Symposium on Toxic Substance Control: DECONTAMINATION

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
Chemical Systems Laboratory
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Contamination avoidance	

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On 22-24 April 1980, Chemical Systems Laboratory sponsored a symposium on decontamination at Columbus, Ohio. This report is the official proceedings of that meeting. A keynote address was given by BG Gerald Watson, Deputy Commander for Training at the US Army Military Police and Chemical Schools/Training Center and Ft McClellan, Ft McClellan, Alabama. Papers were presented on methods of detection, laser destruction of materials, new methods of chemical decontamination of the agents, compatibility of materials with agents and decontaminants,

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biological decontamination, liquid blasting, water-jets as methods for physical decontamination, and surface active displacement solutions. Summaries of one day workshop sessions on the subjects of chemical methods of toxic substance decontamination, physical methods of toxic substance removal, contamination monitoring, personnel decontamination, and contamination avoidance for the future were also presented.

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PREFACE

Chemical and biological (CB) defense must be an integrated system of the components described in Figure 1. The components form a wheel that has four spokes: detection, contamination control, protection, and the medical aspects.

Detection: The first spoke is detection of the presence of a toxic environment – an extremely lethal environment. It requires automatic alarms to warn of the presence of a hazard in time to initiate protective action to continue the mission, monitoring equipment to measure the presence and location of toxics, and kits to identify the nature of the contaminant.

Contamination Control: The second spoke is a two part program – the use of methods to minimize the effects of contamination, and ease the burden of Decontamination, that is, **Contamination Avoidance**; then, **Decontamination** to clean up equipment and critical areas that have become contaminated, with logistically superior methods and less manpower intensive procedures. The current doctrine emphasizes scrubbing. There must be a better way as we cannot afford the time, men, or equipment.

Physical Protection: The third spoke is Physical Protection of people and equipment – for the **individual** so that he/she can operate safely continuing the mission in the highly toxic contaminated area; and **collective** so that areas can be kept clean for individuals to work without the burden and encumbrance of individual protection, and can get rest and relief from the individual protective burden.

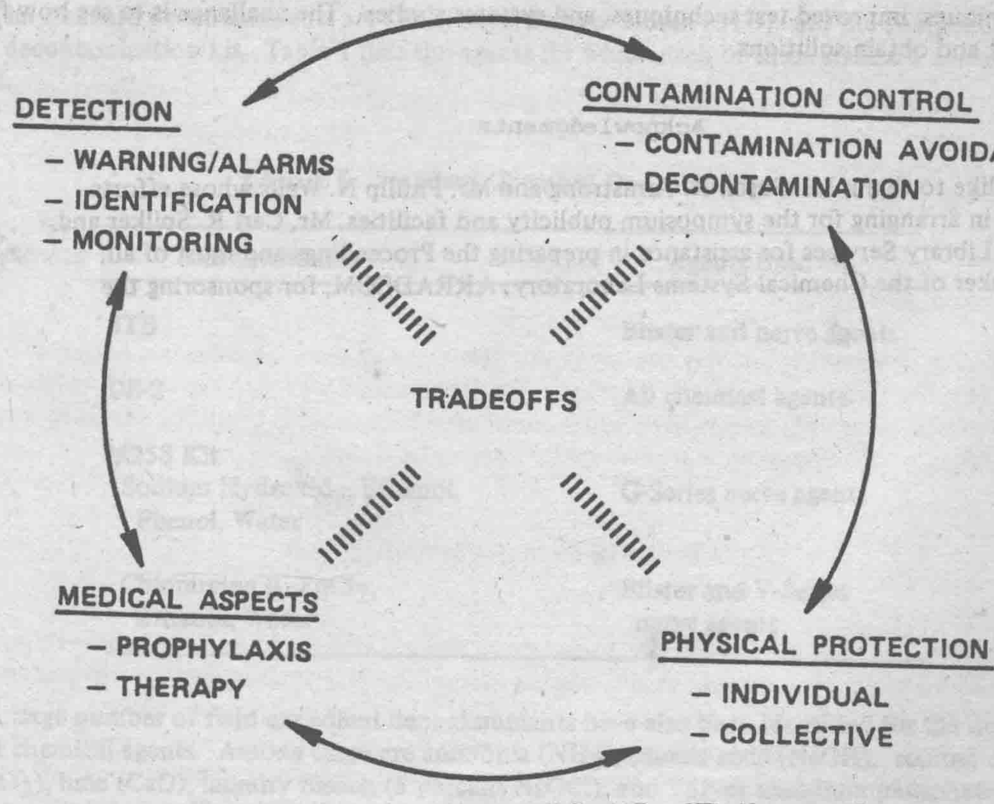

FIGURE 1. Integrated CB defensive system.

Medical: The fourth spoke is medical – **prophylaxis** for the individual to help his body sustain exposure to toxics; and, **therapy** – treatment to sustain life after exposure and return the individual to full functionability at the earliest time. We also need to improve doctrine on handling casualties on a chemical battlefield.

The challenge that we and everyone else faces is where does one make the trade-offs to resolve the total toxic environment problem. How will detection facilitate protection? How will detection assist in contamination control? How do the medical aspects interact with the others? A system approach to the total problem is essential to balance the tradeoffs.

There are rarely enough resources to do the whole job, but right now there are at least two priority programs in the chemical area. They are, develop and field a new mask, and develop and field an improved decontamination system. Detection is important to both of these. We have some approaches in this area and we need more. Monitoring for contamination is a difficult problem, especially as part of the decontamination problem.

The U.S. Army Training and Doctrine Command (TRADOC) is also using Figure 1 except that, from their point of view, they replace the tradeoffs with training. TRADOC is talking in terms of training soldiers to live in a CB environment on the defensive basis. The Chemical Systems Laboratory is talking in terms of tradeoffs so that one can apply limited research and development dollars in a balanced program to achieve greatest payoff.

Summarizing the problem, we are dealing with the most toxic chemicals around. We are dealing with small quantities of these materials that are widely dispersed – in densities of grams per square meter. We are dealing with potentially thickened and tacky materials which make decontamination more difficult. There is needed technology for detection on surfaces, logistically improved decontamination techniques, improved test techniques, and systems studies. The challenge is to see how fast we can move out and obtain solutions.

Acknowledgments

We would like to thank Ms. Susan R. Armstrong and Mr. Phillip N. Wells whose efforts were invaluable in arranging for the symposium publicity and facilities, Mr. Carl R. Spilker and the Report and Library Services for assistance in preparing the Proceedings and most of all, Dr. James A. Baker of the Chemical Systems Laboratory, ARRADCOM, for sponsoring the symposium.

FOREWORD

George G. Outterson
Battelle's Columbus Laboratories

Toxic substances may be decontaminated using chemical and physical methods. Some methods used by the Army to decontaminate primarily chemical agents are outlined.

Several decontamination methods, such as fire or strong bleaches, are designed for use on equipment or terrain and would be far too severe for personnel. Thus, a section addresses personnel decontamination. Associated with decontamination is the need for monitoring to determine when decontamination is complete. Monitors presently available for use are described. Finally, measures can often be taken to minimize contamination before an agent attack are addressed.

Chemical Methods of Toxic Substance Decontamination

There are two general categories of chemical decontaminants presently used by personnel to detoxify chemical agents: standard and field expedient decontaminants. Standard decontaminants are those developed specifically for use by military personnel. Field expedient decontaminants are those materials that are readily available in a military environment.

The standard decontaminants are DS-2, supertropical bleach (STB), and the components of the M258 decontamination kit. Table 1 lists the agents for which each of these standard decontaminants is used.

TABLE 1. Standard Chemical Decontaminants

Decontaminant	Agents Used On
STB	Blister and nerve agents
DS-2	All chemical agents
M258 Kit	
Sodium Hydroxide, Ethanol, Phenol, Water	G-Series nerve agents
Chloramine B, $ZnCl_2$, Ethanol, Water	Blister and V-Series nerve agents

A large number of field expedient decontaminants have also been identified for the detoxification of chemical agents. Among these are ammonia (NH_3), caustic soda (NaOH), sodium carbonate (Na_2CO_3), lime (CaO), laundry bleach (5 percent NaOCl), and TSP or trisodium phosphate (Na_3PO_4). Oxidation by fire and steam hydrolysis are other field expedient techniques. These decontaminants and techniques however, are not effective against all agents in general.

Chemical decontaminants may be applied using either standard or field expedient equipment. The standard equipment for applying chemical decontaminants is the M12A1 Skid-Mounted Power-Driven Decontaminating Apparatus. Table 2 describes the performance and capacity characteristics of the M12A1. DS-2 may be applied using the M-11 1-1/2-quart DS-2 portable decontaminating apparatus. Table 3 describes the performance and capacity characteristics for this equipment item. DS-2 can also be applied from bulk containers using brooms, mops, or brushes.

Physical Methods of Toxic Substance Removal

Physical methods do not necessarily detoxify chemical agents, but remove the agents from personnel, equipment, and/or terrain. Probably the most important physical removal method is aeration. The agents evaporate and are dispersed in the air. Aeration is important for all of the volatile agents.

Active physical removal methods include the use of flat sticks (such as are in the M258 kit), pads containing Fuller's earth, heat in the form of fire or steam, and high pressure water rinses. Another method is simple washing with hot soapy water.

Contamination Monitoring

There are two primary devices that are presently used to monitor for chemical agents: The M-8 series alarm and the M256 chemical agent detector kit. The M-8 series alarm is a point source alarm that actively samples ambient air and reacts to low concentrations of nerve agents. The M-8 alarm detector also detects several other agents including HCN, CNCl, $COCl_2$, Cl_2CNOH, and $BrC_6H_4CH_2CN$. The M256 chemical agent detector kit is a passive detector that shows a color change when a nerve, blister, or blood agent is present. The M256 kit also contains ABC M-8 detector paper that is used to blot the surfaces suspected of agent contamination. The M-8 paper changes color when an agent is present.

A liquid agent detector (LAD) and an advanced liquid agent detector (ALAD) have been developed to replace M-8 paper.

A number of monitoring instruments have been developed or purchased for use during depot storage and demilitarization operations. Typically, these instruments are used to detect extremely low concentrations of specific agents. The instruments are often suitable primarily for fixed installation rather than portable deployment in a rapidly moving battlefield.

Personnel Decontamination

The M258 Skin Decontamination Kit is used by individual soldiers to decontaminate themselves. The kit contains two vials and several plastic sticks. The plastic sticks are used to remove visible droplets of agents from the skin and clothing. Vial I contains an aqueous solution of sodium hydroxide, ethanol, and phenol, and is used to decontaminate the G-series of nerve agents. Vial II contains chloramine B and $ZnCl_2$ in a water-ethanol solution and is used to decontaminate the other agents, i.e., mustard and VX. Portable showers may be erected for personnel decontamination.

TABLE 2. Characteristics of the M12A1 Power-Driven Decontamination Apparatus

Working pressure	60–130 psi
Coverage per filling (Average for smooth surface)	1300 m^2
Discharge rate	
One spray gun	25 gpm
Two spray guns	50 gpm
Tank capacity for STB slurry	310 gal

TABLE 3. Characteristics of M-11 Portable Decontaminating Apparatus

Capacity	1-1/3 quart
Working solution	DS-2
Weight of filled apparatus	6 lb
Effective spray range	6–8 ft
Coverage per filling	15 m^2
Pressurization	N_2 cylinder

Contamination Avoidance

Contamination avoidance refers to measures taken in advance of a chemical attack to minimize chemical contamination. The measures can include both specific actions on the part of military personnel during operations and considerations in the design and specification of military equipment.

An example of the former is the use of overhead shelters to minimize surface contamination f from liquid droplets of agents. An example of the latter is the use of polyurethane paints. Chemical decontamination is easier and more complete when the surfaces being decontaminated have been coated with polyurethane paints, which do not absorb agents.

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KEYNOTE ADDRESS

BG Gerald G. Watson
Fort McClellan, Alabama

Dr. Edward W. Ungar, Director, Battelle's Columbus Laboratories introduced General Watson: "It's a real honor to have as our keynote speaker, Brigadier General Gerald G. Watson. General Watson is Deputy Commander for Training at the U.S. Army Military Police and Chemical School Training Center in Fort McClellan, Alabama. General Watson."

Thank you very much. Dr. Ungar, ladies and gentlemen, it's a pleasure to be here. Wherever there's a group of people gathered together to talk about the chemical warfare program, I am always delighted to participate. It's something I've held very dear, something I've spent a lifetime working on, and finally I can see activity and things happening that should have been going on a long time ago. It's a nice feeling. Why do I feel this way? Simply because I think that for too long our Army has been at risk when compared with the Soviet Union. I hope that we are now in a position to start to reduce this risk through our growth and our industrial and government involvement in the solutions to this problem.

Before I get into our subject for today, I want to report to you where we are in several key areas of the chemical warfare program. As most of you know, the Army decided about a year and a half ago to reestablish its chemical school at Fort McClellan, Alabama. Two-thirds of the school is already at Fort McClellan. We started our first class at Fort McClellan on the 25th of April 1980. By the first of August, the entire school will be operational at Fort McClellan. We'll have a staff of about 400 people. We will have an average student load of about 700. So the combined effort will be somewhere around 1,000 to 1,100 in the initial phase.

With regard to force structure, many of you have read reports that 2 or 3 years ago we had about 2,200 chemical trained personnel through our entire Army. That has changed. We now have in each division an NBC Company. This company plus other chemical trained personnel, totals about 250 people in each of our combat divisions. That isn't much; probably isn't enough, but it's certainly a long way from the 20 that we had there less than 18 months ago. The force structure is probably one of the best successes we have had simply because we have had to swim hard upstream during a period when the entire force structure was being reduced.

The other key area is the chemical systems program review. On the 28th of May, we are going to have a general officer conference that will look at the entire chemical program. It will examine the program in terms of doctrine, retaliatory capability, force structure, our obscuration, and sustainability. I would expect that when the conference opens, it will be attended by most of the leadership of the Army. And we are going to look at this program and from this you will see some action plans that will create new starts within the entire chemical warfare program.

I think it would be foolish of me to stand here and talk to you about a scientific matter since your credentials are rather impressive. I would like to compliment Battelle and, of course, the United States Army Laboratory for this occasion today. Two years ago this would not have been possible. I think both of you are to be complimented on putting together this kind of symposium so that we can come and talk about one of the great problems in our Army today.

I want to talk to you today in terms of tactical situations. I would like to talk to you in terms of what the soldier is going to experience on the battlefield. Because I think, in some cases, we've gotten away from this important concept. I think you as scientists and engineers, need to have an appreciation of just how big the problem is. I have a few simple charts that I hope that I can convey to you the message that the chemical warfare problem on the battlefield is a rather huge one.

In Figure 1, I have taken a simple corps sector consisting of three divisions deployed side by side. To your right, you'll see what we would call our combat battalions and where they are going to be located in the defense, initially. Behind them are the reserve units, our key supply systems, supply routes, and command and control systems.

Now, as we move to the rear we find the corps area and this is where a lot of our general support organizations/functions are located. And then beyond that are the echelons above corps where many of our nuclear weapons systems, our airfields, and those other kinds of combat support activities that we need in order to be able to prosecute the war are located.

Figure 2 is to scale. And it shows you in depth what the Soviet Union is capable of delivering on our forces. Beginning up front with their first echelon divisions, they can simultaneously hit us with nonpersistent agent in our battalion defensive areas. And in our division rear areas with persistent agent: thickened GD, mustard. They can rely on their own second echelon divisions to extend the range all the way into our rear and hit our key support systems, our command and control systems and our key logistics nodes. In Figure 3, the entire battlefield, you can see the downwind distances of the vapor hazards that would exist for short periods of time where the nonpersistent agent has been employed. As we move on into the rear you can see the problem created by the persistent agent. It will be around for several days.

Now, I believe you can begin to see the magnitude of the Soviet effort. They have available within their force structure, the weapons systems that will allow them to strike deep within our forces.

You can see from this chart why the Soviet Union has collective protection and positive pressure systems in their combat vehicles. This allows them to keep the momentum of the battle going.

Figure 4 indicates their capability in terms of its impact on our forces, you can see that as much as 50 percent of the battle could be covered with some kind of toxic cloud for short periods of time and as much as 10 percent with persistent agent.

Here is what we're talking about in terms of casualties and the amount of equipment that we think is going to become contaminated. This should provide you a good appreciation for the kind of job that we have to do, the work that must be accomplished. This is the requirement. We hope that you can develop a system for us to use on the contaminated battlefield in order to minimize the level of effort required to operate.

Figure 5 indicates that when we start to plan and program our chemical defensive efforts we plan and program in four areas.

In looking at decontamination we have traditionally talked of decontamination in terms of emergency decontamination, partial decontamination, and total decontamination. Our decontamination doctrine requires us to talk of it in these terms. We have configured our development program to satisfy these needs. I think the question that really should be raised at this point is "Is this satisfactory?"

When we look at the individual, we're basically talking here in terms of matters of minutes that the individual must react to get the major pieces of contamination off of him if he is going to avoid becoming a casualty. What do we have to do that with? Not a whole lot. We have a kit that will

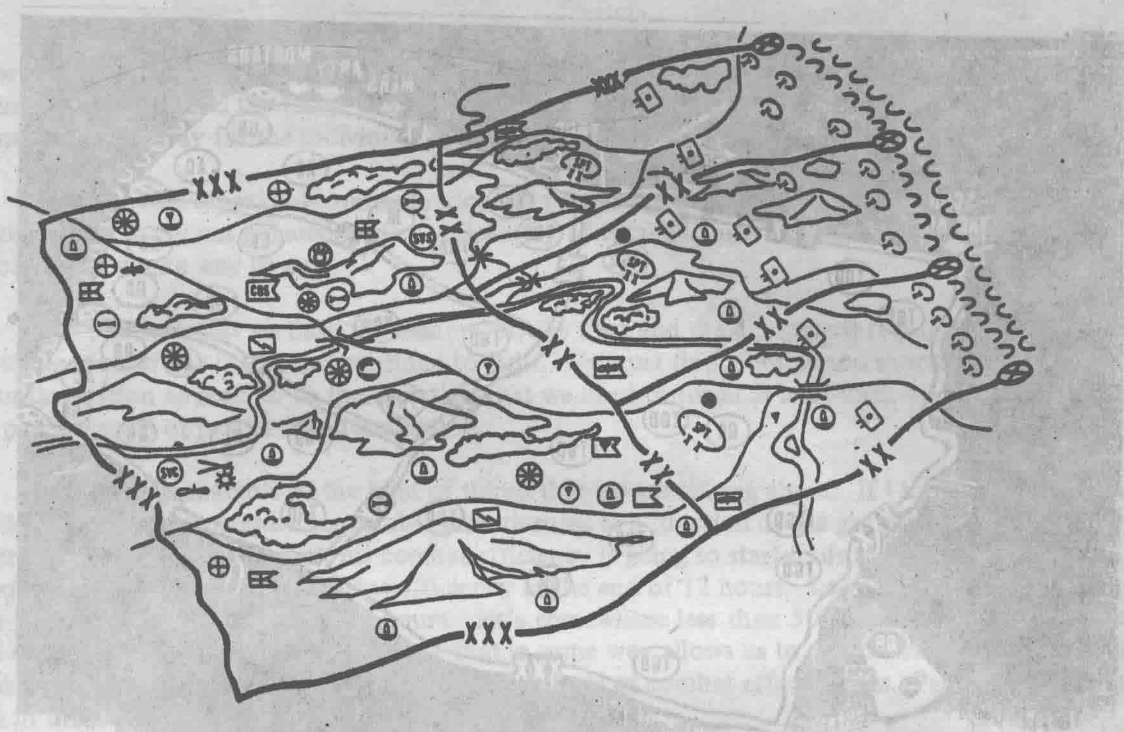

FIGURE 1. The Corps sector.

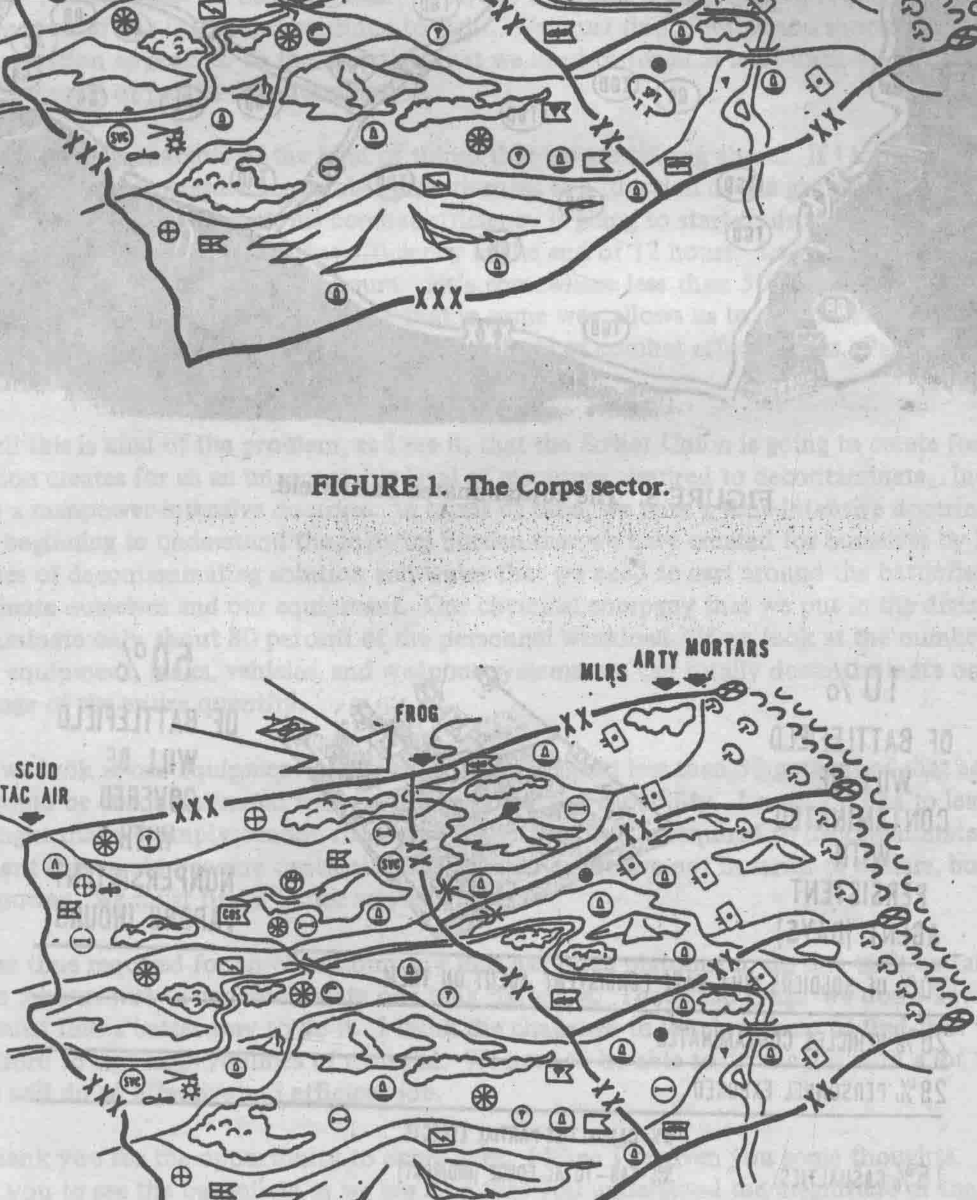

FIGURE 2. The battlefield.

FIGURE 3. The contaminated battlefield.

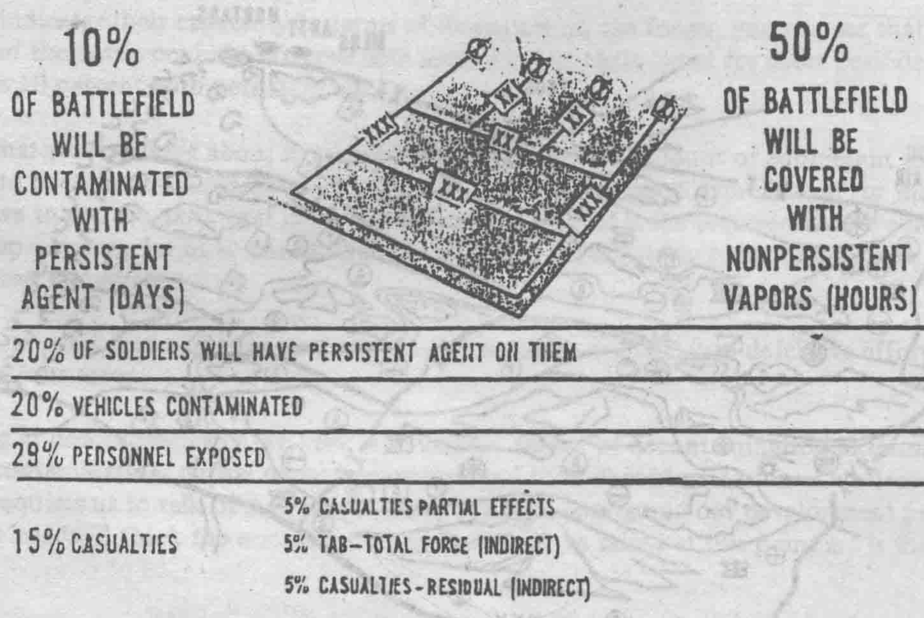

FIGURE 4. Effects of the contaminated battlefield.