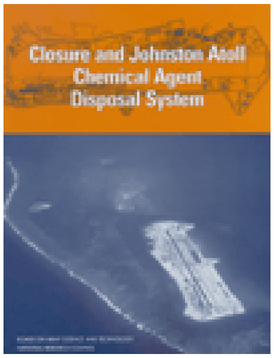

Closure and Johnston Atoll Chemical Agent Disposal System

Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program, National Research Council

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CLOSURE AND JOHNSTON ATOLL CHEMICAL AGENT DISPOSAL SYSTEM

Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program
Board on Army Science and Technology
Division on Engineering and Physical Sciences
National Research Council

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Preface

The Johnston Atoll Chemical Agent Disposal System (JACADS), the first fully integrated U.S. chemical agent disposal facility, was constructed in the late 1980s on Johnston Island, located in the Pacific Ocean some 800 miles southwest of Hawaii. Agent operations began during the summer of 1990. With the disposal of the last land mine on the island in November 2000, this landmark incineration facility concluded more than 10 years of almost uninterrupted, extremely hazardous agent and munitions disposal operations.

The relatively large, two-story JACADS complex included myriad electrical, mechanical, automated, and robotic equipment (including many monitoring devices) used to destroy or dispose of multiple types of agents and all their varied kinds of containers and weapons systems. Constant attention had to be paid to safety while meeting production goals.

Now that the fundamental job of JACADS—to destroy more than 2,000 tons of the U.S. stockpile of chemical agents—has been accomplished, a major operation has begun to clean up the site. Buildings and equipment must be decontaminated of any residual agent and agent degradation products, with all hazardous waste properly disposed of. This is a difficult task and requires extensive coordination among numerous interested local and federal agencies. A lot must be done, and much can be learned from this effort. It is hoped that this report will aid in the process and point to ways of facilitating the closure process at other chemical agent disposal facilities in the future.

We wish to express our appreciation to the members of the committee—particularly Frank P. Crimi, who took the lead for the study—for their contributions to the preparation of this report by collecting significant data and information, making site visits to JACADS and other facilities under construction or in operation, and writing the report. The committee is also grateful to the Office of the Program Manager for Chemical Demilitarization and its contractors for the useful information they provided.

The committee greatly appreciates the support and assistance of National Research Council staff members Donald L. Siebenaler, Harrison T. Pannella, Daniel E.J. Talmage, Jr., Carter W. Ford, and Elizabeth Fikre in the production of this report.

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Committee on Review and Evaluation of the
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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 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 participation in the review of this report:

Charles Baronian, Consultant,
Jan Beyea, Consulting in the Public Interest,
Elvin R. Heiberg III, Heiberg Associates, Inc.,
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Mark N. Silverman, Consultant,
Harold P. Smith, Jr., University of California at Berkeley, and
Gordon J. Wozniak, Lawrence Berkeley National Laboratory.

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 Robert E. Connick (NAS), University of California, Berkeley (professor emeritus). Appointed by the National Research Council, he 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.

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Figure, Plates, Tables, and Boxes

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Acronyms

ACAMS Automatic Continuous Air Monitoring System
ADP agent degradation product
AOI area of interest

CMS carbon micronization system
COC chemicals of concern
CSDP Chemical Stockpile Disposal Program
CSM conceptual site model
CWA chemical warfare agent

DAAMS Depot Area Air Monitoring System
DPE demilitarization protective ensemble
DTRA Defense Threat Reduction Agency

ECP engineering change proposal
EPA Environmental Protection Agency

FWS Fish and Wildlife Service

GB sarin (a nerve agent)
GSA General Services Administration

HD distilled mustard agent
HVAC heating, ventilation, and air conditioning
HWMU hazardous waste management unit

IPT integrated project team

JACADS Johnston Atoll Chemical Agent Disposal System
JCC JACADS Closure Campaign

MACT maximum achievable control technology
MDB munitions demilitarization building
MPF metal parts furnace

NRC National Research Council

OSC Operations Support Command
OVT operational verification testing

PCB polychlorinated biphenyl
PMCD Program Manager for Chemical Demilitarization

RCRA Resource Conservation and Recovery Act
RFA RCRA facility assessment
RFI RCRA facility investigation
RHSA Red Hat Storage Area
RMP risk management program

SIMS secondary ion mass spectrometry
SSC systems, structures, and components
SWMU solid waste management unit

TOCDF Tooele Chemical Agent Disposal Facility
TSDF treatment, storage, and disposal facility
TWA time weighted average

USACAP U.S. Army Chemical Activity–Pacific
USACHPPM U.S. Army Center for Health Promotion and Preventive Medicine
USARPAC U.S. Army Pacific

VX a nerve agent

WDC Washington Demilitarization Company

1X 1X indicates that the level of contamination is unknown or that an item is contaminated to the extent that vapor concentrations from the bagged item exceed 0.0001 mg/m^3 for agent VX or 0.003 mg/m^3 for agent HD.

3X The 3X decontamination level refers to solids decontaminated to the point that the agent concentration in the headspace above the encapsulated solid does not exceed the health-based, 8-hour, time-weighted average limit for worker exposure. The limit for HD is 3.0 μg per cubic meter of air. Materials classified as 3X may be handled by qualified plant workers using appropriate procedures but cannot be released to the environment or sold for general public reuse. In specific cases in which approval has been granted, a 3X material may be shipped to an approved hazardous waste treatment facility for disposal in a landfill or for further treatment.

5X The use of 5X indicates that an item has been decontaminated completely of the indicated agent and may be released for general use or sold to the general public in accordance with all applicable federal, state, and local regulations. An item is decontaminated completely when it has been subjected to procedures that are known to completely degrade the agent molecule, or when analyses, submitted through Army channels for approval by the Department of Defense Explosives Safety Board, have shown that the total quantity of agent is less than the minimal health effects dosage as determined by the Surgeon General. A 5X condition must be certified by the commander or designated representative. One approved method is heating the item to 538°C (1,000°F) for 15 minutes. This is considered sufficient to destroy chemical agent molecules.

5R (No Agent Hazard) Classification. An agent symbol with five Rs means that all previously contaminated surfaces are decontaminated and analyzed to demonstrate the absence of residual agents. 5R is defined as a room sealed (ventilation turned off) for at least 4 hours at a temperature of at least 70°F prior to sampling and that shows an agent vapor concentration less than the 8-hour time-weighted average concentration for unmasked workers.

CLOSURE AND JOHNSTON ATOLL CHEMICAL AGENT DISPOSAL SYSTEM

Executive Summary

This report addresses significant issues related to the ongoing closure of the Johnston Atoll Chemical Agent Disposal System (JACADS) and identifies matters that may influence the closure of other disposal facilities at storage sites in the continental United States. Most notable are issues dealing with (1) establishing final end-state (final environmental condition of the property) cleanliness standards for contaminants remaining after facility closure, (2) ensuring personnel safety, (3) minimizing delays and additional costs due to the processing of RCRA permit modifications not included in the original permit submitted to the U.S. Environmental Protection Agency (EPA), and (4) personnel retention.

JACADS, the first fully integrated baseline incineration system for the disposal of stockpiled chemical agent and munitions, is located on Johnston Island, part of the Johnston Atoll, approximately 800 miles southwest of Hawaii. The facility occupies 130 acres of the 625-acre island and includes one large process building, with three furnaces and auxiliary equipment.

Concurrent with the beginning of construction of the baseline incineration facility at JACADS in 1987, the Army requested that the National Research Council (NRC) review and evaluate the Chemical Stockpile Disposal Program (CSDP) and provide scientific and technical advice and counsel. The NRC established the standing Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program (Stockpile Committee), one of whose early reports was a study of operational verification testing at JACADS prior to the start of agent disposal operations. In the intervening years, the Stockpile Committee produced 27 reports on various aspects of the CSDP.[1]

[1]The 27 reports of the committee are listed in Appendix A; biographical sketches of the committee members are given in Appendix B.

In 1998, the Army's Program Manager for Chemical Demilitarization (PMCD) began planning for the closure of JACADS by September 2003. In January 1999, the Stockpile Committee was asked by the Army to begin a review of JACADS closure planning. To complete the closure, the Army must demonstrate to the EPA that the Army's portion of the island meets applicable regulatory standards for future use. The several federal agencies having an interest in how the atoll will be used after the Army (the main tenant) and the Air Force (the current steward) complete their missions have as yet left undetermined the end use (what the property will be used for) of Johnston Atoll, following closure of JACADS. This may prevent completion of closure as scheduled by the Army for September 2003. The need for prompt action on this matter at a high level was pointed out in a letter report of the committee dated May 4, 2000 (NRC, 2000a).

End use is an important parameter because remediating JACADS to a residential standard typically would be more difficult than remediating the site to an industrial standard. The Army has favored an industrial standard, because the decision on which standard will be used and permitted by regulatory authorities may also set an important precedent for the closures (and costs) of other chemical agent disposal facilities.

Considering the uncertainty surrounding end use, the Army is currently screening in its closure process at JACADS to a residential standard, although it does not necessarily believe that it will ultimately have to clean its portion of the atoll to these criteria. Screening in this context means comparing the analytical results to a standard for each contaminant, if available.

A generic closure process for the remediation of any industrial or government facility, including chemical agent disposal facilities using incineration or other disposal technologies, would involve a planning phase and an implementation phase (see Appendix C). The committee used these phases as a framework for discussing the closure of JACADS.

Decontamination of JACADS will require chemical, mechanical, and thermal processing. The removal of critical structural components and systems from buildings will have to be planned to ensure structural stability. Residuals of any of the agents processed at JACADS (HD, GB, and VX) may be exposed during disassembly activities. These residuals will be harmful to anyone in the immediate area: If they are vaporized, airborne agent concentrations could be harmful, so decontamination procedures for equipment, waste streams, and building materials must ensure that agent residues are destroyed, and the destruction must be verified.

The closure of the baseline incineration system used at JACADS will present unique hazards, risks, and problems that must be anticipated and resolved as the decommissioning work progresses. Because closure is a new activity in the chemical disposal program, all sources of risk might not have been identified in the planning phase. New sources of risk must be addressed carefully, and the experience meticulously recorded to assist in the subsequent closure of other disposal facilities. The JACADS experience may be the prototype for future closures and should provide a wealth of lessons learned for those closures and for the design of new facilities. For example, after closure activities have been completed, long-term monitoring may be needed.

As closure progresses and dismantling of the facility advances, the workforce will be required to handle increasingly heavy materials and equipment. This equipment will include all possibly agent-contaminated machinery, metal ducts, and piping, as well as bulk materials such as concrete. Consequently, some risks to workers may be encountered more frequently during the dismantling and demolition associated with facility closure:

- equipment mistakenly believed to be free of agent, energetics, or other chemical hazard (e.g., lead-based paint, decontamination solutions)
- slips, trips, and falls
- hazards presented by heavy objects and heavy lifting equipment
- utility systems only temporarily connected
- heat stress, uncomfortable working conditions
- confined work spaces
- proximity to flame-producing equipment
- unstable structures and equipment
- noisy environments

The Army has programs for risk management, safety, and occupational and environmental health in place at its chemical stockpile disposal sites. The recommendations set forth below are provided with the committee's expectation that if they are carried out, workers employed in closure operations will be less likely to encounter the posited risks.

Currently, there are closure Resource Conservation Recovery Act (RCRA) permit modifications awaiting EPA approval. To date, there have been no delays due to approval of permit modifications, but they could occur in the future. Permit modifications need to be identified sufficiently early to allow time for regulatory reviews, public comment, resolution of comments, and incorporation of changes into the applicable engineering change proposals (ECPs), work orders, or other management control documents.

The method used at JACADS to process ECPs has become well defined and refined over the life of the project. The processing of proposals relevant to closure of the site should be carefully documented and lessons learned identified to facilitate the closure of other disposal facilities.

The retention of experienced and knowledgeable personnel during facility operation and closure is an important management issue. Personnel staffing and retention plans need to be addressed early in the facility planning process. Implementation of a suitable personnel retention, transfer, and release program is essential to the successful closure of JACADS. The Army's contractor for JACADS has recognized this issue and has developed a staff retention plan.

Public outreach and engagement established during disposal operations must be continued as the emphasis shifts from operations to closure. Outreach activities during closure will also provide the Army with an opportunity to promote its operational accomplishments.

FINDINGS AND RECOMMENDATIONS

Decision Making and Project Planning

Finding 1. The initial JACADS closure plan was developed late and was not comprehensive. Preproject planning and early decision making by management are necessary to support the closure of all chemical agent disposal facilities. A comprehensive, facility-wide, integrated closure plan could have had significant overall cost benefits at JACADS. The plans did not provide detailed information on new required standard operating procedures, nor did they provide training for personnel carrying out the closure tasks in this new environment.

Recommendation 1. The Army should prepare a comprehensive closure strategy for each chemical agent disposal facility. The strategy would provide for responsible project and contractor management personnel to be trained in preproject planning. A comprehensive, integrated closure plan should be developed for each disposal site and surrounding area based on realistic assumptions at the time the facility is designed or as soon as possible if it is in construction or operation. This plan should provide for appropriate standard operating procedures and personnel training for the anticipated activities.

Finding 2. Decisions on the end use and identification of the ultimate owner of Johnston Island or other chemical disposal facilities have not been reached in a timely way. For JACADS, the need for prompt action on this matter at a high level was pointed out in a letter report of this committee dated May 4, 2000 (NRC, 2000a). Regulatory requirements and analytical procedures/protocols to meet end-state requirements for JACADS were not completed as of the writing of this report.

Recommendation 2. The end state, end use, and stewardship issues pertaining to closure of any chemical agent disposal facility should be resolved early so that planning can proceed on an assured rather than an assumed basis. If possible, facility end uses should be included in the RCRA operating permit. If end use and end state cannot be defined early in the planning process, risk assessments and cost and schedule estimates for alternative end states and uses should be prepared.

Finding 3. Closure of any chemical agent disposal facility necessitates the identification of potential exposure pathways and environmental receptors in an initial conceptual site model. Closure of JACADS has been complicated because this was not done early and the end use will not be determined until much of the closure planning has been completed.

Recommendation 3. Development of a conceptual site model should include identification of potential exposure pathways for receptors, their impacts, if any, the risks to be mitigated, and the means of mitigation. Such a conceptual site model should be reviewed and agreed to by the various stakeholders early in the planning phase and before submission of the overall closure plan to the regulatory agency for approval. The RCRA operating permit for the facility should be amended as early as possible to include closure criteria, closure sampling criteria, and mitigation methods. This information could be in the initial operating permit. At the latest, it should be developed while agent disposal operations are under way.

Finding 4. The closure plan is incomplete in that it does not sufficiently address contingencies such as control of spills, dust, or special materials such as asbestos, nor does it specify countermeasures for mitigation of these potential situations. Moreover, the hazardous waste management units (HWMUs) at JACADS and the Red Hat Storage Area differ in the chemicals to be analyzed, their management and associated cleanup levels, and required permit modifications, because new unidentified secondary waste may be generated during decommissioning and closure.

Recommendation 4a. The closure plan must include a consideration of storage, handling, and ultimate disposal of wastes generated from JACADS closure, including provisions for temporary staging and transportation on-site and off-site.

Recommendation 4b. To promote the development and implementation of contingency responses during both closure and postclosure operations, control strategies for unexpected liquid runoff or particle dispersion, as well as for special hazardous substances—such as asbestos—should be integrated in the closure plan.

Finding 5. Stockpile disposal facilities that do not use components of the baseline incineration system, or modified versions of it, lack a means to achieve thermal decontamination of secondary wastes during closure operations.

Recommendation 5. The Army should proceed as soon as possible to develop means to address secondary waste processing/disposal issues at sites employing disposal technologies other than incineration, and should seek early regulatory and stakeholder approval for such means.

Personnel Retention

Finding 6. The loss of experienced personnel prior to completion of closure could jeopardize the cost-effective and safe implementation of closure plans. Fostering personnel retention during facility closure could present a challenge, particularly if the contractor responsible for closure is different from the one responsible for operations.

Recommendation 6. The Army and its contractors for operating chemical agent disposal facilities should develop and adopt a strategy for personnel retention at project inception. The strategy should consider hiring procedures, training (including lessons learned), career development, reward and recognition, management of change, the work environment, retention incentives, and employee morale.

Acquisition Strategy and Procurement

Finding 7. The procurement strategy proposed for closure of the JACADS facility appears to be workable; however, the contracting mechanism is awkward and inherently inefficient.

Recommendation 7. The Program Manager for Chemical Demilitarization should continue to work with the Operations Support Command to make procurement processing as efficient and responsive as possible.

Finding 8. The contract for closure at JACADS is expected to have an award fee based on meeting the schedule for closure.

Recommendation 8. Future contracts should consider all aspects of performance, including (but not limited to) safety, cost, and schedule, in setting criteria for the award fee.

Cost Control

Finding 9. Cost containment efforts in the closure of JACADS are fragmented and have been inhibited by the absence of a total project cost baseline estimate for the Army and all contractors supporting closure activities. A multiyear program cost estimate and schedule that encompasses all closure costs is essential for the cost-effective completion of the JACADS closure campaign. Costs will probably change as the closure project evolves.

Recommendation 9. The Army should develop an earned value system to maintain a comprehensive multiyear cost and schedule for the construction, operation, and closure of each chemical agent disposal facility. The system should be used to control and report the effect on cost and schedule from changes such as permit modifications, proposals for engineering changes, and the phaseout of security for surety material.

Finding 10. Prudent management requires early decisions, accurate assumptions, and full consideration of all cost components, regardless of the entity incurring them, and cost estimates that approach the actual final costs. Project cost control procedures and contract incentives were not established as part of the JACADS contract.

Recommendation 10. The Program Manager for Chemical Demilitarization should assure that for future site closures, all means at his disposal, including JACADS lessons learned, are applied early and continuously to estimate costs more accurately, thus facilitating project management and executive and congressional oversight. This should include the establishment of cost control procedures and contract incentives during development of the relevant contracts.

Monitoring

Finding 11. Contamination at JACADS by multiple agents and agent degradation products is a certainty, but the extent is unknown. At JACADS, weapons and bulk stores containing GB, HD, and VX were destroyed. Any or all of these agents and their degradation products may be present in the munitions demilitarization building, in secondary stored wastes such as used DPE suits, and in spent carbon from air filters. Intrusion of agent into the epoxy coating and concrete floor slabs in processing rooms is likely, and contamination is likely in niches, recesses, joints, and cracks, as well as within process equipment, lines, and valves. There will also be contaminated carbon from the plant air ventilation filter system.

Recommendation 11. Near-real-time monitors (ACAMS) for all three chemical agents (GB, HD, and VX) should be provided to protect workers in any areas where they might be exposed to agent during dismantlement activities or during the handling and treatment of secondary wastes. Multiagent monitoring should also be provided for the common stack.

Finding 12. By rigid adherence to definitions and terminology prescribed by Army regulations on decontamination levels, the Army has failed to communicate clearly with external agencies holding regulatory responsibility or with members of the knowledgeable, interested public. Steps can and should be taken to improve communications in this important area.

Recommendation 12. The Army should either seek relief from the internal regulation prescribing use of the 1X, 3X, 5X, and 5R terms or augment its use of these designators with scientifically derived terms that communicate clearly with external regulators and interested stakeholders. Ideally, EPA standards (or actual values) should be the primary reporting values, with "X" and "R" designations as secondary reporting values.

Finding 13. The sampling and analysis plan for closure, and the need to increase the number of DAAMS tubes to monitor all three agents, will require a substantial increase in the numbers and kinds of chemical analyses.

Recommendation 13. The Army should estimate the numbers of chemical analyses of each kind that will be required as closure proceeds and ensure that adequate instrumentation, laboratory space, and personnel will be available to handle them.

Finding 14. Analytical procedures for the chemical agents and their most toxic degradation products have not been specified and may need to be developed, particularly when these agents and products occur in media such as concrete, soils, and spent carbon.

Recommendation 14. The Army should demonstrate that it has the ability to analyze for agents and their toxic degradation products in concrete, soil, and spent carbon, and to provide assurance that any structures or media left in place will be decontaminated consistent with the island's future use.

Security

Finding 15. Security requirements for Johnston Atoll following the departure of USACAP include (1) protection of personnel, facilities, and materiel, (2) prevention of pilferage, unauthorized use, sabotage, and violation of community rules and regulations, and (3) prevention of unauthorized entry and trespass from either air or sea until the island's end state has been reached and final ownership has been established.

Recommendation 15. Security measures on Johnston Atoll commensurate with personnel safety and the protection of government and personal property should be maintained throughout the closure process.

Safety

Finding 16. Experience gained at JACADS will establish precedents for closure planning at chemical agent disposal facilities in the continental United States. Unusual and unanticipated events during JACADS closure, including those from construction- and demolition-related activities and those due to the inexperience of some workers with these activities, will likely be used by regulatory authorities in setting requirements for closures at other facilities.

Recommendation 16. The detailed plans for decommissioning, dismantlement, and demolition of chemical agent disposal facilities should examine all levels of activity, e.g., task procedures, utility requirements, personnel training, and safety considerations. The examination should include consideration of daily task planning and identification of risk factors inherent in each planned activity and worker adherence to procedures. It should also develop contingency scenarios and intended responses so as to achieve the highest degree of safety and lowest probability of disruptive, unplanned situations. Prompt investigation, reporting, and analysis of every accident and near miss should be ensured, with all safety data assembled in a lessons learned format easily accessible to future closure campaign supervisors and planners.

Finding 17. The introduction of new structural risks during closure operations is a potential source of accidents. Dismantlement and removal of building structural components, such as the concrete floors of the explosion containment rooms, could pose added risks of structural instability during closure operations, as could temporary loadings from stacked materials or heavy equipment.

Recommendation 17. Throughout closure operations, the sequence and extent of building demolition should be planned to ensure continuous separation of contaminated waste from uncontaminated waste. Professional engineers should review the proposed sequence and extent of demolition actions. The effects of demolition on structural integrity in the event of a contingency condition (such as a typhoon) should be considered. A system of work permits and controls should be established for operation of heavy equipment within structures and for sizing and locating material stockpiles.

Finding 18. During closure, utility service becomes less dependable with the changing configuration of a facility. Also, adverse interactions of materials handling and lifting equipment with ongoing changes in building structures and utility distribution systems can create unique risks.

Recommendation 18. The Army should carefully assess the need for redundancy in utility systems so that needed utilities are available for planned operations. Special training may be necessary to assure the safe use of lifting equipment and to preclude utility system failure.

Public Affairs and Public Involvement

Finding 19. The Army has made great strides in the public relations and outreach elements of its public affairs program in support of JACADS, identifying external stakeholders, communicating with them, establishing credibility, and satisfying their needs—often by going well beyond minimal requirements. Completing closure of JACADS as rapidly as possible, and with full regard for safety and the environment, appears in the best interest of the public and the Army. Also, the Army has gone to considerable expense to hold meetings in Hawaii, to sponsor travel to Johnston Island for inspections and discussions, to hold meetings in South Pacific island regions in the vicinity of Johnston Island, and to maintain stakeholder contact. As the Army moves forward with the third element of its comprehensive public affairs program, public involvement, there are measures it can take to continue to improve its results.

Recommendation 19. The Program Manager for Chemical Demilitarization should continue to do the following:

- Maintain contact by multiple means with all stakeholders, taking appropriate public outreach initiatives as the transition from operations to closure occurs.
- Press for opportunities for effective public involvement in closure planning and implementation.
- Press for end-use and end-state criteria as vigorously as possible and communicate this information to stakeholders along with notices of important operational accomplishments.
- Ensure that, as progress in the closure of JACADS continues, the information is disseminated to all stakeholders, especially to communities near other sites.
- Seek coordinated, interagency support for outreach efforts to facilitate the clarity, candor, and consistency of disseminated information at all disposal sites.

1

Introduction

BACKGROUND

The Johnston Atoll Chemical Agent Disposal System (JACADS), the first fully integrated baseline incineration system for the disposal of stockpiled chemical agent and munitions, is located on Johnston Island, approximately 800 miles southwest of Hawaii. The facility occupies 130 acres of the 625-acre island.[1] It is adjacent to a chemical and munitions storage area (known as the Red Hat Area) that once housed about 6.4 percent of the 31,496 tons of the original U.S. stockpile of chemical agents. The residents of Johnston Island are military, government, or contractor personnel. Figure 1-1 shows the location of JACADS, the Red Hat Area, and other facilities on Johnston Island.

JACADS has one large process building where munitions are disassembled and their various components processed and incinerated in three combustion units. There are also a tall stack, auxiliary process off-gas trains, building HVAC equipment, and several auxiliary buildings.

Construction and systemization (operational testing) of JACADS was completed in July 1990. JACADS has had a twofold mission:

- to destroy the chemical agents and munitions stored on Johnston Island
- to serve as a demonstration facility for the baseline incineration system, including final facility closure

Following construction and systemization, as required by Public Law 100-456, operational verification testing (OVT) was conducted at JACADS from July 16, 1990, to March 6, 1993. OVT consisted of four disposal campaigns of a representative variety of munitions and containers for each of the major types of agents in the stockpile. The four OVT campaigns were used to evaluate disposal operations for (1) M55 rockets containing nerve agent GB (sarin); (2) M55 rockets containing nerve agent VX; (3) ton (bulk) containers of the mustard (blister) agent HD; and (4) 105-mm M60 projectiles containing HD.

Chemical Agent Stockpiles Elsewhere

Chemical agents are also stockpiled at eight locations in the continental United States. A disposal facility is either operational or under construction at six of these sites. At the time this report was prepared, there were two operational facilities, JACADS (agent operations completed in November 2000) and the Tooele Chemical Agent Disposal Facility (TOCDF) in Tooele, Utah. Three other baseline incineration facilities are under construction at storage sites in Anniston, Alabama; Umatilla, Oregon; and Pine Bluff, Arkansas. Two facilities employing nonincineration technologies to destroy agent stored only in bulk ton containers are also under construction: Aberdeen, Maryland (HD only), and Newport, Indiana (VX only). These facilities are designed to use hydrolysis, followed by biotreatment of secondary wastes at Aberdeen and by supercritical water oxidation at Newport. For the two remaining sites, Pueblo Chemical Depot in Pueblo, Colorado, and Blue Grass Chemical Activity near Lexington, Kentucky, both of which house assembled chemical munitions, the choice of technologies is still pending.

In accordance with the terms of the international Chemical Weapons Convention, which became effective April 29, 1997, the signatories, including the United States, are to have destroyed their stockpiles of chemical agents and munitions by April 29, 2007.

[1]Johnston Island is approximately 7 percent natural; the remaining 93 percent was created by dredging the surrounding coral reef to build a runway for military operations during World War II. A protective seawall surrounding the island requires periodic maintenance to keep most of the island (which is 7 feet above sea level) from being reclaimed by the sea.

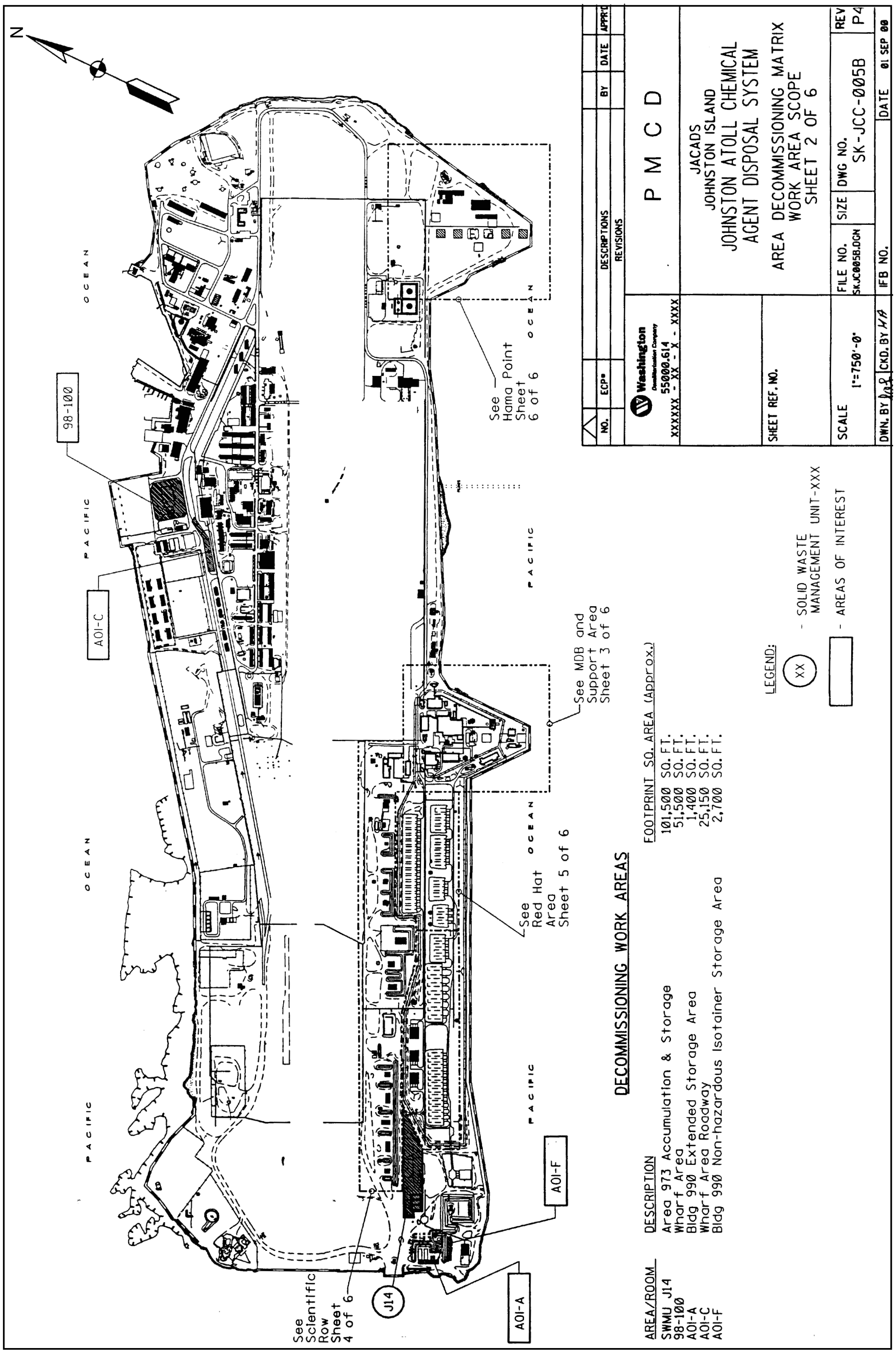

FIGURE 1-1 Location of JACADS, the Red Hat Storage Area, and other facilities on Johnston Island. SOURCE: U.S. Army, 2000a.

TABLE 1-1 Munitions and Bulk Containers Destroyed at JACADS

Munitions/Container Type	Number
HD blister agent-filled projectiles (155-mm)	5,670
HD blister agent-filled projectiles (155-mm from Solomon Islands)	109
HD blister agent-filled mortars (4.2-in.)	43,660
GB nerve agent-filled projectiles (8-in.)	13,020
GB nerve agent-filled projectiles (105-mm)	49,360
GB nerve agent-filled projectiles (155-mm)	107,197
GB nerve agent-filled MK-94 (500 lb) bombs	2,570
GB nerve agent-filled MC-1 (750 lb) bombs	3,047
GB and VX nerve agent-filled M-55 rockets/warheads	72,242
HD blister agent-filled projectiles (105-mm)	45,154
HD blister agent-filled ton containers	68
GB nerve agent-filled ton containers	66
VX nerve agent-filled projectiles (155-mm)	42,682
VX nerve agent-filled projectiles (8-in.)	14,519
VX nerve agent-filled ton containers	66
VX mines	13,302
Total munitions and bulk containers destroyed	412,732

SOURCE: U.S. Army, 2000b.

Johnston Island Chemical Agent Stockpile

Between 1990 and 2000, 2,031 tons of chemical agents were destroyed at JACADS, 6.4 percent of the 31,496 tons in the original U.S. chemical agent stockpile. Table 1-1 lists the chemical agents and munitions processed at JACADS.

ROLE OF THE NATIONAL RESEARCH COUNCIL

When construction of the baseline incineration facility at JACADS began in 1987, the Army requested that the National Research Council (NRC) review and evaluate the Chemical Stockpile Disposal Program (CSDP) in order to provide scientific and technical advice and counsel. The NRC established a standing committee, the Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program (Stockpile Committee), to perform these tasks, beginning with a study of OVT at JACADS. In the intervening years, the Stockpile Committee produced 27 reports on various aspects of the CSDP (see Appendix A).

In January 1999, a working group of the committee was established to study the Army's closure plans and activities for JACADS. This group was briefed on closure activities by the Army and its contractors on several occasions, and it visited JACADS and other facilities under construction. Members of the group also attended meetings of the Army's JACADS closure campaign integrated project team (IPT). Attendees at IPT meetings included representatives of the office of the Army's Program Manager for Chemical Demilitarization (PMCD); Washington Demilitarization Company (WDC)[2] (formerly Raytheon Demilitarization Company, the Army's prime contractor for JACADS); U.S. Army Pacific (USARPAC); U.S. Army Chemical Activity–Pacific (USACAP); U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM); the Environmental Protection Agency (EPA) Region IX (San Francisco); the Defense Threat Reduction Agency (DTRA); the U.S. Air Force; and the Fish and Wildlife Service (FWS). The role of the IPT is to facilitate communication between and among all interested parties to bring into existence overall policies and procedures for achieving the acceptable closure of the JACADS facility.

During initial information-gathering activities by the committee and the working group, certain overarching issues concerning the closure of the facility became apparent. In a letter report delivered May 4, 2000, to the Deputy Assistant Secretary of the Army for Chemical Demilitarization, the Stockpile Committee informed the Army of the crucial importance of resolving these issues to advance the closure of JACADS (NRC, 2000a). The letter addressed two major issues: the ultimate stewardship of Johnston Island and the necessity of establishing end-state criteria for cleanup of the site. Chapter 2 reviews the issues addressed in the letter report and their current status.

Composition of the Stockpile Committee

Over the years, the Stockpile Committee has adjusted the composition of its membership to maintain a balance of disciplines necessary to accomplish the tasks at hand. Current members have expertise in analytical chemistry; biochemical engineering; chemical engineering; chemical industry management; chemical technology and manufacturing; civil engineering; combustion technology; environmental engineering; environmental health policy; environmental restoration; facility closure; hazardous waste management; health risk assessment; incineration; industrial hygiene; materials science; mechanical engineering; monitoring and instrumentation; occupational medicine; organic chemistry; physical chemistry; risk assessment, management, and communication; safety, toxicology, urban studies; and waste treatment and minimization.

PURPOSE OF THE REPORT

This report examines the planning, documentation, and planned execution of closure operations through April 2001[3] for JACADS and provides findings and recommendations

[2]Washington Demilitarization Company is a subsidiary of Washington Group International, Inc.; it was formed in a merger of Raytheon and Westinghouse demilitarization operations.

[3]Because practically no physical demolition had occurred through April 2001, the report does not include an assessment of actual closure operations.

for the Army's consideration. No physical closure activities are addressed. Significant issues specific to the closure of JACADS are addressed, and issues important for the closure of other chemical agent disposal facilities in the continental United States are pointed out. Many of these issues have been recognized by the PMCD, and actions have been taken to resolve them. Early recognition and resolution of similar issues and the application of the relevant lessons learned (described in Chapter 6) should help to ensure that closures of the chemical agent disposal facilities at the eight continental U.S. storage sites are conducted safely, efficiently, and economically and that risks to workers, the surrounding communities, and the environment are minimized.

Statement of Task

The following statement of task is the basis for this report:

> The NRC study will accomplish the following:
>
> - Obtain appropriate information and data from the Army and its contractors relative to the planning and preparations for the decontamination, dismantlement, and closure of JACADS.
> - Assess the overall safety and effectiveness of planned closure operations.
> - Examine state-of-the-art closure technology and identify any requirements for specialized technology development.
> - Travel to JACADS to observe the scope and planning of closure operations.
> - Travel to similar facilities currently under construction to observe the construction complexities associated with agent-contaminated areas of JACADS that are not accessible to committee members.
> - Receive input through documents and briefings from the private and public sectors (including international sources) about lessons learned from closures of similarly complex facilities.
> - Review and evaluate aspects of public involvement and interagency governmental issues pertaining to facility closures.
> - Extract lessons learned that will benefit the closure of other chemical agent disposal facilities.
>
> The NRC will provide a report to the sponsor that contains findings and recommendations.

Organization of the Report

The chapters of the report mirror the four primary stages involved in facility closure: (1) assessment and decision making, (2) development of a closure plan, (3) closure operations, and (4) closeout of the facility, which the Army defines to include postclosure activities.[4] Following the Introduction, presented in this chapter, the closure planning process is presented in Chapters 2 and 3. Chapter 2 identifies the initial issues that should be considered during assessment and decision making as they pertain to JACADS. Chapter 3 addresses key elements of the development of the closure plan for JACADS. Chapter 4 addresses the implementation of the plan, and Chapter 5 considers facility closeout issues. Chapter 6 sums up the preplanning process and the lessons learned to date about the closure of JACADS that may be applied to improve the various stages of closure for disposal facilities at other stockpile storage sites. Findings and recommendations are presented in Chapter 7.

[4]The Army's closure objective is to render the JACADS facility clean according to Resource Conservation and Recovery Act (RCRA) criteria and avoid a permit requirement for postclosure care under RCRA (U.S. Army, 2000a).

2

Initial Considerations for Facility Closure

In this chapter, critical management issues that will have to be addressed early in the JACADS closure planning process are discussed:

- ownership and stewardship
- determination of end use (what the property will be used for)
- end-state cleanup criteria (here, end state means the final environmental condition of the property)
- retention of personnel
- exit strategy for post-closure activities

Although these issues are discussed in the context of the JACADS closure process, they are applicable to any facility that is to be permanently closed, whether the property remains with the original owner or is transferred to another. These issues require timely resolution for closure to be completed safely and cost effectively. Early in its closure study, the committee prepared a letter report addressed to the Deputy Assistant Secretary of the Army for Chemical Demilitarization. Delivered on May 4, 2000, the letter expressed the committee's concerns as they relate specifically to JACADS (NRC, 2000a):

- identification of a lead agency and a steward responsibility for the Johnston Atoll[1] during and following closure of the JACADS facility
- identification of the government agency or entity that would assume ownership of Johnston Island following closure of JACADS
- definition of the end use of Johnston Island after closure (e.g., industrial site, residential site, or wildlife refuge)
- establishment of end-state cleanup level standards to be applied based on the end use of the Johnston Atoll

Although not included in the letter report, two other issues of concern to the committee are the retention of key staff personnel throughout the JACADS closure program and the development of an exit strategy. These issues are reviewed in more detail in the following sections.

OWNERSHIP

Two agencies have asserted ownership of Johnston Atoll, which includes Johnston Island. The Air Force was described to the committee as the owner of the island (and the Army as the main tenant). However, the Fish and Wildlife Service (FWS), and perhaps other government agencies, have documents that appear to give them ownership. FWS cited an executive order as its authority to declare the island a wildlife refuge. The FWS contended that the executive order gave it authority to mandate stringent cleanup standards, but not the responsibility to seek appropriations to pay for the cost of meeting those standards (U.S. Army, 1999a). However, EPA must concur with the lead agency having ultimate responsibility for cleanup.

The Army plans to leave Johnston Island following completion of the destruction of the chemical stockpile. To complete the closure of JACADS, the Army must demonstrate to EPA that its portion of the island is acceptable for future use (whatever that use is determined to be). Other parts of Johnston Island will require cleanup by appropriate government agencies to address contamination by non-JACADS wastes. These include plutonium,[2] Agent Orange,

[1]Johnston Atoll consists of Johnston Island and three much smaller nearby islands that function primarily as nesting sites for various seabird species. The entire atoll complex, including Johnston Island, is managed jointly by the U.S. Department of Defense and the Fish and Wildlife Service as a national wildlife refuge.

[2]Plutonium contamination resulted from missile test failures in the 1960s.

dioxins, polychlorinated biphenyls (PCBs), and other potentially hazardous substances. There are no indications that the area of Johnston Island where cleanup is required by the Army contains any of these contaminants. Accordingly, the Army's closure plan is not required to address issues associated with the cleanup of these substances.

In 1998, the Army's Program Manager for Chemical Demilitarization (PMCD) began planning and making preparations to close JACADS by September 2003. In its letter report, the committee noted that because other federal agencies (as noted in the next section) have an interest in how the atoll will be used after the Army and Air Force complete their missions, the end use at Johnston Atoll has not yet been determined. This may prevent the completion of closure as scheduled by the Army for September 2003, which could result in the expenditure of additional fiscal resources on prolonged cleanup operations, surveillance, and maintenance (NRC, 2000a).

DETERMINATION OF END USE

Because the primary steward and ultimate ownership responsibility for Johnston Atoll have not been determined, the Army has not been able to negotiate final cleanup standards for the JACADS facility. The Stockpile Committee's letter report noted that a decision on the end use of Johnston Atoll would require the participation of at least four federal departments (Commerce, Defense, Interior, and Transportation) as well as EPA (NRC, 2000a).

In the Department of Defense, the Department of the Army (the major tenant) and the Department of the Air Force (the current steward) will play lead roles in various aspects of closure. Another defense agency, the Defense Threat Reduction Agency, has been responsible for cleaning up the plutonium on Johnston Island. Although the Air Force is the current steward for the island, it will probably not be the agency ultimately responsible for the overall atoll and therefore is not in a position to make final determinations about end use.

The National Oceanic and Atmospheric Administration (Department of Commerce) is concerned about aquatic life in the lagoon. The U.S. Coast Guard (Department of Transportation), as well as other agencies, may also be interested in the ultimate use of the atoll. If it is designated surplus property, the General Services Administration (GSA) may become involved. The Federal Aviation Administration (Department of Transportation) operates the runway on Johnston Island. The FWS (Department of the Interior) operates the wildlife refuge and may be the final steward of the atoll.

Pending a resolution of the ownership issue, a number of scenarios can be envisioned. For example, if the Air Force is the owner, the island might be turned over to GSA to sell to the highest bidder for industrial, residential, or recreational use. If FWS becomes the ultimate owner, all of Johnston Island would likely become a national wildlife refuge. The cleanup standards, which EPA would establish for each end use scenario, differ in terms of receptors and exposures to inhabitants, which should be defined in an appropriate risk assessment. Receptors are plants, biota, animals, and humans that are exposed to a contaminant of concern. The risk assessment should assess the risks to both human health and ecological receptors, because they may require different end states. PMCD assigned the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) to prepare the Conceptual Site Model (CSM) for JACADS closure and to perform the risk assessment.

The Army initially proposed an industrial end-use scenario as the most reasonable and cost-effective approach for the JACADS site, because other parts of Johnston Island contain hazardous substances such as plutonium and Agent Orange. A draft of the CSM for the JACADS closure risk assessment, submitted to EPA Region IX in December 1999, provided an outline for a risk assessment performed in support of the JACADS closure plan (U.S. Army, 1999b). The CSM was returned to the Army with comments and a request from EPA for the inclusion of an ecological risk scenario that contains a methodology for conducting an ecological risk assessment based on a wildlife-refuge end use (EPA, 2000). At this writing, the Army is developing a work plan for the ecological risk assessment. The assessment will be completed in late 2003.

Also, agreement on an end use for the JACADS site following closure has not been finalized, but it appears that the FWS is considering several options to maintain a presence or conduct periodic visits.[3]

More specifically, current plans call for the Army to place the site under the jurisdiction of the Air Force upon completion of JACADS closure activities. Although it is likely that FWS will ultimately assume stewardship responsibility for Johnston Island, the Army presently plans to provide part-time monitoring staff for a period of 5 years after closure operations have been completed.

END-STATE CLEANUP CRITERIA

The end state, as defined in this report, is the final required condition of a building, facility, or site after cleanup is accomplished. It must be known so that receptors and exposure to inhabitants can be defined in the risk assessment. The end state also must be known and specified for a realistic, cost-effective, and timely closure program to be developed.

EPA will define the cleanup standards for JACADS closure based on the end use proposed by the owner. It will also monitor and enforce the implementation of the approved

[3]Steve Bushman, Group Leader, Post Operations, Technical Management Office (PMCD), conversation with Stockpile Committee Study Director Donald L. Siebenaler, February 19, 2002.

end-state requirements. EPA regulations (40 *CFR* 264.115)[4] require that the facility owner or operator submit a certification when the facility has been cleaned in accordance with specifications in the EPA-approved RCRA permit and closure plan for the site.

RETENTION OF PERSONNEL

Whenever closure of a facility is announced, a major problem is the loss of personnel to outside jobs and uneasiness among the remaining workforce about prospects for future employment. Industry has successfully mitigated this problem by recognizing it early in the planning process, providing appropriate personnel counseling and career planning, and establishing, communicating, and fully implementing incentives for knowledgeable personnel to remain throughout the closure of a facility.

The Army's contractor for JACADS, Washington Group International, Inc., has recognized the need to retain key supervisory personnel and staff for the duration of the closure campaign. These personnel can provide the corporate memory for the physical plant and help to maintain the safe, disciplined work practices that have evolved throughout the operation and maintenance of JACADS. Subsequently, the orderly transfer of experienced personnel from JACADS to other chemical disposal facilities that are already operational or are being built may be a good way to transfer valuable knowledge about JACADS operations, maintenance, and closure to these facilities. Currently, one chemical agent disposal facility in the continental United States is operational and five facilities are under construction or in the systemization phase. Employment at these facilities can provide career advancement opportunities, as well as an improved family and community lifestyle at sites in the continental United States.

The JACADS operations contractor, WDC, submitted and received approval from the Army for a staff retention plan. The implementation of this plan for JACADS personnel retention, transfer, and release will be critical to successful closure.

EXIT STRATEGY

Defining the end point of any remediation treatment or process for the closure of a chemical agent disposal facility (including JACADS) is critical to limiting the extent and cost of closure activities and to keeping all stakeholders (tenants, owners, nearby communities, employees, and the general public) informed of intended activities. Before a new remediation process is started, the Army should negotiate with the regulators the type of tests, samples to be taken, and frequency, and should specify the end of treatment in sufficient detail that the closure activities and remediation processes can be concluded as soon as possible. For example, if air and groundwater sampling is required, the criteria for reducing the frequency of sampling should be defined, as well as the point at which the sampling can be terminated.

[4]CFR citations refer to the U.S. Code of Federal Regulations with the volume number preceding CFR and the section number following. Copies of volumes of the U.S. Code of Federal Regulations are available through Government Printing Office outlets and commercial document and regulatory services.

3

Planning the Closure Operation

The successful closure of JACADS will be a major accomplishment for the CSDP and will provide guidance for the closure of other chemical agent disposal facilities in the continental United States. This chapter examines a number of the technical considerations involved in planning for the closure. Issues related to the execution of a closure plan and postclosure activities are covered in Chapters 4 and 5.

CLOSURE OBJECTIVES

Key objectives for the closure of a chemical agent disposal facility can be found in Chapter 4 of the *Guide to Closure Planning* (U.S. Army, 1999c):

- protect workers and the public
- protect the environment
- meet applicable regulatory requirements
- meet cost and schedule goals

Table C-1 in Appendix C lists likely activities during planning and implementation phases for closure of an industrial facility. Not all of the activities listed will necessarily apply in every closure situation. The following activities are most important for the successful closure of a hazardous waste site:

- defining the end state of the site to be achieved following closure activities
- developing a conceptual site model (CSM) that identifies all potential receptors, contaminants, pathways, impacts of exposure to contaminants (if any), the risks to be mitigated, and the means of mitigation
- submitting the CSM for review by the appropriate stakeholders very early in the closure planning process
- obtaining regulatory approval of the CSM and the likely mitigation measures early in the planning process, so that ample time is available to react to comments and make the changes required
- ensuring the safety of workers and the public
- protecting the environment

If the final end state is not known at the time the closure plan is first prepared, the Army should develop preliminary plans and costs for various reasonable scenarios. This information could also serve as a very useful negotiating tool with EPA.

The JACADS closure activities will involve the dismantling and destruction of that portion of the facility that cannot be decontaminated to meet the 5R[1] cleanliness standard. An area decommissioning matrix delineates the areas that will be decontaminated and dismantled, decontaminated and abandoned in place, or solely abandoned in place (U.S. Army, 2000c). The remaining systems, structures, and components (SSCs) that are left in place must meet the Resource Conservation and Recovery Act (RCRA) criteria for decontamination as well as the Army standard of 5R. Areas that were kept free of any agent or hazardous materials will be sampled to demonstrate their cleanliness in accordance with the final closure sampling and analysis plan.

For JACADS and the stockpile storage area (Red Hat Storage Area), the Army has defined the following closure objectives (U.S. Army, 2000a):

- safe removal and destruction of agent- and/or explosive-contaminated systems, structures, and components
- protection of workers, the public, and the environment
- compliance with the EPA-issued RCRA permit, as modified

[1] See definition of 5R in the acronyms list, page *xviii*.

- completion of the closure process within the approved schedule and budget

CLOSURE ALTERNATIVES

The JACADS processing area and Red Hat Storage Area are being decontaminated, dismantled, and closed following the completion of processing of all agent material and energetics (November 2000). These closure activities are being performed in accordance with the *JACADS Closure Campaign Facility Closure Plan* and the *JACADS Closure Campaign Decommissioning Plan* (collectively referred to as the JACADS closure campaign documents), which incorporate the requirements of applicable RCRA permits (U.S. Army, 2000a, 2000c, 2000d). Because the Army's objective at JACADS is to reduce cost by pursuing prompt dismantlement, no other closure mode alternatives (e.g., entombment) were studied. Furthermore, the closure plan does not discuss other issues such as spill control, dust control, erosion control, or control of special materials such as asbestos. Countermeasures have been considered should these occur, but they are not detailed in the plan. Suppression, control, and sampling of dust during scabbling operations are not covered in the plan that the committee reviewed.

RISK ASSESSMENT

Modern risk assessment techniques can offer a powerful framework for assembling and presenting critical information for decision makers and thereby become the cornerstone of an effective risk management program. Such a risk management program would address programmatic as well as worker risk issues. Programmatic issues would include cost, schedule, and technology risks arising from, for example, uncertainties in end use, the choice of regulatory requirements, or the evolution of those requirements.

Such a risk management framework should be in place prior to the initiation of closure activities and should be a dynamic process. The constituent risk models should be updated as new information becomes available and should be responsive to changing and emerging hazards.

Delays were encountered in closure risk assessment for JACADS because the Army's first CSM, prepared by USACHPPM and submitted to EPA Region IX in December 1999, provided only a human health risk assessment based on industrial end use for JACADS (EPA, 2000; U.S. Army, 2000e). Neither the Air Force (the present Johnston Island owner) nor the FWS (the anticipated owner) was asked to review the CSM before it was submitted to EPA. After subsequent meetings with all stakeholders, a CSM that included both ecological and human health risk assessment methodologies was submitted to EPA in July 2000 as part of RCRA permit modification C3-050 (U.S. Army, 2000e).

The CSM for JACADS specifies the Army's proposed facility end use, agent contamination levels expected after closure, associated solid waste management units (SWMUs), and areas of interest (AOIs).[2] When it is approved by the EPA, it will provide a basis for determining cleanup requirements that must be met to close JACADS and satisfy the conditions of the RCRA permits.

ACQUISITION STRATEGY

Background

The procurement process at JACADS is subject to the federal acquisition regulations with which the site contractor, WDC, must comply. The WDC contract with the Army is cost-reimbursable, with provisions for an award fee. Prior to the closure stage, the award fee was based on production (disposal of agent and munitions). WDC anticipates that the award fee for the closure stage may be based on meeting the schedule.[3] However, some contracts today in general industry practice also require safety performance and off-site impacts as part of the fee structure. Heavily weighting superior contractor safety and environmental performance is an applicable consideration for award and incentive fees in contracts for closures of chemical agent disposal facilities.

The present contract calls for reimbursement of all allowable expenses, excluding contractor costs disallowed by the federal acquisition regulations, such as business development costs. A small base fee was negotiated as profit. The disallowed expenses must be covered by the base fee. The contractor receives a base fee during execution of the contract, and only in the most unusual circumstances is any part of this fee denied. An additional 3 percent of the contract value is set aside as an incentive fee that can be earned by superior performance. The federal acquisition regulations that govern procurement and acquisition procedures undertaken with federal funds are applicable to both materiel and contract services for closure of JACADS.[4]

Closure Acquisition

Because the scope of work for JACADS closure is too uncertain to permit fixed-price competition, contracts for services under a cost-reimbursable contract with an award fee will be used (Bushman, 2000). The entire process of chemical demilitarization has been a novel experience, both for the Army and its contractors. Consequently, a fixed-price contract for the first closure of a disposal facility was not practical. Fixed-price contracting for JACADS closure

[2]The term "areas of interest" refers to areas that are believed to be of regulatory concern and of interest to regulators because of possible contamination.

[3]Leo O'Shea, JACADS Closure Phase Project Manager, conversation with Stockpile Committee members Charles I. McGinnis and W. Leigh Short on May 24, 2000.

[4]See preceding footnote.

would have involved so many contingencies that the price would probably have been unnecessarily high, even had contractors been willing to bid. This situation prevailed for the pilot phase of each aspect of the CSDP to date; it will likely continue through JACADS closure.

The contractors operating demilitarization facilities have proven themselves capable and responsive. However, if it becomes necessary to change contractors for closure operations, the change should begin as early as possible to facilitate a smooth transition. The new contractors should have comparable safety knowledge and injury-management expertise. One indicator of such expertise is the "experience modification rate" at facilities they operate—that is, the worker's compensation insurance premium adjustment, which reflects the contractor's safety experience. For the closure of JACADS, the Program Manager for Chemical Demilitarization (PMCD) decided to continue the existing cost-plus-award-fee contract with WDC for the following reasons:[5]

- satisfaction with the operations contractors
- the unique nature of closure activities for agent-contaminated facilities
- the probability that there will be concurrent disposal of agent-contaminated materials and closure activities
- time and cost constraints inherent in closure planning
- the time and effort required to obtain authorization for cost-plus-fixed-fee contracting

Considering the remote location of JACADS, the problems involved in coordinating multiple contractors on the island, and the time and cost penalties inherent in educating another contractor, continuation of the operating contract (with appropriate changes to accommodate closure) appears to be justified. With the benefit of the lessons learned at JACADS, the use of another operations contractor to perform site closure at continental U.S. sites should be considered. The best strategy to employ will depend on site-specific considerations.

The acquisition strategy for JACADS closure will be implemented and controlled by issuing engineering change proposals (ECPs) and work orders (U.S. Army, 2000c). The ECP process has been used throughout disposal operations and is well established. However, some changes can be expected. Previously, individual ECPs were converted to contract changes, which the Operations Support Command (OSC) at Rock Island, Illinois negotiated with the contractor.[6] For closure, several ECPs can be aggregated under a single master ECP, and a single contract modification negotiated.[7] This consolidated process involves a sequence of steps—scope identification, coordination of potentially affected operating elements, safety and environmental reviews, and definition of mechanical and electrical boundaries. Material and cost estimates must also be prepared before contract modifications are negotiated (U.S. Army, 1999d). The processing of ECPs for closure should be carefully documented and lessons learned identified to assist other sites.

The JACADS Closure Campaign Decommissioning Plan of October 2000 contains a closure interim cost estimate report that was developed to assist in planning the overall detailed cost estimate submitted for each of the remaining out-years of the closure campaign. The estimate covered the work from January 2001 to September 2003 and consisted of labor, materials, waste treatment and disposal, and travel costs, as well as overhead, general and administrative, and escalation costs. However, there was no information on the costs of ECPs and work orders, which are determined as those documents are prepared. Thus, total project cost cannot be estimated with confidence until the final ECPs have been processed and negotiated (U.S. Army, 2000d). A disadvantage of this system is that there is little incentive to contain costs. The ECP process does not include competitive pressures or pose a serious risk to the contractor's base fee for failure to contain costs. Contract provisions pertaining to other sites will be different to varying degrees.[8]

Project cost control procedures and contract incentives should be included in every CDP contract as a proven means of reducing and controlling costs. Industry practices have shown that better project performance is achieved when incentives are positive and when they flow down, that is, when they are shared by the prime contractor with subcontractors, suppliers, and in appropriate cases, individual managers and craftsmen (CII, 1992).

Closure Materiel Procurement

Although the Army anticipates procuring equipment, systems, and tools that are unique to closure operations, closure planning documents made available to the committee addressed this issue in a cursory way (U.S. Army, 2000c). Section 3.3 of the decommissioning plan simply states a requirement for vendor contracts and engineering guidance. WDC said, however, that it has a very extensive and sophisticated company procurement manual (O'Shea, 2000). Because of the importance of materiel procurement, the Army should insist on full disclosure of the contractor process, and all interested parties must understand and

[5]Jerry Linn, PMCD Closure Manager for TOCDF, conversation with Stockpile Committee members Charles I. McGinnis and W. Leigh Short on May 24, 2000.

[6]OSC handles procurement for PMCD, but PMCD exercises limited delegated authority through a contracting officer representative.

[7]Tim Baker, PMCD Operations Associate Project Manager JACADS, conversation with Stockpile Committee members Charles I. McGinnis and W. Leigh Short on May 24, 2000.

[8]See preceding footnote.

adhere to the process established in the procurement manual and required by the federal acquisition regulations.

Chemical Demilitarization Procurement Process

As a consequence of OSC's responsibility for contract negotiations, PMCD's authority in the procurement process is diluted. Moreover, having OSC as a participant in the procurement process adds to the time needed for processing routine matters.

CATEGORIES OF CONTAMINATION

JACADS area and equipment contamination lists are provided in "System and Area Closure Report," which is Annex 1-A of the draft *JACADS Closure Campaign Planning Documents*, Volume 1 (U.S. Army, 2000c). Annex 1-A lists all equipment, components, and bulk material actually contaminated with agent and/or explosive or that could become exposed to chemical agent liquid or vapor. Hazard categories A, A/B, B, C, D, and E (see Table 3-1) are assigned to areas on the first and second floors of the munitions demilitarization building (MDB) and to the equipment installed there. These hazard categories are described in Annex 2-D of Appendix 2 in the *JACADS Closure Campaign Decommissioning Plan* (U.S. Army, 2000d). The potential for contamination is primarily based on the operational history of the area in which the equipment is located (U.S. Army, 2000a). For example, all equipment in hazard categories A and B is assumed to be contaminated. The Army has not reported any characterization results of measured agent contamination levels of equipment and surface areas.

Permitting Considerations

During the development of the closure plan, changes were identified that necessitated a change to the JACADS RCRA permit. Table 3-2 lists six permit modifications submitted by the Army to EPA to support closure.

These permit modifications were submitted to EPA from April 2000 through July 2000. Currently, two permit modifications are partially approved and awaiting final EPA approval. The remaining four permit modifications have been approved. Permit modifications need to be identified with sufficient lead time to allow EPA regulatory review, public comment, and the resolution of any EPA and/or public comments. Delays in the approval of permit modifications can delay the completion of closure. If the Army elects to implement an ECP prior to EPA approval, it does so at its own financial and/or schedule risk. Potential delays and

TABLE 3-1 Hazard Categories for JACADS Process Areas

Hazard Category	Comment
A	Has greatest probability of agent contamination, both liquid and vapor.
A/B	Are Category A when processing leaking munitions but Category B at all other times.
B	May be vapor contaminated, but liquid contamination is unlikely.
C	Not expected to be to be contaminated, but low levels of vapor are possible under unusual upset conditions by virtue of their location next to Category A and B areas.
D	Are never expected to be agent contaminated.
E	Are supplied with filtered, positive-pressure air.

SOURCE: Adapted from U.S. Army, 2000d.

TABLE 3-2 Permit Modifications Submitted for JACADS Closure

Permit Modification Number	Focus	Date Submitted to EPA	Status
C3-051	Use of a carbon micronization system	July 2000	Partially approved for installation only
C2-052	Multiagent monitoring	July 2000	Approved
C2-022	Performance of halogenated-plastics trial burn	April 2000	Approved
C3-034	Increase of MPF*a* rates	April 2000	Approved
C2-035	Addition of allowable waste streams	April 2000	Approved
C3-050	JACADS closure (sampling protocols, etc.)	July 2000	Partially approved

*a*MPF, metal parts furnace.
SOURCE: O'Shea, 2001.

additional cost could have been minimized if the initial RCRA permit for JACADS submitted to EPA had included the requirements for closure operations.

The closure of JACADS and the Red Hat Area will be conducted under the existing RCRA permit (I.D. No. TTO-570-090-001) for operating the facility, modified as necessary to reflect the closure activities. The *JACADS Closure Campaign Facility Closure Plan*, which is the closure plan as of July 2000, includes a permitting plan and a corrective measures study (U.S. Army, 2000a). The corrective measures study provides details for the closure of areas that are not permitted hazardous waste management units (HWMUs). These areas will be remediated according to the requirements for a corrective action program under the JACADS permit module VIII. The corrective measures study includes a RCRA facility assessment and the RCRA facility investigation sampling and analysis work plan required for approval of the permit modifications submitted to the EPA in July 2000. However, EPA has only partially approved two of these permit modifications, and the areas had not been sampled. The closure criteria list chemicals of concern (COCs) and the contaminant concentration levels that must be met by closure activities. Defining final concentration levels (end-state requirements) will require that the end use of the island be specified. The end use will determine what standards will be applied during (1) the removal of the JACADS operating equipment used to destroy chemical agents and their containers and (2) the cleanup of equipment areas and areas such as storage facilities and soil surrounding the operating equipment. Each new or additional set of standards can lead to additional permit changes as well as increased costs and schedule delays.

The Army's current draft documentation on JACADS closure planning includes the expected modifications to the RCRA permit, but not all of these have been approved by the EPA (U.S. Army, 2000a, 2000c, 2000d). Until appropriate cleanup levels, and the means of quantifying them, have been agreed on between the Army and EPA, the permit modifications cannot be issued, which could seriously delay the closure and increase the costs. Cleanup levels for all contaminants except PCBs are determined under RCRA. Cleanup levels for PCBs are determined under the Toxic Substances Control Act and the issued MegaRule,[9] administered by an EPA office different from the one handling the RCRA permit. Therefore, some intra-agency coordination within EPA will be involved.

A complicating factor is that the Army is responsible for the closure of its portion of the island, while the Air Force and DTRA are responsible for the remainder. Some areas are adjacent to each other.

[9]MegaRule per PCB Disposal Amendments to 40 *CFR* Part 761 (June 29, 1998; 63 FR 35384).

The October 2000 JACADS closure planning documentation fails to discuss fully items such as the following (U.S. Army, 2000a, 2000c, 2000d):

- sampling protocols for areas to be cleaned
- sampling procedures
- location of soil that must be removed
- sampling for leakage into the ocean
- a work plan that incorporates permit requirements (as modified), including provisions for an on-site analytical laboratory (specifically for closure), signature authority for manifests, and training requirements for contractor personnel

The potential volume of soil to be removed and its eventual disposition will be determined from analytical findings during investigations conducted in accordance with the JACADS RCRA permit (U.S. Army, 2000a). These investigations will include soils in the vicinity of or underlying the tank systems, incinerators, miscellaneous treatment units, and container storage units, with testing for contamination. Removal and ultimate disposal of the soil will be based on applicable exposure limits in accordance with permit stipulations. The ultimate disposition of the contaminated soil will be resolved by a negotiated agreement with EPA and, in the case of off-site disposal, with the receiving treatment, storage, and disposal facility.

The Stockpile Committee believes that JACADS has had adequate standard operating procedures to cover operations and maintenance and that management personnel have done a good job of reviewing the procedures to determine those that require change to incorporate closure activities. In addition, the "Procedures Update Manual" in Volume 3 of the June 1999 *Decommissioning Plan* calls out several existing procedures that need to be revised in order to fully reflect closure activities (U.S. Army, 1999d). These include the "Workforce Training Plan," an "Operations Personnel Certification," and related procedures.

With regard to training, Volume 2 of the October 2000 Decommissioning Plan has a closure staffing plan for the Training Department that assigned 13 people in FY 2000 and drops to 3 people in calendar year 2002 (U.S. Army, 2000c). The key to a successful closure will be the degree to which everyone complies with the procedures.

Six permit modifications required to support closure were submitted to EPA by the Army. The permitting plan, Appendix 1 of the *JACADS Closure Campaign Facility Closure Plan*, shows that three were submitted in April 2000 (C-2-022, C3-034, and C2-035) (U.S. Army, 2000a). These modifications address the processing of materials, mostly secondary waste (see Table 3-2).

A second group of three permit modifications which address closure tasks and sequencing was submitted in July 2000 (C3-050, C3-051, C2-52) (U.S. Army, 2000a). These modifications include use of a CMS, multiagent monitoring requirement, sampling protocols, and conceptual site models and assessment methodology for human and ecological risk based closure.

The goal of the cleanup for Army facilities on Johnston Island is to achieve for each contaminant of concern a concentration less than a value established for that contaminant in a standard. Two sets of standards are under consideration: the industrial standard and the residential standard, each established for the end use implied by the name. As might be expected, the industrial standard is less strict than the residential standard, and the concentration will generally be higher for the industrial standard. Because cleaning to the residential standard typically costs more than cleaning to the industrial standard, there is strong interest in the choice that will be made.

At a meeting with representatives of the Stockpile Committee on May 24, 2000, PMCD officials reiterated that cleanup to the industrial standard was the only logical option for *all* future uses of Johnston Island because of the other hazardous materials (plutonium, Agent Orange, etc.) that would remain on the island.[10] It was not known whether these contaminants would be cleaned up to the residential standard, as WDC noted a great many unknowns associated with a residential standard, among them the possibility that measuring contaminants to a lower concentration than called for by the industrial standard might require new technology.

At that time, May 2000, the Army noted that all of the EPA regions with oversight of closure of stockpile disposal facilities appeared to be pushing for residential standards.[11] The decision on which standard would be used at JACADS would probably be considered a precedent for subsequent closures of facilities in the continental United States. If a residential standard was to be set for JACADS, the Army believed that none of the other sites would be allowed to adopt a lesser standard. An environmental working group with participants from EPA, state regulatory agencies, and representatives of public interest groups was established in February 1999 to ensure that JACADS would not be treated as a separate entity for regulatory purposes because of its unique legal and geographical circumstances (Bushman, 1999).

Considering uncertainty regarding end use, the Army finally decided in April 2000 in its closure process at JACADS to screen at a residential standard, even though it believes that it will ultimately not have to clean its entire portion of the atoll to these criteria.[12] Screening in this context means comparing the analytical results with a standard for each contaminant, if available. The Army is not yet cleaning up to any standard except 3X or 5X.[13]

WDC believes that its closure schedule is achievable *unless* EPA's review and approval of any new submitted permit modifications are delayed or denied. For example, if the modification requesting an increased feed rate for secondary waste to the metal parts furnace had been denied, the time required for incinerator processing of primary and secondary wastes would have increased.

In summarizing the permit situation, the committee made the following observations:

- The schedule is intact for now, although the ability to maintain the schedule in the event of unforeseen delays will become constrained as the planned closure date approaches.
- Activities requiring multiagent monitoring could become a problem.
- Cost and schedule risks will typically increase if a residential standard is chosen.
- To the maximum extent practical at CSDP disposal sites, secondary wastes should be identified in the initial RCRA permit so disposal can be done continuously and concurrently with operations.
- The most significant unresolved issues may be the cleanup standards and the analytical methods for measuring agent and agent breakdown products in concrete and soil.

PREPARATION OF DETAILED ENGINEERING REQUIREMENTS

WDC has prepared documentation contained in three large three-ring binders. Collectively known as the JACADS closure campaign documents, this documentation has two main components, the *JACADS Closure Campaign Decommissioning Plan* (two volumes) and the *JACADS Closure Campaign Facility Closure Plan* (U.S. Army, 2000a, 2000c, 2000d). The *Decommissioning Plan* includes several appendixes with detailed information on the following: system and area closure and decontamination; waste disposal; and decontamination cost estimates. Appendixes to the *Facility Closure Plan* cover the following areas: permitting plan; sampling and analysis plan; corrective measures study; final release criteria; and closure schedule.

SAMPLING AND ANALYSIS PLANS

In conducting sampling for preclosure activities (such as the RCRA facility investigation (RFI)) and for closure activities, the Army must either follow accepted published

[10]Bill Stayer, PMCD Environmental Engineer, conversation with Stockpile Committee members Charles I. McGinnis and W. Leigh Short on May 24, 2000.

[11]Leo O'Shea, JACADS Closure Phase Project Manager, and Tim Baker, PMCD Operations Assistant Project Manager JACADS, conversation with Stockpile Committee members Charles I. McGinnis and W. Leigh Short on May 24, 2000.

[12]Leo O'Shea, JACADS Closure Phase Project Manager, conversation with Stockpile Committee Study Director Donald L. Siebenaler, January 14, 2002.

[13]See definitions of 3X and 5X in the acronyms list, page *xviii*.

protocols or obtain regulatory approval for proposed protocols (e.g., for the analysis of agent in concrete). Examples of existing protocols for other materials include documents for Superfund guidance, RCRA guidance, and PCB sampling guidance. The Army should ensure that sample holding times, replicate requirements,[14] and preservation methods provided in existing EPA-approved protocols or new protocols are met for all samples, and that careful photographic and/or written records are kept identifying the sample, its source, the date, and so on.

The *Facility Closure Plan* includes two sampling and analysis plans. The first, "Sampling and Analysis Plan for HWMU Closure" (Appendix 2 in the *Plan*), includes requirements and procedures for conducting field sampling operations and investigations of soils and structures associated with the MDB and the HWMUs, as well as data quality objectives and field sampling protocols that could be used to verify decontamination (U.S. Army, 2000a).

The second, "RCRA Facility Investigation Sampling and Analysis Work Plan" (Appendix 3, Annex 3-B), describes sampling plans to show whether closure conditions specified in the JACADS RCRA permit are met in the operational areas, SWMUs, and AOIs (U.S. Army, 2000a). Samples to be collected and analyzed include concrete, soils, sediment, and sludge. Samples will be obtained and analyzed concurrently with HWMU closure sampling. An integrated sampling and analysis plan prepared by a field sampling subcontractor will be used during the sampling operations.

JACADS Operational and Storage Areas

For purposes of sampling, analysis, and cleanup, the parts of Johnston Island that were involved in agent and munitions storage and disposal have been divided into six operational areas (U.S. Army 2000a): JACADS, the Red Hat Storage Area (RHSA), the Southwest Area, Scientific Row, the Wharf Area, and Hama Point (see Appendix D, Plate D-1). In addition, six other small sites outside these areas will require remediation or cleanup. Plates D-2 through D-6 in Appendix D show the location of hazardous waste management units within the Red Hat Storage Area; sampling strata G, H, I, J, K, L, and M—areas outside the munitions demilitarization building; and Red Hat buildings 850, 851, and 852.

In all, 65 SWMUs and 52 AOIs are known to contain or be suspected of containing chemicals of concern, including volatile organic compounds, semivolatile organic compounds, PCBs, metals, chemical warfare agents (CWAs), agent degradation products (ADPs), and explosives. Five of the compounds listed in the RFI Sampling and Analysis Work Plan are ADPs (see Table 3-3).

TABLE 3-3 Agent Degradation Products Listed in the RCRA Facility Investigation Sampling and Analysis Work Plan

ADP Abbreviation	Chemical Name	Agent Source
TDG	Thiodiglycol	HD
IMPA	Isopropyl methylphosphonic acid	GB
MPA	Methylphosphonic acid	GB or VX
EMPA	Ethyl methylphosphonic acid	VX
DESH	2-diisopropylaminoethanethiol	VX
EA-2192	S-(diisopropylaminoethyl)methyl-phosphonothioate	VX

NOTE: Contained in Appendix 3, Annex 3-B of the *Facility Closure Plan*.
SOURCE: U.S. Army, 2000a.

The situation is even more complex. Weapons-grade agents may contain stabilizers, starting materials, or byproducts of their manufacture, as well as products formed by reactions between these compounds and the agents during storage. In HD alone, 42 degradation products and impurities have been reported (Munro et al., 1999). The Sampling and Analysis Work Plan of the *Facility Closure Plan* that is the source of the information in Table 3-3 lists analytical methods to be used for five of the listed ADPs, but no method is listed for EA-2192, an HD degradation product. The work plan also indicates that methods are to be determined for HD, GB, and VX. Moreover, EPA, states with regulatory authority, and treatment, storage, and disposal facilities (TSDFs) that will treat wastes off-site do not recognize the 1X, 3X, 5X, and 5R measures of decontamination currently used by the Army. Under existing regulations, JACADS and other sites, as they commence closure, will have to meet not only the Army standards, but also the EPA and state-mandated RCRA standards. Through permit modifications, EPA has allowed 5X metal to be shipped off Johnston Island and sold as scrap metal.

Most contaminated carbon will not be analyzed for agent but will be fed through a carbon micronization system[15] and furnace for disposal. However, inevitably, some carbon will be left at the end (e.g., the carbon in the filtration system for the plant ventilation air while the contaminated carbon is being burned). The residual carbon will have to be shipped off the island for disposal, somewhere in the continental United States. Although concentrations of agent on the contaminated carbon are expected to be low, analysis will be required by the receiving disposal facility.

[14]The term "replicate requirements" refers to the number of analytical samples required to provide statistically significant results with the required degree of precision.

[15]The carbon micronization system (CMS) is used for the disposal of agent-contaminated, activated charcoal that was used as an agent filtration medium in the pollution abatement system of the plant cascade ventilation system. CMS is a system that grinds the solid carbon granules into micronized particles so that the carbon can be thermally treated in its furnace.

DECONTAMINATION

Decontamination Technologies

Decontamination techniques and processes, involving chemical, mechanical, and thermal methods, have been developed for the removal of hazardous materials from systems, structures, and components (SSCs), to soil and water. The primary objectives of decontamination are to reduce exposure, reduce the potential release of hazardous materials to clean areas, and enable decontaminated equipment and materials to be salvaged and reused. For JACADS closure, a key objective will be to meet the end-state criteria for the land and the SSCs that are left in place.

The *Decommissioning Plan* provides the engineering and operational details for closure activities (U.S. Army, 2000c, 2000d). The *Plan's* Appendix 2, Annex 2-A, the Decontamination Report, describes potential decontamination methods for SSCs and concrete and the process used for the identification, evaluation, and selection of several decontamination and decommissioning technologies (U.S. Army, 2000d). A search was conducted relating to recent industrial experience with the closure of facilities containing hazardous materials, particularly chemical agents. A plethora of decontamination technologies was identified through this search that included both existing and emerging and innovative technologies. These were summarized in a lengthy table (Table 2-A.1) in the *Decommissioning Plan* (U.S. Army, 2000d).

SSCs that will require decontamination include the tank systems for the collection and storage of agent; spent decontamination and brine solutions; trench and sump liners; heating, ventilation, and air conditioning (HVAC) systems; laboratory support buildings; incinerators, furnaces, and contaminated areas of the Munitions Demilitarization Building (MDB); and pollution abatement systems. The Decontamination Report identifies and evaluates current and innovative decontamination and treatment technologies. The technology evaluation criteria (consistent with RCRA guidance) include the following:

- effectiveness of the method for a specific application
- past reliability in terms of operation and maintenance requirements
- capital costs and operations and maintenance costs
- feasibility of implementation with respect to energy requirements, permit modifications, system modifications, secondary wastes produced, and risks to personnel and the environment
- quantity of secondary wastes produced and their disposal costs

WDC (formerly Raytheon) evaluated many technologies obtained from the literature, the Internet, and equipment vendors. Based on these evaluations, the primary decontamination technologies proposed for JACADS closure were existing technologies that had been successfully used either at other government sites or in industrial applications. The Stockpile Committee agrees that existing technologies appear appropriate and that there does not appear to be any requirement for specialized technology for this application. However, one area in need of further development (discussed in Chapter 4) involves the employment of modern techniques for agent detection and analysis in various media.

The Decontamination Report provides an overall strategy for removing hazardous materials from the MDB, SWMUs, and AOIs. A contamination investigation (RFI), yet to be completed, will provide the detailed characterization data to support closure activities. The characterizations will be based in part on analysis of concrete core borings taken from selected locations.

Adjacent Sources of Contamination

Although the Army is responsible for closure of only the JACADS area of Johnston Island, a closure plan that integrates Air Force and Army closure activities would provide opportunities for cost savings. It might, for example, allow eliminating cross-contamination and reducing disposal costs.

Concrete

The MDB is a two-story, steel-framed building with thick, reinforced-concrete floors and most interior walls made of concrete and foam-core sandwich panels. Explosion containment rooms have 2-foot-thick reinforced concrete floors, walls, and ceilings. Because concrete is a porous material capable of absorbing agent, all concrete surfaces in the JACADS process areas were sealed with an epoxy coating. A total of 134,153 square feet of concrete will require decontamination (U.S. Army, 1999d).

The Decontamination Report assumed that application of a decontamination solution to concrete will not be sufficient for personnel to have unrestricted access to agent-contaminated areas, and that removal of the epoxy coating and some surface concrete will be necessary. Numerous surface cleaning/removal technologies were identified using literature and vendor information, including hydroblasting, carbon dioxide blasting, shot blasting, and scabbling.[16] Scabbling was selected on the basis of its documented industrial performance and proven cost-effectiveness. It has also been used successfully by the Department of Energy and commercial nuclear facilities to decontaminate concrete areas exposed to radiation (DOE, 1994). The Decontamination Report states that it would take 160 days to thermally

[16]Scabbling is a scarification process used to remove concrete surfaces. Scabblers utilize several piston heads, which contain tungsten carbide cutters to cut or chip away concrete surfaces.

decontaminate the total volume of concrete with potential surface contamination to a depth of 0.25 inch by processing it through the MPF (U.S. Army, 2000d).

The technical basis for selecting a nominal 0.25-inch scabbling depth is documented in the *Environmental Closure Plan Outline and Regulatory Review for USACAP Operations Johnston Island, Johnson Atoll* (CH2MHILL, 1998). A 0.25-inch depth is also consistent with the requirements of U.S. law (40 *CFR* 268.45(a)(1) Table 1, "Alternative Treatment Standards for Hazardous Debris") and with previous experience in decontaminating radioactive concrete structures. Although 0.25-inch scabbling may be adequate to decontaminate most concrete surfaces in the MDB, agent may have penetrated much further in some places (e.g., along cracks and reinforcing bars and in joints between the floor and walls). A procedure for verifying the absence of agent in hard-to-reach locations has not been established. If agent has seeped into these places, additional concrete will have to be removed.

The JACADS closure schedule is based on removing 0.25 inch of concrete from agent-contaminated surfaces and an MPF utilization rate of 60 percent, or 345 lb/hr. This is based on a permitted burn rate of 575 lb/hr (feed rate of one munitions tray containing 700 lb of material every 73 minutes) (U.S. Army, 2000d). The thick epoxy coating could limit the scabbling rate and affect the closure schedule unless at least 345 lb/hr can be removed. As the furnace can operate at a higher feed rate, there is some built-in contingency. Beyond that, the completion date will slip.

The schedule could also be compromised by the need to decontaminate places in the concrete where agent has penetrated much more than 0.25 inch. Core borings of floors and walls in the MDB might be expected to show how far agent has penetrated into the concrete. However, borings of this type are usually done with diamond-tipped core bits, often with water cooling the cutting edge. The heat and moisture involved in this operation could substantially change the chemical composition of the sample and might vaporize or chemically alter any agent that was present before the sample was taken; as a result, the analytical results for agent values might underreport the amount of agent actually present in the concrete.

SCHEDULE AND COST ESTIMATES

Closure operations at JACADS began approximately in January 2001 and are estimated by the Army and WDC to be completed in October 2003, a total of 33 months[17] (Bushman, 2001). The closure criteria given in the *Facility Closure Plan* states as follows (U.S. Army, 2000a):

> Closure of JACADS will be accomplished by demonstrating the absence of identified regulated substances or waste-related compounds:
>
> 1. On surfaces within the facility and waste storage areas;
> 2. On surfaces and the subsurfaces surrounding the facility and waste storage areas;
> 3. On subsurfaces directly beneath the facility, and waste storage areas where necessary;
> 4. On or within any other area or structure deemed to be included in the JACADS Closure Campaign (JCC) through the RCRA Facility Assessment (RFA) or other means.

At the time the schedule was developed, there were significant uncertainties, the most important of which was EPA's failure to agree on the end state for the site in the absence of a decision on end use. The Army and WDC assumed that industrial standards would apply rather than more stringent residential standards. However, this issue has not been settled. Moreover, EPA agreement will be required for RCRA permit modifications C3-050 and C3-051 and any new ones. Failure to obtain approval for any of these modifications will further prolong the closure schedule. The main impetus for completing closure as quickly as possible is the high cost of continued operations (it reportedly costs $331,500 per day for JACADS with a full complement of personnel) (Bushman, 2000).

The initial cost estimate in early 1999 for the JACADS closure program was $70 million to $80 million.[18] This estimate was labeled a rough, order-of-magnitude estimate that, because it did not include certain noncontractor charges, was rather optimistic. Another estimate given to the committee in September 1999 was $150 million (Bushman, 1999). The most current estimate is between $200 million and $400 million.[19] Final cost estimates for each permit modification can be made only after EPA approval.

The estimate of $200 million to $400 million is based on the assumption that EPA will require only the industrial cleanup standard. If, however, EPA chooses the residential standard, it is estimated that there will be a substantial increase in cost and considerable uncertainty owing to the unknown difficulty of the more rigorous cleaning and the timing of the switch in standards. The timing of a possible switch in standards, particularly if it occurs after completion of the present cleanup, would give rise to an avoidable cost and therefore merits consideration.

[17]Gary N. McCloskey, JACADS Site Project Manager, conversation with Stockpile Committee member Charles I. McGinnis on February 24, 2000.

[18]See footnote 3.

[19]See footnote 3.

DEVELOPMENT AND IMPLEMENTATION OF A SAFETY PROGRAM

A key element of the mission of the CSDP is to eliminate *safely* the aging U.S. stockpile of chemical agents and munitions. The Army has in place safety and occupational and environmental health programs at chemical agent disposal facilities that have been visited by the Stockpile Committee (NRC, 2001). The committee found these programs to be comprehensive, professional, and adequate to meet the occupational health and safety needs of the CSDP workers as well as to protect the public and the environment (NRC, 2001).

As part of its risk management program (RMP), PMCD has issued requirements that apply to both the operation and the closure of the disposal facilities. The risk management requirements published in *Chemical Agent Disposal Facility Risk Management Program Requirements* (U.S. Army, 1996) include a safety program (PMCD R 385-1), which specifies policies, responsibilities, and procedures to protect workers, the public, and the environment and to avoid the accidental loss of property; a system safety management plan (PMCD R 385-2), which describes a framework for the implementation of a formal safety program; and an incident and accident reporting, investigating, and records component (PMCD-385-3), which provides mechanisms for reporting and analyzing incidents and accidents. Combined with the facility's policies and practices, the RMP requirements are intended to create an effective safety culture, which must be an integral part of closure planning. The RMP is carried out by the management and operations contractors and their subcontractors, but the Army is ultimately accountable.

The safety and industrial hygiene requirements for JACADS are provided in two site-specific plans, *Safety Assessment and Accident Prevention* (PL-11) and *Occupational Health and Hygiene Plan* (PL-40), which incorporate the industrial safety requirements in Occupational Safety and Health Administration 29 *CFR* 1910.120 (U.S. Army, 1997, 2001a). As the transition from operations to closure proceeds, maintaining safety standards will become more difficult because of the changing configuration of the facility and the many one-of-a-kind demolition operations. For example, coprocessing of waste while parts of the facility are being demolished to allow the installation of the carbon micronization system will be a very risky undertaking due to simultaneous operation and alteration of the plant's ventilation system. Safety will require the full commitment of each worker and all levels of management. The committee has observed that the site contractor at JACADS conducts process hazards reviews and frequent safety briefings with the workers that will help prevent accidents and injuries during the closure operations.

SECURITY AND SURETY REQUIREMENTS

General Security

Although the remote location of Johnston Atoll provides a degree of natural security, the sensitive nature of the storage and demilitarization of chemical weapons has required additional security precautions. Johnston Island, where the sensitive operations are concentrated, is the responsibility of the installation commander, Detachment 1, 15th Air Base Wing, U.S. Air Force Pacific: "The mission of the islandwide security force is to provide normal police force function, law enforcement, enforcement of installation traffic control, and air terminal passenger security screening" (U.S. Army, 2000f). The Air Force security force currently comprises 13 civilian employees of the base operations support contractor.

Physical Security of Storage Areas and the Processing Facility

U.S. Army Chemical Activity–Pacific (USACAP) and JACADS, tenants on the island, have larger security contingents associated with their operations. USACAP provides approximately 250 people, military and civilian, for the surety program, and the JACADS security mission has about 720 people, including military, contract civilian, and civil service personnel involved (U.S. Army, 2000f). The Commander USACAP, the JACADS site project manager, and the WDC project manager are responsible for their own people and the organizational elements subordinate to them or under their contract control. "The mission of the JACADS security force and an important objective of the surety program is to properly safeguard chemical agents against sabotage, theft, loss, seizure, or unauthorized access, use or diversion through the application of stringent physical security measures" (U.S. Army, 2000f).

Chemical Surety Program

The chemical surety program is a Department of Defense-mandated program. It is a system of safety and security control measures designed to protect the local population, workers, and the environment by ensuring that chemical agent operations are conducted safely, that chemical agents are secure, and that personnel involved in those operations meet the highest standards of reliability (U.S. Army, 2000f).

The commander at each level and contractor supervisors are responsible for implementation of an integrated management system based on the Army Chemical Surety Program and contract requirements. The program specifies accountability for the chemical agent inventory and controls access to storage and processing areas (U.S. Army, 2000f).

Surety and Security After Completion of Agent Operations

The Army does not anticipate the presence of Army personnel on Johnston Atoll after the completion of the cleanup and closure required by the RCRA permit. USACAP is expected to phase out its surety program first. According to Army Regulation 50-6, dated 1 February 1995, "Installation or site surety status will be terminated when all chemical agent in accessible form has been demilitarized, detoxified, transferred, or consumed in experimentation." At that point, the USACAP commander will send a memorandum requesting termination of surety requirements to Headquarters, Department of the Army. The request must include supporting certifications and reports. Upon approval of the USACAP request, a memorandum will be issued terminating surety status.

Regular safety and routine physical security activities will continue to protect personnel, facilities, and materiel from pilferage, unauthorized use, sabotage, and violation of community rules and regulations by any source, internal or external (U.S. Army, 1995, 2000f). Conceivably, the island could be the target of unauthorized entry and trespassing from the air or sea. Thus, a security presence appears to be warranted until final ownership of the island is established.

JACADS will require a continuing security contingent following the departure of USACAP to protect workmen and other island residents until the JACADS facility has been declared closed and its property transferred to the installation commander. Then, the only security required following JACADS closure would be to protect remaining government property (U.S. Army, 2000f).

4

Executing the Closure Plan

The PMCD intends to close JACADS (and, subsequently, chemical agent disposal facilities at sites in the continental United States) as quickly as possible after agent disposal operations have been completed through cost-effective means and in full compliance with all applicable permits and regulations. To accomplish this, the workforce that conducted the operations phase will be carried over through the closure phase, with the addition of a few specialized subcontractor personnel. Nevertheless, workforce morale may decline, as it almost invariably does, when a construction or demolition project nears completion. In anticipation of the problem, WDC, the Army's contractor for JACADS operations and facility closure, proposed a personnel-retention plan to the Army that provides incentives for personnel to remain at JACADS for specific closure operations. The plan has been approved for implementation; coupled with a worker-recognition program, it should provide workers with more than just satisfaction at the successful completion of a difficult, dangerous, and vitally important task. To this end, the retention plan provides employees with a percentage of gross annual pay that is accumulated monthly and payable at the end of the employee's assignment.

DECONTAMINATION OF SYSTEMS, STRUCTURES, AND COMPONENTS

A decontamination plan must be based on accurate knowledge of the kinds and extent of contamination present. Prior to the removal of systems, structures, and components (SSC) other than those needed for MPF operation, the external surfaces of equipment and components, as well as walls, floors, and ceilings of rooms and areas that have been contaminated with agent, will have to be decontaminated. Three methods will be used:

- chemical decontamination—using sodium hydroxide (1 or 18 percent), sodium hypochlorite (5 or 5.25 percent), soap (Visco 15 and Whistle), and water and steam, alone or in combination
- mechanical decontamination—using mechanical techniques such as scabbling, scarifying, water-jet cutting, and grit blasting
- thermal decontamination—as necessary, particularly after structures are taken down, using existing furnaces or other means

One or more of these methods may be necessary to achieve the desired decontamination levels, four of which are described in Table 2-1 of the Decontamination Report (Appendix 2) in the *Decommissioning Plan* (U.S. Army, 2000d).

During agent processing and during closure of all CSDP disposal facilities, secondary wastes will be generated. Minimizing the quantity of these wastes and developing a plan for their destruction/disposal will reduce both operating and closure costs. The Army has addressed this problem in its waste minimization program (see subsection "Waste Minimization" later in this chapter) (U.S. Army, 2000d). The sites employing alternative technologies will not have furnaces available for processing items such as demilitarization protective ensembles (DPE). How the Army is going to address secondary waste processing/disposal at these sites without using furnaces has not been resolved. The Army should pursue means for addressing site-specific secondary waste processing and disposal issues using technologies other than incineration and incorporate this information into design and/or operating permits where appropriate.

REMOVAL OF SYSTEMS, STRUCTURES, AND COMPONENTS

Risks During Dismantlement

Although processes for razing facilities have been used for years in the chemical industry, detailed procedures vary widely among companies, geographical areas, and types of products that were produced. In this regard, the closure of JACADS will be the first razing of a chemical agent disposal facility anywhere in the United States. Some aspects of the baseline incineration disposal system used at JACADS may present unique hazards, risks, and challenges that will have to be addressed. The JACADS experience can provide a prototype for future closure activities at other sites and a wealth of lessons learned.

The extent of contamination at JACADS can only be estimated at this time. For example, closure experience from other, non-Army sites suggests the possible intrusion of agent contamination into concrete floor slabs in the explosion containment rooms and adjacent processing areas (U.S. Army, 2000a, 2000c, 2000d). The level of protection afforded to the concrete by the epoxy layer is unknown, as is the extent of agent contamination in the epoxy itself. The extent of contamination intrusion into other niches and recesses is also unknown. Processing equipment has been repeatedly saturated with agent and subsequently washed down with decontamination solution during the course of disposal operations, but the extent of residual contamination is unknown. Monitoring for several agents will be necessary during JACADS closure (as it will be for most other baseline incineration facilities) to ensure that the decontamination has been effective. While agent-specific monitors for multiple agents can be used, employing a simple, reliable, single-unit multiagent monitor might prove as effective and more convenient.

Closure demolition operations will generate significant quantities of particulates, which may contain hazardous chemicals, including agent. It is important to evaluate both the need for monitoring (at the location of closure activity and/or at the site boundary) and the potential health and/or ecological risks associated with particulate transport.

During closure, workers in some locations must be initially protected with DPEs. A lesser level of protective dress may be acceptable as work progresses and proof of safe conditions is obtained.

Concurrent closure activities and operations for the disposal of agent-contaminated waste are planned for JACADS and could take place at other facilities as well. Under such circumstances, the normal flow of activities and material could be disrupted and risks increased. Frequent changes in material flow, in HVAC routing, and in utility provisions might be encountered. To minimize the danger, planning must be meticulous and workers must comply with procedures and remain vigilant. In addition, as closure progresses and the dismantlement of the facility advances, workers will increasingly be required to handle heavy materials and equipment, including machinery, metal ducts, piping, and bulk material such as concrete removed from the facility.

Closure activities will necessarily span several typhoon seasons. A direct strike could leave a tangled mass of material that would be difficult and dangerous to handle. Careful planning can reduce the risks associated with scheduled closure operations, but nothing can eliminate the threat of severe weather.

Because closure is a new and unprecedented activity at JACADS and unexpected problems may arise during field activities, it may not be possible to identify all sources of risk during the planning phase. However, good project planning, risk assessment, and experienced proactive management can reduce the uncertainty. If new sources become evident as work progresses, they must be carefully addressed and the experience recorded to assist in closures of other disposal facilities.

In the case of JACADS, there will be no risk to the public or environment other than those already identified in the operational quantitative risk assessment and health risk assessment. This may not be the case for the other eight sites. The JACADS experience will provide information on which assessments for the remaining sites can be based.

Closure Safety and Health Risks

Sources of risk will change during closure. During operations, the main risk is from the handling and destruction of chemical agents and associated energetics. During closure, especially once the agents and energetics have been destroyed, the main hazards will shift to the more conventional risks of dismantling and demolition. Hazards that may be encountered include the following:

- equipment mistakenly believed to be free of agent, energetics, or other chemical hazard (e.g., lead-based paint, decontamination solutions)
- slips, trips, and falls
- hazards presented by heavy objects and heavy lifting equipment
- utility systems only temporarily connected
- heat stress, uncomfortable working conditions
- confined work spaces
- proximity to flame-producing equipment
- unstable structures and equipment
- noisy environments

These conditions may create a hazardous work environment that could be unfamiliar to many disposal operations employees. Safety statistics for the construction industry published by the Occupational Safety and Health Administration for 1997 and 1998 show an annual average of 2.5 times more fatal occupational injuries to workers during wrecking and demolition activities than during heavy construction (SIC Code 162, SIC Code 179, Department of Labor, 1999). The number of nonfatal occupational injuries for wrecking and demolition workers was 4.8 times higher than for heavy construction workers. Obviously, industrial safety will be a continuing challenge that will require a heightened sense of safety awareness and strict compliance with procedures and good work practices. To minimize risk, the Army should consider using the technology used by industry, such as three-dimensional computer graphics that track facility configuration during demolition and remote teleoperated equipment.

Contaminated Material and Equipment

Because the nature and extent of all agent and other chemical contamination will not be established until closure work is already in progress, planning is necessarily uncertain, and decommissioning, dismantlement, and demolition operations are certain to be complicated and potentially hazardous. The uncertainty is complicated by the nature and extent of contamination by agent and agent breakdown products, and the evolving methodologies for detection and analysis (e.g., surface detection techniques). Based on information presented to the committee in March 2001, no analytical method has been developed and approved to detect agent and agent breakdown products in concrete and soil.

The use of protective dress for much of the dismantlement operation introduces additional risk, because such dress compromises a workers' vision and hearing and slows their movements. Moreover, the probability of heat-related injuries increases in proportion to the time worked in protective dress.

Decontamination of machinery will require handling of parts and components that are not normally or easily accessible. Machines may have to be broken or cut into smaller units for handling by workers and processing in the MPF.

HVAC System Utility Services

The committee's review of the closure documentation indicates that the Army has carefully considered HVAC system phasing during closure to ensure that pressure differentials in subsystems are maintained and exhaust gases are routed through appropriate filters before release to the atmosphere. However, a breakdown in coordination and communication during transition and reconfiguration phases could raise safety concerns in addition to those of handling heavy ductwork. Planning is necessarily based on the information and assumptions available at the time the plan is developed. An unexpected discovery of agent contamination may require modification of the plan.

The availability of utility services to areas of the plant that are continuing waste disposal operations will have to be ensured. This includes the operation of secondary systems such as the HVAC cascade ventilation system through which incoming plant air proceeds from areas of low toxic concentration to areas of higher toxic concentration before being passed through carbon filters and then released to the atmosphere. At the same time, the safety of workers will require deenergizing and disconnecting selected electrical power circuits and other utilities to the areas being dismantled.

Equipment

Following decontamination and removal, machinery and equipment can be prepared for final disposition. Disposing of them on Johnston Island would yield significant cost savings but will depend on the criteria and permit requirements for the end state for Johnston Atoll. If off-island shipment is necessary, the risk of accidents from handling and packaging machine components and fragments for shipment by barge and subsequently by rail or truck in the continental United States will have to be addressed.

Buildings and Structures

The removal of significant structural components and systems from buildings must be planned and evaluated to ascertain the effects on structural stability. The removal of floor systems, an increase in the effective length of columns, an increase in the span of beams, and changes in the distribution of loads or load patterns from those assumed in the original design could be dangerous. Temporary loads, such as heavy equipment or stacked material, must be anticipated and controlled. Planning should include access and egress routes, both routine and emergency, to prevent the inadvertent isolation of workers. Because an accumulation of debris invites injury, the cleanliness of the worksite will be especially important during demolition activities.

Dismantling operations will create materials that are heavy and unwieldy. Handling heavy objects will create a risk of damaging structures and equipment still in operation or intended for abandonment in place. Workers could also incur risks. The placement and use of lifting equipment must be carefully planned to minimize the possibility of boom overload, collision of a boom or load with fixed objects, and contact with energized electrical distribution lines.

The end use of Johnston Island will dictate which structures can be abandoned and which will require modifications. Good advanced planning can minimize wasted effort in meeting end-state requirements.

Safety Program

Given the unique nature of JACADS closure activities and the possible lack of worker experience with demolition-related safety procedures, planning and preparation for each task involved in closure will be essential. Timely discussions with appropriate craftsmen, supervisors, and safety professionals in planning the work and determining hazards will help in identifying risks and developing appropriate procedures. The Construction Industry Institute has noted that conferences before execution of a task help to prevent mishaps (CII, 1993). Fail-safe communication and coordination procedures typically used by the construction industry will be essential during decommissioning, dismantlement, and demolition. Lock-out, tag-out, and hazardous activity permit procedures should be mandatory.

In the unique environment of decommissioning, ensuring that agent contamination, agent-breakdown products, and other chemical contamination are within acceptable limits for all media (including solids and liquids) will be essential for worker safety and worker morale. The Army currently uses multiple automatic continuous air monitoring system (ACAMS) and depot area air monitoring system (DAAMS) monitors to detect the presence of multiple agents in air. These systems should be carefully evaluated to ensure that they will provide MACT compliance.[1] Furthermore, as previously noted by the committee in an earlier report on workplace monitoring, testing for surface contamination as currently planned is not state of the art (NRC, 2001).[2] PMCD has no experience with the removal of machinery on a facility-wide basis or the detection of agent intrusion into structural elements such as concrete. To ensure worker safety and compliance with permit requirements, and to minimize the time and cost of closure, the Army will have to use state-of-the-art detection systems and sampling and analysis techniques (NRC, 2001).

Safety Reporting

Reporting accidents and near misses will be critical to the safety program. Procedures must be implemented to ensure that reporting is prompt, reports are professionally analyzed, and lessons learned are quickly disseminated. In the event of a fatality or other serious accident, independent safety experts should investigate causes and formulate corrective actions. Personal accountability throughout the chain of supervision is a proven technique for encouraging commitment to safety. Safety awareness and actions must have the strong personal commitment of all managers, supervisors, and employees in PMCD and its contractor organizations.

MONITORING OF AREAS, WORKERS, AND MATERIALS

Closure activities will require monitoring of solids, liquids, and air to maintain safe working conditions and to prevent the release of agent, agent-contaminated materials, and degradation products to the environment. Monitoring should include the following goals:

- detecting agent
- detecting any contamination that might expose workers, the public, and the environment
- verifying compliance with established standards
- alerting workers to out-of-specification conditions
- demonstrating that no off-site particulate contamination occurs
- providing data to decisionmakers for developing corrective actions
- providing historical data

Agents could be exposed and vaporized as the configuration of the facility changes during disassembly activities. Therefore, air monitoring of areas, materials, and people will require close, continuous management and worker attention. If agent exposure is suspected, the monitoring of blood cholinesterase in potentially exposed employees will be carried out in accordance with the medical surveillance program followed during disposal operations. As closure operations progress, walls and floors will be removed, HVAC systems will be modified, and monitoring instruments will be removed and/or relocated. Monitoring during closure will be quite different from monitoring during normal operations. The monitoring plan should include postclosure monitoring (discussed in Chapter 5) where appropriate.

During scabbling or similar operations, there is a potential to generate significant amounts of particulates. Particulate sampling at the site boundary during these operations is important. It could provide records that demonstrate hazardous chemicals are not leaving the site via this pathway during closure activities.

Multiagent Monitoring of Areas and Workers

Because JACADS has been used to destroy weapons and bulk stores of GB, VX, and HD, closure activities will involve potential worker exposure to all three chemical agents and their degradation products. Residual reservoirs of any of these agents may become exposed during disassembly of the facility, and the agents may vaporize, leading to harmful airborne concentrations. Therefore, it will be necessary to verify that decontamination procedures for equipment, waste streams, and building materials have destroyed any significant agent residue.

The sampling and analysis plan in Annex 2E of the *JACADS Closure Campaign Decommissioning Plan* stated that monitoring of airborne agent other than particulates will be performed by ACAMS monitors backed up by DAAMS monitors (U.S. Army, 2000c). These were the systems used to monitor airborne agent during disposal operations at JACADS, and they continue to be used for this purpose at TOCDF (NRC, 2001). The ACAMS monitors are automated gas chromatographs with flame photometric detectors that automatically set off an alarm when any airborne agent exceeds preset levels (typically 20 percent of a specified

[1]MACT refers to "maximum achievable control technology" regulations recently instituted by EPA defining more stringent limits for emissions into the air.

[2]Charles E. Kolb, vice chair of the committee, memorandum to the committee on new technology to detect chemical agent and agent breakdown products on surfaces (with five enclosures on use of SIMS technique) dated March 22, 2000.

agent hazard level). ACAMS monitors provide a measurement every 2 to 10 minutes, depending on the target agent and the preset hazard level. The DAAMS monitors, which consist of active air sampling sorbent canisters, are periodically collected and transported to the laboratory, where any agent collected is desorbed and analyzed by gas chromatography. The DAAMS monitors are used to confirm ACAMS agent detection and to quantify low-level concentrations of agent collected over several hours.

The primary change to the monitoring program as a consequence of EPA permit modification C-2-052 having been approved, will be a reduction in perimeter monitoring and utilization of DAAMS monitoring in place of many ACAMS detectors for demonstrating compliance with agent emission limits at regulated process vents (EPA, 2000). This approach could be ill-advised as long as agent-contaminated materials are being fed to the furnaces.

The *Decommissioning Plan*, produced by WDC for the Army, states as follows in Annex 2, page 18: "Since the air monitoring devices are equipped to monitor one specific agent at a time, provisions must be in place to monitor all three agents (GB, VX and HD) during sampling activities" (U.S. Army, 2000c). Monitoring for all three agents was done only in the unpack area and on the common stack during disposal operations at JACADS. For closure activities, the *Facility Closure Plan* calls (on page 61) for elimination of ACAMS monitoring on the common stack, because agent is not expected to be present at detectable levels during normal furnace operations, based on trial burns and routine performance data (U.S. Army, 2000a). However, agent-contaminated DPE suits and carbon, for example, could contain substantial amounts of any of the three agents that were stored at Johnston Island. Without near-real-time ACAMS alarms for all three, one or more could conceivably escape from the common stack during abnormal or upset conditions, as occurred in an incident at TOCDF in May 2000.

The sampling and analysis plan from the *Facility Closure Plan* indicates that samples from liquid-phase waste streams and solid materials will be analyzed for agent contamination by chloroform extraction followed by gas chromatographic analysis (U.S. Army, 2000a). However, Table 2-E.4, Analytical Methods Summary (Appendix 2 of the *Decommissioning Plan*), indicates that the analytical method for chemical warfare agents (CWAs) is to be determined (U.S. Army, 2000c). This inconsistency notwithstanding, the analytical procedures will presumably be performed on samples transported to the laboratory and extracted. A sufficient number of gas chromatography instruments equipped with both sulfur and phosphorus detectors will be necessary to analyze these samples and any samples resulting from the increased number of DAAMS tubes. The increase in analyses cannot be handled by the small number of gas chromatographs currently deployed in the laboratory. The number of gas chromatography instruments and operators and the sufficiency of existing laboratory space will have to be determined.

Finally, the possibility of using advanced technologies, such as secondary ion mass spectrometry (SIMS), to directly measure contamination by agent and/or agent breakdown product on solid surfaces is not discussed in the closure planning documentation (U.S. Army, 2000a, 2000c, 2000d). Recent studies indicate that such measurements might eliminate the need for time-consuming extraction procedures that use hazardous solvents such as chloroform (Groenewold et al., 1995, 1998, 1999, 2000). They also indicate that SIMS may be used to detect VX and its breakdown products in soil and concrete and HD on various surfaces.

Relative to the safety program discussed earlier in this chapter, and considering the potential benefits to be derived from the employment of advanced monitoring technologies, the committee believes that there is probably a need for developing specialized technology in this area.

WASTE MANAGEMENT

The Problem

The amount of agent-contaminated wastes to be disposed of during closure is estimated to be approximately 5.8 million pounds, according to the *Facility Closure Plan* (Table 1 in the *Plan*) (U.S. Army, 2000a). This quantity includes (1) waste stored on-site as of April 2000, (2) predicted increases in waste until the end of the munitions campaign (completed November 2000), (3) coprocessing of heavy machinery, (4) USACAP waste inventory, and (5) closure wastes from dismantlement and decontamination primarily in the MDB. Approximately 2.1 million pounds is expected from the dismantlement of the first and second floors of the MDB and the HVAC systems. In addition, approximately 250,000 gallons, or 2.3 million pounds, of spent decontamination solution will be generated during decontamination activities in the MDB. As of April 30, 2000, approximately 900,000 pounds of secondary wastes (including USACAP stored waste) had been generated and kept in long-term storage in the Red Hat Storage Area. In the waste inventory table of the *Facility Closure Plan*, Section 3.2, an estimated additional 120,500 pounds of agent-contaminated materials would be generated from the VX mine campaign and an additional 370,000 pounds during closure (not including spent decontamination solution) (U.S. Army, 2000a).

The closure plan groups the permitted hazardous waste management units (HWMUs) for JACADS and the Red Hat storage area into five categories: (1) tank systems, (2) incinerators, (3) miscellaneous treatment units, (4) the munitions demilitarization building (MDB), and (5) permitted container storage areas. How buried and above-ground piping would be categorized is not apparent. Each category presents a different set of waste management issues that depend on the chemicals to be analyzed and the cleanup levels to be achieved. The closure plan, as submitted, is somewhat unusual in that the RCRA facility investigation (RFI), the analytical protocols, and the risk assessments are not finalized. Because the extent of contamination is uncertain, particularly in concrete, it is difficult to devise a well-documented and -formulated plan for managing closure. Also, the lack of analytical protocols accepted by EPA makes it difficult to specify some elements of the waste management plan, such as appropriate sampling frequencies, furnace feed specifications for materials like concrete, waste storage locations after treatment, and the ultimate destination for wastes if off-island disposal is required.

The Process

Much of the hazardous waste will be stored on the island until treated or transported to a treatment, storage, and disposal facility (TSDF) in the United States. Wastes accumulated as of October 2000 were listed in the *Decommissioning Plan* (U.S. Army, 2000d). These included 132,285 lb of DPE suits, 45,512 lb of inert bulk solid wastes, and 2,010 lb of spent hydraulic fluid. However, final amounts will not be known until closure activities are completed in 2003 and the areas certified as clean. The wastes stored in three buildings in the Red Hat Storage Area (Buildings 850, 851, and 852) and in 16 bunkers have been categorized in the RCRA permit. All of the agent-contaminated hazardous wastes generated during closure will be treated, according to the RCRA permit for the facility, predominantly by incineration. Non-agent-contaminated hazardous waste generated during closure will be managed according to regulations applicable to the generators of such waste (40 *CFR* 261) and shipped off-site before the end of closure. The RCRA permit has been modified to include this newly identified secondary waste.

A description of plans and schedules for temporarily staging and transporting wastes is necessary, in that doing so provides an opportunity to predetermine and accommodate operational contingencies and related risks. Since hazardous wastes, including PCBs, would require appropriate notifications and manifesting, such planning and scheduling could be readily incorporated into the closure plan. This would include shipping requirements of 40 *CFR* 262 and 263 and DOT transportation requirements codified in Title 49. Some recognition is given to issues like these in the October 2000 *Facility Closure Plan* (U.S. Army, 2000a). Moreover, leachate collection, runoff control, spill and discharge controls, erosion control, and asbestos abatement could also be integrated into the overall waste management procedures. Countermeasures for problems such as these are highlighted in JACADS Procedure PL-15, which contains a contingency plan and a spill prevention, control, and countermeasures plan, both of which are required by 40 *CFR* 112 (U.S. Army, 2001b).

Waste Minimization

Waste minimization was considered in initial closure planning documents (June 1999) in terms of the JACADS Waste Minimization Program, PP-42, implemented to govern operational waste reduction efforts in accordance with the 1984 RCRA Hazardous and Solid Waste Amendments (U.S. Army, 1999d). From the more recent *Facility Closure Plan*, it appears that the earlier waste minimization program does not address the activities that will be conducted during closure (U.S. Army, 2000c). Integration of an effective waste minimization program into the closure effort may help focus the development of cost-effective decontamination strategies and overall waste management protocols.

PUBLIC COMMUNICATIONS AND INVOLVEMENT

Background

The Army's Chemical Stockpile Disposal Program (CSDP) for destroying chemical agents and munitions has long been of intense interest to elements of the public, including communities near planned and operational chemical agent disposal facilities. Public involvement is an inherent activity when National Environmental Policy Act[3] and EPA regulations regarding RCRA permit processing apply.

Johnston Atoll has had a long history of military activity dating back to the 1930s, including its use before and during World War II as a Pacific base, during the 1950s and 1960s as a launch facility for testing nuclear weapons, during the 1960s as a staging area for the shipment of Agent Orange to Vietnam, and from the 1980s to the present as a storage and disposal site for chemical agents and ammunition. All of these activities resulted in numerous incidents of hazardous material contamination of the islands comprising the atoll by the several agencies involved. Current regulations require cleanup to standards much more stringent than those that often applied when these incidents occurred.

Public interest in most chemical agent storage sites was moderately high throughout the 1990s. Interest in JACADS peaked in mid-1990 as a result of the decision to transport the U.S. stockpile in Germany to Johnston Island. At that time, stakeholder meetings were well attended, with participants expressing some degree of agitation.[4] In the last 2 years, however, there has been less public interest in the closure of JACADS. Recent public meetings have been relatively amiable, sparsely attended, and supportive of both the

[3]The National Environmental Policy Act requires certain procedures for public input on and documentation concerning the preparation of a thorough environmental impact statement regarding activities undertaken by the federal government that have environmental impacts.

[4]Marilyn Daughdrill, Public Affairs Director, PMCD, personal communication to Stockpile Committee member Charles I. McGinnis on October 26, 2000.

public affairs effort and the operational plan for closure. Factors contributing to the public's apparent disinterest include growing public confidence in the manner in which disposal operations were carried out and completed, the island's remote location, and the absence of an indigenous native population.

Interest in Johnston Island and JACADS activities among members of the public has intensified as a result of the formation of a regulatory working group consisting of state, regional, and national (EPA) regulators with jurisdiction over stockpile sites. This group has met regularly during the closure planning process and apparently perceives decisions involving JACADS as precedents for similar decisions at continental U.S. disposal sites. Some active members of the community (including nongovernmental organizations and Pacific Islanders) have attended these meetings and have filed written opinions with the EPA. Army and contractor representatives believe these opinions have significantly influenced regulatory working group positions.

While JACADS in many ways serves as a prototype for closure expectations and activities elsewhere, the stakeholder challenge is not as great. In the continental United States, closure activities will probably be followed closely by political leaders at every level from local to federal, by concerned local citizen groups, and by activist citizen groups. Stakeholder activity will inject a higher level of uncertainty into planning, regulatory decisions, costs, and scheduling. Intensified public involvement will become increasingly important in planning and executing future closures smoothly.

Public Information and Outreach for JACADS

Public information and outreach activities at continental U.S. storage and disposal sites have been vigorously implemented by PMCD, and the reactions of elected officials and the public at large to these efforts have varied from site to site (NRC, 2000b). No such activities were ever set up specifically for Johnston Island, although support for public information activities concerning JACADS has been provided by the PMCD headquarters in Aberdeen, Maryland. Moreover, the PMCD project manager for JACADS has been directly involved in and personally committed to pursuing a vigorous public information and outreach activity in the Pacific region of the facility, particularly Hawaii. In view of the remoteness of Johnston Island, the experience of public outreach efforts there may not be particularly predictive of the experience of such efforts in the continental United States.

A recent survey on community perspectives at the eight continental U.S. stockpile sites by a PMCD contractor at the University of Arizona excluded JACADS because of its atypical situation (Williams et al., 1999). Because there is no indigenous population adjacent to JACADS with whom to communicate, emphasis has been on other stakeholders, and no citizens advisory commission was established to represent local community interests. Outreach has been promoted by inviting reporters and stakeholder representatives to visit Johnston Island, where they receive briefings and view JACADS operations. The need to coordinate this activity with the Air Force, the current owner of Johnston Island, has added complexity to the outreach activities.[5] Because of the unique jurisdictional issues surrounding the closure of JACADS within the overall context of the ultimate fate of the entire Johnston Atoll (see Chapter 2), it has been difficult to coordinate information given to the public by the multiple governmental agencies involved with Johnston Island.

The Stockpile Committee has maintained a high interest in the public involvement activities associated with the Chemical Stockpile Disposal Program, such that it has published two relatively extensive letter reports on the subject: *Public Involvement and the Army Chemical Stockpile Disposal Program* (NRC, 1996) and *A Review of the Army's Public Affairs Efforts in Support of the Chemical Stockpile Disposal Program* (NRC, 2000b). The Program Manager for Chemical Demilitarization and staff have these reports, which include findings and recommendations, available for their reference.

Stakeholder Issues

It is important to identify site-specific stakeholders early in the closure planning phase. The stakeholders in disposal operations and closure of JACADS include the following:

- U.S. Army, particularly PMCD and the U.S. Army Chemical Activity Pacific (USACAP), which is responsible for managing the Johnston Island stockpile storage area
- contractors and consultants
- U.S. Air Force
- Defense Threat Reduction Agency (U.S. Department of Defense)
- Fish and Wildlife Service (U.S. Department of the Interior)
- National Marine Fisheries Service (National Oceanic and Atmospheric Administration)
- U.S. Coast Guard (U.S. Department of Transportation)
- Environmental Protection Agency
- Federal Aviation Administration (U.S. Department of Transportation)
- environmental activist groups from the United States and Pacific island chains
- potential commercial investors in Johnston Island
- commercial transportation companies doing business on Johnston Island

[5]Gary N. McCloskey, JACADS Site Project Manager, conversation with Stockpile Committee member Charles I. McGinnis on February 24, 2000.

- Pacific Islanders
- media representatives
- Chemical Weapons Convention technical and diplomatic observers
- legislators

Some issues of concern to stakeholders may be addressed by reassuring them of the following:

- JACADS will not be converted to a permanent waste disposal site.
- No residual contamination will remain that could affect the land, water, or air surrounding the site.
- Disposal operations and closure activities are proceeding safely, within regulatory guidelines, according to a published, transparent plan, and without the prospect of bad surprises.
- Upon closure, all regulatory and end-state requirements will have been met.
- After closure, long-term monitoring and stewardship will be provided.

The committee believes that government stakeholders will confront the following responsibilities:

- reaching agreement on end-use and end-state criteria, and communicating the decisions clearly to the public
- living within budgetary constraints and assigning responsibility for multiple tasks and for overall coordination in such a way that the outcomes are acceptable to participants and to their external constituencies
- achieving compliance with U.S. regulations and the Chemical Weapons Convention and minimizing cost, while at the same time earning public support
- safely transporting materials from JACADS to the continental United States
- providing safe and permanent storage or disposal of waste materials

Planning for Transition to Closure

Public outreach established during operations should continue seamlessly as emphasis shifts from operations to closure. Outreach activities for closure provide an opportunity to showcase operational accomplishments. Since public hearings may (depending on the RCRA modification classification) be required before new permits, or significant modifications to existing permits, can be issued, closure planning offers an opportunity to continue dialogue with interested stakeholders. Careful planning can ensure that timely notice of hearings and meetings is provided to all interested parties and that they are encouraged to participate. For issues of special sensitivity, proper responses can be prepared in advance of formal meetings to ensure against surprises to or from internal or external stakeholders (U.S. Army, 1999c).

5

Facility Closeout Activities

The closure activities at JACADS consist of decontamination and removal of process equipment and building structures and some soil removal and disposal. Although no requirement for groundwater treatment is anticipated at Johnston Island, other CSDP disposal sites might require groundwater treatment, which would affect the closure process and the ultimate postclosure monitoring at those sites.

The actual JACADS closure activities should be defined in a detailed closure work plan. The work plan is separate from the closure plan as it contains a great amount of detail about each specific activity that is to be conducted during closure. The plan will be agreed to by all parties involved and approved by EPA Region IX, the regulatory authority with oversight responsibility for JACADS. In this sense, the work plan can be considered a legal document that contains the essential postclosure activities and the postclosure report and certification for the JACADS site. In addition, the closure work plan may also include certain additional elements that the Army plans for closures of other sites where circumstances are different.

A draft RCRA facility assessment (RFA) for JACADS was submitted to EPA for approval on December 12, 2000. This RFA, which forms the basis for developing a closure work plan and a set of postclosure activities, suggested that 19 areas of interest (AOIs) require no further action and that 52 solid waste management units (SWMUs) and 24 AOIs are potentially contaminated and require further action (investigation). These AOIs and SWMUs range in size from about 100,000 square feet to less than 100 square feet. Typically, in a commercial facility closure, they would be combined into as few units as possible for the execution of the closure plan. Based on the information in the RFA and subsequent data from any further field investigations, a closure work plan will be developed that specifies closure activities as well as any postclosure activities.

Demolition activities at JACADS present a particular set of issues, as not all buildings and surfaces are expected to be contaminated with agent or other toxic compounds. Sampling activities for demolition waste consists of confirming whether or not the wastes are contaminated and ensuring that adequate data are compiled to support the classification and disposal methods to be used. Each pile sampled for disposal purposes must be documented as coming from the location specified in the sampling plan. This will ensure that the waste from a particular pile will not contain unknown or unanticipated contaminants that would prevent disposal. It is vital that the final closure report submitted to EPA contain a full and detailed account of what was done, how it was done, and the ultimate disposition of all demolition wastes.

SAMPLING METHODS, SAMPLE ANALYSIS, AND AREA SURVEY METHODOLOGY

The sampling procedures that are used during postclosure activities depend upon the identified areas of concern, specific contaminants in all media, and the required end states (i.e., cleanup levels to be attained). Sampling methods must be scientifically defensible and statistically sound. For example, polychlorinated biphenyl (PCB) sampling protocols for soil disposal specify the number of samples, the frequency, the compositing guidelines, the sample preservation methods, etc. (Keith, 1988, 1990). Although JACADS has chemicals other than PCBs, applying the principles behind the development of the PCB guidelines provides a very useful approach that is widely accepted by EPA. Sampling methods for postclosure may be similar to those for monitoring closure activities. For JACADS, these methods must address the specific contaminants identified in the RFA and in the closure plan: metals, volatile organic compounds, semivolatile organic compounds, agents, and agent degradation products. The philosophy behind postclosure sampling should be to develop and implement procedures that clearly demonstrate that specified end states have been met and that there are no further risks to people or the environment.

Sample analyses should be performed in a laboratory certified for the necessary procedures, and they must be able to meet detection limits in the expected media and chemical mixtures. Some analyses are specified by existing EPA protocols, but this is not the case for agent and agent degradation products. Both the closure plan and the postclosure plan should precisely define the protocols to be used for these classes of compounds, including precision and accuracy for expected contaminants.

The methodology used for the area survey should define procedures to ensure that adequate samples are taken for each area designated for closure activities in the RFA and work plan. Closure activities could include soil removal, demolition, soil remediation, sediment remediation, and groundwater or surface water treatment. An example of a procedure often accepted by EPA is to assess an excavation for cleanliness by analyzing samples taken from the sides and bottom of the excavation. In some circumstances, these samples may be composited, but the technique is unique to each site and to each AOI or SWMU. The postclosure sampling plan should strive to minimize the number of samples needed while demonstrating that the agreed-on cleanup goals have been met.

If required, pump-and-treat groundwater remediation and/or in situ bioremediation are options, but unlike with soil excavation, it may take years for contaminant concentrations to reach the agreed end point. The postclosure part of the closeout activities plan should contain a well-defined exit strategy for any necessary postclosure remediation, based on a sampling methodology that defines progress and determines when the end point is reached.

AREA SAMPLING AND SURVEY DOCUMENTATION

Careful and thorough records documenting closure activities should be kept. These records might include:

- photographic data, including video recordings where appropriate
- thorough and complete field notes that fully describe the samples taken, where taken, chain-of-custody procedures, sample preservation procedures, holding times, and similar items
- documentation showing that the personnel performing the work were qualified and certified when appropriate
- actual postclosure sampling activities with planned activities for AOIs, SWMUs, etc. in order to establish whether all required activities were accomplished

FINAL CLOSURE SURVEY REPORT AND CLOSURE CERTIFICATION

The postclosure survey report should fully and completely document all activities and all results (data), and it should certify that the closure has been done in compliance with the work plan and all applicable laws and regulations. A professional engineer licensed in the state where the closure was done must attest to the report. (In the case of JACADS, the state is California, where the EPA Region IX office is located.) Appendix E provides two sample tables of contents from industrial RCRA closure survey reports accepted by EPA; they can be used as a guide to the contents of the final and interim reports required. Box E-1 shows the table of contents for a final facility RFI postclosure report. Box E-2 shows the table of contents for an interim remedial measures report, used to obtain EPA conditional approval for the cleanup of specific areas prior to final facility closeout.

POSTCLOSURE MONITORING REQUIREMENTS

As noted earlier, long-term monitoring requirements for remediated sites most commonly involve groundwater treatment and/or ongoing soil treatment. The monitoring requirements will be specific to each site and to the chemicals treated. For JACADS closure, because the only groundwater present on Johnston Island is that beneath the original 6 percent of the island that is naturally occurring, and since the facility is not on this land, no groundwater monitoring is planned by the Army. Postclosure monitoring plans at each facility should be developed in a manner that will demonstrate what is to be monitored and when the remediation is complete.

6

Lessons Learned

GENERAL CONSIDERATIONS

Much effort has been (and continues to be) expended to plan the closure of JACADS in advance and in great detail, and much will certainly be learned in the course of closure operations and facility closeout. With eight continental U.S. sites for disposal of the remaining U.S. chemical stockpile now operating, under construction, or planned, significant economies in time and cost associated with their eventual closure may be obtained through careful and timely dissemination of the lessons learned from closure activities at JACADS.

Hand in hand with lessons learned is the preplanning process for facility projects requiring major capital outlays. Preplanning is a recognized industry best practice that is applicable to different types of facilities, technologies, and projects (DuPont, 1995). It is intended to meet many stakeholder needs, to avoid injuries, and to save time and money.

PREPLANNING PROCESS

Outlined below are some key elements of a generic preplanning process that can be addressed concurrently. For each project, the development of additional supporting detail for these elements is led by the owner and contractor project leader:

- agreed-upon and documented project definition, including a procedure for updating if the definition changes
- initial and documented assessment of high hazards
- agreed-upon and documented scope that matches project definition
- site selection process: location, orientation, closure thinking
- cost estimate complete prior to starting work, with agreed-upon cost control plan
- funding and financial strategy to manage project cash flows
- agreed-upon schedule plan and procedures for assessing and altering schedule
- thorough safety, health, and environmental planning for project personnel and neighbors, including ergonomic, worker protection, and ecosystem assessments
- information technology plan that includes documentation, data sharing, and a process for collaboration among sites
- inclusive identification of project teams and training in teamwork roles and responsibilities
- assessment of the state of project technology and a plan to mitigate uncertainties
- construction or demolition plan that includes needed heavy lifts, restricted access, and special permits
- permitting plan covering environmental, construction/demolition, occupancy, and other requirements
- special equipment plan for unique fabrications or tools required and for tracking material and equipment with long delivery times
- maintenance plan that takes into account reliability of processes
- operations plan that includes operations planning/facilities loading and readiness to operate
- procurement/acquisition plan
- personnel plan covering hiring, training, reward and recognition, change management, work environment, retention and morale
- process for identifying hurdles and including a process for approving baseline changes
- crisis management and contingency plans that spell out procedures to manage emergencies, including roles and responsibilities, communication needs, who makes what decisions, who deals with authorities, and who manages press contacts
- community involvement plan

- dismantlement and closure plan for final disposition of site, equipment, and personnel

SPECIFIC CLOSURE LESSONS LEARNED FROM THE JACADS EXPERIENCE

The following lessons learned became apparent to the committee during its review of JACADS closure activities to date:

- Planning for closure should take place from the very beginning, that is, at project conception, through design, and throughout the operations and closure phases. This planning should be reflected as early as possible in the operating RCRA permit. Also, to the maximum extent practical, secondary wastes should be identified in the initial RCRA permit so disposal can be done continuously and concurrently with operations.
- End use and end state must be determined at the earliest possible time during the assessment and decision making stages to facilitate planning.
- Public outreach, including an in-place emergency plan, is essential throughout the operations and closure planning process.
- Planning should include resource allocation, if necessary, as well as a program to retain key personnel.
- To facilitate cost control, a total project technical baseline should be established at the earliest possible time; from this, a cost and schedule baseline can be developed and maintained throughout the project.
- Integrated project team (IPT) meetings provide a useful forum for both intra-agency and interagency communication. The purposes of these meetings must be understood by those involved if maximum benefit is to be obtained. The role and responsibilities of each individual attending the meeting should be carefully addressed. Initially, JACADS IPT meetings were small and focused on coordinating actions; they evolved into very large meetings that had significant logistical requirements and more of an educational and public information role.
- Early involvement of EPA and other stakeholders in closure planning is essential.
- Contingency planning and training are crucial to maintaining safe operating conditions during closure.
- Procurement during operations requires review and coordination to ensure against generating new wastes requiring special treatment, perhaps even permit modification.
- As-built drawings and photographs made during construction are of great value in closure planning. They should be created according to a plan during construction and any plant modification, and carefully filed for use during closure planning and execution.
- The final closure reports will be of significant value in closure planning for other sites. In addition, any supplementary reports that are prepared, such as lessons learned, would also be of value.
- The closure section of the original JACADS RCRA permit required significant modification; a detailed and complete closure plan should be incorporated into the permit for other sites. Early permit modification requests should be processed to minimize surprises and delays near the end.
- A high premium should be placed on capturing and disseminating lessons learned from JACADS closure. To the extent possible, other disposal sites could incorporate applicable JACADS experience in their original permit applications or in early permit modifications; doing so would help avert indecision and potential schedule delays and additional cost impacts associated with late permit modification development and processing.
- Careful attention must be paid during the planning phase to the identification of all waste streams to facilitate timely permit processing.
- Early efforts are required to identify appropriate points of contact, especially with outside agencies such as EPA.
- The structure for disseminating information from JACADS to other sites is important and needs to be improved. In particular, the Army should have a well-defined means of making key personnel, such as the plant manager and the closure manager, available periodically to the other sites and other PMCD contractors for information exchange.

7

Findings and Recommendations

DECISION MAKING AND PROJECT PLANNING

Finding 1. The initial JACADS closure plan was developed late and was not comprehensive. Preproject planning and early decision making by management are necessary to support the closure of all chemical agent disposal facilities. A comprehensive, facility-wide, integrated closure plan could have had significant overall cost benefits at JACADS. The plans did not provide detailed information on new required standard operating procedures, nor did they provide training for personnel carrying out the closure tasks in this new environment.

Recommendation 1. The Army should prepare a comprehensive closure strategy for each chemical agent disposal facility. The strategy would provide for responsible project and contractor management personnel to be trained in preproject planning. A comprehensive, integrated closure plan should be developed for each disposal site and surrounding area based on realistic assumptions at the time the facility is designed or as soon as possible if it is in construction or operation. This plan should provide for appropriate standard operating procedures and personnel training for the anticipated activities.

Finding 2. Decisions on the end use and identification of the ultimate owner of Johnston Island or other chemical disposal facilities have not been reached in a timely way. For JACADS, the need for prompt action on this matter at a high level was pointed out in a letter report of this committee dated May 4, 2000 (NRC, 2000a). Regulatory requirements and analytical procedures/protocols to meet end-state requirements for JACADS were not completed as of the writing of this report.

Recommendation 2. The end state, end use, and stewardship issues pertaining to closure of any chemical agent disposal facility should be resolved early so that planning can proceed on an assured rather than an assumed basis. If possible, facility end uses should be included in the RCRA operating permit. If end use and end state cannot be defined early in the planning process, risk assessments and cost and schedule estimates for alternative end states and uses should be prepared.

Finding 3. Closure of any chemical agent disposal facility necessitates the identification of potential exposure pathways and environmental receptors in an initial conceptual site model. Closure of JACADS has been complicated because this was not done early and the end use will not be determined until much of the closure planning has been completed.

Recommendation 3. Development of a conceptual site model should include identification of potential exposure pathways for receptors, their impacts, if any, the risks to be mitigated, and the means of mitigation. Such a conceptual site model should be reviewed and agreed to by the various stakeholders early in the planning phase and before submission of the overall closure plan to the regulatory agency for approval. The RCRA operating permit for the facility should be amended as early as possible to include closure criteria, closure sampling criteria, and mitigation methods. This information could be in the initial operating permit. At the latest, it should be developed while agent disposal operations are under way.

Finding 4. The closure plan is incomplete in that it does not sufficiently address contingencies such as control of spills, dust, or special materials such as asbestos, nor does it specify countermeasures for mitigation of these potential situations. Moreover, the hazardous waste management units (HWMUs) at JACADS and the Red Hat Storage Area differ in the chemicals to be analyzed, their management and associated cleanup levels, and required permit modifications, because new unidentified secondary waste may be generated during decommissioning and closure.

Recommendation 4a. The closure plan must include a consideration of storage, handling, and ultimate disposal of wastes generated from JACADS closure, including provisions for temporary staging and transportation on-site and off-site.

Recommendation 4b. To promote the development and implementation of contingency responses during both closure and postclosure operations, control strategies for unexpected liquid runoff or particle dispersion, as well as for special hazardous substances—such as asbestos—should be integrated in the closure plan.

Finding 5. Stockpile disposal facilities that do not use components of the baseline incineration system, or modified versions of it, lack a means to achieve thermal decontamination of secondary wastes during closure operations.

Recommendation 5. The Army should proceed as soon as possible to develop means to address secondary waste processing/disposal issues at sites employing disposal technologies other than incineration, and should seek early regulatory and stakeholder approval for such means.

PERSONNEL RETENTION

Finding 6. The loss of experienced personnel prior to completion of closure could jeopardize the cost-effective and safe implementation of closure plans. Fostering personnel retention during facility closure could present a challenge, particularly if the contractor responsible for closure is different from the one responsible for operations.

Recommendation 6. The Army and its contractors for operating chemical agent disposal facilities should develop and adopt a strategy for personnel retention at project inception. The strategy should consider hiring procedures, training (including lessons learned), career development, reward and recognition, management of change, the work environment, retention incentives, and employee morale.

ACQUISITION STRATEGY AND PROCUREMENT

Finding 7. The procurement strategy proposed for closure of the JACADS facility appears to be workable; however, the contracting mechanism is awkward and inherently inefficient.

Recommendation 7. The Program Manager for Chemical Demilitarization should continue to work with the Operations Support Command to make procurement processing as efficient and responsive as possible.

Finding 8. The contract for closure at JACADS is expected to have an award fee based on meeting the schedule for closure.

Recommendation 8. Future contracts should consider all aspects of performance, including (but not limited to) safety, cost, and schedule, in setting criteria for the award fee.

COST CONTROL

Finding 9. Cost containment efforts in the closure of JACADS are fragmented and have been inhibited by the absence of a total project cost baseline estimate for the Army and all contractors supporting closure activities. A multiyear program cost estimate and schedule that encompasses all closure costs is essential for the cost-effective completion of the JACADS closure campaign. Costs will probably change as the closure project evolves.

Recommendation 9. The Army should develop an earned value system to maintain a comprehensive multiyear cost and schedule for the construction, operation, and closure of each chemical agent disposal facility. The system should be used to control and report the effect on cost and schedule from changes such as permit modifications, proposals for engineering changes, and the phaseout of security for surety material.

Finding 10. Prudent management requires early decisions, accurate assumptions, and full consideration of all cost components, regardless of the entity incurring them, and cost estimates that approach the actual final costs. Project cost control procedures and contract incentives were not established as part of the JACADS contract.

Recommendation 10. The Program Manager for Chemical Demilitarization should assure that for future site closures, all means at his disposal, including JACADS lessons learned, are applied early and continuously to estimate costs more accurately, thus facilitating project management and executive and congressional oversight. This should include the establishment of cost control procedures and contract incentives during development of the relevant contracts.

MONITORING

Finding 11. Contamination at JACADS by multiple agents and agent degradation products is a certainty, but the extent is unknown. At JACADS, weapons and bulk stores containing GB, HD, and VX were destroyed. Any or all of these agents and their degradation products may be present in the munitions demilitarization building, in secondary stored wastes such as used DPE suits, and in spent carbon from air filters. Intrusion of agent into the epoxy coating and concrete floor slabs in processing rooms is likely, and contamination is likely in niches, recesses, joints, and cracks, as well as within process equipment, lines, and valves. There will also be contaminated carbon from the plant air ventilation filter system.

Recommendation 11. Near-real-time monitors (ACAMS) for all three chemical agents (GB, HD, and VX) should be provided to protect workers in any areas where they might be exposed to agent during dismantlement activities or during the handling and treatment of secondary wastes. Multiagent monitoring should also be provided for the common stack.

Finding 12. By rigid adherence to definitions and terminology prescribed by Army regulations on decontamination levels, the Army has failed to communicate clearly with external agencies holding regulatory responsibility or with members of the knowledgeable, interested public. Steps can and should be taken to improve communications in this important area.

Recommendation 12. The Army should either seek relief from the internal regulation prescribing use of the 1X, 3X, 5X, and 5R terms or augment its use of these designators with scientifically derived terms that communicate clearly with external regulators and interested stakeholders. Ideally, EPA standards (or actual values) should be the primary reporting values, with “X” and “R” designations as secondary reporting values.

Finding 13. The sampling and analysis plan for closure, and the need to increase the number of DAAMS tubes to monitor all three agents, will require a substantial increase in the numbers and kinds of chemical analyses.

Recommendation 13. The Army should estimate the numbers of chemical analyses of each kind that will be required as closure proceeds and ensure that adequate instrumentation, laboratory space, and personnel will be available to handle them.

Finding 14. Analytical procedures for the chemical agents and their most toxic degradation products have not been specified and may need to be developed, particularly when these agents and products occur in media such as concrete, soils, and spent carbon.

Recommendation 14. The Army should demonstrate that it has the ability to analyze for agents and their toxic degradation products in concrete, soil, and spent carbon, and to provide assurance that any structures or media left in place will be decontaminated consistent with the island’s future use.

SECURITY

Finding 15. Security requirements for Johnston Atoll following the departure of USACAP include (1) protection of personnel, facilities, and materiel, (2) prevention of pilferage, unauthorized use, sabotage, and violation of community rules and regulations, and (3) prevention of unauthorized entry and trespass from either air or sea until the island’s end state has been reached and final ownership has been established.

Recommendation 15. Security measures on Johnston Atoll commensurate with personnel safety and the protection of government and personal property should be maintained throughout the closure process.

SAFETY

Finding 16. Experience gained at JACADS will establish precedents for closure planning at chemical agent disposal facilities in the continental United States. Unusual and unanticipated events during JACADS closure, including those from construction- and demolition-related activities and those due to the inexperience of some workers with these activities, will likely be used by regulatory authorities in setting requirements for closures at other facilities.

Recommendation 16. The detailed plans for decommissioning, dismantlement, and demolition of chemical agent disposal facilities should examine all levels of activity, e.g., task procedures, utility requirements, personnel training, and safety considerations. The examination should include consideration of daily task planning and identification of risk factors inherent in each planned activity and worker adherence to procedures. It should also develop contingency scenarios and intended responses so as to achieve the highest degree of safety and lowest probability of disruptive, unplanned situations. Prompt investigation, reporting, and analysis of every accident and near miss should be ensured, with all safety data assembled in a lessons learned format easily accessible to future closure campaign supervisors and planners.

Finding 17. The introduction of new structural risks during closure operations is a potential source of accidents. Dismantlement and removal of building structural components, such as the concrete floors of the explosion containment rooms, could pose added risks of structural instability during closure operations, as could temporary loadings from stacked materials or heavy equipment.

Recommendation 17. Throughout closure operations, the sequence and extent of building demolition should be planned to ensure continuous separation of contaminated waste from uncontaminated waste. Professional engineers should review the proposed sequence and extent of demolition actions. The effects of demolition on structural integrity in the event of a contingency condition (such as a typhoon) should be considered. A system of work permits and controls should be established for operation of heavy equipment within structures and for sizing and locating material stockpiles.

Finding 18. During closure, utility service becomes less dependable with the changing configuration of a facility. Also, adverse interactions of materials handling and lifting equipment with ongoing changes in building structures and utility distribution systems can create unique risks.

Recommendation 18. The Army should carefully assess the need for redundancy in utility systems so that needed utilities are available for planned operations. Special training may be necessary to assure the safe use of lifting equipment and to preclude utility system failure.

PUBLIC AFFAIRS AND PUBLIC INVOLVEMENT

Finding 19. The Army has made great strides in the public relations and outreach elements of its public affairs program in support of JACADS, identifying external stakeholders, communicating with them, establishing credibility, and satisfying their needs—often by going well beyond minimal requirements. Completing closure of JACADS as rapidly as possible, and with full regard for safety and the environment, appears in the best interest of the public and the Army. Also, the Army has gone to considerable expense to hold meetings in Hawaii, to sponsor travel to Johnston Island for inspections and discussions, to hold meetings in South Pacific island regions in the vicinity of Johnston Island, and to maintain stakeholder contact. As the Army moves forward with the third element of its comprehensive public affairs program, public involvement, there are measures it can take to continue to improve its results.

Recommendation 19. The Program Manager for Chemical Demilitarization should continue to do the following:

- Maintain contact by multiple means with all stakeholders, taking appropriate public outreach initiatives as the transition from operations to closure occurs.
- Press for opportunities for effective public involvement in closure planning and implementation.
- Press for end-use and end-state criteria as vigorously as possible and communicate this information to stakeholders along with notices of important operational accomplishments.
- Ensure that, as progress in the closure of JACADS continues, the information is disseminated to all stakeholders, especially to communities near other sites.
- Seek coordinated, interagency support for outreach efforts to facilitate the clarity, candor, and consistency of disseminated information at all disposal sites.

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Appendixes

Appendix A

Reports by the Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program (Stockpile Committee)

Comments on Operational Verification Test and Evaluation Master Plan for the Johnston Atoll Chemical Agent Disposal System (JACADS) (1989)

Demilitarization of Chemical Weapons: Cryofracture (1989)

Demilitarization of Chemical Weapons: On-Site Handling of Munitions (1989)

Workshop on the pollution abatement system of the chemical agent demilitarization system (Letter Report, May 1991)

Comments on proposed cryofracture program testing (Letter Report, August 1991)

Letter report on siting of a cryofracture chemical stockpile facility (August 1991)

Review of the MITRE report: Evaluation of the GB Rocket Campaign: Johnston Atoll Chemical Agent Disposal System Operational Verification Testing, dated May 1991 (Letter Report, September 1991)

Review of the choice and status of incineration for destruction of the chemical stockpile (Letter Report, June 1992)

Letter report to recommend specific actions to further enhance the CSDP [Chemical Stockpile Disposal Program] risk management process (January 1993)

Evaluation of the Johnston Atoll Chemical Agent Disposal System Operational Verification Testing: Part I (Letter Report, July 1993)

Recommendations for the Disposal of Chemical Agents and Munitions (February 1994)

Evaluation of the Johnston Atoll Chemical Agent Disposal System Operational Verification Testing: Part II (April 1994)

Review of Monitoring Activities Within the Army Chemical Stockpile Disposal Program (April 1994)

Evaluation of the Army's Draft Assessment Criteria to Aid in the Selection of Alternative Technologies for Chemical Demilitarization (December 1995)

Review of Systemization of the Tooele Chemical Agent Disposal Facility (March 1996)

Public Involvement and the Army Chemical Stockpile Disposal Program (Letter Report, October 1996)

Risk Assessment and Management at Deseret Chemical Depot and the Tooele Chemical Agent Disposal Facility (September 1997)

Using Supercritical Water Oxidation to Treat Hydrolysate from VX Neutralization (May 1998)

Carbon Filtration for Reducing Emissions from Chemical Agent Incineration (July 1999)

Tooele Chemical Agent Disposal Facility: Update on National Research Council Recommendations (November 1999)

Obstacles to Closure of the Johnston Atoll Chemical Agent Disposal System (Letter Report, April 2000)

Integrated Design of Alternative Technologies for Bulk-Only Chemical Agent Disposal Facilities (May 2000)

A Review of the Army's Public Affairs Efforts in Support of the Chemical Stockpile Disposal Program (Letter Report, November 2000)

Assessment of Supercritical Water Oxidation Technology Development for Treatment of VX Hydrolysate at the Newport Chemical Agent Disposal Facility (Letter Report, January 2001)

Occupational Health and Workplace Monitoring at Chemical Agent Disposal Facilities (June 2001)

A Modified Baseline Incineration Process for Mustard Projectiles at Pueblo Chemical Depot (August 2001)

Update on NRC Recommendations for a Modified Baseline Process at Pueblo Chemical Depot (February 2002)

Appendix B

Biographical Sketches of Committee Members

Peter B. Lederman (*Chair*), retired executive director of the Hazardous Substances Management Research Center and executive director of the Office of Intellectual Property, is research professor of chemical engineering and environmental policy at the New Jersey Institute of Technology. He received his Ph.D. in chemical engineering from the University of Michigan. Dr. Lederman has 48 years of experience in all facets of environmental management, control, and policy development; hazardous substance treatment and management; and process engineering; and he has more than 18 years of experience as an educator. He is a registered professional engineer and a diplomate of the American Academy of Environmental Engineers. Dr. Lederman has worked on environmental policy at the federal and state levels and has served on several National Research Council committees, most recently the Committee on Decontamination and Decommissioning of Gaseous Diffusion Plants.

Charles I. McGinnis (*Vice Chair*) has an M.Engr. from Texas A&M University. After retiring from the U.S. Army as a major general and a former director of civil works for the U.S. Army Corps of Engineers, he served in senior positions at the Construction Industry Institute in Austin, Texas. He was also director of engineering and construction for the Panama Canal Company and was subsequently vice president of the company and lieutenant governor of the Canal Zone. As director of civil works for the U.S. Army Corps of Engineers, he was responsible for a $3 billion per year budget for the planning, design, construction, operation, and maintenance of public works nationwide. He is a registered professional engineer in Texas and Missouri.

David H. Archer, a member of the National Academy of Engineering, has a Ph.D. in chemical engineering and mathematics from the University of Delaware. He is a retired consulting engineer with the Westinghouse Electric Company and is currently adjunct professor at Carnegie Mellon University. Dr. Archer has worked in both industry (at Westinghouse as an engineer, supervising engineer, department manager, and consulting engineer) and academia (at the University of Delaware and Carnegie Mellon University for almost 10 years). He has considerable experience in research and management related to chemical engineering, as well as experience with combustion and plant management.

Piero M. Armenante has a Ph.D. in chemical engineering from the University of Virginia and is currently Distinguished Professor of Chemical Engineering at the New Jersey Institute of Technology and director of the Northeast Hazardous Substance Research Center, a seven-university center funded by the Environmental Protection Agency. Dr. Armenante's research interests include multiphase mixing in agitated systems, the biological treatment of hazardous waste, industrial sterilization processes, and biomedical engineering. He has an extensive list of peer-reviewed and other publications and has administered numerous grants, studies, and projects.

Jerry L.R. Chandler has a Ph.D. in biochemistry from Oklahoma State University and has done extensive postgraduate study in mathematics. He is currently a research professor at the Krasnow Institute for Advanced Study at George Mason University. During his long career, Dr. Chandler served with the U.S. Public Health Service, the National Institute for Occupational Safety and Health (NIOSH), the Food and Drug Administration, and the National Cancer Institute Epidemiology Program. More recently, he was a neuropharmacologist in the Epilepsy Branch of the National Institute of Neurology and Strokes of the National Institutes of Health. Dr. Chandler is a founding member and president of the Washington Evolutionary Systems Society and has published extensively on using mathematical category theory to understand the origins of disease. He previously served as a

NIOSH observer with the Panel on Risk Assessment of the National Research Council.

John J. Costolnick graduated from Northwestern University with an M.S. in chemical engineering and is a registered professional engineer. He retired as vice president of engineering at Exxon Chemical Company, where he worked for more than 35 years in positions of increasing responsibility, from manufacturing manager and plant manager to vice president for agricultural chemicals and vice president for basic chemical technology. Mr. Costolnick's areas of expertise are chemical operations and manufacturing.

Frank P. Crimi is a part-time consultant and retired vice president of Lockheed Martin Advanced Environmental Systems Company. He has a B.S. in mechanical engineering from Ohio University and has done graduate studies in mechanical engineering at Union College in Schenectady, New York. Mr. Crimi was appointed to the National Research Council's Committee on Decontamination and Decommissioning of Uranium Enrichment Facilities and has firsthand knowledge of and experience with radioactive- and hazardous-waste treatment and disposal technologies.

Elisabeth M. Drake, a member of the NAE, graduated from Massachusetts Institute of Technology with a Ph.D. in chemical engineering. She retired in 2000 as the associate director of the M.I.T. Energy Laboratory. She has had considerable experience in risk management and communication, in technology associated with the transport, processing, storage, and disposal of hazardous materials, and in chemical engineering process design and control systems. She has served on several NRC committees relating to chemical demilitarization. Dr. Drake has a special interest in the interactions between technology and the environment. She belongs to a number of environmental organizations, including the Audubon Society, and the National Wildlife Federation.

Michael R. Greenberg is a professor in the Department of Urban Studies and Community Health at Rutgers, the State University of New Jersey, and an adjunct professor of environmental and community medicine at the Robert Wood Johnson Medical School. His principal research and teaching interests include urbanization, industrialization, and environmental health policy. Dr. Greenberg holds a B.A. in mathematics and history, an M.A. in urban geography, and a Ph.D. in environmental and medical geography.

Deborah L. Grubbe graduated from Purdue University with a B.S. in chemical engineering and received a Winston Churchill Fellowship to attend Cambridge University in England, where she received a Certificate of Postgraduate Study in chemical engineering. She is a registered professional engineer and engineer of record for DuPont, where she is currently corporate director for safety and health. Previously, she was operations and engineering director for DuPont Nonwovens, where she was responsible for manufacturing, engineering, safety, environmental, and information systems. She is a board member of the American Institute of Chemical Engineers' Engineering and Construction Contracting Division and has led several committees of the Construction Industry Institute. Her areas of expertise are safety, chemical manufacturing technology, and project management and execution.

David A. Hoecke, who graduated from Cooper Union with a B.S.M.E., is currently president and chief executive officer of Enercon Systems, Inc. His expertise is in the fields of waste combustion, pyrolysis, heat transfer, and gas cleaning. In 1960, Mr. Hoecke began working for Midland-Ross Corporation as a project engineer, rising to chief engineer for incineration by 1972. At that time, he founded his own company, where he has been responsible for the design and construction of numerous combustion systems, including solid waste incinerators, thermal oxidizers, heat recovery systems, and gas-to-air heat exchangers.

David H. Johnson graduated from the Massachusetts Institute of Technology with an Sc.D. in nuclear engineering. Currently senior vice president and general manager of ABS Consulting. Dr. Johnson has more than 20 years of experience in risk-based analysis for industry and government applications. His area of expertise is probabilistic risk assessments, including probabilistic modeling and investigation of the impacts of industrial projects.

Gary L. Lage is the founding principal of ToxiLogics, Inc., where he is responsible for incorporating the current data on the toxicology of chemicals and modern risk assessment into scientific decisions. For 20 years, he was an educator at the University of Kansas, the University of Wisconsin, and the Philadelphia College of Pharmacy and Science, where he taught pharmacology and toxicology. Dr. Lage was project director, vice president, and practice leader for human health practice at the Roy F. Weston Company for 4 years and a principal in the human health practice area with ENVIRON Corporation. He is a diplomate of the American Board of Toxicology and has a Ph.D. in pharmacology from the University of Iowa.

John L. Margrave, a member of the National Academy of Sciences, graduated from the University of Kansas with a B.S. in engineering physics and a Ph.D. in physical chemistry. Dr. Margrave is currently the chief scientific officer at the Houston Advanced Research Center and the E.D. Butcher Professor of Chemistry at Rice University. His expertise is in high-temperature chemistry, materials science, environmental chemistry, and nanoscience technology. His research interests include various areas of physical/inorganic chemistry, including matrix-isolation spectroscopy/metal atom chemistry; high-temperature chemistry, including mass spectrometry; high-pressure chemistry; environmental chemistry; and nanoscience/technology. Dr. Margrave has previously served on an NRC committee that completed a study in the chemical demilitarization area.

James F. Mathis, a member of the National Academy of Engineering, graduated from the University of Wisconsin with a Ph.D. in chemical engineering. Dr. Mathis was vice president of science and technology for Exxon Corporation, where he was responsible for worldwide research and development programs, and chair of the New Jersey Commission on Science and Technology until his retirement in 1984. Dr. Mathis's expertise is in research and development and chemical engineering.

Frederick G. Pohland, a member of the National Academy of Engineering, graduated from Purdue University with a Ph.D. in environmental engineering and is currently professor and Edward R. Weidlein Chair of Environmental Engineering at the University of Pittsburgh, as well as director of the Engineering Center for Environment and Energy and codirector of the Groundwater Remediation Technologies Analysis Center. He is a registered professional engineer and a diplomate environmental engineer and has taught and written extensively on solid and hazardous waste management, environmental impact assessment, and innovative technologies for waste minimization, treatment, and environmental remediation. Dr. Pohland has expertise in minimizing the impacts of hazardous waste on workers, the public, and the environment.

Robert B. Puyear graduated from Missouri School of Mines and Metallurgy with a B.S. in chemical engineering and from Purdue University with an M.S. in industrial administration. He is currently a consultant specializing in corrosion prevention and control, failure analysis, and materials selection. Mr. Puyear worked for Union Carbide for 16 years developing high-performance materials for chemical and aerospace applications and for Monsanto for 21 years as a corrosion specialist, where he managed the Mechanical and Materials Engineering Section. He is an expert in materials engineering and evaluating materials of construction.

Charles F. Reinhardt, who has an M.D. from Indiana University School of Medicine and an M.Sc. in occupational medicine from Ohio State University School of Medicine, retired after more than 30 years with the DuPont Company. Dr. Reinhardt joined DuPont's Haskell Laboratory in 1966, first as a physiologist, then as chief of the physiology section, and then as research manager for environmental sciences. In 1971, he became assistant director of the laboratory and in 1976 was named its director, a position he held until his retirement in 1996. Dr. Reinhardt has served on numerous National Research Council panels and committees, including the Committee on Toxicology. His areas of expertise are occupational medicine and toxicology.

Kenneth F. Reinschmidt, a member of the National Academy of Engineering and a graduate of Massachusetts Institute of Technology with a Ph.D. in engineering, is currently a consultant specializing in management of engineering, design, and construction projects; project and technology risk analysis; and project simulation and modeling. For 21 years, he worked at Stone & Webster, Inc., from which he retired as senior vice president in 1996. He also taught civil engineering at Massachusetts Institute of Technology for 10 years. Dr. Reinschmidt's expertise is in project design, development, and construction.

W. Leigh Short earned his Ph.D. in chemical engineering from the University of Michigan. He retired as a principal and vice president of Woodward-Clyde, where he was responsible for management and business development 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, site remediation, and project management. He has taught courses in control technologies, both to graduate students and as a part of the Environmental Protection Agency's (EPA's) national training programs. He has also served as chairman of the EPA's NO*x* Control Technology Review Panel.

Jeffrey I. Steinfeld graduated from the Massachusetts Institute of Technology (MIT) with a B.S. in chemistry and from Harvard University with a Ph.D. in physical chemistry and is currently professor of chemistry at MIT, where he has taught for almost 35 years. Dr. Steinfeld's expertise is in high-sensitivity monitoring techniques, pollution prevention, and environmental research and education, as well as bringing scientific knowledge into environmental decision making via stakeholder involvement.

Chadwick A. Tolman received his Ph.D. in physical chemistry from the University of California at Berkeley and until recently was a program officer in organic and macromolecular chemistry in the Division of Chemistry of the National Science Foundation. He is now a staff officer at the National Research Council Board on Environmental Studies and Toxicology. He has extensive experience and expertise in chemistry and chemical process development. Dr. Tolman spent 31 years in Central Research at the DuPont Experimental Station. His work has spanned a broad range of subjects, including hydrocarbon oxidation, organometallic chemistry, and the destruction of toxic organic compounds in wastewater.

Rae Zimmerman, with an A.B. in chemistry from the University of California at Berkeley, masters in city planning from the University of Pennsylvania, and a Ph.D. in planning from Columbia University, is currently Professor of Planning and Public Administration and Director, Institute for Civil Infrastructure Systems (ICIS) at the Robert F. Wagner Graduate School of Public Service of New York University. She has directed and/or advised federal, state and local government agencies on planning and implementation of environmental policies, programs, and plans. With projects in the areas of environmental impact assessment, socioeconomic, community and land use impact evaluations, risk assessment, institutional analysis (legal, financial, and administrative), permitting and regulatory support, public participation and/or public perception studies, she has been involved in extensive development and implementation of public participation and communication programs for government-sponsored water resources projects and hazardous waste cleanup in connection with environmental permits, plans and environmental impact statements. She is a Fellow of the American Association for the Advancement of Science and a past president of the Society for Risk Analysis.

Appendix C

Closure Planning and Implementation

Table C-1 lists activities that are likely relevant to closure of any industrial or government facility. Not all of the activities are necessarily applicable to a particular closure situation. The indented items in the table are primarily illustrative and are not intended to be all inclusive, but rather to indicate the types of activities required at those stages of the closure process under which they appear.

The planning phase consists of (1) an assessment and decision-making period in which general overall objectives and criteria are formulated and (2) a closure plan development period when plans are formulated and written. In practice, there can be considerable overlap between assessment and decision making as a detailed plan is developed.

The implementation phase can be viewed as a period of actual closure operations, followed by facility closeout (postmortem). Here, too, there may be some overlap of the two activities. Finally, the facility site may undergo postclosure activities in accordance with agreed-upon regulatory requirements.

TABLE C-1 Closure Planning and Implementation Activities

Planning Phase		Field Implementation Phase		
Assessment and Decision Making	Closure Plan Development	Closure Operation	Facility Closeout	Postclosure Activities
Establish closure objectives	Finalize end-state requirements	System decontamination	Perform area sampling and analyses	Periodic monitoring and sampling per regulatory requirements
Determine facility end use	Establish acquisition strategy	Removal of systems, structures, and components	Issue closure report and facility certification	
Establish regulatory requirements	Complete engineering plans	Monitoring of areas, workers, and materials	Regulatory reviews	
Establish cost and schedule goals	Technical baseline	Waste management activities	Facility released for end use	
Characterization	Permits and licenses	Concurrent coprocessing	Publish lessons learned	
Obtain samples and analyses	Waste quantities and management plan	Program closure activities and operations		
Identify technology needs	Decontamination plan	Enforce worker safety		
Evaluate closure alternatives	Sampling and analysis plan	Install special systems (e.g., CMS)		
Decision making	D&D sequence	Partial release of areas to EPA closure criteria		
Select closure alternative	Develop schedule baseline			
Establish schedule and funding profile	Develop cost baseline and manpower estimates			
Establish public and community communications program	Develop health and safety plan			
	Develop special technology			
	Prepare facility closure plan			
	Implement quality assurance plan			

Appendix D

JACADS Sampling and Analysis Plan Maps and Photographs

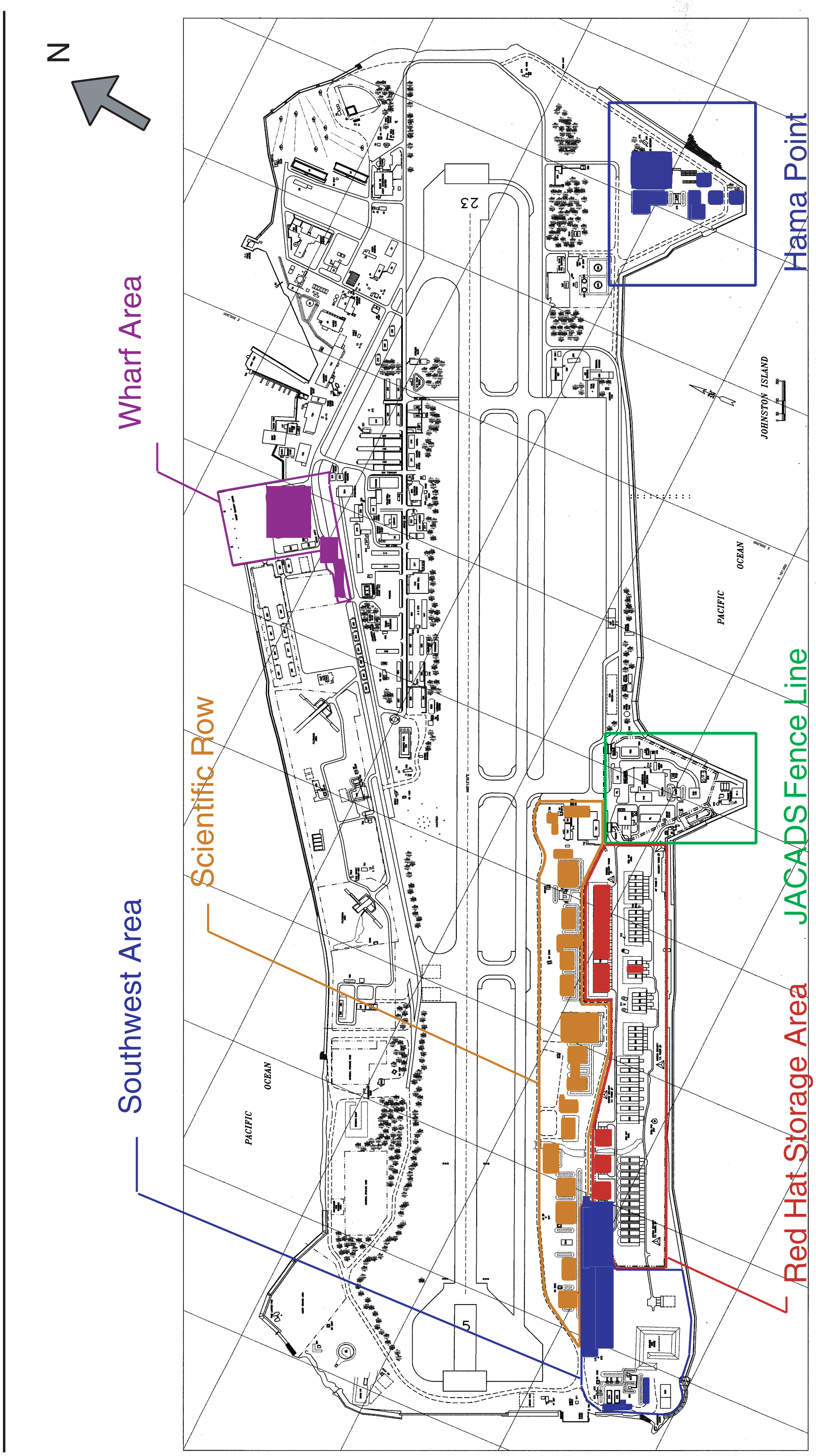
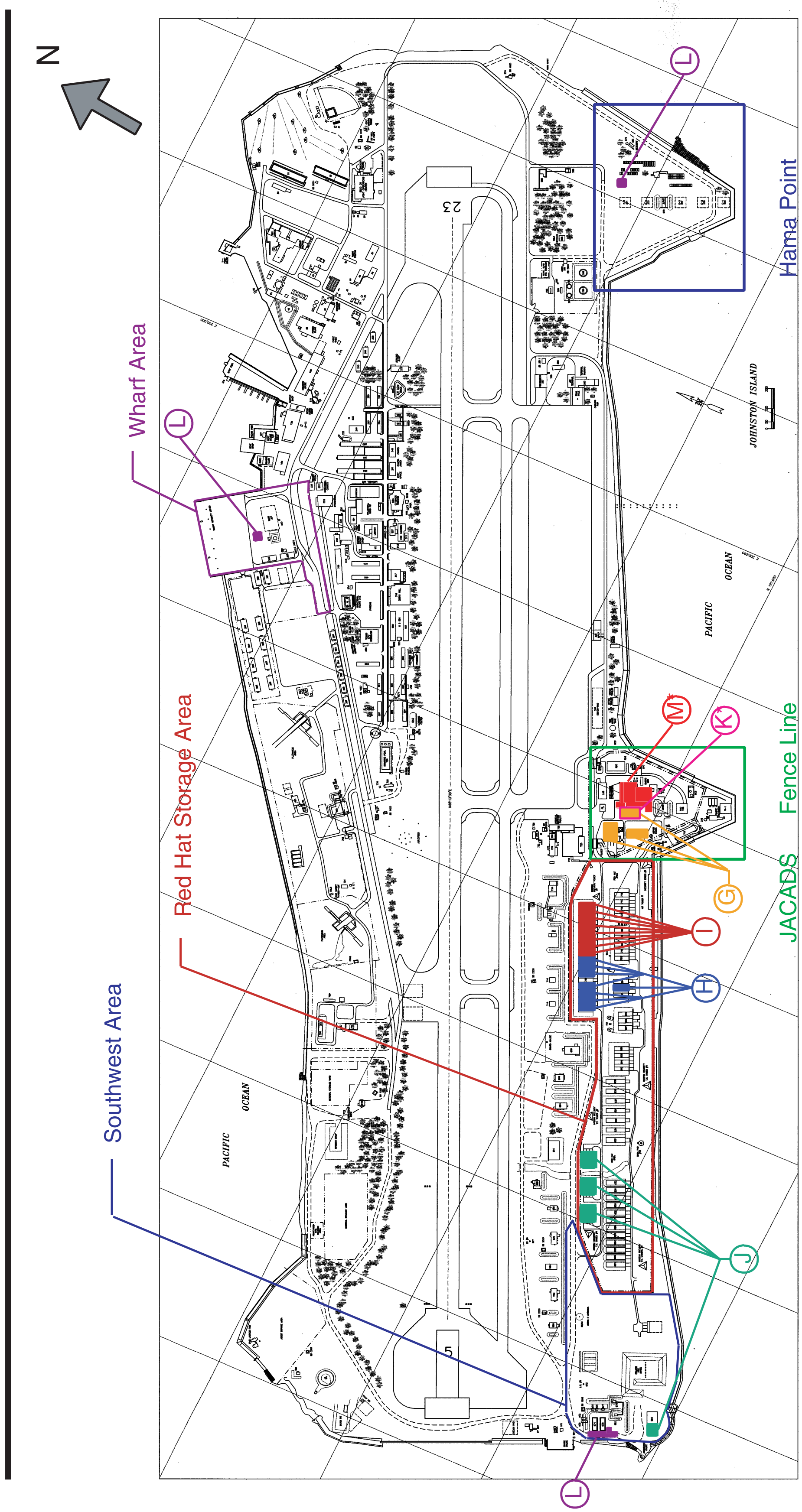


PLATE D-1 Location of areas on Johnston Island.

PLATE D-2 Location of hazardous waste management units within the Red Hat Storage Area.



* NOTE Stratum indicates subsurface sampling under the unit

PLATE D-3 Sampling strata G, H, I, J, K, L, M—areas outside the munitions demilitarization building. Note: Stratum indicates subsurface sampling under the unit.

(a) West Side of Building 850

(b) South Side of Building 850

(c) Drum Storage

(d) Drum Storage (1X Contaminated Waste)

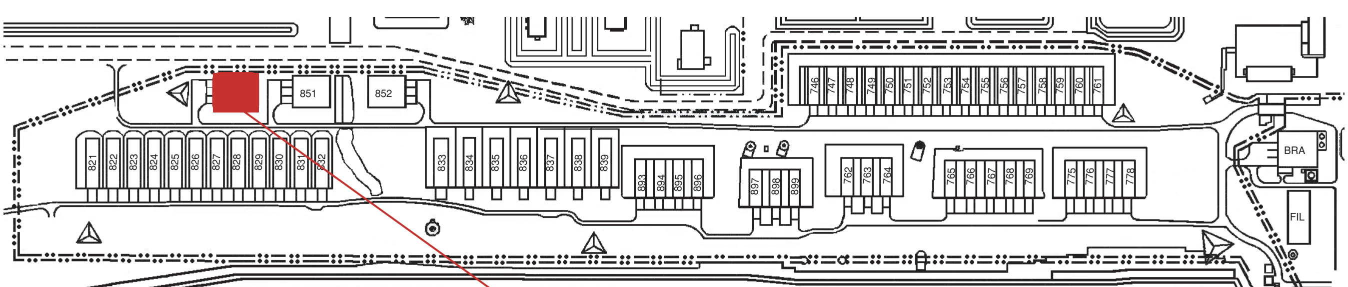


PLATE D-4 Red Hat building 850 (SWMU No. 13).

(a) West Entrance to Building 851

(b) Drum Storage Inside Building 851

(c) Drum Storage Inside Building 851

(d) Drum Storage Inside Building 851

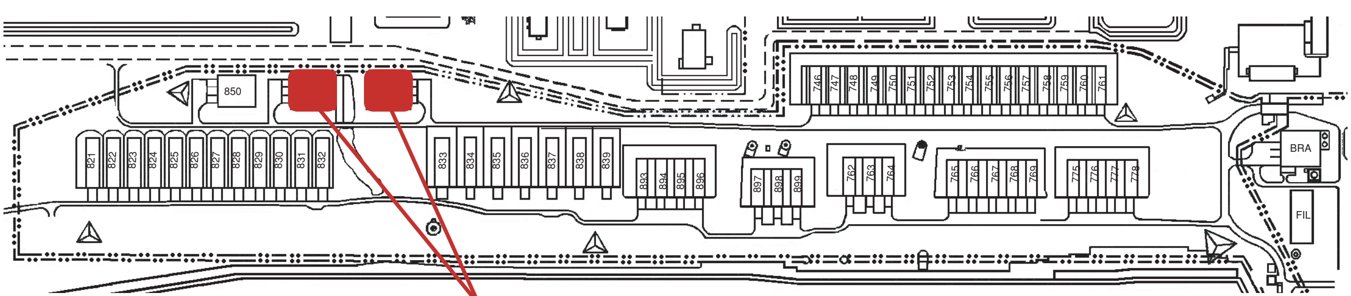


PLATE D-5 Red Hat Area hazardous waste storage warehouse, Building 851 (SWMU No. U21).

(a) East Entrance to Building 851 and Drainage Culvert

(b) Drainage Culvert Between Buildings 851 & 852

(c) Southeast Corner of Building 852

(d) Conex and Drum Storage Inside Building 852

(e) USACAP Storage on North Side of Building 852

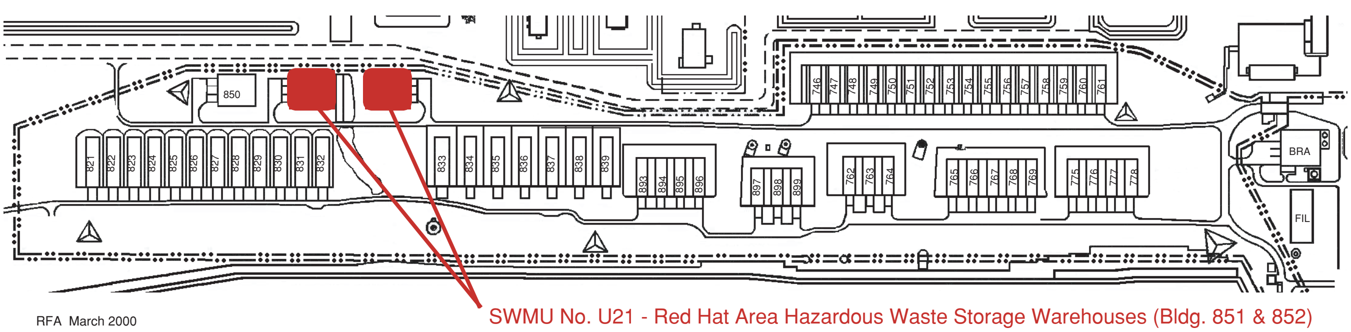


PLATE D-6 Red Hat Area hazardous waste storage warehouse, Building 852 (SWMU No. U21).

Appendix E

Examples of Information Required for Two Types of Final Closure Survey Reports

As JACADS solid waste management units (SWMUs) are remediated, samples will have to be collected, identified, and analyzed to determine if EPA-approved closure end points have been met. The complete list of contaminants that will be evaluated should be included in the RCRA Facility Investigation (RFI) Sampling and Analysis Plan and the final sampling results presented to EPA in a RCRA Facility Investigation report. Box E-1 typifies a table of contents from a report on an industrial facility RFI postclosure. It can be used as a guide during the development and preparation of the postclosure report for the JACADS facility or any other Army chemical agent disposal facility.

As specific areas are remediated during facility closeout, it may be desirable to obtain conditional EPA acceptance of these areas. Box E-2 typifies a table of contents from an Interim Remedial Measures Report for an industrial facility. It lists the areas covered in the report for documenting that contaminant levels were below EPA standards for soil and groundwater following the cleanup effort.

BOX E-1 Typical Contents Page for RFI Facility Investigations

RFI FACILITY INVESTIGATION
TABLE OF CONTENTS
FINAL CLOSURE SURVEY REPORT

Contents

BOX E-2 Typical Contents Page for Interim Remedial Measures Report

INTERIM REMEDIAL MEASURES REPORT
TABLE OF CONTENTS
FINAL CLOSURE SURVEY REPORT