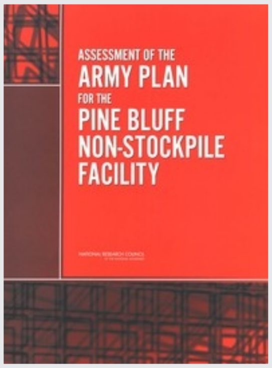

Assessment of the Army Plan for the Pine Bluff Non-Stockpile Facility

DETAILS

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ASSESSMENT OF THE ARMY PLAN FOR THE PINE BLUFF NON-STOCKPILE FACILITY

Committee on Review and Assessment of the Army Non-Stockpile
Chemical Materiel Demilitarization Program: Pine Bluff

Board on Army Science and Technology

Division on Engineering and Physical Sciences

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Preface

The Committee on Review and Assessment of the Army Non-Stockpile Chemical Materiel Demilitarization Program: Pine Bluff (see Appendix A for committee members' biographies) was appointed by the National Research Council (NRC) to conduct studies on the technical, regulatory, and public involvement aspects of the U.S. Army Non-Stockpile Chemical Materiel Disposal Program.

In accordance with its statement of task, the committee reviewed engineering design plans for the construction of the Pine Bluff Non-Stockpile Facility (PBNSF) and plans for its operation.

STATEMENT OF TASK

The Committee on Review and Assessment of the Army Non-Stockpile Chemical Materiel Demilitarization Program: Pine Bluff, convened in February 2003 by the NRC, was charged with the following task:

> The NRC, on behalf of the National Academies, will conduct studies to review and assess Army initiatives in the operational phase of the Non-Stockpile Chemical Demilitarization Program pertaining to facility engineering design planning, technology assessment and insertion, and strategic planning for system deployment. The committee will be composed to address study requests that require expertise in design engineering, strategic planning, government acquisition, materials of construction, and process engineering. The committee will start by reviewing engineering design plans for the non-stockpile facility being planned for the disposal of chemical warfare materiel located at the Pine Bluff, Arkansas, depot. Future reports are, at present, yet to be determined but will be produced as requested by the product manager.
>
> The National Research Council will:
>
> - Establish a committee to review and assess Product Manager for Non-Stockpile Chemical Materiel (PMNSCM) initiatives for the destruction of non-stockpile chemical warfare materiel.
> - As an initial task, review, assess, and provide recommendations on the Army concept of operation of, and on the contractor-submitted engineering design plans for the construction of, the Pine Bluff Non-Stockpile Facility.

COMMITTEE APPROACH

In conducting its review, the committee examined the initial design documents for the facility, the permit applications submitted to the Arkansas Department of Environmental Management, the environmental assessments for the various components of the proposed PBNSF, and the contract for management of secondary wastes. The committee received briefings and updates from the Army. A committee subgroup and staff attended public meetings in Pine Bluff at which non-stockpile issues were presented to the community. A subgroup also participated in a conference call with regulators from the state of Arkansas Department of Environmental Quality. Additionally, the committee received extensive written answers to approximately 200 written questions it had submitted to the Army and its contractors. The committee also conducted follow-up meetings with the Army and its design contractors and had numerous technical discussions among themselves; the committee members had relevant experience in a wide range of technical disciplines.

At its meetings, the committee received a number of briefings (see Appendix B) and held subsequent deliberations. The committee is grateful to the many individuals, particularly Lt. Col. Paul Fletcher, Product Manager for Non-Stockpile Chemical Materiel, and his staff, who provided technical information and insights during these briefings. This information provided a sound foundation for the committee's deliberations.

This study was conducted under the auspices of the NRC's Board on Army Science and Technology (BAST). The chair and vice chair acknowledge the continued superb support of the BAST director, Bruce A. Braun, as well as of NRC staff and committee members, who all worked diligently on a demanding schedule to produce this report.

John B. Carberry, *Chair*
Richard J. Ayen, *Vice Chair*
Committee on Review and Assessment of
the Army Non-Stockpile Chemical Materiel
Demilitarizaion Program: Pine Bluff

Acknowledgment of Reviewers

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

Robert J. Eagan, Sandia National Laboratories,
Jeff Edson, Colorado Department of Public Health and Environment,
Clair F. Gill, Smithsonian Institution,
Deborah L. Grubbe, E.I. du Pont Nemours and Company,
Thom J. Hodgson, North Carolina State University,
Charles E. Kolb, Aerodyne Research, Inc.,
Richard S. Magee, Carmagan Engineering, and
Howard Margolis, University of Chicago.

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 John C. Bailar III, Professor Emeritus, University of Chicago, and James F. Mathis, Exxon Corporation (retired). Appointed by the NRC, they were 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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Figures and Tables

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Acronyms and Definitions

ACWA	Assembled Chemical Weapons Assessment
ADEQ	Arkansas Department of Environmental Quality
APV	auxiliary processing vessel
CAIS	chemical agent identification set(s)
CFR	Code of Federal Regulations
CG	phosgene
CK	cyanogen chloride
CPT	chemical process trailer
CWC	Chemical Weapons Convention
CWM	chemical warfare materiel
DA	diphenylchloroarsine
DAAMS	depot area air monitoring system
DET	detonation chamber
DF	binary chemical agent precursor (methylphos-phonic difluoride)
DM	adamsite
ECC	explosive containment chamber
EDS	explosive destruction system
EIS	environmental impact statement
GA	tabun (a nerve agent)
GB	sarin (a nerve agent)
GD	soman (a nerve agent)
GDL	gross detection level
GS	diethyl malonate
GTR	German Traktor rocket
H	sulfur mustard
HD	sulfur mustard (distilled)
HN	nitrogen mustard
HS	sulfur mustard
HT	sulfur mustard, T-mustard combination
HVAC	heating, ventilation, and air conditioning
L	lewisite
MCE	maximum credible event
MDU	metal decontamination units
MEA	monoethanolamine
mg	milligram
MINICAMS	minatiure chemical agent monitoring system
mm	millimeter
MMD	Munitions Management Device
MPL	maximum permissible limit
NaOH	sodium hydroxide
NEPA	National Environmental Policy Act
NRC	National Research Council
NSCM	Non-Stockpile Chemical Materiel
NSCMP	Non-Stockpile Chemical Materiel Product
NSCWCC	Non-Stockpile Chemical Weapons Citizens' Coalition
PBA	Pine Bluff Arsenal
PBCDF	Pine Bluff Chemical Disposal Facility
PBMAS	Pine Bluff munitions assessment system
PBNSF	Pine Bluff Non-Stockpile Facility
PD	phenyldichloroarsine
PINS	portable isotopic neutron spectroscopy
PMNSCM	Product Manager for Non-Stockpile Chemical Materiel
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PS	chloropicrin
psig	pounds per square inch gauge
PWS	projectile washout system
QL	a binary chemical agent precursor (ethyl-2-diisopropylaminoethyl methylphosphonite)

RAB Restoration Advisory Board
RAP regulatory approval and permitting
RCRA Resource Conservation and Recovery Act
RCWM recovered chemical warfare materiel
RD&D research, development, and demonstration
RRS rapid response system

SDS spent decontamination solution

TP triphosgene
TPA triphenylarsine
TSDF treatment, storage, and disposal facility
TWA time-weighted average

U.S.C. United States Code

VX a nerve agent

3X level of decontamination (suitable for transport for further processing)
5X level of decontamination (suitable for commercial release)

Executive Summary

The U.S. Army requested the National Research Council (NRC) to form a committee to review the design for the facility intended to dispose of some 1,200 recovered non-stockpile munitions in storage at its Pine Bluff (Arkansas) Arsenal (PBA). These munitions, consisting mostly of 4.2-in. mortar rounds containing sulfur mustard agent and 15-cm German Traktor rockets (GTRs) containing a variety of fills, account for most of the non-stockpile inventory located there. Non-stockpile chemical materiel (NSCM) is materiel not in the current U.S. inventory of chemical munitions. It includes buried and recovered materiel (munitions or other), components of binary chemical weapons, former production facilities, and miscellaneous materiel. Much of the NSCM was buried at current and former military installations in 31 states, the U.S. Virgin Islands, and the District of Columbia (U.S. Army, 1996).

This executive summary discusses the committee's primary recommendations only; additional recommendations are found in Chapters 2 through 6.

NON-STOCKPILE MATERIEL AT THE PINE BLUFF ARSENAL

The non-stockpile inventory at PBA (Table 1-1) accounts for about 85 percent of the known non-stockpile materiel in the United States. About 97 percent of this materiel was either recovered from excavated burial pits on the PBA site or has always been in storage at the site. The other 3 percent was transported from other sites around the country. The most problematic items are the 1,200-plus recovered munitions filled with agent or containing residual amounts of agent. Many of these munitions also contain energetic materials whose stability may have deteriorated over time. The Pine Bluff Non-Stockpile Facility (PBNSF) is designed to handle the destruction of these recovered munitions. Other means will be used to destroy the other non-stockpile items at PBA.

The PBNSF site will occupy approximately 25 acres. As currently configured, the main process facility will be a 40,000 ft^2 building containing accessing and treatment facilities, along with support facilities (see Chapter 2). PBNSF relies in large part on legacy equipment from the discontinued Munitions Management Device (MMD) project, as well as on processing equipment developed under the Assembled Chemical Weapons Assessment (ACWA) program, which examined alternatives to incineration for stockpile disposal. The PBNSF equipment consists of trailer-mounted units that can be transported to new locations and assembled. The decision to reuse existing MMD equipment has resulted in continuing modifications, particularly to the explosive containment chamber (ECC) units, and in constraints on accessibility within the chemical processing trailer. PBNSF will employ neutralization and/or oxidation technologies to destroy the chemical agents. A process flow diagram of the PBNSF is shown in Figure ES-1.

THE TASK FOR THE COMMITTEE AND THE COMMITTEE'S FINDINGS

In accordance with the statement of task (see Preface), the committee reviewed engineering design plans for the construction of PBNSF and plans for its operation. The committee did not identify any single event or action that has a high probability of preventing the implementation of PBNSF but also concluded that the basic design of PBNSF, as configured at the time this report was finalized, is incomplete. In addition, the committee noted that because the PBNSF schedule must adhere to the munitions destruction requirements of the Chemical Weapons Convention (CWC), there is very little slack in the time available for construction, testing, and operation of the PBNSF. As an alternative solution, the committee asserts that use of multiple explosive destruction system (EDS) units will work better, with less risk, and in a more timely manner.

The following issues remain to be resolved if PBNSF is to achieve the goal of destroying recovered chemical war-

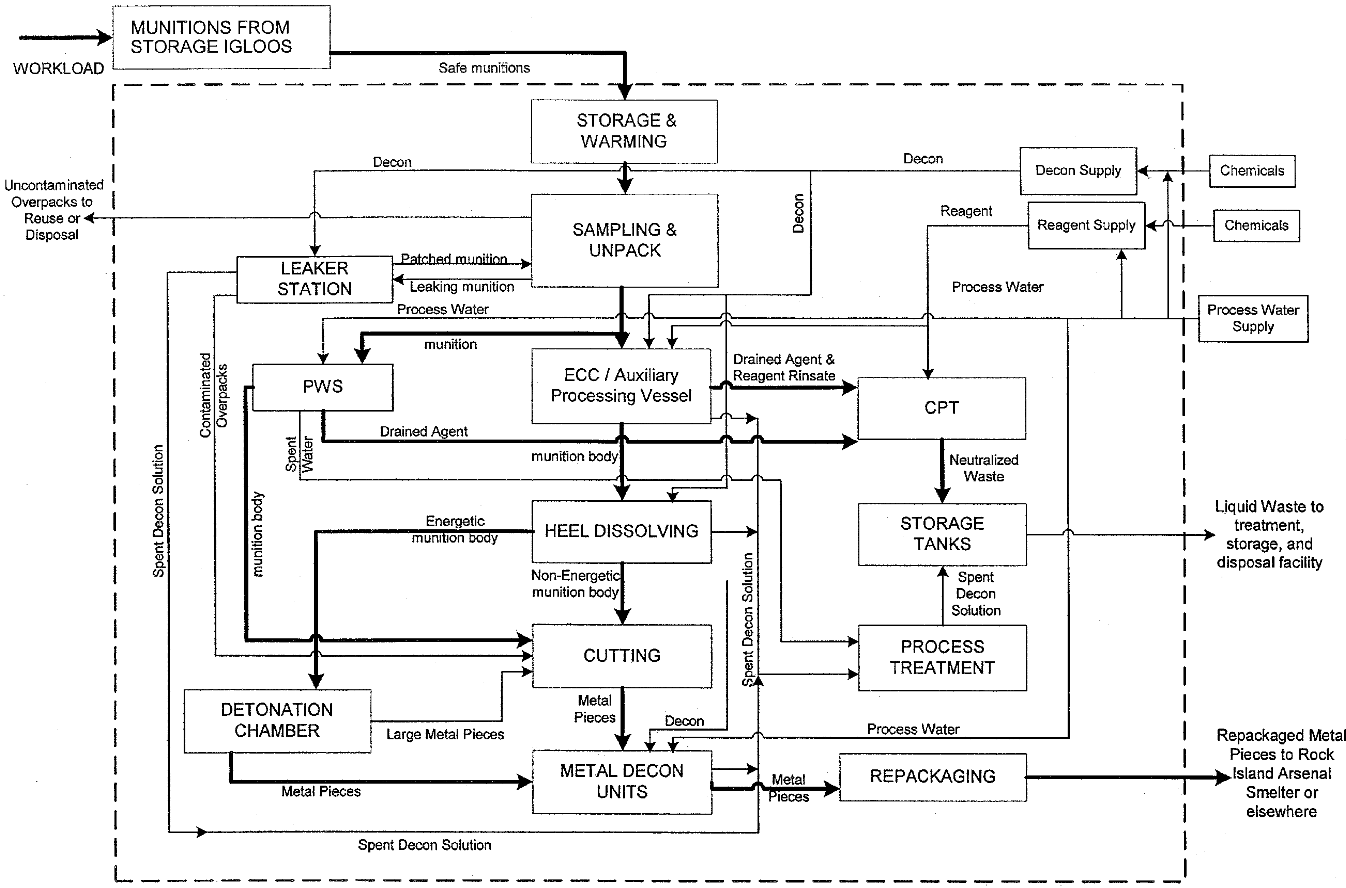

FIGURE ES-1 Process flow diagram of the PBNSF. SOURCE: U.S. Army (2002b).

fare materiel (RCWM) safely and in accordance with the schedule defined in the CWC:

- The ability of the PBNSF processing equipment to process energetically configured 4.2-in. mortar rounds containing gelled or solidified mustard agent has not been demonstrated.
- The current PBNSF design has not been demonstrated to be able to neutralize the arsenical fills in some of the GTRs.
- While the Army has determined the design to be consistent with Army safety regulations, the inability of the building as designed to withstand the maximum credible event (MCE) seems inconsistent with the congressional mandate to provide "maximum protection for the environment, the general public, and the personnel who are involved in the destruction of the lethal chemical agents and munitions" 50 U.S.C. Section 1521(c)(1)(A).[1]

[1]"Maximum protection for the environment" is discussed in Appendix D of *Review of the Army Non-Stockpile Chemical Materiel Disposal Program: Disposal of Chemical Agent Identification Sets* (NRC, 1999).

In addition to having concerns about the unresolved design issues that will affect the currently proposed schedule, the committee has serious reservations about the ability to meet this schedule even if no further changes are made to the design. An assessment by the Army Corps of Engineers, Little Rock District, independently confirms these reservations and leaves no doubt that even minor issues—such as a delay of more than 5 minutes per trip in accessing the site or the effect of rainfall on the workability of the soil, two issues raised by the Corps of Engineers—would result in a failure to meet the proposed schedule (see Chapter 2).

Recommendation 2-1: If the current design for the Pine Bluff Non-Stockpile Facility is pursued, a realistic schedule should be developed based on the time required to properly perform the engineering, construction, commissioning, and processing steps. As part of this task, the required basic design criteria must be finalized. In addition, process hazard analyses must be completed and any issues raised by them resolved.

The committee has serious reservations about the desirability of implementing the PBNSF design concept. In this report, the committee sets forth its reservations about worker safety, the risk of failure to achieve the April 2007 deadline set by the CWC, cost, complexity, and the relative lack of robustness that is inherent in the current design.

The committee recommends that the Army promptly evaluate multi-EDS alternatives (described in Chapter 6) for destroying the PBA non-stockpile inventory. Based on existing information, this alternative could perform most if not all of the tasks intended for PBNSF as currently envisaged, doing so via a demonstrated technology, with improved safety and simplicity and lower costs.

EFFECTS OF THE CHEMICAL WEAPONS CONVENTION DEADLINE

The Army is constrained by the CWC treaty and legislative mandates to destroy the munitions assigned to PBNSF by April 29, 2007.[2] This constrant imposes an arbitrary deadline and creates serious conflicts. The April 29, 2007, deadline is independent of budget constraints imposed by Congress and does not take into account the unique complexity of disassembling aging, unstable weapons that contain not only deadly chemical agent but also explosives and energetics. In addition, the deadline does not recognize the technological limitations of the nonincineration technologies that are used to destroy the chemical agents or the challenge of satisfying both the regulatory requirements and the public's desire that these weapons be destroyed in as safe a manner as possible.

These technological challenges, combined with the unresolved design issues for PBNSF, outlined above, increase uncertainty about whether the Army can attain the April 29, 2007, treaty deadline with the existing PBNSF approach. If the design criteria that are finally agreed upon require modifications to the initial assumptions and result in delays, the pressure on the schedule will increase still further. This could result in even less time for performing the engineering tasks required to design, construct, and systemize PBNSF than is available under the present schedule. The Army Corps of Engineers, Little Rock District, appears to share this concern. In a letter to the Product Manager for Non-Stockpile Chemical Materiel (PMNSCM), it expresses the concern that the development of the basic design is proceeding in parallel with (rather than prior to) the design of the building.

Recommendation 2-3: As soon as possible, the Army should systematically review the design integration and operation of all the equipment in the Pine Bluff Non-Stockpile Facility (including piping, connections, and vessels) to find ways for simplifying the processing taking place there. This review should identify ways of (1) minimizing the chances for equipment or operational or human failures, using preventive redesign and related measures to reduce reliance on protective clothing and (2) optimizing the reliability of the Pine Bluff Non-Stockpile Facility processes.

[2]Late in the report review process, the Army announced that the United States would not meet the 45 percent chemical weapons *stockpile* destruction deadline of April 29, 2004, and requested an extension of the deadline until December 2007 (DoD, 2003). However, the Product Manager for Non-Stockpile Chemical Materiel has stated that the *non-stockpile* program intends to meet the April 29, 2007, deadline.

PINE BLUFF NON-STOCKPILE FACILITY CONTAINMENT DESIGN

The Product Manager for Non-Stockpile Chemical Materiel has defined the MCE for the PBNSF design as the detonation of a fully configured GTR motor and warhead combination while being processed in the PBNSF. The MCE is important because it is used as the basis for facility design. While it is difficult to predict the likelihood of the MCE with any degree of certainty, it is important to review such potential events and investigate designs that protect against even low probability risks when consequences might be severe.

The committee recognizes that the PBNSF design calls for the MCE to be completely contained, but only when that GTR is actually being processed within the ECC-2. However, should the MCE occur within PBNSF but outside the ECC-2, there would be a release of fragments and agent to the immediate area outside the PBNSF building; there are similar concerns should a fully configured GTR be detonated in transit. Nothing in this report should be construed as expressing the view that such a release is likely to occur.

The U.S. Army, citing Department of the Army Pamphlet 385-61 (U.S. Army, 2002a) Section 6.6 requirements with respect to containment, reports that this condition—MCE containment only when occurring within the ECC—is the required level of protection for both the stockpile and the non-stockpile disposal programs. However, should the MCE occur outside the ECC-2, it would almost certainly result in severe worker injuries or death and trigger a public outcry and regulatory review that would seriously delay the completion of the PBNSF task regardless of the impact on the personnel and the environment. For this reason, the committee believes that it would be preferable to design the entire PBNSF to contain the MCE. The possibility of the MCE occurring outside the ECC-2 also supports the committee's recommendation to develop a system to decouple the GTR motor/warhead combinations in a separate facility designed to contain both explosions and releases of lethal chemicals with a minimum of transportation and handling.

Separating the GTR warhead from the rocket motor and processing only the warhead in PBNSF would increase the safety of the PBNSF operation by eliminating the only situation where the energetic capacity of the munition exceeds the containment capacity of the building.

Recommendation 3-2: The German Traktor rocket warheads should be separated from the rocket motors and only the warheads should be allowed to enter the Pine Bluff Non-Stockpile Facility so as to reduce the maximum credible event to a level that can be fully contained by the structure. The Army should continue to investigate thoroughly the feasibility of separating the German Traktor rocket motors from their warheads to determine how and where these operations can be accomplished safely.

Confirming the contents of RCWM items at PBNSF will occur in two stages:

- The munition will be unpacked, examined, analyzed, and classified at the Pine Bluff munitions assessment system (PBMAS) and then returned to storage.
- The munition will be assessed by x-ray and checked for leakage in the receiving room when the munition is first unpacked in the PBNSF facility prior to disposal.

The munition is then sent to the next processing module, which is determined based upon its configuration (agent and explosive content) and condition (clean, corroded, etc.).

Two options exist for gaining access to the chemical agents contained within the munitions. In general, munitions that contain energetics will be processed in one of the two ECC units, which are designed to contain the force of an explosion, should one occur during the drilling and draining operations. Those without energetics will typically be processed in the projectile washout system (PWS) developed under the ACWA program, which has a much higher capacity but is not configured to withstand an accidental detonation. Complete descriptions of these operations are in Chapter 2.

MANAGEMENT OF SECONDARY WASTES

The primary agent neutralization operations in PBNSF will be treatment of arsenicals using caustic or an oxidant as the neutralizing agent, treatment of nitrogen mustard using monoethanolamine as the neutralizing agent, and treatment of sulfur mustard, again using monoethanolamine as the neutralizing agent. While substantial in volume, the quantities of neutralent and decontamination solution generated will be small in comparison with those routinely handled by commercial treatment, storage, and disposal facilities.

The Army plans to dispose of secondary waste from PBNSF at offsite locations through a contract awarded to Shaw Environmental, Inc. Shaw is required to team with one or more commercial hazardous waste treatment, storage, and disposal facilities to transport and dispose of secondary wastes from all Non-Stockpile Chemical Materiel Product (NSCMP) projects, including PBNSF. The contract states that nonincineration treatment is preferred to incineration treatment. The preference for nonincineration technology is part of a decades-long trend, first toward incineration as a preferred treatment technology, then away from incineration (NRC, 1994, 2002a).

REGULATORY APPROVAL AND PERMITTING

Before PBNSF can be constructed and operated, regulators and the public must be satisfied that planned operations can be carried out within the federal and state regulatory and legal framework. The regulatory approval and permitting process involves in-depth examination of the Army's proposed treatment technologies and the requirements they must meet, and provides opportunities for public involvement in the decision making.

Under Arkansas regulations, since the parent agent wastes are not listed as hazardous waste on the basis of agent content (see Chapter 5), neither would be any secondary wastes that result from primary treatment. However, the non-stockpile items themselves, along with the neutralent and most other secondary wastes, will most likely fall in the Resource Conservation and Recovery Act category of ignitable, corrosive, toxic, or reactive waste and will on that basis (not because of agent content) be specified as hazardous waste.

Recommendation 5-1: For non-stockpile materiel to be processed at the Pine Bluff Non-Stockpile Facility, the Army should describe risk-based treatment goals for chemical agent destruction in publicly available documentation. The Army should also describe agent-related treatment goals for secondary wastes treated at offsite treatment, storage, and disposal facilities (e.g., for Schedule 2 compounds) in publicly available documentation. Treatment goals for related non-stockpile operations at the Pine Bluff Arsenal—for example, the rapid response system and the explosive destruction system—should also be discussed in publicly available documents.

PUBLIC INVOLVEMENT

The involvement of the public in significant, potentially controversial activities such as the NSCMP is not only a legal requirement but also a key element of mission success. Public involvement means working with a range of "publics," or stakeholders. It has three components: (1) early provision of public information; (2) outreach, or opening channels of communication to allow the public to articulate its values, concerns, and needs; and (3) involvement, or providing mechanisms that engage the public and allow it to provide input and influence agency decisions (NRC, 2002a).

The committee commends the Army for its continued commitment to working effectively with the Core Group (a group established by NSCMP to exchange information and opinions on non-stockpile issues) in addressing issues raised among stakeholders at the national level; for improving coordination among the various chemical weapons programs at local installations; and for increasing the visibility of non-stockpile activities at Pine Bluff and informal public-Army interactions. The committee believes that the NSCMP is in a position to build upon both the Pine Bluff area community's unusually positive, or at least accepting, view of its proposed activities, as well as on its effective working relationships with national-level stakeholders.

Recommendation 5-4: The committee recommends that the Product Manager for Non-Stockpile Chemical Materiel enhance public involvement by (1) identifying and addressing the reasons for limited participation by the public in meetings at Pine Bluff; (2) establishing an informal advisory group at Pine Bluff similar to a restoration advisory board; (3) augmenting the national Core Group with citizen stakeholders from Pine Bluff and from the yet-to-be determined location of the facility that is selected to treat and dispose of the secondary wastes from the Pine Bluff Non-Stockpile Facility; and (4) ensuring that the contractor(s) for disposal of secondary wastes go(es) beyond information and outreach activities to involve local community stakeholders.

Recommendation 5-6: As part of the public involvement process, the Army should consider preparing a new document that describes, in layman's terms, the treatment technologies and facilities being proposed for non-stockpile materiel at Pine Bluff. These technologies include those outside the Pine Bluff Non-Stockpile Facility and should include the technologies ultimately selected to treat neutralent off-site. The document might include a timeline and a summary of the cumulative environmental impacts. It would give the public a clear understanding of the proposed actions and help them to understand the operation of each technology and the interrelationships among them.

ALTERNATIVE APPROACHES

While evaluating the existing PBNSF design, the committee concluded that there are preferable alternative approaches to destruction of the non-stockpile chemical materiel stored at PBA. The alternatives involve greater use of the well-proven EDS and would be simpler, more reliable, less expensive, and safer because of the smaller number of munition handling steps and improved ability to meet the CWC. That is, the simplicity and reliability of the EDS offers easier operation and maintenance while improving the safety of workers, the public, and the environment.

The new challenges that would be posed by changing to a new operational concept at this late stage in the design planning for PBNSF should be no greater than those associated with meeting the deadline with currently planned PBNSF operations.

Although the committee concludes that PBNSF, as currently designed, may be workable—subject to the findings and recommendations contained in this report—it has serious reservations about the desirability of doing so. Employing the complex prototype equipment inherited from the discontinued non-stockpile MMD program and the stockpile ACWA program has caused many modifications to the design of an integrated system for PBNSF. Further, the complexity of the current PBNSF design raises concerns about the sheer number of munition processing and handling steps. In addition, the current PBNSF processing procedure appears less capable than the EDS of dealing with unexpected variations in munition type and condition. For example, a mischaracterized munition could cause serious problems in the ECC or in the PWS, operations where there is more manual handling and the processing steps are more variable than in the EDS. In contrast, the EDS explosively accesses the munition content and, in doing so, destroys much of the agent. Any remaining agent is destroyed via a neutralization reaction. The key issue is the ability to access the surfaces that contain agent, whether liquid, gelled, or solidified. The EDS is demonstrably superior to the PBNSF drill and drain equipment in exposing the interiors of the munitions and allowing the reagents to contact any residual agent.

Two or three EDS units can perform most if not all of the tasks currently planned to be performed at PBNSF. The committee considered two basic ways in which EDS systems could replace some of the problematic aspects of the current PBNSF design. Both options assume that EDS units can be made available for use in destroying non-stockpile materials intended for PBNSF.

Option 1

Option 1 would eliminate all of the processing equipment (ECC-1, ECC-2, PWS, heel-dissolving tanks, detonation chamber (DET), metal decontamination unit (MDU), and the chemical processing trailer (CPT)) from the current design for PBNSF. In their place, multiple EDS units could be used to dispose of the non-stockpile inventory at PBA (with the exception of GTRs, whose propellant contents exceed the explosive containment capacity of the EDS-2). If it is possible to remove the rocket motors from the 31 GTRs whose rocket motors contain propellant, EDS-2 systems can be used to dispose of the entire PBA inventory. Calculations are provided in Appendix C. In addition to the factors cited above, an important advantage of the EDS over the current PBNSF design is that it is a well-proven system. Complete elimination of the currently designed PBNSF processing equipment could eliminate much manual handling, reduce exposure potential, save much of the anticipated cost of equipment modification, and reduce or eliminate the cost of a permanent building.

Option 2

Option 2 would replace the PWS and the ECC-1 with EDS units but retain the ECC-2 for processing the 31 complete GTRs with propellant-filled rocket motors if the motors cannot be removed from the warheads safely. Use of the ECC-2 is necessary to process the complete GTRs because the total net explosive weight of the GTR, including propellant, exceeds the containment capacity of both EDS systems. Retention of the ECC-2 necessitates retention of several auxiliary facilities, including the chemical processing trailer, a heel-dissolving tank, the DET, and an MDU. The Army is evaluating options akin to Option 2 in which an EDS unit would be used in addition to PBNSF to ensure destruction of the PBA inventory of RCWM by April 2007.

Factors for Consideration

Both Option 1 and Option 2 would involve modification of the current plan for a building to house PBNSF. In Option 2, which retains the ECC-2 and its supporting facilities, most aspects of the building would be retained. In Option 1, it might be possible to house the EDS units in low-cost, temporary containment shelters, as was done for the Spring Valley, Washington, D.C., non-stockpile disposal project completed in 2003. Buildings to house administrative and laboratory facilities would also be needed, but they need not be permanent. The temporary shelters for the EDS units might retain their usefulness after conclusion of the PBA activities because they could be moved to other locations along with the EDS units that they enclose.

The committee notes that some tasks would remain, such as validating the concept of destroying multiple rounds in the EDS equipment, establishing whether GTR motors can be separated from their warheads safely, and determining how many EDS units would be required to meet the April 2007 deadline. Other tasks derive from environmental requirements, including Resource Conservation and Recovery Act and air emissions permitting, as well as demonstrating compliance with the National Environmental Policy Act. Both the Army and the Arkansas Department of Environmental Quality have spent much time preparing and reviewing permit applications, including both the PBNSF application and the application for the EDS unit that will be used in conjunction with the operation of PBMAS. Switching in midstream to an EDS approach for PBNSF operations would cause the expenditure of additional permitting effort and might jeopardize the Army's CWC schedule obligations. However, since permit application documentation already exists for the EDS unit associated with the operation of PBMAS, that documentation could be used as a basis for permitting the more extensive use of EDS units at PBNSF, limiting the additional effort. In addition, because the use of multiple EDS units represents a simpler approach than the current PBNSF design, permit application revisions and resulting permit documentation are likely to be less onerous and less complex. The committee also expects that the frequency of permit modifications over the course of PBNSF operations would be significantly reduced if an EDS approach were implemented. Closure of the EDS units would also be simpler. An additional advantage of the EDS approach is that it has already received regulatory approvals from the Environmental Protection Agency and three states and that it has a good track record.

Cost Comparison

It is the committee's judgment that the multiple-EDS approach is more likely to meet the mandated destruction schedule and to reduce the risk of delay-associated costs. A useful perspective on the relative costs of the multiple-EDS concept versus the current PBNSF design is that the multi-EDS concept, at most, accelerates the acquisition of EDS units already planned for the non-stockpile program. These mobile EDS units should be useful for destroying non-stockpile materiel recovered at Army facilities or found at other locations across the country (as, for example, at Spring Valley in Washington, D.C.). By contrast, the PBNSF equipment would be used to destroy RCWM for less than a year. The PBNSF building itself might have continuing utility, but the equipment it contains is unlikely to be used again.

As summarized in Table ES-1, the multiple-EDS alternative has several advantages (see also Chapter 6).

Recommendation 6-1: The Army should promptly evaluate multi-Explosive Destruction System alternatives for destroying the Pine Bluff recovered non-stockpile munitions inventory. If the committee's premises are borne out, planning, permitting, and public involvement activities aimed at utilizing existing Explosive Destruction System units should be initiated promptly.

Finally, the committee's proposal for an alternative configuration for PBNSF using multiple-EDS units is a consequence of the success of EDS deployments, both technically and with respect to public acceptability, at four non-stockpile sites across the United States. It is also a logical extension of the Army's efforts to enhance the efficacy of EDS units—such as multiple-round testing—as well as ongoing Army activities aimed at separating GTR warheads from their motors and improving the characterization of the contents of the recovered chemical munitions in storage at Pine Bluff.

TABLE ES-1 Detailed Comparison of PBNSF and Multi-EDS Options

Issue	PBNSF[a]	Option 1: Multiple EDS[b]	Option 2: PBNSF + Multiple EDS[c]
Safety	Pro Not applicable.	Pro 1. Minimizes handling of munitions (one handling per munition-loading into EDS). 2. Disposal of munitions can begin immediately after characterization instead of being put back into storage. 3. Significantly reduces risk to personnel in comparison with PBNSF.	Pro 1. GTR warhead and energetic combined can be handled in ECC-2.
	Con 1. Multiple handling activities (average of five) for each munition before final disposal. 2. Current design does not provide for building to contain release from MCE.	Con 1. GTR warhead and energetic combined cannot be handled in EDS.	Con 1. Multiple handling activities (average of five) for each munition before final disposal. 2. Current design does not provide for building to contain release from MCE.
Risk of failure to achieve CWC date (April 2007)	Pro Not applicable.	Pro 1. Low (if multiple rounds can be processed in EDS). 2. No major design issues. 3. No construction schedule issues. 4. EDS is proven to be a robust system on actual non-stockpile disposal projects. 5. Significantly reduces risk of failing to achieve CWC 2007 date.	Pro 1. No major design issues for EDS. 2. Has better chance of achieving CWC deadline than PBNSF option due to use of multiple EDS units.
	Con 1. High due to outstanding design issues (see below). 2. Unrealistically short construction schedule. 3. Lack of robustness of the ECC-1 and ECC-2 (cannot withstand an accidental detonation without serious damage).	Con Not applicable.	Con 1. Unrealistically short construction schedule. 2. Requires retention of the CPT, heel-dissolving tanks, the DET, and an MDU. 3. Lack of robustness of the ECC-2 (cannot withstand an accidental detonation without serious damage).
Cost	Pro 1. Some items already purchased	Pro 1. Costs for EDS units already assigned. 2. No large building required and no significant equipment purchase or installation costs. 3. Personnel costs significantly lower. 4. Minimum closure costs. 5. EDS units can be used at other sites. 6. Significantly reduces cost of destroying inventory at Pine Bluff. 7. Significantly reduces cost of destroying inventory at other sites as EDS units can be moved and reused.	Pro 1. EDS and ECC-2 already purchased. 2. PWS does not need to be developed and ECC-1 is not required.

continued

TABLE ES-1 Continued

Issue	PBNSF[a]	Option 1: Multiple EDS[b]	Option 2: PBNSF + Multiple EDS[c]
Cost (cont.)	Con 1. High cost associated with constructing building; purchasing computer control, instrumentation, monitoring equipment, heating, ventilation, and air conditioning (HVAC), etc.; recruiting, installing, and training personnel; and operations and closure. 2. PBNSF facility cannot be used for destruction of inventory at other sites.	Con Not applicable.	Con 1. High cost associated with constructing building, purchasing computer control, instrumentation, monitoring equipment, HVAC, etc.; recruiting, installing, and training personnel; and operations and closure. 2. PBNSF facility cannot be used for destruction of inventory at other sites.
Personnel	Pro Not applicable.	Pro 1. Fewer staff than PBNSF. 2. Lower overall level of training required.	Pro Not applicable.
	Con 1. Large operational staff required. 2. Significant amount of training. 3. Large associated costs.	Con Not applicable.	Con 1. Large operational staff required. 2. Significant amount of training. 3. Large associated costs.
Complexity	Pro Not applicable.	Pro 1. Simple system. 2. Significantly reduces complexity of destroying inventory at Pine Bluff.	Pro Not applicable.
	Con 1. Highly complex system (control systems, instrumentation, HVAC, ECC, CPT, etc.).	Con Not applicable.	Con 1. Highly complex system (control systems, instrumentation, HVAC, ECC, CPT, etc.).
Robustness[d]	Pro Not applicable.	Pro 1. EDS units are very robust. 2. Significantly increases the overall robustness of the process/system for destroying inventory at Pine Bluff.	Pro 1. EDS units are very robust.
	Con 1. Several equipment items (ECC, CPT, air monitoring, etc.) are known to be designs that have included compromises or have a history of problems. 2. ECC-1 and ECC-2 are not able to withstand an accidental detonation without serious damage.	Con Not applicable.	Con 1. Several equipment items (ECC, CPT, air monitoring, etc.) are known to be designs that have included compromises or have a history of problems. 2. ECC-2 is not able to withstand an accidental detonation without serious damage.
Generation of secondary waste	Pro Not applicable.	Pro 1. EDS units and containment shelters should generate much less carbon filter material for disposal than PBNSF. 2. EDS units generate smaller amounts of liquid secondary wastes.	Pro 1. EDS units and containment shelters should generate much less carbon filter material for disposal than PBNSF. 2. EDS units generate smaller amounts of liquid secondary wastes.

	Con 1. Will generate much more neutralent and carbon filter material than Option 1 and more than Option 2. 2. Neutralization chemistry system for arsenical reagents found in some GTRs must be developed.	Con 1. Neutralization chemistry system for arsenical reagents found in some GTRs must be developed.	Con 1. Will generate more neutralent and carbon filter material than Option 1. 2. Neutralization chemistry system for arsenical reagents found in some GTRs must be developed.
Environmental permitting	Pro 1. Permit documentation has already been prepared and submitted and is under review by the Arkansas Department of Environmental Quality. Con 1. Likely need for numerous permit modifications, which may cause delays and jeopardize ability to meet the CWC schedule.	Pro 1. Use of an EDS-only option would likely result in far fewer permit modifications. 2. The EDS has been permitted previously. Con 1. The effort to withdraw the existing permit application and begin processing a new one is substantial.	Pro 1. Use of an EDS for most of the munitions at PBNSF will help reduce the need for permit modifications. Con 1. The permit application would increase in size and complexity, and processing time would increase as well.
Public acceptability	Pro Not applicable. Con Not applicable.	Pro 1. Multiple-EDS likely to be preferable because technology is fully transportable and generates less secondary waste. Con Not applicable.	Pro Not applicable. Con Not applicable.
Issues to be resolved	1. Is GTR agent covered by CWC? 2. How can the ECC be modified for washout of solidified mustard? 3. How can the arsenical agents in approximately 40% of GTR be neutralized? 4. Design basis for building does not contain MCE. 5. Access issues and piping design issues in the CPT. 6. How can gelled or solidified mustard rounds be handled? 7. Can GTR energetic/warhead be disassembled safely? 8. Final design of munitions processing equipment (ECC, PWS).	1. Is GTR agent covered by CWC? 2. How can the arsenical agents in approximately 40% of GTR be neutralized? 3. Can GTR warhead/energetic be disassembled so that EDS can be used for all items? 4. When can EDS units be online? 5. How many munitions can EDS process at one time? 6. Can the permit be modified without public concern/delay?	1. Is GTR agent covered by CWC? 2. How can the ECC be modified for washout of solidified mustard? 3. How can the arsenical agents in approximately 40% of GTR be neutralized? 4. Design basis for building does not contain MCE. 5. Access issues and piping design issues in the CPT. 6. When can EDS units be online? 7. Can permit be modified without public concern/delay?

[a]PBNSF: ECC-1, ECC-2, PWS, heel-dissolving tanks, DET, MDU, and CPT; no EDS units.
[b]Option 1: Uses multiple EDS units only; eliminates ECC-1, ECC-2, PWS, heel-dissolving tanks, DET, MDU, and CPT.
[c]Option 2: Uses multiple EDS units in lieu of the PWS and ECC-1; retains ECC-2, heel-dissolving tanks, DET, MDU, and CPT for processing 31 complete GTRs.
[d]The committee defines “robustness” as the ability to operate reliably over time under a variety of conditions and with a variety of inputs.

1

Background and Overview

Since World War I, the United States has maintained an extensive array of weapons containing chemical agents. Today, as a result of the United States' decision to sign and ratify the Chemical Weapons Convention (CWC),[1] the long-term storage of aging chemical warfare materiel (CWM) is no longer allowed. Also, the public is concerned about the risks associated with the long-term storage of CWM. Consequently, the United States and other signatories of the CWC are in the process of destroying all declared[2] CWM by the treaty deadline of April 29, 2007.[3]

U.S. law and international treaties have divided CWM into two categories: "stockpile" and "non-stockpile." Stockpile materiel includes all chemical agents available for use on the battlefield, including chemical agents assembled into weapons and in bulk ton containers. Stockpile materiel is stored at eight locations in the United States.

Non-stockpile materiel is a diverse category that includes all *other* chemical weapon-related items.[4] Much of this materiel was buried on current and former military sites but is now being recovered as the land is remediated. Some CWM also is buried at current and former test and firing ranges. Recovered chemical weapons materiel (RCWM) is now stored at several military installations across the United States. According to the CWC, non-stockpile CWM items in storage at the time of treaty ratification in April 1997 must be destroyed within 2, 5, or 10 years, depending on the type of chemical weapon and the type of agent. Non-stockpile CWM recovered after treaty ratification must be declared under the CWC and destroyed "as soon as possible" (U.S. Army, 2001a). Generally, non-stockpile items that are recovered have been transported to the nearest stockpile site for safe storage.[5]

THE NON-STOCKPILE CHEMICAL MATERIEL DISPOSAL PROGRAM

Before 1991, the U.S. effort to dispose of CWM was limited to stockpile materiel. The Defense Appropriations Act of 1991 directed the Secretary of Defense to establish the Product Manager for Non-Stockpile Chemical Materiel (PMNSCM) with responsibility for the destruction of non-stockpile CWM.

The Pine Bluff Arsenal Non-Stockpile Inventory

About 85 percent of the non-stockpile materiel in the United States is stored at the Pine Bluff Arsenal (PBA) in Arkansas, which is also a stockpile storage site.[6] About

[1]Formally, the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and Their Destruction. The treaty was signed by the United States on January 13, 1993, and ratified by the U.S. Congress on April 25, 1997. The CWC specifies the time period within which covered categories of Chemical Warfare Materiel (CWM) must be destroyed.

[2]CWM that remains buried is not subject to the treaty. Once the CWM has been recovered and characterized, it must be declared under the CWC and then be destroyed as soon as possible.

[3]Under the CWC, countries may apply for an extension of the deadline of up to 5 years. Late in the report review process, the Army announced that the U.S. would not meet the 45 percent chemical weapons stockpile destruction deadline of April 29, 2004, and requested an extension of the deadline until December 2007 (DoD, 2003). However, the Product Manager for Non-Stockpile Chemical Materiel has stated that the non-stockpile program intends to meet the April 29, 2007, deadline. Even if the non-stockpile destruction deadline were extended, the schedule for construction of the Pine Bluff Non-Stockpile Facility would be relatively tight. However, for this report, the committee assumed that April 29, 2007, is the official deadline.

[4]The category includes buried chemical warfare materiel, recovered chemical warfare materiel, binary chemical weapons, former production facilities, and miscellaneous chemical warfare materiel.

[5]An exception is recovered chemical agent identification sets, which contain small quantities of chemical agents and militarized industrial chemicals, used for training purposes. These are sometimes stored at the site where they are recovered.

[6]The Army is building a version of its baseline incineration system at PBA to destroy the stockpile materiel stored there. However, due to regulatory and schedule issues, as well as public opposition, the stockpile incin-

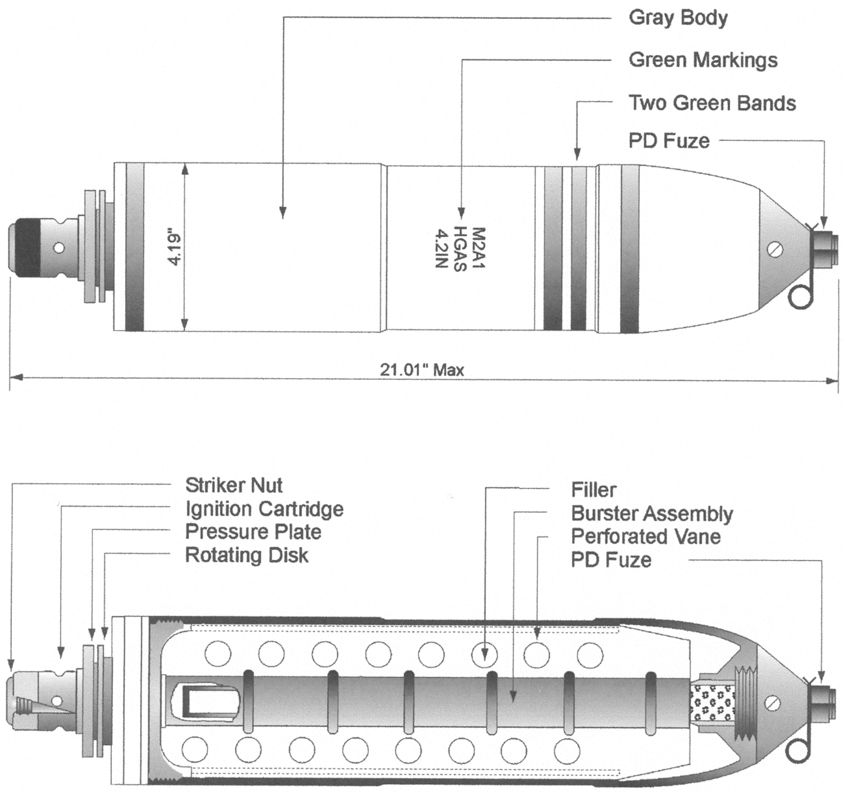

FIGURE 1-1 Diagram of the 4.2-in. mortar cartridge. SOURCE: U.S. Army (2003a).

97 percent of this materiel was either recovered from excavated burial pits on the PBA site or has always been in storage at the site; the other 3 percent was transported from other sites around the country. Table 1-1 presents the most current information available to the committee regarding the numbers, types of agent fills, and explosive configurations of recovered items currently stored at PBA.

Recovered Munitions at the Pine Bluff Arsenal

This report is concerned with the facilities and operations that will destroy the first item category in Table 1-1—recovered munitions. These 1,200-plus recovered munitions are the most problematic items in storage at PBA because (1) they contain full or residual amounts of agent and (2) nearly all of them also contain energetic materials whose stability may have deteriorated over time. Most of these are either 4.2-in. mortars containing sulfur mustard agent or 15-cm German Traktor rockets (GTRs) containing a variety of fills, including nitrogen mustard agent and arsenical-based fills.[7]

A diagram of the 4.2-in. mortar round is shown in Figure 1-1. The round is 21 in. long with fuze and 4.19 in. in diameter. The overall weight with mustard agent fill is approximately 23 lb, including approximately 6 lb of agent. The burster extends the length of the body cavity and contains 0.73 lb of tetryl (U.S. Army, 1998).

A diagram of the 15-cm GTR is shown in Figure 1-2. The rocket motor is at the head of the projectile, with the rear section, which contains the chemical fill, threaded to the motor section. If the rockets are in good condition, the motor and fill sections can be easily separated with the proper tools. The intact rocket head (motor) contains seven sticks of propellant powder weighing 2 lb each. The chemical constituents of the propellant are 62.5 percent nitrocellulose, 33 percent nitroglycerine, and 4.5 percent other fillers. The total length of a GTR is 40 in., and the diameter is 6.2 in. The

erator is not available for use in destroying the non-stockpile CWM stored at PBA, except perhaps for special cases in which the non-stockpile agent is identical to the stockpile agent being destroyed in a particular campaign and the non-stockpile vessel or munition is easily accommodated by the processing equipment of the baseline incineration system.

[7]The arsenical fills appear to be mixtures of diphenylchloroarsine (DA), phenyldichloroarsine (PD), and small amounts of triphenylarsine (TPA). DA is classified as a vomiting agent (nonlethal) and is not covered by the CWC; PD is a blistering and vomiting agent, and it is not yet clear how it will be classified under the CWC or how the Army will dispose of it.

TABLE 1-1 Inventory of Non-Stockpile Items at the Pine Bluff Arsenal

		No. Containing a Chemical(s)									
Item	No. Empty	H/HD/ HN/HS/HT	GA/GB/GD	VX	DM/L	CG/CK	DF	QL	Other	Unknown	Total No. of Items
Munition											
4.2-in. mortar round	596[a]	99[a]				1[b]				36[a]	732[a]
75-mm projectile	4[a]	9[a]									13[a]
200-mm Livens projectile	3[a]	5[a]				3[b]					11[a]
4.7-in. projectile		1[a]									1[a]
155-mm projectile	1[a]										1[b]
105-mm projectile										1[a]	1[b]
M70A1 bomb (poss. explosive)	6[a]	3[a]									9[b]
150-mm German Traktor rocket w/expended motor	224[a]	184[a]									408[a]
150-mm German Traktor rocket w/unexpended motor	13[a]	18[a]									31[a]
150-mm German Traktor rocket w/warhead only	26[a]	12[a]									38[a]
Subtotal	873[a]	331[a]				4[b]				37[a]	1,245[a]
Chemical sample container[c]											
Ton container			2[b]								2[b]
4-in. cylinder		1[b]									1[b]
Lab sample container				2[b]							2[b]
Vial (L)					1[b]						1[b]
Subtotal		1[b]	2[b]	2[b]	1[b]						6[b]
Chemical agent ID set (CAIS)											
Mustard (H/HD/HS)		5,764[b]									5,764[b]
Nitrogen mustard (HN-1 and -3)		50[b]									50[b]
Lewisite (L)					397[b]						397[b]
Chloropicrin (PS)									396[b]		396[b]
Phosgene (CG)						396[b]					396[b]
Chloroacetophenone (CN)									17[b]		17[b]
Adamsite (DM)					17[b]						17[b]
Triphosgene (TP)									17[b]		17[b]
Cyanogen chloride (CK)						33[b]					33[b]
Diethyl malonate, etc. (GS)									33[b]		33[b]
Subtotal		5,814[b]			414[b]	429[b]			463[b]		7,120[b]
Binary agent precursor											
M20							56,820[b]				56,820[b]
Drum							7[b]	293[b]			300[b]
Box, container, can								3[b]			3[b]
Subtotal							56,827[b]	296[b]			57,123[b]
Empty ton container[d]					4,375[b]						4,375[b]
Total	873[a]	6,146[a]	2[b]	2[b]	4,789[b]	433[b]	56,827[b]	296[b]	463[b]	37[a]	69,868[a]

NOTE: Items in the shaded area represent the inventory to be disposed of at PBNSF.

[a]Data from Verrill and Salcedo (2001).

[b]Provided to the Committee on Review and Evaluation of the Army Non-Stockpile Chemical Materiel Disposal Program by the Product Manager for Non-Stockpile Chemical Materiel on July 10, 2001.

[c]Inventory consists of individual CAIS items, not complete CAISs.

[d]Sampling of some of these containers indicated that they may be contaminated with lewisite, arsenic, and/or mercury.

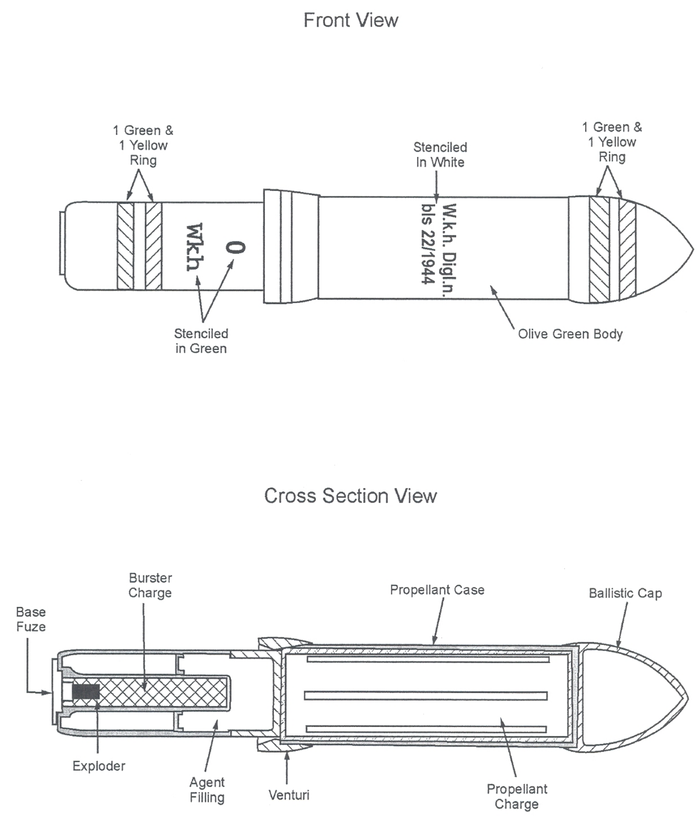

FIGURE 1-2 Diagram of the 15-cm German Traktor rocket (drawing not to scale). SOURCE: U.S. Army (2003a).

overall weight is 79 lb, including 7 to 10 lb of chemical fill, depending on fill type. The burster tube, which is threaded into the aft end, contains 3.4 lb of a mixture of pentaerythritol tetranitrate/wax (95/5) and picric acid (U.S. Army, 1998).

The remainder of the recovered munitions in the PBA non-stockpile inventory are small numbers of M70 bombs, 200-mm Livens projectiles, and 155-mm, 105-mm, and 75-mm projectiles.

Significantly, many of the rounds at PBA are believed to be empty of chemical fill, and fewer than half of the items are believed to contain energetics. Munitions that are empty of fill or energetics can be processed more quickly. Only 36 of the 477 GTRs contain propellant, and these GTRs with intact motors are considered to be the biggest challenge for disposal.[8] (Various sources cited slightly differing numbers of GTRs in submissions and presentations to the committee, in part because the number of such rockets that need to be destroyed has changed over time. For example, seven rockets were utilized in testing access and decoupling technologies, so 470 rockets are now available, but 477 were on the original inventory.)

Other Non-Stockpile Items at the Pine Bluff Arsenal

Numerically, the largest number of items (about 57,000) listed in Table 1-1 are the binary agent precursor canisters and drums. The Army plans to destroy these precursors by water hydrolysis using a building and equipment left over from the integrated binary former production facility at PBA, with secondary wastes to be sent off-site for posttreatment at a commercial treatment, storage, and disposal facility (TSDF). Binary precursors will not be discussed further in this report.

Over 7,000 chemical agent identification set (CAIS) items are stored at PBA; these are for the most part individual vials or bottles of training materials rather than complete CAIS sets. They are to be characterized and then destroyed by chemical oxidation or hydrolysis in the Rapid Response System (RRS), a mobile glove box that was used successfully to destroy CAIS stored at Deseret Chemical Depot in Utah and at Fort Richardson, Alaska. The neutralized wastes will be sent off-site to a commercial TSDF for disposal. The destruction of CAIS in the RRS was reviewed in an earlier

[8]William Brankowitz, Deputy Product Manager, Non-Stockpile Chemical Materiel Product, "Non-Stockpile Chemical Materiel Product Overview," briefing to the committee on March 19, 2003.

National Research Council report (NRC, 1999) and is not discussed further here.

Over 4,000 "empty" ton containers are stored at PBA, some of which may be contaminated with lewisite, arsenic, and/or mercury. These will be decontaminated and subjected to a cut-and-clean operation at PBA, with secondary wastes to be sent off-site for posttreatment at a commercial TSDF. The empty ton containers will not be discussed further in this report.

Table 1-1 lists six "chemical sample" containers of various sizes and containing several different chemical fills. Those containing the nerve agents sarin (GB) or VX may be destroyed by the baseline incineration facility at PBA. The 4-in. cylinder containing mustard agent and the vial containing lewisite could be destroyed either in the Pine Bluff Non-Stockpile Facility (PBNSF) or the explosive destruction system (EDS) (see below). The disposal of the chemical samples will not be addressed further in this report.

Systems for Assessment and Destruction of Non-Stockpile Chemical Weapons Materiel at the Pine Bluff Arsenal

The Army plans to construct and operate a mix of fixed and mobile systems for assessment and destruction of the PBA non-stockpile inventory. These systems are described briefly below. Figure 1-3 is a flow chart summarizing the disposition of RCWM at PBA. The dotted box highlights the operations that are the primary focus of this report.

The Pine Bluff Munitions Assessment System

RCWM at PBA are currently stored in 30- to 85-gallon drum overpacks in four igloos at PBA. About 10 percent of the RCWM items are singly overpacked, and these have been assessed by both x-ray and portable isotopic neutron spectroscopy systems.[9] The other 90 percent of the RCWM items is stored at up to 15 items per drum and has been assessed only by x-ray (Figure 1-4). Using these techniques, explosive ordnance disposal representatives from the Army Technical Escort Unit determined the transportation status of each drum and assigned it to one of three categories. Green drums can be safely transported from their storage site to the Pine Bluff Munitions Assessment System (PBMAS). Yellow drums are those whose explosive train status could not be positively determined to be safe and that therefore require special handling during movement. Red drums denote munitions whose fuze or explosive train status is determined to pose a hazard for transporting and that therefore require special handling during transport (Verrill and Salcedo, 2001).

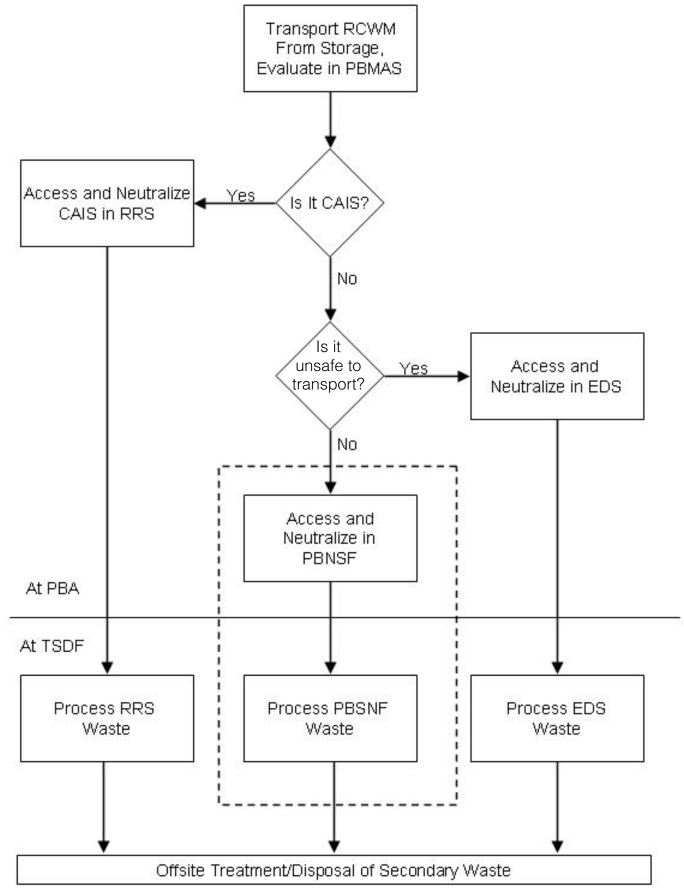

FIGURE 1-3 Flow chart for the disposition of RCWM at PBA. NOTE: Operations in the dashed box are the focus of this report.

The PBMAS will be made up of a series of interconnected steel rooms co-located with the larger PBNSF (see below) and having specialized equipment for warming the drums, opening them, removing the individual munitions, assessing their contents, and repackaging them individually. The assessment will be made by x-ray and portable isotopic neutron spectroscopy systems. The individually packaged and characterized munitions will then be distributed to the various destruction systems for NSCM at PBA, as illustrated in Figure 1-3. PBMAS is expected to be operational between June 2004 and June 2005, about 2 years before PBNSF is to become operational (June 2006 through March 2007).

The Pine Bluff Non-Stockpile Facility

Munitions that are assessed by PBMAS as safe to transport will be destroyed in the PBNSF. The current design of this facility is the main focus of this report and is discussed in detail in subsequent chapters. Briefly, munitions containing energetics will be drilled and drained in an explosive containment chamber, and the fill will be piped to a reactor, where it will be chemically neutralized. Nonexplosive 4.2-in.

[9]Portable isotopic neutron spectroscopy systems spectra contain scattering peaks that indicate the presence of heavy atoms in the fill (e.g., chlorine and arsenic) that are diagnostic of a particular fill.

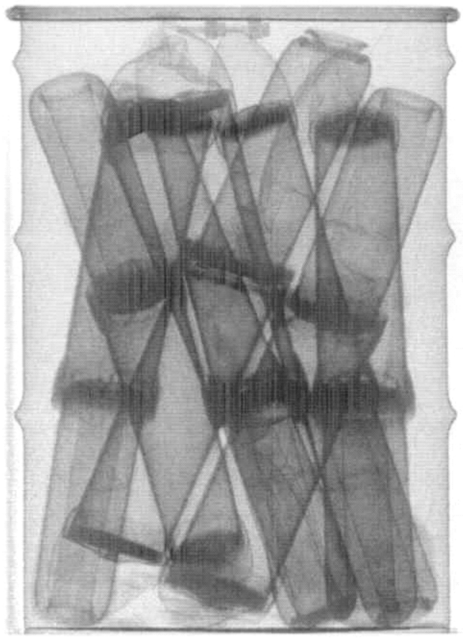

FIGURE 1-4 X-ray of 85-gal drum containing eight German Traktor rockets. SOURCE: Verrill and Salcedo (2001).

mortars and GTR warheads that are nonexplosive will be accessed at a projectile washout system, where a liquid jet will rinse the fill contents out of the munition body. Following overnight soaking in a heel-dissolving[10] tank, munition bodies containing energetics will be detonated in a detonation chamber, and those without energetics will be cut prior to final surface decontamination. Liquid wastes will be sent to a commercial TSDF for posttreatment, by an alternative treatment technology if feasible or by incineration (NRC, 2002a). Solid wastes will be further treated as required by regulation and subsequently disposed of or recycled. PBNSF is being designed to process 10 RCWM items per shift.

Explosive Destruction System

Munitions that are judged unsafe to transport (e.g., fuzed and armed, or unstable due to degradation) will be destroyed in an EDS operated in tandem with PBMAS. EDS mobile units, which utilize explosive accessing to open the munition and detonate the energetics, followed by chemical neutralization of the fill, were successfully used to destroy RCWM at Rocky Mountain Arsenal, Colorado; Camp Sibert, Alabama; and Spring Valley, Washington, D.C.[11] Secondary waste streams from the EDS will be sent off-site to a commercial TSDF for posttreatment.

There are two sizes of EDS. The smaller EDS Phase 1 (EDS-1) is available for destroying munitions containing less than 1 lb trinitrotoluene-equivalent energetics. A larger EDS Phase 2 (EDS-2) is undergoing testing; it is designed to destroy munitions containing up to 3 lb trinitrotoluene-equivalent energetics. The EDS and its waste streams were discussed in a previous National Research Council report (NRC, 2001a).

Other Technologies

A review of other mobile treatment systems, including the RRS, the Single CAIS Accessing and Neutralization System, and the Donovan Blast Chamber, was undertaken in *Systems and Technologies for the Treatment of Non-Stockpile Chemical Warfare Materiel* (NRC, 2002a). Further review of these systems is beyond the scope of this report.

Management of Secondary Waste Streams

Secondary waste streams from PBNSF will include liquid wastes such as effluent from the agent neutralization process, rinsate, and decontamination solution as well as solid wastes such as spent carbon filters, munition bodies, and workers' protective suits. The Army does not intend to posttreat these secondary wastes on-site but will send them instead to a commercial TSDF for treatment and final disposal or recycling (U.S. Army, 2002b).

Typically, a TSDF would destroy these materials in a high-temperature incinerator; however, in recent years there has been growing public opposition to incineration in general and incineration of CWM in particular. Therefore, the PMNSCM has invested considerable resources in testing a variety of alternative (nonincineration) technologies for posttreatment of non-stockpile waste streams (NRC, 2001b). If an alternative technology proves effective in treating these wastes, is economically attractive, and can receive regulatory approval and permitting in a timely way, the Army plans to fund the construction and permitting of such facilities at the TSDF receiving the waste. If no alternative technology proves feasible, the Army plans to proceed with incineration of these wastes at the TSDF.

SCOPE OF THIS REPORT

The statement of task (see Preface) makes it clear that the committee's focus is to be PBNSF rather than other nonstockpile destruction systems at PBA. Nonetheless, some issues surrounding the operation of ancillary facilities such as the PBMAS, the RRS, and the EDS have a bearing on the plans for PBNSF and, as such, are discussed. The committee has also addressed some issues pertaining to the Army's plans for off-site treatment of secondary wastes. Issues relat-

[10] A heel is solid or semisolid residue found in some stored munitions and containers.

[11] William Brankowitz, Deputy Product Manager, Non-Stockpile Chemical Materiel Product, "Non-Stockpile Chemical Materiel Product Program Status Update," briefing to the committee on June 12, 2003.

ing to other non-stockpile activities at PBA, such as destruction of the binary precursor agents DF and QL, destruction of the former binary agent production facility, and the empty ton container cut-and-clean operations, are beyond the scope of the study.

Two nontechnical issues are expected to strongly affect the operational schedule for PBNSF: (1) regulatory approval and permitting and (2) addressing the concerns of affected interest groups. Because the committee believes that the handling of these issues will directly affect the ability of PBNSF to accomplish its mission of destroying NSCM at PBA by April 2007, they are reviewed here.

COMMITTEE APPROACH

As this study began, the engineering design for PBNSF was still evolving. In fact, during the information-gathering phase of the study, the committee had access to only 35 percent of the facility design. At that stage, the gross facility features, treatment technologies, and major equipment to be used were specified, but some basic design matters were unresolved. These include the design basis for the internal pressure that the building must resist, the agent and explosive configuration of the 4.2-in. mortar rounds, and the operational requirements for the explosive containment chamber and the projectile washout system units. All of these matters impact the finalization of the piping and instrumentation diagrams, the structural design, and the detailed design of the facility. Since the final design of PBNSF remained unclear and data-collection activities were to end on August 1, 2003, the committee believed that it could best contribute by addressing the significant issues that needed to be considered as the final engineering design was being prepared.

As noted above, the committee believes that nontechnical issues—namely, regulatory approval and permitting and public involvement—will be as important as the technical issues in determining whether PBNSF will achieve its mission by the April 2007 CWC deadline. The committee attended local meetings of the affected public and examined the Army's plans for involving the public. It also participated in a conference call with regulators from the Arkansas Department of Environmental Quality. This report therefore contains both technical and nontechnical findings and recommendations.

STRUCTURE OF THIS REPORT

Chapter 2 describes the building and site layouts of PBNSF as they were presented to the committee at the time this report was being prepared. It examines the processes that will be used to destroy RCWM at PBNSF, the details of their integration, and the Army's planned schedule of operations. The facility plans for protecting workers, the public, and the environment during PBNSF operations and closure are explored in Chapter 3. In Chapter 4, the committee evaluates the Army's plans for managing the waste streams from PBNSF. Chapter 5 examines key regulatory and public involvement issues. In Chapter 6, the committee presents alternative approaches to the destruction of non-stockpile chemical materiel stored at PBA.

2

The Pine Bluff Non-Stockpile Facility

In this chapter, the committee describes the basic design configuration of the Pine Bluff Non-Stockpile Facility (PBNSF), outlines the intended operation, and discusses a number of issues related to facility design and operation. In conducting its review, the committee examined the initial design documents for the facility (35 percent design) and the permit application submitted to the Arkansas Department of Environmental Quality and received briefings and updates from the Army. The committee also had follow-up meetings with the Army and its design contractors, and members had many technical discussions among themselves.

The committee relied on generally accepted construction practices and benchmarks, such as the Construction Industry Institute Best Capital Practices. However, a project like PBNSF cannot easily be reviewed using such practices, because the entire project has been heavily driven by schedule and the need to use alternative technologies that are fairly new. The U.S. Army Corps of Engineers, which is constructing this project, is active in organizations such as Construction Industry Institute and says it will incorporate as far as practicable such best practices in the design and construction phases. However, owing to the nature of the PBNSF project, the committee could not prepare a detailed comparison of the project's stages against generally accepted practices and benchmarks. As discussed below, the main factor driving this construction project—the treaty deadline—is by and large beyond the control of the Corps and the non-stockpile program.

BUILDING AND SITE LAYOUT

The PBNSF site will occupy approximately 25 acres that previously were used for disposing of construction fill. As currently configured, the main process facility will be a 40,000 ft^2 building (see Figure 2-1) surrounded by an 8-ft chain-link security fence (U.S. Army, 2003b). The process facility will comprise the following:

- receiving dock
- munitions warming and storage room
- unpack area
- fill extraction preparation area
- fill extraction area
- agent treatment area containing:
  - —two explosive containment chambers (ECC-1 and a larger ECC-2) for removing the chemical agent fill from an item that has an energetic component attached and from which the agent can be drained
  - —a chemical process trailer (CPT) with two neutralization reactors for destroying the chemical agent fill emptied from the items in the ECC-1 and ECC-2
  - —a detonation chamber (DET) for the destruction of energetic components that do not contain agent and are not contaminated with agent
  - —a projectile washout system (PWS) for removing chemical agent from nonexplosively configured munitions
- decontamination room
- repacking room
- storage room and associated handling areas

The PBNSF relies mostly on legacy equipment from the abandoned Munitions Management Device (MMD) project, including the ECC units, the CPT, and the DET. This equipment consists of trailer-mounted units that can be disassembled, transported by road or by air, and reassembled at new locations. The decision to reuse this equipment has necessitated continuing modifications, particularly to the ECC units, as well as accessibility constraints in the CPT.

All processing areas will operate under negative pressure to provide chemical vapor containment in the event of a release. The exhaust air from all spaces that could contain agent will be passed through high-efficiency particulate air and carbon filter systems for purification before being passed to the atmosphere. All areas where chemical materiel is handled and processed will be sealed to prevent the migra-

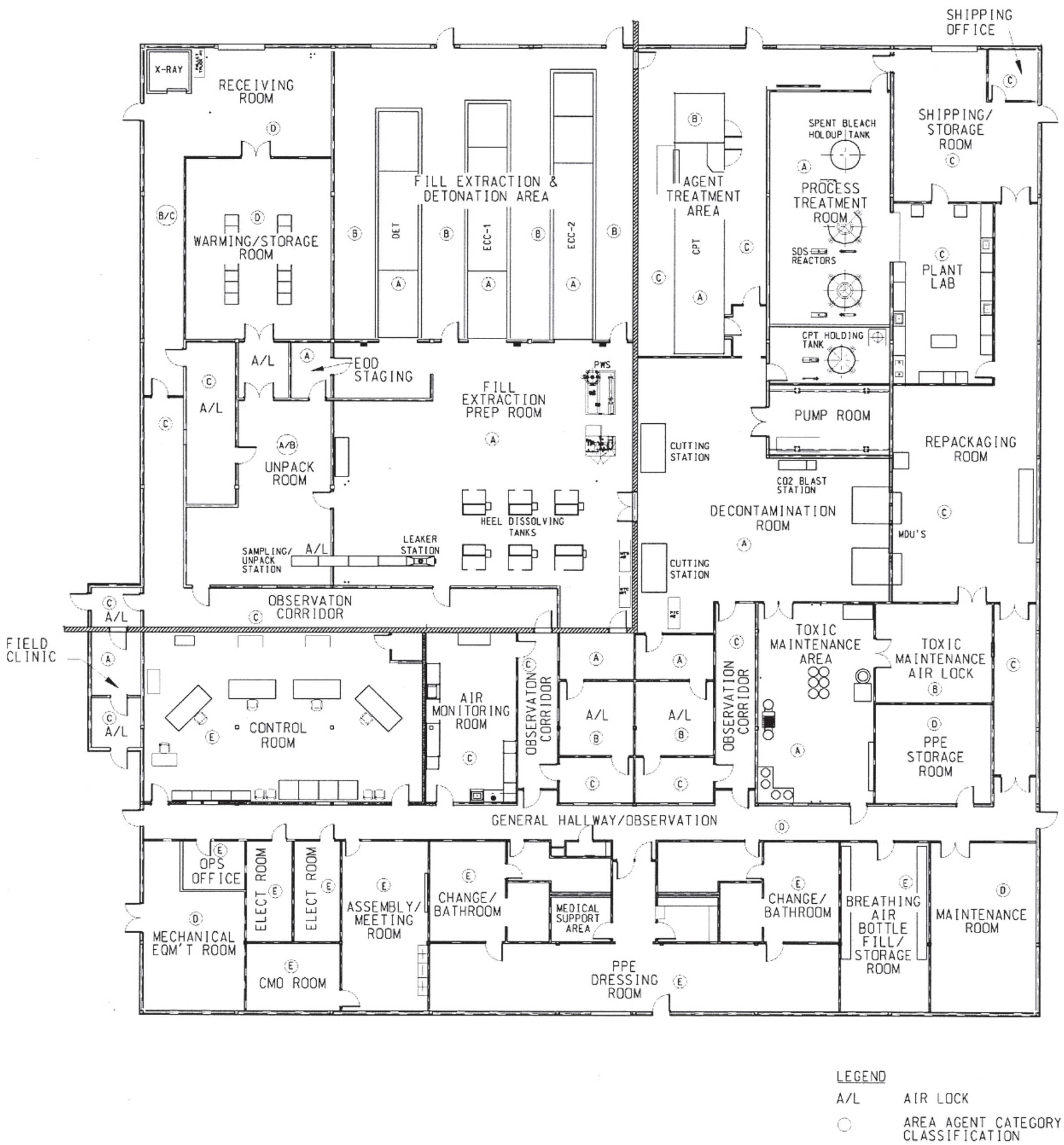

FIGURE 2-1 Diagram of the PBNSF processing area layout. SOURCE: U.S. Army (2003b).

tion of agent or vapor to or from other areas in the event of a release.

The Product Manager for Non-Stockpile Chemical Materiel (PMNSCM) has defined the maximum credible event (MCE) for the PBNSF design as the detonation of a fully configured German Traktor rocket (GTR) motor and warhead combination while being processed in the PBNSF. While it is difficult to estimate the likelihood of the occurrence of the MCE, it is important to review such a low-probability event and investigate designs that protect against it when consequences may be severe.

The committee recognizes that the PBNSF design calls for the MCE to be completely contained, but only when the GTR is being processed within the ECC-2. However, should the MCE occur within the PBNSF but outside the ECC-2, there could be a release of fragments and agent to the immediate area outside the PBNSF building; there are similar concerns should a fully configured GTR be detonated during transit. However, nothing in this report should be construed as expressing the view that such a release is likely.

The Army, citing the containment requirements in Department of the Army Pamphlet 385-61, Section 6.6 (U.S. Army, 2002a), has reported that this condition (less than total containment) is the required level of protection for both the stockpile and the non-stockpile disposal programs. Should the MCE occur outside the ECC-2, it would almost certainly result in severe worker injuries or fatalities and trigger a public reaction and regulatory review. Such a review would seriously delay completion of the PBNSF task regardless of the impact on workers or the environment. For this reason the committee's judgment is that this less-than-total-containment for the PBNSF building is not satisfactory. This containment situation bears out the committee's recommendation to develop a system that would decouple the GTR motor/warhead combinations in a separate facility designed to contain both explosions and releases of lethal chemicals and minimize transportation and handling.

The Army is already evaluating the possibility of decoupling fully configured GTRs in existing igloos prior to their treatment in PBNSF. If this effort is unsuccessful, the committee urges the Army to (1) develop a transport system that would contain the explosion in the event of GTR detonation in transit and (2) revisit the PBNSF design and/or engineering controls to ensure the safety of workers who might be outside the building if a GTR detonated inside PBNSF as well as the safety of the general public.

Ancillary features and areas that would be located on the proposed site include these:

- storage tanks for neutralent and the spent decontamination solution, including spent wastewater and neutralized wastes
- chemical supply tanks
- process chillers
- two standby generators
- a minibunker for storage of explosive charges
- a waste storage and handling area
- an administrative building
- a gatehouse

The process facility building, the fence, and support structures and utilities are being designed and built by contractors to the U.S. Army Corps of Engineers' Little Rock District based on the criteria provided by the PMNSCM.

The processing steps that a munition or other item will undergo as it is transferred into the system are discussed in the following sections.

CONFIRMATION OF MUNITION CONTENTS

The contents of recovered chemical weapon materiel items at PBNSF will be confirmed in two steps. The first step in assessment of the munitions is performed in the Pine Bluff Munitions Assessment System (PBMAS), a facility separate from the PBNSF. The munitions will be unpacked, examined, analyzed, classified, and repacked into overpacks, each containing only a single munition, for storage and subsequent transportation to PBNSF. Adjacent to PBMAS is an explosive destruction system (EDS) that will destroy munitions considered too hazardous to move into storage for future destruction in PBNSF. The second step of the assessment occurs when the munition is first unpacked in PBNSF prior to disposal. The details of these two steps are described in the following sections.

Characterization in the Pine Bluff Munitions Assessment System

Each munition to be processed in PBNSF will be characterized individually in PBMAS by nonintrusive methods, primarily x-rays and portable isotopic neutron spectroscopy (PINS).

The x-ray scan provides two kinds of information. It registers the presence of energetic materials such as a fuze, a burster, explosives, or propellant and detects whether the munition contains a chemical agent.

The PINS measurement provides qualitative information to assist in the identification of the chemical agent contained in the item based on the presence of elements such as sulfur, arsenic, chlorine, and nitrogen. The PINS characterization is generally accurate, but interpretation of the results may be affected by the presence of corrosion products and other effects.

The PBMAS operations allow the munitions to be segregated into those containing energetics only, chemical agent only, or both (with the agent assessed as drainable or gelled). This characterization within PBMAS allows the appropriate processing steps within PBNSF to be selected. The munitions are also classified by agent type because PBNSF processing will be performed in campaigns based on the nature of the agents contained in a set of munitions. Following characterization in PBMAS, the items will be packed into individual overpacks that are color coded to denote the risk associated with future handling and transferred to storage until they can be processed in PBNSF.

Characterization in the Pine Bluff Non-Stockpile Facility

When the overpacked munitions are received in PBNSF, they are again assessed by x-ray in the receiving room and are checked for agent leakage by sampling the air in the overpack (U.S. Army, 2003a). Subsequently, once the agent chamber in the munition has been accessed, a headspace vapor sample is withdrawn to confirm the identity of the agent by coupled gas chromatography-mass spectroscopy. This reconfirmation step is important for ensuring that the chemical agent undergoes the appropriate neutralization treatment and that suitable monitoring devices are in place for worker protection. The munition is then sent to the next processing module, which is selected based on munition configuration (agent and explosive content) and condition (clean, corroded, and so forth).

The nature of the non-stockpile disposal program is such that a wide variety of materials must be dealt with, and there is considerable uncertainty surrounding the characteristics of these materials. For example, originally it was assumed that the overwhelming majority of the 4.2-in. mortar rounds containing mustard agent did not contain an explosive component (fuze, burster tube, etc.). This situation would have allowed these mortars to be processed in the PWS after the bottom of the munition was cut off to allow access for power washing the agent fill out of the munition body. However, more recent test data indicate that there is so much uncertainty about the presence of a fuze or explosive in a burster tube that it is prudent to assume that all of these 4.2-in. mortar rounds contain fuzes and/or bursters.[1] Because it is not possible to definitively determine whether the burster tubes in the mortar rounds contain energetic material or inert material or whether they are empty, it must be assumed that any mortar round containing a burster tube may also contain energetics. In addition, experience from the stockpile disposal facilities has shown that in many munitions mustard agent has gelled or solidified, which prevents the agent from draining and leads to formation of heels. This combination of agent heel in an explosively configured item could make it impossible to achieve the anticipated destruction rate using the PBNSF equipment as presently configured.[2]

It should be noted however, that in a recent PINS assessment of the contents of the munitions to be processed at the PBNSF (Verrill and Salcedo, 2001), 597 of 733 4.2-in. mortar rounds were empty and 218 of the 399 GTRs that did not contain propellant were also empty. Of a total of 1,231 munitions evaluated, 865 were empty. According to communications from the Army, "empty" in this context does not mean that an item does not have trace or residual contamination. For classification purposes—that is, to select a processing campaign—"empty" means no liquid is seen in the x-ray. Since some munitions that are "empty" may indeed contain residual or trace quantities of agent that are not detectable by PINS, the munitions will have to be processed in the PBNSF (or in the EDS) as if they do contain agent. If they contain explosives, they will be drilled and drained in an ECC; if they are inert, they will be cut open and washed out in the PWS. In either case, any residual agent will be treated with a reagent in the neutralization reactor.

[1]Darryl Palmer, Office of the Product Manager for Non-Stockpile Chemical Material, "Multi-pack 4.2-in. mortars," e-mail to the committee on June 5, 2003.

[2]Chapter 6 addresses possible options for the modification of the facility to maintain schedule in view of the reassessment that many, if not all, 4.2-in. mortar rounds should be assumed to be explosively configured.

PROCESS DESCRIPTION

Accessing the Chemical Agent

The first step in processing a munition at PBNSF is to temperature-condition the contents by letting the munition stay in the warming room for at least several hours. This step is necessary because HD agent freezes at 58°F and would not drain from a cold mortar or rocket. The warmed munition will then be x-rayed to ascertain the amount and condition (liquid, solid, or gel) of the agent fill. After this characterization, the munition may be stored in the warming and storage room until it can be accepted in the unpack and fill extraction areas.

Based on the presence or absence of energetic materials and on an assessment of the drainability of the agent, two options exist for gaining access to the chemical agent contained within a munition. In general, munitions without energetics will go to the PWS for cutting, draining, and washout. For example, nonexplosively configured 4.2-in. mortar rounds and GTR warheads might be sent to the PWS for accessing the agent. Alternatively, the same inert mortar round could be sent to the ECC-1 for drilling and draining. Similarly, an inert GTR could be sent to the larger ECC-2 for drilling and draining.

Rockets or mortar rounds that contain energetics will ordinarily be processed in one of the two ECC units, which are designed to contain the force of an explosion should one occur during the drilling and draining operations. However, such an explosion would severely damage the internals of the ECC, and the operation of the PBNSF would be severely impacted by the loss of capacity and by an incident investigation.

Processing via Explosive Containment Chamber Units

Energetically configured munitions containing agent will be processed in the ECC units (the ECC-1 and the larger ECC-2). These contain an auxiliary processing vessel (APV)—a small, movable pressure vessel that contains drills, agent extracting devices, and neutralent injection and drainage capabilities—into which the munition is loaded. This drill-and-drain assembly (containing the munition) is then loaded into an ECC unit, which is essentially a large pressure vessel that will contain any explosion up to the design loading (see Figure 2-2). As stated previously, these ECC units were developed as part of the MMD program and are currently being modified to improve their accessibility and operability (see Figure 2-3).

The procedure for handling an energetically configured munition is to manually load it into the APV. The APV is highly complex and consists of numerous hoses, motors, and movable parts, all of which must work as required within the ECC to drill and drain the munition. The APV containing the munition is then moved into the ECC unit for drilling, sampling, and draining. All processes are performed within the

FIGURE 2-2 Auxiliary processing vessel removed from explosive containment chamber. Note the number of hoses, connections, etc. associated with the requirement to drill and drain munitions remotely when the APV (containing the munition) is inside the ECC containment vessel.

sealed ECC. The first hole is drilled into the top of the munition to allow the collection of a vapor sample to confirm the identity of the agent. Another hole is then drilled in the bottom to drain the agent. The drained agent will be piped directly to a neutralization reactor in the CPT or to a holding tank if neither of the two neutralization reactors is available at the time. If the agent is gelled there is no provision in the current design to enable the agent to be removed from the munition within the ECC.

The drained munition is rinsed with a neutralization reagent appropriate for the particular chemical agent.[3] The neutralent is also sent to the CPT or a holding tank to be processed along with the neat agent.

The operation of the ECC assumes that the agent will drain from the munition when the drilling is completed. This assumption is currently being reassessed by PMNSCM based on the experience of the stockpile disposal facilities with heels of gelled mustard agent (see Finding 2-2). This reassessment may require a redesign of the ECC units to include a high-pressure water wash system. The Army is assessing various methods of washing out any gelled or solidified agent that will not drain, but this work was not available for review by the committee. However, the problems associated with ensuring removal of the gelled agent through the small access holes available, or even smaller holes if a probe has to be inserted to maintain a seal, are significant. At the time this report was prepared, no practicable design for this system had been developed. A completely different approach may be required to overcome the problem of gelled mustard agent, which might be exacerbated by the construction of the 4.2-in. mortar rounds. These rounds have internal baffle plates welded to the sides of the agent cavity. This feature could make it difficult to wash out the additional surface areas upon

[3]The rinsing with neutralization reagent is performed in the ECC and not in the PWS, as the ability to apply large amounts of flushing water into the munition is limited in the ECC by the small size and fixed location of the nozzle. This limitation does not apply to the PWS, where full access and a large amount of water are available.

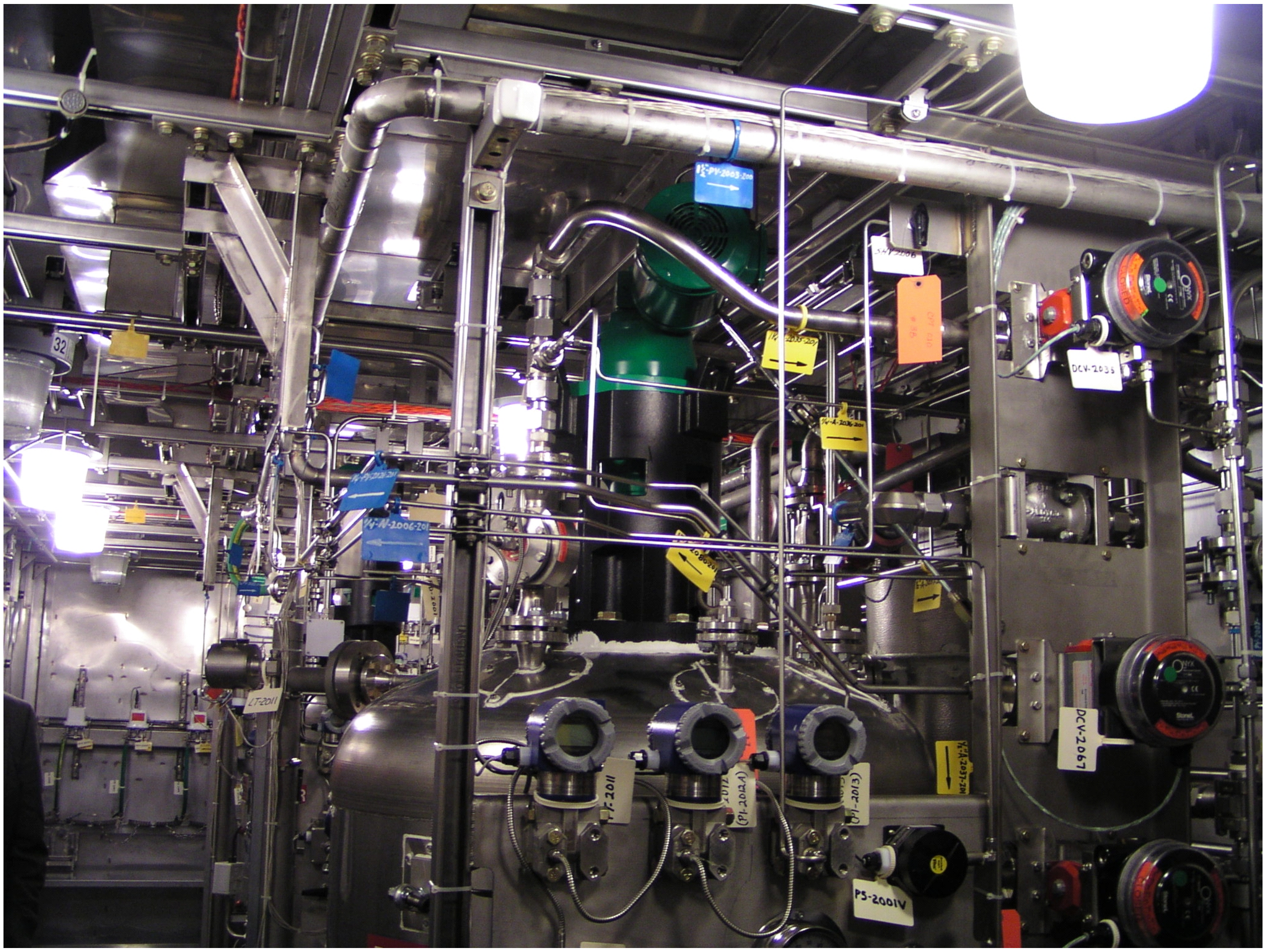

FIGURE 2-3 Internal layout of the chemical process trailer. Note the complexity and congestion of the piping and instruments.

which heel can be deposited. An Army test report states, “the interstices between the baffle central core and the burster well walls could present areas difficult to cleanse even by high-pressure water” (U.S. Army, 2002c).

In addition to these conceptual design issues, the ECC drill-and-drain assembly is already a highly complex system. Adding complexity in the form of a new wash system may affect the reliability of the system.

Processing via the Projectile Washout System

The PWS is an equipment assembly acquired from the Assembled Chemical Weapons Assessment (ACWA) program. The ACWA program demonstrated the ability of this equipment to effectively cut open and wash out 4.2-in. mortar rounds that do not contain any energetic material (fuze, burster, etc.).[4] Eighty-five such rounds were processed in PWS testing; the test report (U.S. Army, 2002c) said, “the agent cavity of all 85 munitions was inspected after washout. All 85 were visibly clean and metal bright.” The test report also said, “The minute amount of agent heel in the munitions after washout did, however, affect observation of the system’s ability to destroy HD.” The system referred to is a thermal metal parts treater (not part of PBNSF) that uses superheated steam to bring the munition body to a 5X condition following washout in the PWS.[5] The point, however, is that regardless of the metal parts treater’s ability to decontaminate the munition body, some agent heel may remain in the munition following washout in the PWS (U.S. Army, 2002c).

[4]The ability of a high-volume, high-pressure water wash to effectively clean out the munition in the PWS eliminates the requirement to use a neutralent wash, which is used for cleaning munitions in the ECC.

[5]5X refers to a level of decontamination at which solids may be released for general use or sold (e.g., as scrap metal) to the general public in accordance with applicable federal, state, and local regulations. A common misconception is that 5X means simply that the solid has been placed in a temperature zone of 1000°F or higher for 15 min. In fact, a 5X condition indicates that the solid has been completely heated to and then held at a temperature of at least 1000°F for 15 min.

The PWS is a glove box system containing equipment to drill, cut, drain, and pressure-wash projectiles (no neutralent rinsing is performed owing to the proven effectiveness of the pressure wash in the PWS). It is not designed to handle energetic material. After the munition is drilled to obtain a sample of the agent vapor for analysis, the base of the munition is cut off with a pinch roller, which allows full access for washing (unlike the ECC, which allows very limited access). The drained liquid agent is then piped to the CPT for neutralization, as is done with drained agent from the ECC. After the agent is drained, the munition body is pressure-washed with water to flush out residual agent and solid residues. The washings are piped to the spent decontamination solution (SDS) reactors for neutralization along with decontamination solutions from other operations. These reactors are new units and are to be located in a separate section of PBNSF.

The original design intent was for inert mortar rounds (i.e., those with no energetic material) and GTRs to be processed in the PWS (U.S. Army, 2002b). The original assessment of the materiel to be disposed of at PBNSF was that the overwhelming majority of the 4.2-in. mortar rounds containing mustard agent were inert. Recent analysis suggests that this assumption may be incorrect and that it may instead have to be assumed that almost all of the 4.2-in. mortar rounds contain energetic material. This change will significantly impact the ability of the PWS to process munitions. If it is concluded that the most recent assessment is correct, then the PWS (as currently configured) will not be able to process the large number of 4.2-in. mortar rounds specified in the current schedule.

To maintain the current schedule, one of two actions would be needed:

- Agent-containing 4.2-in. mortar rounds would have to be processed in another item of equipment (e.g., in a modified ECC with a power washing capability added, or in an EDS unit in addition to the one attached to PBMAS); the 597 rounds that do not contain agent can be processed as planned in unmodified ECC units followed by heel-washing and detonation, or
- The PWS would have to be modified to allow it to be remotely operated within a pressure vessel able to contain an explosion of the energetic material—that is, the PWS becomes a modified version of the ECC.

The effect on schedule and cost of redesigning either the ECC or the PWS is unknown but would probably be significant because of the associated development time, the cost of demonstrating the effectiveness of the modifications, and the need to conduct process safety studies and hazard analyses.

Neutralizing the Agents

The CPT unit was also obtained from the discontinued MMD project. The equipment is contained in a trailer so that it is transportable by road. The requirement that the unit be transportable has led to congestion in the interior of the trailer (see Figure 2-3). Equipment located behind the reactors and on the ceiling may be difficult to access for repair or maintenance, particularly when the operating staff must wear Level A personal protective equipment (PPE) inside the CPT (see Figure 2-4).

The CPT contains two continuously stirred tank reactors, one large and one small (123 gal and 66 gal, respectively). Each is agitated by stirring as well as by circulating the reactor contents through an external loop. The neutralization is carried out in much the same way as in the mobile MMD-1; in fact, much of the MMD-1 neutralization hardware is to be used in the PBNSF CPT. The MMD-1 system was demonstrated extensively in Utah (Cash et al., 2001). The MMD-1 testing was performed using phosgene[6] as the agent and dilute sodium hydroxide as the reagent/neutralent. While phosgene should not be encountered in the munitions to be processed through PBNSF, extensive bench-scale testing with mustard agent was performed at Edgewood Arsenal under conditions applicable to the MMD-1 and PBNSF neutralization processes. Neutralization of mustard agent with MEA containing 10 percent water produced a neutralent solution containing 67-89 percent MEA, 9-10 percent water, varying amounts of MEA hydrochloride, and a sulfur compound derived from reaction of the mustard agent with MEA (see the chemical equation later in this section). No residual mustard agent was detectable by an analytical procedure with a detection limit of 50 parts per billion (ppb). Small amounts of organic sulfur compounds and chlorinated hydrocarbons were detected. These compounds probably arose from impurities in the HD agent or from high-explosive degradation products. The results of these neutralizations are summarized in a National Research Council report (NRC, 2001b).

The drained agent and the reagent neutralent rinses are accumulated in one of the two neutralization reactors until the volume is sufficient for the agitator to function efficiently. Additional neutralization reagent is added as needed to ensure destruction of the agent. Agitation and circulation through the external loop are begun, and the reactor is warmed to about 50°C to initiate the reaction (U.S. Army, 2001a). Since the neutralization reaction is exothermic, no heat input is required once the reaction begins. In the MMD-1, neutralization of HD resulted in peak temperatures of about 80°C. Cooling via the external circulation loop may be required, so this is provided for in the equipment design. The reactor contents are held at the desired temperature for 90 min after adding the contents of the agent fill from the last munition of the batch in order to complete the neutralization reaction. The reactor contents are cooled and sampled

[6]Phosgene, an asphyxiating gas, was used extensively as an antipersonnel agent in World War I and is found in some recovered weapons of World War II vintage.

FIGURE 2-4 Reactor vessel in the chemical process trailer. In this view note the proximity of the reactor vessel to the wall of the trailer and the consequent restricted access for inspection, maintenance, or repair of the pumps and instrumentation.

to ensure that agent concentration has been reduced to a level below the release standard—50 parts per million (ppm) for blister agents such as HD, HN-3 (nitrogen mustard), or phenyldichloroarsine (PD). The reactor contents are drained into a waste retention tank for storage until the agent concentration has been established. If the concentration exceeds the release standard, the batch is returned to the neutralization reactor for additional treatment. When the concentration is determined to be less than the release standard, the neutralent is transferred to a neutralized waste storage tank to await shipment to a treatment, storage, and disposal facility for final disposal.

The reagent used to neutralize the sulfur (HD) and nitrogen mustard (HN-3) agents in the continuously stirred tank reactor is 90 percent MEA and 10 percent water, the same solution as that chosen for the MMD project and the EDS mobile destruction systems. This reagent is miscible with water, is a good solvent for the agents (even better than a 100 percent water wash), and reacts readily with them. It also does not produce significant quantities of products listed as Schedule 2 compounds under the Chemical Weapons Convention (CWC). From an engineering viewpoint, it has low corrosivity with stainless steel under the chosen operating conditions and has low flammability.[7] The main chemical reaction with sulfur mustard is this:

[7]There exists a broad base of experience with MEA in the chemical industry. In addition to its industrial uses, aqueous MEA has been extensively studied for chemical demilitarization applications by both the U.S. (Durst et al., 1988) and Russian (Petrov et al., 1998) demilitarization programs.

$$\underset{\text{HD}}{S(CH_2CH_2Cl)_2} + \underset{\text{MEA}}{2H_2NCH_2CH_2OH} \rightarrow S(CH_2CH_2)_2NCH_2CH_2OH \cdot HCl + MEA \cdot HCl$$

The choice of neutralization reagent for the arsenic-containing agents in the GTRs is more complex. Some rockets may contain *Winterlost*, a solution of HD, PD, and diphenylchloroarsine (DA). The planned destruction of *Winterlost* at PBNSF is based on the operating protocol for the EDS (Verrill and Salcedo, 2001); it uses 90 percent MEA as when treating HD alone. Other GTRs are reported to contain a mixture of PD, DA, arsenic trichloride, and triphenylarsine. Although the initial plan for treating such mixtures involved reaction with 10 percent aqueous sodium hydroxide (NaOH), it is not clear that this reagent will completely destroy the phenylarsenic compounds in the mixture. Current research indicates that treatment with the proprietary reagent HPO_2[8] can destroy the phenylarsenic compounds, but this method may require conditions that are unacceptably severe from an engineering viewpoint.[9] However, neutralization of the arsenic-containing agents generates a liquid waste containing arsenic, the toxicity of which cannot be mitigated by chemical treatments.

The small amounts of mustard agent washed from the PWS, the ECCs, the heel-dissolving tanks, and the metal decontamination units (MDUs) using hot water or alkaline decontamination solution will give rise to some thiodiglycol. This compound has relatively low toxicity but is a Schedule 2 precursor under the CWC (cf. Chapter 5) because it can be reconverted to mustard agent under some circumstances. The thiodiglycol concentration in the effluent from the SDS reactor is expected to be quite variable depending on the source of the washings but always less than 1 percent.

Rinsing the Munition Bodies

Once the chemical agent has been drained from the munitions in the ECC, the munition bodies are rinsed with neutralizing reagent to remove gross quantities of agent adhering to the interior surfaces. (As described previously, rinsing munitions with neutralizing reagent is not performed in the PWS.) As noted earlier, these first rinses are combined with drained agent for treatment in the CPT. The munition bodies are then cleaned to remove trace amounts of agent as well as residues of corrosion products and agent decomposition products. The latter include heels—the tarry or solid agent material that has been found in many HD-containing munitions in the stockpile disposal program. The intent of the rinses and washes is to prepare the metal parts for further handling and disposal.

[8]HPO_2 is formulated from Oxone (a formulation of potassium monopersulfate) and aqueous hydrogen peroxide.

[9]Lucy Forrest, Non-Stockpile Chemical Materiel Product, "Traktor Rocket Sampling," briefing to the committee on April 22, 2003.

Munitions Treated in the Explosive Containment Chamber

Once the munition has been drained and rinsed with neutralizing reagent in the ECC, it is rinsed with three portions of a decontamination solution, typically dilute NaOH solution injected via the drill assembly. The rinse water from this final rinse of the munition before its removal from the ECC is piped to an SDS reactor for treatment. The rinsed munition is sent to one of five heel-dissolving tanks, where any solid residues that remain are dissolved with hot, circulating 10 percent NaOH solution during an overnight soak**.** The HD solids dissolve in the hot caustic solution, enabling the residuals to pass through the small drainage channels created by the drilling. The nearly agent-free munition body is then rinsed with water and sent to the DET, where an explosive charge is used to destroy the energetics remaining in the munition.

The contents of the SDS reactor will be heated, recirculated, sampled, and analyzed for chemical agent (U.S. Army, 2003a). If the agent exceeds the 50 ppm standard set for blister agent, 20 percent NaOH solution will be added to the reactor and the treatment will be repeated until the agent concentration falls below the release standard. The solution will then be held in an SDS storage tank pending shipment to a treatment, storage, and disposal facility for disposal.

Munitions Treated in the Projectile Washout System

In the PWS, the drained mortar round or rocket warhead will be pressure-washed with hot water only, which has been demonstrated to be fully effective because the internals of the munition are fully accessible in the PWS. The agent-contaminated water will be sent to an SDS reactor, where it will be treated along with the aqueous rinses from the ECC processing.

Solids Handling

After rinsing (for munitions processed in the ECC) and washing to remove chemical agent and other residues, the munition bodies undergo several steps to prepare them for shipment off-site for ultimate disposal. The exact sequence of steps depends on whether the munition bodies contain energetics such as bursters or propellants.

Munitions Containing Energetics

Rocket or mortar bodies containing energetics that have been washed in tanks to dissolve any agent heels will be sent to the DET, where an explosive charge will detonate the energetics and fragment the munition body. The DET is an existing item of equipment from the discontinued MMD program. It is not designed to destroy munitions that contain a significant quantity of agent, although the temperature generated within it by the explosion will destroy agent to some extent. The efficacy of the detonation procedure will be assessed by visual inspection of the fragments and residues.

Large metal pieces will be sent to a metal cutting station, where they are reduced in size with a remotely operated saw in a controlled atmosphere enclosure. Small metal fragments from the DET, along with size-reduced pieces from the cutting station, are sent to the MDUs.

In the MDUs, the metal parts will again be washed with 10 percent NaOH solution and rinsed with water. (The decontamination solution and rinse water will be sent to the SDS reactors for decontamination.) After the metal parts have been dried in the MDU, the atmosphere in the unit will be tested. If no agent is detected by headspace sampling with a MINICAMS[10] unit after 4 hours at 70°F, the metal pieces are designated 3X[11] and can be shipped under Army control to another site. Typically, they would go to the Rock Island Arsenal for thermal decontamination and smelting to recycle the metal. Thermal treatment at 1000°F for 15 minutes is defined as leading to a 5X condition, which means that the metal can be released from Army control. If 5X thermal treatment can be done in an existing furnace at the Pine Bluff Arsenal, the scrap metal could be released directly to a recycler.

Munitions Not Containing Energetics

Rocket warheads and mortar rounds not containing energetics that have been drained and washed with water in the PWS will be sent to the metal cutting stations for size reduction. Munition bodies that are heavily corroded will undergo an additional step to remove rust and scale that might entrap chemical agent. The corroded parts will be sent to a station in which they are blasted with solid carbon dioxide (dry ice) pellets. The impact of the CO_2 pellets will flake off the corrosion products to leave a relatively clean metal surface. The clean metal parts will be sent to the metal cutting station or directly to the MDUs, depending on size. The fine-grain corrosion debris deposited after evaporation of the CO_2 will be transferred to a drum of 10 percent NaOH decontamination solution to destroy any residual agent. The resulting slurry of debris in decontamination solution will be tested for the presence of agent before being sent off-site for further treatment (if necessary) and disposal.

[10]MINICAMS is a low-level, near-real-time monitor typically used to provide early warning of airborne exposure hazards. According to the U.S. Army (2000), the "basic operation of the MINICAMS involves collection of analytes onto a solid sorbent held in a preconcentrator tube (PCT). Analytes collected onto the PCT are then heat-desorbed into the gas chromatographic column for separation before passing through a halogen selective detector (XSD)." The XSD detects the chlorine present in all the blister agents.

[11]3X refers to a level of decontamination at which solids are suitable for transport for further processing.

PROCESS INTEGRATION

This section considers how the existing design for PBNSF is intended to operate in terms of material flow, the individual equipment, and the interaction of personnel with the system.

Material Flow

As indicated previously, PBNSF contains a variety of trailer-housed processing equipment obtained from the discontinued MMD program and from the ACWA program. Because the processing equipment and the PBNSF building were not designed at the same time, compromises were made that could adversely affect operations. Examples of such compromises include these:

- The location of the reactor vessels in the CPT (originally for purposes of transportability) has resulted in limited workspace behind these vessels that may impede maintenance activities (see Figure 2-4).
- Space constraints in the trailers that carry the ECC units limit the lengths of hoses and lines and constrain the extent to which the APV can be removed from the containment vessel (see Figure 2-2). They also limit access to the containment vessel and may increase the time and effort needed to maintain equipment in the ECC, particularly if problems arise with the APV's drill/drain/wash assembly while it is within the containment vessel.

PBNSF differs from a stockpile disposal facility in several ways:

- *Munitions characteristics.* The munitions to be processed in PBNSF are in variable condition, with a large proportion being old, corroded munitions containing a variety of fills, some of which are not encountered in the stockpile disposal program (e.g., arsenicals and nitrogen mustard). In some cases, the fill constituents will not be known with certainty until intrusive sampling of the munition contents is carried out. Therefore, each munition has the potential to present unique processing challenges, especially when explosive components are also involved. The effect of the variability of munition characteristics was demonstrated in the recent reassessment of the 4.2-in. mortar rounds. The original basis for the design of the equipment was that the great majority of these munitions would contain mustard agent that would drain and have no energetics (fuzes, bursters, etc.). The most recent assessment is that the great majority of the 4.2-in. mortar rounds might be energetically configured. For example, in one Army assessment, 128 of 130 mortar round x-rays that showed visible burster wells also showed that an explosive burster tube was present, indicating that many more mortar rounds than expected may be explosively configured.[12] If this is the case, throughput could be limited since in a single 10-hour shift, no more than five energetically configured munitions would be processed (U.S. Army, 2003c). The operating goal of processing five inert and five energetic munitions per shift may not be achievable if there are an insufficient number of inert mortar rounds to allow this mix. As a result, PBNSF might be limited to processing only five energetically configured mortar rounds per day, which would have adverse effects on project schedule and cost. In another recent assessment of munition agent contents, it was found that 597 of 733 4.2-in. mortar rounds were nominally empty—that is, they did not have a detectable agent fill—and that for GTRs, 263 of 477 rockets were also nominally empty (Verrill and Salcedo, 2001). Such uncertainties about the quantity of agent in the munitions will require conservative assumptions when deciding on the processing steps required to ensure safe operation of the facility.

- *Throughput rates.* While the stockpile facilities have been designed to process hundreds of essentially identical munitions per day, the PBNSF is designed to process only 10 or so munitions per day. This limitation is due to the munitions' characteristics and to the equipment selected to process the munitions.
- *Processing sequence.* In stockpile facilities the sequence of processing steps for a given munition type rarely varies. In PBNSF, seemingly identical munitions may be processed in a completely different manner owing to uncertainties about whether agent is present, what type of agent is in the munition when it is accessed, and whether the munition contains, or is thought to contain, an energetic component.
- *Munition handling.* In PBNSF, as currently configured, there are a large number of manual handling tasks associated with moving a munition within the facility. This includes unpacking, placing the munition on a cart, removing the munition from the cart, placing the munition in a device for draining/explosion, etc. An average munition will be handled approximately five times.

Systems Integration and Facility Operations

PBNSF contains various pieces of equipment that will be used in the processing steps. The processing steps will be tailored to the configuration of the item being processed. The possible configurations are these:

- Item containing, or assumed to contain, agent that can be drained but known to have no energetic component.
- Item containing, or assumed to contain, agent that cannot be assumed to be drainable but known to have no energetic component.
- Item containing, or assumed to contain, agent that can be drained but known to have, or suspected of having, an associated energetic component.
- Item containing, or assumed to contain, agent that cannot be assumed to be drainable but known to have, or suspected of having, an energetic component.

Each configuration may require a different set of equipment to safely access and neutralize the agent.

Because of the known variability of the munitions to be processed at PBNSF, the process design attempts to provide considerable flexibility in the sequence of unit operations. This flexibility is intended to allow any munition/energetic combination to be safely processed while maintaining the overall schedule for disposal operations. The nature and condition of the agent and the presence or absence of energetics would determine the equipment to be used for processing an individual munition.

For example, 4.2-in. mortar rounds that do not contain energetics can be processed in one of two ways. They can be sent to the PWS for cutting and a high-pressure washout or they can be sent to one of the two ECCs for drilling and draining (assuming the agent will drain freely). In either case, the munition would finally be sent to the cutting station for size reduction.

The recent assessment that a large majority of the 4.2-in. mortar rounds should be considered to be explosively configured and that some will contain agent heels could, if correct, significantly increase the time required to process these munitions. An extension of the schedule can be avoided only if some significant modifications are made to the current configuration of PBNSF. For munitions containing energetics, an attempt could be made to dissolve any heels by placing these munitions in one of the five tanks used to dissolve agent heels. However, this would increase processing time since only one munition containing energetics can be placed in a tank, thus limiting the number being soaked to five per night. It might be possible to process explosively configured munitions in the single EDS associated with PBMAS, but the schedule is likely to slip. It would also be possible for the munition to be placed in the DET and explosively destroyed. However, this would introduce agent into the DET, necessitating the use of decontamination solution in the DET and the collection, treatment, and disposal of the SDS. At present, this option is not being considered in the design of the DET, although it is being considered by the Army. Even if this option were selected, it would slow down operations as a result of the need to manually decontaminate the DET.

For inert munitions containing a solid fill, the Army could treat the munition at the PWS and spray rinse the munition at 300 lb/ft^2 gauge (psig) (low pressure) or at high pressure

[12]Darryl Palmer, Office of the Product Manager for Non-Stockpile Chemical Material, "Multi-pack 4.2-in. mortars," e-mail to the committee on June 5, 2003.

with a 10 percent NaOH solution. A PWS with a caustic spray washout at these pressures resulted in effective removal of solid mustard (HD) agent heels in the rounds tested (U.S. Army, 2002c).

At the time this report was being prepared it had not been decided whether the GTRs will arrive at PBNSF with the warheads separated from the rocket motor or whether the entire munition (warhead plus motor) will have to be processed. If only the nonexplosively configured warheads (the part of the GTR that contains agent) are to be processed, they can go either to an ECC for drilling and agent draining or to a PWS for cutting and agent washout. If the warhead and rocket motor are not separated, they must go to the ECC-2. Two options for the separation of the GTR rocket motors and warheads have been proposed. The first is unscrewing the two units, the feasibility of which depends upon the condition of the body of the munition and the threads. The second option is water jet cutting between the motor and warhead. Neither option has been demonstrated to date, although no conceptual obstacles are foreseen by the committee. The configuration of the GTRs (warhead and rocket motor or warhead only) to be processed through PBNSF could significantly affect the design basis selected for the worst credible internal explosion event for the building.

Manual Materials Handling

Unlike chemical disposal facilities in the stockpile disposal program, the munitions transport in the PBNSF process building is not automated and uses a variety of manually operated equipment:

- an overpack transfer cart
- a munition transfer cart
- a munition cradle cart
- a parts transfer cart

For example, energetically configured munitions travel to and from the ECC/APV on a munitions cradle cart, while a munition transfer cart is used for transport to the heel-dissolving tanks and to the DET. Following detonation, the munition fragments are transferred to the MDUs on a parts transfer cart. The use of such manually operated equipment is acceptable because only 10 munitions per day are expected to be processed, making the use of conveyors uneconomical. In addition, the time spent moving munitions does not affect the throughput of the facility. Elimination (where practicable) or minimization of the number of manual tasks associated with processing munitions would nonetheless significantly reduce risk to operations personnel.

Processing Sequence

The processing sequence for treating munitions in separate campaigns is as follows:

- sulfur mustard
- nitrogen mustard
- arsenicals

Any leaking munitions containing the agent being processed in a particular campaign will be treated at the end of that campaign.

Pine Bluff Non-Stockpile Facility Design Status, Operability, Reliability, and Accessibility by Humans

Status of the Engineering Design

At the time this report was prepared, several issues critical to the finalization of the PBNSF design had not been resolved. First, there are the issues of whether the 4.2-in. mortar rounds are to be assumed to contain energetic material (fuze, burster, etc.) and whether the mustard agent that they contain should be considered drainable or not. These issues are important because facility equipment was selected and the schedule was developed based on the assumption that the 4.2-in. mortars were not energetically configured and that the mustard agent would drain easily. The most recent assessment is that the original assumptions were not appropriate, so that the existing equipment will not be able to process the 4.2-in. rounds fast enough to meet the intended schedule. This is because (1) the PWS cannot be used as currently configured owing to the anticipated presence of energetics and (2) the ECCs cannot be used as currently configured owing to the anticipated inability of the mustard agent to drain.

If the most recent assessment of the 4.2-in. mortar rounds is correct, then meeting the schedule will require either significant modifications to the PWS and/or the ECC or an alternative method of processing the munitions.

Modification of the PWS and/or the ECC would require significant development and testing, which might affect the schedule. No practicable design to enable the reliable removal of gelled/solid agent from a munition in the ECC (with the small access holes currently proposed) was presented to the committee. Chapter 6 addresses possible alternative processing options.

A second processing issue is the current lack of an effective neutralization process for the arsenical fills in approximately 40 percent of the GTRs. Until such a process is developed and any process modifications are designed and implemented, the schedule will be at risk.

Another critical issue is that the maximum overpressure the process facility building should be designed to resist has not been finalized. This is a decision that drives the design of the building walls and roof and the design of the heating, ventilation, and air conditioning (HVAC) system. Initially, it was thought that the design basis should be the explosion of the energetic material in a GTR plus the GTR rocket motor, but this is being reconsidered. Eliminating the potential explosion of the rocket motor components of a GTR from the PBNSF design basis would reduce the pressure the building and HVAC would have to withstand. The cost reduction that could be achieved by doing this was being examined by the Army as this report was being prepared. If complete GTRs were eliminated from processing at PBNSF, the issue of how this munition might be otherwise processed remains. Several options appear possible:

- Deciding that the agent in the GTR is outside the scope of the CWC treaty requirements and addressing its destruction separately and at a later date. (This would also defer the issue of the current lack of a neutralization technology for approximately 40 percent of the GTR fills.)
- Separating the propellant charge from the agent container. This would allow the agent to be handled in the PWS.
- Destroying the GTR in another unit (e.g., the EDS associated with PBMAS).

An associated issue is whether the building is to be designed to prevent its penetration by the shrapnel from a possible explosion or whether such a penetration (and potential agent release) will be tolerated.

The maximum agent release that the various carbon-bed filtration systems must be capable of handling has also not been finalized. The final design of the carbon bed filters cannot be demonstrated until the design bases are further defined.

The process hazard reviews have not been completed even though the piping and instrument diagrams have been issued as final. Typically, these diagrams are issued as final only after the safety reviews have been completed and all issues resolved. It is known that other issues will affect the current heat and mass balance for the process, and so this document must also be considered incomplete.

The reasons these basic design criteria and activities have not been finalized are not clear. The 4.2-in. mortar rounds have been available for inspection for many years, as have the GTRs. The continuing delay in finalizing issues basic to the design of the facility and in performing the safety studies has put pressure on the design staff to meet the requirements of the schedule.

On the basis of a brief review of the proposed construction schedule, several general comments can be made. First, the schedule is based on working 6 days a week, 10 hours per day, for the first 6 months. Although the schedule includes a 40-day margin for weather delays, working 6 10-hour days for an extended period will place a severe strain on the workforce and the supervisory staff—productivity might suffer, and there could be adverse impact on safety.

It would seem that the published schedule, which is based on achieving the CWC-specified end date for disposal operations, is driving the project rather than realistic estimates for the completion of normal engineering tasks. The Army is constrained by CWC treaty and legislative mandates to achieve the destruction of the munitions assigned to PBNSF by April 2007. However, these constraints are at cross-purposes with the accepted practice for designing and building a complex industrial facility, the budget constraints imposed by Congress, and the need to develop a technology that satisfies regulatory requirements and the public's desire that the weapons be destroyed in a safe manner. Given the significance and complexity of these interrelated issues, a discussion of this constraint is warranted.

Any large industrial construction project must balance the desired schedule for completing the project, the time necessary for obtaining regulatory approvals, the cost of the project, and the need for flexibility to address inevitable unanticipated implementation issues. All other factors being equal, there is generally a trade-off between the cost of a project and the schedule for implementing the project (i.e., the time needed to develop the specifications or goals of the project, the time to design the facility, and the time to build it) (GAO, 1997). Typically, the shorter the schedule for implementation, the higher the project costs. A complex project with the potential to adversely affect public safety (such as the destruction of non-stockpile materials) simply cannot be implemented more quickly, and for less money, without potentially compromising effectiveness and, ultimately, safety.

The Army's PBNSF project has several unusual constraints that differ from those of a typical industrial project; these constraints may significantly increase costs if the current design and deadline are maintained.

First, because certain citizen groups expressed great concerns, Congress required the Army to develop technologies other than incineration for the destruction of the non-stockpile chemical weapons material (NRC, 2002a). The task of finding a promising technology and turning it into a viable facility design has not been trivial and has consumed much of the time allowed under the CWC. The additional tasks of obtaining regulatory approval and permits and soliciting public involvement for non-stockpile technologies have also added delay and uncertainty over the ultimate technology to be used (this is discussed more completely in Chapter 5.) In turn, these delays and uncertainties have resulted in increased costs and the need for an unusually long time to develop the conceptual design and goals for PBNSF.

Second, the Army's deadline is imposed by international treaty and U.S. domestic implementing legislation, and so is more inflexible than for a typical industrial project. The desire to shorten implementation schedules on most industrial projects is often driven by the economics of the project. The sooner the capital invested in a commercial project begins returning revenue on the investment, the sooner the company will begin to reap a profit. Thus, when a schedule slips there are economic consequences, and economic expectations must be adjusted.

The schedule for destroying chemical weapons cannot slip without significant international and legal consequences (among other things, giving other countries an excuse to delay destruction of their chemical weapons), and the benefit of destroying this component of the triad of weapons of mass destruction (chemical, biological, and nuclear weapons) is obvious.

It would appear that the schedule for the design, construction, systemization and destruction operations for PBNSF has been developed by taking the April 2007 CWC deadline as the completion date and compressing the normal design and implementation steps into the time until then. As a result, the design process has not always followed generally accepted practices. This conclusion is supported by a letter from the Army Corps of Engineers, Little Rock District, noting situations that will affect the proposed schedule:

- More than 40 days on which weather interferes with construction;
- Approval of the Resource Conservation and Recovery Act permit later than May 2004;
- The fact that the building design and the process design for the facility are taking place concurrently, possibly necessitating modifications to the contract;
- A delay of more than 5 minutes per trip for vehicles accessing the site;
- The known adverse effects that rain will have on the workability of the soil; and
- The lack of project funding to cover unanticipated delays.[13]

Given these uncertainties, there is only one certainty—namely, that delays will occur because so many issues remain unresolved. It would seem that the only option available to the Army is to increase the cost of the project, perhaps precipitously so.

Third, the Army is not a business and must operate within the budget appropriated by Congress. The uncertainties inherent in developing alternative technologies to destroy the chemical agents and resulting neutralents have led to an even greater cost uncertainty. The federal budget allocates funds to a particular project, and sometimes the funds must be expended by a particular date, hampering sound, long-term planning. There may even be pressure to keep the project on a schedule that matches the fund allocation schedule for purchasing equipment, site preparation and construction, and operations, whether or not the engineering status of the project warrants such adherence.

Fourth, as April 2007 approaches, the more likely it is that the PBNSF project will undergo ad hoc changes to overcome obstacles (e.g., making modifications to the ECC or PWS to deal with gelled mustard in an energetically configured munition) rather than moving forward in a well-planned, integrated way. Avoiding an inefficient design is particularly critical when human health or the environment can be compromised by design flaws that result in accidents. Ideally, the owner of an industrial project should consider the environmental requirements applicable to the facility in the design phase (NRC, 2001b). However, in the case of PBNSF, significant regulatory requirements could be imposed in the future.

The committee therefore believes that the published schedule does not reflect the relative immaturity of the engineering design and is likely to be too optimistic. It reached this conclusion after examining the project documentation and communications from Army personnel and the Corps of Engineers and comparing the design process for this project with the typical design process for an industrial construction project of a similar magnitude and complexity.

Fifth, as the schedule is shortened, there is a need for enhanced coordination and communication between the facility design company, the construction company that will build the facility, and the owner who will use the facility. The approach that has been adopted by the Army is to initiate the construction phase, continue to address outstanding issues as they arise, and refine the design up to the time systemization is started. In theory, it is possible to execute a project in this manner. However, experience has shown that attempting to refine a design, perform development activities, and manage changes during construction almost always results in confusion, delay, continual fixes, and cost overruns. This is particularly true where a defined end point, such as the CWC date, and a budget allocation schedule are applying pressure to a project. This conclusion is also supported by communications from the Army Corps of Engineers.[14]

The fact that many of the key design criteria have not been finalized (see above) increases the uncertainty as to whether the Army can attain the April 2007 deadline with the existing PBNSF approach. If the design criteria that are finally agreed upon require modifications to the initial assumptions or result in delays, the pressure on the schedule will increase still further. This could result in even less time being available to perform the engineering tasks required to design, construct, and systemize the PBNSF than is shown by the present schedule.

The current design of PBNSF relies on equipment located in cramped quarters (namely the ECC units and the CPT). Such space constraints may affect the ability of operating staff to perform required maintenance tasks during normal and upset conditions. The committee believes that a review

[13]Benjamin H. Butler, Commander, Little Rock District Corps of Engineers, memorandum to James Fletcher, Product Manager for Non-Stockpile Chemical Materiel, SFAE-CD-N, September 9, 2003.

[14]Benjamin H. Butler, Commander, Little Rock District Corps of Engineers, memorandum to James Fletcher, Product Manager for Non-Stockpile Chemical Materiel, SFAE-CD-N, September 9, 2003.

of the facility design by experienced operations personnel from stockpile chemical demilitarization sites would be of value.

The U.S. Army Corps of Engineers (Little Rock District) is responsible for the construction of PBNSF. The Army intends to offer the contract for systemization and operation of PBNSF to competitive bidding by contractors other than the company performing the design. To permit the bidders to develop a realistic cost and schedule estimate, a significant amount of documentation will have to be prepared. Given the time constraints on the project as currently envisaged, this requirement could retard the construction schedule. Moreover, given all the uncertainties, contractors will find it difficult to provide a cost estimate that accurately reflects the required tasks. Where such uncertainties exist, contractors typically bid low and then rely on change orders to make their profit. In addition, the time required for a new contractor to become familiar with all of the issues on the project will substantially impact the already tight schedule. All of these issues would tend to support retaining the design contractor for the construction and operational phases of the project. Some form of cost control would be required, but any other option will probably result in higher costs and an extended schedule.

In summary, the committee considers that the following factors are now contributing (or will contribute) to the inability of PBNSF (as currently proposed) to achieve the destruction of the non-stockpile munitions by the CWC date:

- Several important design criteria are still undefined. These include the condition of the 4.2-in. mortar shells (gelled agent/explosively configured); the basis for maximum overpressure and the design of the HVAC system; whether the building is to be designed to contain shrapnel from an internal explosion; an effective neutralization technology for the arsenical fills in the GTRs; and the maximum agent release that the HVAC system must handle.
- Because the process hazard analyses have not been completed, no recommendations have been generated or implemented, even though the piping and instrument diagrams have been designated as final.
- The schedule is driven by pressure to meet the CWC date rather than being objectively set by the time required for the design and engineering activities.
- The budget cycle assumes that the CWC date will be met and allocates monies to the project on that basis, requiring the monies to be expended or lost. Therefore, contracts are awarded and equipment is purchased in accordance with the budget schedule and not in accordance with the progress of the design process.
- The project has implemented a "design/build" approach. For a project with many basic design criteria still not finalized, this will probably result in additional schedule delays.
- A new contractor is expected to be awarded the contract to operate the facility. Given the number of existing uncertainties, attempting to hand over the project from one contractor to another will likely result in confusion and schedule delay.

Finding 2-1a: The published schedule for the design and implementation of the PBNSF is driven by the April 2007 congressional and CWC deadlines for destroying the chemical weapons and associated materiel. The committee considers that this schedule should not be allowed to drive the start-up of the facility if the engineering design and the operational design are not mature enough.

Finding 2-1b: Key design and safety criteria for the PBNSF are still undefined. The key criteria include:

- Enabling the handling of gelled and/or energetic 4.2-in. mortars;
- Accommodating a neutralization technology that is not yet defined for the arsenical fills in the GTRs;
- Implementing the findings of the process hazards analyses; and
- Defining the MCE[15] for the building and the HVAC system so that it does not put personnel outside the building at risk.

Recommendation 2-1: If the current design for the Pine Bluff Non-Stockpile Facility is pursued, a realistic schedule should be developed based on the time required to properly perform the engineering, construction, commissioning, and processing steps. As part of this task, the required basic design criteria must be finalized. In addition, process hazard analyses must be completed and any issues raised by them resolved.

Finding 2-2: The Army has attempted to ensure that lessons learned in both the non-stockpile and stockpile disposal programs are shared. However, in certain areas (e.g., the recognition of and response to the gelling of mustard agent), this sharing has not been as effective as it could have been. In another critical area—the ability of maintenance workers in PPE to access equipment in the CPT—engineering and operational personnel experienced in this type of activity have not been asked for input into the design, nor have they been asked to review it.

The purpose of such built-in peer review would be to review the facility design to ensure that engineering and op-

[15]The maximum credible event is defined as the worst single event that could occur at any time, with the maximum release of a chemical agent from a munition, container, or process as a result of an unintended, unplanned, or accidental occurrence (U.S. Army, 1999).

erational lessons from the stockpile disposal facilities are transferred appropriately.

Recommendation 2-2: The Army should increase its efforts to share relevant experience between the non-stockpile and stockpile disposal programs and, where appropriate, seek outside peer review of designs. This review should include assessment of the chemical processing trailer and the explosive containment chamber units to determine which inspection and maintenance activities are feasible for personnel wearing Level A personal protective equipment.

Systematic Design Integration Review Issues

Several specific issues that surfaced during the review of the design may need to be addressed as the design is finalized and an integrated facility is constructed. The CPT is the site of a number of systematic design integration issues.

Inspection of the CPT showed that extensive use has been made of screwed fittings, flanges, couplings, and compression fittings. In some cases—for example, where air, water, caustic, and the like are flowing through the piping—this may be acceptable. In cases where agent or neutralized agent could be present in the piping/tubing, a careful review of the existing connections in the CPT should be performed. Wherever possible, welded connections should be used. At a minimum, only connections certified or approved for Fatal Service should be used in such services, and they should be installed and tested in accordance with the manufacturer's recommendations. Although operators entering the CPT will be in Level A PPE, proper engineering design attempts to minimize the potential for the release of hazardous materials. Historical data from plants handling phosgene and similarly hazardous materials demonstrate that leakage usually occurs from small connections and flanges rather than from large flanges.

The design of the CPT piping systems that contain agent calls for numerous fittings and screwed couplings, which are more prone to leak than welded joints. Additionally, the agent piping contains dead-legs, which could interfere with its flushing. Also, a cursory inspection of the piping layout showed areas where tripping hazards exist (particularly for personnel in Level A PPE). In one case, the outlet of a relief valve was connected to the relief valve header using a flexible hose. It is questionable whether such a design could bear the impact load should the relief valve open. The use of a flexible hose to connect a relief valve to the relief valve header should be carefully considered.

Access to the interior of the ECC units requires moving the APV drill assembly inside the vessel before the operator (wearing Level A PPE) can enter the vessel and then withdrawing the APV drill assembly. This is a clumsy procedure and leaves the operator vulnerable if an emergency arises. In addition, the present design for moving the APV drill assembly has no backup if the motor fails or the drive system breaks or jams. An Army contractor has recommended allowing for the disconnection of the drill assembly from the motor and drive assembly (possibly by a chain link system) and adding a manual pulley for moving the APV assembly in an emergency.[16]

The CPT has been built but will not undergo systemization until the second half of 2005. This means that all the equipment, instrumentation, piping, and so forth will be left untested and idle until then.

Several generally accepted process design approaches are typically utilized to address the issues outlined above. For example, a process hazard evaluation could be used to identify scenarios for which suitable layers of protection are required, but this has not been performed. Also, semiquantitative techniques such as layer-of-protection analysis for a smaller number of scenarios and, possibly, full quantitative studies for an even smaller number of scenarios could be performed. Since there is much human interaction with equipment units in PBNSF, a human factors analysis could also be performed.

This systematic design integration review would include all of the piping, instrument connections, and vessels that handle, or might handle, agent or neutralized agent or any other material that would present a significant hazard to operating staff. It would also include considerations for redesigning and specifying piping and connections to minimize the potential for leakage in the CPT or in any other equipment at PBNSF. This could involve replacement of piping connections with welded connections wherever possible and the use of flanges with covers, seals, or plates.

The systematic design integration review should also examine the elimination of dead-legs and tripping hazards (especially since operators will be working in heavy suits and boots); the feasibility of eliminating flexible hoses; the suitability of using a flexible hose to connect a relief valve to the relief header; and whether the design adequately accounts for impact loads (e.g., relief valve opening) and thermal expansion loads.

As part of this systematic design integration review, the Army and its contractors should decide what equipment will have to be inspected and tested to ensure that the CPT and other equipment will be operational when required. The Army should also consider whether the CPT system should be functionally tested on a regular basis prior to becoming operational to minimize the potential for failures due to dried-out rubber or polymeric materials (e.g., seals). Additionally, the Army should carefully consider the requirements for accessing the internals of the ECC units.

[16]Shaw Engineering, Stone & Webster, Inc., GFE Modification Recommendation, sent to the committee on July 31, 2003.

Finding 2-3: The number of design, implementation, and operational issues that must still be addressed before construction of the PBNSF is greater than is typical for an industrial facility because of the unique complexity of the technical problems, the need for first-time integration of the systems, and the very short deadline imposed by the CWC.

Recommendation 2-3: As soon as possible, the Army should systematically review the design integration and operation of all the equipment in the Pine Bluff Non-Stockpile Facility (including piping, connections, and vessels) to find ways for simplifying the processing taking place there. This review should identify ways of (1) minimizing the chances for equipment or operational or human failures, using preventive redesign and related measures to reduce reliance on protective clothing, and (2) optimizing the reliability of the Pine Bluff Non-Stockpile Facility processes.

Finding 2-4: In keeping with its assigned task of assessing the concept of operation and engineering design plans for the PBNSF, the committee concludes that the PBNSF is unlikely to meet the goal of destroying the non-stockpile materiel by April 2007 for several reasons, including the following:

- The schedule does not recognize the known uncertainties in munition configuration, neutralization effectiveness, and system design.
- The schedule for construction of the building alone is shorter than generally accepted.
- The schedule for installation of the complex piping, other chemical treatment, and instrument and control systems is overly optimistic.
- The schedule does not take into account the potential damage to equipment from an unplanned detonation in the ECC.
- The schedule does not take into account the potential for delays caused by contamination of the DET when a munition containing solidified mustard agent is destroyed.
- The schedule assumes optimal operation of systems, some of which have not been designed, e.g., hot water washout of agent in the ECC.

Although the committee believes that implementation of the findings and recommendations in this and subsequent chapters might increase the likelihood that PBNSF as currently designed will meet the treaty deadline, in Chapter 6 the committee recommends an alternative approach that will increase safety, reduce long-term costs, and increase the likelihood that the treaty deadline is met.

3

Worker Protection and Potential for Offsite Release

The recovered chemical warfare materiel at the Pine Bluff Non-Stockpile Facility (PBNSF) varies more widely in type, agent content, and physical condition than do the stockpile items at the same location. Many of the non-stockpile munitions stored at the Pine Bluff Arsenal (PBA) were recovered from burning pits and are badly corroded and difficult to characterize. This chapter addresses the unusual challenges presented by the handling of recovered chemical warfare materiel, explosively or nonexplosively configured, intended for PBNSF. It will not review nonmunition safety concerns, such as conventional industrial accidents and fires not involving either agent or high explosives.

PROTECTING PINE BLUFF NON-STOCKPILE FACILITY PERSONNEL FROM EXPOSURE TO CHEMICAL WARFARE AGENTS

PBNSF personnel will be protected from exposure to non-stockpile agents by personal protective equipment (PPE), by barriers, and by engineering controls. The PBNSF process areas are categorized by hazard type, and personnel are required to wear different levels of PPE depending on the hazard category of the process area in which they are working. The allowable concentration of agent in the air in a given area determines the type of PPE required. The air in areas requiring Level A PPE is monitored for agent at the gross detection level (GDL) or the maximum permissible limit (MPL). These areas are usually monitored to the GDL (0.2 mg/m^3) but must be below the MPL (100 mg/m^3) for H/HD and HN-3 (U.S. Army, 2003a). The air in the agent-free areas is monitored at the 8-hour time-weighted average (TWA) level.[1] The TWA monitoring level for H/HD and HN-3 is 0.003 mg/m^3. The agent-free areas are monitored 24 hours a day, 7 days a week, to assure a safe working environment.

Pine Bluff Non-Stockpile Facility Personal Protective Equipment and Characterization of Process Area Hazards

PBNSF operating personnel entering known or potentially agent-contaminated areas (i.e., hazard Categories A and B) will use an industrial Level A zipper-type PPE suit.[2] These suits are totally encapsulating (vapor-tight) chemical protective suits with positive pressure, full facepiece, self-contained breathing apparatus and have been approved by the National Institute for Occupational Safety and Health (U.S. Army, 2002a).

Hazard Category A and B areas are under negative air pressure; Category A areas may be contaminated with liquid agent and are assumed to be contaminated with agent vapor; Category B areas may be contaminated with agent vapor. Further details concerning hazard categories, as well as the hazard categories assigned to the various process areas of PBNSF, are provided in Table 3-1.

Pine Bluff Non-Stockpile Facility Chemical Agent Monitoring Devices

The agents to be monitored are

- sulfur mustard (H, HS, and HD)
- nitrogen mustard (HN-3)
- arsenicals (PD)

[1]TWA is the permissible 8-hour airborne concentration of a chemical agent to which a worker may be exposed. A TWA exposure limit is generally set so that workers may be exposed 5 days per week for a working lifetime with minimal risk of adverse health effects.

[2]Vivian Graham, Non-Stockpile Chemical Materiel Product, "Pine Bluff Non-Stockpile Facility Discussion: Safety Issues," briefing to the committee on April 22, 2003.

The air monitoring equipment being considered for PBNSF includes:

- MINICAMS[3] with halogen-specific detectors for mustard-containing chemical agents
- Depot Area Air Monitoring System (DAAMS) monitors (for chemical agents)
- MINICAMS adapted for detection of PD (phenyldichloroarsine) when processing GTRs filled with arsenicals

The MINICAMS and the DAAMS will be used to monitor for chemical agents at the TWA level throughout the facility. The MINICAMS is also used to monitor for agents at the GDL and MPL levels. The DAAMS is frequently used for perimeter monitoring at facilities, but it is unclear whether perimeter monitoring will be conducted.

Category A areas at PBNSF are designed to contain potentially high concentrations of airborne agent vapor. Personnel are required to wear Level A protective gear in all areas where concentrations could approach levels greater than the immediately dangerous to life and health[4] level if there is an accident. This approach protects workers from doses that could lead to acute effects.

MINICAMS

The MINICAMS is considered a near-real-time automated air sampling system with response times that are typically 4 min for the GDL or MPL levels and 10 min for the TWA level. The MINICAMS captures the agents on sorbent; the agents are then desorbed into a gas chromatograph. The MINICAMS is configured with a halogen-specific detector (the primary chemicals anticipated are H/HD, HN-3, and industrial arsenicals, most of which contain the halogen chlorine). The accuracy of the proposed MINICAMS-XSD (halogen-specific detector) units is around the TWA level. When operating in an atmosphere containing a lower concentration of agent (<10 TWA), the air is sampled directly onto a solid sorbent sample tube. In environments with higher concentrations of agent (>10 TWA), the flow automatically switches to a low volume sample loop before the solid sorbent tube to allow monitoring at higher levels (MPL).

TABLE 3-1 Hazard Categorization of PBNSF Process Areas

Process Area	Hazard Category[a]
Receiving storage area (includes warming area)	D
Unpack area	C
Fill extraction preparation area	A/B
Fill extraction area	A
Detonation chamber area	A/B
Decontamination area	A
Holding tank area	A
Agent treatment area	A, B, C
Metal parts repackaging and storage area	C/D

[a]Hazard categories are defined as follows: A identifies a toxic process area under negative pressure, possibly contaminated with liquid agent and assumed to be contaminated with agent vapor. It is a high-hazard area, requiring the use of PPE. B indicates a toxic process area under negative pressure, possibly contaminated with vapor chemical warfare agent. It is a high hazard area requiring the use of PPE. C indicates work areas under negative pressure and subject to inadvertent chemical warfare agent vapor contamination. It is considered a low agent hazard area; protective gear is not required to be worn unless monitoring indicates a need. Although chemical warfare agent contamination of Category C areas is not expected, PPE must be available for use in Category C areas. D indicates areas under ambient pressure that are not subject to contamination. It is considered a negligible chemical warfare agent hazard area. These areas are typically mechanical and electrical equipment support rooms and the facility perimeter.

SOURCE: Adapted from U.S. Army (2002d).

Depot Area Air Monitoring System Monitors

In the event of a TWA MINICAMS alarm, the DAAMS is used to confirm the MINICAMS reading. The samples will be collected using a vacuum pump, a sequencer, and DAAMS sample tubes. The DAAMS sample tubes are packed with solid sorbent to trap the airborne chemicals and will be taken to the laboratory for analysis. DAAMS monitoring is also used for analysis of the air lines of the life support systems to assure personnel they are agent free and for historical monitoring at DAAMS-only sample stations in Category D work areas. The DAAMS monitor is based on solid sorbent preconcentration of the sampled air, followed by thermal desorption and analysis by gas chromatography using a flame photometric detector. Sample vapors are passed directly into the sorbent tube. The preconcentrator tubes are inserted into a heated inlet, where the contents are desorbed into a gas chromatograph. A sulfur band-pass filter and linearizer circuit are used to detect chemical agent. Knowing the amount of chemical agent on the sorbent tube and the total volume of air sampled, the average agent con-

[3]MINICAMS is a low-level, near-real-time monitor typically used to provide early warning of airborne exposure hazards. The MINICAMS-XSD (halogen-specific detector) unit is an automated air sampling system that collects compounds, thermally desorbs them into a capillary gas-chromatography column for separation, and detects the compounds with a halogen-specific detector (U.S. Army, 2000). The combined sampling and analysis time for the MINICAMS is 3 to 10 minutes, depending on the agent being examined (U.S. Army, 2003a).

[4]Immediately dangerous to life and health is the maximum exposure concentration from which an individual could escape within 30 min without experiencing escape-impairing symptoms or irreversible health effects.

centration in the air can be calculated. By increasing the sample time or flow rate, the average concentration sensitivity can be increased. The DAAMS is much more sensitive, and therefore more accurate, than the MINICAMS method (the sensitivity of the DAAMS monitors is <0.0006 mg/m^3); however, the response time is 1 to 12 hours.[5]

Arsenicals Monitoring

The Army plans to use MINICAMS adapted for detection of phenyldichloroarsine (PD) for air monitoring when processing German Traktor rockets (GTRs) filled with arsenicals (U.S. Army, 2003c). PD is the only arsenical to be continuously monitored because it is the only one with significant vapor pressure and blistering properties. Other industrial arsenicals either have very low vapor pressures or lack vesicant properties.

Monitoring of airborne arsenic for historical purposes will be carried out by drawing ambient air through filters that will collect PD and the less volatile arsenical agents as well as arsenic-containing particulates (U.S. Army, 2003a). After sampling, the filters will be digested to convert the arsenic-containing materials into an aqueous solution. The arsenic content of the solution will be determined by conventional means such as atomic absorption spectroscopy or inductively coupled plasma analysis (U.S. Army, 2003a).

PROTECTION OF PINE BLUFF NON-STOCKPILE FACILITY PERSONNEL FROM ACCIDENTAL DETONATIONS

PBNSF must be designed to withstand the accidental detonation of a munition undergoing treatment while minimizing the release of toxic chemical agents to the atmosphere. Adequately withstanding accidental detonations will be defined in terms of the explosion containment requirements of the individual areas at PBNSF where accidental detonations could occur (Chapter 2).

Munitions in specially designed overpack containers are brought from the storage igloos to the PBNSF receiving dock and then into PBNSF at the receiving/storage areas, where they will be warmed during cold weather. After warming, the overpacked munitions are moved to the unpack room, where they are checked for leaking agent. Leakers will be kept in their overpack and returned to storage for treatment at the end of the destruction campaign for the agent being processed. Nonleakers are removed from the overpack, marked as either explosively or nonexplosively configured, and transferred to the fill extraction preparation area.

In the fill extraction area, munitions are emptied either in an explosive containment chamber (ECC) or by the projectile washout system (PWS), depending on whether or not they are explosively configured. After draining the agent and washing out the munition in the ECC or PWS, the munition may be placed in a heel-dissolving tank before being placed in the detonation chamber (DET), where shaped explosive charges are used to access and detonate emptied munitions that are explosively configured.

Accidental detonations are possible at the following locations:

- *Receiving dock.* This area is the outer entry point for munitions coming from the storage igloos and is outside of the designed containment of PBNSF. Therefore, the receiving dock could be the site of the most significant dispersion of agent from an accidental detonation. However, munitions brought to the receiving dock will be overpacked in containers that are specially designed to contain leaks from the munitions within, which will reduce the possibility of a release of agent to the atmosphere. Accidental detonations, however, would not be contained by the overpack containers and would result in the release of explosive force and agent to the atmosphere.
- *Receiving/storage area.* Overpacked munitions are held in this area and, if necessary, warmed prior to further processing. This area is inside PBNSF and the effects of an accidental detonation would be greatly mitigated by facility containment and the munition overpack.
- *Unpack area.* Once munitions are removed from their overpacks in the unpack area, the potential for agent release during an accidental detonation is dependent on the containment design of PBNSF.
- *Fill extraction preparation area and fill extraction and detonation area, including ECC-1, ECC-2, DET, PWS, auxiliary processing vessels, and DET staging area.* Munitions are handled and moved through the various emptying and cleaning processes in this area and are subject to accidental detonation as a result of handling errors and mishaps. Significant amounts of agent could be released if a detonation occurs outside an ECC.

Process hazard analyses are management tools used to examine the accidents that could happen in segregated areas of PBNSF. These analyses describe the accidents that could happen during the processes that take place in the different areas of PBNSF. Design changes or engineering controls are instituted to reduce the probability of their occurrence or to minimize the impacts if they do occur. Another management tool, job hazard analyses, describes accidents that could occur during individual operations in the distinct process areas. The process and job hazard analyses were being performed as this report was being prepared and were not available for review by the committee.

[5]A variance in response time can be due to the use of different analytical techniques and/or different sampling times.

Finding 3-1: The segregation of operations in the PBNSF appears to be appropriate; however, the likelihood of accidental detonation cannot be estimated until the process hazard analyses and job hazard analyses have been completed.

Recommendation 3-1: The Army should complete process hazard analyses and job hazard analyses to provide critical information before finalizing the design of the Pine Bluff Non-Stockpile Facility.

PROTECTION OF THE PUBLIC AND THE ENVIRONMENT

The PBNSF is not designed to contain an occurrence of the maximum credible event (MCE).[6]

The MCE at PBNSF is the accidental detonation of a complete GTR (full warhead and rocket motor), resulting in an energetic force of approximately 17 lb of trinitrotoluene equivalent and the dispersion of 7 lb of agent. The PBNSF building, however, is not designed to contain the effects of the MCE.[7] Rather, it is designed with blowout panels, which will vent internal pressure in the event of the MCE. This design seems not to be consistent with the mandate to provide maximum protection[8] for the environment, the general public, and the personnel who are involved in the destruction of the lethal chemical agents and munitions (50 U.S.C. Section 1521(c)(1)(A)). In the committee's view, the only methods of providing maximum protection are to redesign the building to contain the current MCE or to take action to reduce the MCE so that the current design is adequate to contain it. This and other issues should be resolved in the systematic design integration review (see Recommendation 2-3).

The committee notes that the Army's calculations for the no-effects distance[9] for the MCE show that it extends far beyond the boundaries of PBA (U.S. Army, 2002b). However, no deaths outside the boundaries of PBA are calculated to be caused by an MCE at PBNSF (U.S. Army, 2002b).

The committee did not peer review the air dispersion modeling performed for the no-effects distance calculation, although members of the committee did perform some limited confirmatory calculations that included meteorological data; these calculations suggested that the Army's calculations were conservative (i.e., more likely to overestimate concentrations than to underestimate them).

The committee recognizes that the Army is investigating possible methods for removing the rocket motors from the warheads so that only the warheads will enter PBNSF, and it encourages that effort. Based on the information reviewed by the committee, one or more methods of removing the motors appear feasible.

Finding 3-2: The committee finds that the safety of personnel outside the PBNSF may be compromised because the building is not designed to contain the release of agent from the MCE. Separating the warhead from the rocket motor and processing only the warhead in PBNSF will increase the safety of operations inside PBNSF by eliminating the only situation where the energetic capacity of the munition exceeds the containment capacity of the building.

Recommendation 3-2: The German Traktor rocket warheads should be separated from the rocket motors and only the warheads should be allowed to enter the Pine Bluff Non-Stockpile Facility so as to reduce the maximum credible event to a level that can be fully contained by the structure. The Army should continue to investigate thoroughly the feasibility of separating the German Traktor rocket motors from their warheads to determine how and where these operations can be accomplished safely.

External Monitoring

The heating, ventilation, and air conditioning system will be monitored at the TWA level using both MINICAMS and DAAMS placed at the midpoint of the carbon filters, at the filter-housing vestibules, and at the effluent stack of the heating, ventilation, and air conditioning system. It is unclear whether perimeter monitoring will be performed. The PBA perimeter monitors (DAAMS) for the stockpile disposal facility might be employed to fulfill this function.

Once the systems contract for PBNSF is awarded, a site monitoring plan will be finalized in coordination with the PBA, the Pine Bluff Chemical Activity responsible for stockpile storage, and the Centers for Disease Control. This monitoring plan presumably will encompass the ability to distinguish the point from which any agent is being emitted.

Sampling and Analysis of Liquid and Solid Secondary Wastes at the Pine Bluff Non-Stockpile Facility

Liquid and Solid Waste Streams

As noted in Chapter 2, the agent contained in each munition is sampled and analyzed, first at the Pine Bluff muni-

[6]The MCE is defined as the worst single event that could occur at any time with the maximum release of a chemical agent from a munition, container, or process as a result of unintended, unplanned, or accidental occurrence (U.S. Army, 1999).

[7]Peter Wells, Task Engineer, Shaw Environmental, Inc., "PBNSF Bounding Challenge to HVAC Filters," briefing to the committee on August 1, 2003.

[8]The term "maximum protection" is defined in the Defense Appropriation Act of 1996. Such terms are generally applied on a case-by-case basis. See Appendix D in (NRC, 1999) for a compilation of Army definitions and to learn how this term may fit into general regulatory risk management policy.

[9]The no-effects distance is the downwind distance beyond which no adverse human health effects (e.g., excessive contractions of the pupil of the eye, muscle tremors, airway tightening, nausea, vomiting, and diarrhea) would be expected to occur (U.S. Army, 2002b).

tions assessment system and again at PBNSF, to ensure that the subsequent processing and monitoring operations are appropriate. In general, processing of the munitions generates three secondary liquid waste streams:

- neutralents
- spent decontamination solutions
- miscellaneous process fluids (hydraulic fluids, solvents, etc.)

The first two liquid waste streams will be monitored for chemical agent at various points during processing at PBNSF. All three will be sampled and analyzed before release from Army control.

Munitions processing generates several types of secondary solid wastes:

- metal scrap from munition bodies
- spent carbon from filters
- miscellaneous solid wastes (wipes, personal protective equipment, dunnage, overpacks, etc.)

The metal scrap may either be decontaminated to the 3X[10] level and sent to another Army site or government contractor for recycling or thermally decontaminated to the 5X[11] level on-site and released to civilian recyclers. The spent carbon and other solid wastes will be sent to a treatment, storage, and disposal facility (TSDF) for treatment and disposal after an analysis of the vapors in the headspace of the waste containers to ensure that the waste conforms to the 3X release standard.

Planning for the closure of PBNSF will require analytical procedures that can certify the suitability of materials such as soil, concrete, and metal for recycling or disposal. A previous National Research Council (NRC) report (NRC, 2001c) noted that agent in soil or concrete "is a potential problem during cleanup and closure operations when these materials must be certified as agent free." The Army's program for stockpile demilitarization is developing experience on the necessary analytical procedures. Research on the fate of chemical agents in the environment may also be relevant (Rosenblatt et al., 1996).

[10]3X refers to a level of decontamination at which solids are suitable for transport for further processing.

[11]5X refers to a level of decontamination at which solids may be released for general use or sold (e.g., as scrap metal) to the general public in accordance with applicable federal, state, and local regulations. A common misconception is that 5X means simply that the solid has been placed in a temperature zone of 1000°F or higher for 15 minutes. In fact, a 5X condition indicates that the solid has been completely heated to and then held at a temperature of at least 1000°F for 15 minutes.

Liquids Sampling and Analysis

Neat agent. As previously noted, PBNSF operations will include a reconfirmation of the contents of each munition to be processed. Vapor samples will be drawn from within the auxiliary processing vessel containing the munition body after initially accessing the munition fill. Similarly, when munitions are being processed in the PWS, a hole is drilled in the projectile body to permit removal of a vapor sample for analysis. The agent vapor will be analyzed by gas chromatography and mass spectrometry according to Army procedures.

Aqueous solutions. The neutralents generated in the chemical processing trailer reactors as well as other aqueous streams (e.g., water and 10 percent sodium hydroxide rinses) likely to be contaminated with agents will be analyzed for agent concentration before release. These streams will be sampled by drawing liquid from the neutralization reactors, the waste retention tanks, or the spent decontamination solution tanks. The samples will be tested to ascertain that agent concentrations are below the Army's established 50 ppm release standard for blister agents. Procedures similar to those used to characterize wastes from the EDS or the legacy Munitions Management Device mobile systems will be used (U.S. Army, 2001a). HD in neutralent will be detected by coupled gas chromatography and mass spectrometry. The detection limit of this method is below 5 ppm, which provides a substantial margin for certifying that the HD concentration is 50 ppm or less. (This method is described in the Utah Resource Conservation and Recovery Act (RCRA) permit application for the MMD [DEQ, 1999].) The gas chromatography/mass spectrometry method for HD in hydrolysate is a routine operation, and the committee anticipates that the Army can reliably and in a timely manner make these measurements. The committee did not receive or review information on whether all of the measurements could be made; such a review is beyond the scope of the charge to the committee.

The contents of liquid waste storage tanks will be sampled to ascertain compliance with RCRA standards for hazardous wastes prior to shipment off-site. Analysis of residual agent was covered in some detail in at least three earlier NRC reports. The report *Integrated Design of Alternative Technologies for Bulk-Only Chemical Agent Disposal Facilities* (NRC, 2000a) discusses possible reasons for the presence of residual agent in hydrolysate even though adequate residence time is provided. The report *Occupational Health and Workplace Monitoring at Chemical Agent Disposal Facilities* (NRC, 2001c) shows in depth the mustard hydrolysis pathways and discusses the high toxicity of some of the mustard degradation products. Another report, *Evaluation of Alternative Technologies for Disposal of Liquid Wastes from the Explosive Destruction System* (NRC, 2001a), discusses the possible presence of residual agent in suspended solids in EDS hydrolysates and in the cracks and crevices of metal parts. It concludes that any nonincineration technology used to treat the hydrolysate must be robust and able to deal with these issues. The various categories of liquid waste will be analyzed for toxicity characteristic metals and organics using the toxicity characteristic leaching procedure.[12] Significant concentrations of some metallic corrosion products can be expected in the GTRs because the chemical agents have been in contact with the steel casings for nearly 60 years.

It is likely that similar release standards will be applied to the neutralents and rinses generated from arsenical agents contained in the GTRs. PD, which has vesicant properties in addition to being a vomiting agent, will probably be held to a 50 ppm release standard like HD and HN-3. Procedures to analyze for arsenicals are still being developed. The aqueous streams generated from the arsenical agents will contain toxic arsenic salts. Arsenic and other toxicity characteristic metals (as well as toxicity characteristic organics) will be analyzed under RCRA protocols before the solutions are released to a TSDF for treatment and disposal. No specific release standard for total arsenic concentration has been set.[13]

Solids Sampling and Analysis

Decontamination of metal scrap to the 3X level will be established by analysis of the headspace vapor in the metal decontamination units (MDUs) in accordance with requirements outlined in Army regulations and Department of the Army document 385-61 (U.S. Army, 2002a). In this procedure, the MDU is sealed and the headspace vapor is analyzed using MINICAMS systems adapted to the particular agent being handled in each munitions campaign. Typically, the MDU is held at 70°F for 4 hours before headspace sampling. The 3X decontamination level requires a headspace vapor concentration below 0.003 mg/m^3 for sulfur mustard agent.

Other categories of solid wastes are sampled and analyzed by similar procedures. Typically, the wastes are packed in a drum, and the sealed drum is allowed to stand at 70°F for 4 hours before headspace sampling. Again, the requirement for a 3X decontamination level in campaigns dealing with HD is a vapor concentration of less than 0.003 mg/m^3. A question has been raised about the suitability of this procedure for release of packages containing spent carbon or other filter material. A previous NRC report (NRC, 2001c) noted that activated carbon "has a high adsorptive capacity and could therefore give a very low agent vapor pressure from headspace sampling even if a substantial loading of agent remained in the carbon. If the temperature of the carbon were raised, this agent could be released, posing a danger to anyone not properly prepared or equipped."

Nonvolatile Agents in Sorbent Materials

A potentially troublesome problem is the handling of solid materials containing chemical agents having little vapor pressure. One example might be the handling of wipes and dunnage from the processing of GTRs containing diphenylchloroarsine (DA). The soiled materials may contain significant quantities of DA, which would not be detectable by the standard vapor test used to certify 3X level decontamination. Given proper handling and packaging, these materials might not be a major hazard to current workers but could be of concern during subsequent treatment and disposal, particularly in the event that the Army sends these materials to off-site TSDFs, as planned. Looking ahead to closure of PBNSF, similar concerns may apply to concrete or soil on which DA has been spilled. Recent work in Japan has shown that DA sorbed on celluloid or pumice[14] has persisted for more than 60 years if not exposed to hydrolytic conditions (Science Council of Japan, 2002). Even after hydrolysis, arsenic-containing residues remained. Research done by the Japanese Chemicals Evaluation and Research Institute includes development of methods for analysis of DA and other arsenicals in the presence of solids (Science Council of Japan, 2002).

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[12]The toxicity characteristic leaching procedure is discussed at greater length in Chapter 5.

[13]Information obtained at a meeting of the committee, National Research Council staff, Army personnel, and Stone & Webster staff, Boston, Mass., May 21-22, 2003.

[14]Among the Japanese munitions abandoned in Manchuria after World War II were cylinders of Agent Red containing mixtures of DA and DC sorbed on celluloid and pumice as well as projectiles containing neat Agent Red (a DA/DC mixture).

4

Management of Process and Nonprocess Pine Bluff Non-Stockpile Facility Secondary Wastes

For purposes of preparing the environmental assessment for the PBNSF, it was estimated that about 1.6 million lb of liquid hazardous waste, 110,000 lb of spent carbon and filters, 30,000 lb of decontaminated metal parts, and lesser amounts of other solid hazardous wastes would be produced over the entire period of PBNSF operation (U.S. Army, 2002b). The environmental assessment states that essentially all materials processed in the PBNSF, as well as many system effluents, will be regulated hazardous wastes. All process and storage tanks, except raw material supply tanks, will be subject to Resource Conservation and Recovery Act (RCRA) requirements. Also, all neutralents are expected to be classified as corrosive hazardous wastes based on the highly alkaline nature of their treatment reagents, monoethanolamine (MEA) or caustic, unless the pH has been adjusted to less than 12.5. Effluents from treatment of arsenic-containing agents will contain arsenic (>5 ppm) and other RCRA hazardous materials, requiring them to be classified as a toxic hazardous waste. These streams, and the spent decontamination solutions resulting from the cleaning of equipment and munition parts that have been in contact with these streams, will also carry RCRA waste codes (U.S. Army, 2003a).

The major liquid and solid waste streams are identified in Tables 4-1 and 4-2 (U.S. Army, 2003d). The primary treatment operations in PBNSF will treat arsenicals using caustic as the neutralizing agent, nitrogen mustard using MEA as the neutralizing agent, and sulfur mustard again using MEA as the neutralizing agent. As shown in Table 4-1, the neutralents from these three operations will be significant waste streams, with the sulfur mustard neutralent dominating at 420,000 lb over the life of the campaign. The spent decontamination solutions from the three campaigns will be much larger streams, with that from the sulfur mustard stream again dominating at 840,000 lb over the life of the campaign. MEA will be the major component of the two mustard neutralents, while water and caustic will be the major components of the arsenicals neutralent.

Various Environmental Protection Agency RCRA waste codes will be assigned to the streams listed in Tables 4-1 and 4-2 as a consequence of the agents being treated and some of the agent degradation products. These degradation products, their RCRA-allowed levels, and their Environmental Protection Agency RCRA waste codes are given in Table C-1-2 of the PBNSF RCRA permit application (U.S. Army, 2003a). This table also describes in detail how each stream will be generated and stored before transportation and treatment or disposal.

Other liquid streams and their estimated volumes are as follows:

- Miscellaneous paint: amount to be determined
- Unused liquid 5 percent bleach
- Unused liquid 20 percent caustic
- Flammable industrial waste: amount to be determined
- Spent hydraulic fluid: 40 lb
- Spent lube oil: 40 lb
- Miscellaneous laboratory liquids: 10 gallons per month, 2006-2007

Other solid streams:

- Lead acid batteries: amount to be determined
- Used instrumentation: amount to be determined
- Miscellaneous laboratory supplies: one drum per month, 2006-2007
- Miscellaneous maintenance debris: amount to be determined
- Miscellaneous solids from process tanks and filters: 7,500 lb (U.S. Army, 2003a). (The committee presumes that this includes corroded steel particles from the carbon dioxide blast station and steel saw chips from the metal cutting stations.)

A hazardous waste landfill is located at the northwest corner of the Pine Bluff Arsenal (PBA) (U.S. Army, 2002b).

TABLE 4-1 Major Liquid Secondary Waste Streams from the Treatment Process

Description of Stream	Total Quantity Generated (lb)	Components
Neutralized waste from arsenicals	44,000	Caustic ~20 wt %, water ~80%, sodium chloride <3%. Less than 1 wt % each of sodium arsenite, benzene, diphenylarsene oxide, thiodiglycol, chlorohydrin, monosodium thiodiglycolate, ether-thioether oligomer, and vinylthioethanol.
Neutralized waste from nitrogen mustard (HN)	11,000	MEA 76 wt %, water 9.5%, monoethanolamine hydrochloride 8.5%, 1-(hydroxyethylaminoethyl)4-hydroxyethylpiperazine 6.0%, trace volatile organic compounds <0.1%.
Neutralized waste from sulfur mustard (HD)	420,000	MEA 87.4 wt %, water 10%, N-(2-hydroxyethyl)-thiomorpholine 0.9%, bis[2-(2-hydroxyethylamine) ethyl]sulfide 0.3%, MEA hydrochloride 0.3%, trace volatile organic compounds <0.1%.
Spent decon solution from arsenicals campaign	220,000	Sodium hydroxide ~10 wt %, water ~90%, less than 1% of sodium arsenite, benzene, diphenylarsene oxide, thiodiglycol, chlorohydrin, monosodium thiodiglycolate, ether-thioether oligomer, and vinylthioethanol.
Spent decon solution from nitrogen mustard campaign	90,200	Sodium hydroxide 9.9 wt %, water 89.8%, sodium chloride 0.2%, N-ethyldiethanolamine 0.1%.
Spent decon solution from sulfur mustard campaign	840,000	Sodium hydroxide 16.3 wt %, water 83.2%, thiodiglycol 0.3%, sodium chloride 0.2%.

SOURCE: U.S. Army (2003g).

TABLE 4-2 Major Solid Secondary Waste Streams from the Treatment Process

Description of Stream	Total Quantity Generated	Components
Spent carbon from process vent filters; heating, ventilation, and air conditioning filters; and storage tank vent filters.	95,000 lb	May contain up to 0.5 wt % organic loading. Organics may include sulfur mustard, nitrogen mustard, MEA, N-(2-hydroxyethyl)-thiomorpholine, bis[2-(2-hydroxyethylamine) ethyl]sulfide, MEA hydrochloride, 1-(hydroxyethylaminoethyl)4-hydroxyethylpiperazine, thiodiglycol, arsenical compounds, and trace volatile organic compounds.
Spent high-efficiency particulate air filters and pre-filters from process vent filters; heating, ventilation, and air conditioning filters; and storage tank vent filters.	15,000 lb	May contain sulfur mustard, nitrogen mustard, monoethanolamine, N-(2-hydroxyethyl)-thiomorpholine, bis[2-(2-hydroxyethyl-amine)ethyl]sulfide, monoethanolamine hydrochloride, 1-(hydroxyethylaminoethyl)-4-hydroxyethylpiperazine, thiodiglycol, arsenical compounds, and trace volatile organic compounds.
Decontaminated personal protective equipment.	1,300 suits	May contain residual agent, including sulfur mustard, nitrogen mustard, and arsenicals.

SOURCE: U.S. Army (2003g).

Some hazardous waste from Pine Bluff operations is now disposed of at this landfill. However, the environmental assessment states that no hazardous waste resulting from the operation of the PBNSF will be disposed of at this landfill. No reason is given. Other hazardous waste from PBA is transported off-site by a contractor and disposed of through the Defense Reutilization and Marketing office.

The Army's overall philosophy in managing these streams is that they should be treated on site only to the point that they can be safely shipped to off-site commercial treatment, storage, and disposal facilities (TSDFs) for final treatment and disposal.[1] This reduces the scope of operations

[1] Joseph Cardito, Program Manager, Shaw, Stone & Webster, Inc., "Process Design and Equipment Fabrication for PBNSF Overview and Status," briefing to the committee on March 19, 2003.

involving hazardous materials at the Pine Bluff site, and the committee expects that the local stakeholders would prefer this strategy over more extensive handling of hazardous materials. While substantial in volume, the quantities will be small in comparison with those routinely handled by commercial TSDFs. Thus, the costs associated with managing the streams on-site would be greater than the costs of management at commercial TSDFs. Treatment goals for agent destruction are discussed in Chapter 5.

Many uncertainties surrounded the generation and disposal of spent activated carbon as this report was being generated. The lack of a firm design for the carbon bed filtration system for the currently envisioned process is mentioned in Chapter 2. The regulatory and technical issues surrounding sampling for agent in spent activated carbon are discussed in Chapter 3. A possible reduction in the amount of spent activated carbon generated if the Army elects to employ expanded use of explosive destruction systems (EDSs) is discussed later in this chapter.

The specific means by which the Army plans to dispose of secondary waste from PBNSF at off-site locations is a waste management contract that was awarded to Shaw Environmental, Inc., in July 2003 and that will end in December 2005 (U.S. Army, 2003d). The contractor is responsible for teaming with one or more commercial hazardous waste TSDFs to transport and dispose of hazardous secondary and neutralent wastes from the various Non-Stockpile Chemical Materiel Product projects, including PBNSF. The contract states that nonincineration treatment technology is preferred to incineration.[2] However, Shaw Environmental is required to compare and present the costs of treating the waste using both incineration and nonincineration technologies for each waste stream generated. The Army considers deep well disposal and fuel blending to be comparable to incineration in terms of viability.[3] The TSDF team member(s) chosen by Shaw Environmental must be capable of (1) using an existing nonincineration technology or (2) developing and using a new nonincineration technology. Upon receipt of cost, schedule, and risk information, the government will decide whether to use an incineration or a nonincineration approach for the treatment and disposal of each waste stream. If a nonincineration approach is chosen, the type or types of technology to be employed are to be negotiated with the government. If technology development or addition of capacity is needed for the nonincineration approach, this is also to be negotiated. In either case, the TSDF(s) will be responsible for obtaining any needed RCRA permits or permit modifications, with the costs reimbursed by the Army. Also, in either case, the TSDF(s) must be ready to process waste no later than October 2005. Presumably, this date applies to newly installed or expanded capacity; the contract with Shaw Environmental calls for treatment of waste from ongoing and future non-stockpile chemical warfare materiel treatment operations, including PBNSF, to be begun in October 2003 (U.S. Army, 2003e). Public interactions are to be coordinated with and approved by Non-Stockpile Chemical Materiel Product management and the public affairs office.

The contract with Shaw Environmental does not recommend any alternative technologies or discourage offerors from featuring certain technologies. It does provide reports evaluating alternative technologies, leaving it up to the offerors to study them and come to conclusions regarding their applicability and appropriateness. A list of waste treatment facilities using Zimpro's wet air oxidation technology was made available to potential offerors. However, these facilities typically treat only sewage sludge or spent caustic and may not be of direct use to potential offerors. Whether any of these facilities would be able to accept and treat wastes from PBNSF was not clear.

Under the contract, Shaw Environmental is to provide and periodically update pricing for disposing of waste using nonincineration technologies that might need to be developed. No quantity guarantees are provided by the Army. It is anticipated by the Army that the TSDFs would find other users of the disposal technology. However, the committee expects that any new facilities developed under this program will be too small to be practical for commercial operation after the wastes from PBNSF have been treated. Therefore, the costs associated with closure might also have to be covered by the Army.

The committee judges that disposal of secondary wastes by incineration and deep welling is to be avoided if at all possible and practical. If the current waste management contract does not result in disposal costs that are considered acceptable by the Army, incremental funding for the process development effort might need to be supplied by the Army. Considerable effort has already been devoted to process development, and the most promising technologies have been identified and explored. Incremental effort might be needed to make one or more of these technologies available at an acceptable cost. Alternatively, and especially in consideration of the small volumes involved, the Army might have to reconsider what is an acceptable cost.

Finding 4-1: Under the waste management contract issued to Shaw Environmental, Inc., costs are provided by the contractor for disposal of liquid secondary wastes by means of incineration or nonincineration technologies. Whether nonincineration technologies will ultimately be selected by the Army could not be determined by the committee at the time this report was prepared.

[2]The indicated preference for nonincineration technology is consistent with trends over the past several decades, first to incineration as a preferred treatment technology, then away from incineration (NRC, 1994; 2002a).

[3]Joseph Cardito, Program Manager, Shaw, Stone & Webster, Inc., "NSSCII Task: Waste Management Support Task Status," briefing to the Non-Stockpile Chemical Materiel Program (NSCMP) Core Group Technology Subcommittee and Ad Hoc Next Steps Group Meeting on August 27, 2003.

Recommendation 4-1: The Army should continue to pursue alternatives to incineration and deep welling of liquid hazardous wastes. If the current waste management contract does not result in costs that are acceptable to the Army for disposal using nonincineration technologies, alternative approaches to disposal using nonincineration technologies should be identified and pursued.

Three options are being considered for the management of an expected 30,000 lb of contaminated metal parts (U.S. Army, 2002b):

1. Decontamination to a 3X level at PBNSF, followed by transport to a commercial TSDF for recycling or landfill disposal. Metal parts that have been so treated could be released to a commercial TSDF under contract with the U.S. government (U.S. Army, 2003a).
2. Decontamination to a 3X level at PBNSF, followed by transport to the Rock Island Arsenal smelter, where they would be smelted for recycle, with 5X decontamination as a consequence of the process.
3. Decontamination to a 3X level at PBNSF, followed by decontamination to a 5X level in an existing PBA furnace and disposal in a landfill or sale for recycling.

The Army plans to build metal decontamination units for treatment of the contaminated metal parts. The parts will be placed in chambers and exposed to high-pressure 10 percent caustic spray, followed by rinsing with water and air drying. The air in the chamber will be sampled to verify the 3X decontamination level of the metal pieces. Once this is accomplished, the pieces will be packaged in containers and shipped off-site to an approved smelter or furnace for metal recovery (U.S. Army, 2003a).

Munition overpacks that held leaking munitions will be decontaminated to a 3X level, cut into pieces, and managed like other decontaminated metal parts.

Nonhazardous solid waste from all of PBA is now disposed of at the Jefferson County municipal landfill, located 3 miles west of the arsenal (U.S. Army, 2002b). The Army plans to dispose of nonhazardous solid wastes from PBNSF at this landfill. These wastes would consist primarily of dunnage from the delivery of munitions and supplies. The amount generated would be small in comparison with the amount of nonhazardous solid waste generated by other PBA operations and would result in no appreciable effect on Jefferson County landfill operations.

The committee does not expect that expanding the use of EDSs, described in Chapter 6, would greatly affect the composition of the waste streams. However, if EDSs are used extensively and if they are used with multiple rounds per shot, especially if six or nine rounds per shot are employed in the EDS-2, the volume of liquid wastes, neutralents, and rinses might be reduced significantly. The Army has stated that additional rounds can be fired in each EDS shot without increasing the volume of liquid waste produced.[4] The EDS-1 produces actual average volumes of less than 125 gallons per munition in single-shot operation (U.S. Army, 2003f). The committee was not aware of analogous information for the EDS-2. As a rough approximation, one round per shot operation on 1,245 munitions (Table 1-1) would produce less than $125 \times 1{,}245 = 156{,}000$ gallons of liquid waste, or less than 1.3 million lb. This compares reasonably well to the 1.6 million lb indicated for PBNSF in Table 4-1. Operation on a three-rounds-per-shot basis in EDS-1s could reduce the amount to less than about 430,000 lb, a major reduction.

Another difference might be a significant reduction in the quantity of activated carbon to be disposed of, especially if the EDS-2 is used and operated with six or nine rounds per shot. The activated carbon filters used on the EDS-1 would normally be changed after each shot. The EDS-1 uses either two 10-lb filters or a single 20-lb filter (U.S. Army, 2003f). Presumably, this amount of carbon would be used in either a single-round shot or a triple-round shot. For single-round-per-shot operation, the amount of waste activated carbon to be disposed of would be about $1{,}245 \times 20 = 24{,}900$ lb, which compares reasonably well with the 95,000 lb shown for PBNSF in Table 4-2. Presumably, multiple-rounds-per-shot operation would reduce the quantity of carbon waste even further. The committee was not aware of similar information for the EDS-2. The containment system for the EDS also has an activated carbon filter bank (U.S. Army, 2003f). For the EDS-1, this filter bank contains 800 lb of carbon. However, replacement is expected to be infrequent.

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[4]Darryl Palmer, Non-Stockpile Chemical Materiel Product, e-mail to the committee, August 25, 2003.

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Regulatory Approval and Permitting and Public Involvement

Before PBNSF can be constructed and operated, it must undergo a permitting process established within the federal and state regulatory and legal frameworks to protect human health and the environment. The regulatory approval and permitting (RAP) process involves in-depth examination of the Army's proposed treatment technologies and the requirements they must meet and provides opportunities for public involvement in the decision making process. In this chapter, the committee examines regulatory approval and permitting issues, as well as public involvement issues.

REGULATORY APPROVAL AND PERMITTING

There are several federal and state regulatory programs under which the Army and off-site treatment, storage, and disposal facilities (TSDFs) must operate to successfully accomplish the non-stockpile mission at the Pine Bluff Arsenal (PBA), particularly the hazardous waste regulations issued pursuant to the Resource Conservation and Recovery Act (RCRA), the Clean Air Act limitations on air emissions, and the Chemical Weapons Convention (CWC) obligations. Each of these has a different focus and impact, as discussed below.

The NRC report *Systems and Technologies for the Treatment of Non-Stockpile Chemical Warfare Materiel* discussed extensively the environmental regulatory framework under which non-stockpile chemical materiel (NSCM) must be treated and disposed of (NRC, 2002a).

Scope of Committee's Regulatory Approval and Permitting Review

The committee's review was based on the draft RCRA permit application, which the Army prepared when the PBNSF design was 35 percent complete (U.S. Army, 2003a). However, the committee believes there are RAP issues associated with the other NSCM operations that also warrant discussion and therefore includes them in its review. This includes operation of the rapid response system (RRS) and EDS systems. The committee is especially concerned about the Army's plans for off-site treatment of secondary wastes from PBNSF and these other systems. Here again, detailed plans for off-site treatment of secondary wastes at commercial TSDFs were not available for review in time to be reflected in this report, so the committee is able to consider such treatment only in a general way.

RESOURCE CONSERVATION AND RECOVERY ACT AND ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY REGULATIONS

Pine Bluff Non-Stockpile Operations and the Regulatory Approval and Permitting Approach

The Product Manager for Non-Stockpile Chemical Materiel (PMNSCM) plans to destroy non-stockpile materiel at PBA using several separate facilities rather than relying upon one integrated facility. Whereas the Army plans to operate the PBNSF under a RCRA permit, the initial identification and characterization of NSCM to be treated within PBNSF will be conducted by the Pine Bluff munitions assessment system, which because it is primarily an analytical and sorting operation, will be operated outside RCRA permitting requirements. In addition, the RRS for treatment of chemical agent identification sets and the EDS for treatment of explosively configured (fuzed) NSCM will be constructed and operated under separate RCRA permits. The Arkansas Department of Environmental Quality (ADEQ) has exempted the Pine Bluff binary facility from RCRA permitting requirements pursuant to the "generator accumulation tank treatment" exemption found in 40 CFR 262.34.[1] Also, the ton container cut and clean-out operation, because it is treating

[1]Arkansas Department of Environmental Quality, letter to Pine Bluff Arsenal, January 31, 2003.

containers defined as "empty" under RCRA (40 CFR 261.7), is exempt from RCRA permitting requirements. The integrated binary facility demolition is similarly being conducted outside RCRA permitting requirements. Finally, the Army plans to send secondary wastes generated from the above operations, some of which will be defined as hazardous waste under the RCRA program, to off-site (and perhaps out-of-state) RCRA-permitted commercial TSDFs (U.S. Army, 2003g).

Under RCRA, the Environmental Protection Agency was charged with developing regulations that would define hazardous wastes and establish a cradle-to-grave system for managing these wastes. States would then adopt these regulations and seek authorization from the Environmental Protection Agency to implement the RCRA program within their boundaries (APC&EC, 2002). Although their programs cannot be less stringent than the federal program, the states can develop regulations for implementation within their borders that are more stringent or broader in scope. With few exceptions, the regulatory program within Arkansas is identical to the federal program.

Under the RCRA program, wastes may be designated hazardous waste by being listed as hazardous waste or if they exhibit the RCRA hazardous waste characteristics (ignitability, corrosivity, reactivity, and toxicity (40 CFR §§261.21- 261.24)).[2] Chemical agent wastes in Arkansas are not specifically listed as hazardous waste. However, non-stockpile materials to be treated at the PBNSF typically exhibit reactivity and toxicity (U.S. Army, 2003a). PBNSF neutralent and some other secondary wastes would be considered corrosive and toxic and may also exhibit other characteristics (U.S. Army, 2003a). Energetics removed from NSCM at Pine Bluff would be considered reactive, and possibly ignitable, and may also exhibit the RCRA toxicity characteristic.

In summary, under Arkansas regulations, since the parent agent wastes are not listed as hazardous waste because of agent content, neither would any secondary wastes that result from primary treatment. However, the non-stockpile items, along with the neutralent and most other secondary wastes, will most likely exhibit a RCRA characteristic, as discussed above, and will thus be regulated as hazardous waste.

Waste Management Requirements and Treatment Goals

The RCRA permit application prepared for PBNSF focuses on waste management and treatment requirements pertaining to the hazardous waste characteristics (U.S. Army, 2003a). There is little reference within the PBNSF permit application to waste management requirements and treatment goals with respect to the chemical agents themselves (U.S. Army, 2003a).

Similarly, permit applications for off-site TSDFs treating secondary wastes would probably focus on waste management and treatment requirements pertaining to the hazardous waste characteristics. Public attention might nevertheless focus on the possible presence of chemical agents within these secondary wastes (albeit at very low concentrations) and the possible presence of their degradation products (some of which may be classified as CWC Schedule 2 compounds[3]).

As noted in prior reports, the Army may benefit from explaining the basis for its treatment goals, e.g., generally achievable detection limits, generally achievable treatment levels, and/or risk (NRC, 2001a; 2002a). For example, in the environmental impact statement for the non-stockpile transportable treatment systems, the Army compared residual levels after neutralization of chemical agent in the RRS, EDS, and Munitions Management Device (MMD) with various analogous regulatory levels (U.S. Army, 2001a). The Army could help the community to understand the non-stockpile chemical weapons disposal program by providing some explanation of the basis for the treatment goals to be used for the neutralization of agent at PBNSF, and for the treatment of secondary wastes.

Finding 5-1: As required in Arkansas, the PBNSF permit application discusses treatment of wastes only with respect to RCRA characteristics. Yet the primary hazard associated with these wastes, and the one most likely to be of concern to the public, is the chemical agents and their toxic properties. For non-stockpile secondary wastes, the primary concern is CWC Schedule 2 compounds, but there may also be concern about low concentrations of chemical agents as well.

Recommendation 5-1: For non-stockpile materiel to be processed at the Pine Bluff Non-Stockpile Facility, the Army should describe risk-based treatment goals for chemical agent destruction in publicly available documentation. The Army should also describe agent-related treatment goals for secondary wastes treated at offsite treatment, storage, and disposal facilities (e.g., for Schedule 2 compounds) in publicly available documentation. Treatment goals for related non-stockpile operations at the Pine Bluff Arsenal—for example, the rapid response system and the explosive destruction system—should also be discussed in publicly available documents.

[2]The ignitability, corrosivity, and reactivity characteristics consist of a combination of prose descriptions and test methods. A toxic waste is a waste that contains concentrations of certain listed contaminants above established thresholds when tested using the Toxicity Characteristic Leaching Procedure, a leaching test.

[3]Under the CWC, Schedule 2 chemicals have limited commercial utility and can be readily converted to chemical weapons. Production of these chemicals above specified limits is subject to reporting requirements and verification through on-site inspections.

Permitting Approach for the Pine Bluff Non-Stockpile Facility

The PBNSF includes storage containers, tanks, vaults and miscellaneous units,[4] with each category having its own permit requirements, which the permit application must address. Whereas the regulatory standards for containers, tanks and vaults are fairly prescriptive, requirements for miscellaneous units are performance-based. The regulations under RCRA Subpart X do not refer to specific technical standards as do regulations for other hazardous waste management units, but instead specify environmental performance standards under which units must be operated to be protective of human health and the environment. The permitting agency bases permit requirements on the information provided in the permit application, and for Subpart X units, may draw upon the prescriptive standards used for the other types of permitted units, such as those established for incinerators. The permitting process for these types of complex operations is typically long and arduous.

For non-stockpile chemical agent treatment facilities, the Army has several RAP options in addition to the standard RCRA permit (NRC, 2002a). The committee recommended that RCRA Research, Development and Demonstration (RD&D) permits be established for facilities like PBNSF, in lieu of standard RCRA permits, considering the facilities' developmental nature. Operations could then transition from RD&D to a full RCRA operating permit once operations become routine. This approach is being implemented for the Munitions Assessment and Processing System at Aberdeen Proving Ground (NRC, 2002a). The PMNSCM initially proposed the RCRA RD&D permit approach for PBNSF; however, this option was dismissed in favor of a standard RCRA permit approach.[5]

The Anticipated Need for Frequent Permit Modifications

Changes in operations during the RCRA permit life require permit modifications. Unlike most commercial TSDFs, stockpile facilities have been historically associated with an extraordinary number of permit modifications. For example, the Pine Bluff Chemical Demilitarization Facility (PBCDF) was permitted under RCRA in January 1999. Although not yet operational at the time this report was prepared, over 70 permit modifications have been processed to date for the PBCDF, which is scheduled for agent operations beginning April 2004. More permit modifications are anticipated during the operational phase. Stockpile facilities typically are associated with hundreds of permit modifications; over 300 modifications have been required to date for the Johnston Atoll Chemical Agent Disposal System (Johnston Island), and over 500 have been processed for the Tooele Chemical Agent Disposal Facility (Tooele, Utah). According to interviews with stockpile facility staff, however, few of these permit modifications have resulted in facility downtime.[6]

The PBNSF is a first-of-its-kind treatment facility. In addition, it is the PMNSCM's first large-scale non-stockpile operation. There is considerable uncertainty about the agent fills of NSCM and the choice of accessing technology (as discussed in previous chapters of this report). As a result, the committee expects that there will be a need for numerous permit modifications as PBNSF proceeds through construction, systemization, operations, and, eventually, closure.

Finding 5-2: The committee expects that numerous permit modifications will be needed as PBNSF proceeds through construction, systemization, operations, and, eventually, closure.

Recommendation 5-2: The Army should urge the state to craft the Pine Bluff Non-Stockpile Facility permit to allow maximum flexibility during systemization and start-up, thus minimizing the need for frequent permit modifications to the extent possible. Further, the Army should develop plans for efficient management of Resource Conservation and Recovery Act permit modifications for the Pine Bluff Non-Stockpile Facility. Because the stockpile program has experienced numerous permit modifications with respect to stockpile operations, the Product Manager for Non-Stockpile Chemical Materiel should examine lessons learned from the stockpile program in developing a Pine Bluff Non-Stockpile Facility permit modification management plan.

Permit Schedule and Chemical Weapons Convention Schedule

Another issue that affects both permitting and compliance is the CWC schedule. The CWC requires that stockpile and non-stockpile munitions be destroyed in accordance with a very aggressive schedule in order to meet the April 2007 deadline.[7] The Army's schedule has the RCRA permit for PBNSF being prepared and approved by ADEQ over a 13-month period, with issuance in April 2004. As this report was being prepared, permitting was already behind schedule.

PBNSF is a developmental facility and is likely to face problems during systemization and start-up. It is similar in complexity to stockpile demilitarization facilities. Experi-

[4]Miscellaneous units are often referred to as Subpart X units, since they are described in RCRA regulations at 40 CFR Part 264, Subpart X.

[5]Conference call question and answer meeting between committee members and PMNSCM staff, May 20, 2003.

[6]Clara Moraga, Deputy Site Project Manager for Compliance, PBCDF, various e-mail and phone contacts with Todd Kimmell, committee member, and NRC staff, April-May 2003.

[7]It is noted, however, that signatories to the CWC may request a 5-year extension to the April 2007 treaty deadline.

ence in the stockpile program shows that permit issuance for demilitarization operations involving chemical agent typically takes far longer than the 13 months allocated for PBNSF.

Agent operations at PBNSF are scheduled to begin in June 2006 and end in April 2007, the CWC schedule deadline. Since numerous permit modifications are expected to be needed during the operational period, the Army clearly faces a daunting challenge in meeting CWC schedule requirements for treatment of non-stockpile items at PBNSF.

Finding 5-3: The PBNSF is a developmental facility similar in complexity to stockpile demilitarization facilities and is likely to face problems during systemization and start-up. The PMNSCM expects that a permit for the PBNSF will be issued in 13 months. Typically, RCRA permits for large, complex facilities can take well in excess of a year to obtain. The permitting process for the PBNSF is already behind schedule. The PMNSCM expects that operations at the PBNSF will be completed within 10 months. Experience with the stockpile program indicates that hundreds of permit modifications are typically needed during the life of the permit.

Recommendation 5-3: The Product Manager for Non-Stockpile Chemical Materiel should reevaluate the schedule for permitting and operation of the Pine Bluff Non-Stockpile Facility. Schedules for operation of the Rapid Response System and Explosive Destruction System, and other non-stockpile operations at the Pine Bluff Arsenal should be similarly reevaluated.

PUBLIC INVOLVEMENT

Public involvement in significant, potentially controversial activities such as the Non-Stockpile Chemical Materiel Program (NSCMP) is not only a legal requirement but is also a key element of mission success. As an earlier NRC committee noted in its report *Systems and Technologies for the Treatment of Non-Stockpile Chemical Warfare Materiel* public involvement means working with a range of "publics," or stakeholders (NRC, 2002a). The report emphasized that an effective public affairs approach has three components: (1) early provision of written information materials to the public; (2) outreach, or opening channels of communication to allow the public to articulate its values, concerns, and needs; and (3) involvement, or providing mechanisms that engage members of the public and allow them to provide input and influence agency decisions.[8]

The publics interested in NSCMP activities at Pine Bluff include local stakeholders who work at and live near the arsenal; national stakeholders such as the Non-Stockpile Chemical Weapons Citizens' Coalition (NSCWCC)[9] and the Core Group[10]; and stakeholders along transportation routes and near sites (as yet unknown) where secondary wastes will be transported and treated or disposed of.

Legal Basis for Public Involvement under the National Environmental Policy Act

Each of the regulatory programs discussed above gives the public an opportunity to comment on the regulatory agency's proposed decisions. The National Environmental Policy Act (NEPA), on the other hand, imposes no substantive environmental requirements (e.g., emission limits or specifications for the design standard for buildings in which an explosion may occur). Rather, NEPA is "essentially procedural" (Vermont Yankee Nuclear Power Corp. *v.* Natural Resources Defense Council, 435 U.S. 519 (1978)). These procedures are intended to ensure that environmental information is available to public officials and citizens before decisions are made and before actions are taken so that government and public attention can be focused on the environmental impacts (40 CFR § 1508.8; Robertson *v.* Methow Valley Citizen Council, 490 U.S. 332 (1989)). Also, where there is a clear and unavoidable conflict between the schedule dictated by NEPA and other U.S. legislation (e.g., as there may be in the future between deadlines in CWC implementing legislation and NEPA), the more specific statutory deadline may supersede NEPA (Flint Ridge Development Co. *v.* Scenic Rivers Association of Oklahoma, 426 U.S. 776 (1976)). In some situations, the NEPA process may "spur all interested parties to rethink the wisdom of the action" (Natural Resources Defense Council *v.* Hodel, 865 F.2d 288 (D.C.Cir. 1988)). The federal agency's sole obligation is to disclose in either an environmental assessment or an environmental impact statement (EIS) the significant impacts on the environment of the federal action. Nonetheless, there is a long history of federal agencies being sued by citizen groups who are opposed to the underlying federal decision, even when their suit is unlikely to succeed.

Given the relatively short time available to design, construct, and implement destruction technologies for chemical weapons, a legal challenge alleging that the Army did not follow the procedural requirements of NEPA could cause a critical delay.

[8]See also the threefold division of public affairs activities described in a letter report from the Committee on Review and Evaluation of the Army Chemical Stockpile Disposal Program (NRC, 2000b).

[9]The NSCWCC is a coalition of grass-roots organizations that developed out of the Chemical Weapons Working Group.

[10]The Core Group includes NSCMP personnel, representatives of regulatory agencies, and representatives of citizens' groups who meet regularly to exchange information and opinions on programmatic non-stockpile issues. The group, which was established by NSCMP and is funded by it, is facilitated by staff from the Keystone Center.

Background to the National Environmental Policy Act

NEPA (42 U.S.C. §§ 4321-4347) requires federal agencies that are implementing "major federal actions" that could significantly affect the quality of the human environment to assess the environmental impacts of such actions, alternatives to them, the short- and long-term impacts, and any irreversible and irretrievable commitments of resources, including the cumulative impact.[11] Agencies must rigorously examine the environmental effects (including, where appropriate, cumulative impacts) of their planned action. This must be done even after a proposal has received initial approval, although courts have held that a rule of reason should be applied in determining whether to supplement an EIS (Marsh *v.* Oregon Natural Resources Council, 490 U.S. 360, 109 S.Ct. 1851 (1989)).

When and how to consider cumulative impacts is decided case by case, in large part because there is not "a single, universally accepted conceptual approach, nor even general principles accepted by all scientists and managers" (CEQ, 1997).

Typically, an environmental assessment is performed when the environmental impact is expected not to be significant or where additional evaluation is needed to determine whether the impact is significant. If the environmental impact is expected to be significant, the agency proceeds to perform an EIS. The primary difference between an environmental assessment and an EIS is the level of detail and evaluation. Generally, environmental assessments "are a cost-effective way to determine whether potentially significant effects are likely and whether a project can mitigate these effects" (CEQ, 1997). In a typical year, 45,000 environmental assessments are prepared as opposed to 450 EISs (CEQ, 1997).

Thus, NEPA provides a mechanism to involve the public in decision making. Of course, regardless of the boundaries of the NEPA process, an agency can always encourage more public involvement if it deems such action will further its other statutory mandates or otherwise further its mission.

The Application of National Environmental Policy Act to the Pine Bluff Non-Stockpile Facility

On August 8, 2001, the Army announced its intent to prepare an EIS for all of the actions planned for the destruction of stored non-stockpile chemical materiel at PBA, and a scoping meeting was held on October 18, 2001.

In parallel, the Army issued an EIS for the transportable treatment systems for destroying chemical agent (U.S. Army, 2001a), including the MMD (which is the basis of the technology used in the PBNSF), the RRS, and the EDS. The record of decision for the final EIS on the transportable systems concluded that the MMD technology was "environmentally safe" and that the "subsystems could be used in the future" (Federal Register, 2002).

The Army concluded that implementation delays would be less likely if several separate facilities were used to destroy the non-stockpile materiel rather than a single integrated facility. As a result the Army proposed separate facilities and released seven separate environmental assessments for the following:

- PBNSF,
- EDS,
- RRS,
- Treatment of the empty ton containers,
- Neutralization of binary weapons,
- Destruction of the integrated binary production facility, and
- Pine Bluff munitions assessment system.

According to the Army, this change in strategy was necessitated by several factors, including the need for additional research on nonincineration alternatives to the destruction of non-stockpile materiel, potential funding delays, and the limited time available for regulatory approval, facility design and construction, and treatment operations before the April 29, 2007, CWC deadline (U.S. Army, 2002b.)[12]

Based on the environmental assessment for PBNSF, the Army concluded that there would be no significant impact on land use, ecologic resources, water use, or socioeconomic resources (Federal Register, 2002). In fact, the net impacts were determined to be positive because acutely toxic chemicals are permanently destroyed (U.S. Army, 2003h).

The Army has not determined whether or to what extent NEPA applies to off-site treatment and disposal of neutralent and other secondary wastes at a commercial TSDF using as yet unselected technology. An NRC committee concluded that the secondary waste from the destruction of neutralents from the RRS, MMD, and EDS was likely to be treatable using the same technologies as those used to treat industrial RCRA hazardous wastes (NRC, 2002a). As noted earlier in this chapter, the nature and characteristics of the secondary wastes generated by the PBNSF and other non-stockpile treatment systems also fall within the range of characteristics of RCRA hazardous wastes (NRC, 2002a).

Regardless of whether NEPA applies to off-site treatment, the Army has provided for a public involvement program in

[11]A cumulative impact is one that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of which agency (federal or nonfederal) or person undertakes such other actions (40 CFR § 1508.7), including not only the project proposal but all connected and similar actions that could contribute to cumulative effects (CEQ, 1997).

[12]William Brankowitz, Deputy Product Manager, NSCMP, "Non-Stockpile Chemical Materiel Product Overview," briefing to the committee on March 19, 2003.

its offsite secondary waste treatment contract. If this effort is well conceived and implemented, local citizens are more likely to understand the treatment process(es) and what, if any, risk may be posed by the transportation and treatment and disposal of these secondary wastes. In many ways, the Army may be facing a win-win situation because citizens groups have almost universally expressed a preference for chemical weapons destruction technologies that neutralize the agent and then use some nonincineration alternative on the secondary waste.

Even if it is determined that NEPA does not apply to off-site secondary waste transportation and treatment, it would be prudent to provide enhanced public outreach to affected communities. The history of wastes of concern (such as the Navy's program for the destruction of Vietnam-era napalm) suggests that public concerns and passions can be fanned by the perception that views of the local community were not solicited (U.S. Navy, 2001).

Delays could be caused by legal challenges to the environmental assessment issued for PBNSF and by challenges to the off-site facility used to treat the neutralent from Pine Bluff. Proactive public involvement in secondary waste disposal issues can eliminate or at least minimize the likelihood of delays due to legal challenges.

Involvement of Local Area Stakeholders

At Pine Bluff, as at other non-stockpile sites, the PMNSCM provides program-level information and guidance, consistent with Army Regulation 360-1, dated September 15, 2000. Authority for planning and conducting stakeholder interactions resides with the installation (arsenal) commander, who requests assistance from PMNSCM as he deems appropriate.

Several changes have occurred at Pine Bluff since the NRC report that expressed concern about the limited public involvement program at Pine Bluff (NRC, 2002a). Chemical stockpile and non-stockpile disposal programs have increased their coordination of activities: PMNSCM staff share in the operation of the community outreach office with the staff of the Chemical Stockpile Disposal Program. The Citizens' Advisory Commission for Pine Bluff stockpile operations recently discussed non-stockpile issues at its meetings.[13] In addition, from an initial focus on activities that are legally required under NEPA or RCRA, the arsenal has expanded the range of its informal non-stockpile activities. For example, it makes presentations and meets informally with school and civic groups.[14] The arsenal has held a series of public meetings and availability sessions related to NEPA and RCRA actions. It has publicized its activities in the local press and has developed a contact list of officials, civic groups, and activists.

A number of NRC reports have emphasized going beyond provision of information and the opening of channels of communication. They call for also developing effective relationships with the public and expanding public involvement (see NRC, 2002a and references cited therein; see also NRC, 2002b). The installation continues, however, to provide only limited opportunities for public involvement. For example, it has not included the third component of an effective public affairs program—developing mechanisms that engage members of the public and encourage their inputs into program decisions. Such mechanisms have not been utilized for either the larger, more visible stockpile demilitarization program or the non-stockpile program. Further, in contrast to other communities with chemical materiel demilitarization activities, the public at Pine Bluff has not participated extensively in RCRA and NEPA public meetings and has not raised many of the issues raised at other locations.[15] For example, only six non-governmental residents—as compared with about 50 officials—attended an environmental assessment meeting conducted by the PMNSCM in August 2002 (U.S. Army, 2002e).[16]

In the course of preparing this report, committee subgroups and staff attended public meetings in Pine Bluff at which non-stockpile issues were presented to the community, visited the local outreach office, reviewed news accounts of chemical demilitarization issues in Pine Bluff, and interviewed state representatives as individuals who monitor public opinion. Based on these observations as well as on previous studies elsewhere, the committee believes that there are many reasons why members of the local public do not participate in public meetings. These reasons apply to different segments of the public to varying degrees; however, the public affairs staff's responsibilities should include identifying and addressing the reasons that may apply in a specific situation, such as Pine Bluff. The following are some of the more prominent reasons:

- *Many people in the local community trust the installation.* The PBA is a significant, long-term employer. There is a feeling of kinship between the arsenal and the surrounding communities. For example, in previous research, one community resident said in an interview: "We have a much more personal kind of relationship with the arsenal. . . the arsenal is 'us'"

[13]This trend toward greater coordination is being stepped up by the establishment of site-centric public outreach plans that incorporate activities from stockpile, non-stockpile, and assembled chemical weapons assessment programs.

[14]The NSCMP provided a binder of news clippings and meeting schedules detailing these activities to the committee on May 2, 2003.

[15]Elizabeth Crowe, NSCWCC, teleconference with members of the committee, July 11, 2003.

[16]Jeff Lindblad, NSCMP Public Outreach and Information Office, "Non-Stockpile Chemical Materiel Outreach Activities for Pine Bluff Arsenal," briefing to the committee on April 22, 2003.

(Bradbury et al., 1994). A similar viewpoint was expressed more recently by a state regulator, who noted that the arsenal has been in the community and people have worked there for years.[17]

- *Residents tend to support the Non-Stockpile Program's proposals.* Nationally, the most significant challenge to chemical materiel demilitarization programs has come from activist groups that oppose incineration. However, incineration is not an issue for the inventory of non-stockpile items at the PBA, since the PMNSCM has made it clear that it is not proposing incineration at that site. Local opponents of the stockpile incinerator support the PMNSCM's choice of neutralization. Transportable technologies such as the RRS and EDS, which are dismantled and removed after the waste is destroyed, are generally viewed favorably by the public.[18] And, as one state regulator who is also a Pine Bluff resident said, the local public generally appears to be more concerned about getting rid of the chemical materiel (whether stockpile or non-stockpile) than about the technologies per se. Further, he reported that in addition to not raising issues at public meetings, members of the public have not raised any negative issues related to the proposed facilities in written and telephonic communication with state personnel.[19] Approximately 3 percent (45 munitions and 34 liters of dilute chemicals such as those found in chemical agent identification sets) of the inventory of recovered chemical weapon materiel at Pine Bluff has been brought in from sites such as the Spring Valley neighborhood in Washington, D.C., Fort Devens, Massachusetts, and Jackson, Mississippi.[20] Both opponents and supporters of incineration have long expressed the concern that Pine Bluff might become a national dumping ground for chemical munitions. There appears to be broad support, therefore, for the PMNSCM's decision to bring in transportable treatment systems. The Pine Bluff Commercial editorialized, "Let the federal government step up efforts to develop such a transportable system. It may well be the safest way to go" (Pine Bluff Commercial, 2000).
- *People are confused by all the projects and the process for reviewing them.* For several years, residents of the Pine Bluff area have been invited to a long series of meetings on chemical weapons disposal. The PMNSCM is careful to distinguish its program from the larger stockpile demilitarization incineration program. However, the inclusion of the binary weapons precursor stockpile in the non-stockpile program is a cause for confusion. Many members of the public reportedly have difficulty distinguishing between the programs.[21] The PMNSCM holds meetings in connection with its RCRA permit applications and as part of the NEPA process. However, when it shifted from initial consideration of a single EIS for the non-stockpile program at Pine Bluff to a series of environmental assessments, it did not clearly explain the effect of the switch on public involvement and, indeed, provided confusing and sometimes incorrect information about NEPA documentation (see, especially, U.S. Army, 2003i; 2003j). It is probably not clear to the average area resident what requirements for public review apply to each proposed activity now covered by a separate environmental assessment (PBNSF, Pine Bluff Munitions Assessment System, the EDS, the RRS, treatment of the empty ton containers, neutralization of binary weapons, and destruction of the integrated binary production facility). Nor is the entire scope of work at Pine Bluff likely to be clear. The average person is simply aware of a series of meetings related to chemical materiel disposal sponsored by the Army.

  It would seem difficult enough for experts in federal environmental policy to keep track of what is going on in Pine Bluff. Local residents are therefore unlikely to have a clear picture of what is being proposed, let alone a notion of how to influence Army decisions.
- *People in the local community feel powerless.* This is a common complaint in less affluent communities across the country, and it does not apply solely to activities by the Army or other government agencies. It is often a self-fulfilling sentiment. Most people have not seen large institutions respond to their concerns and complaints directly, so they are reluctant to express them. Some observers note that, in Pine Bluff there is a history of keeping quiet—a feeling that "asking too many questions or raising a fuss is something you just don't do."[22] Longstanding cultural constraints may contribute to such reluctance. For example, Battelle researchers reported that some people they interviewed "saw the lack of involvement, especially among the poor

[17]Joe Hoover, ADEQ, teleconference with members of the committee on July 24, 2003.

[18]Elizabeth Crowe, NSCWCC, teleconference with members of the committee on July 11, 2003; Theodore J. Henry, U.S. Army Corps of Engineers, contractor overseeing community outreach for Spring Valley, teleconference with members of the committee on July 23, 2003.

[19]Joe Hoover, ADEQ, teleconference with members of the committee on July 24, 2003.

[20]Larry E. Wright, Executive Assistant, PBA, "Pine Bluff Arsenal Non-Stockpile Chemical Material," briefing to a fact-finding team on August 9, 2001.

[21]Joe Hoover, ADEQ, teleconference with members of the committee on July 24, 2003.

[22]Elizabeth Crowe, NSCWCC, teleconference with members of the committee on July 11, 2003.

and black communities, as having roots in the economic and political history of the region" (Bradbury et al., 1994). According to their report, a business leader in Pine Bluff recalled a conversation with a prominent black educator, who said: "This is really a lower Mississippi delta problem. . . an overwhelming sense of powerlessness, despair, hopelessness; a sense that nothing has changed and nothing ever will. . . .The black community harbors feelings of betrayal, anger, and frustration behind a mask of passive acceptance" (Bradbury et al., 1994).

- *Information may not be reaching all community members.* In some cases, community leaders and officials may be the primary recipients of information. Information may not filter down to ordinary citizens for a variety of reasons, including insufficient educational attainment and literacy, discomfort with the format and location of meetings, and the poor clarity of information materials. In Pine Bluff, educational attainment and literacy are below the national average.[23] In addition, and despite a plethora of fact sheets, there is no overarching "plain English" explanation of the various non-stockpile activities and regulatory processes. Further, residents may feel intimidated by formal meetings. The Battelle researchers, for example, noted the unease of low-income residents about participating in formal public meetings where Army experts are separated from the audience (Bradbury et al., 1994). They recommended small face-to-face meetings in familiar settings to encourage discussion. Others reported that some residents are reluctant to attend meetings held near the arsenal and are concerned, rightly or wrongly, about possible security checks.[24]
- *People expect other community members to represent them.* This reason is by no means unique to Pine Bluff but may be more common there for the reasons discussed above. Army public affairs specialists explain that people think of the neighbors who attend public meetings as their representatives and/or as having expressed their views through informal contacts with representatives of the Core Group or the NSCWCC.

The reasons for the low level of public attendance at meetings notwithstanding, the Army, as well as the community, might benefit from more intensive and continuing public involvement. If non-stockpile operations at Pine Bluff proceed without incident, the current situation probably will have been satisfactory. But if something goes wrong, the Army may wish that more community members had invested time and ideas in understanding and improving the program up front.

For example, an incident or even a false alarm at any Pine Bluff chemical demilitarization facility—non-stockpile or stockpile—could arouse an otherwise accepting or complacent public.[25] Such incidents have been reported at the Johnston Atoll Chemical Agent Disposal System on Johnston Island and the Tooele Chemical Agent Disposal Facility in Utah, and they might happen at Pine Bluff (NRC, 2002b).

An example of how public participation can strengthen a program against undesirable contingencies occurred when non-stockpile materiel found in the Spring Valley neighborhood of Washington, D.C., was destroyed.[26] At a recent meeting of the Restoration Advisory Board (RAB), PMNSCM officials explained the planned use of the EDS on site. Community members of the RAB were generally supportive or at least accepting. At least one member, however, expressed concern about the Army's proposed procedures, saying she would "feel better if there was always someone trained for emergencies on-site, rather than have a distant monitoring system watched by security guards. . . .The challenge with an emergency is that there is no way to know what will happen and time could be critical" (U.S. Army, 2003k).

Ten days later, the Army Corps' project manager for Spring Valley responded, in a letter to the RAB; "As a result of your feedback during that meeting the Corps and PMNSCM have agreed that having a qualified technician on site and monitoring the EDS during all hours of operation is a prudent course of action. . . . PMNSCM will modify its operating procedures, for the Spring Valley destruction operation, to have a trained operator monitor the system on a 24-hour basis while the EDS is in operation."[27]

There were no reported incidents during the June 2003 use of the EDS at Spring Valley, but if one had occurred, the community would have had reason to believe that the Army acted in consonance with community concerns to limit the potential impact of such an incident. Similarly, a community

[23]Census data for 2000 show that the percentage of the population with less than ninth grade education is 9.3 percent for Pine Bluff City and 8.6 percent for Jefferson County, as compared with 7.5 percent for the U.S. overall. Adult literacy estimates show that 35 percent of the population in Pine Bluff City and 31 percent in Jefferson County are at the first reading level as compared with 21-23 percent in the United States overall (at level one, most adults can read a little, but not enough to fill out an application, read a food label, or read a simple story to a child (Reder, 1996)).

[24]Elizabeth Crowe, NSCWCC, teleconference with members of the committee on July 11, 2003.

[25]See also Perrow's classic critique of the inevitability of accidents in complex systems (Perrow, 1999).

[26]The Army's Formerly Used Defense Sites cleanup program in Washington, D.C.'s Spring Valley neighborhood has been using the transportable EDS—a system also proposed for Pine Bluff—to dispose of locally recovered chemical munitions. The site has a RAB (which is authorized for cleanup sites) and extensive public participation by an educated, empowered community faced with a serious environmental problem.

[27]Gary Schilling, Project Manager and Military Co-Chair of the Spring Valley RAB, letter to the Spring Valley RAB, April 18, 2003.

affairs program in Pine Bluff that goes well beyond legal requirements by holding informal meetings to ensure genuine public involvement could provide significant benefits: It would not only prepare the PMNSCM to deal with potential incidents, but might also enable the program to develop an on-site alternative for neutralent disposal, with community buy-in, should its plans for off-site disposal encounter opposition in destination communities and communities along the transportation routes.

However, when the committee asked PMNSCM management about potential changes in the program's public affairs strategy, PMNSCM officials said their authority to institute change at the installation level was constrained by Army policy, although they promised to discuss possible improvements with their counterparts at PBA. The notion that the approach of the local installation may diverge from that of headquarters is confusing to the public and makes it difficult to implement change. If the PMNSCM is unable to represent its own activities to the NRC and the public, then representatives from PBA should be brought into closer contact with outside parties.

Involvement of Nonlocal Stakeholders

In addition to providing guidance to the arsenal, PMNSCM has been working directly with stakeholders at the national level through the Core Group, which includes regulators, community representatives, and NSCMP officials. The group has met over a period of 4 years to exchange information and opinions, focusing on the development of publicly acceptable disposal technologies, policies, and practices. A recent activity has been to use technical criteria drawn up by group members in developing a matrix of nonincineration treatments for secondary wastes. Community representatives are also emphasizing associated institutional issues and working with PMNSCM to "trouble-shoot [and] raise red flags where there are potential problems with shipping waste off-site."[28] Potential problems include the location of other facilities such as incinerators or refineries, the propensity to site disposal facilities where there is an environmental justice community (i.e., one with a high percentage of minority and low-income persons), and whether a given community is opposed to receiving more waste.

Members recognize that the Core Group is not a decision-making body and that its role is to provide useful input to the Army. Significantly, the dialogue that has occurred over the past 4 years among community activists, regulators, and Army personnel has contributed to changes in both Army policy and activists' positions. From a position of strong opposition to shipping secondary wastes off-site, the NSCWCC has moved to a position that reluctantly recognizes and is willing to address the inevitable trade-offs in addressing non-stockpile issues. To quote a leading representative of the NSCWCC:

> On the one hand, the NSCWCC wants to prevent chemical weapons, per se, from moving around; on the other hand, they recognize the hard reality that no-one has yet figured out how to reduce chemical weapons to nothing and that secondary waste will need to be shipped. This brings us back to the environmental justice issue—if we cannot make the wastes disappear, where is the place where wastes will have the least impact on the community and the environment?[29]

The effective working relationships with national stakeholders that PMNSCM has fostered through the years may help address some of the difficult issues related to off-site shipment that have made policy implementation difficult for other programs. For example, residents in communities along transportation routes or in communities that receive neutralent and other wastes from Pine Bluff may object to treatment or disposal in their communities. While it is possible that such opposition is based on an analysis of health risks from transportation, incineration, or some other technology, it is likely to be fueled by the stigma associated with chemical weapons.

For example, in 1998, when the Navy sought a location to dispose of Vietnam-era napalm products without a well-developed public involvement program, strong local opposition thwarted the shipment program. Similarly, some local residents have filed an environmental justice complaint because of the Army's plan to ship hydrolysate from the Newport, Indiana, chemical stockpile plant for biotreatment at a facility near Dayton (DeBrosse, 2003).

Neutralent from non-stockpile chemical weapons, also a potential "waste of concern," might generate similar opposition. While congressional restrictions on transporting chemical agents[30] do not apply to secondary wastes, the committee is concerned about the potential impact of political, regulatory, and public concerns about transporting non-stockpile secondary wastes to off-site, perhaps even out-of-state, TSDFs.

Building on the foundation already established with Core Group and NSCWCC representatives, PMNSCM could do more to anticipate and address problems with off-site disposal of secondary wastes. It could clarify or strengthen its upfront requirements for public involvement in oversight of the off-site waste disposal contract. The request for proposals for waste disposal services requires that the contractor "review the Public Affairs sections of all NRC reports, as well as citizen comments." The Army has reportedly said that it "will make available further, and more detailed, information on the plans for disposal of this waste material after

[28]Elizabeth Crowe, NSCWCC, teleconference with members of the committee on July 11, 2003.

[29]Elizabeth Crowe, NSCWCC, teleconference with members of the committee on July 11, 2003.

[30]See Public Law 91-121 (1969) and Public Law 103-337 (1995).

the partnership has had time to talk with appropriate community representatives and received input to finalize locations" (DEA, 2003). Therefore, it should not be too difficult to insist on a proactive public involvement strategy that incorporates the positive lessons learned from stakeholder interactions with the Core Group and at installations such as the Aberdeen Proving Ground.[31]

Public Involvement Findings and Recommendations

In summary, the committee commends the PMNSCM for its commitment to working effectively with the Core Group at the programmatic level. Although more remains to be done at the installation level, increased coordination with the stockpile and Assembled Chemical Weapon Assessment programs at local installations and increased visibility and informal interactions with Pine Bluff residents are positive steps. The committee believes that the PMNSCM is in a position to build on the Pine Bluff community's unusually positive, or at least accepting, view of the proposed activities, as well as on its working relationships with national-level stakeholders.

Finding 5-4a: Although the local community around Pine Bluff appears generally supportive of the PMNSCM's current strategy for the disposal of recovered chemical munitions and other non-stockpile materiel, the Army would benefit from a more consistent level of public involvement that is integrated into key project decisions before they are made. Such involvement would strengthen the Army's ability to work through both anticipated and unanticipated problems in a timely fashion and would minimize the likelihood of a challenge to the Army's decision on the basis of a failure to comply with NEPA.

Finding 5-4b: The shipment and off-site treatment of neutralent and other non-stockpile secondary wastes is likely to generate controversy elsewhere in the region or wherever the Army proposes to ship wastes from the Pine Bluff facilities. To resolve and preferably preempt such controversies constructively, the Army could pursue broader public participation, in addition to whatever outreach is conducted by the selected contractor(s) for disposal of secondary waste.

Recommendation 5-4: The committee recommends that the Product Manager for Non-Stockpile Chemical Materiel enhance public involvement by (1) identifying and addressing the reasons for limited participation by the public in meetings at Pine Bluff; (2) establishing an informal advisory group at Pine Bluff similar to a restoration advisory board; (3) augmenting the national Core Group with citizen stakeholders from Pine Bluff and from the yet-to-be determined location of the facility that is selected to treat and dispose of the secondary wastes from the Pine Bluff Non-Stockpile Facility; and (4) ensuring that the contractor(s) for disposal of secondary wastes go(es) beyond information and outreach activities to involve local community stakeholders.

Finding 5-5: The Army has not expanded its public affairs program at the Pine Bluff Arsenal to include involvement as well as public relations and outreach activities, nor has it ensured coordination of program and installation missions at the arsenal, as recommended in a previous NRC report.[32] Thus, the PMNSCM continues to be constrained in its authority to institute an expanded public *involvement* program at the PBA.

Recommendation 5-5: The Army should consider revising Army Regulation 360-1 to expand its definition of public affairs activities to include involvement as well as information and outreach activities. At the same time, the Army should evaluate its traditional institutional roles and responsibilities to ensure greater consistency between installation and program-level approaches to public involvement, particularly as they apply to the Pine Bluff Arsenal.

Finding 5-6: Some members of the public might believe that the environmental assessments prepared by the Army for non-stockpile materiel at Pine Bluff do not give an adequate overview of the activities being conducted.

Recommendation 5-6: As part of the public involvement process, the Army should consider preparing a new document that describes, in layman's terms, the treatment technologies and facilities being proposed for non-stockpile materiel at Pine Bluff. These technologies include those outside the Pine Bluff Non-Stockpile Facility and should include the technologies ultimately selected to treat neutralent off-site. The document might include a timeline and a summary of the cumulative environmental impacts. It would give the public a clear understanding of the proposed actions and help them to understand the operation of each technology and the interrelationships among them.

[31]Some lessons learned at the Aberdeen Proving Ground are discussed in Chapter 5 of NRC, 2002a.

[32]See NRC, 2002a, pages 69-70.

6

A Greater Role for the Explosive Destruction System in Destruction of the Pine Bluff Inventory of Recovered Chemical Warfare Material

While evaluating the current PBNSF design, the committee concluded that there are preferable alternative approaches for destroying the non-stockpile chemical materiel stored at the Pine Bluff Arsenal (PBA). The alternatives involve greater use of the well-proven EDS and are simpler, more reliable, less expensive, and better able to meet the Chemical Weapons Convention (CWC) deadline of April 2007. As outlined in this chapter, the EDS would be easier to operate and maintain without compromising the safety of the workers, the public, or the environment. Although changing to a new operational concept at this late stage in the design planning for PBNSF would present new challenges for meeting the CWC deadline, these challenges should be no greater than those for meeting the deadline with PBNSF operation as currently planned. The factors involved in deciding between the current PBNSF design and a design using multiple EDS units are explored in this chapter.

CONCERNS ABOUT THE DESIGN OF THE PINE BLUFF NON-STOCKPILE FACILITY

Upon reviewing the engineering design plans for the construction of PBNSF and the operating plans, in accordance with the statement of task, the committee concluded that the basic design of PBNSF, as configured at the time that this report was finalized, is incomplete. The following issues remain to be resolved if the design is to destroy all of the RCWM safely and in accordance with the schedule defined in the CWC:

1. The ability of the PBNSF processing equipment to process energetically configured 4.2-in. mortar rounds containing gelled or solidified mustard agent has not been demonstrated.
2. The current PBNSF design has not been demonstrated to be able to neutralize the arsenical fills in some of the German Traktor rockets (GTRs).
3. While the Army has determined that the building design is consistent with Army safety regulations, its inability to withstand the maximum credible event (MCE) seems inconsistent with the congressional mandate to provide "maximum protection for the environment, the general public, and the personnel who are involved in the destruction of the lethal chemical agents and munitions."[1]

The committee has additional reservations regarding the complexity, safety, and robustness of PBNSF, as described below.

Complexity

The current PBNSF design employs complex prototype equipment inherited from the discontinued non-stockpile Munitions Management Device (MMD) program and the stockpile Assembled Chemical Weapons Assessment (ACWA) program. Although the equipment is functional, many modifications have been required to create an integrated system for PBNSF. As an example, the auxiliary processing vessel (APV) employed in the explosive containment chamber (ECC) uses a remotely operated, hollow drill that is designed to drill access holes into the munition and then drain the contents. The APV is currently being considered for modification by retrofitting a high-temperature water injection system to flush out the solidified mustard agent that is expected to be found in some recovered 4.2-in. mortar rounds.[2] In the opinion of the committee, increasing the complexity of the equipment in such a manner is likely to

[1]50 U.S.C. Section 1521(c)(1)(A), "Maximum protection for the environment," is discussed in Appendix D of *Review of the Army Non-Stockpile Chemical Materiel: Disposal of Chemical Agent Identification Sets* (NRC, 1999).

[2]Meeting between members of the committee and National Research Council staff, the Army, and Stone & Webster, Boston, May 21–22, 2003.

require excessive equipment maintenance and to delay the schedule.

Safety

The complexity of the current PBNSF processing sequence (drill and drain with washout, cut and washout, heel dissolving, metals washing, detonation chamber (DET), chemical neutralization) and its associated equipment leads to concerns about worker safety. The number of munition processing and handling steps and the need for on-the-spot choices of alternative processing modes are the basis for these concerns. The current design requires handling and moving each munition from one process station to another. As an example, an explosively configured 4.2-in. mortar round will be drilled in the ECC. If it contains solidified agent, an attempt will be made to wash it out with a water injector. It will then be transferred to the heel-dissolving tank for an overnight soak and then to the DET for final destruction of the energetics in the munition body and any remaining undrained agent (U.S. Army, 2002b). In the EDS, all operations, including neutralization of the chemical agent, are done in the EDS chamber with no potential for exposure of personnel between steps. The only handling step when using the EDS is to place the munition(s), which have been prepared for EDS processing by being placed in a fragment suppression system, into the EDS unit. All munition accessing, chemical neutralization, and explosive destruction operations are accomplished without handling the munition.

Making operational decisions during processing at PBNSF may often be difficult and require judgment calls on the part of the operating management. For example, if the interior of a 4.2-in. mortar round could not be completely cleaned in the heel-dissolving tank, a decision would have to be made between cutting open the munition in a projectile washout system (PWS) within an explosion containment enclosure or detonating it in the DET. In either case, detonation, whether accidental or intentional, risks contaminating a piece of equipment that will be difficult to clean properly, especially by workers in Level A personnel protective equipment. In contrast, the EDS processing procedure is the same for every munition and tolerates great variations in condition of the munitions.

Robustness

In the judgment of the committee, the current PBNSF processing procedure appears less capable of dealing with unexpected variations in munition type and condition than the EDS. For example, a mischaracterized munition could cause serious problems in the ECC or PWS operations, where there is more manual handling, and the processing steps are more variable than in the EDS. In addition, the current MMD-derived process appears to be vulnerable to unplanned detonations. For example, although the APV is housed in an ECC to protect workers in the event of accidental detonation while processing an explosively configured munition, such an event would probably severely damage the APV, resulting in lengthy schedule delays.

An additional impetus for considering a multi-EDS alternative in preference to the currently designed PBNSF arises from the fact that the latter employs equipment and processes from the abandoned MMD-1 and MMD-2 projects (U.S. Army, 2003f). As indicated in an earlier National Research Council report (NRC, 2001b), the MMD projects experienced numerous delays due to frequent equipment and process modifications as well as many regulator-imposed permit changes. Although the PBNSF design includes some non-MMD equipment such as the PWS (from the ACWA program) and has improved the MMD components, it is still conceptually much like MMD-2. The committee's concern is that the need for continuing equipment, process, and permit modifications could recur in the PBNSF program. The committee notes that the Army canceled the MMD program in 2000, citing in its press release the success of the EDS program (U.S. Army, 2001b).

For the reasons above, the committee concludes that although PBNSF can successfully process the non-stockpile munitions stored at PBA, there are significant potential weaknesses and unresolved issues in its current design. Processing of RCWM in the EDS overcomes most of these problems. The relative merits of PBNSF and the multi-EDS alternatives are compared in Table 6-1. The EDS alternative increases reliability and reduces schedule risks due to equipment failure.

POTENTIAL EDS-BASED SYSTEMS

The EDS has been used successfully to destroy non-stockpile munitions similar to the PBA inventory in operations at Porton Down (U.K.); Spring Valley, Washington, D.C.; Camp Sibert, Alabama; and Rocky Mountain Arsenal, Colorado.[3] To date, the committee is aware of the destruction of 86 munitions and chemical agent containers in testing and use of the EDS. This experience is summarized in Table 6-2.

Two or three EDS units can perform most if not all of the tasks currently planned for PBNSF. (Under one scenario, a larger EDS—the EDS-2—could also perform most if not all the tasks envisioned for PBNSF.) The committee considered two options by which EDS systems could resolve some of the problems of the current PBNSF design. Both options assume that EDS units can be made available in a timely manner for use in destroying non-stockpile materials intended for PBNSF.

[3]William Brankowitz, Deputy Product Manager, Non-Stockpile Chemical Materiel Product (NSCMP), "Non-Stockpile Chemical Materiel Product Program Status Update," briefing to the committee on June 12, 2003.

TABLE 6-1 Detailed Comparison of PBNSF and Multi-EDS Options

Issue	PBNSF[a]	Option 1: Multiple EDS[b]	Option 2: PBNSF + Multiple EDS[c]
Safety	Pro Not applicable.	Pro 1. Minimizes handling of munitions (one handling per munition-loading into EDS). 2. Disposal of munitions can begin immediately after characterization instead of being put back into storage. 3. Significantly reduces risk to personnel in comparison with PBNSF.	Pro 1. GTR warhead and energetic combined can be handled in ECC-2.
	Con 1. Multiple handling activities (average of five) for each munition before final disposal. 2. Current design does not provide for building to contain release from MCE.	Con 1. GTR warhead and energetic combined cannot be handled in EDS.	Con 1. Multiple handling activities (average of five) for each munition before final disposal. 2. Current design does not provide for building to contain release from MCE.
Risk of failure to achieve CWC date (April 2007)	Pro Not applicable.	Pro 1. Low (if multiple rounds can be processed in EDS). 2. No major design issues. 3. No construction schedule issues. 4. EDS is proven to be a robust system on actual non-stockpile disposal projects. 5. Significantly reduces risk of failing to achieve CWC 2007 date.	Pro 1. No major design issues for EDS. 2. Has better chance of achieving CWC deadline than PBNSF option due to use of multiple EDS units.
	Con 1. High due to outstanding design issues (see below). 2. Unrealistically short construction schedule. 3. Lack of robustness of the ECC-1 and ECC-2 (cannot withstand an accidental detonation without serious damage).	Con Not applicable.	Con 1. Unrealistically short construction schedule. 2. Requires retention of the CPT, heel-dissolving tanks, the DET, and an MDU. 3. Lack of robustness of the ECC-2 (cannot withstand an accidental detonation without serious damage).
Cost	Pro 1. Some items already purchased	Pro 1. Costs for EDS units already assigned. 2. No large building required and no significant equipment purchase or installation costs. 3. Personnel costs significantly lower. 4. Minimum closure costs. 5. EDS units can be used at other sites. 6. Significantly reduces cost of destroying inventory at Pine Bluff. 7. Significantly reduces cost of destroying inventory at other sites as EDS units can be moved and reused.	Pro 1. EDS and ECC-2 already purchased. 2. PWS does not need to be developed and ECC-1 is not required.

Cost (cont.)	Con 1. High cost associated with constructing building; purchasing computer control, instrumentation, monitoring equipment, heating, ventilation, and air conditioning (HVAC), etc.; recruiting, installing, and training personnel; and operations and closure. 2. PBNSF facility cannot be used for destruction of inventory at other sites.	Con Not applicable.	Con 1. High cost associated with constructing building, purchasing computer control, instrumentation, monitoring equipment, HVAC, etc.; recruiting, installing, and training personnel; and operations and closure. 2. PBNSF facility cannot be used for destruction of inventory at other sites.
Personnel	Pro Not applicable.	Pro 1. Fewer staff than PBNSF. 2. Lower overall level of training required.	Pro Not applicable.
	Con 1. Large operational staff required. 2. Significant amount of training. 3. Large associated costs.	Con Not applicable.	Con 1. Large operational staff required. 2. Significant amount of training. 3. Large associated costs.
Complexity	Pro Not applicable.	Pro 1. Simple system. 2. Significantly reduces complexity of destroying inventory at Pine Bluff.	Pro Not applicable.
	Con 1. Highly complex system (control systems, instrumentation, HVAC, ECC, CPT, etc.).	Con Not applicable.	Con 1. Highly complex system (control systems, instrumentation, HVAC, ECC, CPT, etc.).
Robustness[d]	Pro Not applicable.	Pro 1. EDS units are very robust. 2. Significantly increases the overall robustness of the process/system for destroying inventory at Pine Bluff.	Pro 1. EDS units are very robust.
	Con 1. Several equipment items (ECC, CPT, air monitoring, etc.) are known to be designs that have included compromises or have a history of problems. 2. ECC-1 and ECC-2 are not able to withstand an accidental detonation without serious damage.	Con Not applicable.	Con 1. Several equipment items (ECC, CPT, air monitoring, etc.) are known to be designs that have included compromises or have a history of problems. 2. ECC-2 is not able to withstand an accidental detonation without serious damage.
Generation of secondary waste	Pro Not applicable.	Pro 1. EDS units and containment shelters should generate much less carbon filter material for disposal than PBNSF. 2. EDS units generate smaller amounts of liquid secondary wastes.	Pro 1. EDS units and containment shelters should generate much less carbon filter material for disposal than PBNSF. 2. EDS units generate smaller amounts of liquid secondary wastes.

continued

TABLE 6-1 Continued

Issue	PBNSF[a]	Option 1: Multiple EDS[b]	Option 2: PBNSF + Multiple EDS[c]
Generation of secondary waste (cont.)	Con 1. Will generate much more neutralent and carbon filter material than Option 1 and more than Option 2. 2. Neutralization chemistry system for arsenical reagents found in some GTRs must be developed.	Con 1. Neutralization chemistry system for arsenical reagents found in some GTRs must be developed.	1. Will generate more neutralent and carbon filter material than Option 1. 2. Neutralization chemistry system for arsenical reagents found in some GTRs must be developed.
Environmental permitting	Pro 1. Permit documentation has already been prepared and submitted and is under review by the Arkansas Department of Environmental Quality. Con 1. Likely need for numerous permit modifications, which may cause delays and jeopardize ability to meet the CWC schedule.	Pro 1. Use of an EDS-only option would likely result in far fewer permit modifications. 2. The EDS has been permitted previously. Con 1. The effort to withdraw the existing permit application and begin processing a new one is substantial.	Pro 1. Use of an EDS for most of the munitions at PBNSF will help reduce the need for permit modifications. Con 1. The permit application would increase in size and complexity, and processing time would increase as well.
Public acceptability	Pro Not applicable. Con Not applicable.	Pro 1. Multiple-EDS likely to be preferable because technology is fully transportable and generates less secondary waste. Con Not applicable.	Pro Not applicable. Con Not applicable.
Issues to be resolved	1. Is GTR agent covered by CWC? 2. How can the ECC be modified for washout of solidified mustard? 3. How can the arsenical agents in approximately 40% of GTR be neutralized? 4. Design basis for building does not contain MCE. 5. Access issues and piping design issues in the CPT. 6. How can gelled or solidified mustard rounds be handled? 7. Can GTR energetic/warhead be disassembled safely? 8. Final design of munitions processing equipment (ECC, PWS).	1. Is GTR agent covered by CWC? 2. How can the arsenical agents in approximately 40% of GTR be neutralized? 3. Can GTR warhead/energetic be disassembled so that EDS can be used for all items? 4. When can EDS units be online? 5. How many munitions can EDS process at one time? 6. Can the permit be modified without public concern/delay?	1. Is GTR agent covered by CWC? 2. How can the ECC be modified for washout of solidified mustard? 3. How can the arsenical agents in approximately 40% of GTR be neutralized? 4. Design basis for building does not contain MCE. 5. Access issues and piping design issues in the CPT. 6. When can EDS units be online? 7. Can permit be modified without public concern/delay?

[a]PBNSF: ECC-1, ECC-2, PWS, heel-dissolving tanks, DET, MDU, and CPT; no EDS units.
[b]Option 1: Uses multiple EDS units only; eliminates ECC-1, ECC-2, PWS, heel-dissolving tanks, DET, MDU, and CPT.
[c]Option 2: Uses multiple EDS units in lieu of the PWS and ECC-1; retains ECC-2, heel-dissolving tanks, DET, MDU, and CPT for processing 31 complete GTRs.
[d]The committee defines "robustness" as the ability to operate reliably over time under a variety of conditions and with a variety of inputs.

TABLE 6-2 Usage Data for the EDS

Site	Month/Year	Usage
Porton Down, U.K. Phase 1 tests	November 1999-November 2000	4 cylinders and 7 mortars containing CG 2 cylinders, 7 4.2-in. mortars, and 5 4.5-in. projectiles containing HD 1 cylinder containing GB
Rocky Mountain Arsenal, Colorado	2001	10 M139 bomblets
Former Camp Silbert, Gadsden, Alabama	August 2002	1 CG-filled 4.2-in. mortar round
Spring Valley, Washington, D.C.	May-June 2003	15 75-mm artillery rounds containing HD
Porton Down, U.K. Phase 2 tests	2003	Single-shot tests 4 4.2-in mortar rounds containing HD 3 DOT bottles containing GB Multiple-shot tests 2 tests, each consisting of 3 stokes mortar rounds containing CG 4 tests, each consisting of 3 British 25-lb artillery projectiles containing HD 3 tests, each consisting of 3 DOT bottles containing HD

NOTE: The EDS was cleaned and rinsed after each shot in each test and the committee is unaware of any unusual or unexpected maintenance activities that may have occurred. Following the destruction of the bomblets at Rocky Mountain Arsenal, the test report stated: "There were no injuries or first aid cases reported for this project." Also, none were reported in the test report issued following the completion of EDS Phase 1 testing at Porton Down. The committee has not reviewed any other reports issued following EDS testing and use and is not aware of any injuries or safety incidents that may have taken place (U.S. Army, 2001c).

Option 1

Option 1 would eliminate all of the currently designed processing equipment (ECC-1, ECC-2, PWS, heel-dissolving tanks, DET, metal decontamination units (MDUs), and the chemical process trailer (CPT)) from PBNSF. In its place, multiple EDS units could be used to dispose of the non-stockpile inventory at PBA (with the exception of 31 GTRs whose propellant contents exceed the explosive containment capacity of the EDS-2). If it is possible to remove the rocket motors (including propellant) from these GTRs, EDS-2 systems can be used to dispose of the entire PBA inventory. The calculations by which this conclusion was reached are provided in Appendix C. In addition to the factors cited above, a major advantage of the EDS technology over the current PBNSF design is that it is a well-proven system. Complete elimination of the currently designed PBNSF processing equipment could eliminate much manual handling, reduce exposure potential for workers, save much of the anticipated equipment modification cost, and reduce or eliminate the cost of a permanent building. The integration of agent accessing and neutralization operations within the EDS unit would greatly simplify the agent monitoring requirements for the munitions destruction process.

Option 2

Option 2 would replace the PWS and the ECC-1 with EDS units but retain the ECC-2 for processing the 31 complete GTRs with propellant-filled rocket motors in the event that the motors cannot be removed from the warheads safely. The ECC-2 would be needed to process the complete GTRs because the total net explosive weight of the GTR, including propellant, exceeds the containment capacity of both EDS systems. Retention of the ECC-2 requires retention of several auxiliary facilities, including the CPT, a heel-dissolving tank, the DET, and an MDU. The Army is evaluating options akin to Option 2 in which an EDS unit would be used in addition to PBNSF to ensure destruction of the PBA inventory of RCWM by April 2007.

Factors for Consideration

Both Options 1 and 2 would involve modification of the current plan for a building to house PBNSF. In Option 2, which retains the ECC-2 and its supporting facilities, most aspects of the building would be retained. In Option 1, it might be possible to house the EDS units in low-cost, temporary containment shelters, as was done for the Spring Valley, Washington, D.C., non-stockpile disposal project completed in 2003. Buildings to house administrative and laboratory facilities would also be needed, but they need not be permanent. The temporary shelters for the EDS units might retain their usefulness after conclusion of the PBA activities because they could be moved to other locations along with the EDS units that they enclose.

FACTORS IN IMPLEMENTING A MULTIPLE-EDS DESIGN

Need for Early Decisions and Testing

The Army is committed to completing destruction of the PBA non-stockpile inventory by the CWC deadline of April 29, 2007. Meeting this deadline using the current PBNSF design will be challenging. Starting over with a new conceptual approach based on the EDS system also presents schedule risk, but this risk might be offset by the advantages of using a relatively simple, well-proven system. For an EDS approach to succeed, several key tests and decisions must be made soon:

Validation of Concept

Some key assumptions about the utility of the EDS equipment need to be evaluated. Two of the most critical issues are (1) EDS productivity, i.e., whether an EDS can destroy more than one munition at a time, and (2) EDS capability, i.e., whether the GTR warheads can be safely separated from the propellant-containing rocket motors.

EDS productivity. To calculate the number of EDS units required to destroy the 4.2-in. mortars and GTRs, the throughputs of the EDS units need to be established. Current tests at Porton Down suggest that the EDS-2 unit can process at least three mortar rounds per detonation.[4]

Tests to establish whether the EDS-2 can treat six or nine rounds at a time are to be conducted in late 2003, when the EDS-2 unit is returned to the Aberdeen Proving Ground.[5] If multiround capability is verified and does not entail problems in neutralization and subsequent secondary waste treatment and disposal, the number of EDS units required to destroy the munitions within the available time window could be reduced significantly. Additional testing is needed to establish the following points:

- Can the EDS-1 successfully destroy three rounds in a single shot? The EDS-1 units on hand can handle the explosive load from detonation of three 4.2-in. mortars, but the physical arrangements in the EDS chamber need to be worked out.[6]
- Does the destruction of multiple rounds per shot entail greater quantities of neutralizing reagent or a longer neutralization time? Preliminary results from the multiround tests at Porton Down indicate that the amount of neutralent per munition treated is substantially less than in single-round shots.[7] Indeed, there may be a significant reduction in the amount of liquid secondary wastes when multiround processing in the EDS is used rather than operations in PBNSF. Confirmation of this by tests at Aberdeen Proving Ground would be a significant advantage for the multi-EDS concept.
- Does the multiround strategy cause any problems in waste treatment or disposal? The EDS units and the EDS containment shelters should generate much less carbon filter material for disposal than would the proposed PBNSF building system (cf. Chapter 4). A chemical neutralization system for arsenical reagents found in some GTRs must still be developed for either a multi-EDS approach or the currently proposed PBNSF design.

EDS capability. A critical question is whether GTR motors can be separated from their warheads safely. The Army is currently studying this question. If the separation can be effected, the warheads of the 31 GTRs containing propellant-filled motors can be processed in an EDS-2 unit. This finding would confirm that all the non-stockpile munitions under consideration for PBNSF could be destroyed in EDS units (Option 1 above). The ECC-2 and attendant processing facilities would not be required.

Availability of Explosive Destruction System Units

The number of EDS units that would need to be operated concurrently to meet the April 2007 deadline would be based on the effective capacity of an EDS unit and on the anticipated operational schedule. This will determine whether additional EDS units must be procured beyond the three[8] EDS-1 units and the single EDS-2 unit now existing, and if so, when. Based on the schedule and capacity information given by the Army and summarized in Appendix C, two of the three EDS-1 units and the one EDS-2 unit, all now existing

[4]Laurence Gottschalk, NSCMP, "Non-Stockpile Chemical Material Product Explosive Destruction System - Phase 2 Unit 1 United Kingdom Testing Update," briefing to the committee on June 12, 2003.

[5]Laurence Gottschalk, NSCMP, "Non-Stockpile Chemical Material Product Explosive Destruction System - Phase 2 Unit 1 United Kingdom Testing Update," briefing to the committee on June 12, 2003.

[6]John Gieseking, NSCMP, "Multi-Round Testing with EDS PII," briefing to the committee on July 31, 2003.

[7]Laurence Gottschalk, NSCMP, "Non-Stockpile Chemical Material Product Explosive Destruction System - Phase 2 Unit 1 United Kingdom Testing Update," briefing to the committee on June 12, 2003.

[8]One of the three EDS-1 units is to be stationed at Aberdeen Proving Ground for deployment to other sites as necessary, so it is not included in schedule calculations for disposal operations at PBNSF.

and planned for Pine Bluff, should be sufficient.[9] A significant factor is when the EDS-1 unit currently planned for handling sensitive munitions with Pine Bluff munitions assessment system (PBMAS) could begin routine processing of munitions rather than just unstable mortars and rockets. Offsetting that need is that the "sensitive" munitions handled for PBMAS will commensurately decrease the inventory to be routinely handled in the PBNSF facility, and that the Army is developing increased processing capacity for the EDS-1 and 2 units.

Buildings Needed for Explosive Destruction System Units

In previous deployments—for example, at Spring Valley—an EDS was housed in a temporary containment shelter. If EDS units were to replace the PBNSF processing equipment, the Army must decide whether they will be housed in similar temporary buildings and what sort of administrative and laboratory facilities might be needed, including a choice between a permanent building and trailers.

Schedule Factors

The committee considered the impact on the schedule of changing to a multi-EDS design. Although the primary concerns of the committee were reliability, safety, simplicity, and life-cycle costs, neither the Army nor the committee can ignore the fact that the United States is obligated to destroy its chemical weapons by April 2007 (if no extension is requested). The implementing United States legislation requires that the Army attain that schedule.

Thus, the committee evaluated whether a significant change in the conceptual approach at this relatively late date in the facility design might result in failure to meet the April 2007 CWC deadline. Such a failure could result from technical difficulty in implementing the revised design approach (including integration or operational issues), from a longer regulatory approval process due to the change in design, or from public opposition.

Interplay of Schedule and Technical Factors

Current plans for destruction of 4.2-in. mortar rounds and GTRs in PBNSF require completion of destruction operations during a 10-month period beginning June 1, 2006.[10] Achievement of this starting date requires that design, permitting, construction, and systemization of PBNSF adhere to a tight schedule. The anticipated high productivity of the ECC units (five rounds per day in each of the two planned units) and the PWS unit (ten rounds per day) should permit completion of the tasks within 10 months if there are no delays due to unforeseen technical or other problems.[11] The committee is concerned that the complexity of the PBNSF processing is likely to cause just such problems.

Implementing either of the two multi-EDS options to attain the April 2007 CWC deadline also depends critically on when munitions processing begins. Under current plans, one EDS-1 unit will be placed adjacent to the PBMAS facility to destroy unstable munitions promptly instead of sending them to PBNSF (U.S. Army, 2003f). If regulatory and safety approvals allow this EDS to also be used for routine mortar destruction, it could contribute significantly to reducing the non-stockpile inventory intended for PBNSF. However, the EDS-1 alone could not destroy all the mortar rounds before April 29, 2007, if operated on a one-round-per-shot basis.

As stated earlier, it is critical to meeting the schedule that three or more rounds be destroyed in each EDS operational cycle. The Army believes that it would not be possible to begin EDS processing of mortar rounds on a three-per-shot basis before December 31, 2004. If the PBMAS EDS-1 unit were to be used routinely to destroy RCWM intended for PBNSF instead of just unstable munitions, it would have 28 months of operating availability (1/1/05-4/29/07). During this time, it could reasonably process all 732 4.2-in. mortars using a single-shift schedule with three rounds destroyed per shot.[12] The schedule implications of several EDS-based operational modes are outlined in Appendix C.

Destroying the 38 GTR warheads and 439 complete GTRs (including 31 with propellant in the motors) is included in the currently planned PBNSF operating schedule. The EDS-based approach can also handle the GTRs except for the 31 with live rocket motors containing propellant. Option 2, which retains the ECC-2 unit, is included in the proposal for an EDS alternative concept to address the latter situation. The EDS-2 unit, which is larger than the EDS-1, can accommodate the physical dimensions of the complete GTRs but cannot accommodate the amount of explosive potential in the rockets containing propellant.[13] If Army studies indicate that the live rocket motors containing propellant can be separated from the GTR warheads safely, one

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[9]As of July 2003, the Product Manager for Non-Stockpile Chemical Materiel planned to order three more EDS-2 units in the FY06-07 timeframe (two in FY06 and one in FY07) (Darryl Palmer, personal communication to the committee on July 10, 2003). The committee anticipates that, if required, this number should be more than sufficient to dispose of the 31 GTR warheads that are separated from the motors plus the number of stand-alone GTR warheads that contain agent.

[10]William Brankowitz, Deputy Product Manager, NSCMP, "Non-Stockpile Chemical Materiel Product Program Status Update," briefing to the committee on June 12, 2003.

[11]George East, Task Manager, Stone & Webster, Inc., "Non-Stockpile Chemical Materiel Product PBNSF Munitions Processing Update," briefing to the committee on June 12, 2003.

[12]Based on the following assumptions: 10 weeks for systemization; operating 40 weeks per full year or 82 weeks total, with three three-rounds-per-shot per week.

[13]Laurence Gottschalk, NSCMP, "Non-Stockpile Chemical Material Product Explosive Destruction System - Phase 2 Unit 1 United Kingdom Testing Update," briefing to the committee on June 12, 2003.

or two EDS-2 units can destroy the GTR inventory within the time allocated.

Regulatory Aspects

Several factors that must be considered in determining whether EDS units in addition to the one associated with PBMAS units should be employed in place of the current PBNSF design derive from environmental requirements, including the Resource Conservation and Recovery Act (RCRA) and air emissions permitting, as well as the National Environmental Policy Act (NEPA).[14] Much time and effort have been spent by the Army in preparing the current permit applications, which include both the PBNSF permit application and the permit application for the EDS unit that will be used in conjunction with the operation of PBMAS, and by the Arkansas Department of Environmental Quality in reviewing them. Switching to a multiple-EDS approach for PBNSF operations would necessitate an additional permitting effort and might jeopardize the Army's CWC schedule obligations. However, the permit application documentation already existing for the EDS unit associated with the PBMAS (U.S. Army, 2003f) could be used as a basis for changes toward a multiple-EDS approach for PBNSF, thus limiting the additional effort that will be needed. In addition, because the use of multiple EDSs is a simpler approach than the current PBNSF design, permit application revisions and resulting permit documentation are likely to be not as long or complex. The committee also expects that the frequency of permit modifications during the life of the permit would be significantly reduced if a multi-EDS approach were implemented for PBNSF operations. Closure of the EDS units would also be simpler. Additional advantages of the multi-EDS approach are that the EDS has already received regulatory approvals from the Environmental Protection Agency and from Alabama, Colorado, and the District of Columbia and that it has a good track record.

Another factor is whether new or revised environmental assessment documentation would need to be prepared and offered for public comment to satisfy NEPA. Preparing additional NEPA documentation and coordinating decisions considering public comment would entail additional time and effort. Whether additional or replacement environmental assessments would be needed is uncertain, however, since the Army has issued assessments that discuss both PBNSF and PBMAS EDS operations. This matter will no doubt need to be evaluated carefully by the Army. The committee believes that the public should be involved in this decision.

Considering the above, from a permitting and NEPA standpoint, there are reasons why a multi-EDS approach should be considered further. While the regulatory permitting concerns associated with switching to another approach do pose some disadvantages, the advantages are significant. Permitting concerns are of less importance in this instance, and the decision on whether to consider the multi-EDS approach further for PBNSF operations should be based on the merit of the approach.

If a multi-EDS approach is considered, either of two permitting options could be pursued. The permit application now being processed for the single-unit EDS that will be used in conjunction with operations at PBMAS could be changed, or the current PBNSF permit application could be changed. With either approach, it is conceivable that multi-EDS operations could be combined under one permit. However, it must be recognized that the PBMAS EDS permit would pertain to fuzed munitions that need to be dealt with expeditiously. While there are many similarities, using multi-EDS devices to routinely destroy non-stockpile materiel at PBNSF would entail a different mode of operation. The amount of non-stockpile munitions that would be processed routinely, for example, is likely to be substantially higher at PBNSF than the amount that would be processed in the PBMAS EDS. In addition, the operation of the EDS at PBMAS is expected to be completed far sooner than would be required for processing the remaining Pine Bluff non-stockpile inventory at PBNSF. Perhaps equally important, the PBMAS EDS unit is in a different physical location from the PBNSF EDS units. There are enough differences between the operational uses of the PBMAS EDS unit and the PBNSF EDS unit to warrant a separate permitting approach.

This does not necessarily mean that separate permits are required for these operations. A 2002 National Research Council report recommended the use of alternative RCRA regulatory approval mechanisms when mobile treatment systems or technologies are employed, particularly for small or even moderate quantities of newly discovered non-stockpile chemical warfare materiel (NRC, 2002a). One such alternative mechanism is the RCRA emergency permit. This regulatory approval mechanism was discussed at length in that report. The committee believes that considering the short-lived campaign planned for the PBMAS EDS unit, use of a RCRA emergency permit would be a viable, if not preferable, alternative approach.

Public Acceptance

While community preference is in itself not a sufficient reason to switch technologies midway in the PBNSF development process, community opposition could easily derail an Army proposal to replace the current PBNSF design with multiple EDSs. Through either political or legal action, opponents could delay and perhaps prevent such a change. In this case, however, all evidence suggests that both the Pine Bluff community and the national activist public that follows chemical weapons disposal would welcome an EDS-based facility.

[14]Environmental permitting and other requirements are reviewed more completely in Chapter 5.

For example, in urban Washington, D.C., members of the Spring Valley Restoration Advisory Board, as well as residents at large, appeared to support the use of the EDS to dispose of recovered munitions similar to those found at Pine Bluff. Reportedly, residents preferred the EDS to off-site transportation, both before and after the Army destroyed fifteen 75-mm shells containing HD in June 2003 (U.S. Army, 2003m). Similarly, at Rocky Mountain Arsenal, the community supported the use of the EDS to dispose of several M139 GB bomblets in 2001.[15]

The Chemical Weapons Working Group (a national citizen group with a record of opposition to the use of incineration technology that reviews and comments on the U.S. chemical weapons destruction program) applauded the Army's development of the EDS as a safer approach for dealing with non-stockpile weapons (Williams, 2003).

Pine Bluff residents, local newspapers, and the local member of Congress have repeatedly expressed a strong preference that Pine Bluff not become the national dumping ground for recovered chemical weapons. While there is no evidence that the Army has sent or intends to send large numbers of non-stockpile materiel to Pine Bluff, the fear that this could occur should be considered in the Army's decisions. As a result, some Pine Bluff residents have expressed support for transportable systems over fixed facilities. If the Army modified its design to include more extensive use of the EDS technology rather than a fixed facility, the committee anticipates that there would be community support because it would probably reassure them that when munitions are recovered elsewhere in the future, the disposal equipment will be moved to the recovery site rather than bringing the munitions to Pine Bluff.

If the Army decides to consider a multi-EDS option, it should quickly prepare explanatory material and organize a community meeting in Pine Bluff, both to explain the potential of such a change and to let the community express its preferences and concerns.

Cost Factors

Except for the $19.0 million estimate for the cost of constructing the "bare" PBNSF building (i.e., without the equipment, piping, instrumentation), the committee has not had access to capital or operating cost data for either the PBNSF or the EDS equipment because it is procurement-sensitive information and not publicly available (U.S. Army, 2002f). Hence, any comparison of costs is qualitative rather than quantitative. Several aspects of a multi-EDS operation seem likely to be less expensive than the PBNSF as currently designed.

A multi-EDS operation would not need a building designed to withstand the currently projected MCE because the EDS is designed to contain such an event once the munition is placed within it.[16] Whether the Army chooses to use trailers or a fixed structure to house laboratory and other support personnel during operations, the cost of the support structures should be much less than $19.0 million.

The multi-EDS approach should yield significant savings in personnel-related operating expenses. From systemization through operations to closure, the simplicity and reliability of the EDS units should reduce long-term personnel costs. Because the EDS units are similar and have operated reliably under widely varying circumstances, systemization operations can be expected to be shorter, with savings in both schedule and cost. The commonality of the units would facilitate maintenance once routine operations begin. Training of operating crews would be simpler, and the destruction operations might require fewer personnel. At the end of operations, closure might be simplified if there is no permanent structure to decontaminate.

It is the committee's judgment that the multi-EDS approach is more likely to meet the mandated destruction schedule and to reduce the risk of delay-associated costs. A useful perspective on the relative costs of the multi-EDS concept and the current PBNSF design is that the multi-EDS concept, at most, accelerates the acquisition of EDS units already planned for the non-stockpile program. These mobile EDS units should be useful for destroying non-stockpile materiel recovered at Army facilities or other locations across the country (e.g., situations similar to Spring Valley in Washington, D.C.). By contrast, the PBNSF equipment would be used for RCWM destruction for less than a year. The PBNSF building itself might have continuing utility, but the equipment it contains is unlikely to be used again.

The relative merits of PBNSF and the multi-EDS alternatives are summarized in Table 6-3.

FINDING AND RECOMMENDATION

Finding 6-1: The current design for the PBNSF, which employs prototype equipment acquired from the non-stockpile MMD and stockpile ACWA programs, may be capable of destroying the entire inventory of 4.2-in. mortars and GTRs at the PBA but for a number of reasons might miss the April 29, 2007, CWC deadline for completion of the task. An alternative concept in which multiple EDS units replace the PBNSF processes appears safer, more reliable, and at least as likely to meet the deadline for destruction.

Recommendation 6-1: The Army should promptly evaluate multi-Explosive Destruction System alternatives for destroy-

[15]Teleconference with Elizabeth Crowe, Non-Stockpile Chemical Weapons Citizens' Committee, July 11, 2003.

[16]The risks involved in transporting a munition to the EDS would be equivalent to those in moving it to the PBNSF. The risks involved in unpacking the munition and loading it into the EDS would be mitigated by use of a containment shelter, as was done at Spring Valley.

TABLE 6-3 Summary Comparison of PBNSF and Multi-EDS Options

Issue	PBNSF[a]	Option 1: Multi-EDS[b]	Option 2: PBNSF + Multi-EDS[c]
Safety	C[d]	A	C
Risk of failure to achieve CWC treaty date (2007)	C	A	B
Cost	C	A	C
Personnel[e]	C	A	C
Complexity	C	A	C
Robustness[f]	C	A	C
Generation of secondary waste	C	A	B
Environmental permitting	B	A	C
Public acceptability	A	A	A
Issues to be resolved	C	B	C

[a]PBNSF: ECC-1, ECC-2, PWS, heel-dissolving tanks, DET, MDU, and CPT; no EDS units.

[b]Option 1: Uses multiple EDS units only; eliminates ECC-1, ECC-2, PWS, heel-dissolving tanks, DET, MDU, and CPT.

[c]Option 2: Uses multiple EDS units in lieu of the PWS and ECC-1; retains ECC-2, heel-dissolving tanks, DET, MDU, and CPT for processing of 31 complete GTRs.

[d]A, best; B, better; C, good. These ratings represent the collective judgment of the committee. Note that the committee has not conducted a poll of Pine Bluff residents and is basing its judgment of public acceptability on public support for transportable technologies and secondary waste reduction.

[e]In evaluating the issue of personnel, the committee considered the total number of site workers and the amount of specialized training required to operate the various systems and options. A system that requires fewer personnel with less specialized training is considered superior to a system that requires more personnel with more specialized training.

[f]The committee defines robustness as the ability to operate reliably over time under a variety of conditions and with a variety of inputs.

ing the Pine Bluff recovered non-stockpile munitions inventory. If the committee's premises are borne out, planning, permitting, and public involvement activities aimed at utilizing existing Explosive Destruction System units should be initiated promptly.

Finally, the committee's proposal for an alternative configuration for PBNSF using multiple EDS units is a consequence of the success of EDS deployments, both technically and with respect to public acceptability, at three non-stockpile sites across the United States. It is also a logical extension of the Army's efforts to enhance the efficacy of EDS units—such as multiround testing—as well as ongoing Army activities aimed at separating GTR warheads from their motors and improving the characterization of the contents of the recovered chemical munitions in storage at Pine Bluff.

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LAWS GOVERNING CHEMICAL DEMILITARIZATION

Treaty

Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction (P.L. 105-277)

Statutes

Chemical Safety Information, Site Security and Fuels Regulatory Relief Act, P.L. 106-40.

Clean Air Act (CAA), 42 U.S.C. §7401 et seq.

Clean Water Act (CWA), 33 U.S.C. §1251 et seq.

Emergency Planning and Community Right to Know Act (EPCRTKA), 42 U.S.C. §11001 et seq.

The National Environmental Policy Act (NEPA), 42 U.S.C. 4321-4347 et seq.

Occupational Health and Safety Act (OSHA), 29 U.S.C. 1920.120 et seq.

Resource Conservation and Recovery Act (RCRA), 42 U.S.C. §6901 et seq.

Toxic Substance Control Act (TSCA), 15 U.S.C. §2601 et seq.

Appendixes

Appendix A

Committee Member Biographical Sketches

JOHN B. CARBERRY, *Chair,* is director of environmental technology for the DuPont Company in Wilmington, Delaware, where he has been employed since 1965. He is responsible for recommendations on technical programs for DuPont based on an analysis of environmental issues. He is also responsible for a team to obtain world class, affordable, publicly acceptable environmental treatment technologies. Since 1988 he has led this function, shifting its emphasis to waste prevention and product stewardship while maintaining excellence in treatment. Mr. Carberry is a fellow of the American Institute of Chemical Engineers, a registered professional engineer, a founding member of the Green Power Market Development Group, a founding member of the Chemical Industry Vision2020 Technology Partnership and chair of its technology committee, and a member of the NAE Committees on Metrics for Evaluating Global Warming Research and Novel Technologies for Sequestering CO_2. He holds an M.S. in chemical engineering from Cornell University and an M.B.A. from the University of Delaware.

RICHARD J. AYEN, *Vice Chair,* who is also a member of the NRC Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons (I and II), received his Ph.D. in chemical engineering from the University of Illinois. Dr. Ayen, now retired, was director of technology for Waste Management, Inc. He managed all aspects of Waste Management's Clemson Technical Center, including treatability studies and demonstrations of technology for the treatment of hazardous and radioactive waste. His experience includes 20 years at Stauffer Chemical Company, where he was manager of the Process Development Department at Stauffer's Eastern Research Center. Dr. Ayen has published extensively in his fields of interest. He has extensive experience in the evaluation and development of new technologies for the treatment of hazardous, radioactive, industrial, and municipal waste.

JUDITH A. BRADBURY, a technical manager at Battelle Pacific Northwest National Laboratory, is experienced in the practice of public involvement and research into this topic. She is currently responsible for public involvement in the seismic study of the Ohio River Valley that is examining the feasibility of carbon sequestration. Dr. Bradbury recently completed an evaluation of public involvement programs across the U.S. Department of Energy (DOE) complex. Before that she completed a series of evaluations of the effectiveness of DOE's 12 site-specific advisory boards and led an assessment of community concerns about incineration and community perspectives on the U.S. Army Chemical Weapons Disposal Program. She earned a B.S. in sociology from the London School of Economics, an M.A. in public affairs from Indiana University of Pennsylvania, and a Ph.D. in public and international affairs from the University of Pittsburgh. She has expertise in public involvement issues.

MARTIN GOLLIN, an independent consultant affiliated with Carmagen Engineering, Inc., has over 20 years of experience in process engineering and management of capital projects, risk assessment, process safety, loss prevention, and product development. From 1988 to 1999 he served as process design manager and principal engineer at ARCO Chemical Co., where he developed the design basis for a catalytic incinerator system that has served as a design model for subsequent plants. He was also EM & S manager for a $1 billion grass-roots project. He earned B.S. and M.S. degrees in chemical engineering from Loughborough University of Technology. Mr. Gollin has expertise in process design and process safety.

FREDERICK T. HARPER is a Distinguished Member of Technical Staff, High Consequence Assessment and Technology Department at Sandia National Laboratories in Albuquerque, New Mexico. He manages and performs research on the effects of chemical and biological releases from explosive and nonexplosive dissemination mechanisms and explosive aerosolization of nuclear materials from nuclear weapons and other nuclear sources. Dr. Harper has served as the U.S. delegate to numerous international and national working groups in the field of probabilistic risk assessment and consequence analysis and developed computer codes for toxicological and radiological consequence assessment and accident progression. Dr. Harper earned a bachelor's degree from Yale University in physics, a master's degree from the University of Virginia in nuclear engineering, and a doctorate, also in nuclear engineering, from the University of New Mexico. He is a member of Tau Beta Pi, the American Physical Society, and the American Nuclear Society.

PAUL F. KAVANAUGH is an engineering and construction management consultant. Previously, he was the director of government programs for Rust International, Inc., and director of strategic planning for Waste Management Environmental Services. In the Army, he served with the Army Corps of Engineers, the Department of Energy, and the Defense Nuclear Agency, and managed projects at the U.S. Army Chemical Demilitarization Program at Johnston Atoll. He earned a B.S. in civil engineering from Norwich University and an M.S. in civil engineering from Oklahoma State University. He is a member of Chi Epsilon, a registered professional engineer, and a fellow in the Society of American Military Engineering. His expertise is in military and civil works design and construction.

TODD A. KIMMELL is principal investigator in the Environmental Assessment Division at Argonne National Laboratory. He is an environmental scientist and policy analyst. Mr. Kimmell is nominated for membership on the committee for his expertise as an environmental regulatory and permitting specialist with 25 years of extensive experience in solid and hazardous waste management, program and policy development, chemical munitions and explosives waste, and cleanup programs as well as in many other activities related to regulatory and permitting issues. He graduated from the George Washington University with a master's degree in environmental science.

DOUGLAS M. MEDVILLE retired from MITRE as program leader for chemical materiel disposal and remediation. He has led many analyses of risk, process engineering, transportation, and alternative disposal technologies and has briefed the public and senior military officials on the results. Mr. Medville led the evaluation of the operational performance of the Army's chemical weapon disposal facility on Johnson Atoll and directed an assessment of the risks, public perceptions, environmental aspects, and logistics of transporting recovered non-stockpile chemical warfare materiel to candidate storage and disposal destinations. Before that, he worked at Franklin Institute Research Laboratories and General Electric. Mr. Medville earned a B.S. in industrial engineering and an M.S. in operations research, both from New York University.

GEORGE W. PARSHALL (NAS) is a consultant for E.I. Du Pont de Nemours & Company, having retired from there in 1992 after a career at the company spanning nearly 40 years. From 1979, he served as director of chemical science in Central Research and Development. Dr. Parshall is a past member of the NRC Board on Chemical Science and Technology and has taken part in earlier NRC chemical demilitarization studies. He continues to play an active role in National Research Council activities. He graduated from the University of Illinois with a Ph.D. in organic chemistry. His experience is in organic and inorganic chemistry and catalysis and in conducting and supervising chemical research.

JAMES P. PASTORICK is president of Geophex UXO, Ltd., an unexploded ordnance (UXO) consulting firm based in Alexandria, Virginia, that specializes in UXO planning and management consulting to state and foreign governments. Since he retired from the U.S. Navy as an explosives ordnance disposal officer and diver in 1989, he has been working on civilian UXO clearance projects. Prior to starting his present company, he was the senior project manager for UXO projects at UXB International, Inc., and the IT Group. He is an unexploded ordnance technician with over 17 years of experience in explosive ordnance disposal. Mr. Pastorick is a member of the UXO Working Group of the Interstate Technology Regulatory Council and has been responsible for management and supervision of numerous projects concerning investigation and remediation of sites contaminated with unexploded ordnance. His expertise is in explosive ordnance handling, transport, disassembly, and disposal.

LEONARD M. SIEGEL is director of the Center for Public Environmental Oversight, Mountain View, California, an advocate of public participation in the oversight of military environmental programs and federal facilities cleanup and revitalization and a project of the Tides Center. He is one of the environmental movement's leading experts on military base contamination and serves on the National Environmental Justice Advisory Council Federal Facilities Working Group, the U.S. EPA's Negotiated Rulemaking Committee on All Appropriate Inquiry, and the Moffett Field Restoration Advisory Board. He has served on the Defense Science Board Task Force on Unexploded Ordnance, the Federal Facilities Environmental Restoration Dialogue Committee, and the Subcommittee on Waste and Facility Siting of the National Environmental Justice Advisory Committee. Mr. Siegel edits *Citizens Report on the Military and the Environment*, and his organization conducts an Internet forum on military environmental issues.

WILLIAM J. WALSH is an attorney in the Washington, D.C., office of Pepper Hamilton LLP and was made partner in 1989. Prior to joining Pepper, he was section chief in the EPA Office of Enforcement. His legal experience encompasses environmental advice and environmental injury litigation on a broad spectrum of issues pursuant to a variety of environmental statutes, including the Resources Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act (TSCA). He represents trade associations, including the American Dental Association and the Rubber Manufacturers Association, in rule making and other public policy advocacy; represents individual companies in environmental actions (particularly in negotiating cost-effective remedies in pollution cases involving water, air, and hazardous waste); and advises technology developers and users on taking advantage of the incentives for, and eliminating the regulatory barriers to, the use of innovative environmental technologies. He previously served on NRC committees concerned with Superfund and RCRA corrective action programs, Navy remediation sites, the use of appropriate scientific groundwater models in environmental regulatory programs, and non-stockpile chemical weapons disposal and related activities. Mr. Walsh holds a J.D. from George Washington University Law School and a B.S. in physics from Manhattan College. His expertise is in environmental and regulatory law.

Appendix B

Committee Meetings and Other Activities

MEETINGS

First Committee Meeting, March 19-20, 2003, Edgewood, Maryland

Product Manager's Overview of Army Non-Stockpile Program
LTC Paul Fletcher, product manager, Non-Stockpile Chemical Materiel Command
William Brankowitz, deputy product manager, Non-Stockpile Chemical Materiel Command

Design Basis of Pine Bluff Non-Stockpile Facility
Jerry Hawks, project engineer, Product Manager for Non-Stockpile Chemical Materiel

NSCM Technology Update
Edward Doyle, group leader NSCWM
Joseph Cardito, project manager, Stone & Webster, Inc.

Wrap-up Discussion
LTC Paul Fletcher, product manager, Non-Stockpile Chemical Materiel Command
William Brankowitz, deputy product manager, Non-Stockpile Chemical Materiel Command

Second Committee Meeting, April 22-23, Aberdeen, Maryland, and Aberdeen Proving Ground, Maryland

Product Manager's Report on Pine Bluff Non-Stockpile Facility
LTC Paul Fletcher, product manager, Non-Stockpile Chemical Materiel Command
William Brankowitz, deputy product manager, Non-Stockpile Chemical Materiel Command

German Traktor Rocket Chemistry
Lucy Forrester, Non-Stockpile Chemical Materiel Command

Pine Bluff Non-Stockpile Facility Discussion
Vivian Graham, Non-Stockpile Chemical Materiel Command
Ed Doyle, Non-Stockpile Chemical Materiel Command

Regulatory and Permitting Issues
William Brankowitz, deputy product manager, Non-Stockpile Chemical Materiel Command

Pine Bluff Non-Stockpile Facility Outreach Plan
Jeff Lindblad, Public Outreach and Information Office

Aberdeen Proving Ground Tour
MAPS Tour
SCANS Presentation
CDTF Tour

Third Committee Meeting, June 11-12, 2003, Washington, D.C.

Non-Stockpile Chemical Materiel Product Program Status Update
William Brankowitz, deputy product manager, Non-Stockpile Chemical Materiel Command

Status Update for Pine Bluff Non-Stockpile Facility
John Gieseking, group leader, Pine Bluff Non-Stockpile Facility

Chemical Process Trailer Piping Update
George East, task manager, Stone & Webster, Inc.

Pine Bluff Non-Stockpile Facility Muntions Processing Update
George East, task manager, Stone & Webster, Inc.

Explosive Destruction System-Phase 2 Unit 1 United Kingdom Testing Update
Allan P. Caplan, group leader, Systems Development/Acquisition Group, Non-Stockpile Chemical Materiel

Fourth Committee Meeting, July 31-August 1, 2003, Woods Hole, Massachusetts

Program Overview
Laurence Gottschalk, site operations team chief, Non-Stockpile Chemical Materiel

German Traktor Rocket Disassembly Options
John Gieseking, group leader, Pine Bluff Non-Stockpile Facility

Multi-Round Testing of the EDS
John Gieseking, group leader, Pine Bluff Non-Stockpile Facility

Comparison of the Munitions Management Device to the Pine Bluff Non-Stockpile Facility
Jerry Hawks, project engineer, Product Manager for Non-Stockpile Chemical Materiel

Regulatory Comparison Munitions Management Device Version 1 and Pine Bluff Non-Stockpile Facility
John Gieseking, group leader, Pine Bluff Non-Stockpile Facility

PBNSF Building Pressure Transient Analysis
George East, task manager, Stone & Webster, Inc.

PBNSF Bounding Challenge to HVAC Filters
George East, task manager, Stone & Webster, Inc.

PBNSF HAZOP Analysis
George East, task manager, Stone & Webster, Inc.

U.S. Army Corps of Engineers Update
Bill Betts, site operations team, Non-Stockpile Chemical Materiel

Summary
Laurence Gottschalk, site operations team chief, Non-Stockpile Chemical Materiel

SITE VISITS

Pine Bluff, March 12-14, 2003

Site team
Judith Bradbury, committee member
Nancy Schulte, study director

Pine Bluff Arsenal, March 26-28, 2003

Site team
Nancy Schulte, study director

Aberdeen Proving Grounds, April 10, 2003

Site team
Martin Gollin, committee member
Douglas Medville, committee member
James Pastorick, committee member
Nancy Schulte, study director

Aberdeen Proving Grounds, May 8, 2003

Site team
John Carberry, committee chairman
Nancy Schulte, study director

Stone & Webster, Inc., May 21-22, 2003

Site team
Martin Gollin, committee member
Douglas Medville, committee member
Nancy Schulte, study director

Aberdeen Proving Grounds, July 8, 2003

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Appendix C

Analysis of the Pine Bluff Non-Stockpile Facility Schedule

ANALYSIS OF SCHEDULE LEADING TO START-UP AND FOR PROCESSING MUNITIONS

Table C-1 shows the major milestones for the design, construction, and operation of the Pine Bluff Non-Stockpile Facility (PBNSF); Figure C-1 illustrates the schedule for their completion.

The processing schedule is based on the following inventory. As information from inspections and other records is reexamined, the numbers may change slightly but not significantly. The inventory consists of the following:[1]

- 730 4.2-in. mortar rounds
- 32 (other) mortar rounds
- 470 German Traktor rockets (GTR), 38 with warhead only, 31 that are full assemblies—that is, they include the rocket motor and propellant
- 9 bombs
- 17 projectiles

The operating plan for PBNSF is based on the following:

- All chemical weapon items are to be processed in the explosive containment chamber (ECC)-1 or ECC-2; all GTRs would be processed in the ECC-2 (U.S. Army, 2003a). However:
  - — Mortars, bombs, and projectiles that are too sensitive for further standard handling will be processed through the EDS-1 or EDS-2 (U.S. Army, 2003b).
  - — The plan is still evolving for processing GTRs containing both a motor and a burster classed as sensitive. GTRs with motors contain too large a load of energetics to process even in the EDS-2.
  - — Items with energetics but no agent fill will instead be processed through the detonation chamber (U.S. Army, 2003a).
  - — Items with no energetics but with agent fill (and those with no energetics and no fill) will instead be processed through the projectile washout system (U.S. Army, 2003a).
- The design basis capacity is 10 rounds per shift (5 rounds per shift per ECC) (U.S. Army, 2003a).
- The operations plan is for one 10-hour shift per day, 5 days per week. Operation at 6 days per week would be a particularly expensive and cumbersome option. The wide range of staff support functions provided through

TABLE C-1 Major Milestones in the Overall PBNSF Schedule

Milestone	Date
Resource Conservation and Recovery Act (RCRA) permit application submitted to the Arkansas Department of Environmental Quality (ADEQ)	March 2003
Facility 65 percent design completion	April 2003
Facility 95 percent design completion	July 2003
Complete facility design package	October 2003
Start-up of Pine Bluff munitions assessment system (PBMAS)	December 2003
Award facility construction contract	February 2004
Receive RCRA permit from the ADEQ	April 2004
Facility construction Notice to Proceed	May 2004
Complete facility construction	August 2005
Complete equipment systemization	May 2006
Start PBNSF processing operations	June 2006
PBNSF processing operations finish[a]	March 2007

[a]Processing operations finish date of March 2007 selected by Army as one month in advance of April 29, 2007, CWC deadline.

SOURCE: J. Hawks, NSCMP, "Pine Bluff Non-Stockpile Chemical Materiel Product," briefing to the committee on March 19, 2003.

[1]Joseph Cardito, Program Manager, Shaw, Stone & Webster, Inc., "Process Design and Equipment Fabrication for PBNSF Overview and Status," briefing to the committee on March 19, 2003.

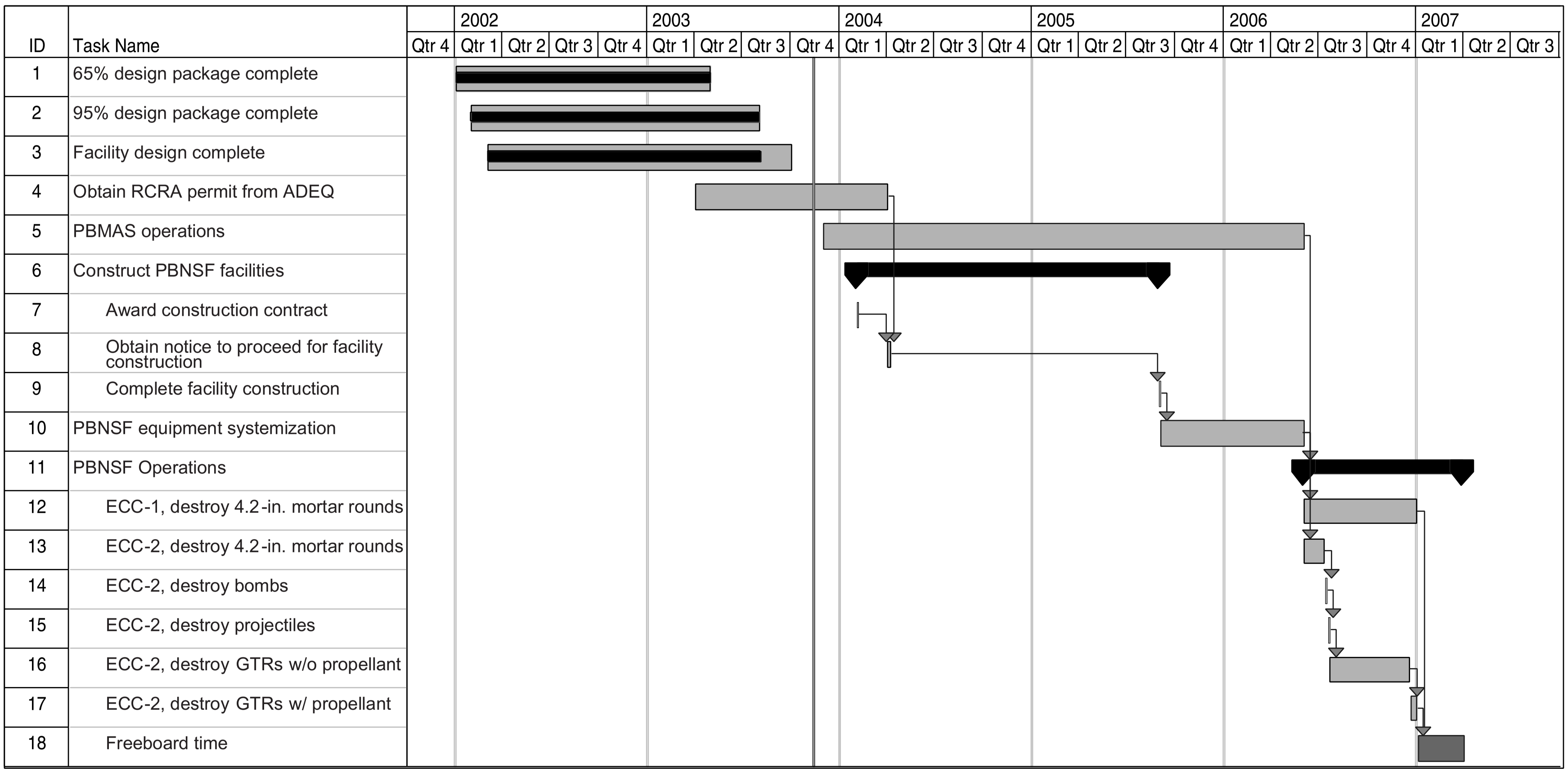

FIGURE C-1 Gantt chart for the entire PBNSF project. Based on using only the ECCs and processing two agents when necessary. The three design tasks (ID3 1-3) were assumed to start in early 2002 for simplicity. Actual starting dates do not affect the chart.

TABLE C-2 PBNSF Base Case Processing Schedule Parameters

Start of operations	6/1/06
End of operations	3/31/07
Total days	303
Days of operation per week	5
Percent availability	80
Mortars, bombs, and projectiles to ECC-1 as a percent of the total to ECC-1 and ECC-2	81
GTR warheads in ECC-1?	No
Percent GTRs for the EDS	0
Percent GTR warheads for the EDS	0
Percent of mortars, bombs, and projectiles that go to the EDS	0
Capacity (items per day per ECC)	5
Capacity (items per day per EDS)	Not applicable

TABLE C-3 PBNSF Base Case with GTR Campaign at Least Partially in Parallel with Campaigns for Mortars, Bombs, and Projectiles

		ECC-1		ECC-2	
Munition	Total Number	Feed Number	Total Days	Feed Number	Total Days
4.2-in. mortar rounds	732	593	208	139	49
Bombs	9	7	3	2	1
Projectiles	17	14	5	3	1
GTRs w/o propellant	439	NA	NA	439	154
GTRs w/propellant	31	NA	NA	31	11
Total days			215		215
Scheduled completion: days prior to March 31, 2007			88		88

concurrent stockpile disposal operations will not be routinely available on the sixth day.

- After every 10 days, 1 day of maintenance is required. This also fits well with the EDS operation of two days per shot, two shots per week and 80 percent availability expected for the equipment.
- Two of seven GTRs that were examined contained material not covered under the Chemical Weapons Convention. However, extrapolating this observation to project that a significant number of GTRs can be processed after the treaty deadline would be presumptuous.

THE BASE CASE: USE OF THE PINE BLUFF NON-STOCKPILE FACILITY FOR ALL ITEMS

The processing schedule based on the above information calls for completion 88 days ahead of the scheduled completion date of March 31, 2007, as shown in Tables C-2 and C-3 and Figure C-2. However, if only the ECC-2 can be used to process GTRs and if mortars, bombs, and projectiles containing a different agent cannot be simultaneously processed in the ECC-1 because of limitations such as the single-agent detection capabilities of the air monitoring analyzers, the overall design capacity of PBNSF drops to five GTRs per shift during the processing of GTRs. This may cause serious capacity problems and reduce to only 6 days the flexibility built into the schedule to meet an on-time completion of PBNSF operations (see Table C-4 and Figure C-3).

OPTION 1: USE OF THE EDS-2 AT HIGH CAPACITY BUT WITHOUT APPROVAL FOR THREE ROUNDS PER SHOT IN THE EDS-1

Option 1 uses two EDS-1[2] units and one EDS-2 unit to process mortars, bombs, and projectiles, and the EDS-2 unit also is used for the GTRs (see Tables C-5 and C-6 and Figure C-4). The Army is confident that high-capacity operation of the EDS-2 processing six mortars, bombs, or projec-

[2]One of the 2 EDS-1 units is that which is associated with the PBMAS operations and would be used to process both stable and sensitive rounds.

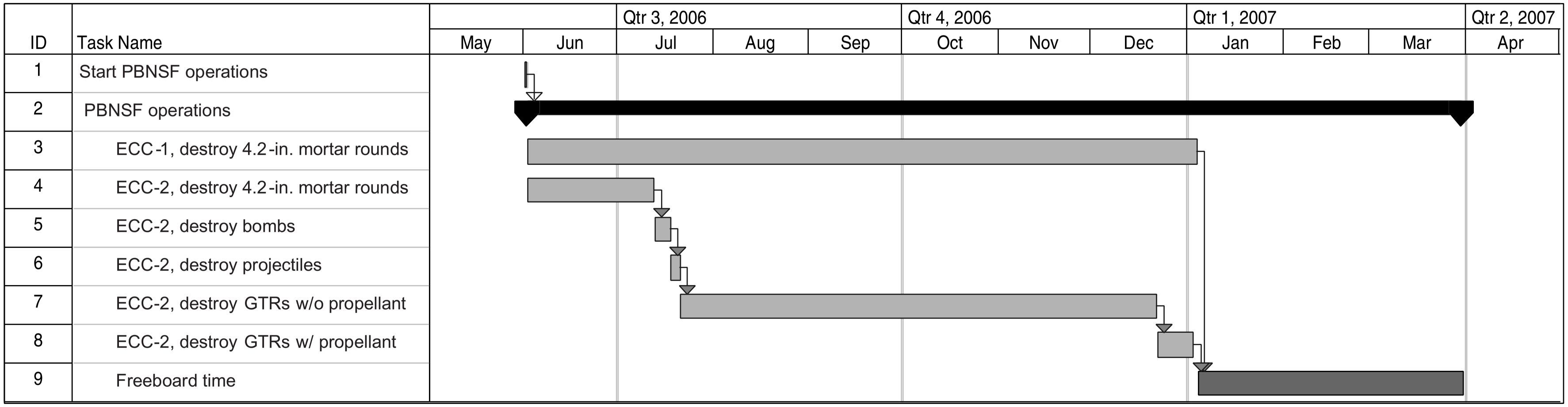

FIGURE C-2 Gantt chart for the PBNSF operations only. Based on using only the ECCs and processing two agents when necessary.

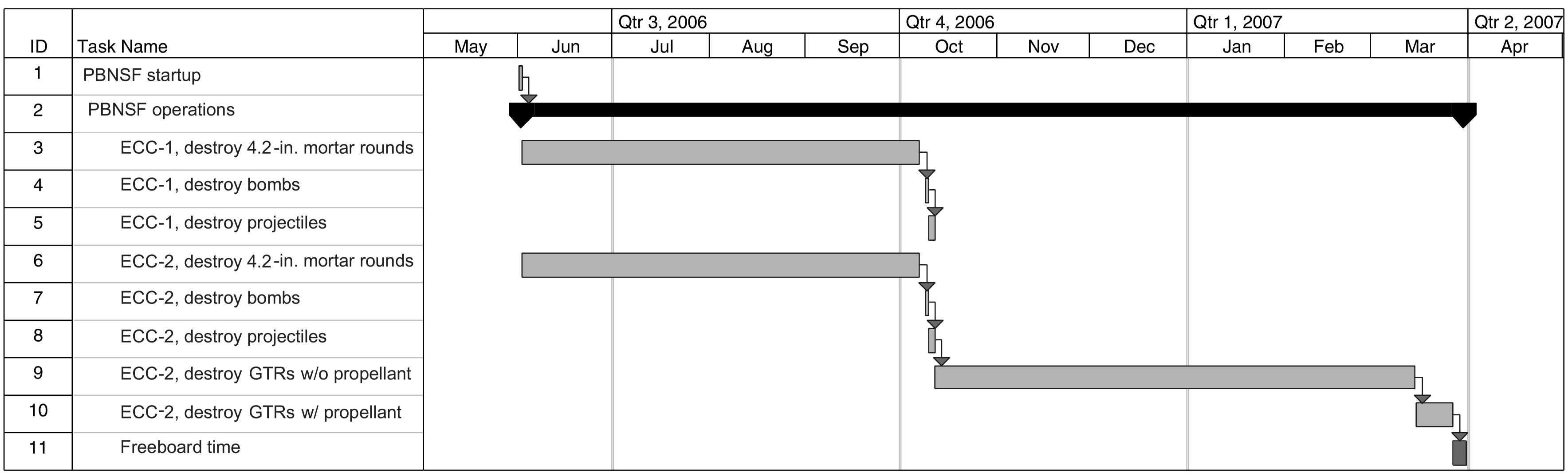

FIGURE C-3 Gantt chart for the PBNSF operations only. Based on using only the ECCs and being able to process only one agent at a time.

TABLE C-4 PBNSF Base Case with GTR Campaign Necessarily Following Campaigns for Mortars, Bombs, and Projectiles

		ECC-1		ECC-2	
Munition	Total Number	Feed Number	Total Days	Feed Number	Total Days
4.2-in. mortar rounds	732	366	128	366	128
Bombs	9	5	2	5	2
Projectiles	17	9	3	9	3
GTRs w/o propellant	439	NA	NA	439	154
GTRs w/propellant	31	NA	NA	31	11
Total days			133		297
Scheduled completion: days prior to March 31, 2007			170		6

TABLE C-5 Option 1 Processing Schedule Parameters

Start of EDS-1 and EDS-2 operations	1/1/05
End of operations	3/31/07
Total days ECC-2 operations	Not applicable
Total days EDS-1 and EDS-2 operations	819
Days of operation per week	5
Percent availability	80[a]
Mortars to EDS-1 as a percentage of mortars to EDS-1 and EDS-2	58
Capacity (items per day per ECC-2)	Not applicable
Shots per day per EDS-1 or EDS-2	0.5
Number of mortars per shot in an EDS-1	1
Number of mortars, bombs, or projectiles per shot in an EDS-2	6
Number of GTR warheads per shot in an EDS-2	3

[a]80 percent availability is based on availability 4 days in a 5-day work week.

TABLE C-6 Option 1: Use of Only One EDS-2 Unit at High Capacity and Two EDS-1 Units at Low Capacity

		EDS-2		EDS-2[a]	
Munition	Total Number	Feed Number	Total Days	Feed Number	Total Days
4.2-in. mortar rounds	732	307	179	425	743
Bombs	9	9	5		
Projectiles	17	17	10		
GTRs w/o propellant	439	439	512		
GTRs w/propellant	31	31	36		
Total days			743		743
Scheduled completion: days prior to March 31, 2007			76		76
Last day to start		3/18/05		3/18/05	
Requires EDS capability to break GTR agent cavity and neutralization technology for GTRs to be demonstrated and approved by 9/28/05					

[a]Two EDS-1 units, including that associated with PBMAS.

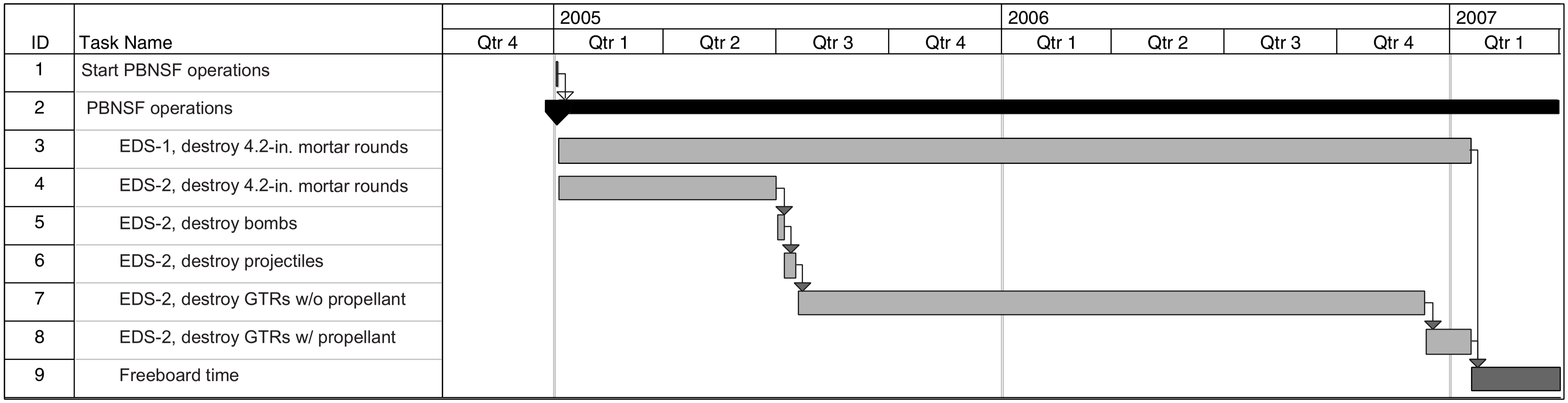

FIGURE C-4 Gantt chart for the PBNSF operations only. Based on using only the EDSs, having demonstrated an alternative method to separate GTRs from their motors and processing two agents when necessary.

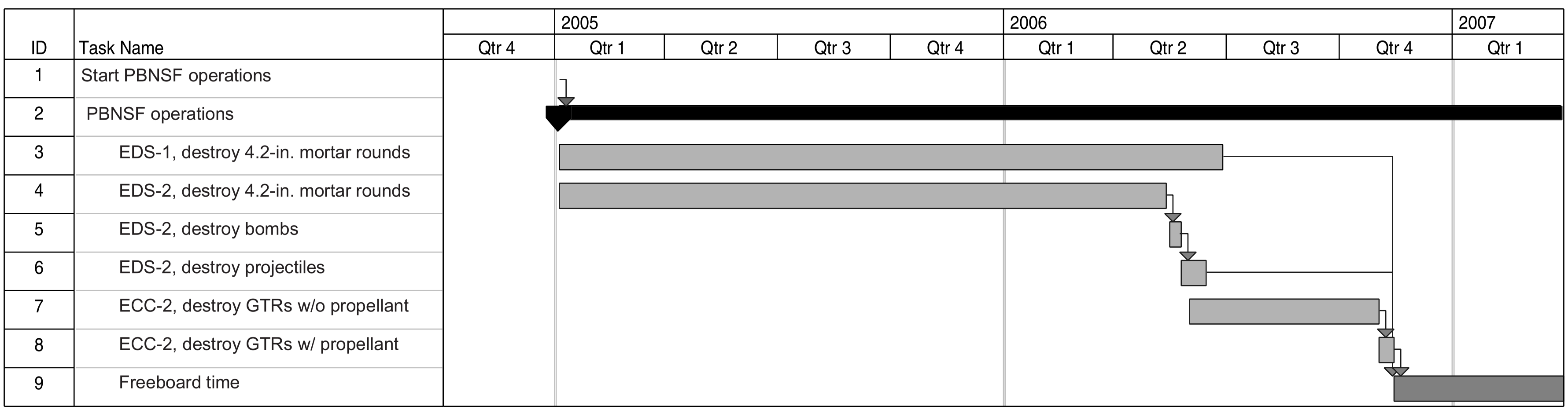

FIGURE C-5 Gantt chart for the PBNSF operations only. Based on using the EDSs for all but the GTRs and processing two agents when necessary.

tiles per shot in the EDS-2 or three or more GTRs per shot is feasible, but this is still to be demonstrated and approved by regulatory authorities. Likewise, EDS ability to break the GTR agent cavity and the neutralization chemistry to be used for processing the GTR agent fills must be demonstrated and approved by regulatory authorities. A capacity greater than one item per shot ("low capacity" in Table C-6) for the EDS-1 is not needed. In addition to the processing benefits covered in Chapter 6 of this report, this approach avoids entirely the need for the currently designed PBNSF while providing for completion of non-stockpile disposal operations 76 days prior to the scheduled completion date of March 31, 2007.

In summary, an all-EDS approach requires the following:

- Demonstration and permitting of decoupling of GTR motors from warheads.
- Demonstration and permitting of EDS-2 capability to break GTR agent cavity and of neutralization chemistry technology for GTRs by the date shown in Table C-6.
- Demonstration and permitting of six rounds per shot in the EDS-2 for mortars, bombs, and projectiles and demonstration and permitting of at least three rounds per shot in the EDS-2 for GTRs.
- Demonstration and permitting of multiple-round shots in the EDS-1 (not required, but helpful).
- Purchase and start-up of a second EDS-2 (not required, and probably too expensive).

OPTION 2: USE OF MULTIPLE EDS UNITS ALONG WITH USE OF THE PINE BLUFF NON-STOCKPILE FACILITY ECC-2 TO PROCESS GERMAN TRAKTOR ROCKETS

Option 2 uses two EDS-1 units and one EDS-2 unit to process mortars, bombs, and projectiles along with the ECC-2 for processing all of the GTRs. Although the Army is confident that more than three mortars will fit into the EDS-2 for each shot, such extra capacity is not essential—that is, low-capacity, single-shot operation was anticipated in developing Tables C-7 and C-8 and Figure C-5. The limiting operation is the processing of GTRs in the ECC-2. In addition to the processing benefits covered in Chapter 6 this report, this mixed approach for PBNSF using an ECC-2 and multiple EDS units increases schedule flexibility by allowing for completion 139 days prior to the scheduled completion date of March 31, 2007.

TABLE C-7 Option 2 Processing Schedule Parameters

Planned start of PBMAS	12/31/03
Start of ECC-2 operations	6/1/06
Start of EDS-1 and EDS-2 operations	1/1/05
End of operations	3/31/07
Total days ECC-2 operations	303
Total days EDS-1 and EDS-2 operations	819
Days of operation per week	5
Percent availability	80[a]
Percent full-assembly GTRs to EDS-2	0
Percent GTRs to EDS-2	0
Mortars to EDS-1 as a percent of mortars to EDS-1 and EDS-2	42
Capacity (items per day per ECC-2)	5
Shots per day per EDS-1 or EDS-2	0.5
Number of rounds per shot in an EDS-1	1
Number of mortars, bombs, and projectiles per shot in an EDS-2	3
Number of GTR warheads per shot in an EDS-2	Not applicable

[a]80 percent availability is based on availability 4 days in a 5-day work week.

TABLE C-8 Option 2: Use of Multiple EDS Units at Low EDS-2 Capacity with All GTRs Processed in the ECC-2

		EDS-1		ECC-2		EDS-1s[a]	
Munition	Total Number	Feed Number	Total Days	Feed Number	Total Days	Feed Number	Total Days
4.2-in. mortar rounds	732	425	495			307	538
Bombs	9	9	11				
Projectiles	17	17	20				
GTRs w/o propellant	439	0	0	439	154		
GTRs w/propellant	31	0	0	31	11		
Total days			526		165		538
Scheduled completion: days prior to March 31, 2007			293		139		281
Last day to start		10/21/05		10/17/06		10/8/05	

[a]Two EDS-1 units, including that associated with PBMAS.

REFERENCES

U.S. Army. 2003a. Resource Conservation and Recovery Act Hazardous Waste Permit Application for the Department for the Army Pine Bluff Non-Stockpile Facility, February. Pine Bluff, Ark.: Pine Bluff Arsenal Public Affairs Officer.

U.S. Army. 2003b. Proposed Deployment and Operation of an Explosive Destruction System at Pine Bluff Arsenal, Arkansas, Environmental Assessment, February. Prepared by Program Manager for Chemical Demilitarization, Product Manager for Non-Stockpile Chemical Materiel. Aberdeen Proving Ground, Md.: Product Manager Non-Stockpile Chemical Materiel.