Appendix B

U.S. Army Risk Assessment for Off-Site Transportation of Chemical Weapons

In 1987a risk assessment on transportation alternatives was conducted by the Mitre Corp. to support the Army's 1988 Programmatic Environmental Impact Statement (PEIS) (1, 2). It was intended to give a consistent and quantitative comparison of the risks of accidental chemical agent exposure to the public during on-site disposal versus various regional or national transportation and disposal alternatives. The analysis assumed that disassembly and incineration would be used with any of the transportation alternatives considered, so that the alternatives consisted only of variations on the logistics of chemical weapons (CW) transportation and the location of disposal facilities. However, many of the conclusions about transportation alternatives, and details about specific storage sites, were independent of the method of CW destruction. The analysis is unique in that it systematically examined and compared risks associated with certain CW transportation options, some of which are still being seriously discussed. Therefore a review of this document is relevant to a consideration of new alternatives.

In the Mitre analysis, risk was specifically defined as risk to the public (individuals outside the boundaries of the military installation) at the proposed disposal sites or along potential transportation corridors. Risks to persons involved in operating and maintaining the facilities were not considered. Only accidents that could result in agent release at potentially lethal concentrations were considered. Risks from chronic effects of long-term, low-level exposure to CW agents, or to materials released during CW incineration, were not included. This present review focuses on the assumptions and conclusions of Mitre's risk assessment and not with the risk assessment methodology.

Five alternatives were evaluated in the Mitre report and in the 1988 PEIS:

1. ***On-site disposal.*** Chemical weapons would be destroyed at their current locations. Risk was assumed to come from handling, on-site transport, and plant operations.
2. ***Regional disposal.*** Chemical weapons stored in the eastern United States would be shipped by rail to Anniston Army Depot (Alabama), while those in the western United States would be shipped to Tooele Army Depot (Utah). Risk was assumed to come from the same activities as on-site disposal, with additional risks from handling and off-site transport.
3. ***National disposal. All*** chemical weapons in the continental United States would be shipped by rail to Tooele Army Depot. Risk was assumed to come from the same activities as on-site disposal, with additional risks from handling and off-site transport.
4. ***Partial relocation.*** On-site CW disposal would be used at most sites, but the stockpile from Aberdeen Proving Ground (Maryland) and Lexington-Blue Grass Army Depot (Kentucky) would be relocated by air transport to Tooele.
5. ''No-action' ***alternative.*** Chemical weapons would be stored at their current locations for-at least 25 years. Risk was assumed to come from relatively rare catastrophic events such as tornadoes or airplane crashes. Although the probability of such accidents is low, the consequences would be great, and the risk extends over a relatively longer time. Risk would also come from normal monitoring and handling operations of the CW stockpile, including the processing of leaking munitions.

Risk was measured exclusively in terms of acute effects as the following:

- Maximum individual risk;
- Maximum lethal plume distance, or minimum distance of an individual from a given site or transportation corridor with no risk of lethal exposure;
- Maximum total time at risk for an individual;
- Probability of one or more fatalities;
- Maximum number of fatalities;
- Expected fatalities;
- Total person-years at risk and
- Expected plume area (used in the study as a surrogate for overall ecological impact).

Comparative risk assessments based on the above criteria were done both on the entire CW disposal program, along with site-specific assessments for the eight individual sites.

Events identified by the risk assessment process that might potentially lead to accidents involving release of and exposure to CW agents could often be mitigated or reduced through design and procedural changes. Risks were analyzed for the unmitigated case and again after appropriate mitigation. Mitigation strategies included: using foam or other materials for rapid spill cleanup, battery-powered lifting devices, blunt bumpers on lift truck tines, improved mobile fire control systems, seismic actuated gas cutoff valves in the munition demilitarization

buildings, metal shields at the explosive containment entry and seismically actuated warehouse circuit breakers, changing the munition unpacking area to prevent mines and rockets from being inadvertently conveyed to the dunnage furnace, freezing mustard ton containers for transportation, and restricting airspace at all sites and eliminating military helicopter flights. The following discussion of the Mitre report emphasizes the conclusions about risk assessments with all appropriate mitigation steps in effect.

Uncertainty in these risk assessments was assumed to come from uncertainty in the estimated probability that an accident would take place, not uncertainty about the consequence of an accident or about estimates of population density, atmospheric conditions, and dose response.

PROGRAMMATIC RISK COMPARISONS (RISK COMBINING ALL SITES)

With mitigation, on-site disposal had the lowest probability of causing one or more fatalities, whereas regional relocation, continued storage, national relocation, and partial relocation with disposal alternatives had 5, 7, 10, and 11 times greater probability of one or more fatalities, respectively. Regional disposal, partial relocation, and national disposal alternatives had, respectively, 10-, 26-, and 30-fold greater expected fatalities than on-site disposal. Even with mitigation, the continued storage alternative had the greatest number of expected fatalities and on-site destruction the least. This resulted largely because the estimated risk from continued storage occurred over a relatively long period (25 years) and came from rare catastrophic events that would have relatively large consequences. With mitigation, on-site disposal had the lowest probability of causing one or more fatalities and partial relocation had the highest. Mitigation did not change the number of maximum possible fatalities. As in the unmitigated case, continued storage had significantly greater expected fatalities than all other alternatives. With mitigation, on-site disposal was significantly less risky than any other alternative considered.

For the continued storage with mitigation programmatic alternative, 99 percent of the expected fatalities were associated with CW storage, and the risk associated with handling and stockpile movement for maintenance and surveillance accounted for the remaining 1 percent. Accidents with bulk containers accounted for 99 percent of the expected fatalities. For the programmatic on-site disposal alternative with mitigation, on-site transportation activities accounted for 44 percent of expected fatalities, and plant operations for 48 percent. The M55 rockets in the CW stockpile accounted for 50 percent and bulk containers 42 percent of expected fatalities.

For the partial relocation alternative without mitigation (which calls for air transport of the CW stockpile from the Aberdeen (Maryland) and Lexington-Blue Grass (Kentucky) facilities to Tooele (Utah) using C141 airplanes), accidents involving rockets contributed 77 percent and in-flight air accidents along the transportation corridor accounted for 46 percent of the total risk Accidents with the highest consequence were considered to occur during aircraft takeoff involving rockets and projectiles containing GB. Mitigation reduced the probability of one or more fatalities approximately threefold, although expected fatalities were not significantly decreased. Mitigation had the largest effect on reducing risk from plant operations.

SITE-SPECIFIC RISK COMPARISONS

The conclusions reached about programmatic risks for the combined eight sites described above were often different from the conclusions reached by site-specific risk analysis. For example, the risk from continued storage with mitigation was much lower at Lexington-Blue Grass Army Depot than at the seven other U.S. sites. Although the risk associated with continued storage with mitigation clearly was greater than on-site disposal with mitigation at the sites in Aberdeen, Maryland; Newport, Indiana; Pueblo, Colorado; Tooele, Utah; and Umatilla, Oregon, this was not the case with Lexington-Blue Grass and Pine Bluff (Arkansas) facilities.

Major differences were reported in the distribution of risk among populations at the eight continental U.S. sites, in terms of expected fatalities. For the continued storage option with mitigation, the total program risk is mostly from potential accidents involving the CW stockpiles at the Newport Army, Aberdeen Proving Ground, and Umatilla depots. The risk of continued storage with mitigation at the other five sites contributes little to the overall programmatic risk. For on-site disposal with mitigation, 75 percent of the total program risk is borne approximately equally by the Army depots in Pueblo, Colorado, and Newport, Indiana.

For the regional disposal alternative with mitigation, 75 percent of the total program risk is borne by populations along transportation corridors. For the national disposal site alternative with mitigation, 98 percent of the total risk is borne by the population along the transportation corridor. An intuitive understanding of these relative risks may explain why transportation alternatives are more popular with people living near existing stockpile sites.

The total program risk from on-site versus regional disposal was not statistically distinguishable (3). Other factors entered into the Army's decision to select on-site, rather than regional, disposal. The Army argued that the results showing a lack of significant difference in risk

associated with these two programmatic alternatives did not consider the location and mitigation of possible accidents. A qualitative consideration of this risk factor led to the conclusion that any option that involves transportation of chemical weapons off-site is more risky (3).

Appendix B References

1. U.S. Department of the Army, "Chemical Stockpile Disposal Program Final Programmatic Environmental Impact Statement," vols. 1,2,3, Office of the Program Manager for Chemical Demilitarization, Aberdeen Proving Ground, MD, 1988.
2. Mitre Corp., McLean, VA, "Risk Analysis Supporting the Chemical Stockpile Disposal program (CSDP)," prepared for the Office of the Program Manager for Chemical Demilitarization, U.S. Army, Aberdeen Proving Ground, MD, December 1987.
3. Azuma, E., Office of the Assistant Secretary of the Army, The Pentagon, Washington, DC, briefing at the Office of Technology Assessment, Washington, DC, Oct. 18, 1991.