosive destruction technology chamber will be brought on-site to handle mustard agent munitions referred to as "rejects," which present problems for processing through the TOCDF disassembly and destruction processes. A further complication affecting the closure of TOCDF is the approximately 2 million pounds of legacy secondary wastes in storage that must be managed and disposed of during closure operations.

Closure planning for TOCDF, including the disposal of legacy wastes and the planning for the new units noted above, is presently at an early stage. While a general closure plan was initially submitted as part of the initial permit application for TOCDF, a more detailed closure plan is expected to be submitted to the state for TOCDF in June 2010. This and other information on the use of specific processes and analyses will be the subject of the full NRC report, to be prepared. Discussions with the state of Utah Department of Environmental Quality (UDEQ) are already under way to identify challenges that will eventually be addressed in the more detailed closure plan.

The closure of CAMDS is at an entirely different stage, and except for the laboratories (discussed below), CAMDS is no longer operational. It was the pilot facility for the U.S. Army's chemical demilitarization activities and operated between 1979 and 2005. The CAMDS site encompasses 61 hazardous waste management units, a ventilation system, and a number of buildings, some of which were used in testing equipment for chemical agent destruction processes. Initial closure activities were carried out by personnel affiliated with the Tennessee Valley Authority, who have recently been replaced by the TOCDF systems contractor, the EG&G Division of URS Corporation. Closure has progressed, with some equipment already removed from the buildings. More detailed closure plans are being written for CAMDS, and their approval is being requested on a unit-by-unit basis from the UDEQ. Final closure is expected to be completed by the first quarter of 2012. The main challenges associated with CAMDS closure stem from its age, its use as a pilot facility, and to the site having many interconnected buildings and common utility services whose closure requires careful staging.

Laboratory capabilities at CAMDS are being upgraded and will be used throughout the remaining disposal operations at DCD and the closure campaigns for CAMDS and TOCDF. It is anticipated that the laboratory closure will take place in 2015. The committee is not aware of any current detailed closure plans for the laboratory.

The committee spoke with the chair of the Citizens Advisory Commission (CAC), who indicated that the CAC fully understands that the closures of the TOCDF and CAMDS facilities are a separate issue from the disposition of other solid waste management units (SWMUs) on the site that will require remediation. The CAC chair further indicated that at this time closure has not yet become an important issue except for concern about loss of jobs. The Army and community have not so far developed a plan for community involvement during closure.

The committee also spoke with members of the UDEQ that oversee compliance with state hazardous waste laws and requirements. In its exercise of regulatory jurisdiction over the TOCDF and CAMDS, the state of Utah developed some unique regulatory requirements.[1] Authority to regulate hazardous waste facilities and closure under the Resource Conservation and Recovery Act (RCRA) was delegated to the state by the federal Environmental Protection Agency (EPA). Utah requirements generally adhere to all the EPA RCRA regulations, but in addition to these, waste listings specific to chemical agent operations have been added to the regulations. That is, "Nerve, Military and Chemical Agents" is a class of materials listed as acute P999 hazardous waste. "Residues from Treatment and Testing of Nerve Military and Chemical Agents" are a class of materials listed as F999 hazardous waste. In addition, all wastes that have been potentially exposed to agent liquid or vapor are considered a P999 or F999 "listed waste." Any hazardous waste that meets the waste control limits (WCL) for agent by chemical analysis is an F999 waste that, on a case-by-case basis, can be considered for shipment off-site for additional treatment if necessary and subsequently sent to a hazardous waste landfill. Used (spent) activated carbon poses a particular challenge in this regard because Utah considers any activated carbon from chemical agent disposal operations, whether or not it was actually exposed to one or more chemical agents, to be a P999 waste that must be treated on-site. Utah's practices for chemical agent wastes and residues are atypical within Utah; commercial hazardous wastes within the state are not so regulated. That is, these practices are considered more restrictive and may impede the efficient disposition of wastes and the closure of the TOCDF and CAMDS sites.

In this interim study, the committee also considered prior closure experiences for three other chemical agent disposal facilities: the prototype baseline Johnston Atoll Chemical Agent Disposal System on Johnston Island in the Pacific Ocean and the hydrolysis-based facilities in Aberdeen, Maryland, and Newport, Indiana, where, respectively, bulk mustard agent and VX nerve agent were destroyed. In doing so, the committee remained mindful of the differentiating characteristics of these facilities in relation to TOCDF and CAMDS. After evaluating these earlier closures and the closure planning to date for TOCDF and CAMDS, the committee identified parameters that are key to the successful closure of the still-operating CMA facilities. These are discussed in more detail in Table 1 of the main body of this interim report, which follows the committee's findings and recommendations.

FINDINGS AND RECOMMENDATIONS

Finding 1. The Tooele Chemical Agent Disposal Facility operates with a strong safety culture, but this admirable approach to safety as an overriding parameter was not

[1]Unique in this context has two meanings. Utah's regulations and practices for chemical demilitarization activities located in Utah differ from those of other states. Utah also regulates chemical demilitarization facilities and the wastes they produce in a manner different from how it regulates other hazardous waste facilities in Utah—that is, facilities that do not produce chemical agent wastes.

sufficiently emphasized in either the briefings the committee received or the Programmatic Closure Planning document.

Recommendation 1. The management of the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System should consider safety the primary value in all of its decisions and work activities, and it should make its commitment to a safe operation highly visible to all workforce personnel and site visitors.

Finding 2. Parameters and metrics provide important guidance for planning, organizing, and implementing efficient closure of chemical demilitarization sites.

Recommendation 2. The Army should consider the parameters and metrics presented in Table 1 (in the main body of this report) as it plans for the closure of the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System.

Finding 3. As deconstruction activities proceed over the course of closure operations at the Chemical Agent Munitions Disposal System and the Tooele Chemical Agent Disposal Facility, a separate workforce will be on-site specifically to conduct demolition. This situation raises the possibility that safety performance could degrade because the new demolition workforce may be unfamiliar with the dangers of agent and agent degradation products and unfamiliar with the background circumstances regarding any demolition work done before its arrival.

Recommendation 3. The Tooele Chemical Agent Disposal Facility/Chemical Agent Munitions Disposal System management should establish a cross-training and hazards familiarization program to ensure continued strong safety performance and effective utilization of personnel.

Finding 4. The Utah Department of Environmental Quality (UDEQ) and the Army and contractor continue to have good relations. Some UDEQ regulatory practices differ from those in force for commercial hazardous waste management facilities in Utah and, in some cases, in other states that host chemical demilitarization facilities. All wastes from agent operations are considered listed wastes even if there is only a potential for exposure to vapor, and they often require treatment on-site to meet waste control limits before they are transported off-site and ultimately disposed of in a hazardous waste landfill.

Recommendation 4. The Army should negotiate risk-based criteria based on attainable waste control limits with Utah Department of Environmental Quality to establish the reuse, recycling, on-site treatment, off-site treatment (if necessary), and off-site disposal for all major waste streams—especially metal, activated carbon, and concrete.

Finding 5a. The Army and its contractor have been planning for the Tooele Chemical Agent Disposal Facility closure for some time. Plans are to submit a request for a Resource Conservation and Recovery Act (RCRA) permit modification that will establish details for meeting relevant regulatory requirements applicable to the closure plan by June 2010. Although some early closure activities have been initiated as approved partial closure authorizations under RCRA, formal closure operations of the munitions demilitarization building are expected to begin in September 2011, with closure of the metal parts furnace and liquid incinerators later on (mid-2013) to allow their availability for continued waste processing, including closure waste processing. The committee finds this schedule optimistic.

Finding 5b. Based on the information provided in the basic closure plan of the current permit, which will be combined into a single permit covering both the Chemical Agent Munitions Disposal System and the Tooele Chemical Agent Disposal Facility, there appears to be sufficient time to meet the Army's indicated milestones for closure of the Chemical Agent Munitions Disposal System.

Recommendation 5. The Army should confirm with the regulators their willingness to consider partial closure with attendant more detailed closure plans and permit modifications. It should establish a realistic accelerated schedule for submitting its Tooele Chemical Agent Disposal Facility Resource Conservation and Recovery Act Closure Plan to ensure that closure operations are not delayed.

Finding 6. At the time of this report, it is anticipated that the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System sites will be closed to an industrial use specification and have an end use that involves becoming part of the Tooele Army Depot. Still, a risk-based closure performance standard that would reflect an industrial end use, in the form of specific concentrations of specific constituents in the various waste types and media, has not been negotiated. It is also unclear whether analytical methods have been approved in Utah that are capable of measuring the analytes at the selected performance standard.

Recommendation 6. The end use for the Tooele Chemical Agent Disposal Facility and Chemical Agent Munitions Disposal System sites should remain as defined at the start of closure planning to avoid extensive delays. The Army should expedite its discussions with Utah Department of Environmental Quality on specific risk-based closure performance standards that must be achieved. Further, if necessary, the Army should expedite its effort to gain approval of analytical methods.

Finding 7. The risk of exposure to chemical agents during closure operations is expected to be significantly lower than what potentially could be encountered during agent disposal operations. The regulatory standards and practices used by the state of Utah for controlling agent-contaminated materials were developed early in the program when there was little experience with managing the risks of materials exposed to agent. These practices and regulations may be more restrictive than necessary considering the nature of the closure operations.

Recommendation 7. The Army should evaluate the reduced risk of exposure to chemical agents and their degradation products from closure operations and waste materials in view of Utah's restrictive regulatory practices and consider negotiating with the Utah

regulatory community to obtain less restrictive, but safe, regulatory practices that allow for more efficient closure operations.

Finding 8. Through the Citizens Advisory Commission, Outreach Office, and other forums, the Army has created a successful public participation program. The Army and community have not developed a plan for community involvement during closure.

Recommendation 8. The Army should discuss with the Citizens Advisory Commission ways to establish a continuing, constructive public involvement between the end of demilitarization and formal closure.

Finding 9. A comprehensive Lessons Learned program for operations has been implemented by Tooele Chemical Agent Disposal Facility (TOCDF) management, and is also being applied to the TOCDF and the Chemical Agent Munitions Disposal System closure. For example, a comprehensive worker retention program for use during closure operations is in place.

Sincerely,

Peter B. Lederman, Ph.D., *Chair*
Committee on Review and Assessment of Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System

Attachments:

A Statement of Task
B Acronyms and Abbreviations
C Committee on Review and Assessment of Closure Plans for the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System
D Acknowledgement of Reviewers

Assessment Criteria and Status Review of Closure Planning for TOCDF and CAMDS

CLOSURE PARAMETERS AND RELATED METRICS

In satisfying the statement of task, the committee identified a series of key parameters for overall program management of the closure of the Tooele Chemical Agent Disposal Facility (TOCDF) and the Chemical Agent Munitions Disposal System (CAMDS). The committee considered the lessons learned by the U.S. Army Chemical Materials Agency (CMA) at earlier facility closures, specifically, the closure of the Johnston Atoll Chemical Agent Disposal System (JACADS), which was the first full-scale incineration-based disposal facility; the Aberdeen Chemical Agent Disposal System (ABCDF), which was the first neutralization-based disposal facility; and the Newport Chemical Agent Disposal Facility (NECDF), another neutralization-based facility. It used the information from these closure experiences and committee member expertise and knowledge of the plans and activities for TOCDF and CAMDS as the basis for developing the parameters in Table 1, which are discussed below.

The parameters in Table 1 are shown along with associated metrics for promoting a safe and successful program for facility closure. These metrics are of two kinds: leading metrics, which help predict performance, and lagging metrics, which indicate the actual performance. While the metrics listed are considered important by the committee, they should not be considered all-inclusive. Moreover, it is important to note that as has been the practice during agent disposal operations, all plans and actions regarding closure need to be fully documented for future use and analysis.

Safety, Health, and Security

The committee believes that safety must continue to be at the forefront during closure operations. Both leading and lagging metrics for safety, health, and security (as well as other parameters) need to be tracked and documented as part of the normal deconstruction process. While not an exhaustive list, the metrics provided in Table 1 for this parameter represent a strong start. Good outcomes concerning safety and health are supported by the establishment of systemic data collection, site observations, and incident reporting and investigation processes. Also, the committee believes that the existing operations workforce should be briefed on the hazards of the deconstruction activities.

Communications for Promoting Safety Culture

The committee likewise believes that a strong, positive, safety culture will continue to prevail at TOCDF/CAMDS if the management maintains an active and involved safety communication and audit program. A good safety and operations culture rests on frequent formal and informal sharing of information and ongoing dialogue.

TABLE 1 Facility Closure Parameters and Associated Leading and Lagging Metrics[a]

Parameter	Leading Metrics	Lagging Metrics
Safety, health, and security	• Near misses (potential injury, potential exposure, potential breach) • Site orientation for visitors and workforce • Incident investigations completed within 30 days • Cross training for workforces and supervisors • Appropriate personal protective equipment for all tasks (goal is 100 percent) • Closure of open safety items in a timely manner • Random drug testing	• First aid cases by body part • Recordable injuries and exposures • Lost-time injuries (number) • Days away from work due to workplace incident/injury • Fatalities (all causes) • Transportation incidents on-site/off-site • Fires (ranging from smoke through explosion) • Security (actual breach of fence line, procedures)
Communications for promoting safety culture	• Periodically survey employees, supervisors, and managers with respect to criteria important to a strong safety culture	• Document frequency of safety communication sessions where employee leadership and participation are encouraged
Maintenance	• Planning and scheduling of all maintenance work • Appropriate maintenance for construction equipment • Preventive maintenance program for key equipment • Predictive maintenance program for key equipment • Appropriate calibration and checking of instrumentation and controls	• Audit maintenance process regularly • Monitor maintenance
Training and development	• Cross train and educate for critical operation and deconstruction positions • Continuing education: at least 40 hours per year of technical coursework • Workforce training on the facility and on non-normal process situations for operation personnel, including drills for abnormal conditions • Workforce training on the facility and on non-normal process situations for deconstruction personnel, including emergency and abnormal conditions	• Not applicable

Parameter	Leading Metrics	Lagging Metrics
Communications with various stakeholders	• Scheduled communications with a local community action committee with a consistent agenda • Communications with the state of Utah regulatory personnel on a regular and as needed basis • Regularly scheduled two-way communications with the workforce throughout the life cycle of the site • Track the lessons-learned program to ensure that the lessons are utilized throughout the chemical demilitarization program	• Measure response to meetings scheduled with stakeholders
Quality criteria	• Identify complete inventory of units to be closed and the end state plan for each • Ensure the environmental health and safety management system is complete and operating with appropriate data analysis and management • Develop project schedule milestone projections for the next period (week, month)	• Track engineering changes • Regularly track project schedule milestones from preplanning to completion
Cost criteria	• Project program costs over similarly selected periods and verify	• Track program costs over selected periods
Operations and deconstruction	• Monitor lockout-tag-clear-and-try process • Establish and document safe operating conditions for all major process equipment • Establish expected frequency and duration of “hot” electrical work	• Document excursions outside operating conditions • Document frequency and duration of safety interlock bypasses • Document frequency and duration of “hot” electrical work • Track deconstruction progress (e.g., weight, volume, or number of units)

Parameter	Leading Metrics	Lagging Metrics
Management	• Ensure that supervisors and managers have appropriate experience with respect to operations, maintenance, or laboratory skills for high-hazard processes • Develop processes by which top managers regularly audit and assess all key activities	• Monitor implementation of personnel development and retention plan
Environmental regulatory compliance	• Establish facility end-state conditions • Establish performance standards for closure wastes • Modify Resource Conservation and Recovery Act (RCRA) permit to include detailed closure plans • Modify other applicable permits to include closure	• Monitor compliance with RCRA permit • Monitor compliance with closure plans • Monitor compliance with other permits
Monitoring plan compliance	• Develop waste analysis plan and waste characterization protocols • Develop monitoring plans for air and other media	• Monitor implementation of waste analysis plan
Analytical	• Establish criteria for use of generator knowledge • Identify validated analytical methods to be used • Obtain regulatory acceptance of validated analytical methods	• Not applicable
Materials management	• Identify reuse and recycling options for deconstruction materials • Develop protocols for segregation of generated hazardous and nonhazardous materials • Obtain prior regulatory agreement for reuse, recycling, or disposal of all materials • Identify means for control of inventory of hazardous and nonhazardous materials • Establish a time line for risk-based disposition of all materials resulting from closure	• Implement control of inventory of hazardous and nonhazardous materials

[a] A leading indicator is a prospective metric or set of metrics that can be used to develop strategies for project success; a lagging indicator is a retrospective metric or set of metrics that can point to a need for corrective action (NRC, 2009).

Maintenance

Many injuries can be prevented through well-managed maintenance work processes. Basic maintenance begins with planning and scheduling, and it is a good goal to have at least 85 percent of all maintenance activities planned and scheduled at least one week in advance. To minimize worker exposure, it would be advantageous to implement both preventive and predictive maintenance programs for equipment that will operate during closure, such as the metal parts furnace.

Training and Development

Training and development of the workforce is a key strategic element for successful program completion. The technical aspects of the TOCDF and CAMDS closure operations mandate that the workforce be properly prepared through education and training provided by their employer. Additionally, it is imperative that an effective communication strategy be developed to ensure that there is open two-way dialogue with the workforce, regulators, and the community on critical issues. The committee believes that a concerted effort should be made to train the deconstruction workforce on hazards awareness pertinent to the site situation. This cross training between personnel familiar with operations at the site and the deconstruction workforce is believed to be essential for the safe outcomes that all stakeholders are interested in seeing. Establishing a program to assess the effectiveness of the training provided is also necessary.

Communications with Various Stakeholders

TOCDF/CAMDS management must actively lead and support communications with key stakeholders. Good communications build trust and provide more opportunities to understand the changing nature of risk.

Quality Criteria

Program quality is a key strategic element for successful program completion. Quality elements, such as adequate and appropriate analytical capabilities and retention of key personnel, comprise critical program management items that can significantly affect the outcome. Integrating quality into the operation supports all activities for continuous improvement.

Cost Criteria

Program cost objectives are a key strategic parameter of the successful completion of site closure. Management should be able to both forecast anticipated costs and to effectively explain all expenditures—both committed and expended— during any period.

Operations and Deconstruction

The committee identified some common work activities for this parameter and listed them in Table 1). If done safely, these activities can lead to a safe and reliable closure operation.

Management

With all work activities, management sets the tone and leads the site effort by its example and their leadership. The metrics listed for this parameter in Table 1 offer ways to consider how management may want to measure their activities and their effectiveness along with exercising appropriate oversight of all leading and lagging metrics in Table 1.

Environmental Regulatory Compliance

Obtaining regulatory agreement to the closure plan in a timely manner is key to achieving efficient closure. This requires close coordination with the regulatory community to obtain early agreement on closure performance standards. Before closure performance standards can be negotiated, the end state must be established. Based on this anticipated end use, environmental standards and guidelines can be established, closure plans completed, and permits modified. Continued monitoring for meeting the permit requirements will minimize delays.

Monitoring Plan Compliance

Development of the waste analysis plan requires agreement between the site contractor, the Army, and the Utah Department of Environmental Quality (UDEQ). This requires determination of what is to be analyzed and what analytical methods are to be used. If methods have to be developed or validated, this activity requires a long lead time. If waste is to be shipped off-site, the recipient of the off-site waste may require additional testing and certification of the waste.

Analytical

For closure wastes, there are several methods for determining whether the waste poses residual hazards. Typically, generator knowledge[2] and standard methods such as those provided in the EPA publication SW-846 are used to determine if a waste meets the release criteria. When these are not available, new methods may have to be developed and validated. This may be time- and resource-intensive.

Materials Management

Careful materials management is a key to successful facilities closure. Decontamination, reuse, recycle, and disposal options for equipment and secondary waste materials generated during closure should be identified. Protocols for segregation of generated hazardous and nonhazardous materials should then be implemented, including planning for prevention of cross-contamination. This will require proper identification and inventory control of these materials. A time line for risk-based disposition of all materials resulting from closure should be developed. Prior regulatory agreement and approval should be obtained for reuse, recycling, and disposal of all materials. In addition, protocols that have been established to prevent releases from stored waste should be continued.

[2] "Generator knowledge" is an evaluation method for hazardous waste that is commonly accepted and defined by the EPA and individual states based on some or all of the following information (EPA, 2005):

1. Facility process flow diagram or narrative description of the process generating the waste (should be used in most cases).
2. Chemical makeup of all ingredients or materials used in the process that generates the waste (should be used in most cases).
3. List of constituents that are known or believed to be by-products or side reactions of the process that produces the waste.
4. Material safety data sheets and/or product labels or substances used in the process that generates the waste.
5. Data obtained from approved methods of sampling and laboratory analysis of waste generated from the same process using the same ingredients/materials.
6. Data obtained from literature regarding waste produced from a similar process using the same ingredients/materials.
7. Documentation of product specifications or input materials and output products.

TOCDF CLOSURE STATUS AND ISSUES

Facility Description

To dispose of chemical agents, TOCDF uses an incineration process comprising five interconnected systems:

- System for unloading and unpacking system for munitions from the adjacent Area 10 storage of the Deseret Chemical Depot (DCD);
- Separate disassembly systems for rockets, bulk containers, mines, and projectiles;
- Furnace and incinerator systems that include a deactivation furnace system for energetic materials, a metal parts furnace, and two liquid incinerators for agent;
- Various safety systems that include areas for explosive containment, a cascaded ventilation system that moves plant air from less contaminated to more contaminated areas, airborne agent monitoring, fire protection, and door access monitoring; and
- Various support systems, including pollution abatement systems, and controls for electric, fuel gas, instrumentation, compressed air, hydraulics, and cooling. The pollution abatement system has recently been upgraded by the addition of a postcombustion mercury abatement system to capture various degrees of mercury contamination in mustard agent ton containers and projectiles.

Current Operations

TOCDF began agent disposal operations in August 1996 and completed disposal of GB nerve agent and munitions in March 2002. Disposal operations for VX nerve agent began in March 2003 and were completed in June 2005. The mustard agent campaign began in July 2006 and is projected for completion in the third quarter of 2011. This date will meet the treaty obligation date of April 29, 2012.

Closure Planning Status

Closure planning for TOCDF is in early stages. A project management approach is envisioned, with experienced senior management personnel presently assigned to closure planning and implementation as their chief responsibilities. Moreover, experienced technical personnel familiar with the facility will be engaged during closure planning and implementation. Subject matter experts and proven procedures are also expected to be used as much as possible during closure. Closure planning will employ best practices and approaches based on lessons learned from JACADS and other closures. Detailed plans and procedures have yet to be developed, but a general framework and time line have been established. The committee anticipates that these plans and procedures for closure would include an appropriate emphasis on safety, which were not discussed fully in the closure documents and presentations obtained while this letter report was being prepared. Approval of the basic closure plan is expected to be requested from the UDEQ in June 2010. The target date for planning completion is January 2011, and the expanded plans will include development of new documentation for unit-by-unit closure and the closure implementation schedule.

TOCDF closure planners are maintaining good relations and cooperation with the UDEQ. Closure operations, including those for the munitions demilitarization building, are projected to begin in September 2011, but some advance work was being carried out as this report was being prepared (as discussed below). The metal parts furnace and liquid incinerators will be closed later in the schedule (mid-2013) to allow for their availability to process closure waste process.

Present planning for TOCDF closure is based on a strategy of decontamination by moving progressively from the most contaminated to the least contaminated areas and structures. In general, this will involve removal of any residual agent and explosive material residues, followed by removal of agent-exposed equipment and subsequent decontamination of occluded spaces and exposed surfaces. Scabbling will be used if in-progress sampling shows it is needed.[3] When an area and structure have been completely decontaminated, the strategy for decontaminating the cascaded ventilation systems is to use a final washdown, certify that occluded spaces have been appropriately decontaminated, and, finally, use ventilated and unventilated testing to measure internal ambient air agent concentrations in a controlled manner.

Certain closure tasks, such as decontamination and removal of equipment, will be performed under partial-closure plans when possible without disrupting disposal operations. Already a number of such tasks have been completed. Early closure activities are projected to continue through August 2011.

A large quantity of stored legacy secondary waste, secondary waste being generated during continuing munitions disposal operations, and waste from TOCDF closure operations is projected to be either processed on-site and/or shipped off-site. Treatment, if necessary, and shipment of such wastes will take place during continuing disposal operations as scheduling opportunities present themselves or, alternatively, during closure operations. Secondary waste from all sources is projected to be disposed of by the third quarter of 2014.

The time line for TOCDF closure indicated above takes into consideration uncertainties concerning the UDEQ determinations on allowable standards for secondary waste treatment and off-site disposal. Site deconstruction is projected to continue until June 2014, with final administrative closure of TOCDF in February 2016. Notwithstanding the planning described above, and based largely on committee members' collective experience and observations in obtaining permit changes, the committee believes that the current schedule is optimistic. Moreover, certain members of the public are known to take great issue with some of the activities surrounding the chemical demilitarization program. Generally speaking, the more contentious the issues, the longer the permitting processes are likely to take.

[3]Scabbling is the removal of a surface layer of material (such as concrete) to a specified depth.

Current Permit Status

The currently approved version of the TOCDF RCRA permit includes a basic closure plan (Army, June 2009). The Army is presently pursuing a permit modification for both CAMDS and TOCDF that combines active operations of both facilities, including closure, under the TOCDF permit.[4] Utah officials have indicated that they will soon be ready to act on permit modification approvals, following RCRA public involvement and administrative actions.[5]

TOCDF has held initial discussions with the UDEQ regarding closure, focusing on specific issues. A RCRA permit modification to establish details for the regulatory-required closure plan is planned for submittal by June 2010. TOCDF closure plans within the existing (prepermit modification) permits indicate that the closure performance standard will be based on an industrial future use scenario.

The TOCDF closure plans also indicate that the incinerators and other units will be decontaminated as needed and dismantled. Some structures for TOCDF (primarily those used for nonagent operations) may remain following closure. Presently, TOCDF plans to remove all materials, including scrap metal and demolition wastes (e.g., concrete) from structures. Current requirements call for all of these materials to be disposed of in a hazardous waste landfill as designated F999 wastes. Some wastes, such as demilitarization protective ensemble suits, may retain the combined P999/F999 waste code (discussed later under *Utah Regulatory Requirements*) following decontamination.

Waste analysis to meet waste control limits (WCLs) and other criteria have been required for both chemical agent and for agent degradation products prior to the off-site transport of various wastes generated during disposal operations (such as decontaminated munitions casings). However, analytical methods for these analytes in certain closure wastes (such as concrete and carbon) are still under development and will require regulatory approval.

End Use and End Use Status

The site is envisaged at present to be closed to meet an industrial end use specification and will become part of the Tooele Army Depot following closure. Complete closure of the TOCDF site and remediation to levels of residual contamination for industrial use is envisioned.

[4]Information here has been taken from a question-and-answer session between Ted Ryba, Site Project Manager, TOCDF Field Office, and the committee, on October 22, 2009.

[5]Information in the final sentence of this paragraph and from the next three paragraphs is from a question-and-answer session between Dennis Downs, Director, Utah Department of Solid and Hazardous Waste, and the committee, on October 22, 2009.

CAMDS CLOSURE STATUS AND ISSUES

Description

CAMDS was constructed to develop and test equipment and technologies for dismantling and treating the stockpile of chemical agents and munitions stored on Johnston Island and at eight storage sites in the continental United States. The CAMDS facility was originally constructed between 1974 and 1978 and began munitions processing on September 10, 1979. CAMDS was a pilot plant for various processes later constructed as fixed units at either baseline incineration or chemical hydrolysis-based chemical agent disposal facilities. Some of the processes developed and tested at the facility are listed in Table 2. A total of 98,051 munitions and 363,524 pounds of chemical agents, including GB, VX, and mustard agent, were destroyed at the facility ending in March 2005.[6] Many of the process units and much of the equipment at CAMDS have been dismantled. CAMDS closure is complicated by a number of factors, including the following: (1) the age of the various units, resulting in incomplete knowledge of the operating history; (2) its use as a pilot plant, resulting in use for a wide variety of chemical demilitarization operations; and (3) its configuration as multiple interconnected buildings having a common ventilation system and common utility services that require careful attention to the order of shutting down parts of the system.

TABLE 2 Examples of Equipment Developed at CAMDS

Process type	Equipment
Bulk neutralization	Area detection system Instrumented ton container
Incineration	Liquid incinerator Deactivation furnace system Metal parts furnace
Hydrolysis (Assembled Chemical Weapons Alternative [ACWA] program)	Projectile washout system
Thermal destruction (ACWA program)	Metal parts treater

SOURCE: Elizabeth Lowes, Deputy General Manager, Closure Integration, EG&G, "CAMDS and TOCDF closure approach/status," Presentation to the committee, October 21, 2009.

[6]Elizabeth Lowes, Deputy General Manager, Closure Integration, EG&G, "CAMDS and TOCDF closure approach/status," Presentation to the committee, October 21, 2009.

Current Closure Operations

Current operations are limited to closure activities and the on-site laboratory, the last mentioned of which continues to provide analytical support for the DCD, including capabilities not found elsewhere at DCD. Closure activities are focused on 61 hazardous waste management units, including the following:

- 14 Subpart I units (chemical storage areas)
- 43 Subpart J units (tank systems)
- 1 Subpart O unit (incinerator)
- 3 Subpart X units (miscellaneous)

Closure activities will involve the facility ventilation system as well, including the carbon filter units; the destruction of a number of buildings from which the bulk of the processing units have already been removed and that will also require asbestos abatement measures; and outside chemical and agent transfer lines.

Closure Planning Status

The current operator of the CAMDS facility, the EG&G Division of URS Corporation, only recently assumed control of the facility, and final closure planning is not complete. However, many of the processing units were dismantled and removed by an earlier contractor. The current contractor has prepared partial closure plans for the material treatment facility and chemical test facility, and acceptance is being negotiated with the UDEQ. Current efforts are directed toward the material treatment facility to refine and test closure procedures. They will be followed by deconstruction of the remaining buildings, from the most contaminated to the least contaminated. For each building, decommissioning work packages will be prepared that recognize the unique processes and contamination history of the building and utilize a 10-step approach for each building as follows:

(1) Establishment of engineering controls and monitoring,
(2) Preliminary survey,
(3) Preparation for work execution,
(4) Decontamination and equipment disposition,
(5) Post-disposition survey,
(6) Ventilated vapor screening level (VSL) monitoring,[7]
(7) Unventilated VSL monitoring,
(8) Final isolation,
(9) Demolition, and

[7]The VSL concentrations are equivalent to the short-term limit (STL) value, which is a concentration typically expressed in milligrams of specific agent per cubic meter of air. STLs are similar to short-term exposure limits (STELs) but without the 15-minute exposure time component. The VSL and short-term limit values for agents of interest are as follows: GB, 0.0001 mg/m^3; VX, 0.00001 mg/m^3; mustard agent, 0.003 mg/m^3 (NRC, 2007).

(10) Closure verification sampling.

CAMDS closure involves some unique complications. Because different process units were originally constructed over time, their closure involves dismantling numerous buildings with potentially different challenges. The buildings are also tied together with common utilities, including ventilation and sump drains, which could also complicate the decontamination procedures.

The analytical laboratory at CAMDS is not a hazardous waste management unit identified within the permit covering CAMDS, so no specific permit actions are required to remove it from the applicable RCRA permit. However, it is anticipated that the heating, ventilation, and air conditioning filters for the laboratory will need to be worked out in the future.

Finally, current closure planning does not address issues that will limit reuse of the property, such as the presence of subsurface fuel oil contamination. This contamination, unrelated to the destruction of agent, is designated Solid Waste Management Unit (SWMU) 13. This and other SWMUs on DCD are separate from the closure of CAMDS.

Current Permit Status

A pending permit modification for both CAMDS and TOCDF provides for combining the active operations of both facilities, including closure, under the TOCDF permit.[8] Utah officials have indicated that they will soon be ready to act on permit modification approvals, following RCRA public involvement and administrative actions. The resulting permit will contain basic closure plans for CAMDS, which will eventually need to be expanded into unit-by-unit detailed closure plans and approved by the state prior to execution.[9] CAMDS has already started work on these more detailed closure plans, which were not, however, made available to the committee in time for this report. In the interim, CAMDS has proceeded with preclosure decommissioning activities (e.g., decontamination, removal of equipment) with the knowledge and oversight of the UDEQ.[10]

End Use and End Use Status

Like TOCDF, the CAMDS site will become part of the Tooele Army Depot upon closure. Closure will involve decontamination and disposal of all agent-contaminated facilities and all buildings and facilities not needed by the depot. Closure of the CAMDS site will not resolve outstanding contamination issues, if any, associated with the analytical laboratory. In addition, subsurface fuel oil contamination from SWMU 13,

[8]Information from a question-and-answer session between Ted Ryba, Site Project Manager, TOCDF Field Office, and the committee, on October 22, 2009.

[9]Information from a question and-answer session between Dennis Downs, Director, Utah Department of Solid and Hazardous Waste, and the committee, on October 22, 2009.

[10]Information from a question-and-answer session between Jerold Lynn, Site Project Manager, CAMDS, and the committee, October 22, 2009.

below the CAMDS site, is being addressed under a general permit corrective action program for DCD and thus is not an issue for TOCDF or CAMDS closure.

ENVIRONMENTAL REGULATORY ISSUES APPLICABLE TO CAMDS AND TOCDF

In closing CAMDS and TOCDF, the Army must comply with regulations established by the UDEQ under its delegated authority for a number of different environmental regulatory programs, including the Clean Air Act, the Clean Water Act and hazardous waste management regulations established under RCRA. The most challenging of these for CAMDS and TOCDF are the facility closure regulations under RCRA (40 CFR Part 264, Subpart G).

RCRA Regulatory Background

Utah has adopted EPA's RCRA closure regulations established under 40 CFR Part 264, Subpart G (Utah R315-8-7). These require facilities to comply with a closure performance standard. The performance standard for closing a facility is typically translated into risk-based quantitative criteria (such as concentrations) for specific constituents in waste materials. These criteria depend on the future use of the site. Criteria for unrestricted (residential) use are generally more protective than those for industrial use. The RCRA closure regulations also require facilities to submit detailed closure plans when applying for the permit. The plan then becomes part of the permit when it is issued. It may dictate a simple closure that applies to the entire unit or facility or may propose a series of partial closures for specific units that will eventually lead to final closure for the entire facility. Further, the closure plan includes waste inventory estimates, identification of the closure performance standard, and a schedule for closure, among other information. Closure plans may be revised as needed as closure operations proceed, but such revision would require a formal permit modification.

Utah Regulatory Requirements and Practices

Utah has imposed regulations and practices with respect to chemical agents, many of which can be considered more restrictive than the usual RCRA requirements. These unique regulations and practices have evolved over the years and are currently applicable to closure. Specific Utah regulations and practices are identified below.

Utah Regulatory Requirements

P999 and F999 Waste Codes. Utah has listed "Nerve, Military, and Chemical Agents" as acute hazardous waste under hazardous waste code P999 and "Residues from Demilitarization, Treatment and Testing of Nerve Military and Chemical Agents" as listed hazardous waste under hazardous waste code F999.[11] Throughout the demilitarization campaign at CAMDS and TOCDF, restrictions were placed on management of acutely hazardous waste P999, and wastes resulting from treatment of the P999 wastes were designated F999. Residues from treatment, storage, or disposal of F999 wastes retain the hazardous waste designation and the code F999. Thus, wastes produced during closure, even those that result from treatment of F999 wastes, are required to be managed as F999 hazardous wastes, even if they are known to contain no detectable agent or other hazardous constituents.[12]

Cleanup Action and Risk-Based Closure Standards. Utah has established specific requirements for closure of industrial sites: "Cleanup Action and Risk-Based Closure Standards" (UDEQ, 2001). Closure performance standards are developed in accordance with RCRA regulations. Risk-based closure performance standards are determined case by case for nearly all facility closures.

Utah Regulatory Practices

Agent Vapors. Utah includes materials contaminated as a result of actual or potential contact with agent vapors as F999 waste. The result is that significant additional volumes of various types of materials would become regulated as hazardous waste once generated during closure.

Off-site Restrictions. Utah places restrictions on the off-site transportation of potentially agent-contaminated materials for further treatment and/or disposal. In Utah, wastes must be tested against the WCLs and may be transported off-site only if these levels are met. The WCLs were initially developed as drinking water standards for soldiers in the field (HQDA, 2005; HQDA, 2008). Even if the WCL is met, these wastes are still controlled as hazardous waste under the Utah F999 waste code.

Waste Characterization. Since the early days of the chemical demilitarization program, the Army, being concerned primarily with worker exposure to agent vapor hazards, has relied on the vapor screening of materials and wastes that have been exposed to chemical agents (HQDA, 2008). In contrast, RCRA has historically used direct chemical analysis of wastes for constituents of concern (EPA, 2009). Utah has been reluctant to accept vapor screening as a means of characterizing wastes that may have been exposed to liquid or vapor chemical agent. In those limited cases where it has accepted vapor screening, Utah has required the Army to apply more stringent criteria than the Army itself has established. For example, whereas the Army's screening level for protection of workers is 1.0 VSL, Utah requires the Army to apply a more stringent standard, 0.5 VSL, as added protection. Further, some waste streams, in particular those that may absorb chemical agent, must be decontaminated before vapor screening.

[11] Acute hazardous wastes are established under the RCRA program at 40 CFR 261.33(e) (Utah R315-2-9). F999 is added by the UDEQ to the listing of hazardous wastes from nonspecific sources found in 40 CFR 261.31 (Utah R315-2-11).

[12] While RCRA and the Utah regulations provide means of demonstrating that F999 wastes are not hazardous (that is, of "delisting"), the demonstration required is often arduous and prohibitively expensive.

Waste Activated Carbon and P999. Waste carbon that is actually or potentially contaminated with chemical agent is designated P999 under Utah regulations. Under present Utah restrictions, P999 wastes may not be sent off-site for treatment and disposal. For example, much of the activated carbon (the final four of six banks) of the heating, ventilation, and air conditioning system has not, based on generator knowledge, been exposed to agent. It will also be necessary to evaluate in detail the disposal of carbon from the TOCDF pollution abatement system filter system, which is likely to contain mercury or mercury compounds from the processing of mustard agent munitions having mercury contamination.

Dual Waste Code for Some Materials. Some waste materials, primarily permeable solids, can be difficult to sample and analyze for chemical agents. Others, such as demilitarization protective ensemble suits that become waste after use, can be difficult to sample. In these cases, Utah has required decontamination of the materials and application of a dual P999/F999 waste code prior to off-site transport for disposal.

The standards and practices that Utah uses to address demilitarization disposal operations were developed before chemical agent began to be destroyed at CAMDS and TOCDF. Now, however, there will not be any significant amount of agent present during closure. Furthermore, decontamination procedures will further reduce any agent residues that may be contaminating waste materials. Thus, the risks to human health and the environment from agent and its degradation products during closure operations will be reduced. This should provide the basis for considering less restrictive practices than the present UDEQ requirements, based on an evaluation of the risks of managing the closure wastes.

PUBLIC PARTICIPATION

Community involvement at the Utah demilitarization facilities is conducted primarily through the Citizens Advisory Commission (CAC), appointed by the Governor of Utah. The committee expects the CAC to provide opportunities for public participation in closure planning. Thus far, although the CAC is aware that closure planning is under way, it is still engaged in the oversight of demilitarization operations. Although the committee found the community was concerned that the end of demilitarization operations might lead to layoffs or have other economic consequences, it did not find any community concerns that the closure of TOCDF and CAMDS would affect the environment. The CAC, as well as other community bodies, such as the Restoration Advisory Board for the entire DCD, are concerned about munitions response, corrective action, and related disposal activities, but those issues are beyond the scope of the task for this committee.

The Army and community have not yet developed a plan for community involvement during closure other than the requisite state forums under RCRA. While closure oversight is likely to be less intense than discussions of demilitarization, the CAC or a similar body can serve a valuable role during closure. The committee urges the Army to discuss with the CAC ways to continue constructive public involvement between the end of demilitarization and formal closure.

REFERENCES

EPA (U.S. Environmental Protection Agency). 2005. RCRA Hazardous Waste Identification Training Module, 40 CFR 261, September, Washington, D.C.: Environmental Protection Agency.

EPA. 2009. SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Available online at http://www.epa.gov/waste/hazard/testmethods/sw846/online/index.htm. Last accessed November 23, 2009.

HQDA (Headquarters Department of the Army). 2005. TB Med 577 Sanitary Control and Surveillance of Field Water Supplies. Available online at http://chppm-www.apgea.army.mil/documents/TBMEDS/TBMed577-15Dec2005.pdf. Last accessed November 19, 2009.

HQDA. 2008. DA-PAM 385-61 Toxic Chemical Agent Safety Standards. Washington, D.C.: Department of the Army.

NRC (National Research Council). 2007. Review of Chemical Agent Secondary Waste Disposal and Regulatory Requirements. Washington, D.C.: The National Academies Press.

NRC. 2009. Evaluation of Safety and Environmental Metrics for Potential Application at Chemical Agent Disposal Facilities. Washington, D.C.: The National Academies Press.

TOCDF (Tooele Chemical Agent Disposal Facility). 2009. Closure Plan Attachment 10. Stockton, Utah: Tooele Chemical Agent Disposal Facility.

UDEQ (Utah Department of Environmental Equality). 2001. Title V Operating Permit. Available online at http://www.airquality.utah.gov/Permits/DOCS/11339pmt.20060502.pdf. Last accessed November 19, 2009.

UDEQ. 2001. R315-101: Cleanup Action and Risk-Based Closure Standards. Available online at http://www.hazardouswaste.utah.gov/Rules/Adobe/HazardousWasteRules/R315-101.pdf. Last accessed December 17, 2009.

Attachment A

Statement of Task

The NRC will form a committee to provide two reports. The first is an interim report assessing the following:

- Examine the current closure plans for TOCDF and CAMDS and make recommendations as required.
- Recommend key parameters to assess an integrated approach to common closure requirements.
- Assess planning for compliance with unique regulatory requirements of the State of Utah towards closure of the two chemical disposal facilities.

Following the issuance of the interim TOCDF-CAMDS closure report, the National Research Council will issue a comprehensive report as follows:

- Update the 2002 NRC report, Closure and Johnston Atoll Chemical Agent Disposal System Report, as required.
- Using the key parameters to assess an integrated approach to common closure requirements (as recommended in the interim TOCDF-CAMDS closure report), determine applicable lessons-learned from the closure of JACADS, ABCDF, and the ongoing closure of NECDF for potential use during TOCDF and CAMDS closure.

The interim report will be issued not later than six months after receipt of the contract and the comprehensive report will be issued no later than twelve months after the release of the interim report.

Attachment B

Acronyms and Abbreviations

ABCDF	Aberdeen Chemical Agent Disposal Facility
ACWA	Assembled Chemical Weapons Alternatives (program)
CAC	Citizens Advisory Commission
CAMDS	Chemical Agent Munitions Disposal System
CMA	Chemical Materials Agency
DCD	Deseret Chemical Depot
EPA	Environmental Protection Agency
GA	a nerve agent (tabun)
GB	a nerve agent (sarin)
JACADS	Johnston Atoll Chemical Agent Disposal System
NECDF	Newport Chemical Agent Disposal Facility
RCRA	Resource Conservation and Recovery Act
SWMU	solid waste management unit
TOCDF	Tooele Chemical Agent Disposal Facility
UDEQ	Utah Department of Environmental Quality
UDSHW	Utah Division of Solid and Hazardous Waste
VSL	vapor screening level
VX	a nerve agent
WCL	waste control limit

Attachment C

Committee Members

COMMITTEE TO REVIEW AND ASSESS CLOSURE PLANS FOR THE TOOELE CHEMICAL AGENT DISPOSAL FACILITY AND THE CHEMICAL AGENT AND MUNTIONS DISPOSAL SYSTEM

PETER B. LEDERMAN, *Chair,* New Jersey Institute of Technology (retired), New Providence, New Jersey
JOHN B. CARBERRY, E.I. du Pont de Nemours & Company (retired), Newark, Delaware
DEBORAH L. GRUBBE, Operations and Safety Solutions, LLC, Chadds Ford, Pennsylvania
JOHN R. HOWELL, The University of Texas, Austin
TODD A. KIMMELL, Argonne National Laboratory, Washington, D.C.
DANNY D. REIBLE, The University of Texas, Austin
LEONARD M. SIEGEL, Center for Public Environmental Oversight, Mountain View, California
DAVID A. SKIVEN, General Motors Corporation (retired), Brighton, Michigan

Staff

MARGARET N. NOVACK, Study Director (until January 2010)
NANCY T. SCHULTE, Study Director (from January 2010)
HARRISON T. PANNELLA, Senior Program Officer
NIA D. JOHNSON, Senior Research Associate
JAMES C. MYSKA, Senior Research Associate
ALICE V. WILLIAMS, Senior Program Assistant

Attachment D

Acknowledgement 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:

Harold K. Forsen, NAE, Bechtel Corporation (retired),
George W. Parshall, NAS, E.I. du Pont de Nemours & Company (retired),
John A. Pendergrass, Environmental Law Institute,
William R. Rhyne, Consultant,
W. Leigh Short, Consultant,
Charles F. Zukoski, NAE, University of Illinois.

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 Hyla S. Napadensky, 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.

Appendix B

Safety and Environmental Metrics Employed by Private Companies Surveyed for This Report

Table B-1, which compiles the safety and environmental metrics used by the private companies surveyed for this report, is reprinted from the National Research Council report *Evaluation of Safety and Environmental Metrics for Potential Application at Chemical Agent Disposal Facilities* (The National Academies Press, Washington, D.C., 2009).

TABLE B-1 Safety and Environmental Metrics Employed by Private Companies Surveyed for This Report

Measure	Area	Definition	Type	Comments
Number of recordable injuries (RIs) or illnesses	Personal safety		Lagging	Per OSHA requirements
Number of lost workday cases (LWCs)	Personal safety		Lagging	Per OSHA requirements
Contractor injury or illness rate	Personal safety	Number of RIs per number of work hours × 200,000	Lagging	RMTC, RWC, and DAWC (all OSHA definitions)
Company injury or illness rate	Personal safety	Number of RIs per number of work hours × 200,000	Lagging	RMTC, RWC, and DAWC (all OSHA definitions)
Near miss	Personal/environmental/transportation/process safety	Number of unsafe conditions or events that almost injured someone but didn't or almost spilled something but didn't	Leading	Can identify unsafe conditions, safety incidents that could have been more serious in different circumstances, etc.
Corrective and preventive actions	Personal/environmental/transportation/process safety	Proportion of corrective and preventive actions closed on time to total number of action items	Leading	Percent of action items related to employee health and safety (EH&S) incidents that have been closed by the due date
Behavior-based process (BBP) observation	Personal/environmental/transportation/process safety	Number of observations of behavior as part of a behavior-based safety program	Leading	Total number of observations made of a work group in a given time
Percent safe BBP observations	Personal/environmental/transportation/ process safety	Number of safe behaviors/total behaviors	Leading	The percentage of safe behaviors should be less than 100 percent since your program should be looking at behaviors that you want to change and at behaviors that you are getting much better at

TABLE B-1 Continued

Measure	Area	Definition	Type	Comments
BBP observation—analysis to drive behavior change	Personal safety	Number of analyses performed	Leading	Should analyze the antecedents and consequences of an unwanted behavior at least quarterly. Behavior might be improved by adjusting an antecedent.
BBP observation—driving behavior change	Personal safety	Number of critical behaviors that reached habit strength	Leading	Try to drive at least one behavior to habit strength per year by adjusting the antecedents and consequences of that behavior.
Procedure use	Personal/process safety	Number of critical procedures used/number of critical procedure required tasks performed	Leading	Can be daily, weekly, or monthly depending on the size of the organization. Tasks that require a critical procedure are defined by the facility.
Quality of root cause investigation (RCI)	Personal/environmental/transportation/process safety	Number of minimum quality criteria met for the RCIs in a given period	Leading	RCI minimum criteria are defined by the company.
Pretask hazard assessment participation	Personal safety	Number of pretask hazard assessments performed	Leading	Assessment can be conducted per person or per work group, weekly or monthly.
Performance tracking on permits	Personal safety	Number of defects found per permit	Leading	Permit documentation is audited and any mistake or omission is a defect (safe work permit/isolation of energy/confined space entry).
Training timeliness	Personal/environmental/transportation/process safety	Required training completed on time—not overdue	Leading	Overdue EH&S training is a sign of a slipping safety culture and priority.
Compliance task tool	Personal/environmental/transportation/process safety	Number of required compliance tasks overdue/total number of required compliance tasks	Leading	Overdue safety compliance tasks are a sign of slipping safety culture and priority. An example of these tasks is fire extinguisher inspections.
Severity rate	Personal safety	Number of (RMTC × 1) + (RWC × 3) + (DAWC × 9) + (fatalities × 27) per 200,000 work hours	Lagging	Gives a weighted rate
DAWC count	Personal safety	Number of DAWCs	Lagging	
DAWC rate	Personal safety	Number of DAWC per 200,000 work hours	Lagging	
Loss of primary containment (LOPC) count	Personal safety	Number of LOPCs	Lagging	For example, leaks, breaks, and spills
Severe LOPC (Categories 1,1A, and 2A)	Personal/environmental/process safety	Number of Category 1, 1A, and 2A LOPCs	Lagging	Category 1 is any loss of primary containment resulting in the release of >5,000 lb flammable chemical. Category 1A is a release causing a DAWC. Category 2A is a spill resulting in a RI.
Category 4 LOPC count	Personal/environmental/process safety	Number of Category 4 LOPCs	Leading	Category 4 is a minor spill of <100 lb that has no measurable impact on people or the environment.
Ratio of Category 4 LOPC to Categories 1, 2, and 3 LOPCs	Personal safety	Ratio of Category 4 LOPCs to all other categories of LOPCs	Leading	Try to achieve a 40:1 ratio in order to find the small spills and fix them before they become larger spills. (Category 2 is a loss of primary containment with a release of >1,000 lb or an RMTC or a RWC (2A). Category 3 is any LOPC that loses >100 lb of chemical or 1,000 lb of dry inert solids).

Continued

TABLE B-1 Continued

Measure	Area	Definition	Type	Comments
Number of process safety events	Process safety	Number of events within a specified time period. The severity of events may be low, medium, or high.	Both lagging and leading	For near misses, it's a leading indicator.
Number of fatality potential events	Personal/transportation/process safety	Number of such events within a specified time period	Lagging	Measure progress in addressing high-potential events.
Motor vehicle accident (MVA) count	Transportation	Number of MVAs	Lagging	An MVA is a motor vehicle accident resulting in personal injury or at least $500 in damage.
MVA rate	Transportation	Number of MVAs per million miles driven	Lagging	Includes all miles driven from company owned, leased, or rented vehicles and miles driven on company business from personal vehicles
Number of preventable accidents or number of preventable accidents per unit time or distance	Transportation	Number of preventable product-carrying vehicle accidents or a rate based on this number	Lagging	
Number of high-severity accidents or number of high-severity accidents per unit time or distance	Transportation	Number of high-severity product-carrying vehicle accidents or a rate based on this number	Lagging	
Number of rollovers/rollover rate	Transportation	Number of product-carrying vehicle rollovers or a rate based on this number	Lagging	
Energy intensity	Environmental	British thermal units per pound production	Lagging	
Greenhouse gas (GHG) energy efficiency	Environmental	Quantity of carbon dioxide (CO_2) generated per unit of production	Lagging	
Wastewater intensity	Environmental	Pounds of wastewater per pound of production	Lagging	Water that is treated at a wastewater treatment facility
Waste intensity	Environmental	Pounds of waste per pound of production	Lagging	Material that receives end-of-pipe treatment; report as the bulk amount prior to treatment.
Total waste weight	Environmental	Weight by type and disposal method	Lagging	
Chemical emissions	Environmental	Chemical emissions (tons)	Lagging	Material that is released to the environment that does not receive end-of-pipe treatment (not including water). Chemical emissions exclude conventional emissions such as combustion products (nitrogen oxides, carbon monoxide, sulfur oxides, CO_2, and particulates), methane, and hydrogen. Also excluded are the "normally excluded as an emission" compounds from GEI such as nitrogen, oxygen, water, aluminum, and salts (chlorides, sulfates, hydroxides, oxides, hypochlorite, and carbonates).

TABLE B-1 Continued

Measure	Area	Definition	Type	Comments
Priority compound emissions	Environmental	Priority compounds (tons)	Lagging	A list of priority chemicals that include persistent bioaccumulative and toxic compounds; selected known human carcinogens; selected ozone depletors; and high-volume toxic compounds
Volatile organic compound emissions	Environmental	Volatile organic compounds (tons)	Lagging	
Total water use	Environmental	Pounds or gallons water used/time period	Lagging	
Direct GHG emissions	Environmental	CO_2-equivalent metric tons	Lagging	Direct GHG emissions are those that are emitted from a company location. Direct emissions include all GHGs emitted from any on-site fugitive or air point source.
Kyoto GHGs as CO_2-equivalent intensity	Environmental	Pounds of CO_2-equivalent per pound production	Lagging	
Assessment compliance performance	Personal/environmental/transportation/process safety	Assigned grade to each area reviewed in assessment	Leading	Commonly understood measure for assessing improvement in performance
Percent of safety alerts completed	Personal/environmental/transportation/process safety	Percent completion by facilities covered by alerts	Leading	Drives implementation of lessons learned from safety incidents
Number of potential environmental noncompliances	Environmental	Internally reported potential environmental noncompliances per month	Leading	Proactive measure of effectiveness of environmental program
Number of significant environmental spills	Environmental	Spills per unit time	Lagging	
Toxic release inventory on site releases	Environmental	Number of releases per unit time	Lagging	

NOTE: RCI, root cause investigation; OSHA, Occupational Safety and Health Administration; RMTC, reportable medical treatment case; RWC, restricted work case; DAWC, days away from work case; LOPC, loss of primary containment; BBP, behavior-based process; ES&H, employee safety and health; RI, recordable injury; GHG, greenhouse gas; GEI, greenhouse gas emissions.

SOURCE: Data provided by Corning, Dow Chemical, Motorola, and Praxair.

Appendix C

Discussion of Hydrolysis Reactions of GB, VX, and H

The risk posed by agents depends upon their tendency to partition to phases where exposure could occur and on their stability and the toxicity of their degradation by-products. Thus, consideration of the physical and chemical properties of the agents provides a basis for evaluation of the potential risks of residual contamination. The risk associated with agents can be prolonged if they are sequestered in occluded spaces, and this tendency is also related to agent physical properties. Therefore, a brief review of the volatilization and hydrolysis reactivity of GB (sarin), VX, and mustard (H) are provided in the following paragraphs.

PROPERTIES OF GB (SARIN)

Although all three agents are considered semivolatile liquids, GB has a markedly higher vapor pressure (2.9 mm Hg at 25°C) and will volatilize, leading to the conclusion that any residual GB would have been depleted by volatilization by the time facility destruction occurs (Reutter, 1999). Under normal environmental conditions, it also undergoes rapid hydrolysis, forming nontoxic products isopropyl methylphosphonic acid and fluoride (Kingery and Allen, 1995). GB can permeate into polymeric or porous materials, and there has been a report of unhydrolyzed GB in paint in an Iraqi shell fragment several years after exposure to the atmosphere (Black et al., 1994). The small residual levels of GB detected in this example suggest, however, that the potential exposure to residual GB after permeation into a polymeric or porous surface is likely minimal. In soil samples collected during the same Iraqi sampling campaign, intact GB was not detected (Black et al., 1994). Because GB is volatile and diffuses fairly rapidly, materials containing occluded spaces would be expected to release GB during the years between exposure and demolition. On the basis of these considerations, GB is considered to be a relatively nonpersistent agent.

PROPERTIES OF VX

VX has a much lower vapor pressure compared to GB (only 7×10^{-4} mm Hg at 25°C) (Reutter, 1999), and exhaustive depletion due to volatilization from occluded spaces in porous or permeable surfaces may not occur. In situations where VX fills cracks or diffuses into permeable materials, volatilization will be inhibited, but subsequent disturbances of the system could expose intact VX, resulting in a potential exposure scenario resulting from volatilization or more likely from direct dermal contact.

For the most part, hydrolysis of VX results in detoxification. VX can be detoxified rapidly (rate constant on the order of 0.1 day^{-1}) via hydrolysis reactions; however, not all hydrolysis reactions detoxify VX (Davisson et al., 2005; Love et al., 2004).[1] The compound undergoes hydrolytic degradation via three pathways, involving cleavage of the P-S, S-C, and P-O bonds (Epstein et al., 1973; Munro et al., 1999). The principal pathway is cleavage of the P-S bond,

[1]Rate studies of degradation of EA-2192 are few, and rates will certainly vary depending on the specific temperature, moisture present, and the surface with which the compound is in contact.

which forms ethyl methylphosphonic acid (EMPA) and 2-(diisopropylamino) ethane thiol (DESH), which are both relatively nontoxic (Kingery and Allen, 1995; Munro et al., 1999). Cleavage of the S-C bond is a less prevalent process, and it also produces relatively nontoxic products. Basic sites such as those found on concrete have been shown to greatly increase the rates of hydrolysis via P-S and S-C cleavage (Groenewold et al., 2002; Williams et al., 2005).

VX hydrolysis via P-O cleavage is a matter of concern because this furnishes S-[2-(diisopropylamino)ethyl] methylphosphonothioic acid and ethanol (Yang et al., 1990). The former product, known as EA-2192, retains much of the neurotoxicity of the intact agent, and hence presence of this compound is an ongoing source of concern. In fact, the state of Utah requires measurement of EA-2192 to ensure detoxification to closure standards (see Chapter 5). Concerns related to EA-2192 are reasonably mitigated, however, by the following considerations:

- EA-2192 has no volatility and poses no inhalation hazard.
- EA-2192 does not diffuse through the skin barrier.
- Hydrolysis of the EA-2192 proceeds fairly rapidly, with a rate constant on the order of that of the parent compound (0.1 day^{-1}) (Kaaijk and Frijlink, 1977; Verweij and Boter, 1976).

With regard to occluded spaces and permeable polymers, it should be noted that there may be potential for survival of intact VX sequestered in these environments. This may occur because VX thus sequestered may be protected from hydrolysis.

PROPERTIES OF H (MUSTARD AGENT)

Bis-(2-chloroethyl)sulfide, or sulfur mustard, can refer to H, HD (distilled mustard), or HT (distilled mustard mixed with bis-(2-(2-chloroethylthio)ethyl) ether) in the context of this report. H is relatively involatile, with a vapor pressure of 9×10^{-2} mm Hg at 25°C (Reutter, 1999). Thus H, in any form, would be expected to display some persistence.

Mustard is detoxified by hydrolysis, but in general, rates of mustard hydrolysis are slower than those of the nerve agents. Nevertheless, hydrolysis would be expected to result in depletion of mustard under most situations if enough time passes between the end of operations and demolition. Chemical decontamination will accelerate rates of hydrolysis.

The generally slower rates of hydrolysis and low volatility serve to make the compound susceptible to surviving for extended periods of time in occluded spaces. This phenomenon is exacerbated by H polymerization reactions that can form a "skin" (Yang et al., 1988) over the surface of intact mustard. The skin can protect the underlying agent from exposure to water and other naturally occurring hydrolysis reagents. Rupture of the skin during scabbling[2] or other demolition activities could release mustard and result in a toxic exposure risk. In addition to occupying pores, mustard will also permeate many polymeric materials, and it can be released later either as a result of demolition activities or by heating the polymer.

REFERENCES

Black, R., R. Clarke, R. Read, and M. Reid. 1994. Application of Gas Chromatography-Mass Spectrometry and Gas Chromatography-Tandem Mass Spectrometry to the Analysis of Chemical Warfare Samples, Found to Contain Residues of the Nerve Agent Sarin, Sulphur Mustard and Their Degradation Products. Journal of Chromatography A 662(2): 301-321.

Davisson, M., A. Love, A. Vance, and J. Reynolds. 2005. UCRL-TR-209748 Environmental Fate of Organophosphorus Compounds Related to Chemical Weapons. Livermore, CA: Lawrence Livermore National Laboratory.

Epstein J., J. Callahan, and V. Bauer. 1973. The Kinetics and Mechanisms of Hydrolysis of Phosphonothiolates in Dilute Aqueous Solutions. Phosphorus 4: 157-163.

Groenewold, G., J. Williams, A. Appelhans, G. Gresham, J. Olson, M. Jeffery, and B. Rowland. 2002. Hydrolysis of VX on Concrete: Rate of Degradation by Direct Surface Interrogation Using an Ion Trap Secondary Ion Mass Spectrometer. Environmental Science & Technology 36(22): 4790-4794.

Kaaijk, J., and C. Frijlink. 1977. Degradation of S-2-di-isopropylaminoethyl O-ethyl methylphosphonothioate in Soil. Sulphur-Containing Products. Pesticide Science 8(5): 510-514.

Kingery, A., and H. Allen. 1995. The Environmental Fate of Organophosphorus Nerve Agents: A Review. Toxicological & Environmental Chemistry 47(3): 155-184.

Love, A., A. Vance, J. Reynolds, and M. Davisson. 2004. Investigating the Affinities and Persistence of VX Nerve Agent in Environmental Matrices. Chemosphere 57(10): 1257-1264.

Munro, N., S. Talmage, G. Griffin, L. Waters, A. Watson, J. King, and V. Hauschild. 1999. The Sources, Fate, and Toxicity of Chemical Warfare Agent Degradation Products. Environmental Health Perspectives 107(12): 933-974.

Reutter, S. 1999. Hazards of Chemical Weapons Release during War: New Perspectives. Environmental Health Perspectives 107(12): 985-990.

Verweij, A., and H. Boter. 1976. Degradation of S-2-Di-isopropylaminoethyl O-ethyl Methylphosphonothioate in Soil: Phosphorus-Containing Products. Pesticide Science 7(4): 355-362.

[2]Scabbling is a scarification process used to remove concrete surfaces.

Williams, J., B. Rowland, M. Jeffery, G. Groenewold, A. Appelhans, G. Gresham, and J. Olson. 2005. Degradation Kinetics of VX on Concrete by Secondary Ion Mass Spectrometry. Langmuir 21(6): 2386-2390.

Yang, Y.-C., L. Szafraniec, W. Beaudry, and D. Rohrbaugh. 1990. Oxidative Detoxification of Phosphonothiolates. Journal of the American Chemical Society 112(18): 6621-6627.

Yang, Y.-C., L. Szafraniec, W. Beaudry, and J. Ward. 1988. Kinetics and Mechanism of the Hydrolysis of 2-chloroethyl Sulfides. Journal of Organic Chemistry 53(14): 3293-3297.

Appendix D

Committee Meetings

FIRST COMMITTEE MEETING, OCTOBER 20-22, 2009, TOOELE AND SALT LAKE CITY, UTAH

Objective: To introduce required administrative procedures set forth by the National Research Council, read the committee statement of task and background review with committee sponsor, receive detailed process and equipment briefing presentations, review preliminary report outline and report-writing process, confirm committee writing assignments, and discuss next steps and future meeting dates.

U.S. Army Chemical Weapon Demilitarization 101, Mr. Ted Ryba, Site Project Manager, TOCDF Field Office

Consideration of Statement of Task, Dr. Peter B. Lederman, Chairman, CMA Closure Committee; and Mr. Raj Malhotra, Special Projects Officer, CMA

Final JACADS Closure Lessons Learned, Ms. Carla Heck, Project Manager, URS

CMA's Site and Programmatic Closure Experience, Ms. Amy Dean, Environmental Engineer, Project Manager for Elimination of Chemical Weapons, Chemical Materials Agency

NECDF Closure Experience, Mr. Jerry Spillane, Closure Engineer, NECDF

Status of Sites' Closure Planning and Schedules, Mr. Tim Garrett, Site Project Manager for ANCDF, Chemical Materials Agency

Established Infrastructure for Sharing of Lessons, Mr. Raj K. Malhotra, Special Projects Officer, Risk Management Directorate, Chemical Materials Agency

TOCDF and CAMDS Closure Scope, Schedule and Status, Team Partners/Stakeholders and Their Responsibilities, Ms. Elizabeth Lowes, Deputy General Manager, Closure Integration, EG&G

SECOND COMMITTEE MEETING, NOVEMBER 3-4, 2009, WASHINGTON, D.C.

Objective: To review the draft report, produce a preliminary concurrence draft report, determine what is not yet known and how to learn it, and determine the path forward. Only committee members and staff attended.

THIRD COMMITTEE MEETING, JANUARY 26-28, 2010, DESERET CHEMICAL DEPOT, UTAH

Objective: To introduce required administrative procedures set forth by the National Research Council, read the committee statement of task and background review with committee sponsor, receive detailed process and equipment briefing presentations, review preliminary report outline and report-writing process, confirm committee writing assignments, and discuss next steps and future meeting dates.

U.S. Army Chemical Weapon Demilitarization 101, Mr. Ted Ryba, Site Project Manager, TOCDF Field Office

Consideration of Statement of Task, Dr. Peter B. Lederman, Chairman, CMA Closure Committee; Mr. Raj Malhotra, Special Projects Officer, CMA

Response to Letter Report on Review and Assessment of Closure Plan, TOCDF Staff

Programmatic Closure Strategy Document Development and Status of Sites' Closure Planning and Schedules, Ms. Carla Heck, Closure Manager, URS

Regulatory Challenges, Ms. Amy Dean, Team Leader, Closure and Secondary Waste, HQ, CMA

FOURTH COMMITTEE MEETING, MARCH 1-3, 2010, EDGEWOOD, MARYLAND

Objective: To review and revise the report concept draft, determine what is not yet known and how to learn it, and a path forward.

Status of Overall Closure Planning, Ms. Amy Dean, Team Leader, Closure and Secondary Waste, HQ, CMA

FIFTH COMMITTEE MEETING, APRIL 22-23, 2010, WASHINGTON, D.C.

Objective: To review the draft report, produce a preliminary concurrence draft, determine what is not yet known and how to learn it, and a path forward.

VIRTUAL MEETING, MAY 17, 2010

Objective: To discuss portions of the report draft, resolve remaining issues, and generate a document that is ready for concurrence. This meeting was conducted over the Web, with document editing carried out online and in real time and an accompanying teleconference.

VIRTUAL MEETING, MAY 18, 2010

Objective: To discuss portions of the report draft, resolve remaining issues, and generate a document that is ready for concurrence. This meeting was conducted over the Web, with document editing carried out online and in real time and an accompanying teleconference.

SIXTH COMMITTEE MEETING, JUNE 2-4, 2010, WASHINGTON, D.C.

Objective: To review the draft report, produce a concurrence draft, reach concurrence, and determine a path forward.

URS CLOSURE COLLABORATION AND ALIGNMENT TEAM MEETING, JUNE 15-17, 2010, DENVER, COLORADO

Objective: To observe the quarterly meeting of the baseline incineration chemical agent disposal facility closure managers and teams.

Site Team

Peter B. Lederman, committee chair
W. Leigh Short, committee member
Nancy T. Schulte, study director

Appendix E

Biographical Sketches of Committee Members

Peter B. Lederman retired as executive director, Hazardous Substance Management Research Center, and Executive Director, Office of Intellectual Property, New Jersey Institute of Technology. He is active as the principal of Peter Lederman & Associates. He is a member of the Science Advisory Board of the New Jersey Department of Environmental Protection. He has a Ph.D. in chemical engineering from the University of Michigan. Dr. Lederman has more than 50 years of broad experience in all facets of environmental management, control, and policy development; considerable experience in hazardous substance treatment and management; process design and development in the petrochemical industry; and more than 18 years of experience as an educator. He has industrial experience as a process designer and has managed the development of new processes through full-scale plant demonstrations. He is well known for his work as a professor in chemical process design. He led his company's safety program in the early 1980s. He directed the nation's oil spill R&D effort in the 1970s when he was at the Environmental Protection Agency. Dr. Lederman is a registered professional engineer, registered professional planner, and a diplomate in environmental engineering. Dr. Lederman has also worked at the federal (EPA) and state levels with particular emphasis on environmental policy. He is a national associate of the National Academies. Dr. Lederman has been a chair and a member of several NRC committees related to the demilitarization of chemical weapons, including serving as chair of the "Stockpile" Committee from 1999 to 2003 and chairing the committee that produced the 2002 NRC report *Closure and Johnston Atoll Chemical Agent Disposal System*.

Gary S. Groenewold is a staff scientist who has conducted research in surface chemistry, gas-phase chemistry, and secondary ion mass spectrometry at the Idaho National Laboratory (INL) since 1991. His research has focused on determining the speciation of absorbed radioactive and toxic metals (U, Np, Pu, Am, Hg, Al, and Cu) and organic compounds (e.g., VX, G agents, HD, organophosphates, amines, and sulfides). Prior to this, Dr. Groenewold served three years in line management at the INL and as the technical leader of an environmental organic analysis group. Before going to the INL, Dr. Groenewold worked in anticancer drug discovery for Bristol-Myers, using mass spectrometry as an identification tool. He received his Ph.D. in chemistry at the University of Nebraska, where he studied ion-molecule condensation and elimination reactions in the gas phase. He has authored 85 scientific publications on these subjects.

Deborah L. Grubbe is currently the president of Operations and Safety Solutions, LLC. Most recently she was vice-president, Group Safety and Industrial Hygiene, for BP International where she was accountable for providing global safety leadership in all business areas. Prior to that, Ms. Grubbe was employed by DuPont in Wilmington, Delaware, where she held corporate director positions in safety, operations, and engineering. Her many assignments have included capital project implementation, strategic safety assessments, manufacturing management, and human resources. In 2007, Ms. Grubbe chaired the National Institute of Standards and Technology Visiting Committee for Advanced Technology. She has served as a consultant to the Columbia Shuttle Accident Investigation Board and has been appointed to the NASA Aerospace Safety Advisory Panel. From 2005 to 2008, Ms. Grubbe was a member of the Board of Directors of American Institute of Chemical Engineers, and she sat on the Board of Advisors to the Center for Chemical Process Safety. She is currently a member of the Board of Trustees of the National Safety Council. She serves as a member of the Purdue University College of Engineering Advisory Council and was the first woman and youngest elected member on the State of Delaware Registration Board for Professional Engineers (1985-1989). Ms. Grubbe graduated with a B.S. in chemical engineering with highest distinction from Purdue University. She received a Winston Churchill Fellowship to attend Cambridge University in England, where she received a Certificate of Post-Graduate Study in Chemical Engineering. She is a registered professional engineer in Delaware. Ms. Grubbe has been a member of several NRC committees related to the demilitarization of chemical weapons, including the committee that produced the 2002 NRC report *Closure and Johnston Atoll Chemical Agent Disposal System*.

John R. Howell (NAE) is the Ernest Cockrell, Jr., Memorial Chair and Baker Hughes Incorporated Centennial Professor of Mechanical Engineering at the University of Texas at Austin. He is a former director of the Advanced Manufacturing Center at the University of Texas. Professor Howell received his Ph.D. in engineering, his M.S. in chemical engineering, and his B.S. in chemical engineering, from the Case Institute of Technology (now Case Western Reserve University). Professor Howell joined the faculty of the University of Texas at Austin. He has received national and international recognition for his continuing research in radiative transfer, particularly for adapting Monte Carlo techniques to radiative transfer analysis. His recent research has centered on inverse analysis techniques applied to the design and control of thermal systems with significant radiative transfer. Professor Howell served on the NRC Committee to Review and Assess Developmental Issues Concerning the Metal Parts Treater Design for the Blue Grass Chemical Agent Destruction Pilot Plant, as well as the NRC Panel on Benchmarking the Research Competitiveness of the United States in Mechanical Engineering. He is a member of the National Academy of Engineering.

Todd A. Kimmell is principal investigator with the Environmental Science Division at the U.S. Department of Energy's Argonne National Laboratory. He is an environmental scientist and policy analyst, with more than 30 years of experience in solid and hazardous waste management, permitting and regulatory compliance, cleanup programs, environmental programs policy development, and emergency management and homeland security. He has supported the Army's chemical and conventional munitions management programs, and has contributed to the Army's Assembled Chemical Weapons Assessment Program and the Chemical Stockpile Emergency Preparedness Program. Mr. Kimmell also has a strong technical background in analytical and physical/chemical test method development, and analytical quality assurance and control. He has served on the Environmental Protection Agency's National Homeland Security Research Center on environmental test methods for chemical, biological, and radiological assessment for emergency response. Mr. Kimmell has also supported a number of environmental permitting programs at Army chemical weapons storage sites and at open burning/open detonation sites. He graduated from George Washington University with an M.S. in environmental science.

Kalithil E. Philipose is a senior research engineer and project manager with Atomic Energy of Canada at the Chalk River Laboratories Centre. He holds a master's degree in civil and structural engineering and is a registered professional engineer with the province of Ontario, Canada. He has more than 35 years of experience on various projects involving design and construction of nuclear waste disposal facilities and decommissioning of major facilities contaminated with highly radioactive waste materials. He was responsible for developing a durable concrete with an engineered service life of 500 years for a low-level waste repository. His responsibilities included decommissioning planning of large, buried carbon steel tanks containing heels of high-level waste, and research and development on the storage of cement-grouted fissile high-level liquid waste, development of aging management program guidelines for detection and monitoring of aging related degradation, and mitigation for nuclear generating stations and waste disposal facilities.

Louis T. Phillips is director of engineering for Resource: PM. Most recently he was a senior process design consultant for Sunoco, Inc., Philadelphia. Prior to that, he was a process design engineer for ICI Americas in Wilmington, Delaware. He has more than 33 years of experience in process plant engineering; his assignments have included process design, project engineering, decommissioning, and maintenance, along with safety relief system and hazop studies. At Sunoco he was the project manager for decommissioning of a lubricants storage and blending facility that included removing from service more than 200 storage tanks while complying with Pennsylvania storage tank environmental regulations. Mr. Phillips was responsible for authoring the Sunoco mothballing, decommissioning, and demolition procedures and was program manager for these efforts throughout the Northeast Refining Division. Mr. Phillips has authored a publication on decommissioning of process plants. He received his M.S. in chemical engineering from Villanova University and his B.S. in chemical engineering from the New Jersey Institute of Technology. He is a registered professional engineer in Pennsylvania, New Jersey, and Delaware.

Danny D. Reible (NAE) is currently the Bettie Margaret Smith Chair of Environmental Health Engineering Coordinator for the University of Texas. He received a B.S. from Lamar University and an M.S. and a Ph.D. from California Institute of Technology—all in chemical engineering. Dr. Reible leads both fundamental and applied efforts in the assessment of risks of hazardous substances. Dr. Reible has led the development of in situ sediment capping, and he has evaluated the applicability of capping technology to a wide range of contaminants and settings including PAHs from fuels, manufactured gas plants and creosote manufacturing facilities, PCBs, and metals. He has also advised both industry and regulatory groups on the applicability and design of capping for remediation at a variety of specific sites. His research has focused on the natural attenuation processes of contaminants as a result of a variety of processes in the environment. These processes are biological, chemical, and physical in nature, and thus the research has encouraged the development of interdisciplinary teams focused on understanding and manipulating these processes. He is a professional engineer who has also advised industry and regulatory groups.

W. Leigh Short, with a Ph.D. in chemical engineering from the University of Michigan, retired as a principal and vice president of Woodward-Clyde responsible for the management and business development activities associated with the company's hazardous waste services in Wayne, New Jersey. Dr. Short has expertise in air pollution, chemical process engineering, hazardous waste services, feasibility studies and site remediation, and project management. He has taught courses in control technologies, both to graduate students and as a part of the EPA's national training programs. He has served as chairman of the NO_x control technology review panel for the EPA. Dr. Short's considerable project management experience related to remediation and closure of large industrial sites is of direct application to the work of this committee. Dr. Short was a member of the committee that produced the 2002 NRC report *Closure and Johnston Atoll Chemical Agent Disposal System*.

Leonard M. Siegel is executive director of the Mountain View, California-based Center for Public Environmental Oversight (CPEO), a project of the Pacific Studies Center that facilitates public participation in the oversight of military environmental programs, federal facilities cleanup, and Brownfields revitalization. He is one of the environmental movement's leading experts on military facility contamination, community oversight of cleanup, and the vapor intrusion pathway. For his organization, he runs two Internet newsgroups: the Military Environmental Forum and the Brownfields Internet Forum. Mr. Siegel also serves on numerous advisory committees. He is a member of the Interstate Technology & Regulatory Council's work team on permeable reactive barriers, the Department of Toxic Substances Control (California) External Advisory Group, and the Moffett Field (former Moffett Naval Air Station) Restoration Advisory Board.

David A. Skiven is currently serving as co-director of the Engineering Society of Detroit (ESD) Institute. He is recently retired as the executive director of the General Motors Corporation Worldwide Facilities Group. As GM's Center of Facilities Expertise, the Worldwide Facilities Group is responsible for providing global leadership in the facilities, utilities, construction, and environmental segments, allowing corporate clients to focus on their core business, resulting in structural cost savings and improved utilization of assets. After joining GM's Fisher Body Division in 1970, Mr. Skiven worked in various engineering operations. He was plant engineer at the Fisher Guide-Trenton, New Jersey, plant from 1981 to 1985. Subsequently, he was named manager of Manufacturing Planning, Industrial Engineering, and Facilities at Fisher Guide Division's General Office. In 1985, he was appointed manager of Facilities and Future Programs Manufacturing Engineering for the Saturn Corporation. In 1992, Mr. Skiven was promoted to director of Plant Environment and the Environmental Energy Staff, and in early 1993, he was appointed executive director of the Worldwide Facilities Group. He has served on the NRC's Board on Infrastructure and the Constructed Environment. Mr. Skiven has been a frequent advisor to a number of federal facilities organizations, including the U.S. Navy and the U.S. Air Force. He is currently consulting in the facilities-related fields. He is also on the Board of Directors of BioReaction, Inc., a pollution control technology company. He recently received ESD's Horace H. Rackham Humanitarian Award, the highest award given by the society. Mr. Skiven has a B.S. from General Motors Institute (GMI) and an M.S. from Wayne State University. He is also a registered professional engineer.

Sheryl A. Telford is director of the DuPont Corporate Remediation Group, managing the company's global environmental remediation responsibilities. Prior to joining DuPont, she was an environmental policy manager at PSEG in Newark, New Jersey, working on issues related to land use, waste, and site remediation programs for the company's combined electric and gas businesses. She has 10 years of experience as an environmental regulator in the New Jersey Department of Environmental Protection developing program and policy initiatives for the Site Remediation and Waste Management programs, including work on the state's first Brownfield law. She has presented at numerous national forums on matters related to site remediation, redevelopment, and brownfields. She holds a B.A. in chemistry and physics from Wheaton College.

Lawrence J. Washington, retired corporate vice president for Sustainability and Environmental Health and Safety (EH&S), worked for the Dow Chemical Company for more than 37 years. Among his many distinctions, Mr. Washington chaired the Corporate Environmental Advisory Council and the EH&S Management Board and Crisis Management Team. He also served as an officer of the company. In his previous role as corporate vice president, EH&S, Human Resources, and Public Affairs, Mr. Washington supported the creation of the Genesis Award Program for Excellence in People Development and initiated several new programs to support employee development. His career included many roles in operations, including leader of Dow's Western Division and general manager and site leader for Michigan operations. Mr. Washington earned bachelor's and master's degrees in chemical engineering from the University of Detroit.