

## *Battelle Assesses Risks of Fog Oil Smoke*



The Base Realignment and Closure (BRAC) Acts of 1988 and 1990 resulted in the closure or transfer of many military installations around the country. One such action required that the U.S. Army Chemical School relocate from Fort McClellan, Alabama, to Fort Leonard Wood (FLW), Missouri. In connection with the relocation, Battelle was contracted by the Kansas City District of the U.S. Army Corps of Engineers to conduct a human health risk assessment of the School's fog oil smoke training activities.

Fog oil is a battlefield obscurant that is used to produce a visual smoke screen to mask troops by confounding enemy sensors and smart munitions. It consists of a de-aromatized middle distillate petroleum (MIL-F-12070E) that is heated and expelled from mobile smoke generators. Upon contact with the air the expelled oil droplets condense to form a thick white smoke.

Under the right atmospheric conditions the smoke plumes can persist and migrate at ground level. Therefore, the U.S. Environmental Protection Agency (EPA) required the Army to evaluate the health risk posed by smoke training to civilians residing within FLW. Battelle was contracted to conduct chemical characterization and field testing of fog oil and fog oil smoke, use an atmospheric dispersion model tailored to FLW to predict downwind concentrations, and perform a human health risk assessment based upon these results.

Extensive field tests with two smoke generators, the M56 and M157A2, were conducted in July 1998 at Utah's Dugway Proving Ground. Battelle set up samplers at varying distances from the generators in order to capture and analyze elements in the fog oil smoke and the generators' exhaust. An inert tracer gas (SF<sub>6</sub>) was used to monitor plume meander and migration and allow identification and determination of the emission rate of the chemicals of concern in the exhaust and fog oil smoke. The exhaust and smoke samples were subjected to detailed chemical analysis, the results of which were used in an air dispersion model to predict fog oil smoke concentrations under a variety of meteorological conditions. The model was tailored for the topography, meteorologic conditions, and scheduled training scenarios to be conducted at FLW. The concentrations and frequency of any chemicals reaching the civilian population were predicted and incorporated into the human health risk assessment.

The risk assessment revealed that the increased risk of cancer that fog oil smoke training at FLW poses to people residing there is well below the limit set by the EPA. While the exhaust produced by the smoke generators did contain possible carcinogens – volatile organic compounds and polycyclic aromatic hydrocarbons, their concentrations were comparable to or lower than those found in urban air or in the exhaust of gasoline, diesel, or jet fuel engines. The fog oil smoke itself was found to contain several possible carcinogens, including 1,3-

butadiene, benzene, and quinoline. The estimated total risk of cancer resulting from chronic exposure to fog oil smoke during training exercises amounts to approximately five additional cancers per 10 million children and one additional cancer per 10 million adults residing in FLW.

For more information, please contact Scott Stout at (781) 934-0571 or via e-mail at [stouts@battelle.org](mailto:stouts@battelle.org).



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