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Review of Biotreatment, Water Recovery, and Brine Reduction Systems for the Pueblo Chemical Agent Destruction Pilot Plant

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Under the direction of the Department of Defense, the U.S. Army Element known as the Assembled Chemical Weapons Alternatives (ACWA) program will destroy the remainder of the outdated U.S. stockpile of chemical weapons that are stored at two sites: the Pueblo Chemical Depot (PCD) in Colorado and the Blue Grass Army Depot in Richmond, Kentucky. Construction of the Pueblo Chemical Agent Destruction Pilot Plant (PCAPP) was completed in late 2012, and the facility is currently undergoing systemization (pre-operational testing) until agent destruction operations begin in 2015 and continue in operation for 3 to 5 years. The depot stores a stockpile of projectiles and mortars containing the blister agent called mustard to be destroyed by hydrolysis. This report reviews the biotreatment, water recovery system (WRS), and brine reduction system (BRS) at PCAPP and identifies risks, possible problems, and modifications that may be required.

Brief Description of the PCAPP Process

The chemical agent stockpile at the PCD contains 105-mm and 155-mm artillery projectiles along with 4.2-inch mortar rounds. Together, these number approximately 780,000 munitions containing a total of about 2,600 tons of mustard blister agent. PCAPP will robotically disassemble the projectiles, remove the energetic materials, destroy the chemical agent with hot water, and decontaminate the mustard agent projectile casings by heating them to 1,000°F for more than 15 minutes.

The process for munition disassembly involves removal of munitions from their pallets, separation of propellant from the projectiles, and removal of bursters. Propellant and bursters are sent offsite for disposal. Munitions that are leaking or otherwise contaminated from agent, or that present problems for disassembly, will instead be detonated intact by using an explosive destruction technology that is separate from the PCAPP processes.

The mustard agent is washed out of disassembled projectile bodies by the munition washout system (MWS) with a high-pressure water stream. The mustard agent and MWS wash water is sent to the agent hydrolysis reactors where the agent is hydrolyzed with hot water (194°F) and caustic is added to neutralize the HCl produced. The hydrolysis step—also referred to as neutralization—produces a high pH stream called hydrolysate, which must be further treated to conform to requirements of the Chemical Weapons Convention treaty.

After the agent hydrolysis is completed and the hydrolysate has been determined to contain no more than 20 parts per billion (ppb) distilled mustard agent (HD) or no more than 200 ppb HD with bis(2-chloroethylthioethyl) ether (HT), it is transferred to the biotreatment area (BTA). The hydrolysate is treated in immobilized cell bioreactors (ICBs) where the main product of the hydrolysis, thiodiglycol (TDG), will be degraded by microorganisms. The effluent from the ICBs will undergo further treatment for purposes of water recovery—approximately 145,000 gallons per day (gpd) of the combined ICB effluent and utility wastewaters.

Biotreatment, Water Recovery, and Brine Reduction Systems

The biotreatment process produces the bulk of the water to be treated in the WRS and BRS. The ICBs are designed to remove at least 95% of the influent TDG. Among considerations to be managed are toxicity impacts from initially high influent concentrations of TDG, heavy metals, or sulfide. Optimal pH and temperature ranges will need to be maintained in the ICBs . Solids, both organic and inorganic, may build up and require attention. Finally, oxygen demand may exceed supply and will therefore need to be managed properly.

The WRS collects and mixes liquid ICB effluent with other wastewater streams and provides equalization of the collected liquid streams before the combined stream is delivered to the BRS.

The blended feed stream from the WRS flows to the evaporator portion of the BRS where most of the recycled water is produced, leaving behind a brine concentrate (BC) which is sent to the BRS crystallizer. There the brine is further concentrated, and the distillate product (water) from both the evaporator and the crystallizer is passed through carbon filters for removal of any residual constituents. Solids produced in the crystallizer are dewatered in a filter press and are sent offsite to a

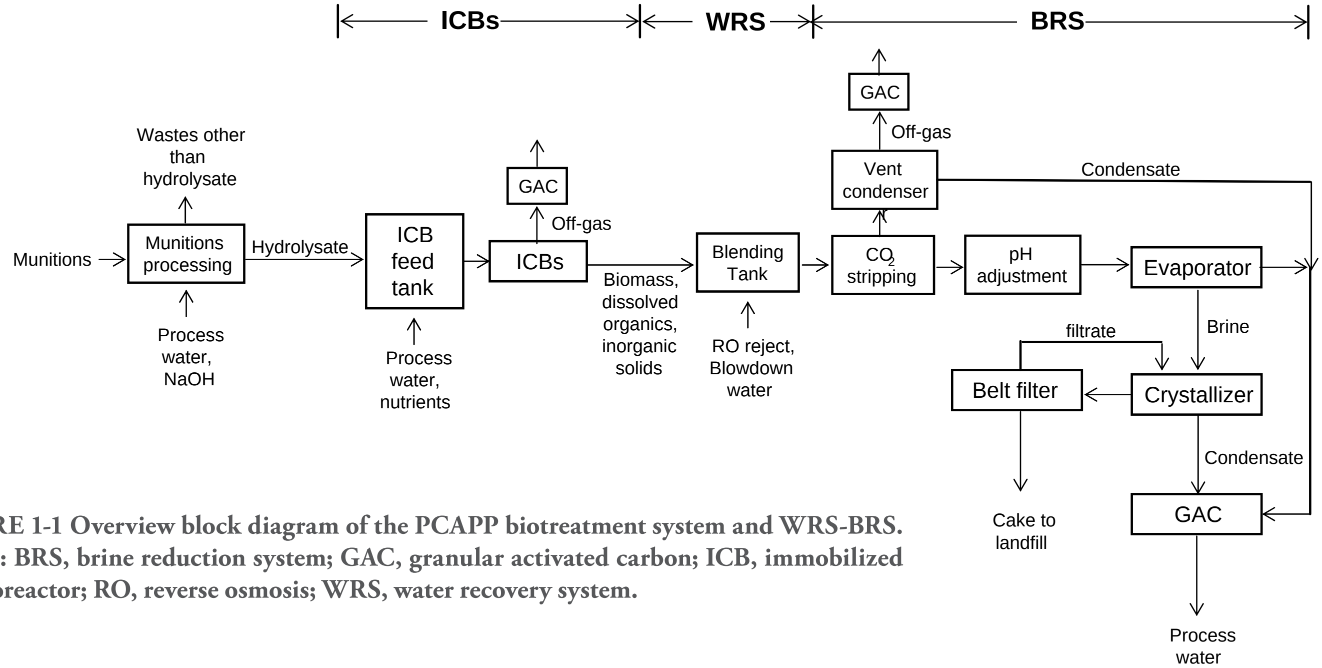

FIGURE 1-1 Overview block diagram of the PCAPP biotreatment system and WRS-BRS. NOTE: BRS, brine reduction system; GAC, granular activated carbon; ICB, immobilized cell bioreactor; RO, reverse osmosis; WRS, water recovery system.

hazardous waste disposal site. The overall BRS process involves acid addition to the evaporator feed, feed/distillate heat exchange, deaeration (CO2 stripping), evaporation with steam compression, caustic addition, crystallization, belt filtration, condensation, and activated carbon adsorption applied to both condensates and off-gases. These are complex operations made more so due to uncertainties regarding the particular composition and consistency of the feed stream that will originate from the ICBs.

Because the facility requires large quantities of water, which is a limited commodity in Colorado, PCAPP intends to purify and recycle at least 80% of the water back into the process after treatment. Permitting requirements mandate that the product water from the BRS must be adequate as a substitute for well water, indicated by the ability of the water to meet primary drinking water standards.

Major Observations

The following overarching concerns, findings, and recommendations are expressed in detail in the full report:

- The selection of a biofilm process for the biotreatment system was a wise selection.
- The feed, consisting of hydrolysate and recycled process water, is unique, complex, and not well defined. This may present challenges and require PCAPP to be particularly flexible and proactive in the operation of the plant.
- Proprietary information limited the study committee's ability to provide a thorough review of some aspects of the plant.
- Consequently, a conservative approach of starting the ICB units sequentially instead of simultaneously is strongly urged.
- The build-up of solids could be a major problem.
- Continuous and extensive process monitoring throughout the BTA-WRS-BRS is required to prevent system failure. A comprehensive corrosion monitoring program is also necessary.

Committee on Review of Biotreatment, Water Recovery, and Brine Reduction Systems for the Pueblo Chemical Agent Destruction Pilot Plant: Robert A. Beaudet, University of Southern California, Pasadena, Chair; **Pedro J.J. Alvarez,** Rice University; **Edward J. Bouwer,** Johns Hopkins University; **David L. Freedman,** Clemson University; **Kimberly L. Jones,** Howard University; **Ronald M. Latanison,** Exponent, Inc.; **Michael J. Lockett,** University of Buffalo, State University of New York; **Paige J. Novak,** University of Minnesota, Minneapolis; **Gene F. Parkin,** University of Iowa, Iowa City; **Ronald F. Probstein,** Massachusetts Institute of Technology; **Robert B. Puyear,** Independent Consultant, Chesterfield, Missouri; **Vernon L. Snoeyink,** University of Illinois, Urbana

Staff: Harrison T. Pannella, Study Director; **Nia D. Johnson,** Senior Research Associate; **Ann F. Larrow,** Research Assistant (from April 1 to August 10, 2012); **Joseph L. Palmer,** Senior Program/Project Assistant

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