Assembled Chemical Weapons Assessment Program

Report to Congress

December 2001

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Message from Mr. Michael A. Parker, Program Manager

During the past year's activities within the Assembled Chemical Weapons Assessment (ACWA) Program, tremendous progress has been made regarding possible alternative technology pilot facility implementation. Engineering Design Studies are ongoing and Engineering Design Packages are being developed. The information gathered from all the studies and packages is being used to determine if an alternative technology can be implemented as stipulated in Section 142 of Public Law 105-261. Based on all information produced to date, meeting the requirements of safety, cost, and schedule criteria required by Public Law 105-261 looks to be possible.

Soon the Under Secretary of Defense (Acquisition, Technology & Logistics) as Defense Acquisition Executive (DAE) will determine what technologies will be implemented in Colorado and Kentucky, respectively. As previously stated, information to help the DAE make this determination has and will continue to be submitted for consideration. The DAE will determine if an alternative technology facility can be measured equally with an incineration facility, with regard to safety, cost, and schedule. Additionally, the DAE will determine what management structure will oversee the future facilities to be constructed in both Colorado and Kentucky.

Maintaining public trust is always a high priority for the ACWA program. Stakeholder endorsement of program efforts continues, due to the transparent nature of day-to-day operations. The work effort put forth by all involved – affected stockpile community members, government personnel, and private industry representatives – has been outstanding. It is my commitment to maintain public involvement measures through pilot activities if an alternative technology decision is forthcoming.

Given the tragic events of September 11, 2001, all involved must continue to work diligently toward the swift yet safe destruction of our nation's chemical weapons stockpile. To help expedite this mission, the ACWA program will continue to work cooperatively with the Program Manager for Chemical Demilitarization, Department of the Army, and the Office of the Secretary of Defense to ensure the best information is presented in making future decisions for our country.

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Message from the Dialogue on Assembled Chemical Weapons Assessment

The Assembled Chemical Weapons Assessment (ACWA) Dialogue was established in May 1997 to ensure the upfront integration of concerns and ideas of the diversity of individuals likely to be impacted by or having an impact on chemical weapons demilitarization. The Dialogue, as noted by the signatories of this Message, includes individuals supporting and opposing incineration from the eight states with stockpiles of chemical weapons; federal, state, and tribal regulators and representatives; Department of Defense (DOD) staff from affected sites and headquarters; and representatives from national citizen groups such as the Chemical Weapons Working Group (CWWG), Global Green USA, and the Sierra Club, who regularly work on chemical weapons demilitarization issues.

The ACWA Program was established in 1996 under Public Law 104-208 to facilitate and accelerate the ongoing destruction of chemical weapons stockpiles in the United States by demonstrating non-incineration, alternative technologies. The Dialogue has met twelve times since its inception and once during calendar year 2001 to review and discuss criteria for evaluating these technologies and provide overall advice to the ACWA Program Manager. In addition, a four-person subgroup, the Citizens Advisory Technical Team (CATT), and an independent technical advisor have been actively involved in week-to-week activities. Through the Dialogue, members have developed a greater appreciation for the complex challenges inherent to the chemical weapons demilitarization program and have focused on shared problem solving. With the military, regulators, and community members all pulling in a common direction, Dialogue members truly believe that this will help ensure a more effective and successful demilitarization effort.

The tragic deaths of our fellow citizens in September brings home to all of us how unimportant our many policy differences really are, but they also emphasize to us that we must finish our task—safely and soundly abolishing all of the U.S. chemical weapons stockpile so that these deadly agents never again endanger, either through accidental release or terrorist attack, our local communities and innocent civilians.

Based on our in-depth monitoring of the ACWA Program over the past four and a half years, the Dialogue puts forth the following consensus recommendations and summary opinions.[1]

Dialogue Views and Recommendations

The ACWA program has met the mandate of the law to demonstrate not less than two alternatives to baseline incineration for the destruction of assembled chemical weapons. The ACWA program to date has identified six technologies, all of which have now been demonstrated, and four of which have passed on to engineering design studies this year. These four groups are: 1) neutralization and biotreatment; 2) neutralization and supercritical

[1]The reader may refer to past ACWA Reports to Congress for greater detail on the history of the ACWA Program and Dialogue or to review prior recommendations from the ACWA Dialogue. These documents may be obtained by calling the ACWA information line at (888) 482-4312, or logging onto the ACWA website at http://www.pmacwa.org.

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water oxidation (SCWO); 3) neutralization, SCWO, and gas phase chemical reduction; and 4) electrochemical oxidation. A full technical report on this year's engineering scale-ups will be forthcoming in early 2002. We believe that some, perhaps all, of these could be effectively utilized at several stockpile sites in coming years.

Public health and environmental protection must remain our top priorities, as mandated by the law for chemical weapons demilitarization. The stated mission of the Program Manager for Chemical Demilitarization (PMCD) is "to destroy the U.S. stockpile of unitary chemical weapons while ensuring maximum protection to the environment, general public, and personnel involved in the destruction effort." We fully support this. The September 11th attacks, and the perceived vulnerability of parts of the chemical weapons stockpiles, however, have led some observers to argue for expediting the destruction process. While we support any necessary security enhancements for the eight remaining U.S. stockpiles and agree that expeditious destruction is important, we do not support any "hurried" approach that could place local populations and the environment at greater risk. We are also concerned that moving to incentivized contracts for contractors, i.e. monetary incentives for speed, could encourage cutting corners at the expense of safety. Although many of these concerns may be manageable, DOD and others have noted that such incentives may raise public concerns that speed is valued over safety.

If the ACWA-demonstrated technologies are certified by the Defense Acquisition Executive (DAE) to be as safe, cost-effective, and timely as incineration, these technologies should be seriously considered for implementation at both Pueblo, Colorado and Blue Grass, Kentucky.[2] DOD is now evaluating both incineration and non-incineration technologies for these two remaining chemical weapons stockpile sites, the last of nine site-specific technology decisions. We believe that the four demonstrated ACWA technologies noted above are applicable to these two sites. Furthermore, there is evidence that these alternative technologies could be more acceptable to the public as evidenced by ongoing implementation activities of alternative technologies in Indiana and Maryland.

The ACWA-demonstrated technologies may have application at some or all of the other chemical weapons sites. Of the seven other sites, Johnston Atoll completed incinerator operations of live agent this past year. One other site—Tooele, Utah—has incinerated more than one-third of its original tonnage of agent during the past five years. Two other sites—Anniston, Alabama and Umatilla, Oregon—have just completed incinerator construction and are scheduled to begin operations in 2002 and 2003, respectively, based on PMCD's current projections. A fifth site—Pine Bluff, Arkansas—is currently scheduled to complete incinerator construction and testing in 2003. The two remaining sites—Aberdeen, Maryland and Newport, Indiana—are currently scheduled to begin pilot operations of non-incineration technologies in 2004 and 2005, respectively. The ACWA technologies may have application at all of these sites in the destruction of agent, energetics, and treatment of metal parts, wood,

[2]Wesley Stites and Suzanne Winters remain skeptical that the alternative technologies can be implemented as quickly as baseline incineration even if certified by the DAB. These two Dialogue members believe that the ACWA technologies are immature and thus face greater engineering uncertainties.

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plastic suits, and other contaminated materials. This application may be as a complement or alternative to the baseline incinerator technology, or in support of existing alternative technology development programs in Indiana and Maryland.

The ACWA-demonstrated technologies may have broader application in toxic waste management. While the ACWA program has been designed to apply to chemical weapons, the technologies demonstrated have been able to demilitarize all components of an assembled weapon, which can include agent, propellant, energetics, plastics, metal, fiberglass, polychlorinated biphenyls (PCBs), and other contaminants. We are optimistic that the potential spin-offs from this program into the fields of pollution cleanup and site remediation will be great.

The future management of the chemical weapons demilitarization program should be consolidated and made more rational. All Dialogue participants strongly agree on the need to restructure the management of the chemical weapons demilitarization program in order to reduce bureaucratic inefficiencies and unnecessary delays. The future program should adopt an open and transparent management style. All Dialogue members agree that Michael Parker, Program Manager for ACWA, Bill Pehlivanian, Deputy Program Manager, and the ACWA staff have demonstrated this forthrightness since the Program's inception.

The ACWA Dialogue is a successful model for consensus building in contentious public policymaking. The enormous chemical weapons demilitarization program, as well as the Cold War legacy of chemical weapons, has come under widespread scrutiny and policy debate at every site and community. The Dialogue provides a method for ensuring a marriage of the best science available while incorporating the concerns of the communities and the political realities of this hotly debated topic. The Dialogue process has helped to address a variety of issues in a cooperative and productive way. This process deserves to be emulated elsewhere.

Transparency and public involvement remains key to a successful chemical weapons demilitarization program. A National Dialogue on Chemical Weapons Demilitarization should be established. The ACWA Dialogue and other consensus-building processes have illustrated the importance of transparency in information and process, and of timely stakeholder involvement in decision-making. The national chemical weapons demilitarization program has not always been effective in either of these areas. Timely, accurate, and full responses to public inquiries and timely release of all key data are very important. The Dialogue strongly recommends that public involvement be emphasized in any future decision-making that involves the destruction of chemical weapons in our communities. We believe that the Program Manager of any organization charged with this responsibility would be well served by and should seriously consider the use of groups similar to the ACWA Dialogue as a method of ensuring adequate public involvement throughout the life of the program.

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As noted in last year's Dialogue message, we continue to support the establishment of a formal mechanism for ensuring broad stakeholder involvement in decision-making for chemical weapons demilitarization. While some issues obviously must remain in the domain of local advisory committees and officials, a national Dialogue can serve to help resolve many regional and national issues, share lessons learned, and encourage joint problem solving. This new Dialogue should address all topics related to the destruction of chemical weapons and not just be limited to assembled chemical weapons. This new effort should have a clear mission and a method for closure once the goals have been met.

As long as the ACWA Program continues as a separate entity, we recommend that it continue to solicit public involvement through the ACWA Dialogue mechanism. We recognize and support that such a mechanism should be consistent with any new statutory goals for ACWA and thus, could require changes in the Dialogue mission and membership. Any new mission statement should also have clear goals for the group and a method for concluding the effort once the goals have been met.

In addition, the Dialogue recommends that the DOD make significant efforts in upcoming months to increase transparency and public involvement in its decision-making process. The public is much more likely to understand and support the difficult decisions that face the DAB over the next eight months, if they have access and are allowed input into the process in a meaningful way.

Conclusion. The Dialogue believes that the continued safe and environmentally sound destruction of all chemical weapons stockpiles—American, Russian, and others—is of utmost importance to both environmental and national security. The recent terrorist attacks in the U.S. and elsewhere have illustrated this point more clearly and we welcome more public and official attention to and support of this top national priority.

At the same time, we point out that ridding ourselves of dangerous arsenals of weapons of mass destruction is a very technically and politically challenging task, laden with high levels of emotion. It is important now, more than ever, that we dedicate ourselves to working cooperatively and effectively together as citizens, as a nation, and as an international community, in order to meet this challenge and abolish chemical weapons worldwide forever.

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Dialogue on Assembled Chemical Weapons Assessment
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Executive Summary

This report responds to the requirements contained in Title VIII, section 8065 of the Omnibus Consolidated Appropriations Act, 1997 (Public Law 104-208), and describes the activities accomplished for the Assembled Chemical Weapons Assessment (ACWA) Program during fiscal year 2001. Significant activities included:

- **Participation in Defense Acquisition Board (DAB) Review activities.**

  In July 2000, the Under Secretary of Defense for Acquisition, Technology and Logistics, in his role as the Department of Defense Acquisition Executive (DAE), requested a Defense Acquisition Board (DAB) review of all aspects of the Chemical Demilitarization Program including the ACWA program. During a DAB Review on September 6, 2001, Program Manager for ACWA (PMACWA) presented an update on the program and the status of the certification process. PMACWA will continue to participate in the DAB process to support the certification of ACWA technologies and the technology decisions for Pueblo and Blue Grass. The technology decision for Pueblo is tentatively scheduled for February 2002; the technology decision for Blue Grass is tentatively scheduled for June 2002.

- **Conducting Engineering Design Studies (EDS) for the four alternative technologies that were validated during demonstration testing to be effective in the destruction of chemical weapons.**

  The four technologies are: neutralization followed by biotreatment, which was validated for processing mustard-containing munitions only; neutralization followed by supercritical water oxidation, which was validated for processing all chemical weapons; electrochemical oxidation, which was validated for processing all chemical weapons; and neutralization followed by transpiring wall supercritical water oxidation and gas phase chemical reduction, which was validated for processing all chemical weapons. EDS will result in a preliminary full-scale design for the construction of a demilitarization facility with the associated cost, schedule, and preliminary hazard analysis. This information will be the basis for certification under the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (Public Law 105-261).

- **Participation in acquisition activities regarding construction of chemical demilitarization facilities at Pueblo Chemical Depot, Colorado and Blue Grass Army Depot, Kentucky.**

  ACWA is participating in ongoing acquisition activities in Colorado and Kentucky. These activities include: developing a life cycle cost and schedule to support the technology decisions at both locations, participating in Environmental Working Integrated Product Teams in Colorado and Kentucky to address issues related to environmental permits, and preparing a request for proposal for a pilot plant in Colorado.

- **Conducting National Environmental Policy Act (NEPA) and Resource Conservation and Recovery Act (RCRA) activities.**

  PMACWA published the Draft Program Environmental Impact Statement (EIS) on May 11, 2001. The Draft EIS examines the potential impacts of the design, construction, and operation of one or more pilot test facilities for assembled chemical weapons destruction technologies at one or more chemical weapons stockpile sites. Public meetings were held in Pueblo, Colorado; Pine Bluff, Arkansas; Anniston, Alabama; and Blue Grass, Kentucky to receive comments on the Draft EIS. Comments are now being reviewed and will be addressed in the Final EIS, which ACWA expects to complete in early 2002. A Record of Decision (ROD) will follow shortly thereafter.

  The PMACWA will be required to obtain Resource Conservation and Recovery Act (RCRA) permits for technologies proposed for the destruction of the chemical weapons stockpiles at Pueblo Chemical Depot in Colorado and Blue Grass Army Depot in Kentucky. PMACWA has prepared draft RCRA permit applications for the two ACWA technologies being considered for the Pueblo Chemical Depot. Development of the Blue Grass Army Depot draft RCRA permit application will not begin until after a technology decision has been made for that location.

I. INTRODUCTION/BACKGROUND

This annual report is submitted to the United States (U.S.) Congress in compliance with the requirements contained in Title VIII, section 8065 of the Omnibus Consolidated Appropriations Act, 1997 (Public Law 104-208). This report presents the activities associated with the Department of Defense (DOD) Assembled Chemical Weapons Assessment (ACWA) Program accomplished during Fiscal Year (FY) 2001.

In accordance with Public Law 104-208, the Under Secretary of Defense for Acquisition, Technology and Logistics selected Mr. Michael A. Parker as the Program Manager for ACWA with the mission to "demonstrate not less than two alternatives to the baseline incineration process for the demilitarization of assembled chemical munitions." Assembled chemical munitions for this purpose represent the chemical weapons stockpile configured with fuzes, explosives, propellant, chemical agents, shipping and firing tubes, and packaging materials. The submission of the June 2001 Supplemental Report to Congress satisfied the requirements of Public Law 104-208.

The Program Manager for Assembled Chemical Weapons Assessment (PMACWA) is currently conducting Engineering Design Studies (EDS) of four successfully demonstrated technologies to develop the information necessary to satisfy the requirements in the Strom Thurmond National Defense Authorization Act for FY 1999 (Public Law 105-261). The four technologies include: neutralization followed by biotreatment; neutralization followed by supercritical water oxidation; electrochemical oxidation; and neutralization followed by transpiring wall supercritical water oxidation and gas phase chemical reduction.

II. DEFENSE ACQUISITION BOARD (DAB)

In July 2000, the Under Secretary of Defense for Acquisition, Technology and Logistics, in his role as the Department of Defense Acquisition Executive (DAE), requested a review of all aspects of the Chemical Demilitarization Program including the ACWA program. Issues to be covered by this Defense Acquisition Board (DAB) review include: compliance with the Chemical Weapons Convention Treaty, update of the life cycle cost estimate, update of program plans for closure of Chemical Stockpile Disposal facilities, and the path forward to implement a destruction method for the chemical stockpile sites at Pueblo and Blue Grass. The DAB review will also include the certification process for the ACWA technologies as required by Public Law 105-261.

To address the review topics included above, three Working Integrated Product Teams (WIPTs) were formed – Cost/Schedule, Programmatic/Acquisition, and Safety/Environment. Output from these WIPTs will be provided to an Integrating Integrated Product Team (IIPT). The IIPT will provide a report and certification recommendation to an Overarching Integrated Product Team (OIPT). The OIPT will report to the DAE the status of the Chemical Demilitarization Program and whether or not the ACWA technologies can meet the certification requirements. The DAE will consider all the information presented and document the results of the DAB Review in an Acquisition Decision Memorandum.

In May 2001, the DAB Review was split into three phases due to the extended public comment period for the Environmental Impact Statements. The first phase of the review addresses the cost, schedule, and Chemical Weapons Convention (CWC) compliance status of each Chemical Demilitarization program element. The second and third phases address the technology selections for Pueblo and Blue Grass, respectively.

The first phase of the DAB Review was held on September 6, 2001. The cost, schedule, and CWC compliance status of each Chemical Demilitarization program element, excluding Pueblo and Blue Grass, was presented by the Army to the Defense Acquisition Executive. At this DAB, PMACWA presented only an update on the program and the status of the certification process.

The second and third phases of the DAB Review will occur in 2002. PMACWA will participate in the integrated product team structure to support the certification process for ACWA technologies and the technology decisions for Pueblo and Blue Grass. The second phase of the DAB review, providing the technology decision for Pueblo, is tentatively scheduled for February 2002. The third phase of the DAB review, providing the technology decision for Blue Grass, is tentatively scheduled for June 2002.

III. ENGINEERING DESIGN STUDIES (EDS)

Public Law 105-261 directed the continuation of the ACWA Program and stated that if an alternative technology is chosen to be piloted, the Under Secretary of Defense for Acquisition, Technology and Logistics must certify in writing to Congress that any ACWA technology to be implemented is successful and as safe and cost effective for disposing of assembled chemical munitions as incineration; and, is capable of completing the destruction on or before the date by which the destruction of the munitions would be completed if incineration were used.

A. Engineering Design Studies I (EDS I)

The EDS I continued for the two alternative technologies that were validated during the Demonstration I program as having the potential to be effective in the destruction of chemical weapons. These two technologies use neutralization as the main destruction mechanism for the agent and energetics contained in the chemical weapons. The technology proposed by Parsons/Honeywell is neutralization followed by biotreatment, which was validated for processing of mustard-containing munitions only. The technology proposed by General Atomics is neutralization followed by supercritical water oxidation and was validated for processing of all chemical weapons.

The EDS I has resulted in a preliminary full-scale design for the construction of a Pueblo Chemical Depot demilitarization facility with the associated cost, schedule, and preliminary hazards analysis (PHA) for each of the two technologies validated during Demonstration I. This information is the basis for certification under Public Law 105-261. The design package will be made available as part of the request for proposals that will be developed for implementation of a technology.

1. Neutralization Followed by Supercritical Water Oxidation

The approach proposed by General Atomics for a total solution for the destruction of all assembled chemical weapons and associated propellant and packaging materials uses baseline shearing for rockets and modified reverse assembly plus cryofracture for projectiles. Cryofracture is a process developed by General Atomics for the U.S. Army in which munitions are embrittled by cooling in liquid nitrogen and then fractured to access the agent after the energetics have been removed. General Atomics proposes to neutralize (hydrolyze with water and caustic) the agents and energetics separately. Agent hydrolysate and energetics hydrolysate combined with shredded dunnage will be destroyed using separate supercritical water oxidation (SCWO) units. SCWO mineralizes the hydrolysates at temperatures and pressures above the critical point of water, and produces solid and liquid effluents that can be held and tested before release. General Atomics proposes to recover process water for reuse and to dispose of dry salts and solid residues in a permitted waste landfill. Recovered metal parts will be thermally treated using resistance heating and released as scrap.

As stated in the December 2000 report, the following General Atomics unit operations have been tested as part of the EDS I program in order to provide the engineering basis for the designs being developed for the General Atomics Total Solution at Pueblo Chemical Depot: an Energetics Rotary Hydrolyzer (ERH) to neutralize the weapons energetics, a SCWO unit to separately treat the neutralized agent and energetics, and a Dunnage Shredding and Hydrolysis System (DSHS) to size reduce and pretreat miscellaneous dunnage for subsequent treatment in SCWO. Additionally, General Atomics is participating in EDS II studies for the engineering design basis for the Blue Grass Army Depot.

a. Energetics Rotary Hydrolyzer (ERH)

The ERH testing conducted as part of EDS I has been completed with all of the objectives met. The ERH testing was conducted with sections of rocket motors representing pieces that would result from the current rocket segmenting process.

b. Dunnage Shredding/Hydrolysis System (DSHS)

The DSHS testing conducted as part of EDS I has been completed with all of the objectives met. The DSHS testing was conducted with demilitarization protective ensemble (DPE) material, wood, and carbon to address size reduction and material transport issues resulting from testing conducted during Demonstration I.

c. Supercritical Water Oxidation System (SCWO)

The originally scheduled testing conducted as part of EDS I has been completed with all of the objectives met. The SCWO testing was conducted with: 1) HD hydrolysate and simulant; 2) tetrytol energetics hydrolysate and dunnage; and 3) GB hydrolysate and GB hydrolysate simulant; and 4) Composition B energetics hydrolysate, M28 propellant hydrolysate, and dunnage. Testing was expanded to include VX hydrolysate simulant in order to gain additional knowledge not available through the Engineering Scale Test that was conducted in support of the Newport Chemical Demilitarization Facility. The testing being conducted during EDS II on this feed will support both the PMACWA and Program Manager Alternative Technologies and Approaches (PMATA) programs.

d. Schedule

All testing has been completed including the EDS II VX hydrolysate simulant portion of the SCWO. This was an addition to the original test plan because sufficient information was not available from the Engineering Scale Testing of the SCWO unit that was tested by PMATA as part of the Newport demilitarization effort. This testing was completed in November 2001.

2. Neutralization Followed by Biotreatment

The approach proposed by Parsons/Honeywell for a total solution for the destruction of mustard chemical weapons uses modified reverse assembly for chemical agent access. Modifications to reverse assembly include a gravity drain with water bath and rinse for agent removal and high-pressure wash to remove the energetics. Parsons/Honeywell proposes to neutralize (hydrolyze with water and caustic) the agent and energetics and then destroy the hydrolysates using a biological treatment process operated at ambient temperature and pressure. Organic vapors and odors will be passed through a catalytic purifier (similar to an automotive catalytic converter) developed by Honeywell. Parsons/Honeywell proposes to recover process water for reuse and to dispose of dry salts and solid residues in a permitted waste landfill. Recovered metal parts will be thermally treated, in the presence of steam, and released as scrap.

The following Parsons/Honeywell unit operations were tested as part of the EDS I program in order to provide the engineering basis for the designs being developed for the Water Hydrolysis of Explosives and Agent Technology. Four primary process systems were tested separately and concurrently by the Parsons/Honeywell team at locations including: Edgewood Chemical and Biological Center (ECBC) at Aberdeen Proving Ground (APG), Maryland; Illinois Institute of Technology Research Institute (IITRI) in Chicago; and Chemical Agent Munitions Disposal System (CAMDS) in Tooele, Utah. These systems included: an Immobilized Cell Bioreactor (ICB™) to treat neutralized mustard and energetics, Continuous Steam Treater (CST) to treat metal parts and miscellaneous dunnage, a Catalytic Oxidation Unit (CatOx) to treat organics in the gaseous phase prior to carbon filtration, and a water washout system to treat mustard munitions that may contain heels.

a. Immobilized Cell Bioreactor™ (ICB™)

The ICB™ testing conducted as part of EDS I has been completed with all the objectives met. The ICB™ testing was conducted with feeds consisting of combined process liquids of agent hydrolysate, energetic hydrolysate and condensate from the CST.

b. Continuous Steam Treater (CST)

The CST testing conducted as part of EDS I has been completed with all the objectives met. The CST testing was conducted with feeds consisting of process wastes to include carbon, wood pallets, and DPE.

c. Catalytic Oxidation (CatOx)

The CatOx testing conducted as part of EDS I has been completed with all the objectives met. The CatOx testing was conducted using HD agent as a straight challenge to the system as a worst case scenario to determine catalyst effectiveness and duration.

d. Projectile Washout System

The Projectile Washout System has been successfully tested using actual HD-filled 4.2-inch mortars. The testing will continue with HT-filled 4.2-inch mortars. In addition, 155mm H-filled projectiles are being considered for testing.

e. Schedule

All testing has been completed except for the Projectile Washout System test using HT-filled 4.2-inch mortars, which is scheduled for early 2002.

3. Engineering Design Package

The testing outlined above supported the preparation of an Engineering Design Package that is the basis for the cost, schedule, and safety criteria development. The Engineering Design Package includes drawings and documentation sufficient to generate capital and operational and maintenance costs to within +/– 20 percent. The design package also includes a cost estimate that was evaluated and used to develop a program life cycle cost estimate. A program schedule was included in the package along with a Preliminary Hazards Analysis that was used as a tool in the safety certification process. Since Pueblo Chemical Demilitarization Facility (PUCDF) will have a stockpile of mustard-only weapons and Blue Grass Chemical Demilitarization Facility (BGCDF) will have both mustard and nerve agent weapons, Parsons/Honeywell has generated an Engineering Design Package for the PUCDF only, while General Atomics has developed a package for PUCDF and BGCDF. These packages will be used for the certification process, the request for proposals for the two demilitarization sites, and for the Environmental Impact Statement (EIS) process and Resource Conservation and Recovery Act (RCRA) permit applications.

Draft Engineering Design Packages for Pueblo were submitted to the Government on October 27, 2000. Design reviews were conducted at the end of November 2000 and changes were made to these packages as a result. The final Engineering Design Packages were submitted to the Government on January 5, 2001. A review of these packages took place to include a technical assessment and a life cycle cost and schedule were developed based on this evaluation.

B. Engineering Design Studies II (EDS II)

The EDS II were initiated for the two alternative technologies that were validated during the Demonstration II program as having the potential to be effective in the destruction of chemical weapons. One technology, proposed by AEA Technology/CH2MHill, uses electrochemical oxidation as the main destruction mechanism for the agent and energetics contained in the chemical weapons. The other technology, proposed by EcoLogic/Foster Wheeler/Kvaerner, uses neutralization as the main destruction mechanism for the agent and energetics contained in the chemical weapons. Neutralization is then followed by transpiring wall supercritical water oxidation and gas phase chemical reduction.

EDS II will result in a preliminary full-scale design for the construction of a Blue Grass Army Depot demilitarization facility with the associated cost, schedule, and preliminary hazards analysis for the AEA Technology/CH2MHill and EcoLogic/Foster Wheeler/Kvaerner technologies. This information will be the basis for certification under Public Law 105-261. The design package will be made available as part of the request for proposals that will be developed for implementation of a technology at Blue Grass Army Depot.

1. Electrochemical Oxidation

The approach proposed by AEA Technology and CH2MHill for a total solution for the destruction of all assembled chemical weapons uses modified baseline reverse assembly for chemical access, AEA Technology's patented SILVER II™ process for destroying chemical agent and energetics, a Metal Parts Treater for the treatment of metal parts, and a Dunnage Treater for the treatment of dunnage.

Modifications to reverse assembly for accessing rockets include tube cutting, burster washout, propellant push-out and milling. Rockets are punched and drained to remove the chemical agent. The agent is treated in the SILVER II™ process. Rockets are cut in a Rocket Disassembly Machine. The first cut removes the fuzes, which are then deactivated in the Metal Parts Treater. The burster is then washed out and the second cut removes the warhead section and exposes the motor. Once the propellant is exposed, it is pushed out and milled. The washed out burster energetics and milled propellant are treated in a separate SILVER II™ process. Any metal fragments are processed in the Metal Parts Treater. Shredded dunnage is treated in a Dunnage Treater.

The SILVER II™ process uses an electrochemical cell containing nitric acid and silver nitrate to generate silver (II) ions. Energetics and agents are oxidized either directly by the silver (II) ions or by other oxidizing compounds produced from reactions involving silver (II) ions. The process operates at 190°F and near atmospheric pressure (14.7 psia). All effluents from the SILVER II™ process will be contained and tested to be agent-free before release, recycling or disposal.

The following unit operations are being tested as part of the EDS program in order to provide the engineering basis for the preliminary designs being developed for the AEA Technology/CH2M Hill total solution: energetics feed system, 12-kW SILVER II™, cell membrane life, fluoride removal system, hydrocyclone, high shear mixer, organic transfer, silver recovery, and evaporator.

a. Energetics Feed System

The purpose of this test is to demonstrate a continuous, safe system in which to control and release measured quantities of a water-based energetic slurry to the anolyte vessel in the SILVER II™ process. This testing was conducted at APG, Maryland. The specific objectives of this testing include the following:

- Design, build, and test an energetics feed system that allows consistent operation of the SILVER II™ plant. For example:
  - Dispensing known volumes of energetics slurry with up to 20 percent (by weight) solids to the SILVER II™ anolyte vessel.
  - Effectively monitoring the level of the energetics slurry within the feed vessel.
  - Operating the energetics feed system for long periods with limited maintenance.
  - Verifying that the slurry is homogeneous and that stratification does not occur.

The energetic feed system performed as it was intended.

b. 12-kW SILVER II™ Plant

(1) Energetics/Propellant

The purpose of this test is to validate the ability of the SILVER II™ process to achieve and maintain a steady-state electrochemical efficiency and achieve destruction and removal efficiency (DRE) of 99.999% for Composition B and M28 propellant. This testing was conducted at APG, Maryland. The specific objectives of this testing include the following:

- Verify long-term, continuous operability, reliability, and maintainability (i.e., operation of the full length of the test without unintended shutdown) of the SILVER II™ system as proposed for full-scale. For example:
  - Demonstrate that organic, silver, acid, and water in the catholyte circuit can be effectively managed over prolonged operational periods.
  - Demonstrate that process impurities that build-up in the anolyte circuit can be effectively managed over prolonged operational periods.
  - Determine the cell current efficiency to be used in the full-scale design.
- Verify that system modifications (i.e., high shear mixers and hydrocyclones) allow for effective treatment of organic material.
- Demonstrate the applicability of the 12-kW impurities removal system (IRS) design to the full-scale design, and develop data necessary for the design of the full-scale IRS.
- Confirm and supplement Demonstration II process effluent characterization.
- Determine impact of operations on materials of construction to be used in a full-scale system such as polymer-lined pipework.
- Validate the ability of the SILVER II™ unit operation to achieve a DRE of 99.999% for Composition B (RDX and TNT).

- Demonstrate the operation and performance of the following key process components for future scale-up:
  - Instrumentation, valves, pumps, etc.
  - Electrochemical cell (electrodes and membranes).
  - Full height NO_x reformer.
  - Off-gas scrubber operating in conjunction with NO_x reformer.
- Demonstrate the ability/inability to recycle, reuse or dispose of nitric acid.
- Characterize gas, liquid and solid process streams of the SILVER II™ process for selected chemical constituents and physical parameters and for the presence/absence of hazardous and toxic compounds.

Initial testing of energetics in the 12-kW system was successfully completed in October 2001. Successful destruction of dinitrotoluene (DNT), an energetic simulant; Composition B; and the mixture of Composition B and M28 propellant have been conducted.

(2) Agent Simulant

The purpose of this test is to validate the ability of the SILVER II™ process to achieve and maintain a steady-state electrochemical efficiency and verify long term continuous operability, reliability, and maintainability of the process with the organic feed, dimethyl methylphosphonate (DMMP). This testing is being conducted at APG, Maryland. The specific objectives of this testing include the following:

- Verify long-term, continuous operability, reliability, and maintainability (i.e., operation of the full length of the test without unintended shutdown) of the SILVER II™ system as proposed for full-scale. For example:
  - Demonstrate that organic, silver, acid, and water in the catholyte circuit can be effectively managed over prolonged operational periods.
  - Demonstrate that process impurities that build-up in the anolyte circuit can be effectively managed over prolonged operational periods.
  - Determine the cell current efficiency to be used in the full-scale design.
- Verify that system modifications (i.e., high shear mixers and hydrocyclones) allow for effective treatment of organic material.
- Demonstrate the applicability of the 12-kW IRS design to the full-scale design and develop data necessary for the design of the full-scale IRS.
- Confirm and supplement Demonstration II process effluent characterization.
- Determine impact of operations on materials of construction to be used in a full-scale system such as polymer-lined pipework.

Agent simulant testing of the 12-kW plant began in October 2001 with DMMP.

c. Cell Membrane Life

The purpose of this test is to provide information relating to any changes in cell membrane characteristics over an extended operating period. This test also provided data on the long-term chemical stability of several gasket materials. The results will provide an estimate of the lifetime of these components in the presence of the silver (II) ion. This testing was conducted in Oxfordshire, United Kingdom. The specific objectives of the testing include the following:

- Confirm the selection of the membrane and gasket material for full-scale.
- Determine (estimate) the expected membrane and gasket life.

The cell membrane life test was completed in October 2001.

d. Fluoride Removal System

The purpose of this testing is to provide information relating to the movement of fluorine through the plant and investigate the potential to remove it. This testing was conducted in Oxfordshire, United Kingdom. The specific objectives of the testing include the following:

- Confirm how fluorine moves through the plant, especially across the cell membrane and in the gas phase.
- Investigate the possibility of containing or removing the fluorine from the system to allow more economical materials of construction to be used.

The fluoride system testing consists of two experiments on two separate test rigs. They are the fluoride transport test and the fluoride removal test. The fluoride transport tests were completed in October 2001. The fluoride removal tests were completed in November 2001.

e. Hydrocyclone Testing

The purpose of this testing is to provide information on the hydrocyclones ability to remove large particles of solid organic from the recirculating anolyte and catholyte circuits and return them to their respective feed vessels, thereby preventing them from entering the cell. This testing will allow the anolyte system to operate with higher organic levels, which will increase the destruction performance of energetics while maintaining protection for the cell. This testing was conducted in Risley, United Kingdom. The specific objectives of this testing include the following:

- Determine appropriate design parameters for the hydrocyclone to be used in the 12-kW plant.

The hydrocyclone testing was successfully completed in June 2001.

f. High Shear Mixer Testing

The purpose of this test is to provide information relating to the operation of high shear mixers to size reduce and homogenize the solid particulate found in both the anolyte and catholyte vessels.

Previous testing during Demonstration II showed that breakdown products from energetics formed solids, which caused handling issues within the plant. The use of high shear mixers will significantly reduce the average particle size of the breakdown products allowing handling and increasing surface area exposure to the silver (II) ion process. This testing was conducted in Derbyshire, United Kingdom and at APG, Maryland. The specific objectives of this testing include the following:

- Determine performance (maximizing surface area of organics) of high shear mixers.

The high shear mixer tests were completed in September 2001.

g. Organic Transfer Testing

The purpose of this test is to provide information relating to the mechanism, which describes how organics and their intermediate products transfer across the cell's membrane. This testing was conducted at APG, Maryland. The specific objectives of this testing include the following:

- Quantitatively assess the rate and mechanism (diffusion vs. electrochemical) of transfer of organics and their breakdown products across the membrane.

The organic transfer tests were completed in September 2001. The process efficiencies for Composition B and the Composition B/M28 mixture were significantly better when compared to process efficiency for tetrytol in the 12-kW during Demonstration II testing.

h. Silver Recovery Testing

The purpose of the test is to provide information relating to the recovery and recycle of silver from metallic contaminated silver chloride in a process, which does not utilize sodium borohydride as a reducing agent. The tests quantified the form and yield of recovered silver in order to demonstrate a simpler and less expensive process that can be incorporated during plant operations without the need for off-site processing. This testing was conducted in Oxfordshire, United Kingdom. The specific objectives of this testing include the following:

- Demonstrate silver recovery from silver chloride spiked with potential impurities.
- Determine the levels of impurities in the recovered silver. Characterize the slag for purposes of reuse or disposal.
- Determine the feasibility of reusing reclaimed silver in the process.
- Determine the most economical scenario for full-scale silver recovery (i.e., on-site vs. off-site operation).

- Determine the utility and chemical requirements for a full-scale silver recovery facility.
- Obtain design information (AEA Technology to specify) to develop equipment specifications and estimate equipment cost.

The silver recovery tests were successfully completed in August 2001.

i. Evaporator Testing

The purpose of this test is to provide information relating to the recovery and recycle of water and nitric acid from a waste discharge stream coming from the impurities removal system. The impurities removal system is fed from a continuous bleed stream containing impurities from the anolyte tank. The purpose is to generate data and understand the recovery of water and nitric acid through a simple evaporation system. This testing was performed in Manchester, United Kingdom. The specific objectives of this testing include the following:

- Demonstrate the ease of evaporation and recovery of water and nitric acid from simulated feed solutions.
- Characterize the evaporator blowdown (for precipitated solids, residual acid, and general composition) and recovered acid (for impurities, especially fluoride).
- Verify that aluminum added to the evaporator can suppress fluoride volatility to reduce the fluoride content and corrosivity of recovered acid.
- Establish the maximum evaporation ratio (i.e., quantity evaporated/quantity fed) without:
  - Compromising the pumpability or viscosity of bottoms discharge stream.
  - Excessively decomposing the bottoms stream.
  - Volatilizing any bottoms components (such as HF or HCl) or decomposing the overheads components.
- Determine the appropriate materials of construction for the evaporator.
- Determine the utility and chemical requirements for a full-scale evaporator system.
- Obtain design information (AEA Technology to specify) to develop equipment specifications and estimate equipment cost.

Evaporator testing was successfully completed in October 2001.

j. Schedule

All laboratory scale testing was completed in November 2001. The 12-kW Composition B/M28 run is complete. The 12-kW DMMP run was initiated in October 2001 and is scheduled for completion in December 2001.

2. Neutralization Followed by Transpiring Wall Supercritical Water Oxidation and Gas Phase Chemical Reduction

The approach proposed by EcoLogic/Foster Wheeler/Kvaerner for a total solution for the destruction of all assembled chemical weapons uses: modified reverse assembly for chemical access to separate agent, energetics, and metal parts; chemical neutralization followed by supercritical water oxidation for treatment of the liquid; and gas phase chemical reduction for treatment of the gas effluent from agent/energetics neutralization and for the treatment of the metal parts and dunnage.

Modifications to reverse assembly include: extracting and grinding the propellant from rockets, using a high pressure wash to remove agent heels from projectiles, and using a Continuously Indexing Neutralization System (COINS™) to remove the energetics. The chemical agents and energetics are neutralized (hydrolyzed with water and caustic). The resulting product, known as hydrolysate, is processed in a transpiring wall supercritical water oxidation system (TW-SCWO). The TW-SCWO oxidizes the Schedule 2 compounds and other organic compounds in the hydrolysate at conditions above the critical point of water. A continuous supply of clean water is introduced at the inside liner surface of the reactor to create a continuous film on the liner protecting it from corrosion and salt deposition. Liquid effluent from the TW-SCWO is processed in an evaporator. The resulting salts are sent to a landfill. The washed out metal parts, dunnage, solid process wastes, and gaseous emissions from the neutralization process are processed in the Thermal Reduction Batch Processor (TRBP)/Gas Phase Chemical Reduction™ (GPCR)™ system. By heating in a hydrogen-rich atmosphere, metal parts and dunnage are decontaminated to a 5X level and volatile organic vapors are chemically reduced. The decontaminated solids can then be disposed. The gaseous effluent is scrubbed and potentially used as a fuel to generate steam in the boiler.

The following EcoLogic and Foster Wheeler unit operations are being tested as part of the EDS program in order to provide the engineering basis for the preliminary designs being developed for the EcoLogic/Foster Wheeler/Kvaerner Total Solution: M28 propellant grinding; transpiring wall supercritical water oxidation; evaporator/crystallizer; and gas phase chemical reduction.

a. M28 Propellant Grinding

The Propellant Grinding system is used to size reduce the M28 propellant from the rockets so that the size-reduced propellant can be neutralized in the full-scale neutralization reactors. The Propellant Grinding system was tested at the vendor's facility and at the Holston Army Ammunition Plant (HSAAP), Tennessee. The specific objectives of the testing included the following:

- Validate the ability of the grinding equipment to safely reduce M28 propellant grains to ¼″ pieces.
- Determine the output particle size distribution for grinder screen sizes of ¼″.
- Determine the throughput of propellant for grinder screen sizes of ¼″.
- Demonstrate the ability of grinding equipment to safely process foreign objects such as detached anti-resonance rods and ignitor cables.
- Determine optimum operating parameters (i.e., water flow) and equipment sizes (i.e., pump and motor sizes).

All propellant sections were successfully size reduced. The propellant grinding tests occurred in September 2001.

b. Transpiring Wall Supercritical Water Oxidation (TW-SCWO)

The TW-SCWO system is used to treat the products of the agent and energetic neutralization process. This unit is being tested at Dugway Proving Ground (DPG), Utah. The testing is comprised of two phases: Optimization Testing and Long Term Operability Testing. The specific objectives of the testing include the following:

(1) Optimization Testing

- Establish hydrolysate throughput design basis for application to both the EDS reactor and the full-scale reactor.

(2) Long Term Operability Testing

- Verify long-term, continuous operability (i.e., operation for the full length of the test without unintended shutdown) of the SCWO system as proposed for full-scale with no plugging. Long-term, continuous operability includes, but is not limited to the following:
  - Operation with materials of construction proposed for the full-scale system.
  - Operation with all expected full-scale operating procedures (i.e., any SCWO system flushing sequences at expected intervals).
  - Operation with downstream solids separation units, new reactor, and oxygen.
  - Operation without plugging/fouling upstream and downstream of the reactor.
  - Operation without liner cracking/deformation.
  - Operation without feed port plugging.
  - Operation with minimal or no corrosion of the SCWO reactor.
  - Operation without plugging of the SCWO reactor.
  - Operation without erosion of the pressure control valve.
  - Destruction of Schedule 2 compounds.
- Characterize all operability issues to determine their causes and impact on the full-scale design.
- Confirm and supplement Demonstration II process effluent characterization.
- Improve the monitoring of effluent quality and develop an effective control strategy with respect to Schedule 2 compounds and organic carbon destruction.

The TW-SCWO testing is being conducted with feeds consisting of agent hydrolysates (or simulated agent hydrolysates) and energetics hydrolysates. The Optimization Testing occurred from early March 2001 to early April 2001 on the TW-SCWO equipment that was used in Demonstration II. Modifications were then made to the existing system to better represent the full-scale design for Blue Grass. The Long Term Operability testing was initiated, using the modified TW-SCWO system in October 2001. This testing will be completed by February 2002.

c. Evaporator/Crystallizer

The Evaporator/Crystallizer is used to concentrate the SCWO effluent, by evaporation, in the full-scale system. The Evaporator/Crystallizer testing will occur at the vendor's facility and with a pilot-scale unit that will be located along with the TW-SCWO in DPG, Utah. The specific objectives of the testing include the following:

- Determine critical design parameters for the full-scale evaporator/crystallizer, including:
  - Maximum salt concentration in evaporator/crystallizer effluent.
  - Filterability of salt crystals and solids in the evaporator/crystallizer effluent.
  - Operating parameters for the filter press.
- Demonstrate the ability of the evaporator/crystallizer to operate as proposed for full-scale.

Lab testing will be conducted on actual TW-SCWO effluent to determine the critical design parameters. In addition, an Evaporator/Crystallizer pilot-scale unit will be tested with actual effluent from the TW-SCWO at DPG, Utah. This testing will occur concurrently with the TW-SCWO, which will be completed by February 2002.

d. Gas Phase Chemical Reduction™ (GPCR™)

Metal parts, dunnage, solid process wastes, and gaseous emissions from the neutralization process are processed in the TRBP/GPCR™. Four tests were required as part of the Engineering Design Studies for these unit operations. These tests included analytical methods development, explosivity tests, metallurgy tests, and elastomer tests.

(1) GPCR™ Analytical Methods Development

The GPCR™ Analytical Methods Development focused on validating agent sampling and process monitoring techniques from the GPCR™ product gas that can be used in full-scale operations. This work also validated a method for the sampling and analysis of GPCR™ for selected Schedule 2 compounds and specific process-related breakdown products. This testing was conducted at Southwest Research Institute in San Antonio, Texas. The specific objectives of the testing included the following:

- Develop and validate methods for sampling and analysis of agent (GB, VX, and HD) in GPCR™ product gas.
- Validate the safe and effective use of the MINICAMS® for continuous monitoring of agent (GB, VX, and HD) in GPCR™ product gas.
- Develop and validate methods for sampling and analysis of Schedule 2 Compounds (resulting from GB, VX, and HD) in GPCR™ product gas.
- Develop the information necessary to support acceptance/approval of the validated methods.

The testing was conducted with GB, VX, HD and non-agent compounds. The GPCR™ Analytical Methods Development was initiated in late June 2001 and was completed in October 2001.

(2) GPCR™ Explosivity Testing

The GPCR™ explosivity testing was conducted to obtain test data to design the full-scale TRBP so that it could handle residual energetics. These tests were conducted at the Holston Army Ammunition Plant, Tennessee. The specific test objective was to:

- Develop the data necessary to design the TRBP to process residual energetics from the munitions disassembly process.

The testing was conducted with seven different types of energetics and propellant found in the Blue Grass stockpile. Temperature and pressure profiles were generated for each energetic and heating rate in the hydrogen environment. The GPCR™ Explosivity Testing was completed in early August 2001.

(3) GPCR™ Metallurgy Testing

The GPCR™ Metallurgy Testing was conducted to expose selected metal alloys to the conditions expected in the TRBP and GPCR™ reactor. These tests were necessary to determine the appropriate materials of construction for the full-scale TRBP and GPCR™ reactor. The metallurgy testing was conducted at the University of Toronto in Canada. The specific test objectives were as follows:

- Determine the appropriate materials of construction for the full-scale TRBP and reactor.
- Determine (estimate) the expected TRBP and reactor required maintenance (type and frequency).

The GPCR™ Metallurgy Testing was completed in mid-September 2001.

(4) GPCR™ Elastomer Testing

The GPCR™ Elastomer Testing was conducted to expose different elastomers to aqueous and gaseous environments to determine the effects on the elastomers. These tests were conducted at the Southwest Research Institute, San Antonio, Texas. The specific test objectives were as follows:

- Determine the appropriate elastomers for the full-scale system.
- Determine (estimate) the expected elastomer life.

The testing was conducted with test coupons made of three types of elastomers selected for their chemical resistance. The test coupons were exposed to the GPCR™ process water and the GPCR™ process gas. Each exposure test lasted 500 hours. The GPCR™ Elastomer Testing was initiated in July 2001 and was completed in early September 2001.

e. Schedule

Initial test plans for the EcoLogic/Foster Wheeler/Kvaerner EDS testing were submitted in January 2001, and were finalized in June. Test preparations were made by coordinating efforts with the test sites, the state environmental offices in which the tests were conducted, the Treaty Compliance Office, and sampling and analysis contractors in order to maximize the success of the program. Testing was initiated in March 2001 and is ongoing. All tests have been completed with the exception of the TW-SCWO and the Evaporator/Crystallizer, which will be completed by February 2002. Where testing has been completed, test reports have been provided by the Technology Providers.

3. Engineering Design Package

AEA Technology/CH2MHill and EcoLogic/Foster Wheeler/Kvaerner are generating an Engineering Design Package for the Blue Grass Chemical Demilitarization Facility (BGCDF) only. The Initial Engineering Design Packages were submitted to PMACWA on June 29, 2001. The Draft Engineering Design Packages were submitted to PMACWA on September 28, 2001. Design presentations to the independent evaluators, including the National Research Council, Mitretek, Army Materiel Systems Analysis Activity (AMSAA), and the Cost Analysis Improvement Group (CAIG) were conducted after the receipt of each submittal. Design reviews with PMACWA were also conducted after each submittal and changes are being made to these packages as a result. The Final Engineering Design Packages will be submitted to PMACWA in December 2001. PMACWA will use the final design packages to conduct design and PHA assessments to develop cost and schedule estimates. The life cycle cost and schedule estimates will be available in April 2002.

IV. ACQUISITION ACTIVITIES

A. Colorado

Current acquisition activities for Colorado include preparation of a request for proposal (RFP) for a pilot plant and development of a life cycle cost and schedule to support the technology decision.

The current acquisition strategy for the Pueblo Chemical Depot involves releasing a request for proposal after a technology decision has been made. This will allow the statement of work to reflect the actual technology chosen to be built and operated at the site. PMACWA has continued to make use of the documentation and strategies established under the Joint Program Manager for Chemical Demilitarization (PMCD)/ACWA Acquisition Working Group when the strategy was to build one RFP that could satisfy any technology decision.

PMACWA has also developed life cycle costs and schedules for the two alternative technologies (neutralization followed by supercritical water oxidation and neutralization followed by biotreatment) being considered for piloting at Pueblo. These life cycle costs and schedules are currently going through an independent review and will be submitted for consideration to the Defense Acquisition Board (DAB) to support the technology decision.

B. Kentucky

With the completion of Demonstration II Testing, design and planning of a pilot destruction facility at Blue Grass Army Depot has begun. The four alternative technologies, that successfully completed demonstration have been included in the ACWA EIS for piloting an alternative technology at four potential sites, which include Blue Grass, Kentucky[3]. Engineering Design Studies of the alternative technologies have started for the preparation of Blue Grass Engineering Design Packages, which will support the Defense Acquisition Board technology selection and any required environmental permit applications.

ACWA continues its communications and participation with the Kentucky Citizens' Advisory Commission (CAC) on a routine basis. ACWA has presented briefings at many of the CAC meetings to keep the CAC informed on the status of the program and the specifics of the alternative technologies. The CAC holds regularly scheduled meetings, which are open to the public, to address the many issues and concerns of the community relative to the alternative technologies.

All of these efforts within ACWA and at Kentucky are being focused to provide the Defense Acquisition Board with the necessary information to make a technology selection for Blue Grass in the summer of 2002.

V. ENVIRONMENTAL ACTIVITIES

A. National Environmental Policy Act (NEPA)

The NEPA sets forth policy, responsibilities and procedures for integrating environmental considerations into federal actions. In accordance with NEPA, the ACWA program published a Program Draft Environmental Impact Statement (EIS) on May 11, 2001. The purpose of the ACWA Program EIS is to assess the potential impacts of the design, construction and operation of one or more pilot test facilities for assembled chemical weapon destruction technologies at one or more chemical weapons stockpile sites, potentially simultaneously with any existing demilitarization programs and schedules at these sites. Publication of the Draft EIS started a 45-day comment period.

PMACWA held a series of public meetings to receive comments on the draft document. The Public meetings were held at: Anniston Army Depot in Alabama, Pine Bluff Arsenal in Arkansas, Pueblo Chemical Depot in Colorado, and Blue Grass Army Depot in Kentucky. At the request of citizens, special interest groups, and the EPA, the Deputy Assistant Secretary of the Army extended the public comment period for 45 additional days.

PMACWA received approximately 974 comments on the Draft EIS. These comments are now being reviewed and will be addressed in the Final EIS; which will be published in early 2002.

[3]Only three technologies, neutralization followed by supercritical water oxidation, electrochemical oxidation, and neutralization followed by transpiring wall supercritical water oxidation and GPCR™ are being considered for Blue Grass, Kentucky.

B. Resource Conservation and Recovery Act (RCRA)

The RCRA regulates the handling, storage, treatment, and disposal of hazardous waste. A RCRA permit is required for the treatment, long-term storage, and disposal of hazardous waste.

PMACWA will be required to obtain RCRA permits prior to facility construction for the technologies proposed for the destruction of the chemical weapons stockpiles at Pueblo Chemical Depot in Colorado and Blue Grass Army Depot in Kentucky.

Public Law 106-398 limits the technologies to be considered for Pueblo Chemical Depot to those demonstrated before May 1, 2000; therefore, only two of the ACWA technologies are in consideration for Pueblo Chemical Depot:

- Neutralization followed by biotreatment.
- Neutralization followed by supercritical water oxidation.

Three of the ACWA technologies are in consideration for the Blue Grass Army Depot.

- Neutralization followed by supercritical water oxidation.
- Electrochemical oxidation.
- Neutralization followed by transpiring wall supercritical water oxidation and gas phase chemical reduction.

Draft RCRA permit applications have been prepared for the two ACWA technologies being considered for the Pueblo Chemical Depot. Both RCRA applications support the current level of design for the Pueblo site. As the technology engineering designs approach a complete effort, the RCRA applications will be updated to reflect the full design.

Although the RCRA permit applications for the three technologies being considered at Blue Grass Army Depot have not been prepared, reviews of the designs have been ongoing. Preparation of the Blue Grass Army Depot RCRA permit will not begin until after the technology selection process has been completed, which is expected to be in the summer of 2002.

C. Environmental Working Integrated Product Teams

PMACWA is tri-chairing a Colorado Environmental WIPT with the Program Manager for Chemical Demilitarization (PMCD) and the Colorado Department of Public Health and Environment (CDPHE). Other members include representatives from the Pueblo Chemical Depot (PCD), Environmental Protection Agency (EPA) Region 8, and the Army Corps of Engineers. The mission of this WIPT is to expedite the planning, development, and implementation of the environmental permitting process for a destruction facility at Pueblo, Colorado. The WIPT meets approximately every six weeks with meetings rotated between Pueblo, Colorado; CDPHE headquarters in Denver, Colorado; and Edgewood, Maryland.

A key area of discussion has been the initiation of infrastructure projects at PCD that would be required regardless of the ultimate technology decision. To that end, CDPHE and EPA Region 8 have granted tentative approval to begin certain non-technology-specific infrastructure projects prior to a technology decision. Contracts for some of this work are already underway. The WIPT is also pursuing the possibility of additional construction projects that could be started once a technology decision is made, but prior to the approval of the RCRA permit.

To make the process as transparent as possible to the public, sharing of information outside of the WIPT with members of the public is a key goal. To that end, the WIPT has developed a Community Involvement Plan that lays out numerous ways information is exchanged with the public. These include mailings, updates in PCD newsletters and providing information on the CDPHE web site. To go one step beyond simply providing information to the public, all WIPT meetings are announced in the Pueblo Chieftain, the local newspaper, and are open to the public. Opening the WIPT meetings to the public has facilitated the exchange of information between the organizations involved in preparation of the permit application and the public.

A similar WIPT has been formed in Kentucky to address environmental permitting issues for a destruction facility at Blue Grass, Kentucky. This team is tri-chaired by PMACWA, PMCD, and the Kentucky Department for Environmental Protection. Other organizations supporting the Kentucky WIPT include representatives from EPA Region 4, Blue Grass Army Depot, Blue Grass Chemical Activity, and Madison County. The Kentucky WIPT also developed a community involvement plan, similar to the plan developed by the Colorado WIPT, to encourage public participation at its meetings, held approximately every two to three months. As part of that plan, the WIPT meetings are open to the public. They are announced in the Richmond Register and other regional newspapers.

VI. NATIONAL RESEARCH COUNCIL (NRC)

The NRC Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons: Phase 2 (ACW II Committee) continues to support the Assembled Chemical Weapons Assessment Program as required by Public Law 105-261 (1999). This support entails comprehensive, independent, scientific, and technical evaluations of processes other than incineration that may be used to destroy assembled chemical weapons at U.S. storage sites. The evaluations are divided into three tasks. For the first task, the NRC is to review and evaluate demonstration test results for three technologies that have previously passed the PMACWA threshold (Go-No Go) criteria and that have been selected for demonstration testing (Demonstration II). Based on its findings, the NRC is to determine whether each of the technologies is ready to proceed to the next stages of engineering development. Tasks 2 and 3 involve assessments of Engineering Design Packages for previously demonstrated technologies that could be suitable for implementation at weapons storage sites in Pueblo, Colorado or Blue Grass, Kentucky. The results of each task will be presented in an individual NRC report. The reports concerning the site-specific engineering design packages are expected to play a critical role in the DOD

Records of Decision for the selection of a technology for chemical agent destruction at Pueblo and Blue Grass.

The NRC ACW II Committee consists of 14 scientists and engineers that are recognized for their distinguished work in chemical process engineering, safety and risk analysis, environmental waste management, biochemical engineering, hazardous waste treatment, energetics, and public involvement. The committee chair is Dr. Robert Beaudet who chaired the former ACW I Committee. Approximately two thirds of the members of the initial ACW Committee were nominated and approved by the NRC to serve on the ACW II Committee. The ACW I Committee provided the first NRC reports on alternative technologies for destroying assembled chemical weapons.

The ACW II Committee has met five times during the current year for the purposes of technical discussions, report development, and updates from the PMACWA technical team and its consultants. In addition to committee meetings, members have made visits to testing sites to observe operational units, and participated in engineering reviews conducted by ACWA for each of the technology providers. The committee's findings are based on intensive studies of the test results, operational logs, and engineering diagrams supplied by the technology providers and on the technical discussions taking place at the reviews or during a site visit. Committee representatives attend and make a presentation of the NRC activities at all of the ACWA Dialogue meetings.

The Committee's first report, *Analysis of Engineering Design Studies for Demilitarization of Assembled Chemical Weapons at Pueblo Chemical Depot*, was presented to PMACWA on August 23, 2001 and released to the public on August 28, 2001. The second report, *Evaluation of Demonstration Test Results of Alternative Technologies for Demilitarization of Assembled Chemical Weapons: A Supplemental Review for Demonstration II* was presented to PMACWA on October 4, 2001 and released to the public in November 2001. The executive summaries for both reports, as written and published by the NRC, can be found in Appendices B and C of this report. Electronic versions of both full reports are available on the National Academies website at http://www.national-academies.org.

The report containing the technology evaluations for Blue Grass, Kentucky is expected to be completed in May 2002, approximately one month prior to the expected Record of Decision.

Appendix A

Dialogue on Assembled Chemical Weapons Assessment
List of Participants

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Appendix B

Executive Summary of the National Research Council Report

Analysis of Engineering Design Studies for Demilitarization of Assembled Chemical Weapons at Pueblo Chemical Depot

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Appendix B

Analysis of Engineering Design Studies for Demilitarization of Assembled Chemical Weapons at Pueblo Chemical Depot

Executive Summary

The Program Manager for Assembled Chemical Weapons Assessment (PMACWA) of the Department of Defense (DOD) requested the National Research Council (NRC) to assess the engineering design studies (EDS) developed by Parsons/Honeywell and General Atomics for a chemical demilitarization facility to completely dispose of the assembled chemical weapons at the Pueblo Chemical Depot in Pueblo, Colorado. To accomplish the task, the NRC formed the Committee on Review and Evaluation of Alternative Technologies for the Demilitarization of Assembled Chemical Weapons: Phase 2 (ACW II Committee). This report presents the results of the committee's scientific and technical assessment, which will assist the Office of the Secretary of Defense in selecting the technology package for destroying the chemical munitions at Pueblo. The record of decision (ROD) for selecting the technology package is expected in the second half of 2001.

The committee evaluated the engineering design packages proposed by the technology providers and the associated experimental studies that were performed to validate unproven unit operations. A significant part of the testing program involved expanding the technology base for the hydrolysis of energetic materials associated with assembled weapons. This process was a concern expressed by the ACW I Committee in its original report in 1999. The present study took place as the experimental studies were in progress. In some cases, tests for some of the supporting unit operations were not completed in time for the committee to incorporate results into its evaluation. In those cases, the committee identified and discussed potential problem areas in these operations. Based on its expertise and it aggressive data-gathering activities, the committee was able to conduct a comprehensive review of the test data that had been completed for the overall system design.

This executive summary is divided into four sections. The first section provides historical background for the DOD's program for chemical demilitarization and NRC's involvement. The next section shows the statement of task for the ACW II Committee's studies. The third section briefly describes the technologies and test programs assessed in this report, and the final section presents the committee's general findings. Detailed findings and recommendations found in the chapters relating to the individual technologies are not repeated here, but they may be found at the end of each chapter.

Historical Background

The U.S. Army is in the process of destroying the United States' stockpile of aging chemical weapons, which is stored at eight locations in the continental United States and on Johnston Atoll in the Pacific Ocean. The deadline for completing the destruction of these weapons, as specified by the Chemical Weapons Convention (CWC) international treaty, is April 29,

2007. Originally, the Army selected incineration as the preferred baseline destruction technology, and it currently operates two incineration facilities—one on Johnston Atoll and one at the Deseret Chemical Depot near Tooele, Utah. The Johnston Atoll Chemical Agent Disposal System completed destruction of the stockpile on Johnston Island in late 2000, and plans for closure of the facility are under way[4]. Similar baseline incineration system facilities were planned for all of the remaining storage sites. However, incineration has met with public and political opposition. In response to this opposition, neutralization processes (based on the hydrolysis of chemical agent using either water or sodium hydroxide solution) have been developed to destroy the chemical agents stored in bulk containers at Aberdeen, Maryland, and Newport, Indiana. For the remaining sites, where munitions containing both chemical agent and energetic materials (i.e., assembled chemical weapons) are stored, incineration is still the planned approach for destruction. In late 1996, however, Congress enacted Public Law 104-201, which instructed DOD to "conduct an assessment of the chemical demilitarization program for destruction of assembled chemical munitions and of the alternative demilitarization technologies and processes (other than incineration) that could be used for the destruction of the lethal chemical agents that are associated with these munitions."

Another law, Public Law 104-208, required a new program manager (the Program Manager for Assembled Chemical Weapons Assessment) to "identify and demonstrate not less than two alternatives to the baseline incineration process for the demilitarization of assembled chemical munitions." In addition, the law prohibited any obligation of funds for the construction of incineration facilities at two storage sites—Lexington/Blue Grass, Kentucky, and Pueblo, Colorado—until the demonstrations were completed and an assessment of the results had been submitted to Congress by DOD.

As a result of Public Laws 104-201 and 104-208, DOD created the Assembled Chemical Weapons Assessment (ACWA) program. To ensure public involvement in the program, the program manager for ACWA (PMACWA) enlisted the Keystone Center—a nonprofit, neutral facilitation organization—to convene a diverse group of interested stakeholders, called the Dialogue on ACWA (or, simply, the Dialogue), who would be intimately involved in all phases of the program. The 35 members of the Dialogue include representatives of the affected communities, national citizen groups such as the Sierra Club, state regulatory agencies, affected Native American tribes, the Environmental Protection Agency, and DOD.

The PMACWA established an elaborate program for evaluating and selecting technologies that would be appropriate for destroying the stockpile at Pueblo Chemical Depot and Blue Grass Chemical Depot. The selection process is described in detail in the 1999 NRC report *Review and Evaluation of Alternative Technologies for the Demilitarization of Assembled Chemical Weapons*. Six technology packages were originally considered for the demonstration tests. Three of these technologies underwent demonstration testing in the first round (Demonstration I) and two technology packages survived as candidates for the destruction of chemical weapons at the Pueblo Chemical Depot: those of General Atomics and Parsons/Honeywell. In Public Law 105-261 (1999), Congress mandated as follows:

[4]The stockpile on Johnston Island comprised 2,031 tons, or 6.4 percent, of the original 31,496 tons of chemical nerve and blister (mustard) agents in the U.S. stockpile.

"The program manager for the Assembled Chemical Weapons Assessment shall continue to manage the development and testing (including demonstration and pilot-scale testing) of technologies for the destruction of lethal chemical munitions that are potential or demonstrated alternatives to the baseline incineration program." It also directed that the Army continue its coordination with the NRC. The PMACWA subsequently initiated engineering design studies (EDSs) for the two technologies that successfully completed demonstration testing. The purpose of this EDS phase is to (1) support the development of a Request for Proposal (RFP) for a pilot facility; (2) support the certification decision of the Under Secretary of Defense for Acquisition and Technology, as directed by Public Law 105-261; and (3) support documentation required for the National Environmental Policy Act (NEPA) and the data required for a permit under the Resource Conservation Act (RCRA). Each EDS comprises two parts: an engineering design package (EDP) and the results of experimental studies conducted to generate required data that were not obtained during the demonstration test phase.

In response to Public Law 104-201, which required that DOD coordinate its efforts with the NRC in assessing alternatives to incineration, PMACWA asked the NRC to evaluate each of the seven technologies that had passed DOD's initial screening. The Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons (ACW I) Committee published its report in August 1999. That report found that the primary treatment processes could decompose the chemical agents with destruction efficiencies of 99.9999. However, major concerns for each technology package remained, including the adequacy of secondary treatment of agent hydrolysates and the primary and secondary treatment of energetic materials contained in the chemical weapons. A supplemental report, requested by PMACWA to evaluate the actual demonstration tests for the three technologies that were considered to warrant further investigation, was published in February 2000. Two of the technologies, those of General Atomics and Parsons/Honeywell, were considered ready to proceed to an engineering design phase. Upon completion of the supplemental report, the ACW I Committee was dissolved. Subsequently, under the continuing mandate from Congress, the PMACWA requested that the NRC form a second committee (the ACW II Committee) to evaluate the engineering design packages (EDPs) and related tests for the engineering design studies for the Pueblo and Blue Grass Depots and to examine and evaluate the Demonstration II tests of three additional technologies.

STATEMENT OF TASK

The statement of task for the NRC ACW II Committee is shown below. The present report is the committee's response to Task 2, and will be produced in time to contribute to the Record of Decision (ROD) by the Office of the Secretary of Defense on a technology selection for the Pueblo site. The latter will occur following satisfaction of NEPA requirements.

> At the request of the DoD's Program Manager for Assembled Chemical Weapons Assessment (PMACWA), the NRC Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons will provide independent scientific and technical assessment of the Assembled Chemical Weapons Assessment (ACWA)

program. This effort will be divided into three tasks. In each case, the NRC was asked to perform a technical assessment that did not include programmatic (cost and schedule) considerations.

Task 1

To accomplish the first task, the NRC will review and evaluate the results of demonstrations for three alternative technologies for destruction of assembled chemical weapons located at U.S. chemical weapons storage sites. The alternative technologies to undergo demonstration testing are: the AEA Technologies electrochemical oxidation technology, the Teledyne Commodore solvated electron technology, and the Foster Wheeler and EcoLogic transpiring wall supercritical water oxidation and gas phase chemical reduction technology. The demonstrations will be performed in the June through September 2000 timeframe. Based on receipt of the appropriate information, including: (a) the PMACWA-approved Demonstration Study Plans, (b) the demonstration test reports produced by the ACWA technology providers and the associated required responses of the providers to questions from the PMACWA, and (c) the PMACWA's demonstration testing results database, the committee will:

- perform an in-depth review of the data, analyses, and results of the unit operation demonstration tests contained in the above and update as necessary the 1999 NRC report, *Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons* (the ACW report)

- determine if any of the AEA Technologies, Teledyne Commodore, and Foster Wheeler/EcoLogic technologies have reached a technology readiness level sufficient to proceed with implementation of a pilot-scale program

- produce a report for delivery to the PMACWA by July 2001 provided the demonstration test reports are made available by November 2000. (An NRC report delivered in March 2000 covered the initial three technologies selected for demonstration phase testing.)

Task 2

For the second task, the NRC will assess the ACWA Engineering Design Study (EDS) phase in which General Atomics and Parsons/Honeywell (formerly Parsons/Allied Signal) will conduct test programs to gather the information required for a final engineering design package representing a chemical demilitarization facility at the Pueblo, Colorado stockpile site. The testing will be completed by September 1, 2000. Based on receipt of the appropriate information, including: (a) the PMACWA-approved EDS Plans, (b) the EDS test reports produced by General Atomics and

Parsons/Honeywell, (c) PMACWA's EDS testing database, and (d) the vendor-supplied engineering design packages, the committee will:

- perform an in-depth review of the data, analyses, and results of the EDS tests
- assess process component designs, integration issues, and overarching technical issues pertaining to the General Atomics and the Parsons/Honeywell engineering design packages for a chemical demilitarization facility design for disposing of mustard-only munitions
- produce a report for delivery to the PMACWA by March 2001 provided the engineering design packages are received by October 2000

Task 3

For the third task, the NRC will assess the ACWA EDS phase in which General Atomics will conduct test programs to gather the information required for a final engineering design package representing a chemical demilitarization facility at the Lexington/Blue Grass, Kentucky stockpile site. The testing will be completed by December 31, 2000. Based on receipt of the appropriate information, including: (a) the PMACWA-approved EDS Plans, (b) the EDS test reports produced by General Atomics, (c) PMACWA's EDS testing database, and (d) the vendor-supplied engineering design package, the committee will:

- perform an in-depth review of the data, analyses, and results of the EDS tests
- assess process component designs, integration issues, and overarching technical issues pertaining to the General Atomics engineering design package for a chemical demilitarization facility design for disposing of both nerve and mustard munitions
- produce a report for delivery to the PMACWA by September 2001 provided the engineering design package is received by January 2001.

Description of the Technology Packages

The assembled chemical weapons at Pueblo contain only mustard agent and energetic materials. The operations required for their destruction include (1) unpacking and disassembling the weapons, (2) separation of agents, energetics, and metal parts, (3) destruction of agent and energetic hydrolysates, (4) decontamination of the metal parts, (5) destruction of the dunnage, and (6) treatment and disposal of all associated solid, liquid, and gaseous by-products.

For both the General Atomics and the Parsons/Honeywell design packages, the primary treatment to destroy the agent and the energetic materials is hydrolysis with caustic. However, the hydrolysis products (hydrolysates) must be further treated before the final products can be properly disposed of. For this secondary step, General Atomics proposes to use supercritical water oxidation (SCWO) and Parsons/Honeywell proposes to use biotreatment via immobilized cell bioreactors (ICBs).

Both technology packages consist of multiple unit operations that work in sequence or concurrently to carry out all aspects of chemical weapons destruction. Both processes are designed to treat agent, energetic materials, metal parts (including munitions bodies), dunnage (e.g., wooden pallets and packing boxes used to store munitions), and nonprocess waste (e.g., plastic demilitarization protective ensemble (DPE) suits; the carbon from DPE suit filters and plant heating, ventilating, and air conditioning (HVAC) filters; and miscellaneous plant wastes). Each engineering design package (EDP) includes engineering drawings and documentation, a preliminary hazards analysis, and life-cycle costs and schedule for the technology to be implemented at the Pueblo Chemical Depot. Short descriptions are given below. More detailed descriptions of the unit operations for each technology are given in Chapters 3 and 4.

General Atomics uses the acronym GATS (General Atomics total solution) to denote its technology process for the demilitarization of assembled chemical weapons. The following major operations are included:

- A modified baseline disassembly process is used; however, cryofracture is used to open the projectile bodies to access the agent. The bodies are cooled to liquid nitrogen temperature and fractured. Then the metal parts are separated from the agent.
- Agents and energetics are hydrolyzed in a bath reactor with caustic to form a hydrolysate.
- Fuzes are digested in an energetics rotary hydrolyzer with caustic.
- Munition bodies are decontaminated to a 5X condition by using an electrically heated discharge conveyor.
- The dunnage is shredded and slurried.
- All the resulting hydrolysates and the slurried dunnage are further treated with supercritical water oxidation (SCWO) to produce environmentally benign products.
- System off-gases are processed through carbon filters.

The unit operations tested during the EDS phase are the dunnage shredder hydrolysis system (DSHS), the energetic rotary hydrolyzer (ERH), and the supercritical water oxidation (SCWO) reactor. The testing of the SCWO reactor had not been completed when this report was prepared.

The Parsons/Honeywell technology team uses the acronym WHEAT (water hydrolysis of explosives and agent technology) to denote its technology package for the demilitarization of assembled chemical weapons. It consists of the following main operations:

- The Army's baseline disassembly process, with modifications, is used to separate agent, energetics, and metal parts.

- The solid heel or sludge that remains inside the munitions casing is washed out in the projectile rotary washout machine (RWM) using recirculated wash water through high-pressure water jets.
- Bursters from the mortars and projectiles are fed into the burster washout machine (BWM) by a pick-and-place machine and processed in the BWMs to wash out all explosives.
- The energetics rotary deactivator (ERD) receives fuzes, booster cups, and miscellaneous parts, and it heats them until they are deflagrated.
- Agents and energetics are hydrolyzed in a bath reactor with caustic to form a hydrolysate.
- Agent and energetics hydrolysates are diluted with water, mixed with inorganic nutrients, and fed to the ICBs, which contain aerobic microorganisms that will consume most of the organic content of the hydrolysates.
- Biological processing, followed by evaporation/crystallization, converts the hydrolysis products to liquids or solids acceptable for discharge to the environment or liquids acceptable for recycling. Biological treatment is done in the ICBs.
- Metal parts are all treated either in the batch metal parts treater (batch MPT) or the rotary metal parts treater (rotary MPT) to decontaminate metal parts to 5X.
- Dunnage is heat treated in the continuous steam treater (CST) to decontaminate it to 5X.
- Gas discharges from the plant are passed through catalytic oxidizer (CATOX) units. Some of the gas streams are also passed through activated carbon filters.

The ICB, the CST, the CATOX unit, and the projectile washout system were tested during EDS. However, the CST and the projectile washout operations were not finished at the time this report was prepared.

The committee formed two working groups to perform in-depth evaluations of each EDP. As part of their efforts, the groups visited the EDS test sites at Aberdeen Proving Ground, Maryland; Dugway Proving Ground, Utah; and Deseret Chemical Depot, Utah. Committee members also attended PMACWA status-review meetings, which were held periodically, and a review meeting at Parsons/Honeywell in Pasadena, California, where both Parsons/Honeywell and General Atomics personnel described their EDPs and the results of ongoing tests. The technology providers and PMACWA staff kindly provided draft copies of reports as they were generated. The final EDPs were released in October 2000.

In evaluating the general efficacy of the design plans for a chemical demilitarization facility suited to the Pueblo Chemical Depot and the readiness of each technology to go forward to the next level of pilot plant testing, the committee relied upon its knowledge of the proposed systems, available test results, aggressive data collection activities, and thorough review of the engineering design plans.

General Findings

General findings on the EDS phase of the ACWA program for the two technology packages evaluated in this report appear below. The general findings must be considered with acknowledgment of the fact that some ACWA EDS testing was not completed in time for the committee to obtain final test results and that some process steps remain to be demonstrated on a pilot scale. Specific findings and recommendations for each technology package, as well as the PMACWA-sponsored investigations on hydrolysis of energetic materials, appear in the body of the report. The energetics hydrolysis test program is progressing at a pace satisfactory to meet the engineering requirements for construction of a disposal facility at Pueblo Chemical Depot. Issues surrounding the hydrolysis of neat tetryl, optimum granulation sizes, more complete characterization of hydrolysis products from aromatic nitro compounds, and optimum process control strategies for full-scale operations are yet to be investigated.

General Finding (Pueblo) 1. Based on the results of the demonstration tests, the engineering design package, and available data, the committee believes that the Parsons/Honeywell WHEAT technology package can provide an effective and safe means of destruction for the assembled chemical weapons stored at the Pueblo Chemical Depot. However, some of the process steps remain to be demonstrated.

The Parsons/Honeywell technology process provides effective means to:

- disassemble munitions by a modified baseline disassembly process that removes the agent from the projectile bodies by washout
- destroy chemical agent HD to a 99.9999 percent DRE by caustic hydrolysis
- destroy fuzes with the energetics rotary hydrolyzer
- destroy energetic materials to a 99.999 percent DRE by hydrolysis in 15 weight percent hot caustic solution, provided that the following safeguards are observed:
  - —different energetic materials are not processed together
  - —precautions are taken to ensure that all emulsified TNT is completely destroyed
- control the very large volumes of off-gases emitted from the biotreatment plant through a CATOX unit

However, the committee notes that the effectiveness of some process steps, including removal of energetics from munitions, has not been tested during the EDS. Treatment of metal parts, dunnage, and DPE suit material remain to be demonstrated. No tests are currently planned to demonstrate the efficacy of the burster washout and energetic materials size reduction steps. The projectile washout system is currently being tested. Other remaining munition disassembly operations are very similar to those used in the baseline system and have therefore been proven. The energetics rotary deactivator concept appears workable but has not been demonstrated at the pilot scale. Energetics hydrolysis is relatively immature, but current testing at Holston AAP has the capability to resolve many, but not all, of these issues (see Chapter 2).

The testing of the continuous steam treater for dunnage and the projectile washout system will not be complete until October 2001. Dioxins and furans are present in the off-gas from the CATOX units on the bioreactors but are below levels of regulatory concern. The batch metal parts treater for small metal parts is being tested, and preliminary data are encouraging.

The carousel fixture for the rotary metal parts treater for large metal parts has not been demonstrated. The use of catalytic oxidizers for various streams is currently being tested, but sufficient test data have not been provided to the committee. Because the honeycomb structure of the CATOX unit is susceptible to plugging, proper design must be employed to prevent particulates from entering the catalyst structure.

General Finding (Pueblo) 2. Based on the results of the demonstration tests, the engineering design package, and available data, the committee believes that many aspects of the General Atomics technology package can be effective and safe for the destruction of assembled chemical weapons at the Pueblo Chemical Depot. However, to achieve prolonged operability of the supercritical water oxidation (SCWO) system as designed will require extensive maintenance. In addition, the SCWO processing of dunnage slurried in energetics hydrolysate, which constitutes the vast majority of the feedstock to be processed, remains unproven. The viability of the General Atomics technology package will depend on acceptable operability of the SCWO systems.

The General Atomics technology process provides effective means to:

- disassemble munitions by using a modified baseline disassembly process for munitions and removal of the agent from the projectile bodies by cryofracture.
- destroy chemical agent HD to a 99.9999 percent DRE by caustic hydrolysis
- destroy fuzes with the energetics rotary hydrolyzer
- destroy energetic materials to a 99.999 percent DRE by hydrolysis in 15 wt percent hot caustic solution, provided that the following safeguards are observed:
  —different energetic materials are not processed together
  —precautions are taken to ensure that all emulsified TNT is completely destroyed
- provide effective 5X-level decontamination for munition bodies through the use of an electrically heated discharge conveyor
- readily control the very low volumes of off-gases produced through activated carbon adsorption systems

For dunnage, the materials are shredded and reduced in size to 1.0 mm. The slurry is then fed into the SCWO reactors to destroy all the dunnage.

However, the committee has serious concerns about the SCWO system that is used to process the hydrolysates and the slurried dunnage. At the time this report was prepared, not all of the long-term processing tests had been completed. On the basis of results to date, the committee has concerns about the ability of the SCWO reactor to operate continuously for adequate lengths of time. An additional concern is the ability of the size reduction system to remove 100 percent of the tramp metal that comes with the dunnage. If the tramp metal is not removed from the dunnage, the committee believes it will clog the injectors of the SCWO system and further reduce the system's online availability.

The SCWO tests that have been performed to date, especially those involving chlorinated organic compounds such as HD hydrolysate, have consistently encountered severe corrosion of the reactor material or plugging of the reactor with salts. General Atomics proposes to solve the problem of plugging by periodically (every 22 hours of operation) reducing the pressure of the reactor to slightly below the critical point of water and flushing with clean water for two hours to remove the accumulated salts. The technology provider proposes to deal with the corrosion problem by inserting into the SCWO reactor a sacrificial titanium liner and shutting down at approximately every 140 hours of operation to open the reactor and replace or reverse the liner.[5] In the committee's opinion, the flushing step does not pose an unreasonable operating requirement; however, it considers the need for a liner replacement at six-day intervals to be excessively disruptive and not in keeping with sound principles of effective operation. In the full-scale system, liner replacement will require the following steps:

1. Cooling down and depressurizing the reactor,
2. Unbolting and removing an approximately 16-inch diameter, several-inch-thick pressure head from the top of the reactor,
3. Withdrawing the 12.5-inch diameter, 19-foot long titanium liner from the tubular SCWO reactor,
4. Reinserting the same liner reversed end to end or a new liner,
5. Setting the pressure gasket back into place and reattaching the gasket coolant lines,
6. Resetting and bolting the pressure head onto the reactor,
7. Pressure testing the SCWO reactor to assure proper head seating and sealing, and
8. Restarting the heat-up of the system and restarting the waste feed.

This appears to the committee to be a very time-consuming procedure. The experience of a number of committee members has been that large pieces of high-pressure equipment are very difficult and time consuming to seal. Tests have only been conducted with reactors 2 inches to 4 inches in diameter. The time required for this procedure at the far larger size of the full-scale SCWO unit is highly uncertain.

General Atomics proposes to build duplicate SCWO reactors so that one is operating while the second is being serviced; however, the committee has reservations about whether this level of redundancy is adequate to maintain the proposed operating schedule.

General Finding (Pueblo) 3. As the ACW I Committee observed, the unit operations in both the General Atomics GATS and the Parsons/Honeywell WHEAT technology packages have never been operated as total integrated processes. As a consequence, a prolonged period of systemization will be necessary for both to resolve integration issues as they arise, even for apparently straightforward unit operations.

This finding continues to be valid following development of and testing for the EDS design packages for the General Atomics and Parsons/Honeywell technologies. Also, in both cases, some of the routine unit operations have not yet been designed or tested. Thus, although they

[5]The corrosion is restricted to the top part of the liner so each liner can be used twice by opening the reactor and reinstalling it in the reactor with the uncorroded lower part up.

appear straightforward, these unit operations could require some redesign during systemization.

General Finding (Pueblo) 4. Several of the unit operations in both the General Atomics and Parsons/Honeywell processes are intended to treat process streams that are not unique to the chemical weapons stockpile and that could potentially be treated at existing off-site facilities. These streams include agent-free energetics, dunnage, brines from water recovery, and hydrolysates. Off-site treatment would simplify the overall processes and facilitate process integration by eliminating the need for further development of these unit operations. It might also simplify design requirements to meet safety concerns.

All of the process streams that could potentially be treated off-site have compositions similar to waste streams routinely treated by commercial industrial waste treatment facilities and do not exhibit any unique toxicity. Thus, they could be transported by standard commercial conveyance to commercial facilities that are appropriately permitted to receive the waste.

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Appendix C

Executive Summary of the National Research Council Report

Evaluation of Demonstration Test Results of Alternative Technologies for Demilitarization of Assembled Chemical Weapons: A Supplemental Review for Demonstration II

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Appendix C

Evaluation of Demonstration Test Results of Alternative Technologies for Demilitarization of Assembled Chemical Weapons: A Supplemental Review for Demonstration II

Executive Summary

By direction of Congress, the U.S. Department of Defense's (DoD's) program manager for the Assembled Chemical Weapons Assessment (PMACWA) asked the National Research Council (NRC) Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons: Phase II (the ACW II committee) to conduct an independent scientific and technical assessment of three alternative technologies (referred to as Demo II) under consideration for the destruction of assembled chemical weapons at U.S. chemical weapons storage sites. The three technologies are AEA Technologies' electrochemical oxidation process; the transpiring-wall supercritical water oxidation and gas-phase chemical reduction processes of Foster Wheeler/Eco Logic/Kvaerner (FW/EL/K); and Teledyne-Commodore's solvated electron process. Each of these technologies represents an alternative to incineration for the complete destruction of chemical agents and associated energetic materials. The demonstration tests were approved by the PMACWA after an initial assessment of each technology. The results of that initial assessment were reviewed by an earlier NRC committee, the Committee for Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons (the ACW I committee) (NRC, 1999).

For the present review, the committee conducted an in-depth examination of each technology provider's data, analyses, and demonstration test results for the critical components tested. This review report supplements the ACW I report and considers the demonstration performance of the Demo II candidate technologies and their readiness for advancement to pilot-scale implementation. Because testing in these areas is ongoing, the committee decided to cut short its fact-finding efforts for input to this report as of March 30, 2001. This cut-off was necessary in order to provide the sponsor with the needed information in a timely fashion.

In 1996 the U.S. Congress enacted two laws, Public Law 104-201 (authorization legislation) and Public Law 104-208 (appropriation legislation), mandating that the DoD assess alternative technologies to the baseline incineration process for the demilitarization of assembled chemical munitions. In December 1996 the deputy to the commander of the Soldier Biological Chemical Command was appointed as the PMACWA. Subsequently seven technologies designed for the complete destruction of assembled chemical weapons were evaluated (ACW I report), and on July 29, 1998, three of them were selected for the Demonstration I (Demo I) phase of the ACWA program.

The PMACWA requested that the NRC perform an independent evaluation of the seven technology packages that had been selected originally during earlier phases of the Assembled Chemical Weapons Assessment (ACWA) program and deliver a report by September 1, 1999. However, to meet that deadline, the NRC ACW I committee had to terminate its data-gathering activities on March 15, 1999, before the demonstration tests had been completed (NRC, 1999).

In September 1999, the PMACWA asked the ACW I committee to examine the results of tests demonstrating the operations of three of the original seven alternative technologies and to determine if they had changed the committee's original findings, recommendations, and comments. Accordingly, the NRC published a supplemental report in March 2000 (NRC, 2000), at which time the ACW I committee was disbanded.

> In 1999, Congress passed Public Law 105-261 mandating as follows:
>
> The program manager for the Assembled Chemical Weapons Assessment shall continue to manage the development and testing (including demonstration and pilot-scale testing) of technologies for the destruction of lethal chemical munitions that are potential or demonstrated alternatives to the baseline incineration program. In performing such management, the program manager shall act independently of the program manager for Chemical Demilitarization and shall report to the Under Secretary of Defense for Acquisition and Technology.

The Army was also directed to continue its coordination with the NRC.

Congress extended the PMACWA's task through Public Law 106-79 by mandating that he "conduct evaluations of [the] three additional alternative technologies under the ACWA program, ". . . proceed under the same guidelines as contained in Public Law 104-208 and continue to use the Dialogue process and Citizens' Advisory Technical Team and their consultants." In response, the PMACWA initiated a new test program, commonly referred to as Demo II, to investigate whether three of the alternative technologies remaining from the original testing were ready to proceed to an engineering design phase.[6] The remaining technologies were from AEA, FW/EL/K, and Teledyne-Commodore. The seventh of the original technologies had been judged to be too immature for further testing during the original multitiered selection process.

In response to Congress, a second NRC committee, the Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons: Phase II (ACW II committee) was formed and tasked to produce three reports: (1) an evaluation of the Demo II tests (Task 1), (2) an evaluation of two engineering design

[6]The AEA, Eco Logic, and General Atomics technology packages were chosen by the PMACWA to undergo engineering design studies for the destruction of the assembled chemical weapons at the Blue Grass Army Depot. This decision was made by the PMACWA prior to the issuance of this NRC report.

studies (EDSs) and tests for use at the Pueblo, Colorado, storage site (Task 2), and (3) an evaluation of EDS packages and tests for the Blue Grass, Kentucky site (Task 3).

The statement of task for Task 1 is as follows:

At the request of the DoD's Program Manager for Assembled Chemical Weapons Assessment (PMACWA), the NRC Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons will provide independent scientific and technical assessment of the Assembled Chemical Weapons Assessment (ACWA) program. This effort will be divided into three tasks. In each case, the NRC was asked to perform a technical assessment that did not include programmatic (cost and schedule) considerations.

Task 1

To accomplish the first task, the NRC will review and evaluate the results of demonstrations for three alternative technologies for destruction of assembled chemical weapons located at U.S. chemical weapons storage sites. The alternative technologies to undergo demonstration testing are: the AEA Technologies electrochemical oxidation technology, the Teledyne Commodore solvated electron technology, and the Foster Wheeler and Eco Logic transpiring wall supercritical water oxidation and gas phase chemical reduction technology. The demonstrations will be performed in the June through September 2000 timeframe. Based on receipt of the appropriate information, including: (a) the PMACWA-approved Demonstration Study Plans, (b) the demonstration test reports produced by the ACWA technology providers and the associated required responses of the providers to questions from the PMACWA, and (c) the PMACWA's demonstration testing results database, the committee will:

perform an in-depth review of the data, analyses, and results of the unit operation demonstration tests contained in the above and update as necessary the 1999 NRC report, Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons (the ACW report)

determine if any of the AEA Technologies, Teledyne Commodore, and Foster Wheeler/Eco Logic technologies have reached a technology readiness level sufficient to proceed with implementation of a pilot-scale program

> produce a report for delivery to the PMACWA by July 2001 provided the demonstration test reports are made available by November 2000. (An NRC report delivered in March 2000 covered the initial three technologies selected for demonstration phase testing.)

In this current supplemental review, which responds to Task 1, the ACW II committee provides an extensive review of the data, analyses, and demonstration test results for critical components of the demilitarization processes of AEA, FW/EL/K, and Teledyne-Commodore. Like the first supplemental review (NRC, 2000), this review evaluates the effects of the new test results on the findings and recommendations in the original ACW I committee report (NRC, 1999) and assesses the level of maturity attained by each technology for proceeding to the engineering design phase of development. A separate chapter is devoted to each technology, and the chapters are organized as follows: descriptions of the demonstrated unit operations; descriptions of the tests used in the study, including committee commentary; a discussion of the effects of the demonstration results on previous findings; and, finally, new findings derived from this supplemental review. Chapter 5 considers the earlier general findings and recommendations and presents new ones in light of the demonstration test results.

In general, very few of the original findings and recommendations were changed as a result of the new tests. In some cases, the original findings and recommendations were confirmed. The new findings and recommendations are presented below by technology. The level of development of unit operation processes from the candidate technologies is summarized in Table ES-1. General findings and recommendations are also presented below.

Supplemental Findings and Recommendations

AEA Demonstration Tests

Finding DII AEA-1. The overall process flow has been further complicated by major design changes in response to the Demo II testing. These changes include the addition of the IRS, CATOX units, and a flow return circuit from the catholyte to the anolyte circuit. All three changes require small-scale and pilot-scale testing. Such modifications further complicate the interfaces between process units, which increases the time required for development, start-up, and commissioning of the full-scale system. Integration of the operating units will make achievement of a viable total solution very difficult.

Finding DII AEA-2. The discovery of organic material migration across the electrochemical cell membrane will require major modifications in design and operation, such as recycling of the catholyte material to the anolyte circuit and the addition of hydrocyclones in the catholyte circuit.

Finding DII AEA-3. The formation of intermediate oxidation by-products raises operational issues, including slower processing rates and reduced electrochemical efficiency. During the testing with tetrytol in the 12 kW unit, the problems were severe enough to cause the runs to be extended well beyond the planned processing times.

Finding DII AEA-4. The generation of new energetic compounds (TNBA, PA, TNB) in the course of processing increases the complexity and hazards of the SILVER II™ process. Although the explosion hazard is reduced as the energetic feed is consumed, it is not completely eliminated until all energetic intermediates are destroyed.

Finding DII AEA-5. During the treatment of M28 in the Demo II test, lead oxide and other materials accumulated on cell anodes. The committee believes that a maintenance procedure for routine cleaning of the anodes will be required.

Finding DII AEA-6. Low steady-state electrochemical efficiencies (20 to 30 percent) were observed during treatment of tetrytol. These low efficiencies will decrease the throughput per cell and increase processing time and energy consumption.

Finding DII AEA-7. VOCs were detected in the off-gas of the AEA process technology. AEA has now included a CATOX unit in the preliminary design. The committee believes that the introduction of this additional unit operation will further complicate the scale-up and integration.

Finding DII AEA-8. The IRS for removing salts (sulfates, phosphates, silver fluoride), excess water, and any metals that may be present requires extensive development and integration. The IRS has not yet been described in sufficient detail to allow for a meaningful assessment.

Recommendation DII AEA-1. The possible formation of lead picrate when mixed energetic feeds are treated must be investigated before any processing of lead-containing propellant, TNT-based energetics, or tetryl is undertaken.

Recommendation DII AEA-2. The IRS, the CATOX units, the return flow, and all other major modifications to the system must be tested and proven during the EDS design phase.

Recommendation DII AEA-3. AEA must validate complete destruction of all energetic intermediates during the EDS design phase.

Recommendation DII AEA-4. AEA must conduct additional tests to identify suitable materials of construction to overcome corrosion problems encountered owing to the formation of HF in the treatment of GB.

Foster Wheeler/Eco Logic/Kvaerner Demonstration Tests

Finding DII FEK-1. The proposed full-scale TW-SCWO system has design and operating conditions significantly different from those tested in Demo II. These include the temperature of the transpiration water at the inlet; pH of the feed; turbulence in the reactor; and use of pure oxygen, not air, as the oxidant.

Finding DII FEK-2. The proposed full-scale design for the TW-SCWO system involves a factor of 2.25 scale-up in reactor cross-sectional area from the Demo II test unit and an increase in reactor throughput by a factor of 35. Performance under these full-scale design conditions has not been demonstrated.

Finding DII FEK-3. Aluminum present in the hydrolysates, which could lead to the formation of slurries and plugging, could be a problem. The proposed changes for mitigating this problem (e.g., changing operating conditions and/or removing aluminum during weapon disassembly) must be tested.

Finding DII FEK-4. Demo II tests confirmed that firing tubes and other solids could be treated to a 5X condition by the GPCR™ process.

Finding DII FEK-5. All waste streams have been or can be characterized sufficiently for engineering design to proceed.

Finding DII FEK-6. The current sampling and monitoring systems for agent in gaseous streams have not been certified or validated for use with the GPCR™ process off-gas.

Finding DII FEK-7. The product gas from the GPCR™ process does not meet the EPA syngas requirements because of high benzene and polyaromatic hydrocarbon content.

Finding DII FEK-8. While no agent was detected in the scrubbing solutions and scrubber filters, the ability of the GPCR™ process to destroy HD in mortars and neat GB could not be confirmed because sampling and analysis problems hampered the gathering of gas-phase data.

Finding DII FEK-9. Little evidence of soot formation was indicated when the GPCR™ unit was tested separately with PCP-spiked wood, HD mortars, M55 rocket firing tubes, and neat GB.

Finding DII FEK 10. The full-scale SCWO reactor design has not been tested and is different in size and in the flow rates of the feed streams from those used in the Demo II tests. The full-scale design treats hydrolysate at a rate per unit volume of reactor that is almost 10 times higher than that used during the Demo II tests. In addition, the ratio of the flow rates of all other streams to the flow rate of hydrolysate in the full-scale unit has decreased by approximately a factor of ten from those used during the Demo II tests. These changes in hydrolysate processing per unit of reactor volume and the reduction of other feed streams relative to the hydrolysate may reduce the efficacy of the SCWO reactor, and may be expected to exacerbate problems of corrosion and plugging.

Finding DII FEK-11. The experience of multiple shutdowns during Demo II testing of the TW-SCWO and the resulting thermal stresses and crack generation in the liner indicate a potential reliability issue, which must be significantly reduced or eliminated.

Recommendation DII FEK-1. Since the hydrolysate/total feed ratio and flow velocity used in Demo II testing are so different from those of the proposed design, the TW-SCWO reactor must be tested at a hydrolysate/total feed ratio and flow velocities close to the proposed design conditions.

Recommendation DII FEK-2. Long-term testing of appropriately designed SCWO reactor liners under the new operating conditions for the proposed full-scale operation will be necessary to prove the reliability and effectiveness of the TW-SCWO unit.

Recommendation DII FEK-3. Long-term testing of the TW-SCWO should include feeds containing chlorine, phosphorus, and sulfur and be at residence times and flow velocities close to the proposed design conditions.

Recommendation DII FEK-4. The Army or the technology provider must develop analytical methods to determine the quantities of agent in the gas streams containing hydrogen.

Teledyne-Commodore Demonstration Tests

Finding DII TC 1. Demo II tests were delayed and could not be completed for the Teledyne-Commodore process because of incidents in which the immaturity of the process became apparent. For example, an exothermic reaction between ammonia vapor and M28 propellant led to an ignition incident. At another time, Comp B dissolved in liquid ammonia leaked through flanges into valves and piping that were intended to transfer the material from the ammonia fluid jet-cutting vessel to the SET™ reactor. These incidents revealed serious safety problems associated with the Teledyne-Commodore process.

Supplemental General Findings

General Finding DII 1. The demonstration tests were not operated long enough to show reliability in long-term operation. The PMACWA's Demo II tests were required to be of the same duration as the Demo I tests. The technology providers had neither the time nor the resources for extensive systemization (preoperational testing) in Demo II. Consequently, these tests were simply proof-of-concept demonstrations that indicate whether or not a particular unit operation (with more development) might be applicable to the disposal of assembled chemical munitions.

General Finding DII 2. The AEA technology package is a very complex, immature chemical processing system. Several new unit operations required to address problems revealed in the Demo II tests will significantly increase the complexity of an integrated processing system and extend the time required for its development.

General Finding DII 3. The demonstrated components of the FW/EL/K technology package are ready to progress to the EDS phase. However, certain key units were not tested (or the results were inconclusive). Additional testing will be needed to verify the ability of the transpiring-wall technology to minimize corrosion; the testing should be carried out in parallel with development of an engineering design.

General Finding DII 4. Because of fire and safety problems, the basic process for the Teledyne-Commodore technology was not tested in Demo II. The Army decided against going forward because the Demo II goals could not be met in time. As a result, the committee had no technical basis on which to evaluate the process any further.

General Finding DII 5. As was true for Demo I, none of the unit operations tested in Demo II has been integrated into a complete system. The lack of integration is a major concern and a significant obstacle to full-scale implementation.

Supplemental General Recommendations

General Recommendation DII 1. Further development of the Teledyne-Commodore technology package for the destruction of assembled chemical weapons should not be pursued under the ACWA program.

General Recommendation DII 2. Before the AEA technology proceeds to the EDS phase, extensive testing should be performed on the SILVER II™ process, including all the new unit operations that are being proposed to address the shortcomings identified in Demo II results.

General Recommendation DII 3. For the FW/EL/K technology package, additional testing should be performed in the EDS phase to complete GPCR™ off-gas characterization and demonstrate long-term operation of the modified TW-SWCO unit.

TABLE ES-1
Summary Evaluation of the Maturity of Demo II Unit Operations and Processes

Technology Provider/Unit Operation or Process	Hydrolysates			Agent Munitions			
	VX/GB	HD	Energetics	VX/GB	HD	Energetics	Other
AEA							
- SILVER II™[a]				C	C	C	
- Solid/liquid waste treatment				C	C	C	
- Gaseous waste treatment				D	D	D	
Foster Wheeler/Eco Logic/Kvaerner							
- TW-SCWO	B	B	C				
- GPCR™				B	B	B	B[b,c]
Teledyne-Commodore							
- Ammonia fluid jet cutting and wash out system				D	D	E	
- SET™				D	D	D	C[b]
- Persulfate oxidation (agent)				D	D	D	
- Peroxide oxidation (energetics)				D	D	D	
- Metals parts and dunnage shredding							A[b,c]

Note: Environmental and safety issues were considered in assigning maturity categorizations. Schedule and cost issues were not considered. The letter designations are defined as follows (a blank space indicates that categorization was not applicable for that material).

A. Demonstration provides sufficient information to justify moving forward to full-scale design with reasonable probability of success.
B. Demonstration provides sufficient information to justify moving forward to the pilot stage with reasonable probability of success.
C. Demonstration indicates that unit operation or process requires additional refinement and additional demonstration before moving forward to pilot stage.
D. Not demonstrated and more R&D is required.
E. Demonstrated unit operation or process is inappropriate for treatment.

[a]Includes integrated gas polishing system to support demonstration.
[b]Dunnage.
[c]Metal parts.

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Appendix D

Acronyms/Abbreviations

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Appendix D

Acronyms/Abbreviations

ACW	Assembled Chemical Weapons
ACWA	Assembled Chemical Weapons Assessment
AMSAA	Army Materiel Systems Analysis Activity
APG	Aberdeen Proving Ground (Maryland)
BAA	Broad Agency Announcement
BGAD	Blue Grass Army Depot
BGCDF	Blue Grass Chemical Demilitarization Facility
CAMDS	Chemical Agent Munitions Disposal System (Utah)
CatOx	Catalytic Oxidation
CAC	Citizens' Advisory Commission
CAIG	Cost Analysis Improvement Group
CATT	Citizens Advisory Technical Team
CDPHE	Colorado Department of Public Health and Environment
CO_2	Carbon Dioxide
COINS™	Continuously Indexing Neutralization System™
CST	Continuous Steam Treater
CWC	Chemical Weapons Convention
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DCD	Deseret Chemical Depot (Utah)
DMMP	Dimethyl Methylphosphonate
DNT	Dinitrotoluene
DOD	Department of Defense
DPE	Demilitarization Protective Ensemble
DPG	Dugway Proving Ground (Utah)
DRE	Destruction and Removal Efficiency
DSHS	Dunnage Shredding and Hydrolysis System
ECBC	Edgewood Chemical and Biological Center (Maryland)
EDS	Engineering Design Studies
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERH	Energetics Rotary Hydrolyzer
FY	Fiscal Year
GB	Designation for Nerve Agent Sarin
GPCR™	Gas Phase Chemical Reduction™
H_2O	Water
HCI	Hydrochloric Acid
HD	Designation for Distilled Sulfur Mustard H
HSAAP	Holston Army Ammunition Plant (Tennessee)
HT	Designation for Blistering Agent Mustard (H) with T
ICB™	Immobilized Cell Bioreactor™
IIPT	Integrating Integrated Product Team

IITRI	Illinois Institute of Technology Research Institute
IRS	Impurities Removal System
kW	Kilowatt
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NRC	National Research Council
OIPT	Overarching Integrated Product Team
PCD	Pueblo Chemical Depot
PET	Program Evaluation Team
PHA	Preliminary Hazard Analysis
PMACWA	Program Manager Assembled Chemical Weapons Assessment
PMATA	Program Manager Alternative Technologies and Approaches
PMCD	Program Manager Chemical Demilitarization
POTW	Publicly Owned Treatment Works
PUCDF	Pueblo Chemical Agent Disposal Facility
PWS	Projectile Washout System
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylenetrinitramine Explosive
RFP	Request for Proposal
ROD	Record of Decision
SCWO	Supercritical Water Oxidation
T	Designation for Bis-Chloroethyl Thioethylether
TNT	Trinitrotoluene
TRBP	Thermal Reduction Batch Processor
TSD	Treatment, Storage and Disposal
TW	Transpiring Wall
U.S.	United States
VX	Designation for Nerve Agent Methylphosphonothioic Acid
WIPT	Working Integrated Product Team